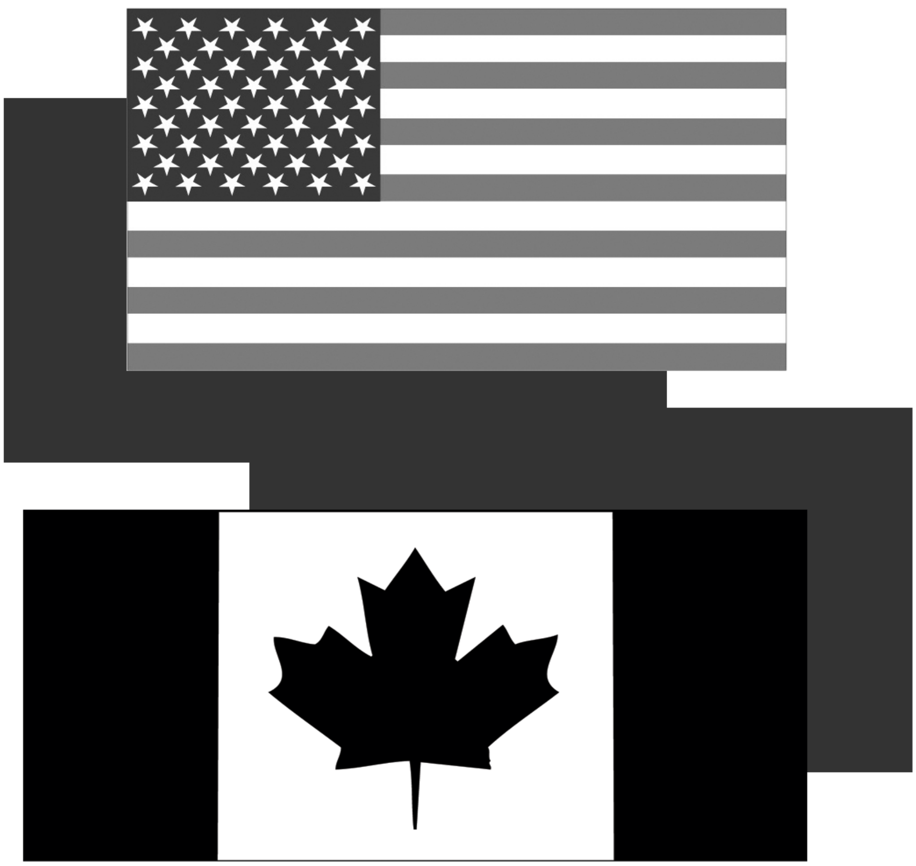
Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

56th Annual Meeting of the TSC

April 28-29, 2015
Sidney, BC Canada



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
2013	April 30-May 1	Seattle, WA	Palsson	Larinto
2014	April 29-30	Seattle, WA	Dykstra	Larinto
2015	April 28-29	Sidney, BC	Yamanaka	Larinto
2016	April 26-27	Newport, OR	Whitman	Yamanaka

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A. History and Purpose

Purpose:

The Technical Subcommittee (TSC) of the Canada-U.S. Groundfish Committee was formed in 1960 out of a need to coordinate fishery and scientific information resulting from the implementation of commercial groundfish fisheries operating in US and Canadian waters off the West Coast. Today, representatives from Canadian and American state and federal agencies meet annually to exchange information and to identify data gaps and information needs for groundfish stocks of mutual concern from California to Alaska. Each agency prepares a comprehensive annual report highlighting survey and research activities, including stock assessments. These reports are compiled into an annual TSC report that is published online (www.psmfc.org/tsc2). The TSC reviews agency reports and recommends collaborative work or plans workshops on topics of shared interest. Historically, the TSC has prepared catch databases that led to the development of the Pacific Fisheries Information Network (PacFIN) catch reporting system, hosted 21 scientific/management workshops, organized 27 working groups, and created the Committee for Age Reading Experts (CARE). Each year the committee discusses and recommends actions to improve and coordinate groundfish science among agencies and these recommendations are sent to agency heads and managers to inform research and management priorities.

History:

Before the U.S. and Canada implemented exclusive domestic fisheries off their respective coasts, commercial fishers from either country could fish in both American and Canadian waters. In 1959, an International Trawl Fishery Committee (later renamed the Canada-U.S. Groundfish Committee) was established by groundfish management and research agencies to track transboundary fisheries and examine biological questions pertinent to the stocks and fisheries. This committee established the Technical Subcommittee (TSC), which held its first meeting in 1960 and has held annual meetings ever since. Initial activities and concerns focused on reporting and resolving catch estimates, stock identification and assessment, tagging, ageing techniques, and hydroacoustic techniques. These earlier studies focused on Petrale, Rock, and English Soles; Lingcod; Pacific Ocean Perch; and Sablefish. The TSC has fostered new science and improved methodologies by forming workgroups to focus on specific problems and by holding workshops to bring scientists and managers together to discuss aspects of groundfish science that are of mutual concern. Some recent workshops include Trawl and Setline Survey Methods, Catch Reconstruction, and Visual Survey Methods.

Evolution:

Over time, the TSC's role has changed with the implementation of new management and legislative authorities but the annual reports provide a common and concise forum to both disseminate information on current groundfish science and to learn about agency programs and activities. The TSC continues to highlight timely research topics, hold workshops, and establish workgroups, as well as send their recommendations to agency directors, fishery managers, and program managers to lay the foundation for trans-boundary coordination through open communication.

Final, February 4, 2016

B. Executive Summary

The TSC met April 28-29, 2015 in Sidney, British Columbia, Canada. This year's meeting was hosted by the Department of Fisheries and Oceans, Canada (list of attendees is included in the minutes). The meeting was chaired by Traci Larinto, California Department of Fish and Wildlife. As is done each year at the meeting, participants review previous year (2014) research achievements and projected current year (2015) 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. The TSC thanked CARE for taking time during their biennial meeting to work towards developing a set of best practices for short and long-term storage of otoliths.

The TSC again recognized the value of the 2014 Visual Survey and understands there will be a session or workshop at either the American Fisheries Society Annual Meeting in 2015 or the Western Groundfish Conference in 2016. Additionally, new information about visual surveys by researchers is forthcoming. While interest was expressed in forming a working group or initiating a second workshop, the TSC agreed to carry this over to the next meeting.

Other important topics discussed at the meeting included: 1) TSC recommends that agencies, universities, and jurisdictions work together to advance fish maturity studies through joint scientific projects, workshops, and manuscripts, 2) The TSC suggests that a special session or workshop be held at the 2016 Western Groundfish Conference that will highlight research, findings, and management strategies to understand and adapt to groundfish responses to climate change, 3) The TSC continues to express interest in another trawl and longline survey methods workshop. Many ideas for the workshop were discussed, including electronic data capture methods, and 4) The TSC discussed the need to share tagging data for transboundary stocks. Sharing of data for species such as sablefish, black rockfish, lingcod and sharks that are tagged in both countries will enhance the scientific understanding of the population dynamics of these species which will lead to improved management. The TSC recommends sharing data for all tagged species where transboundary tag interception may occur and urges agencies in both countries to enable data exchange.

The 57th Annual Meeting of TSC will be held April 26-27, 2016 in Newport, Oregon and hosted by Ali Whitman, ODFW.

C. Minutes of the Technical Subcommittee

Minutes of the Fifty Sixth Annual Meeting of the TSC
Sidney Pier Hotel and Spa - Sidney, British Columbia
April 28-29, 2015

<u>Tuesday, April 28</u>

I. **Call to Order –** Traci Larinto, Chair, called the meeting to order at 8:05 am

II. **Appointment of Secretary** - Lynne Yamanaka (meeting host) arranged for Kendra Holt (4/28 am), Maria Surry (4/28 pm), and Kate Rutherford (4/29) to record meeting minutes. The Chair thanks them for taking notes.

III. **Introductions** - Stephen provided housekeeping information. Reports that were made available online before the meeting, or provided at the meeting, including the 2013 TSC Report, and the 2014 reports from ADFG, AFSC, DFO Canada, IPHC, NWFSC, ODFW, SWFSC, WDFW, and CARE. TSC members and guests introduced themselves.

IV. **List of Participants**

Jim Armstrong, North Pacific Fishery Management Council, Anchorage, AK, (James.Armstrong@noaa.gov)

Claude Dykstra, International Pacific Halibut Commission, Seattle, WA, (Claude@iphc.int)

Jon Heifetz, Alaska Fisheries Science Center, NOAA, Auke Bay Lab, Juneau, AK (Jon.Heifetz@noaa.gov)

Kendra Holt, Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada, Nanaimo, BC (Kendra.Holt@dfo-mpo.gc.ca)

Aimee Keller, Northwest Fisheries Science Center, Seattle, WA, (Aimee.Keller@noaa.gov)

Scott Kelley, Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas, AK. (Scott.Kelley@alaska.gov)

Traci Larinto, California Department of Fish and Wildlife, Los Alamitos, CA (Traci.Larinto@wildlife.ca.gov)

Dayv Lowry, Washington Department of Fish and Wildlife, Olympia, WA, (Dayv.Lowry@dfw.wa.gov)

Kirsten MacTavish, International Pacific Halibut Commission, Seattle, WA, (Kirsten@iphc.int)

Norm Olson, Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada, Nanaimo, BC, (Norm.Olson@dfp-mpo.gc.ca)

Wayne Palsson, Alaska Fisheries Science Center, NOAA, Seattle, WA, (Wayne.Palsson@noaa.gov)

Kate Rutherford, Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada, Nanaimo, BC (Kate.Rutherford@dfo-mpo.gc.ca)

Jenny Stahl, Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas, AK (Jennifer.Stahl@alaska.gov)

Maria Surry, Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada, Nanaimo, BC (Maria.Surry@dfo-mpo.gc.ca)

Tom Wilderbuer, Alaska Fisheries Science Center, NOAA, Seattle, WA, (Tom.Wilderbuer@noaa.gov)

Lynne Yamanaka, Science Branch, Pacific Biological Station, Department of Fisheries and Oceans Canada, Nanaimo, BC (Lynne.Yamanaka@dfo-mpo.gc.ca)

Stephen Phillips, Pacific States Marine Fisheries Commission, Portland, OR, (SPhillips@psmfc.org)

V. **Approval of 2014 Report** - The report was approved. Past reports may be found at: www.psmfc.org/tsc2/.

VI. **Approval of 2015 Agenda** - The agenda was approved.

VII. Working Group Reports

Committee of Age Reading Experts (CARE) – presented by Lynne Yamanaka, DFO, for Elisa Russ, ADFG, CARE Chair

The most recent biennial CARE Conference was held in Seattle, WA, April 14-17, 2015. Topics covered at the conference included new techniques for age determination, age validation studies, and the use of ageing data in fisheries stock assessment. A workshop on crustacean age determination was also part of the conference.

There was a discussion of best practices for long-term storage of otolith storage at the conference in response to a TSC recommendation in 2014. In particular, the TSC recommended that CARE develop recommendations for both short and long term storage of otoliths. Although this was discussed at the 2015 CARE workshop, there was no consensus reached among agencies on best practices because the most appropriate method will depend on species, fish age, and availability of storage space.

2015 Recommendations from CARE to TSC:

1. Remove recommendation for CARE to develop a set of best practices for otolith storage from 2015 TSC to CARE recommendations. There is currently no consensus among CARE on a best method. A recommended recipe for glycerin-thymol solution will be included in 2015 report.

Initial TSC discussion of a response to this recommendation suggested that the TSC would like to find an avenue for further study of this issue. This topic will be re-visited tomorrow afternoon during the development of TSC recommendations for 2015.

2. New age readers should have training on ergonomic equipment. In addition, there is a continued need to ensure that all agencies have access to ergonomic equipment and training.

   TSC is supportive of this recommendation; however, there should be more discussion tomorrow when developing TSC recommendations on what additional support, if any, TSC can provide. This recommendation was made by TSC to the Supervisors last year, and some agencies have made progress.

3. CARE recommends that they should continue pursuing more invertebrate ageing technique, with the support of the TSC.

   The TSC is supportive of this recommendation and will include it in the 2015 recommendations from TSC to CARE.

VIII. Other Topics

A. Marine Reserves

CDFW – Marine reserves are detailed in the CDFW report for this year. Traci notes that Rockfish Conservation Areas (RCA) for rockfish are in place, and that boundaries for some national marine sanctuaries in California have been extended this year.

WDFW – NOAA is developing a recovery plan for three species of rockfish in Puget Sound in which they recommend a large network of RCAs in the Sound that will cover 20-30 percent of the surface area. The definition of a RCA under this plan is still being worked on. The plan will not be completed until after the five-year review has occurred for these species (due in early 2016).

DFO - There are two sets of legislation in Canada that govern the establishment of marine reserves: the Oceans Act and the Fisheries Act. Ongoing work related to the Oceans Act includes the establishment of marine reserves for areas such as sponge reefs and hydrothermal vents. Ongoing work related to the Fisheries Act includes changes in time and area closures. Previously established RCAs in BC were made under the Fisheries Act. Discussions are currently taking place at the national level of DFO as to the role RCAs can play in protecting biodiversity, as required under Canada's international commitments.

ADFG – There is currently only one reserve in Southeast (SE) Alaska, which is a marine pinnacle reserve. There are also some coral reserves in the Eastern Gulf.

AFSC – There are several habitat closures in the Aleutian Islands, primarily for coral reef habitat. There have also been recent efforts to establish marine reserves in the Bering Sea canyons, which have been hypothesized to support high coral, sponge and groundfish diversity. A study by AFSC scientists is underway in the Bering Sea to determine whether there is a detectable difference in biodiversity between the canyons and the slope.

NWFSC – The time required to obtain permits to conduct survey sampling in some protected areas has been slow this year.

In general, the TSC notes the potential for long-term survey series to become compromised when new reserves are established (or existing reserves expanded) that prevent survey sampling within previously surveyed areas.

B. Genetics and stock structure

AFSC – Ongoing work related to species differentiation of blackspotted and rougheye rockfish shows a recent improvement in field identification of these two species. There have also been recent advancements in methodology to differentiate these two species based on otolith morphology, with preliminary results showing high accuracy.

IPHC – The IPHC has been collecting genetic samples and morphometric measurements from sixgill sharks encountered during survey work for the Seattle Aquarium. Recent genetic studies aimed at determining halibut stock structure have not shown genetic differentiation coastwide. Genetic analysis has also been used recently to identify sex from commercial catch gutted at sea; a pilot study to determine the success of this approach is currently underway with fishers marking females versus male fish at sea for comparison with genetic results.

DFO – A study of stock structure of Pacific cod is being undertaken, with genetic samples being collected from summer field surveys and from commercial fishing vessels during the winter spawning season. The Elasmobranch Program at Pacific Biological Station (PBS) has gathered a fairly large collection of genetic samples from shark species in recent years. Genetic samples collected from sleeper sharks and blue sharks are currently being used in collaborative studies. Development of microsatellite markers for salmon sharks is planned for the coming year.

WDFW – Genetic work on Pacific cod has shown that the Salish Sea stock appears to be genetically distinct. A cross-breeding study of Pacific cod genetics is also ongoing; however, keeping captured fish alive has been a challenge. WDFW is contributing to genetic work of sixgill sharks and sevengill sharks by the Seattle Aquarium. WDFW and NOAA have been working together on a study aimed at collecting genetic samples from ESA-listed rockfish species (canary, yelloweye, and bocaccio). Survey catches for this study have been good, and early indicators suggest good release survival of sampled fish. A study of surf smelt genetics in Washington inside waters suggest a single panmictic stock though some season-specific variation is suggestive of distinct “runs.” An expansion of previous genetic work on herring stock structure is also being undertaken by WDFW and the Port Gamble Jamestown Tribe to help identify genetic links for several spawning stocks that have not previously been genetically studied (including Port Gamble spawning aggregation).

NWFSC – The collection of genetic fin clip samples from rougheye and blackspotted rockfish from surveys and commercial observer samples began last year to aid in species differentiation. Ongoing work is also underway to distinguish habitat differences for two cryptic species, vermilion and sunset rockfish. Genetic samples and maturity data is also being collected from these two species to assist with species differentiation. Recently identified differences in maturity schedules for Pacific hake samples collected north versus south of Point Conception, California have raised the question of whether there are multiple stocks or sub-species. A study of lingcod genetics is being initiated. Milton Love at the University of California, Santa Barbara has suggested that pygmy rockfish may also be a cryptic species.

CDFW – No genetic work is underway at this time. Samplers in California have indicated that they are confident in their ability to distinguish rougheye and blackspotted rockfish.

ODFW *(Davy)* – Blue rockfish has recently been differentiated into two species by scientists at Oregon State University. A primary publication on this topic is expected to be published soon.

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

A. Agency Overviews

ADFG – ADFG manages fisheries as three regions: Southeast, Central and Westward. Alaska elected a new governor in 2014, which has also meant a new commissioner for ADFG. Recent declines in the price of oil have led to budget shortfalls in Alaska. It is not yet clear how these shortfalls will affect survey work, personnel, or conference travel. The Central region of ADFG has had recent budget cuts for habitat work.

AFSC **–** The primary mission of AFSC is to support stock assessment and management. There are currently 181 permanent staff to support groundfish work in 4 divisions. Most are located in Seattle, WA; however, some are also located in Alaska at the Auke Bay and Kodiak Labs, as well as in Newport, Oregon. If the observer program is included in the staff count, the number increases to 218. The AFSC conducts 6 regular surveys. In 2014, AFSC personnel produced 79 scientific studies and 66 published papers.

DFO **–** The groundfish section at the Pacific Biological Station was been able to add a few new survey technicians to its staff in 2014, which brings the section up to 23 staff, as well as 1 post doc, and two emeritus scientists. There has been a reduction in A-base funding within DFO, with more funding allocated to special projects. Ongoing challenges in funding surveys since 2006 due to a ban on using fish sales to pay for surveys seem to have been resolved; legislation has been changed and joint project agreements have been established with industry to allow fish (directed and non-directed) captured during surveys to be sold.

IPHC **–** There have been several personnel changes recently with more expected in the coming year, including: (i) a new admin assistant, (ii) ongoing staffing process to hire someone in the Biological/Ecosystem Science Head position, (iii) Steve Kaimmer has retired and Claude Dykstra will be filling his Research Biologist position, (iv) ongoing staffing process to fill the survey manager position, (v) Heather Gilroy will be retiring from the statistics manager position, and (vi) a hiring process has been initiated to fill the Executive Director position. The IPHC budget has remained stable.

NWFSC – The NWFSC is divided into four divisions. NWFSC budgets are up a bit this year, but are still depressed compared to the past. The budget for the Fishery Resource Analysis and Monitoring Division (FRAM) has declined due to a need to cover salmon personnel in other divisions. There have been some retirements in the last year, as well as ongoing efforts to build science capacity in FRAM through new hires. A new data manager has been hired. The Economics group within FRAM is also growing. FRAM staff published 45 papers last year.

WDFW – Washington State has a new governor, as well as a new WDFW Director. The general fund for WDFW was recently cut by the legislature, so the marine fish group of WDFW has been looking to outside sources to fund projects. For example, the US Navy has been funding some projects, and funds have been made available for forage fish work due to a legislative mandate. Two projects funded under the latter include a systematic survey of surf smelt and sand lance spawning beaches and midwater trawl survey for adult forage fish. There are currently 8 fulltime staff working in Puget Sound, as well as 7 part-time staff and age readers. A new research scientist has recently been hired. An additional 7 staff work with groundfish on the outer coast. Some retirements are expected in the coming years, as well as some movement of existing staff between positions. WDFW produced 5 publications this year, plus two agency reports.

CDFW – There are currently 9 groundfish staff at CDFW, of which 4 are full-time and the remainder part-time. There are also 12 Pacific States Marine Fisheries Commission staff that manage the commercial sampling program as well as
CDFW recreational fishery sampling staff that sample all recreational fisheries, not just groundfish. Retaining part-time sampling staff has been a challenge lately due to increased minimum wage in some cities in California. Overall, staffing levels have been fairly constant. There is an upper level marine policy position in Sacramento that has been a challenge to fill. Recent funding pools are largely for research related to the California drought. The California Fish and Game journal recently had its 100-year anniversary; Marine Region was able to contribute 14 papers to the special 100-year anniversary issue.

B. Multispecies Studies

AFSC – Several multispecies surveys are conducted, including bottom trawl surveys, acoustic surveys, longline surveys, and fisheries oceanography surveys (including surface trawls to look at young-of-year Pollock and rockfish). These are described in the agency report for this year. A national group has been formed to focus on reproductive biology called MARVLS (Maturity Assessment Reproductive Variability and Life Strategy). This group includes stock assessment and reproductive biologists from all five NMFS science centers and other agencies. A MARVLS workshop was help at AFSC in Seattle in 2014 to share research methods and needs. Other multispecies work conducted this year is described in the agency report, including a funded workshop in ecosystem modelling (Anne Hollowed), attempts to move towards electronic monitoring of small boats, using bathymetry to identify trawlable and untrawlable habitats (Mark Zimmerman and others), modelling of benthic habitats with links to rockfish settlement and coral recruitment studies, prediction of coral and sponge habitat (Chris Rooper), and estimation of rock sole catchability based on the amount of trawlable habitat and trawl efficiency (Wayne Palsson). The AFSC produces its annual SAFE document that includes an ecosystems chapter that reports ecosystem indicators.

ADFG – Multispecies data are digitally archived from ROV surveys in central and SE Alaska. Data on multiple species are also collected from trawl surveys in Central region and longline surveys in the SE region. No active multispecies research, but multispecies data available.

DFO – Multispecies data are collected from several ongoing DFO surveys, including the Strait of Georgia dogfish survey, inshore rockfish survey, the Strait of Georgia and offshore hake acoustic surveys, sablefish trap surveys, West Coast Vancouver Island shrimp survey, and bottom trawl synoptic surveys. Work has been initiated on a tiered approach to providing stock assessment and harvest advice that will facilitate advice provision for a number of data deficient species. Work is also continuing on a project aimed at building a harvest decision-framework that incorporates relationships between climatic variables and species productivity (post-doctoral research fellow Jean-Baptiste Lecomte).

IPHC – Continue to collect and share data from non-halibut species collected during the IPHC survey. Last year was the second year of survey expansion into shallower and deeper waters that previously fished, with the expansion focused in the Aleutian Islands and Bering Sea. Over 180 stations have been added to the survey, with some of these additions in areas that were previously considered unfishable zones. Data collected from these expanded zones include data on corals, sponges, and skates.

NWFSC – Two multispecies surveys are conducted by NWFSC: the groundfish trawl survey and the southern California hook and line survey. The ageing lab at NWFSC processed samples from several species last year, including China and black rockfish which have not previously been aged at the center.

WDFW – The Puget Sound trawl survey collected data from plankton tows and gut contents this year; this data will link to NWFSC work on forage fish consumption. The Puget Sound trawl survey had low observations of dogfish and skates this year. There have been Remotely Operated Vehicle (ROV) systematic surveys of all habitat types in Puget Sound, with work focus on San Juan Islands in the last few years. A report on the ROV survey work is forthcoming. The ROV survey work has been linked to research on trawlable versus untrawlable areas, with an attempt to estimate the portion of abundance for various species that occur over unfishable habitat. Results of this work to date have shown that the ROV is not suitable for identifying flatfish species and that more rockfish species than expected occur over mud. Scuba-based visual surveys have been used to compare species composition and size distributions within and outside of closed areas. There has also been ongoing work on removing derelict/abandoned fishing nets from Puget Sound (mostly gillnets and purse seines). Initial net removal efforts have focused on shallow waters accessible by divers, but methods are now being tested to remove deepwater nets.

CDFW – ROV surveys focused on visiting rocky areas and reefs will continue in 2015, with a focus on waters north of San Francisco. The CDFW agency report includes a link to the report from a workshop on the effects of the California reserve network on fish species

C. By Species

1. Pacific Cod

WDFW **–** This year's survey found low Pacific cod levels inside Puget Sound. Genetics projects have already been discussed.

AFSC **–** The Newport, OR fisheries behavioral ecology program is looking at what age-0 cod are doing in Gulf of Alaska and on shelf; also looking at vertical availability of Pacific cod to bottom trawls. The results of a vertical tagging project were used as an index to calibrate/tune stock assessments. Researchers are looking at ES60 acoustic data to see if they can use Echoview to look at fish paths to see where fish are in relation to trawl head rope. None of stocks have been overfished.

ADFG **–** Working on a report on Pacific cod to get out within the next year. We have developed a better maturity guide for Pacific cod that's been used over the last two years. There has been an ongoing issue with ageing methodology with differences between ADFG and NMFS; therefore ADFG did not age Pacific cod otoliths this year (however, the issue may now have been resolved). ADFG is practicing in-season management and performs closures in areas to prevent localized depletion; the state gets a percentage of the federal TAC. Changes in markets have been noted, with more cod going for food now, so cod as bait getting more expensive. CDFW noted that fresh Pacific cod can now be found in California fresh fish markets.

2. Nearshore Rockfish

CDFW – is still planning to start ageing copper rockfish for the next assessment. Work has been postponed but should be underway soon. We now have over 500 otoliths.

DFO **–** Over next few years will be working on rockfish densities by habitat type adjacent to RCAs from video. The yelloweye rockfish assessment has been delayed to September.

ADFG **–** Hydroacoustic surveys for black and dark rockfish in the Kodiak Management Area in an effort to produce biomass estimates. Recompression studies on nearshore species continued in Prince William Sound showing 87 percent survival consistent with previous work and indicating high survival for yelloweye and quillback rockfishes. Habitat mapping for yelloweye rockfish in the SE Region covered over 3000 km^2 with over 1200 km^2 of rocky habitat identified. A yelloweye rockfish assessment was conducted for the SE Region. Age structured model saw general declines in yelloweye rockfish. This is then applied to other species in the demersal shelf rockfish assemblage. The SE Region yelloweye rockfish ROV survey will be completed in 2015, having surveyed all 3 major grounds by end of this year to compare to previous submersible work. The Central Region does conduct ROV surveys to assess lingcod and yelloweye rockfish but did not produce estimates last year.

Management now requires recompression of all rockfishes caught on sports charter vessels that are in excess of the bag limit (sports fish did research and found 70 percent survival – see website for details, some publications). Currently all captures count against the TAC – survival/mortality rates not applied to releases. Note: California is the only state applying mortality rates when descending devices used and observers present; Washington assumes 100 percent mortality although Puget Sound anglers got funding to hand out free descenders and catch logs, and are asking for photo verification – they are pushing for mortality rates to be applied in Washington State waters.

WDFW – is preparing a Recovery Plan for ESA-listed rockfishes that has had informal review but is still pre-public and pre-agency. There are issues with cultivated fish (e.g. salmon, lingcod) posing potential threats (eating larvae). Critical habitat formally designated by NOAA – model used is being evaluated now (was simply based on vegetation, rugosity, depth).

They are conducting a randomized ROV survey: 460 stations for this year and next year – looking at manmade structures also (wrecks etc.) – counting other species as well as listed species including rockfishes, lingcod, greenlings, Pacific cod, etc. Staff are collecting fin clips for future DNA work. Looking at groundtruthing habitat classifications from very fine multi-beam data, and comparing to coarser scales of data - have found that 5-m is the requirement to detect things like a boulder in the middle of a mud flat. Black rockfish assessment now expanded to other species and to a broader depth range along the outer coast. Blue rockfish have been split into two species: the new species is deacon rockfish – there is a clear break in distribution at Cape Mendocino.

3. Shelf Rockfish

This began with a general discussion of what constitutes shelf rockfish as the species groups vary between agencies. This was eventually deferred to the discussion about future reports and agendas.

NWFSC – Some shelf rockfish work is upcoming.

DFO – The first ever yellowtail rockfish assessment was conducted in 2014. Results of the assessment show that the population has declined from a median spawning stock depletion of about 0.7 to about 0.49 of the unfished state over the last eight years as a relatively strong 2001 year class is removed by fishing and natural mortality. The population is forecast to decline modestly over the next 10 years, at current harvest levels, to a median depletion of about $0.4B_0$.

CDFW – Experimental fishery permit for vertical longline for yellowtail and chilipepper rockfish to utilize these species without getting a lot of bycatch of demersal species.

4. Slope Rockfish

AFSC – has been working on barotrauma experiments on rougheye and blackspotted rockfish, having tested lab survival and recovery. Additional rougheye/blackspotted work being done on growth and genetics. For Pacific Ocean Perch (POP), researchers are planning to attempt tagging of POP off Kodiak.

Researchers have built a “livebox” to trawl at depth to prevent damage. The POP assessment is looking at predicting abundance and distribution of POP in Aleutians. Others are working on maturity of deepwater species (age at maturity, timing, size). The have noticed that blackspotted rockfish are “skip-spawning”; therefore, it’s hard to figure out how to categorize these fish for maturity to include in models as spawning stock biomass. Researchers are starting to notice this (skip-spawning) more in other species, perhaps this a function of the resolution of modern studies. They are trying to determine how to age shortraker rockfish.

DFO – An updated stock assessment for redbanded rockfish was conducted in 2014. It was determined that ageing redbanded rockfish is difficult and the ages were likely inaccurate making it difficult to model.

NWFSC **–** They have also observed skip-spawning in some rockfish species - Jim Thorsen is developing a model for this. Working on assessments of aurora rockfish and others.

5. Thornyheads

AFSC – Thornyheads are being tagged as part of the Marine Ecology and Assessment Program with over 700 thornyheads tagged and 24 recoveries in 2014. Tagging continues but there have been no data analyses to date.

ADFG **–** Thornyheads are measured and released when they see them.
NWFSC – The West Coast groundfish bottom trawl survey is collecting ovaries for maturity studies.

DFO – Thornyheads are caught in the trawl surveys with shortspine being more prevalent. Staff are trying to develop an ageing methodology.

6. Sablefish

AFSC – Sablefish tagging programs continued in 2014. A notable 2014 tag recovery was at liberty for 36 years, while another was recovered 2000 nautical miles away from tagging location. Additionally, archival tags were recovered from two juvenile and two adult sablefish—data still being analyzed. The juvenile sablefish tagging survey will continue in 2015 and may expand into Prince William Sound and/or Kodiak due to high YOY presence in 2014. Analysis of 30 years of tagging data were published in Canadian journal. They are trying to get funding for putting tag data online - all the US tag data is in one database regardless of agency of origin.

A paper was recently published on sablefish spawning and maturity and included observations of skipped spawning. There is a survey planned to collect more maturities this winter off Kodiak.

The annual longline survey has tagged sablefish with pop-up satellite tags during the last three years and 2014 tags are programmed to pop off in early 2015 in the hopes of determining the spawning season. The success rate was about 50 percent and the tag information is being analyzed.

A question was raised whether sperm whales present during tagging surveys impact recovery rates during the annual Gulf of Alaska longline survey. Analysis of past survey data revealed that whale depredation was sporadic, so a model was developed to better account for whale depredation in sablefish stock assessment and management.

Pot gear (traps) now approved in Gulf of Alaska so expect change in fishery.

ADFG – There was a satellite tag study by master's student at the University of Alaska, Fairbanks School of Fisheries working with ADFG; skipped tag-release survey last year, but plan to go out this year; southern Southeast longline survey in recent years cover more area in Dixon Entrance because fishery has started covering this area; ADFG fin clips as well as Floy tag to get abundance – rely on clips more than tags – counting all the fish landed, and looking at proportion of clips. Sport fishery is growing; now there are bag limits in areas where there are allocation issues.

NWFSC – Looking at stomach contents with preliminary results for sablefish showing that fish make up 50-90 percent of their diet. Additional work to be done to see if this is a recent or long term trend.

Looking at geographic (north-south) differences in sablefish maturity and growth – a break is observable at Cape Mendocino, but not at Point Conception, even though the populations are not genetically distinct.

Looking at impacts of mesh size and mesh orientation on catchability of different species, comparing 114 mm and 140 mm codend mesh. The effects of mesh size and orientation varied between species and studies continue using a wider variety of mesh sizes, mesh orientations, and codend circumferences.

Also looking at the retention of sablefish using different bycatch retention devices (BRD) aimed at reducing Pacific halibut bycatch. The BRD for the Dover sole/thornyhead/sablefish trawl fishery reduced Pacific halibut bycatch by 83 percent and retained 90 percent of the sablefish. The BRD for the nearshore flatfish fishery reduced Pacific halibut bycatch by 94 percent and roundfishes, including sablefish, by 96 percent.

Looking at climate change and potential effects on sablefish productivity and evaluating different management strategies.

DFO – In recent years, we have conducted a random, stratified sablefish tagging program. This tagging program also collects biological samples.
In 2013, trap cameras were added to the survey to record benthic substrate, gear interactions with the substrate and benthic communities, and include probes to gather oceanographic data at depth.

7. Halibut and IPHC activities

A previous study of Pacific halibut hooking success using cameras estimated increasing hooking success with size for 70-110 cm fish, but there was not enough information collected on larger fish. In 2014, a Go Pro camera was used to look at hook attacks by larger fish. While there were not enough observations for larger fish, it did confirm the previous study's results for 60-100 cm fish. More work needs to be done to see if hooking success declines with larger Pacific halibut.

Work on re-evaluating female Pacific halibut maturity staging was conducted in 2014, with histological slides prepared so that individual oocyte diameters can be used to assign reproductive stages. This work will continue in 2015.

Work continues on improving Pacific halibut sex ratio estimation in the fishery using sex-specific genetic markers by developing a marking method that can be used in the field, and developing a genetic sexing assay. These new methods can then be tested in the field. This will be used to better estimate sex ratios by regulatory area and year that can be used in stock assessments.

Satellite tagging project (popup tags) was conducted to look at whether Pacific halibut found in the southern Salish Sea are part of the larger outer coast population or represent an inside waters stock that should be managed separately. A total of 12 fish were tagged in two locations in the southern Salish Sea. A total of nine tags were returned, and of those, five reported fish still located near where they were tagged, and two had moved into outer coastal waters. There were some problems with the tags; two tags did not reveal endpoint locations, and three were not recovered.

The project to re-assess the halibut length-weight relationship and to re-test the head conversion factor continued in 2014. Scales were provided to the port samplers and length and weight data were collected in most ports and throughout the entire commercial fishing season so that seasonal and or area-specific relationships can be developed.

Work is ongoing to investigate the decreasing size at age over time by comparing surface ageing with break and bake methods to count otolith increments in order to look at changing size at age over time. Both methods were found to become increasingly biased beyond 15 years.

Looking at condition factors (liver condition etc.).

Collected oceanographic (Seacat) data from 1300 out of 1400 stations on Pacific coast (California to Russian zone) in 2014 as part of an ongoing project.

The toxins/pollutant study in Pacific halibut continued with almost 2300 samples analyzed to date. The mean level of total mercury (0.311 ppm) was less than FDA and EPA levels of concern (~0.85 and 0.500 ppm, respectively). Analysis of other persistent organic pollutants are undetectable or well below other fish species. Another study is looking at the prevalence of the *Ichthyophonus* parasite. Although quite widespread in Pacific halibut, you can't see it histologically and we don't know its effect in halibut; however, the parasite can be grown from heart tissue. One study looks to develop a fluorescent marker to see where in the halibut it resides. For smaller fish, the prevalence rate is low (2.4 percent), but for larger fish it is highly variable with Pacific halibut from Prince William Sound having some of the highest rates observed in marine fish.

Work is ongoing to develop a tablet-based electronic data capture system for the annual longline survey. A pilot study for the longline survey was conducted in 2014 and the goal is to have it in place for 2016. Port samplers are using Panasonic toughbooks with an eLogs application installed. Port samplers are still collecting paper logs until they pass a strict set of criteria, then they will be allowed to enter the skipper interviews directly to the eLogs application.

It was noted that WDFW and ADFG are also developing WIFI/cloud-based electronic data capture systems, and CDFW is use dataloggers portside for their CPS monitoring.

Upcoming work for 2015 includes:

- Continuation of the genetic sexing & commercial sex marking project
- IPHC will be working with Makah Tribe in the Neah Bay area to study the effect of using a "traditional" hook on bycatch in the Pacific halibut fishery - hook may reduce halibut catch somewhat but may drastically reduce bycatch.
- Continuation of evaluating the length-weight relationship at sea – scales integrated into sampling table; looking for seasonal and regional differences.

Bait experiments – The IPHC survey is standardized to a certain size and type of bait. The price for chum salmon is now $2.50/pound! The IPHC conducted a study in 2012 with different bait types, and found regional differences, and suspect differences over time in connection factor between bait type and results. So for now, the survey continues using the expensive, original bait.

8. Flatfish

DFO – Conducted the first ever arrowtooth flounder assessment in BC, it was a female-only catch-at-age model, because the commercial catch is primarily female (75-80 percent). Work on a Petrale sole stock assessment is underway, due November 2015.

AFSC – Conducting maturity studies on 3 Bering Sea species and 4 Gulf of Alaska species. Looking at the distribution of rock sole in relation to temperature along with possible differences in latitude and age. Also looking at where the eggs go in the Bering Sea.

WDFW – The 2012/13 ROV survey counted flatfish (poor abundance estimates – unidentified were 3x total of everything else). A series of reports on the trawl survey is coming soon. Hood Canal has been closed since 2004 for bottom fishing, but WDFW has opened a small portion for flatfish only (northern Quilcene and Dabob Bays).

NWFSC – Analysis of data collected during the groundfish trawl surveys revealed that Petrale sole was sensitive to low levels of oxygen in the near bottom but Dover sole showed no change. In 2014, the Petrale sole abundance doubled, and has generally been increasing in recent years. The Petrale sole length-weight regressions show significant correlation with Pacific Decadal Oscillation over 11 year period in northern part of range. There is another Petrale sole assessment planned for 2015.

9. Lingcod

ADFG **–** Last year a report was completed on a lingcod tagging study (9000 tags since ~1997) demonstrating that most lingcod exhibit high site fidelity, although there are a small number that travel great distances, even to Canada. Additionally, sex composition changes based on depth. ADFG is using otoliths to age lingcod. There will be a change to the logbooks to require latitude and longitude for dinglebar fishery. ROV surveys are looking at abundance at index sites in Central Region.

DFO – The Strait of Georgia lingcod assessment is based on recreational catch, and shows increasing trend, especially given the low abundance in the 1980s and 1990s.

NWFSC **–** Studying lingcod home ranges based on diver surveys (feeds into recovery rates in relation to MPAs). Mean home range and similar estimates predicted higher biomass and numbers and underestimated the size of reserves necessary to achieve the same level of recovery of biomass.

AFSC – A recent study shows that when lingcod sit with mouth agape, longfin sculpins hanging around are actually eating lingcod parasites. Also, scalyhead sculpins have actually been observed inside lingcod mouths.

WDFW – A 2012 ROV survey : Lingcod was a target species – coefficient of variation good for lingcod. There have been some studies on the feasibility of raising lingcod; however, culturing lingcod is listed as potential threat to ESA-listed rockfish in Puget Sound.

10. Pacific Whiting (Hake)

DFO **–** There was no acoustic survey for Pacific whiting in 2014, but the 2015 acoustic survey found lots of age 1 Pacific whiting. The survey is currently looking at differences between one tow vs. multi-tows.

NWFSC **–** also conducted an acoustic survey for Pacific whiting

WDFW **–** Sees possibly one strong age class of Pacific whiting in ROV survey.

11. Walleye pollock – scientific name change to *Gadus chalcogrammus*

AFSC – Ecosystem studies relating year class strength to oceanographic conditions. Studying factors affecting growth and recruitment where it appears that pollock do better during cold water periods with higher nutrients.

ADFG – Some fishery closures in Prince William Sound due to bycatch limits being reached. The presence of squid was also noted.

WDFW – Abundant gadids were seen during the ROV survey, very likely pollock – looks like one year class.

12. Dogfish and other sharks

NWFSC – An observer collected cookie cutter shark.

AFSC – Tagged 180 dogfish with satellite tags to provide data on movements and depth residency. Results show spiny dogfish can undertake large scale migrations rapidly and that they do not always stay near the coast (e.g. a tagged fish swam from near Dutch Harbor to Southern California in 9 months in a mostly straight line, not following the coast). Also, the spiny dogfish that do spend time far offshore have a different diving behavior than those staying near shore. A manuscript about these movements is underway. Ageing of dogfish using spines is biased because of wear on spine. Staff have developed a method to use vertebrae instead, but needs to validate ages. It was noted that vertebrae are more difficult than spines for ageing.

Pacific sleeper sharks genetics work indicates that there are two divergent populations, once separated, that are now currently living together.

ADFG – Work is underway on the reproductive biology of salmon sharks to get more precise information on the timing of and frequency of reproductive activity. Another study is looking at the energetics of salmon sharks using temperature/depth transmitters and accelerometers.

IPHC – Currently recording dogfish sex on IPHC survey (1st five dogfish per skate) data is available.

Survey staff frequently see sixgill sharks secondary to dogfish (i.e., depredating the dogfish caught on the longline). The sixgill shark mouths are lined with dogfish spines, have also seen some ratfish spines, suggesting that predating them naturally and not just when hooked.

WDFW – Participated in IUCN re-evaluation of all shark stocks. Genetics work on sixgill and sevengill sharks has just been published. Two Sixgill sharks were recently observed in Hood Canal with ROV.

Developed a video about spiny dogfish harvest methods for the recreational fishery. Ongoing work to recover carcasses of salmon sharks on outer coast – to date have archive of 30 specimens with biological data including body condition, tissue samples for genetics, some preserved brains; most are juveniles, but have an adult from 2012; also, research on causes of death. Suggests that pupping may occur in southern California and juveniles are stranding on their way to Alaska.

Found evidence of white shark biting a seal in half this year near Ocean Shores, WA. It was identified based on tooth spacing, mouth gape, clean nature of bite (not marine mammal), obvious speed with which attack occurred (seal heart contained sand indicating heart was still beating when seal hit the sand). *At the beginning of Day 2, Dayv Lowry showed video of the seal that had been attacked in Washington State and how he came to identify it as a white shark.*

CDFW – The Commission decided not to list white shark as threatened or endangered under CESA in 2014. White shark research is still being conducted by outside researchers, with work on both juvenile and adult populations.

DFO – Conducted triennial longline indexing survey in 2014 and dogfish were quite abundant. A dogfish assessment was scheduled for 2014 but cancelled at request of fisheries management – next scheduled assessment is possibly 2019.
Shark sightings network: collecting information on basking shark sightings since 2007 (about 50 plausible sightings to date in BC waters –incl. 6 confirmed sightings; 2 additional confirmed sightings in nearby U.S. waters – WDFW notes there is one more recent sighting in Puget Sound). Codes of conduct for encounters with basking sharks and other sharks published in 2014, so sightings network extended to other sharks (except dogfish) – available on DFO website: www.pac.dfo-mpo.gc.ca/sharks.

Lynne also noted that her son may have seen a white shark in Canadian waters.

13. Skates

AFSC **–** Wayne reported that Duane Stevenson working on the classification of skate species, Bering skate-*Bathyraja interrupta* and Sandpaper skate-*B. kincaidii*. Also looking for skate nursery zones.

ADFG – Has conducted some skate tagging. Previously there were skate fisheries, but they were not sustainable. However, it is a choke species in the fisheries.

IPHC **–** Have collected vertebral columns, etc. for NWFSC. Also recording maturities, egg cases for big and longnose skates.

WDFW **–** Lots of skates were seen in Puget Sound on the ROV survey. A fisher wants to fish in Puget Sound and has developed a novel "square-shaped" hook (traditional design?) to target skates. Allegedly this hook wedges in the mouth of the skate during feeding but does not pierce the tissue. Upon landing, the hook can be twisted to dislodge it. Bycatch with this hook is claimed to be extremely low.
DFO – Conducted an assessment of big and longnose skates in 2013. Collaborating with Alaska on age validation. Results were good for longnose but not for big (not old enough for bomb carbon).

NWFSC **–** Has collected skates, vertebrae for ageing.

14. Grenadiers

AFSC **–** looking at otolith morphology. There appears to be several different shapes for giant grenadiers. Also conducting genetic studies. Grenadiers are not in the Fishery Management Plan and it was suggested they go back in but the Alaska

Fishery Management Council put them in as an ecosystem component. There are no TACs but they are monitored and there is an unofficial assessment.

NWFSC – Grenadiers have been downgraded to an ecosystem component and removed from the Fishery Management Plan. Lots of Pacific grenadiers are encountered. The NWFSC has collected a couple of years of giant grenadier information for background.

15. Hagfish

ADFG – Black hagfish are encountered all over Clarence Strait and are a widespread problem. They are getting in gear and interfering with CPUE. Canada was asked if they got hagfish in their fishery, and they do, but Pacific hagfish is more abundant.

WDFW – Harvest reports are posted on the website. There are a couple of fishers using large traps.

CDFW – The fishery continues and we are taking samples. Proposed regulations will include a minimum escape hole of 9/16 inches, and Korean traps will no longer be allowed.

DFO – there is an experimental fishery using large traps. Catch rates have been decreasing.

16. Other Species

AFSC – working on giant Pacific octopus – impacts on blue king crab, discard mortality. Octopus have a tendency to limit fisheries.

WDFW – forage fish. Assess each spawning population separately. Surf smelts – big survey on the outer coast, randomized; looking for smelts. Have also done work in Puget Sound to find spawning grounds. Trying to fill gaps where bottom trawl doesn't work using mid-water trawl – will get hake and pollock, too.

D. Other Related Studies

1. Ecosystem Studies

AFSC – staff have developed ecosystem report cards; further information is in the agency report. The systematics lab is looking at taxonomic issues. There will be a new book in the next year or so titled "Fishes of the Salish Sea" and also a checklist of "Invertebrates of North America". The pathology group is working on *Ichthyophonus*. The Conservation Engineering Division is working to decrease salmon catch in the pollock fishery. They have been looking at footrope design and underwater video system so fishers can see how their gear is working.

E. Other Items

1. Marine mammal predation on groundfish

There was some discussion on what this topic was meant to cover – perhaps depredation. Wayne thought it was marine mammals competing with fish, eating. Lynne noted that pinnipeds are a source of mortality for inside yelloweye rockfish and Dayv added that they are also a threat for rockfish in Puget Sound.

F. Potential future TSC-sponsored workshops, workgroups and/or symposia

1. Visual Survey, part 2

Lynne suggested waiting for Dave Somerton's work to come out on work in the Gulf of Mexico to see how it works on the west coast. There will be some sessions on this topic at the AFS meeting. If new methods come up then we can consider holding another survey, maybe in 2017. The TSC agreed to keep this in mind for a future workshop (see TSC to TSC recommendations below).

2. Trawl and Longline Survey

Last workshop was in 2011 and Wayne asked if technology has changed sufficiently to hold another workshop. Lynne asked about electronic data capture. Wayne said that a conveyor belt image system was being developed to measure fish with camera. If a workshop was held the correct mix of people would be required – computer experts, biologists, etc. and the workshop should have a focus. Lynne suggested that there could be exchanges between agencies to see how various systems work.

The possibility of having a session (special workshop or theme) on survey electronic data capture, including image analysis, at the 2016 Western Groundfish Conference was suggested (see TSC to TSC recommendations below).

3. Climate Shifts, being "climate ready"

Wayne said that there is an MPRP proposal to look at the "warm water blob". Looking for any changes in species distribution and diversity using survey data. He suggested that there could be a workshop or Western Groundfish Conference theme session on the effects of climate. There was some discussion on this and it was decided that email should be sent to the WGC organizing committee to suggest a climate change session (see TSC to TSC recommendations below).

4. Fish Maturity Workshop

Work has started already and we don't want to duplicate the efforts. It would be better to encourage broader participation (including DFO) at planned maturity workshops, e.g., at AFSC. There is a need for cooperative research on fish maturity, especially for inter-agency stocks and TSC can facilitate broader participation (see TSC to TSC recommendations below).

G. Review of the updated TSC Overview document

There was a suggestion that the group be rebranded because the existing name is "terrible" and obscure. Also, it was suggested that there could be a more formal link to the WGC but it was pointed out that the TSC is government and WGC has broader participation. Wayne suggested we could advertise TSC at WGC – perhaps chair a session and give a talk on the TSC at the start of the session. Produce a flashy poster. Wayne and Tom agreed to design a poster.

It was decided that the TSC would suggest a session or workshop (e.g., visual surveys, climate change, electronic data capture) for the WGC and offer to chair that session. Jon Heifetz agreed to chair if he attends the WGC.

It was also agreed that Wayne would update the introduction to the Overview document to better reflect the role of the TSC. Jon recommended that additions should be made to the Overview document each year rather than leaving it for years. The TSC agreed to add an agenda item addressing this to the agenda as a reminder to update the document annually.

H. Potential redesign of TSC agency reports and/or meeting agenda

There was a really good discussion about the current agenda, as there was confusion regarding some of the topics, especially when it comes to defining the Ecosystem and Multispecies Studies sections. The TSC also discussed the current agency reports, which are all set up differently.

The TSC members reviewed the current agenda format and worked together to come up with a new suggested format for the meeting agenda:

1. Agency reports
2. CARE report
3. Surveys, with maps as a resource (need projector). Include ROV, marine reserves.
4. Single species – include genetics, maturity information. Just have a Rockfish category – not nearshore, shelf and slope).
5. Ecosystem – include habitat mapping, climate, food web analysis/modelling, forage fish related to groundfish
6. Recommendations

The TSC also agreed that the agency reports should follow the same format at the meeting agenda. There was discussion that maps showing management or survey areas should be included in reports. It would be beneficial to keep the publications and list of staff. Catch information does not need to be included as it is available via PacFIN and AKFIN, unless the catch information is regarding assessments. It would be beneficial to add a table of contents and page numbers to each report, listing the publications at the end.

Traci said she would write up the new proposed format for the agenda and reports and send that out for review by TSC members.

X. Progress on 2013 and 2014 Recommendations

A. From TSC to itself

1. *Talk to our respective agencies suggesting that they investigate ergonomic remedies for age readers.*
   This was included in the 2014 letter to supervisors.
2. *Notify our respective agencies that the IPHC has gender and length frequency data for dogfish shark for 2011 to present.*
   This was included in the 2014 letter to supervisors.

3. *Update the Overview document on TSC website to reflect TSC's accomplishments and the terms of Reference.*
   Stephen Phillips, PSMFC, was able to get funding and Rick Stanley, DFO-Retired, was able to complete the project.

4. *Have each agency and Western Groundfish Conference provide a link to the TSC website and annual reports.*
   This was included in the 2014 letter to supervisors.

5. *Post the 2011 Trawl and Longline Survey workshop summary document on the TSC website and distribute widely to groundfish researchers, industry members and university students in the fisheries filed.*
   Stephen Phillips, PSMFC, posted the 2011 Trawl and Longline Survey workshop documents to the TSC webpage.

6. *Update the TSC website to include other workshops*
   Stephen Phillips, PSMFC, posted other workshop documents to the TSC webpage.

7. *Discuss potential development of new TSC-sponsored workshops, working groups and/or symposia (visual survey, trawl and longline survey, climate shift, fish maturity)*
   This was discussed in Section IX, G above.

8. Redesign TSC agency reports and/or meeting agenda
   This was discussed in Section IX, H above.

It was suggested that the Letter to Supervisors be sent electronically, cc'ing the TSC members.

B. TSC to Parent Committee

1. *Support CARE by acknowledging the TSC's request to investigate ergonomic remedies to minimize ergonomic injuries to age readers*.

2. *Remind the Agencies about the valuable information available on the TSC website*.

C. TSC to CARE

1. *The TSC understands that CARE is looking into issues surrounding long-term storage of otoliths. TSC suggests that CARE researchers document their findings and develop a set of best practices for short and long term otolith preservation and storage*.

   This discussion was continued from the 2013 CARE meeting and also in response to the TSC recommendation in 2014 to develop a set of best practices for short and long term otolith preservation and storage. CARE members from WDFW, AFSC, and IPHC conducted a cursory review of archived otoliths and all found some archived otoliths that had shown degradation, however, there was no consensus as to the reason for the degradation. Possible reasons included the solution used, cleanliness of samples, incorrect solution mixing, or possibly the age of fish sampled (e.g. young sablefish otoliths appeared to be affected after long-term storage). The various agencies all plan to continue with their current practices and therefore there was no consensus between agencies about the best methods for otolith storage.

XI. 2015 Recommendations

A. From TSC to itself

1. The TSC recognizes the potential for climate change to impact the distributions, fisheries, and biology of groundfishes across the entire West Coast. We encourage managers and scientists across all constituent agencies to cooperate and coordinate research and management activities to evaluate and predict climate impacts on groundfishes. The TSC suggests that a special session or workshop be held at the 2016 Western Groundfish Conference that will highlight research, findings, and management strategies to understand and adapt to groundfish responses to climate change.

2. Fish maturity and reproduction rates are important parameters that are critical to stock assessments. A recent NOAA workshop showed an overwhelming interest in sharing and advancing the science and technology of fish maturity determination and reproductive biology. TSC recommends that agencies, universities, and jurisdictions work together to advance fish maturity studies through joint scientific projects, workshops, and manuscripts. The TSC recommends sending a letter to the NMFS Fish Maturity workshop committee applauding their work and suggesting that they should also engage Canadian biologists and state agency biologists in any future workshops.

3. The TSC again recognized the value of the 2014 Visual Survey and understands there will be a session or workshop at either the American Fisheries Society Annual Meeting in 2015 or the Western Groundfish Conference in 2016. Additionally, new information about visual surveys by researchers is forthcoming. While interest was expressed in forming a working group or initiating a second workshop, the TSC agreed to carry this over to the next meeting.

4. The TSC continues to express interest in another trawl and longline survey methods workshop. Many ideas for the workshop were discussed, including electronic data capture methods (see item 5). While interest was expressed in forming a working group or initiating another workshop, the TSC agreed to carry this over to the next meeting.

5. The TSC recognizes that new technologies are rapidly developing to electronically capture catch and biological data collected during scientific and resource surveys. Most of the agencies are developing electronic data capture technologies, and TSC recommends that scientists and technologists share approaches and lessons learned with each other. TSC suggests that a special session or workshop be held at the 2016 Western Groundfish Conference that focuses on electronic data capture for scientific and resource surveys.

6. The TSC discussed the need to share tagging data for transboundary stocks. Sharing of data for species such as sablefish, black rockfish, lingcod and sharks that are tagged in both countries will enhance the scientific understanding of the population dynamics of these species which will lead to improved management. The TSC recommends sharing data for all tagged species where transboundary tag interception may occur and urges agencies in both countries to enable data exchange. For follow-up in 2016, TSC requests agencies to identify species that are tagged and the contact information for tag returns. TSC recommends that formal data agreements be investigated to facilitate data flow, if necessary.

7. The TSC recognizes the need to advertise the work of the TSC and its website which contains a lot of good information on groundfish research including annual reports from 1980 forward, workshop summaries, and the TAC Accomplishments document. To increase exposure at the 2016 Western Groundfish Conference, the TSC discussed preparing a poster highlighting the TSC's accomplishments and activities. TSC members Wayne Palsson and Tom Wildebuer have agreed to make the poster.

8. The TSC discussed the updated TAC Accomplishments document completed by Dr. Rick Stanley, DFO-retired, and former TSC member. The TSC thanks Dr. Stanley for his work on the TSC Accomplishments. The document is now up to date, however, after much discussion the TSC is recommending revising the abstract to really make it more interesting and a "hook" for getting folks to read the entire document. Additionally, the TSC recommends updating the TSC Accomplishments document annually. To facilitate this, the TSC recommends adding an agenda item to the meeting as a reminder to have a member update the accomplishments.
9. The TSC discussed writing a letter to CDFW expressing the need to be able to conduct research surveys in marine protected areas. After the meeting the Chair spoke with the TSC member who proffered the recommendation and it was subsequently withdrawn as the matter is being worked on between NMFS and CDFW.

B. TSC to Parent Committee

1. In 2014, the TSC requested that CARE researchers document and develop a set of best practices for short and long term otolith preservation and storage. This was in

response to concerns by CARE about the long term storage of otoliths in a glycerin-thymol solution that degraded some otoliths. CARE responded in 2015 saying that they discussed the issue but could not come to consensus and requested that the TSC remove the recommendation.
After much discussion, the TSC recommended to CARE that they continue to try to develop best practices for short and long term otolith preservation and storage. Additionally, the TSC recommends to the Parent Committee that they reach out to the Groundfish Management Teams on the North Pacific Fishery Management Council and the Pacific Fishery Management Council and make them aware of the potential issues regarding otolith storage.

2. The TSC requests that the Parent Committee support their efforts to chair a special session or workshop be held at the 2016 Western Groundfish Conference that will highlight research, findings, and management strategies to understand and adapt to groundfish responses to climate change and/or a session or workshop focusing on sharing information and lessons learned regarding recent advances in electronic data capture for scientific and resource surveys. Additionally, the TSC would like support for a poster for the WGC highlighting the TSC and its accomplishments.

3. The TSC requests that the Parent Committee support their efforts in sharing sablefish and other groundfish tagging data. One of the outcomes of the meeting was the need for sharing tagging data for transboundary groundfish stocks. Sharing of data for species such as sablefish, black rockfish, lingcod and sharks that are tagged in both countries will enhance the scientific understanding of the population dynamics of these species which will lead to improved management. Should it become necessary that formal data agreements are developed, the TSC would request support from the Parent Committee.

C. TSC to CARE

1. The TSC thanks CARE for taking time during their biennial meeting to work towards developing a set of best practices for short and long-term storage of otoliths. However, the TSC is discouraged that CARE was unable to come to agreement on this and considers this important to all member agencies. The TSC believes that CARE members are experts in the field of otolith reading and storage, and are thus best suited to develop and use best practices. The TSC asks CARE to reconsider TSC's request at their next meeting and initiate this process by documenting structures and storage methods currently in use (by species and agency) with notes on their benefits and deficits. The TSC will also move this request forward to the U.S. groundfish management teams for their consideration through the Councils' Science and Statistical Committees to develop a study proposal to investigate best practices. The TSC acknowledges the valuable work of CARE and encourages work on this problem and recognizes that this is a long term goal for agencies.

2. The TSC understands the importance of ergonomic issues for CARE members and shares their concern regarding potential ergonomic injuries to age readers. In response, the TSC voiced their concern about this issue in the 2014 Letter to Supervisors that was sent to each TAC member agency, specifically to supervisors and managers for groundfish research activities in each agency. The TSC places this issue within agencies' health and safety policies and urges agencies to pursue

this matter directly through lab supervisors and their agency's health and safety committees. The TSC recommends that, where there are concerns in this regard, CARE send a letter to the specific agency or supervisor, with specific suggestions to alleviate the ergonomic conditions, highlighting the health and safety issue.

3. The TSC is supportive of CARE taking on non-groundfish work because it advances fisheries research. However, the TSC reminds CARE that its mandate has always been groundfish and they should be given priority within CARE. CARE does not need to include shellfish investigations in their report to the TSC.

4. The TSC understands that CARE is concerned about the short amount of time, usually less than one month, between the biennial CARE meeting and the TSC meeting which makes it difficult for the CARE Chair to prepare the CARE minutes in time for the TSC meeting. If there is not enough time to submit a full report for the TSC annual meeting, the TSC will accept a brief summary and conclusions from the CARE meeting along with any recommendations to the TSC. The full report can then be submitted at a later date when the final agency reports are due, usually the end of June.

   In recent years the TSC has met the last week of April, and that should not change. The TSC cannot schedule their meeting any later because many TSC members start their research season the first week of May.

XII. Selection of the next Chair, Schedule and Location of 2016 Meeting

The next TSC meeting will be held April 26-27, 2016 in Newport, Oregon and hosted by Ali Whitman, ODFW.

Stephen Phillips, PSMFC, said that he would begin the search for a new Chair. After the meeting, Lynne Yamanaka, DFO, agreed to be the new Chair for 2016.

XIII. Adjourn 12:30 p.m. April 29, 2015.

D. Parent Committee Minutes

Minutes of the 56th 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 Ms. Lynne Yamanaka, DFO, represented Canada. The meeting was called to order at 10:00 am, Wednesday, April 29, 2015.

II. The Agenda

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

III. The 2014 Parent Committee meeting minutes

The Parent Committee minutes were adopted as presented

IV. Progress on 2014 Parent Committee recommendations

a) Parent Committee agrees with the 2013/2014 TSC recommendation that agencies examine the long-term health exposures and issues resulting from evaluating fish age structures. This "ergonomic remedies" item will be reflected in the annual letter to agencies.

   Action: *This item was reflected in the annual letters to agencies.*

b) The Parent Committee agrees with the TSC on updating the TSC "Agency Overview" document. An updated document will be reviewed at the 2015 meeting.

   Action: *The language was updated for the 2015 report.*

V. 2015 Parent Committee Recommendations

a) Parent Committee agrees with the TSC's position that ergonomics in the workplace is a health and safety issue and is the responsibility of all employees to identify such issues to their supervisors and associated agency health and safety committees for resolution.
b) Parent Committee will bring to the attention of the Groundfish Management Teams on the North Pacific Fishery Management Council and the Pacific Fishery Management Council of the potential issues regarding otolith storage and the long-term affects on these ageing structures.
c) Parent Committee supports the TSC in their efforts to chair a special session or workshop to be held at the 2016 Western Groundfish Conference (WGC) that will 1) highlight research and management strategies to understand and adapt to groundfish responses to climate change and/or 2) focus on sharing information

and lessons learned regarding recent advances in electronic data capture for scientific and resource surveys.

d) Parent Committee supports the TSC in their efforts to promote the work of the TSC and agrees that submitting a poster for the WGC highlighting the TSC and its accomplishments would achieve this.

e) Parent Committee supports the TSC's efforts in sharing transboundary groundfish tagging data and agrees to support formal data sharing agreements, should they be necessary.

VI. 2016 Meeting Location

Parent Committee agrees with the proposed location and schedule for the 2016 TSC and Parent Committee Meeting: Newport, Oregon, April 26 and 27, 2016. ODFW will be the host agency.

VII. Other Business

a. The Parent Committee thanked Traci Larinto for serving chair for the past 2 years

b. The Parent Committee thanks PSMFC for its ongoing support for the Annual TSC meetings.

c. The Parent Committee thanks DFO staff for hosting the meeting.

VIII. The Parent Committee meeting was adjourned at 10:45 am, Wednesday April 29, 2015.

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

2014 Agency Report

to the

Technical Subcommittee of the

Canada-US Groundfish Committee

April 2015

Compiled by Wayne Palsson, Tom Wilderbuer, and Jon Heifetz

VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2014

A. Agency Overview

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

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

RACE DIVISION

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

In 2014 one of the primary activities of the RACE Division continued to be fishery-independent stock assessment surveys of important groundfish species of the northeast Pacific Ocean and Bering Sea. Regularly scheduled bottom trawl surveys in Alaskan waters include an annual survey of the crab and groundfish resources of the eastern Bering Sea shelf and biennial surveys of the Gulf of Alaska (odd years) and the Aleutian Islands and the upper continental slope of the eastern Bering Sea (even years). Two Alaskan bottom trawl surveys of groundfish and invertebrate resources were conducted during the summer of 2014 by RACE Groundfish Assessment Program (GAP) scientists: the annual Eastern Bering Sea Shelf Bottom Trawl Survey, and the biennial Aleutian Islands Bottom Trawl Survey.

RACE scientists of the Habitat Research Team (HRT) continue research on essential habitats of groundfish including identifying suitable predictor variables for building quantitative habitat models, developing tools to map these variables over large areas, investigating activities with potentially adverse effects on EFH, such as bottom trawling, and benthic community ecology work to characterize groundfish habitat requirements and assess fishing gear disturbances. The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock abundance during the summer in the Eastern Bering Sea Shelf as well as winter acoustic trawl surveys in the Gulf of Alaska. Research cruises investigating bycatch issues also continued.

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

REFM DIVISION

The research and activities of the Resource Ecology and Fisheries Management Division (REFM) are designed to respond to the needs of the National Marine Fisheries Service regarding the conservation and management of fishery resources within the US 200-mile Exclusive Economic Zone (EEZ) of the northeast Pacific Ocean and Bering Sea. Specifically, REFM's activities are organized under the following Programs: Age and Growth Studies, Economics and Social Sciences Research, Resource Ecology and Ecosystem Modeling, and Status of Stocks and Multispecies Assessment. REFM scientists prepare stock assessment documents for groundfish and crab stocks in the two management regions of Alaska (Bering Sea/Aleutian Islands and Gulf of Alaska), conduct research to improve the precision of these assessments, and provide management support through membership on regional fishery management teams.

For more information on overall REFM Division programs, contact acting Division Director Dan Ito at (206) 526-4232.

AUKE BAY LABORATORIES

The Auke Bay Laboratories (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL's Marine Ecology and Stock Assessment Program (MESA) is the primary group at ABL involved with groundfish activities. Major focus of the MESA Program is on research and assessment of sablefish, rockfish, sharks, and grenadiers in Alaska and studies on benthic habitat. Presently, the program is staffed by 14 scientists and 1 post doc. ABL's Ecosystem Monitoring and Assessment Program (EMA) has also been conducting groundfish-related research for the past few years.

In 2014 field research, ABL's MESA Program, in cooperation with the AFSC's RACE Division, conducted the AFSC's annual longline survey in Alaska. Other field and laboratory work by ABL included: 1) continued juvenile sablefish studies, including routine tagging of juveniles and electronic archival tagging of a subset of these fish; 2) satellite tagging and life history studies of spiny dogfish and sablefish; 3) recompression experiments on rougheye and blackspotted rockfish; 4) large-scale, epipelagic trawl survey of the northern Bering Sea shelf conducted by ABL's EMA Program; and 5) an upper trophic level fisheries oceanography survey of the Gulf of Alaska.

Ongoing analytic activities in 2014 involved management of ABL's sablefish tag database, analysis of sablefish logbook and observer data to determine fishery catch rates, and preparation of eleven status of stocks documents for Alaska groundfish: Alaska sablefish, Gulf of Alaska Pacific ocean perch, northern rockfish, dusky rockfish, rougheye/blackspotted rockfish, shortraker rockfish, "Other Rockfish", and thornyheads, and Gulf of Alaska and Eastern Bering Sea sharks and grenadiers.

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.

FMA DIVISION

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

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

B. Multispecies Studies

1. Stock Assessment and Surveys

2014 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP
The thirty-third in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 6 August 2014 aboard the AFSC chartered fishing vessels *Vesteraalen* and *Alaska Knight*, which bottom trawled at 376 stations over a survey area of 492,898 km^2. 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 2014 were 7.4 million metric tons (t) for walleye pollock, 1.1 million t for Pacific cod, 2.5 million t for yellowfin sole, 1.9 million t for northern rock sole, 28 thousand t for Greenland turbot, and 171 thousand t for Pacific halibut. There were increases in estimated survey biomass for most major fish taxa compared to 2013 levels. Walleye pollock biomass increased 62%, Pacific cod 35%, arrowtooth flounder 15%. yellowfin sole 10%, northern rock sole 6%, and Greenland turbot 12.5%. There were slight decreases for Alaska plaice (11%) and Pacific halibut (7%).

Average surface temperature was 8.2°C, the third warmest in the 33 year time series after 1983 and 2004, and in increase from last year's value of 6.4°C. Bottom temperatures averaged 3.0°C, greater than last year's average of 1.7°C and the warmest value since 2005.

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

2014 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Aleutian Islands – RACE GAP

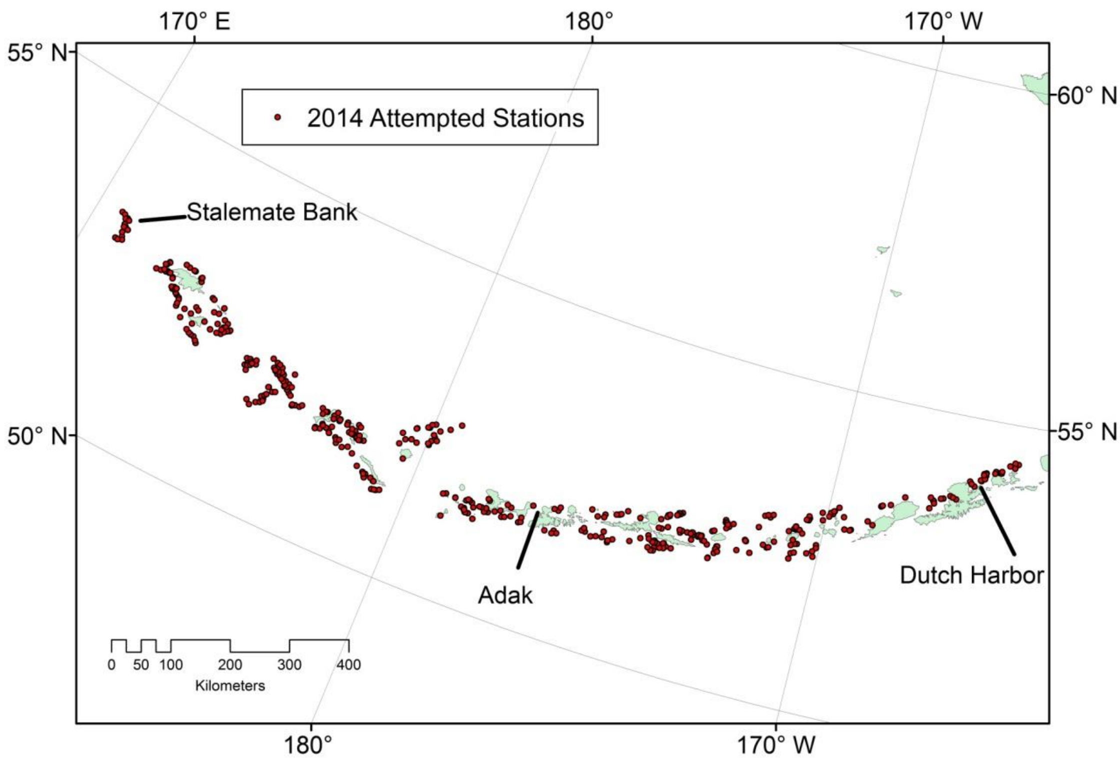
The National Marine Fisheries Service Alaska Fisheries Science Center (AFSC) Resource Assessment and Conservation Engineering (RACE) Division chartered the fishing vessels *Alaska Provider* and *Sea Storm* to conduct the 2014 Aleutian Islands Biennial Bottom Trawl Survey of groundfish resources. This was the thirteenth survey in the series which began in 1980, was conducted triennially for most years until 2000, and then biennially since. However, there was no survey in 2008. Both vessels were chartered for 70 days, and the cruise originated from and concluded at Dutch Harbor, Alaska . The charter began on 5 June 2014 and ended on 13 August. The Alaska Provider was chartered for an additional two days to conduct net efficiency studies for the survey trawl. After the vessels were loaded and other preparations (*e.g.,* wire measuring, wire marking, and test towing) were made before the first survey tows were conducted on 11 June. The vessels first proceeded eastwards conducting stations to Unimak Pass (165° W) and then proceeded westward to Stalemate Bank (longitude 170°E), west of Attu Island (Figure 1). The cruise was divided into three legs with breaks in Adak to change crews and re-provision.

A primary objective of this survey is to continue the data time series begun in 1980 to monitor trends in distribution and abundance of important groundfish species. During these surveys, we measure a variety of physical, oceanographic, and environmental parameters while identifying and enumerating the fishes and invertebrates collected in the trawls. Specific objectives of the 2014 survey include: define the distribution and estimate the relative abundance of principal groundfish and important invertebrate species that inhabit the Aleutian archipelago, measure biological parameters for selected species, and collect age structures and other samples.

The survey design was a stratified random sampling scheme consisting of 420 stations selected randomly from a combination of successful tows completed during previous surveys and sites not previously trawled. The selected sampling sites were allocated to 45 sampling strata defined by geographical location, depth, and regulatory area, ranging from shallow, nearshore depths to approximately 500 m on the continental slope. Stations were sampled with the RACE Division's standard four-seam, high-opening Poly Nor'Eastern survey trawl equipped with rubber bobbin roller gear. This trawl has a 27.2 m headrope and 36.75 m footrope consisting of a 24.9 m center section with adjacent 5.9 m "flying wing" extensions. Accessory gear for the Poly Nor'Eastern trawl includes 54.9 m triple dandylines and 1.8 × 2.7 m steel V-doors weighing approximately 850 kg each. The charter vessels conducted 15-minute trawls at pre-assigned stations. Catches were sorted, weighed, and enumerated by species. Biological information (sex, length, age structures, individual weights, stomach contents, etc.) were collected for major groundfish species. Specimens and data for special studies (*e.g.,* maturity observations, tissue samples, photo vouchers) were collected for various species, as requested by researchers at AFSC and other cooperating agencies and institutions. Specimens of rare fishes or invertebrates, including corals, sponges, and other sessile organisms were collected on an opportunistic basis.

Four-hundred fifty-eight stations were attempted during the regular survey (Figure 1). Of these, 410 hauls were successful and used for determining catch per unit effort and estimating biomass. Forty-eight hauls were unsuccessful because of net damage, poor net performance, or the station was duplicated. Four stations were not occupied because of poor weather at the end of the cruise. The survey activity resulted in a total fish catch of 534 mt and 878,000 individuals representing 163taxa. Nearly 16 mt of invertebrates were captured representing 497 taxa.

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



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

The MACE Program conducted winter acoustic-trawl (AT) surveys in 2014 aboard the NOAA Ship *Oscar Dyson*, targeting walleye pollock (*Gadus chalcogrammus*) in Sanak Trough, the Shumagin Islands, Marmot Bay, and Shelikof Strait. Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl (AWT), and on-bottom backscatter was sampled with a poly Nor'eastern (PNE) bottom trawl. A modified Marinovich trawl was also used once to determine compatibility for future operations.

The Shumagin Islands survey was delayed for 2 weeks from original plans due to vessel mechanical issues. The survey was subsequently conducted 23-26 February along parallel transects spaced 5 nautical miles (nmi) apart within Shumagin Trough, 1 nmi apart east of

Renshaw Point, and 2.5 nmi apart elsewhere. The Sanak Trough survey was conducted 27 February 2014 along transects spaced 2 nmi apart.

Dense aggregations of walleye pollock were observed in the West Nagai Strait, Renshaw Point, and outer Shumagin Trough portions of the Shumagin Islands survey. The vast majority of walleye pollock found in the Shumagin Islands were age-2 walleye pollock (16-26 cm fork length (FL)). The measured maturity composition for males longer than 40 cm FL (n=117) was 0% immature, 11% developing, 25% pre-spawning, 43% spawning, and 21% spent. The maturity composition of females longer than 40 cm FL (n = 105) was 0% immature, 12% developing, 73% pre-spawning, 7% spawning, and 8% spent. The high percentage of pre-spawning females and the low percentage of spawning and spent females suggested that the survey timing was appropriate to coincide with the onset of spawning for the majority of the population based on findings from the Shelikof Strait pre-spawning pollock survey. The mean gonadosomatic index (GSI: ovary weight/body weight) for mature pre-spawning females was 0.13. The pollock AT survey abundance estimate in the Shumagin Islands area was 37,346 metric tons (t) (80% of which was age-2 pollock), based on catch data from 7 trawl hauls and acoustic data from 357.5 nmi of survey transects. The relative estimation error for this biomass estimate was 18.2%.

The densest pollock aggregations in Sanak Trough were located over the southeast portion of the trough and consisted entirely of adult pollock 42-78 cm FL (mode 59 cm). Unlike 2013, we found no age-1 or age 2 walleye pollock in Sanak trough. The unweighted maturity composition for males longer than 40 cm was 0% immature, 9% developing, 16% pre-spawning, 16% spawning, and 59% spent. The unweighted maturity composition for females longer than 40 cm FL was 0% immature, 0% developing, 50% pre-spawning, 6% spawning, and 44% spent. The average GSI for pre-spawning females was 0.14. The abundance estimate for Sanak Trough of 7,319 t (relative estimation error 9%) was the lowest in the survey’s history and was based on catch data from 1 trawl haul and acoustic data from 36 nmi of survey transects.

The MACE Program also conducted winter AT surveys in Marmot Bay and Shelikof Strait. Marmot Bay was surveyed 22-24 March 2014 along parallel transects spaced 2 nmi apart in the outer bay and 1 nmi apart in the inner bay and in Spruce Gully. Shelikof Strait was surveyed from Ban Island off Afognak Island to southwest of Chirikof Island 15-22 March 2014 along parallel transects spaced 7.5-nmi apart.

The majority of pollock biomass in Marmot Bay consisted of dense schools of walleye pollock primarily in the 16 to 40 cm FL range and found north of Spruce Island and in Spruce Island Gully. Smaller fish, 10 to 16 cm FL (age-1 fish) were found in outer Marmot Bay. The unweighted maturity composition in Marmot Bay for males longer than 40 cm FL was 0% immature, 30% developing, 18% pre-spawning, 20% spawning, and 32% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 37% developing, 63% pre-spawning, 0% spawning, and 0% spent. The biomass estimate for Marmot Bay was 14,992 t (relative estimation error 9.4%) from 5 trawl hauls and acoustic data from 152 nmi of survey transects.

As in previous years the highest walleye pollock densities found in Shelikof Strait were observed along the northwest side of the Strait near Kukak Bay. Within this deepest section of the strait along the steep banks of the Alaska Peninsula, dense aggregations of pre-spawning adult fish, primarily in the 40- 60 cm FL range, were detected. These pre-spawning adult fish were predominantly between the ages of 4 and 9 years old, with some as old as 13 years. Mid-sized fish (16 – 40 cm) were observed in the central portion of the Shelikof Strait north of Chirikof

Island to Kukak, and a small amount of biomass represented by age-1 pollock was present in the north and central part of the Strait. The numerical dominance of age-2 fish in 2014 reflects continued success of the 2012 year class, which was abundant as 1-yr olds in the 2013 survey.

In Shelikof Strait, the unweighted maturity composition for males longer than 40 cm FL was 1% immature, 34% developing, 24% mature pre-spawning, 39% spawning, and 1% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 61% developing, 30% pre-spawning, 7% spawning, and 1% spent. The small fraction of spawning and spent females relative to pre-spawning females suggests that the survey was timed appropriately to coincide with the onset of spawning for the majority of the population, based on findings from earlier Shelikof Strait pre-spawning surveys. The average GSI for mature pre-spawning females was 0.14. The pollock abundance estimate of 842,138 t for the Shelikof Strait is the second largest reported for the region since 1985, and similar to the 2013 estimate of 891,261 t (relative estimation error 4.7%). The 2013 estimate was based on catch data from 21 trawl hauls and acoustic data from 780 nmi of survey transects.

Winter acoustic-trawl survey in the southeast Aleutian Basin near Bogoslof Island
The MACE Program conducted an AT survey of walleye pollock in the southeastern Aleutian Basin near Bogoslof Island aboard the NOAA Ship *Oscar Dyson* during 7-11 March, 2014. Although the original survey plan was for 35 transects, the 4 western-most transects were dropped because of poor weather conditions. Thus, the surveyed area was contracted to 31 north-south parallel transects, spaced 3-nmi apart, covering 1,150 nmi^2 of the Central Bering Sea Convention Specific Area.

Walleye pollock were concentrated in two main regions, north of Samalga Pass and northeast of Umnak Island. Based on catch data from seven trawl hauls, the overall pollock size composition ranged from 13 cm to 70 cm FL, with prominent modes at 45 and 58 cm FL. The pollock size composition in the Samalga Pass region was bimodal (47 and 58 cm FL), whereas pollock in the Umnak region was unimodal (43-45 cm FL). Female and male pollock maturity composition varied between the two regions. In the Samalga Pass region, 89% of the female pollock were in pre-spawning condition, whereas in the Umnak region, only 21% of the females were in the same, pre-spawning condition. Similarly, 66% of the males in the Samalga Pass region were in pre-spawning condition, and 37% were in the pre-spawning condition. For both regions combined, the average gonado-somatic-index for mature pre-spawning females was 0.14.

The pollock abundance estimates for the southeastern Aleutian Basin near Bogoslof Island were 113 million fish, weighing 112 thousand t (relative estimation error 11.8%). The 2014 estimates represent a 133% increase in abundance and a 67% increase in biomass from the 2012 survey estimates, though both abundance and biomass remain extremely low compared to late 1980s and early 1990s. Fifty percent of the population was distributed in the Samalga Pass region, and 50% was distributed in the Umnak region.

The estimated age composition for 2014 was dominated by younger pollock. Fifty-eight percent of the pollock abundance was represented by the 5 and 6 year old fish (2009 and 2008 year classes) and 12% was represented by 8 year old fish (2006 year class). Overall, 80% of the pollock population was less than 9 years of age.

Summer Acoustic-Trawl Survey on the Bering Sea Shelf -- MACE Program

The MACE Program conducted an AT survey of midwater walleye pollock between 12 June and 13 August 2014 aboard the NOAA ship *Oscar Dyson*. This survey has been conducted since 1979; triennially through 1994, and biennially or annually since then. The survey design covered the EBS shelf between roughly the 50 m and 200 m isobaths, from 162° W across the U.S.–Russian Convention Line to about 178° 20 E, including the Cape Navarin area of Russia. It consisted of 28 north-south transects spaced 20 nautical miles (nmi) apart in the U.S. In mid-July, a motor board control failed resulting in 2 weeks of sailing at reduced ship speed and subsequent loss of about 4 days of ship time. After the repair, transect spacing was increased to 40 nmi in the Russian EEZ in order to complete the survey in the time available. The primary objective was to collect daytime 38 kHz acoustic backscatter and trawl data to estimate the abundance of walleye pollock. Additional survey sampling included conductivity-temperature-depth (CTD) measurements to characterize the Bering Sea shelf temperature conditions, and supplemental trawls to improve acoustic species classification and to obtain an index of euphausiid abundance using multiple frequency techniques. A number of specialized sampling devices were used during the survey, including a modified Marinovich midwater trawl to sample fish and macro-zooplankton which was rigged with pocket nets to estimate fish escapement, a trawl-mounted stereo camera (CamTrawl) designed to identify species and determine size and density of animals as they pass by the camera during a haul, and a set of 6 small, bottom-moored, trigger–camera systems to autonomously collect images of fish near the seafloor.

Biological data and specimens were collected from 142 trawl hauls. The majority of these hauls (122) targeted backscatter during daytime for species classification: 88 with an AWT, 18 with a bottom trawl, and 16 with a Methot trawl. The remaining 20 hauls, some of which also assisted with species classification, were nighttime Marinovich tows near surface to evaluate gear performance, the net's suitability for catching age-0 pollock, and the placement of pocket nets to monitor escapement. Among midwater hauls used to classify backscatter for the survey, walleye pollock was the most abundant species by weight (84.8%) and by number (96.1%), followed by northern sea nettle jellyfish (*Chrysaora melanaster*) (14.8% by weight and 2.7% by number). Among bottom trawls, pollock was the most abundant species (61.7% by weight and 48.5% by number) followed by northern sea nettle jellyfish (16.6% by weight and 9.5% by number). In Marinovich hauls, northern sea nettles (91.7%), Pacific herring (4.1%), and age-1+ pollock (3.5%) dominated the catch by weight, while euphausiids (91.1%), northern sea nettles (3.7%), and age-0 pollock (1.8%) dominated the catch numerically. Finally, Methot hauls were dominated by northern sea nettles (76.0%), euphausiids (12.6%), and unidentified jellyfish (10.2%) by weight, respectively, and numerically, by euphausiids (98.4%).

Water temperatures in 2014 (both surface and near bottom) were much warmer on average than they have been in the past several years; in particular, water temperatures during the previous AT survey in 2012 were the coldest of a sequence of several cold years (2006-2012). About 45% of the summed acoustic backscatter at 38 kHz observed between near the surface and 3 m off bottom during the 2014 survey was attributed to adult or juvenile walleye pollock. This was less than in the past several surveys (56% in 2012, 82% in 2010, and 62% in 2009). The remaining non-pollock water column backscatter was attributed to an undifferentiated plankton-fish mixture (53%), or in a few isolated areas, to rockfishes (*Sebastes* spp.) or other fishes (~2%). Most walleye pollock biomass was distributed relatively evenly across the shelf from a region north of Unimak Island to Navarin Canyon, between roughly the 50 m and 1000 m isobaths.

Estimated pollock abundance in midwater (between 16 m from the surface and 3 m off bottom) in the U.S. EEZ portion of the Bering Sea shelf was 17.4 billion fish weighing 3.439 million t (relative estimation error 4.6%). This was nearly twice the 2012 biomass estimate (1.843 million t) and higher than has been observed since 2002. Pollock abundance east of 170° W was 6.623 billion fish, weighing 1.425 million t (40% of total midwater biomass); notably, two-year-old pollock (26 cm modal FL) comprised 49% of that biomass. This was an increase from 2012, and was the highest pollock biomass observed east of the Pribilof Islands since 2002. Pollock biomass increased by a similar amount inside the Steller sea lion conservation area (SCA), and annual variation there correlates well with the entire survey estimates ($r^2 = 0.76$, $p << 0.05$). In U.S. waters west of 170° W, pollock numbered 10.76 billion and weighed 2.013 million t (59% of total shelf-wide biomass). Dominant modal lengths were 15, 27, and 38 cm FL, corresponding to pollock aged 1, 2, and 4-5 years, respectively. In Russia, estimated midwater pollock abundance was 0.257 billion fish weighing 0.104 million t (3% of total biomass). There, the dominant modal length was 38 cm FL, corresponding to 4-5-year-old fish, with fewer 2-year-olds observed than west of 170° W in the U.S.

In terms of age composition, the 2014 survey estimated the largest group of two-year olds in the AT survey time series. Most of these fish were observed east of the Pribilof Islands, rather than north and west of the Pribilofs as in recent years. The preliminary age information for pollock in the U.S. EEZ confirmed that juvenile pollock (ages 1, 2 and 3) were dominant numerically (accounting for 26%, 48% and 8% of the population, respectively) overall. These three age groups represented 44% of the total biomass. Adult pollock (ages 4+) totaled 19% of the population numerically, and made up 56% of the total biomass. Six-year-old fish from the 2008 year class represented 23% of the shelf-wide midwater biomass. In Russia, age-5s were most numerous among the mix of predominantly age 3 to 6 year-old fish, consistent with 2012 survey observations of relatively large numbers of 3-year-olds there. Analyses of walleye pollock vertical distribution indicated that among adults (≥30 cm FL) shelf-wide, more than 93% were found within 50 m of the bottom, whereas for juveniles, the percentage in the near bottom region was lower, ranging from 75% east of 170° W to 81% west of 170° W.

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

Longline Survey - ABL

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2014. 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 2014, the thirty-sixth annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Aleutian Islands was conducted. One hundred-forty-eight longline hauls (sets) were completed during June 1 – August 26, 2014 by the chartered fishing vessel *Alaskan Leader*. Total groundline set each day was 16 km long and contained 160 skates and 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 Pacific halibut (*Hippoglossus stenolepis*). A total of 62,809 sablefish, with an estimated total round weight of 197,068 kg (434,461 lb), were caught during the survey. This represents an increase of nearly 6,000 sablefish over the 2013 survey catch. Sablefish, shortspine thornyhead, and Greenland turbot (*Reinhardtius hippoglossoides*) were tagged with external Floy tags and released during the survey. Pop-up satellite tags (PSAT) were implanted in 43 sablefish. Length-weight data and otoliths were collected from 1,780 sablefish. Killer whales (*Orcinus orca*) depredating on the catch occurred at three stations in the eastern Aleutian Islands, and four stations in the western Gulf of Alaska. Sperm whales *(Physeter macrocephalus)* were observed during survey operations at 21 stations in 2014. Sperm whales were observed depredating on the gear at one station in the Aleutian Islands, four stations in the central Gulf of Alaska, six stations in the West Yakutat region, and four stations in the East Yakutat/Southeast region.

Several special projects were conducted during the 2014 longline survey. Sperm whale photo identification was done in the eastern and central Gulf of Alaska and depredation behavior was recorded. Killer whale observations were conducted in the western Gulf of Alaska.. In addition, Pacific halibut lengths were recorded in the eastern Aleutian Islands and western Gulf of Alaska. Satellite pop-up tags were deployed on sablefish throughout the Gulf of Alaska. Information from these tags will be used to investigate movement patterns within and out of the Gulf of Alaska and potentially help identify spawning areas for sablefish.

Longline survey catch and effort data summaries are available through the Alaska Fisheries Science Center's website: http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_ls.php. Full access to the longline survey database is available through the Alaska Fisheries Information Network (AKFIN). Catch per unit effort (CPUE) information and relative population numbers (RPN) by depth strata and management regions are provided. These estimates are available for all species caught in the survey. Previously RPN's were only available for depths that corresponded to sablefish habitat but in 2013 these depths were expanded to 150m - 1000m. Inclusion of these shallower depths provides expanded population indices for the entire survey time series for species such as Pacific cod, Pacific halibut, and several rockfish species.

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

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

On January 1st 2013, new regulations that govern how observers are deployed into the fisheries of Alaska became effective. Amendments 86 to the Fisheries Management Plan (FMP) of the Bering Sea and Aleutian Islands and 76 to the FMP of the Gulf of Alaska establish the new North Pacific Groundfish (and Halibut) Observer Program. Since the way observers are deployed and paid for has changed, the Observer Program is considered to be "restructured". The new Observer Program replaces the "interim program" that was in place for the last for 23 years. Under the interim Program, vessels and plants paid for observers by the day at coverage rates specified in law based on *days in a calendar quarter* at-sea (not fishery as is often assumed) and on *tons processed* for shoreside processors. Catcher vessels between 60 and 125' in length were allowed to self-select which trips were to be observed under the interim Program. Since vessels less than 60' or those targeting Pacific halibut were not observed, the former static regulatory structure of observer coverage not only created an incentive for owners to change the length of their vessels (indeed a disproportionately high number of 124' and 58' vessels exist in the fleet), but also created a mechanism for owners to skew observer coverage towards trips with lower bycatch rates (e.g. pollock) and away from those with higher bycatch rates (e.g. most flatfish fisheries).

The 2013 Observer Program is the result of the third attempt by NMFS to restructure the interim Observer Program since 1990. The effort involved over 53 separate people from five agencies and took five years to accomplish. The new Program places *all* vessels and processors in the groundfish *and halibut* fisheries off Alaska into either full- or partial-coverage categories. No operations are exempt from the new Program. Vessels and processors in the full-coverage category will continue to obtain observers by contracting directly with observer providers. Vessels and processors in the partial coverage category will obtain observers through NMFS, paying a fee on landings to cover the costs.

The full-coverage category now includes:

- catcher/processors (CPs)
- motherships,
- catcher vessels while participating in American Fisheries Act (AFA) or Community Development Quota (CDQ) pollock fisheries,
- catcher vessels while participating in CDQ groundfish fisheries (except: sablefish; and pot or jig gear catcher vessels),
- catcher vessels while participating in the Central Gulf of Alaska Rockfish Program (RP), and
- inshore processors when receiving or processing Bering Sea pollock

Vessels and processors now in the partial coverage category include:

- catcher vessels designated on a Federal Fisheries Permit (FFP) when directed fishing for groundfish in federally managed or parallel fisheries, except those in the full coverage category,
- catcher vessels when fishing for halibut IFQ or CDQ,
- catcher vessels when fishing for sablefish IFQ or fixed gear sablefish CDQ , and
- shoreside or stationary floating processors, except those in the full coverage category.

The new Program establishes greater coverage requirements for those vessels with the potential to take long trips (i.e. CPs) compared to catcher vessels that cannot because of the potential for catch spoilage. Since the full-coverage requirement for CPs and motherships is based on the endorsement on a vessels' FFP and not their length, these changes bring new CPs less than 60' long into the Observer Program. The full-coverage requirements that remain for some catcher vessel operations represent those "inherited" from existing catch-share programs or required for detailed quota accounting (e.g. AFA, A80, RP, and CDQ). Catcher vessels greater than 125' that were previously fully observed could move to partial coverage in the new Program if they participate in certain target fisheries such as pollock in the Gulf of Alaska.

How vessels in partial-coverage attain their observers in the new Program represents a major change from the interim Program. Under the new Program, coverage requirements for the partial-coverage category are specified in an Annual Deployment Plan (ADP). The intent of the ADP is not to adjust policy, but rather to focus on science driven deployment to reduce potential bias and meet NMFS's data needs. The allocation strategy used to deploy observers in the partial-coverage category is the principal aspect of observer deployment that can be adjusted through the ADP. The ADP process is initiated as a science-based recommendation through committee that is vetted into an initial draft document by the Fisheries Monitoring and Analysis Division (FMA) of the AFSC and the Sustainable Fisheries Division (SF) of the Alaska Regional Office (AKR). The initial draft ADP is presented to the Council at their June meeting. NMFS will subsequently analyze Council recommendations and release a final draft ADP by September 1. This final draft ADP is presented to the Council's Plan Teams in September, the Council's

Scientific and Statistical Committee (SSC) and Council in October. Based on accepted minor Council recommendations made in October, a NMFS final ADP is issued for the following year.

In May 2014, NMFS provided its first Annual Report to the North Pacific Fishery Management Council (Council) on observer deployment under the restructured observer program. The report, North Pacific Groundfish and Halibut Observer Program 2013 Annual Report (Annual Report) assesses the degree to which the objectives of the observer program restructuring have been met and includes recommendations to improve the program. Chapter 3 of the report, Deployment Performance Review, was formalized as a separate NOAA Technical Memorandum.
As part of the annual review process, a set of performance metrics were used to assess the efficiency and effectiveness of observer deployment into the trip-selection (vessels > 57.5 feet in length) and vessel-selection (vessels 40-57.5 feet in length) strata of the partial coverage category. There was a marked difference in the relative performance of the two deployment methods in 2013. In the vessel-selection stratum, coverage levels were less than expected during the five of the six 2-month selection periods. Coverage shortages in vessel-selection were due to a lack of a proper sampling frame and a substantial non-response (17-71% among selection periods). In total, 52% of the vessels, and 50% of the trips resulting from these vessels were not observed due to conditional releases from observer coverage. This high level of non-response, coupled with a low sample size resulted in systematic spatial coverage issues, most notably in NMFS Reporting Area 650.

In contrast, the trip-selection stratum met the anticipated coverage goals throughout the year. Based on the results presented in the Annual Report, at the June 2014 Council meeting NMFS recommended, and the Council agreed, that NMFS should consider placing participants in the vessel selection category into the trip selection category for 2015. This recommendation was further analyzed and formally proposed in the 2015 Draft Annual Deployment Plan (ADP) provided to the Council in October 2014. The Draft ADP proposed maintaining coverage rates of 12% for vessels 40-57.5 feet in length, but increasing observer coverage from 16 to 24% for vessels >57.5 feet. This was based on the Council's June recommendation to consider higher coverage rates for all trawl vessels and fixed gear vessels over 57.5 feet. The ADP also proposed limiting the conditional release policy for vessels 40-57.5 feet to include life raft capacity only in order to improve the sampling efficiency within this stratum.

At their October 2014 meeting, the Council unanimously approved the Draft ADP with the caveat that if vessels in the small vessel trip selection stratum are selected randomly three trips in a row, the third selected trip be released from coverage. The proposed changes to observer coverage will take effect in January 2015 and remain in effect for the calendar year.

During 2014, the Observer Program trained and deployed 778 observer cruises to vessels fishing in the full and partial coverage fleets off of Alaska. The Program was responsible for defining the sampling duties and data collection methods used by observers, training of the observers prior to deployment, debriefing of observers upon their return, and editing and managing the resulting data. The catch data were provided to the Alaska Regional Office to assist in management decisions regarding the catches of groundfish and prohibited species. Data were also collected regarding the operations of the groundfish fishery.

Status of Stocks and Multispecies Assessment Task - REFM
The Status of Stocks and Multispecies Assessment Program is responsible for providing stock assessments and management advice for groundfish and crab in the North Pacific Ocean and

the Bering Sea. Scientists conducted status assessments and projected future stock status for managed fish stocks including both target species and species incidentally caught in target fisheries. In 2014, program members conducted statistical analyses of survey, fishery, observer, and life history data; assessed model performance; convened workshops and meetings to report stock assessment results to the Councils and the public, and provided technical support for the evaluation of potential impacts of proposed fishery management measures.

During the past year, 24 Bering Sea/Aleutian Islands (BSAI) and 13 Gulf of Alaska (GOA) groundfish assessments, 4 BSAI crab assessments, and 2 forage fish assessments were prepared by program members and submitted for review to the GOA and BSAI Groundfish and BSAI Crab 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 and crab stock assessments; 2) development and implementation of a generalized modeling framework for Alaskan crab stocks 3) development of a simulation model to evaluate the performance of different harvest strategies in a multi-fishery management system, 4) technical support for improvement of the multispecies technical interaction model, 5) research activities associated with the impacts of climate change 6) research activities associated with the incorporation of ecosystem variables in stock assessments 7) significant contributions and development of the analyses for the Bering Sea Chinook and Chum salmon bycatch environmental assessment and the Steller Sea Lion Environmental Impact Statement. In addition, program members participated in numerous national and international committees, advisory panels, stock assessment review panels, and symposia 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

Barbeaux, S. J. and S. Kang. Status of the Korean pollock stocks. US-ROK JPA (Funded)

Barbeaux, S. J. and J.B. Lee. Fisher Collected Ocean Data (FCOD). US-ROK JPA (Funded)

Beaudreau, A. Hunsicker, M., Dorn, M., and Ciannelli, L. (PCCRC) Developing an index of predation to improve the assessment of walleye pollock in the Gulf of Alaska. (Funded)

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

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

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

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

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

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

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

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

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

TenBrink, T. and T. Wilderbuer (AFSC Coop.) Developing maturity schedules to improve stock assessments for data-poor commercially important flatfishes in the Gulf of Alaska.

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

2. Research

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

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

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

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

FY14 Research Activities

In FY14, the main task of fieldwork was to complete an underwater camera survey of the Aleutian Islands. This survey was conducted for 1 month in April-May and 116 stations were occupied from Dutch Harbor to Stalemate Bank. Image analysis is ongoing, but preliminary results indicate that coral and sponge are widely distributed in the area and can grow to heights of over 1 m. Densities of coral estimated to date ranged from 0 to 1.66 individuals*m^2, and averaged 0.13 individuals*m^2.The average density of sponges was 0.19 individuals*m^2 and ranged to 1.86 individuals*m^2. The average density of pennatulaceans was 0.03 individuals*m^2 and ranged as high as 1.33 individuals*m^2.

In addition to this survey of the Aleutian Islands, a research cruise in August collected comparative information on rockfish from coral and non-coral habitats in the central Gulf of Alaska. This data collection was designed to measure productivity (in terms of reproductive potential, growth and fish condition) of rockfish to determine if coral habitat conferred an energetic advantage to fish that occupied this habitat.

In addition to these cruises funded by AKCSI, there were also a number of field data collections carried out in partnership with other research activities in Alaska. In FY14 the final phase of a pilot project was conducted to construct a camera system that could be attached to longline and pot fishing gear in Alaska to collect information on the impacts of these gears on benthic habitats. A prototype camera system and inertial measurement system was constructed by research partners in the RACE division and tested throughout the winter of 2014. These instruments were successfully deployed in the Gulf of Alaska during the AFSC longline survey in July 2014 on 20 longline deployments. The inertial data and images collected on this cruise are currently being analyzed.

In FY14, with partners in the AFSC RACE division we collected O2, salinity, turbidity and pH measurements on the headrope of bottom trawls used to conduct annual stock assessment surveys. Oceanographic data were collected on 135 tows from the Seguam Pass in the eastern Aleutian Islands to Stalemate Bank in the western Aleutian Islands.

Oceanographic equipment to measure O2, pH, salinity and temperature installed at a long-term study site in Tracy Arm (southeastern Alaska) in 2013 was recovered and collected oceanographic data on 6-hour intervals until March 2014.

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

Additional work was conducted at the AFSC and U.S. Geological Survey to compile bathymetry and sediment maps from NOAA smooth sheets for the Aleutian Islands and Gulf of Alaska in anticipation of completing a geologically interpreted substrate map for these regions in FY15. The compiled sediment and bathymetry map for the Aleutian Islands region was released as a NOAA Technical Memorandum. The data compilation in the Gulf of Alaska has been completed for the majority of this region as well, thanks to collaboration with the NPRB-funded Gulf of Alaska-Integrated Ecosystem Research Program, which has similar needs for bathymetric data.

Planned FY15 Activities

In FY15, the only field effort will focus on projects at the Dixon Entrance, Prince of Wales, Fairweather Grounds, and Cape Ommaney sites. We will again use a remotely operated vehicle (ROV) to conduct transect surveys at two of the study sites in southeastern Alaska that were not completed in FY13 (Fairweather Grounds and Dixon Entrance). A stereo drop camera will again be used to measure size structure of *Primnoa* at these sites, plus some additional transects at the Prince of Wales site. Samples for genetics analysis will also be collected at two sites (Dixon Entrance and Fairweather Grounds) to complete the collections for that project. In addition, two of the settlement plates deployed in FY13 will be recovered in FY15 and any newly settled recruits collected. Then the plates will be redeployed for collection at a later date.

With the completion of this final cruise, the AKCSI project will be finished and a final report written by December 2015.

Camera Survey of Coral Habitat on the Eastern Bering Sea Slope-RACE GAP and ABL

Last summer, NOAA Alaska Fisheries Science Center completed the first comprehensive camera survey targeting corals on the eastern Bering Sea outer shelf and slope. The survey was completed during 9 August - 5 September 2014. This research was requested by the North Pacific Fisheries Management Council in response to concerns about the distribution of potentially vulnerable coral habitat in Bering Sea canyons. Some of the largest submarine canyons in the world incise the eastern Bering Sea shelf break and are proximate to some of the worlds largest commercial fisheries.

The objectives of the survey were to:

- Validate coral and sponge distribution model predictions
- Acquire height and density data for coral using the stereo imaging capabilities of the camera system

- Identify the role of coral as fish habitat
- Document presence and degree of fishing gear effects on coral and sponge habitats
- Estimate the vulnerability of coral and sponge habitats to fishing gear effects, and
- If necessary improve or refine predictions of coral presence

A total of 250 successful camera drops were completed during the survey covering Bering, Pribilof, Zhemchug and Pervenets canyons and most of the slope in between. The depths sampled ranged from 91 to 810 m (median = 279 m). Navarin Canyon, the northernmost canyon (30 planned stations), and much of the area between Pervenets and Zhemchug canyons (10 planned stations), were left unsampled. The survey was conducted from the chartered fishing vessel Vesteraalen and the participating scientists were Chris Rooper (AFSC) and Steve MacLean (NPFMC) (leg 1) and Mike Sigler (AFSC) and Pat Malecha (AFSC) (leg 2).

Over 225,000 images were collected at the 250 camera drops. The results of preliminary reviews of the images collected during the camera drops indicates that coral densities were generally low throughout the area even at the 31 transects where they occurred (< 0.01 individuals*m^{-2}). In general, observations of coral were similar to predictions from an existing coral model, which was based on trawl survey data. The presence of coral was primarily observed in Pribilof canyon and the slope area to the northwest of the canyon. The heights of corals ranged from ~ 5 – 90 cm, with most individuals < 20 cm in height. A final report on the analyses will be presented to the North Pacific Fisheries Management Council meeting in Sitka in June 2015.

Contact Chris Rooper and Mike Sigler, NOAA Alaska Fisheries Science Center.

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. However, 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 August 2009, a team of four divers located and tagged 48 *Calcigorgia spiculifera* colonies in Kelp Bay, Southeast Alaska. Of that total, 9 colonies were fitted with settlement rings equipped with natural rock tiles. The tiles were observed for recruitment of coral planulae and polyps. The remaining 39 tagged colonies were ascribed to three damage treatment groups and a control group to assess the response to damage of disturbed coral.

Response to Damage
The damage treatments were designed to mimic actual damage that can occur from passing fishing gear. These treatments were performed *in situ* and included deflection, gorgonin excision, and branch severance. The deflection treatment was completed by passing a simulated trawl footrope over each coral. The gorgonin excision treatment was completed by carefully cutting and scraping off the soft outer tissue (gorgonin) from three branches of each colony. Branch severance was completed by cutting three branches away from the main stem of each colony. Video of each colony was recorded before and immediately after the treatments were performed to establish baseline coral characteristics and to identify immediate treatment effects. Observations were also made at 9 months, 13 months, 2 years, and 5 years. Video

review is ongoing for the most recent observations. Data generated from the video observations will include colony growth rates, tissue and branch regeneration rates, and colony survival.

Preliminary observations of damaged corals have revealed a mixed level of resiliency. For example, some colonies that had gorgonin removed showed signs of tissue regeneration (Fig. 1) while other damaged corals have exhibited fairly robust growth rates. One colony that was broken from its holdfast during the deflection treatment continued to have living tissue for over a year. However, this colony was eventually found completely denuded of living tissue and dead. Overall, the treatments have had negative effects on most colonies and many have necrotic tissues or have shed branches and a few colonies have disappeared completely. Analyses of the final observations from 2014 and the synthesis of previous observations will provide important information about the resiliency and recovery of these small coldwater gorgonian corals on both short-term and long-term scales.

Figure 1. *Calcigorgia spiculifera* colony #574 immediately after gorgonin excision (left) and 2 years later (right). The branches on the lower left were denuded of gorgonin in August of 2009 but the excised tissue was mostly regenerated 2 years later in August 2011.

Recruitment

Settlement rings were anchored to the seafloor with an adult coral colony located in the middle of the ring (Fig. 2) in August 2009. Each ring had 8 natural rock tiles and over the course of the study, a subsample of tiles were collected and inspected for adhesion of coral recruits. Tiles were collected 9 months, 13 months, 2 years, and 5 years after they were placed on the seafloor. During the first three collections, 16 tiles (in total) were removed from the settlement rings on each occasion and replacement tiles were installed where tiles had been removed so that each ring had its full complement of tiles throughout the study period. During the final site visit in 2014, all tiles were removed from the seafloor. Retrieved tiles were placed in seawater and immediately examined under a dissecting microscope for evidence of coral planulae and polyps.

Figure 2. ***Calcigorgia spiculifera*** **colony #566 with a newly installed settlement ring and natural rock tiles.**

After the first three settlement tile collections, no evidence of coral recruitment was observed among the 48 tiles examined. However, when all remaining tiles were retrieved during the final collection in July 2014, coral recruits were found on 18 of the 96 tiles collected and at least 60 individual recruits were identified. These observations may be the first documented coral recruitment events in Alaska and the discovery provides much needed insight into coldwater coral reproduction processes. The majority of recruits were small single- or two-polyp organisms (Fig. 3) that were likely recent recruits, presumably less than one year old. There were also some very small potential recruits that lacked definitive structural characteristics of coral polyps but were pigmented similarly to *Calcigorgia spiculifera*. These specimens are scheduled to be examined with genetic analyses to determine their identity. If these are indeed coral recruits, they may be only days or weeks old. Most recruits were small and probably relatively recent settlers. However, there were a few multi-polyp colonies observed that were probably more than a year old. Thus it is apparent that coral recruitment happened in multiple years and a rate of recruitment could be estimated based on the different sizes or “age classes” of the recruits. Tiles were placed on the seafloor on varied dates and thus were “seasoned” *in situ* for different amounts of time. The original tiles were in place for five years while the most recently installed tiles were on the seafloor for 35 months. Recruits were found on tiles of all ages, however. Genetic analyses will also be utilized to explore the relatedness between recruits and adults and to examine genetic diversity and dispersion potential.

Figure 3. *Calcigorgia spiculifera* recruits on a marble settlement tile. Each recruit is approximately 2 mm long and consists of one large polyp and one small polyp developing on the lower right of each recruit. The edge of a 25 mm stainless steel washer can be seen at the bottom of the image.

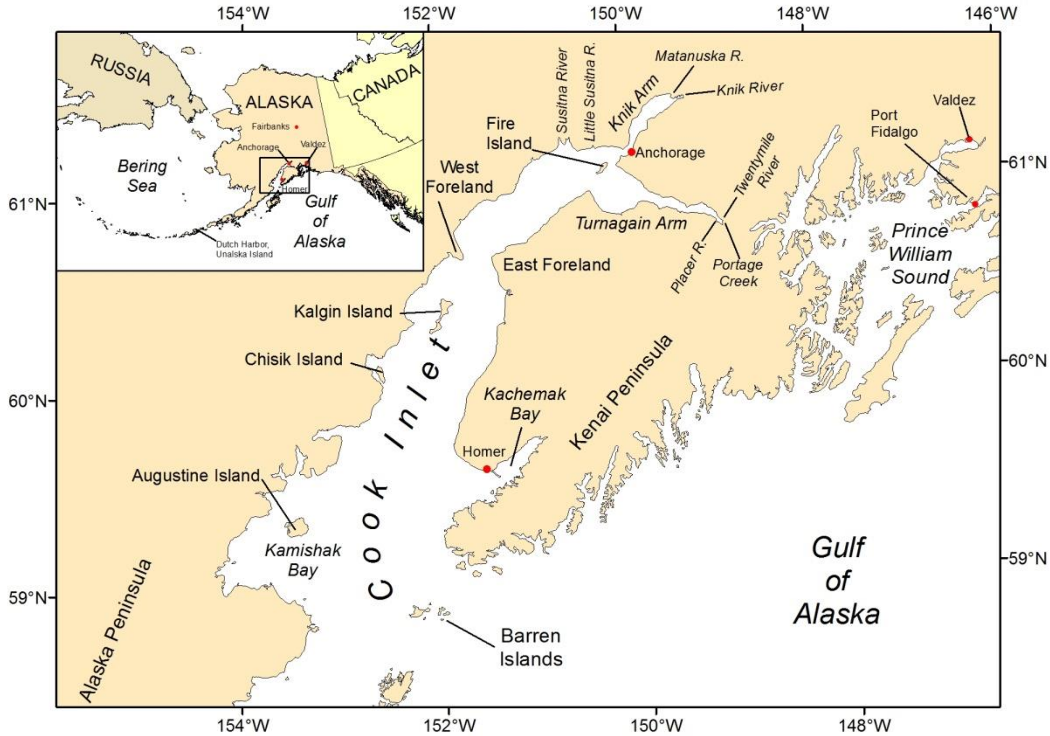
For more information, contact Patrick Malecha at (907) 789-6415 or pat.malecha@noaa.gov.

Habitat Use and Productivity of Commercially Important Rockfish Species in the Gulf of Alaska — RACE GAP

The contribution of specific habitat types to the productivity of many rockfish species within the Gulf of Alaska remains poorly understood. It is generally accepted that rockfish species in this large marine ecosystem tend to have patchy distributions that frequently occur in rocky, hard, or high relief substrate. The presence of biotic cover (coral and/or sponge) may enhance the value of this habitat and may be particularly vulnerable to fishing gear. Previous rockfish habitat research in the Gulf of Alaska has occurred predominantly within the summer months. This project will examine the productivity of the three most commercially important rockfish in the Gulf of Alaska (Pacific ocean perch, *Sebastes alutus*, northern rockfish, *S. polyspinis*, and dusky rockfish, *S. variabilis*) in three different habitat types during three seasons. Low relief, high relief rocky/boulder, and high relief sponge/coral habitats in the Albatross Bank region of the Gulf of Alaska will be sampled using both drop camera image analysis and modified bottom trawls. We will sample these habitats examining differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success within the different habitat types. This research will enable us to examine the importance of different habitat types for these rockfish species providing data critical for both protecting essential habitat as well as effective management of these species. In the spring and summer of 2012 two research cruises were conducted in May and August. An additional two cruises were conducted in May and December 2014. All field work for this project has been completed and sample processing and data analysis will be completed within the next year.

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

Smooth Sheet Bathymetry of Cook Inlet, Alaska



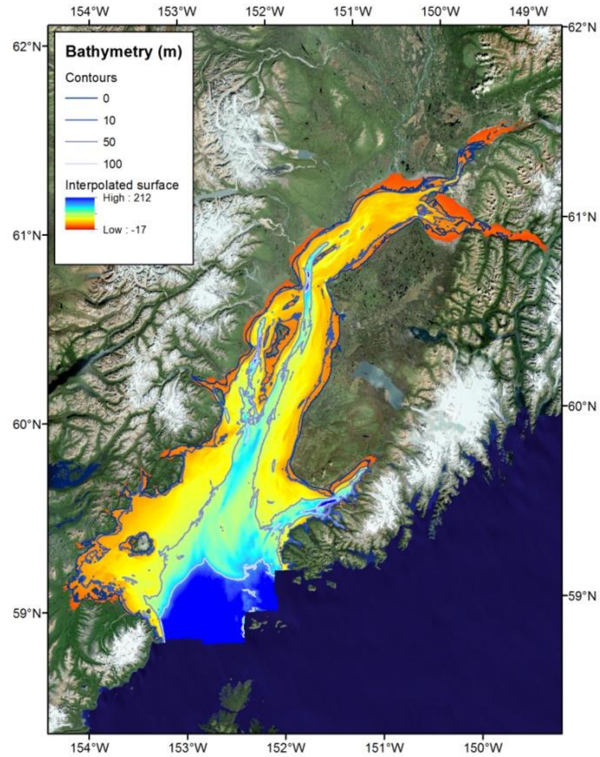
Scientists with the AFSC's Groundfish Assessment Program (GAP) have expanded earlier mapping efforts for the Aleutian Islands to include Cook Inlet, Alaska. This work is part of an effort to provide better seafloor information for fisheries research. The Cook Inlet project included the same smooth sheet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

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

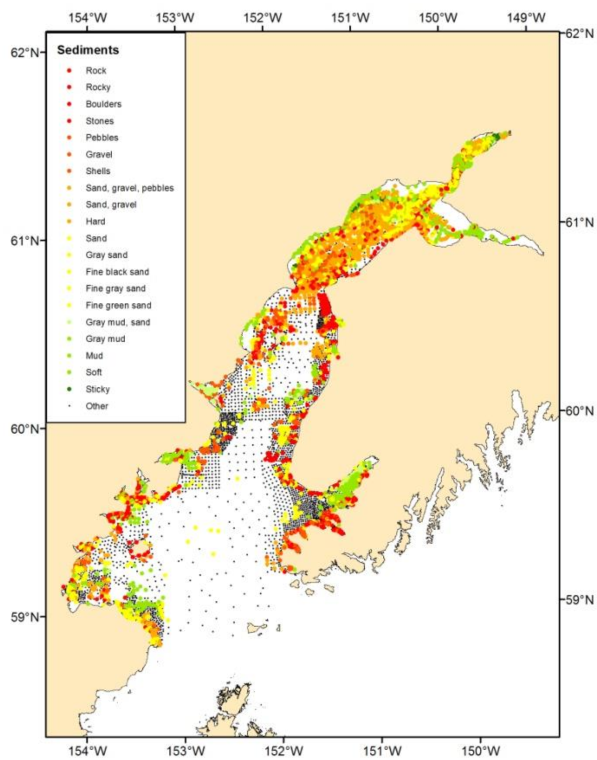
   The smaller area of Cook Inlet, greater amount of project time, and higher quality of smooth sheets than in the Aleutian Islands made these additions possible. The NMFS Alaska Regional Office's Essential Fish Habitat funding made much of this work possible.

Bathymetry of Cook Inlet

A total of 1.4 million National Ocean Service (NOS) bathymetric soundings from 98 hydrographic surveys represented by smooth sheets in Cook Inlet were corrected, digitized, and assembled. Overall, the inlet is shallow, with an area-weighted mean depth of 44.7 m, but is as deep as 212 m at the south end near the Barren Islands. The original, uncorrected smooth sheet bathymetry data sets are available from the [National Geophysical Data Center (NGDC)](), which archives and distributes data that were originally collected by the NOS and others.



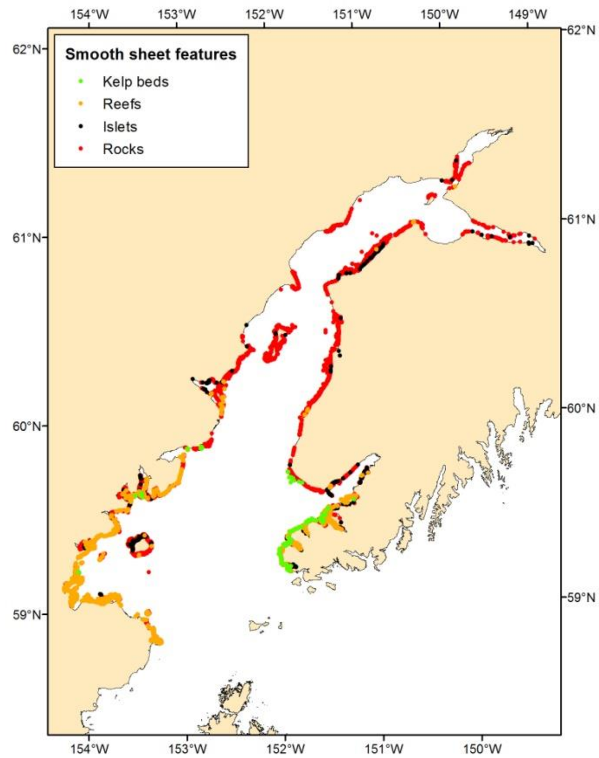
Sediments of Cook Inlet



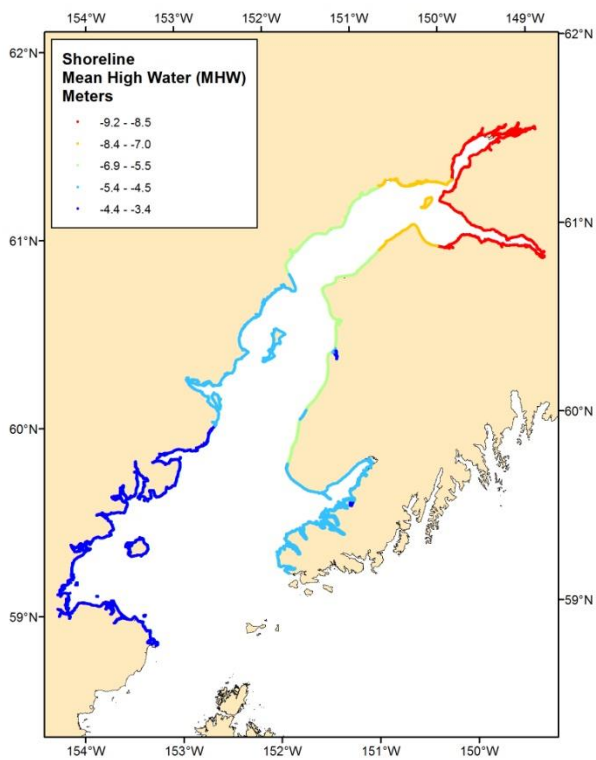
A total of 9,000 verbal surficial sediment descriptions from 96 smooth sheets were digitized, providing the largest single source of sediment information for Cook Inlet. There were 1,172 unique verbal descriptions, with most of the sediment description categories (58%) only having a single occurrence.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

Smooth Sheet Features of Cook Inlet

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



Shoreline of Cook Inlet



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

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

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

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

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

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

This project supported by NMFS' Habitat Assessment Improvement Plan (HAIP) evaluates whether enhanced bathymetric and other sea floor data obtained from hydrographic smooth sheets can predict whether the sea floor can be trawled during research surveys.

Biennial bottom trawl surveys in the Gulf of Alaska (GOA) and Aleutian Islands (AI) provide fishery independent estimates of catch per unit effort, abundance, and biological parameters used in stock assessments for managed fisheries and species in the North Pacific. Not all bottom types or oceanographic conditions accommodate the bottom trawl survey method. The bottom trawls can only be towed on smooth and unconsolidated seafloors, so whether trawl stations are "trawlable" or "untrawlable" becomes a major factor limiting the sampling frame of the survey. In the AI, much of the seafloor consists of rock, pinnacles, and steep drop-offs and stations are resampled from a limited pool of previously sampled stations. In GOA, about half of all stations have been visited and about 20% were found to be untrawlable. Having prior and complete knowledge of trawlable areas would clearly define the survey frame for bottom trawl surveys and could become the basis for defining a survey of untrawlable habitats with acoustic or visual survey tools.

We wanted to evaluate whether hydrographic smooth sheets which are charts contains original soundings and seafloor observations could be used to predict whether areas the survey have not visited are trawlable or untrawlable. These charts are electronically available from the National Ocean Service through the National Geophysical Data Center. They contain many more observations than are found on nautical charts, but they require extensive validation for analytical use (visit http://www.afsc.noaa.gov/RACE/groundfish/bathymetry/). The reprocessed sheets may offer a data source to identify untrawlable habitats from criteria and approaches from focused seafloor studies. We wanted to identify criteria to predict untrawlable habitat from smooth sheet data, test these criteria with a predictive model with known areas of rocky habitat and unsuccessful bottom trawls, and assemble and interpret existing smooth sheet data into a map of untrawlable habitat that can be evaluated in future surveys and studies.

We applied digitized coverages of National Ocean Service (NOS) hydrographic smooth sheet soundings and seafloor observations to evaluate and physical attributes associated with habitat suitable to bottom trawl surveys in GOA. We used random forest methods to evaluate the relative importance of a suite of benthic terrain (depth, slope, rugosity, and substrate composition) and oceanographic predictors (bottom currents) on whether an area was accessible to bottom trawl gear. To do this, we used records of unsuccessful bottom trawls where the net was torn or the vessel was stopped by underwater obstructions. We calculated the approximate position of the trawl and matched the trawl path with the underlying seafloor features. We examined the marginal importance of each physical predictor and quantified the response gradient, then applied a piecewise regression to determine threshold values. Confidence bounds for threshold values and indices of threshold strength (e.g., monotonicity, bimodality) and diagonality (e.g., influence of multiple predictors) were developed. We then developed preliminary, predictive maps of trawlable habitat on the basis of these thresholds. Using available data, preliminary results indicate that untrawlable habitat was associated with increased depth, slope, rugosity, bottom current and coarser sediments at the scale of both discrete tow paths and aggregate survey stations. Distinct thresholds were noted in rugosity, slope, and depth range within the survey area. Preliminary maps of critical thresholds suggest different suites of variables will constrain the probability a successful trawl in different areas of the system. A draft manuscript is in progress detailing the finding of the random forest methods and results.

We are still comparing and modeling the thresholds to independent assessments of trawlability obtained during survey operations. These comparisons between survey stations and actual towpaths suggest smooth sheet data are useful in predicting trawlable habitat at coarse scales, but reflects low resolution beyond nearshore or highly transited areas.

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

Estimating the survey catchability of Rock Sole in the Gulf of Alaska-RACE and REFM
Rock soles are captured in trawl and other groundfish fisheries in the Gulf of Alaska (GOA) and yield 7 to 9 million dollars in ex-vessel value per year. They are a component of shallow-water and other flatfish species principally targeted by catcher and catcher-processor trawl vessels. An age-structured stock assessment model has been developed for rock soles and this model is related to fishery-independent estimates of abundance from the Gulf of Alaska (GOA) Biennial

Bottom Trawl Survey. Direct comparisons, however, are difficult because the catchability of the survey is not completely known, and survey selectivity and availability of groundfishes is identified as a frequent and important data gap in the stock assessment process. Through a grant from NOAA Fisheries' Improve a Stock Assessment (ISA) Program, we are attempting to estimate the total catchability for rock soles captured during the bottom trawl surveys in order to provide a direct comparison to age-structure stock assessments in the GOA. To estimate total catchability, we will combine estimates of trawl efficiency, or how many rock soles are captured that were in the path of the net, with a new estimate of how many rock soles were available to the survey gear.

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

Several AFSC researchers and contractor Neal McIntosh have been focusing effort on this project. To date, they found that the Echoview bottom typing software could be applied to ES-60 acoustic data, and metrics produced by the software could differentiate a series of areas that were clearly trawlable from those that were clearly untrawlable. Based upon this result, we are refining and testing the prediction power of the software and underlying GAM model on a wider range of grid cells with acoustic observations. We have evaluated the data frame of 10,667 ES-60 acoustic files collected since 2005. This evaluation consisted of several labor-intense activities including indexing these data to the station numbers of the GOA sampling grid and the times of previous vessel visits, calibrating the data, removing the systematic dithering "triangle wave" from suitable acoustic files, determining whether a second return echo was present in the file, and developing a database for the GOA acoustic files. We have found that the ES-60 acoustic data will not be as informative as we desired. Acoustic data from 2005 and 2007 were not usable because of the single beam transducers and poor calibrations. Acoustic data were better calibrated beginning with one boat in 2009 and each of two vessels during the 2011 and 2013 surveys. Additionally, we discovered that the critical second echo return of seafloor was only recorded in 31% of the ES-60 data stream. At present the nature of this limitation is not understood, but between the lack of a second echo and uncalibrated echo returns, only 16% of the ES-60 may provide usable information on the nature of the seafloor.

Regardless of these limitations, 1,663 files contained calibrated, undithered acoustic data with second echo returns. We selected 26, fifteen minute segments of acoustic data in previously visited grid cells that were either classified as trawlable (at least two successful trawl samples) or as untrawlable (determined by the skipper's classification of echo returns). Nine variables of seafloor characteristics were obtained by applying the Bottom Classification module of Echoview, and these were entered into a stepwise General Linear Model (GLM) to determine the best set of bottom type variables for predicting trawlability. When used without any other environmental information, these bottom type variables correctly predicted trawlable or untrawlable seafloors 83% of the time. This indicates that the trawlability model may be quite informative for predicting the likelihood of trawlability in areas of the sampling grid that have never been examined, and thus predict the proportion of the GOA that is trawlable and therefor included in the survey sampling frame. The bottom type data are also being used, along with other environmental variables, in a companion study using GLM models to predict the presence/absence and abundance of rock sole based on GOA survey catches. If both modeling approaches are successful, the rock sole habitat model will then be used to estimate the proportion of the area within untrawlable grid elements that comprises suitable rock sole habitat. Further work is being conducted to expand the sample size of the reference test and to see if other variable combinations improves the predictability of the GLM. Work during the next few months will define proportions of trawlable and untrawlable habitat in the depth range of rock soles where acoustic data exist and to see if other information from hydrographic smooth sheets, other acoustic data, and a habitat occupancy model can be used to define the amount of habitat available to rock sole.

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

Contact Wayne Palsson, David Somerton, or Teresa A'mar for more information (wayne.palsson@noaa.gov).

Bering Sea Infauna Communities and Flatfish Habitats - RACE GAP

Research continues on characterizing flatfish habitat and productivity in the eastern Bering Sea (EBS). Climate change has spurred impetus for research into the marine resources of the subarctic and arctic oceans north of the EBS. A report on flatfish habitat in the subarctic: "Habitat and infauna prey availability for flatfishes in the northern Bering Sea" (Yeung and Yang 2014) resulted from the northward expansion of EBS bottom trawl survey in 2010 (Lauth 2011). The survey marked the return of large-scale, systematic groundfish research in the northern Bering Sea after a 30-year hiatus. The study found plentiful infauna prey and relatively low competition among flatfishes in the northern Bering Sea. The northern Bering Sea appeared especially favorable for yellowfin sole (*Limanda aspera*), and may possibly become more so should there be further increase in bottom temperature and decrease in ice cover. Recent studies also focused on juvenile habitats in the EBS, particularly on how prey availability affect the distribution and condition of yellowfin sole and rock sole (*Lepidopsetta* spp.). Studies were conducted in 2011 and 2012 on juvenile (<20 cm total length) flatfish habitats near Bristol Bay and along the Alaska Peninsula. Juvenile fish distribution, diet and condition are being analyzed in relation to prey fields to define prime habitats. In 2013, a juvenile rock sole "hotspot" – area of high concentration - around Nunivak Island was investigated. Northern (Nunivak) and the southern (Bristol Bay) hotspots are hypothesized to be utilized alternately – the former during periods of "warm" oceanographic environment in the EBS, and the latter during "cold" periods (Cooper et al. 2015). This hypothesis is proposed for both rock sole and yellowfin sole. Incidentally, ocean and air temperatures in the EBS in 2013 were one of the highest in 30 years. A test of the hypothesis will require monitoring at these hotspots over multiple "warm" and "cold" periods.

Cooper D, Duffy-Anderson JT, Norcross BL, Holladay BA, Stabeno P (2015) Northern rock sole (*Lepidopsetta polyxystra*) juvenile nursery areas in the eastern Bering Sea in relation to

hydrography and thermal regimes. ICES J Mar Sci 72 (2):515-527. doi:doi:10.1093/icesjms/fst210
Lauth RR (2011) Results of the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey of groundfish and invertebrate fauna. US Dep Commer NOAA Tech Memo NMFS-AFSC-227
Yeung C, Yang M-S (2014) Habitat and infauna prey availability for flatfishes in the northern Bering Sea. Polar Biol 37 (12):1769-1784. doi:10.1007/s00300-014-1560-4

Northern Rock Sole and Yellowfin Sole Nursery Habitats in the Bering Sea - RACE FBEP
The Fisheries Behavioral Ecology program is collaborating with the RACE-Recruitment Processes Program to examine the use of coastal nursery habitats by important flatfish species. Work in 2014 continued on processing of specimens collected in the vicinity of Port Moller along the Alaska Peninsula in Autumn 2012 and initial work on distributional patterns across species. Northern rock sole and yellowfin sole were the most common flatfishes encountered in coastal habitats.

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

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

Long-term Monitoring of Demersal Macrofauna in Alaskan Arctic Seas Using Bottom Trawls: A Comparison Study - RACE GAP
Long-term monitoring of the Arctic marine biota is needed to understand how community structure is changing in response to diminishing ice (i.e., climate change) and increasing anthropogenic stimuli. Dating back to 1959, bottom trawls (BT) have been a primary research tool for investigating bottom fishes, crabs and other demersal macrofauna in the Arctic (however, the BTs used in past surveys have varied widely in terms of their construction, dimensions, mesh-sizes, etc.) Moreover, the spatial and temporal coverage of past BT surveys has been patchy, and sampling procedures employed using various BTs have generally lacked standardization. Such inconsistencies prohibit synthesizing results into a coherent time series for investigating changes in the community structure. By adhering to rigorous standards, BTs can be effective research tools for monitoring general population trends and detecting geographic shifts of bottom fishes, crabs and other demersal macrofauna. Although relatively limited in their application, two BT gears have been used in Arctic surveys employing moderately consistent sampling techniques: the University of Alaska Fairbanks 3 m plumb-staff beam trawl (PSBT) and the Alaska Fisheries Science Center 83-112 Eastern bottom trawl (EBT). The PSBT has been used periodically for small-scale surveys on the eastern Bering Sea shelf since 2000. North of the Bering Strait, the PSBT was first used in 2004 for a transboundary

study of demersal fishes, crabs and other macrofauna in the eastern and western Chukchi Sea. Since 2007, there have been annual demersal surveys using the PSBT in either the Chukchi or Beaufort Seas. In comparison, the EBT's primary use has been for investigating the population dynamics of commercial bottom fishes and crabs on the eastern and northern Bering Sea shelf. North of the Bering Strait, the EBT has also been used for surveying demersal macrofauna in the eastern Chukchi Sea in 1976, 1990,1991, and 2012 and in the Beaufort Sea in 2008.

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

For more information, contact Bob Lauth, e-mail: bob.lauth@noaa.gov

The Development and Use of a New Spectral Irradiance Logger (SIL) on Groundfish Surveys: Seeing the Bering Sea in a New Light.

Collection of underwater ambient light level data on the RACE Groundfish Assessment Programs' bottom trawl surveys began in 2004. Early measurements were of the relative brightness of light as it penetrated downward through the water column (known as downwelling irradiance) and were collected using a modified Wildlife Computers MK-9 fish tag. This simple measure of brightness proved useful for understanding vertical and horizontal distribution patterns of walleye pollock (Kotwicki et al. 2009, 2013) and in current modelling efforts of essential fish habitat. For instance, fish size, bottom depth, and light intensity at the bottom have been found to be the three most important factors in determining the vertical distribution of walleye pollock. These results have increased the interest by several researchers to incorporate measurements of environmental light into investigations on the distribution, abundance, and ecology of commercially important fishes. However, the MK-9 light data are relatively crude, lack resolution at low light levels, require tedious calibrations, and provide absolutely no information on the spectral qualities of light in the water column.

To address the need for accurate light intensity and spectral distribution data, we recently developed the first-ever trawl-mounted spectral irradiance logger (SIL) that was successfully tested and deployed during the eastern Bering Sea bottom trawl survey in 2014. The SIL uses a spectral irradiance sensor coupled with a programmable data logger developed by Rick Towler of the MACE program. This spectroradiometric characterization of the underwater light field will enable scientists to address questions involving the impact of spectral distribution, as well as light intensity, on aquatic organisms. Studies have shown that even subtle changes in the intensity and spectral characteristics of the water column can greatly influence the distribution of a fish, the ability of fish to detect and successfully acquire prey, and the ability of fish to evade capture. Routine spectral measurements using the SIL during AFSC bottom trawl surveys are planned in future years, and scientists plan to use this new time series of environmental data to provide more insight into processes such as larval survival and recruitment success, spatial patterns of distribution and abundance, availability of individual fish species to bottom trawls, and gear avoidance. Additionally, this high-resolution spectral irradiance data serves as an efficient way to monitor environmental changes in the water column, such as the presence or absence of plankton blooms or other scattering layers present at depth, and optical changes due to the extent of the cold pool each year within the Bering Sea.

Testing and confirmation of the quality of this exciting new set of environmental data are still underway, but should soon be available to AFSC researchers.

The SIL consists of an underwater spectroradiometer and data logger (A) that contains a power supply for autonomous deployments. For trawl survey use, the spectroradiometer is placed in a protective housing and mounted vertically through a bracket that secures the data logger (B) and mounts directly to the headrope of the net (C). A hole is cut into the top of the trawl net to give the sensor unobstructed access to the downwelling light field for measurement.

Representative spectral irradiance curves from Bristol Bay, Alaska, collected at survey station J-16 during the 2014 eastern Bering Sea bottom trawl survey using the SIL.

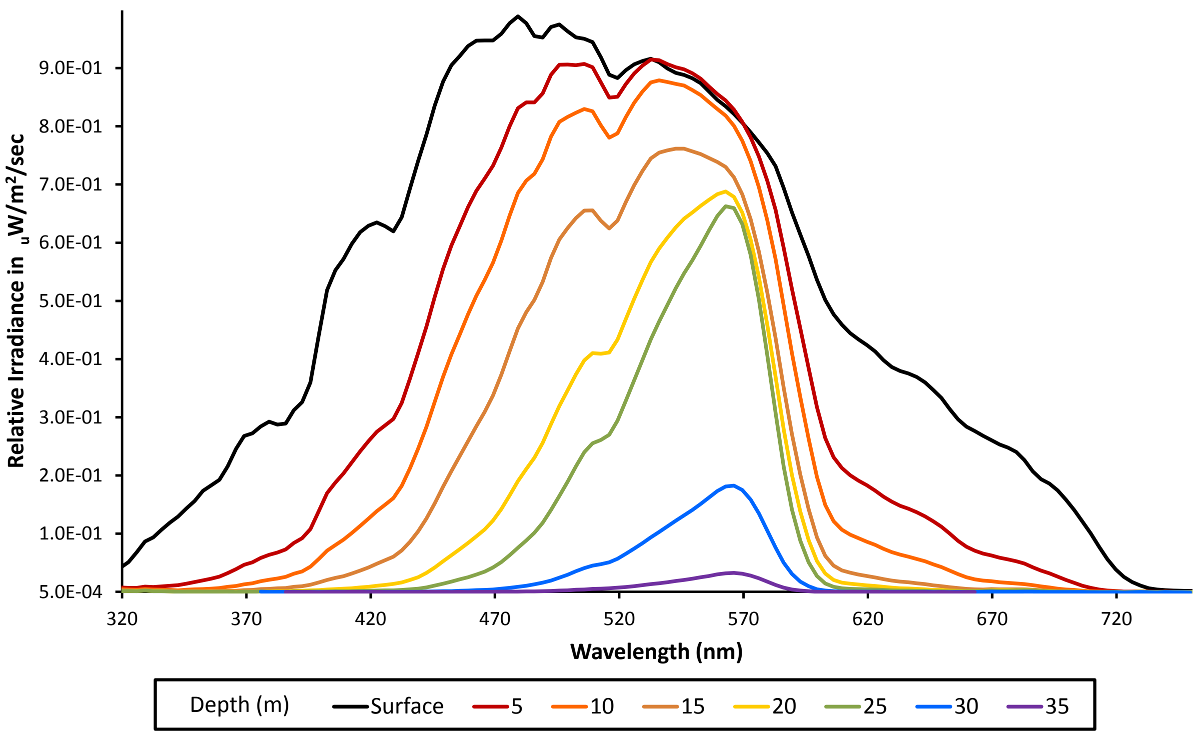


Figure shows the normalized attenuation of light above between 320 nm (UV) and 720 nm (near-infrared) with depth.

Contact Lyle Britt@noaa.gov for more information.

RACE Recruitment Processes (RPP)

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

Shelf-associated Flatfish Juveniles in the Bering Sea

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

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

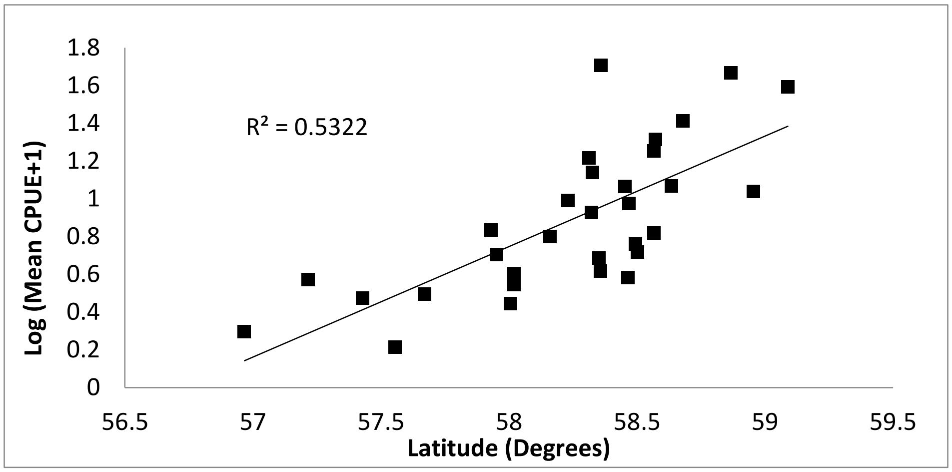


Figure 1. Relationship between annual mean catch per unit effort and the latitude of the catch-weighted center of age-2 and age-3 sized northern rock sole in the EBS groundfish survey from 1982 through 2012.

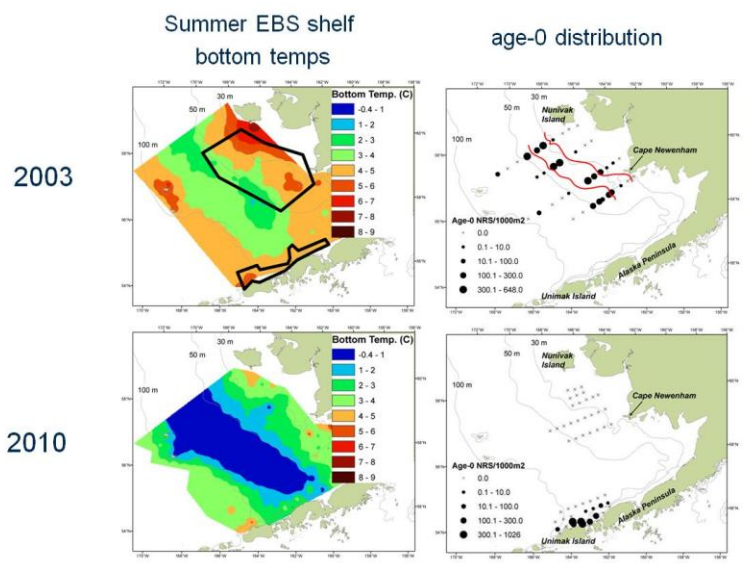


Figure 2. EBS Summer bottom temperatures in 2003 (upper left) and 2010 (lower left) and autumn age-0 northern rock sole distributions in 2003 (upper right) and 2010 (lower right). Age-0 northern rock sole mean length is higher in warm, nearshore areas than in cold, offshore areas, suggesting temperature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

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

Deep-sea Spawning Flatfishes in the Bering Sea

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

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

Shelf-associated Flatfishes in the Gulf of Alaska

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

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

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

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

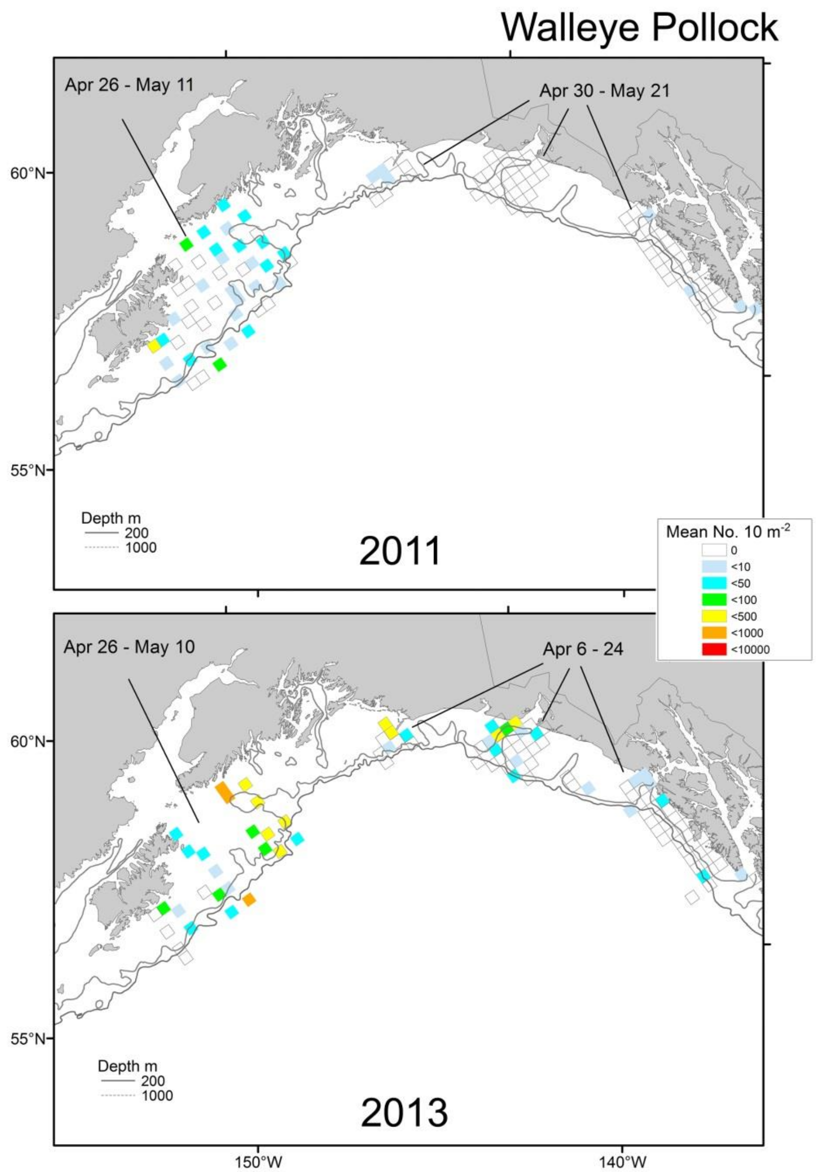
Multi-species Approaches – Development of DNA-based Methods for Identification of Fish Eggs, Larvae and Prey Remains

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

Lower Trophic Level Contributions to the GOAIERP Project

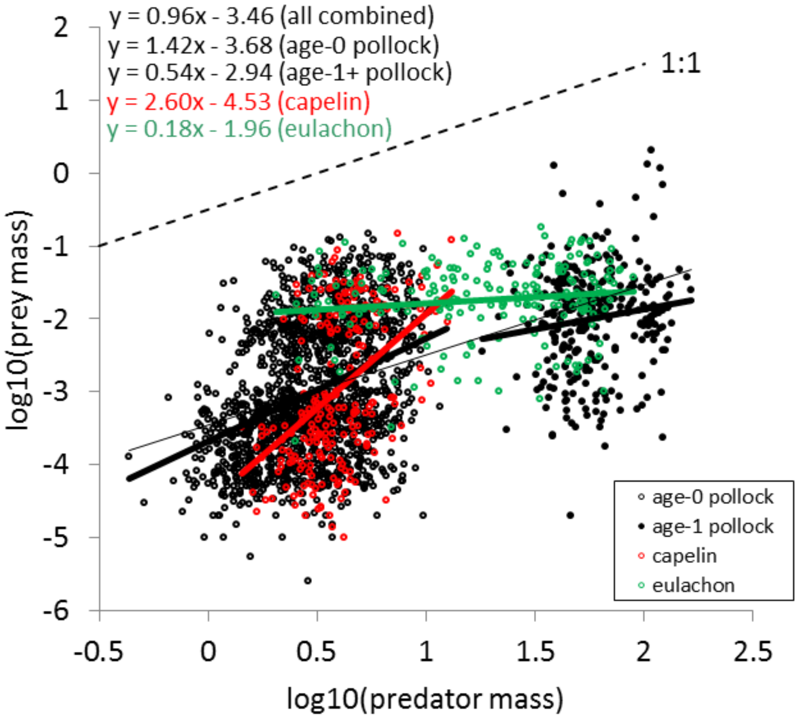
The Gulf of Alaska Integrated Ecosystem Program (GOA-IERP) is a four year (2011–2014) multi-disciplinary study examining the interactions between physical and biological oceanography to understand how the environment influences the survival of early life history stages (egg to age-0 juvenile) and recruitment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

As part of the Lower Trophic Level Component of the GOA-IERP, the Recruitment Processes Program has been involved in the planning and execution of ichthyoplankton and oceanographic sampling in the eastern and western Gulf of Alaska for the 2011 and 2013 field years. Currently, we are analyzing results from the surveys in preparation for a manuscript on the distribution and abundance of GOA ichthyoplankton. In the spring (April–May), larvae of all five target taxa and eggs of only one target taxa (Walleye Pollock) were collected. In general, the two gadid species (Walleye Pollock and Pacific Cod) were collected in higher abundance in the western Gulf of Alaska while both Arrowtooth Flounder and Sablefish were collected in higher abundance in the eastern Gulf of Alaska. Rockfish were ubiquitous throughout the study area in the spring. Between the two field years, abundance in 2013 was higher for gadid species (both regions) and Arrowtooth Flounder (eastern Gulf of Alaska). Conversely, Sablefish were lower in abundance in 2013 (both regions). In the summer months (July–August), only two target taxa were collected; rockfish larvae were collected in both the eastern and western Gulf of Alaska and Sablefish were collected in low abundance in the eastern Gulf of Alaska only. It should be noted that at this time we are unable to identify larval rockfish collected in our samples to the species level due to ambiguous morphological characters. Genetic analysis on specimens collected in the spring and summer has shown that in the spring Pacific Ocean Perch make up the majority of rockfish larvae collected, while in the summer it appears that another rockfish species is dominant.



Ecology of small neritic fishes in the western Gulf of Alaska. III. Linking predator selectivity to prey size and trophic transfer efficiency

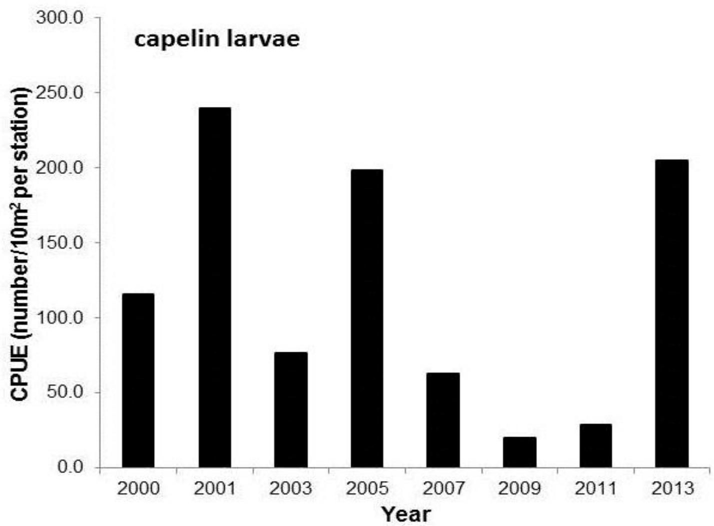
Prey selection by juvenile pollock (*Gadus chalcogrammus*), capelin (*Mallotus villosus*), and eulachon (*Thaleichthys pacificus*) helps support the predator-dominated trophic structure of the Gulf of Alaska ecosystem. These fishes select zooplankton partly on body size. Preliminary results indicate that prey selection by age-0 pollock and capelin resulted in steep (slope >1) logarithmic predator-prey size relationships (Fig. 1). Selection by older pollock and eulachon resulted in low-slope (<1) logarithmic predator-prey size relationships. Observed predator-prey mass ratio theoretically implies that at 10 g these predators would produce about 75 mg for every 1 g produced by their prey, and that capelin and eulachon tend to be more efficient than pollock due to relatively low predator-prey mass ratio.

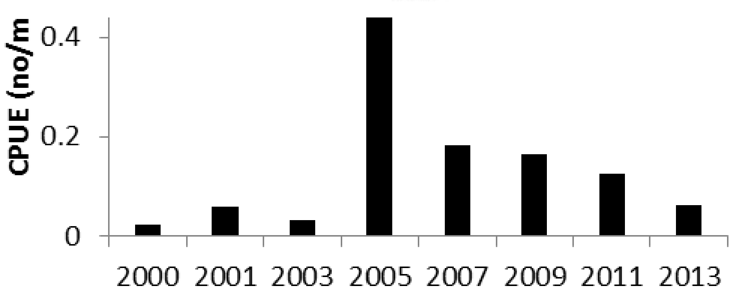


Contributed by Matt Wilson, FOCI
Contributed by Matt Wilson, FOCI

Time Series of Capelin Abundance in the Western Gulf of Alaska, 2000-2013

The Ecosystem and Fisheries-Oceanography Coordinated Investigations Program (Eco-FOCI) is developing time series of larval and post-larval forage fish abundance and body size from on-going sampling of zooplankton and small neritic fishes in the western Gulf of Alaska (GoA). We present here some results on capelin (*Mallotus villosus*) from surveys conducted in late summer during odd years since 2000, inclusive. The results are preliminary because the geographic area has not been standardized, and a potential day-night effect on catch efficiency has not been accounted for. Ichthyoplankton species are collected with 60-cm bongo nets (or 1-m Tucker trawls during 2000-2003). Small neritic fishes are collected with a small-mesh trawl. Samples were collected at predetermined sites from the upper 200 m of water depth. Abundance of capelin larvae was variable over the years examined (Fig. 1). Peak abundance occurred in 2001 and abundance was lowest in 2009 and 2011. Survey-wide abundance of post-larval capelin (*Mallotus villosus*) collected in small-mesh trawls appears to have been decreasing in the GoA since peaking in 2005 (Fig. 2). A proposal to examine the factors affecting changes in the abundance and distribution of forage fish species in the GoA is currently in review at NPRB.





Contributed by Steve Porter and Matt Wilson, FOCI

New Approaches to Sampling for Small Neritic Fishes in the Eastern Bering Sea
Eco-FOCI and EMA researchers have been working on updating the sampling design for age-0 pollock and other forage fishes during the EBS BASIS survey. The efforts include development of a new midwater trawl to replace the Cantrawl, changing from surface tows to oblique midwater tows, and using acoustics to study fish vertical distribution. A new trawl is being designed to replace the Cantrawl and attempt to improve retention of smaller age-0 pollock. MACE pocket net studies of the Cantrawl indicate small gadoid fishes have low retention. The new midwater trawl will have smaller mesh and will be towed more slowly than the Cantrawl in an attempt to increase retention of smaller age-0 pollock. A previous gear comparison conducted by Eco-FOCI and EMA between the Stauffer trawl (aka anchovy) and the Cantrawl indicated that the two gears caught a similar species composition, so the new trawl will have a mouth opening size similar to the Stauffer trawl. The new survey design will also use oblique tows instead of surface tows to reduce the effect of variability in vertical fish distribution on the catch. Acoustics will be used primarily to understand the vertical distribution of age-0 pollock; particularly, the difference between warm and cold years in the Bering Sea. Oblique trawls, instead of targeted trawls, will be used to identify the dominant acoustic scatterers.

Contributed by Dan Cooper, Adam Spear (FOCI) and Alex Andrews (EMA)

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

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

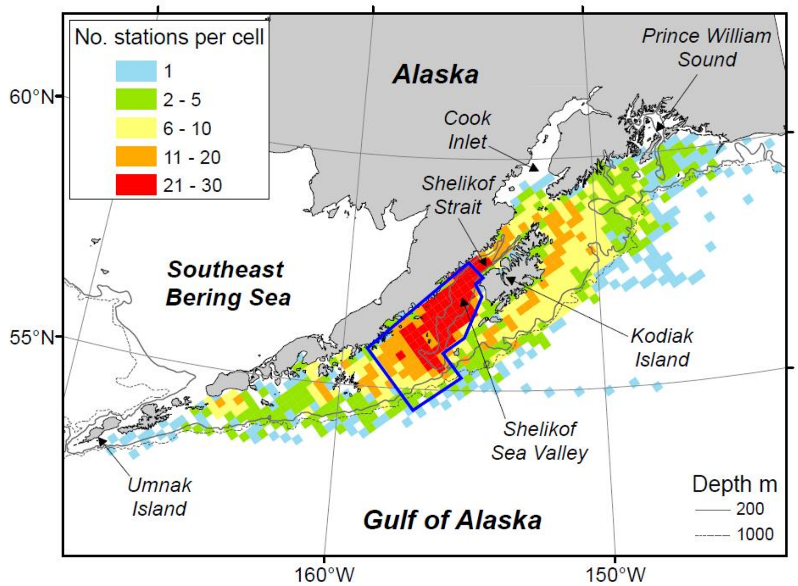


Figure 1. Distribution of historical ichthyoplankton sampling in the GOA by the Alaska Fisheries Science Center (1972, 1977-2009), based on 60-cm bongo net sampling of the upper 100 m of the water column. The polygon outlined in blue is the area from which the late spring ichthyoplankton time series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

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

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

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

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

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

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

*Used to be considered *A. hexapterus* prior to Mecklenberg et al. (2011)[2]

#Larvae associated with neuston

Level of abundance: Lowest, Moderate, Highest, Absent

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

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

Modeling Contributions to the GOAIERP Project

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

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

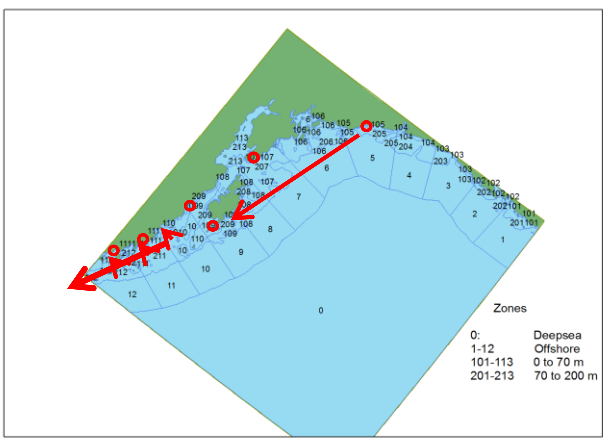


Figure 1. Connectivity zones for Pacific cod. Spawning zones are 101-113 and 201-213. Nursery zones are 101-113. Red circles and arrows indicate areas where variability in connectivity due la Nina may be high (see below).

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

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

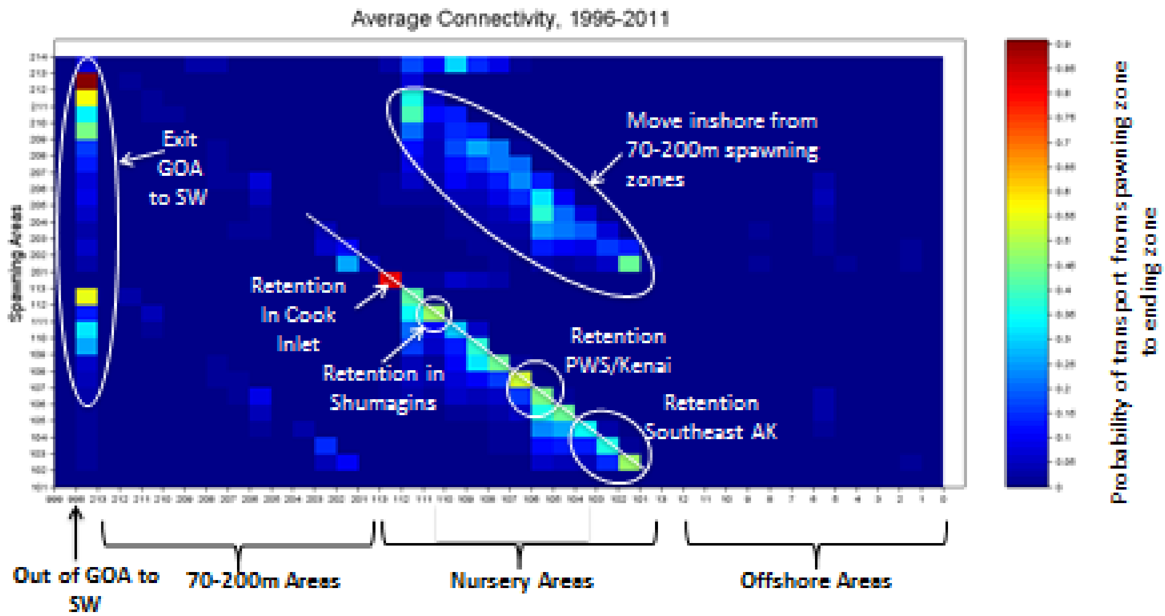


Figure 2. Mean connectivity matrix for the years 1996-2011 (right) from the Pacific cod IBM. The X-axis represents ending zones of individuals, the Y-axis indicates spawning (start) zones. Zones 101-113 represent nursery areas.

Scientific Exchange

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

Gulf of Alaska Assessment: Fisheries Oceanographic Surveys - ABL

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

The GOA Assessment was conducted during July and August 2014 off southeast by the F/V

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

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

The five species of marine fish that were most often captured in surface trawls during the 2014 field season were arrowtooth flounder, rockfish, pollock, Pacific cod, and sablefish (Figures 1-3). We intend to sample a reduced sample grid that will span from Sitka Sound north to Yakutat Bay during summer 2015. For more information, contact Jamal Moss at (907)-789-6609 or jamal.moss@noaa.gov

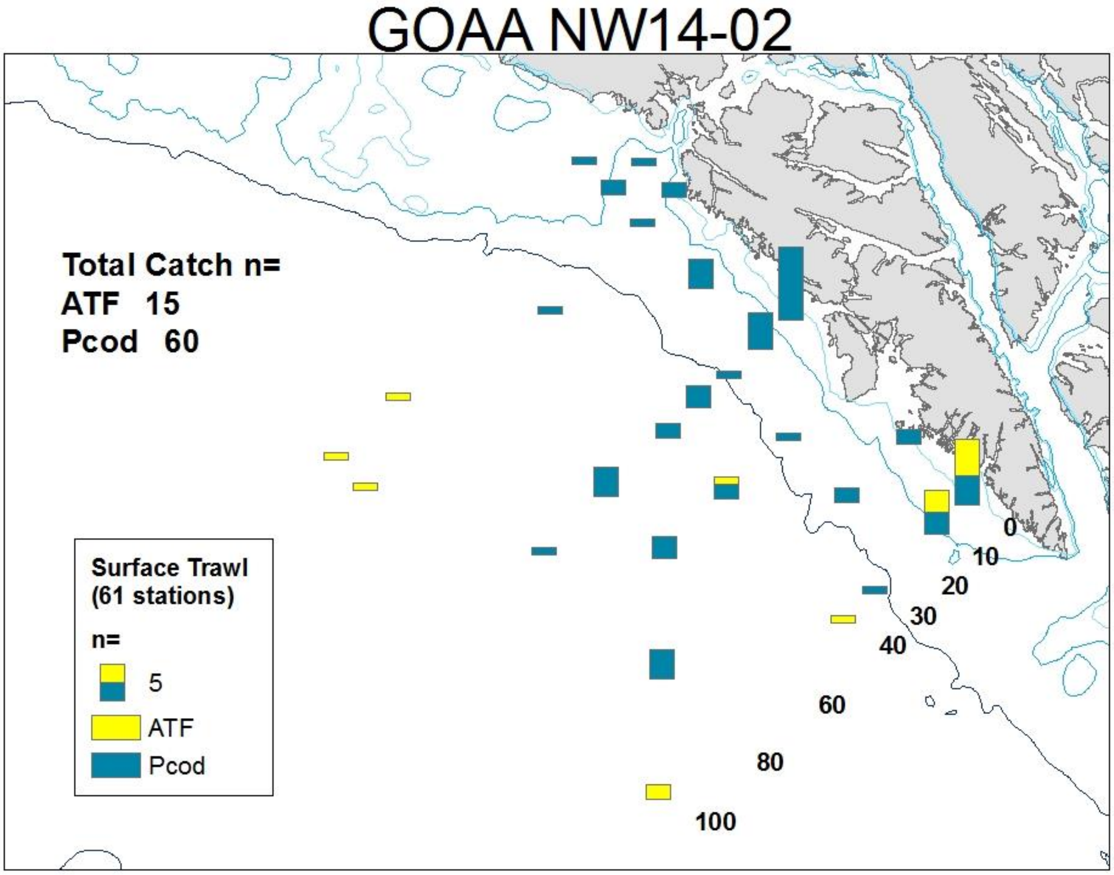


Figure 5. Catch per 30 minute net tow for age-0 arrowtooth flounder (ATF) and Pacific cod (Pcod) in the eastern Gulf of Alaska during July 2014.

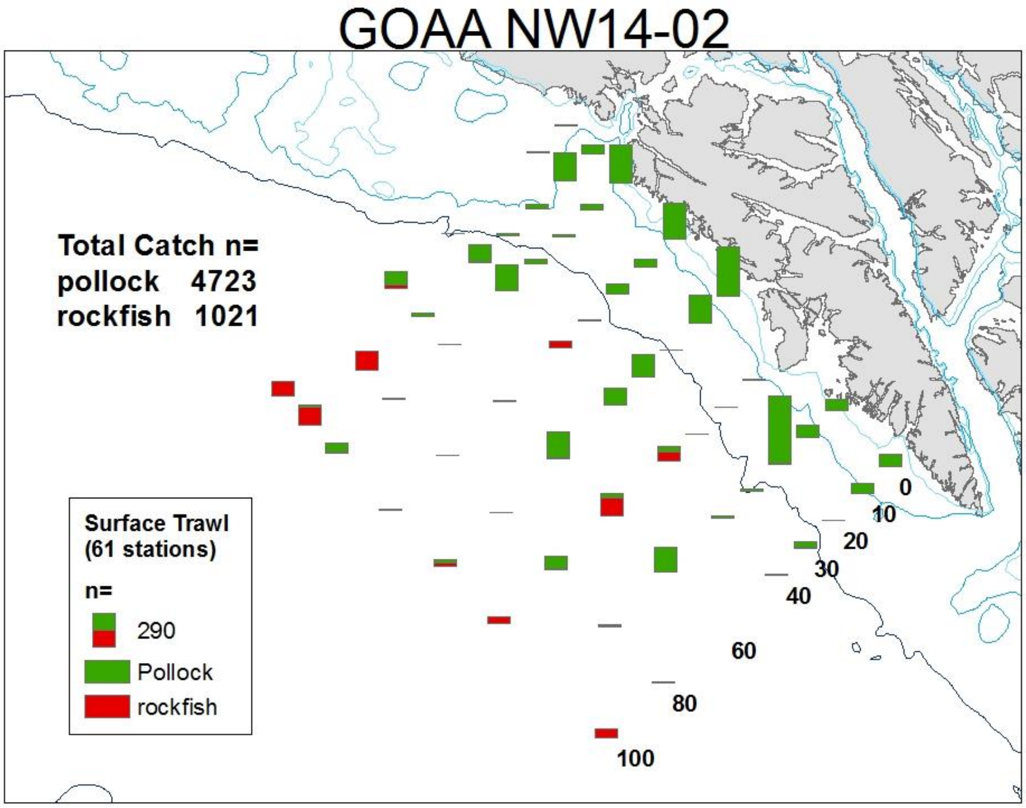


Figure 2. Catch per 30 minute net tow for age-0 pollock and rockfish in the eastern Gulf of Alaska during July 2014.

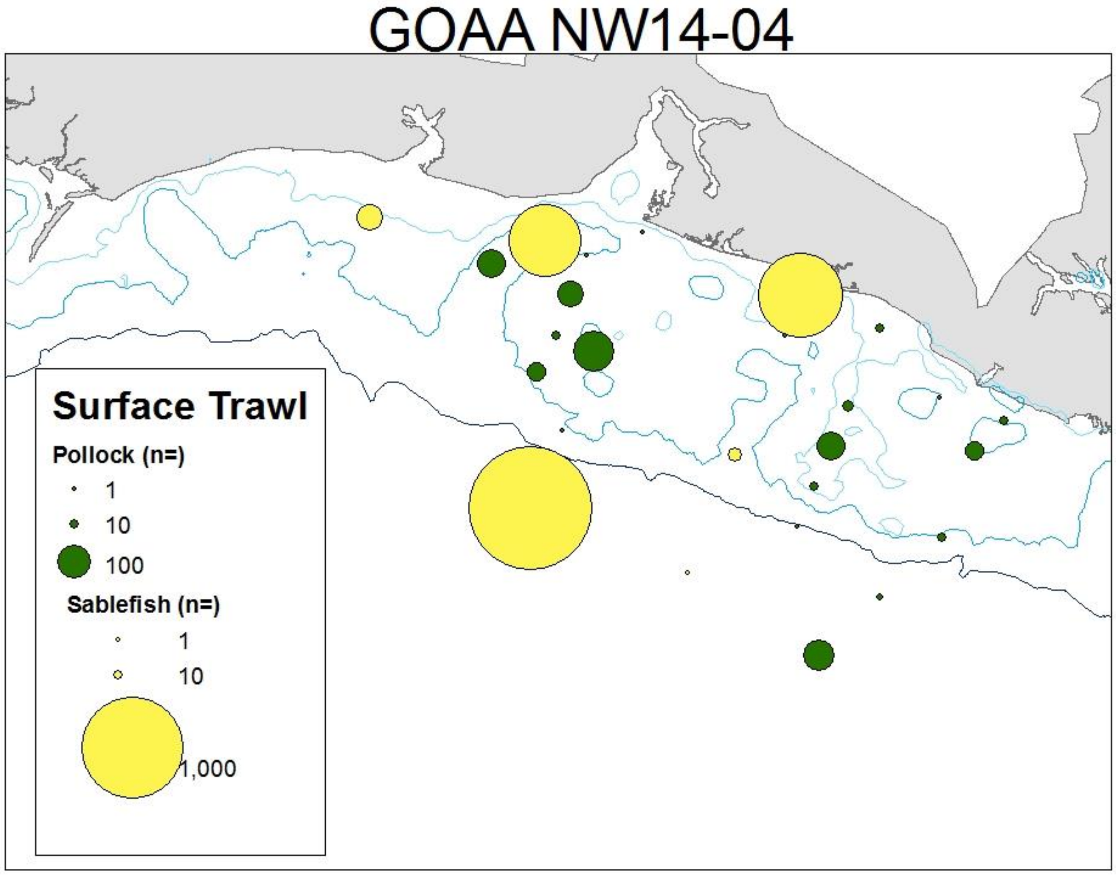


Figure 3. Catch per 30 minute net tow for age-0 sablefish in the eastern Gulf of Alaska during August 2014.

Gulf of Alaska Project: Benthic Habitat Research - ABL

The primary goal of the Gulf of Alaska (GOA) benthic habitat research project is to characterize the preferred settlement habitat for the five focal groundfish species specified by the GOA Project Upper Trophic Level component. There are five main objectives for the habitat project: 1) conduct a literature review and synthesis of early life (EL) preferred habitat and observational data of five focal species, 2) collect, validate, digitize, and grid available benthic habitat data, 3) create benthic metrics from habitat data, 4) model species-specific habitat by early life stage, and 5) generate species-specific suitability maps of the literature and modeling results. Objectives 1-3 have been completed by the habitat team which includes full life history tables of habitat preference for the five focal species, extensive EndNote library of the literature synthesis, collection and validation of high resolution bathymetry (over 20 million soundings) and sediments (100 thousand plus points), GIS framework with gridded benthic habitat metrics and digitized species observations, final literature-based habitat suitability surfaces, and preliminary modeled habitat suitability surfaces.

Final literature surfaces were provided to the various components of the GOA Project (e.g. lower, middle, upper trophic level and modeling). These surfaces are currently being used in a variety of ways to inform conclusions on survey distributions, energetic analyses, and individual based model (IBM) connectivity and trajectories. Draft modeled habitat suitability surfaces were also produced for the recent final primary investigators meeting (April 7-10, 2015). These surfaces were shown as examples of the final product for this benthic habitat research project and inspired several discussions on useful avenues for incorporating this information to improve model trajectories and interpretation. These modeled benthic habitat suitability surfaces are also slated for providing the base structure of a newly funded essential fish habitat (EFH) project (Pirtle, Shotwell, Rooper). This project will coordinate with another EFH effort to characterize the EFH of the groundfish fishery management plans (FMP) species. The final output of these projects would assist with improving the current and upcoming EFH five-year updates for the early juvenile to adults stages. For more information, please contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@noaa.gov.

RACE Habitat Research Group (HRG)

Scientists in the RACE Habitat Research Group (HRG) continue research on essential habitats of groundfish, including identifying informative predictor variables for building quantitative habitat models, developing efficient tools to map these variables over large areas, investigating activities with potentially adverse effects on Essential Fish Habitat (EFH), such as bottom trawling, and conducting benthic community ecology studies to characterize groundfish habitat requirements and assess fishing gear disturbances. Research in 2014 was primarily focused on evaluating acoustic backscatter as a quantitative predictor of groundfish distributions in the eastern Bering Sea (EBS) and the development of next generation habitat-utilization models for managed species. An analysis of short-term trawling effects on soft-bottom benthos was published, and a global study of mobile bottom-contact fishing gears continued as part of an international effort.

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

Habitat Modeling

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

Current research (the “FISHPAC” project) is investigating whether quantitative information about seafloor characteristics can be used to improve existing habitat models for EBS species.

Preliminary work[3] demonstrated that surficial sediments affect the distribution and abundance of groundfish, however direct sampling with grabs or cores is impractical over large areas. Subsequent pilot studies[4,5] showed that acoustic systems were suitable for broad-scale seafloor surveys and that processed acoustic data can be used to improve the numerical habitat models.

A major field experiment in 2012 collected more than 3,800 gigabytes of acoustic data and groundtruthing information on multiple tracklines spanning strong gradients in groundfish and crab abundances (Fig. 1). Five different sonars were deployed on multiple passes over each line and these data were post-processed in 2014, for multiple purposes. Bathymetric data were cleaned and submitted for nautical charting. Backscatter data were post-processed to produce standardized statistics, using quantitative sediment properties from grab samples to normalize the values. Still image mosaics of the seafloor were generated from towed video to serve as additional groundtruthing for the acoustic data.[6] Thirty-three years of trawl survey data (catch per unit effort, kg ha^{-1}) have been assembled and statistical analyses with the backscatter statistics are being prepared to compare the contributions of the different sonar systems in the habitat models. The most cost–effective sonar system will be used to systematically map and characterize the seabed of the EBS shelf (Fig. 2), and will be the basis for improved EFH models for multiple species.

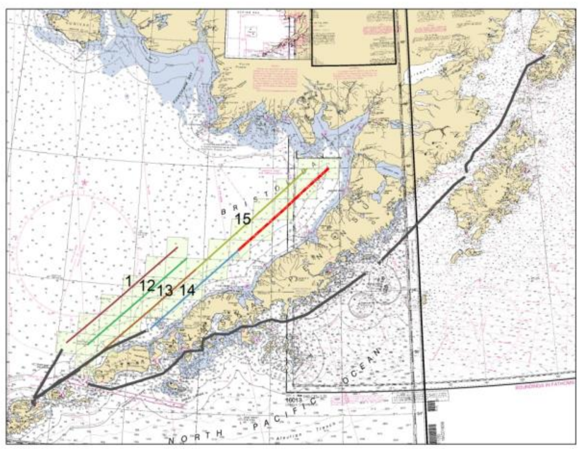


Figure 6. Completed FISHPAC 2012 survey tracklines. Shaded boxes represent 20 by 20 nautical mile squares centered on RACE bottom trawl survey stations for the Bering Sea shelf. Each line was surveyed with five different sonar systems, with the exception that only multibeam echosounder data were collected over the northeast section of line 14 and during the transits to and from the numbered tracklines. For additional information, see http://www.afsc.noaa.gov/RACE/surveys/cruise_archives/cruises2012/results_Fairweather_FISHPAC-2012.pdf.

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3 McConnaughey, R.A. and K. R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 57: 2410-2419.

4 McConnaughey, R.A. and S.E. Syrjala. 2009. Statistical relationships between the distributions of groundfish and crabs in the eastern Bering Sea and processed returns from a single-beam echosounder. ICES J. Mar. Sci. 66: 1425-1432.

5 Yeung, C. and R.A. McConnaughey. 2008. Using acoustic backscatter from a side scan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES J. Mar. Sci. 65: 242–254.

6 Representative video and the resulting geo-referenced mosaic are available at http://www.afsc.noaa.gov/Quarterly/jas2012/divrptsRACE4.htm.

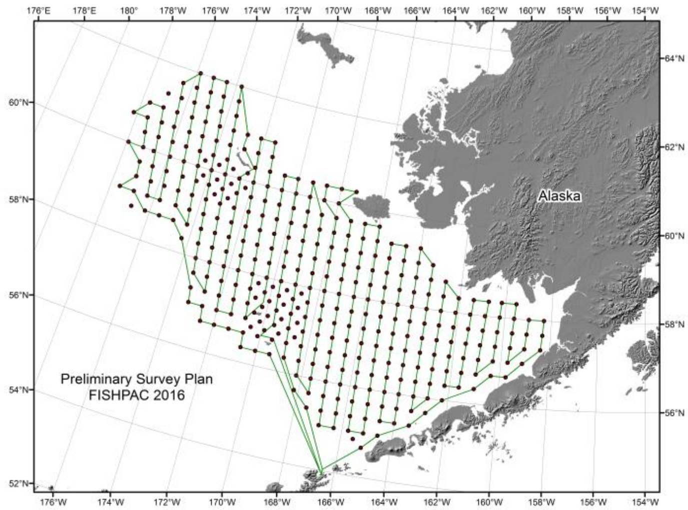

Figure 7. The Bering Sea shelf will be systematically mapped to improve groundfish habitat models and fishery stock assessments. Quantitative sonars will be used characterize the seafloor at 349 trawl-survey stations during a planned multi-mission cruise. In addition to quantitative backscatter data, the survey will also produce IHO-quality bathymetric data for updating nautical charts of areas with outdated or non-existent information, as well as continuous measurements of chemical and physical properties in the pelagic and benthic environments.

Tool Development for Broad-scale Habitat Mapping

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

There was considerable interaction with commercial software developers in 2014, related to the continuing development of LRSSS capabilities and the need for high-quality backscatter data in next-generation habitat models. In particular, the HRG worked closely with the new owners of *Fledermaus* (QPS, Inc, a division of Saab Maritime) and *IMPACT* (Maritime Way Scientific, Ltd.) software in order to improve the accuracy of statistical outputs and to enable processing of very large data sets with their commercially available products.

The Rolls Royce free-fall cone penetrometer (FFCPT) [7] is a 52 kg instrumented probe that is designed to free fall through the water column and can penetrate up to 3 meters into the seabed. Measurements of deceleration and pore pressure allow for the determination of undrained sheer strength and a profile of sediment types. Sensor data are captured 2000 times per second on flash memory and transmitted to topside computers where they can be quickly processed with specialized software. In addition to sediment data, an instrument in the tail fin of the FFCPT acquires sound velocity profiles for use by the ship's acoustic systems. When combined with an appropriate winch, it is possible to yo-yo the instrument through the water column and into the seafloor while the ship is underway at speeds up to 6 kts, thereby improving surveying efficiency over more traditional sediment- and sound-velocity-sampling methods that require the ship to slow or even stop headway for data acquisition. The geotechnical data are being evaluated as new predictor variables for use in the HRG habitat models.

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

HAIP-QTC Opilio

The HRG is also investigating whether acoustic backscatter from the seafloor can be used to improve stock assessments. In stock assessment models, catchability is the link between an index of relative abundance from a fishery-independent survey and the modeled population size. For bottom trawl surveys that estimate the population size using swept-area methods, catchability can be estimated because it is largely determined by sampling efficiency (*i.e.*, the proportion of animals within the sampled area that is caught) which can be experimentally measured. However, estimating survey catchability is complicated because trawl efficiency has been shown to vary over a survey area in response to variation in bottom sediment type.

Catchability experiments have been conducted on the bottom trawl used for the annual EBS survey, [8] resulting in a survey-wide estimate of catchability for snow crab (*Chionoecetes opilio*) which, when included in the stock assessment model, produced significant changes in the Allowable Catch Limit. This catchability model accounted for spatial variation in trawl efficiency as a function of crab size, sex, water depth, and sediment type. Unfortunately, sediment data over the geographic distribution of snow crab are quite fragmentary due to the remoteness of the area, and direct estimates of sediment properties such as grain size are generally unavailable at the trawl-sampling locations.[9] In some cases, estimates were based on sediments collected over 60 miles away. The option to collect sediment data at all 270 trawl-sampling stations included in the snow crab distribution is prohibitively expensive considering the additional ship time required and the sample processing costs.

This project is examining whether indices of bottom type, derived from standardized and calibrated ES-60 acoustic data collected at each snow crab sampling station, are more

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

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

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

informative in the snow crab bottom trawl catchability model than measured values of sediment type that were broadly extrapolated. This determination will be based solely on the amount of spatial variation in the snow crab efficiency model that is explained by the two kinds of sediment information. While the currently used data are based on a directly measurable attribute of the sediment (mean grain diameter), the acoustically derived index is related to this attribute but also to a variety of previously unmeasured variables affecting the time-dependent shape of the bottom echo. Although there is not a simple mathematical relationship between the two types of information, we believe an acoustic index is sufficiently related, will be more reliable, can be collected more efficiently, and will result in a better fitting catchability model for EBS snow crab. In the future, it may be possible to expand this study to other species after completion of the systematic acoustic survey for all EBS trawl-survey stations (Fig. 2).

Effects of Bottom Trawling

In 2014, the HRG published an analysis of short-term effects of bottom trawling on soft-bottom benthos of the EBS.[10] In particular, a Before-After Control-Impact (BACI) experiment was conducted to investigate the effects of a commercial bottom trawl on benthic invertebrates in a sandy and previously untrawled area of the EBS. Six pairs of experimental and control corridors were sampled with a research trawl before and after four consecutive tows with the commercial otter trawl. A major storm event occurred during the experiment and it was possible to differentiate its effect from that of the trawling using the BACI model. Species composition changed very little; *Asterias amurensis* and *Paralithodes camtschaticus* comprised over 80% of the total invertebrate biomass (kg ha^{-1}) during each year of the study. In general, the commercial trawl did not significantly affect the biomass of the benthic invertebrate populations. The trawling effect after 4-14 d was statistically significant at $\alpha = 0.10$ for only three of the 24 taxa that were analyzed, a number expected due to nothing more than random variation. Biomass immediately after the trawling disturbance was lower for 15 of the taxa and higher for the other nine, with a median change of -14.2%. Similarly, the effect of trawling on invertebrate biomass after one year was not statistically significant for any of the taxonomic groups ($p \geq 0.23$ for each group), indicating no evidence of a delayed response to the commercial-trawl disturbance. Further analysis suggests that storms have an overall greater effect on the benthos than do bottom trawls at this location. Both the numbers of taxa significantly affected by trawling and the storm (3 *vs.* 12), and the median sizes of these effects (-14.2% *vs.* -22.0%), were greater for the storm event. Results from this study are combined with those from a related investigation of chronic trawling effects (Fig. 3) to propose an adaptive management strategy for the study region, including rotating area closures to mitigate for temporary trawling effects.

[10] McConnaughey, R. A. and S. E. Syrjala. 2014. Short-term effects of bottom trawling and a storm event on soft-bottom benthos in the eastern Bering Sea. ICES J. Mar. Sci. 71: 2469-2483.

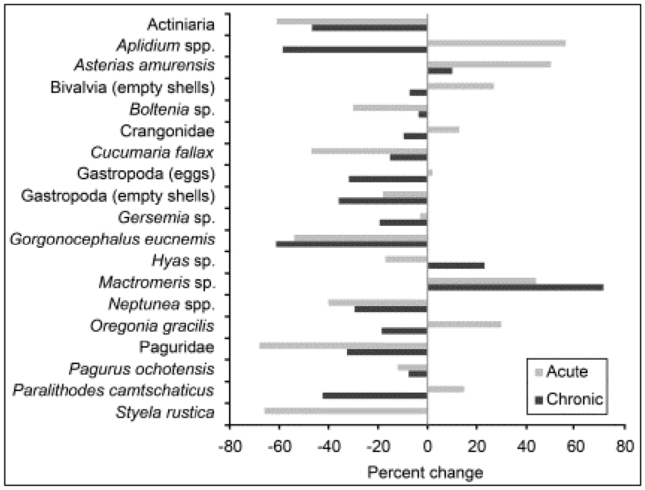

Figure 8. Changes in the biomass (kg ha^{-1}) of benthic invertebrate taxa 4-14 d after four consecutive passes of a commercial trawl (acute effects; present study) and after decades of intensive trawling by the fishery (prior HRG study of chronic effects). The chronic effect for *Styela rustica* was 0%.

International Committee Forms to Study Bottom-trawl Effects

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

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

The full project consists of five phases. Phase 1 of this project is systematically mapping MBCG effort and its distribution with respect to benthic habitats (Fig. 4). Phase 2 has compiled data and conducted a meta-analysis to evaluate the impacts of MBCG on the abundance and diversity of biota.[11] Phase 3 will use information from the first two phases to conduct a risk assessment of the effects of trawling and to illustrate trends in the risk of change to seabed habitats and communities. Phase 4 is studying the medium- and long-term impact of trawling on the productivity and sustainable yield of different target species and ecosystems. Phase 5 will identify and test a range of management options and industry practices that may improve the environmental performance of trawl fisheries, with a view to defining 'best practice.' The scope of the Phase 5 effort was broadened in 2014 to include a closer look at trawl-fishery management in South and Southeast Asia. There are approximately 80,000 trawlers operating in the region under a variety of management practices and contrasting policy drivers. Additional details about the project, products, and the study group are available at http://trawlingpractices.wordpress.com/.

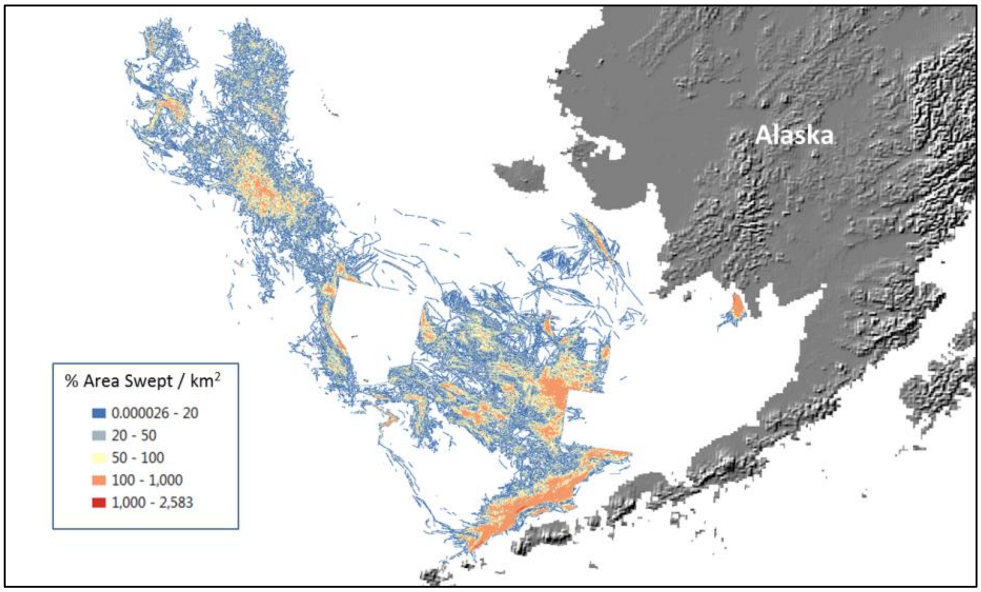

Figure 9. Distribution of trawling effort in the eastern Bering Sea, based on VMS data. Percentages indicate the total area swept in each 1 km^2 grid cell during 2008. Values greater than 100% indicate the total area swept in a cell exceeded 1 km^2. (Summary produced by S. Intelmann.)

Invertebrate Species Synopsis - *Asterias amurensis*

Invertebrates are an important element of the benthic ecology on the EBS continental shelf, with a significant role in the food web supporting not only the benthos, but also commercially important demersal fish species. The HRG is synthesizing sparse literature and reports to produce synopses of the life history and ecology of significant species. The second in a series of NOAA Technical Memoranda has been completed to aid the interpretation of mobile fishing gear effects on these invertebrates, their linkages to fishery production, and their overall role in

[11] Hughes, K. M., M. J. Kaiser, S. Jennings, R. A. McConnaughey, R. C. Pitcher, R. Hilborn, R. Amoroso, J. S. Collie, J. G. Hiddink, A. M. Parma, and A. D. Rijnsdorp. 2014. Investigating the effects of mobile bottom fishing on benthic biota: a systematic review protocol. Environmental Evidence 3: 23.

the ecosystem.[12] The document presents a synopsis of the current knowledge of the life history and ecology of the *Asterias amurensis*; it includes detailed maps of its distribution in the EBS based on abundance data from the 1982-2013 RACE bottom trawl-surveys. The biological characterizations are from the available published literature and are based on observations of populations in the native and invaded ranges of the species.

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

Consistent Taxonomic Classification of Invertebrates Caught in AFSC Bottom Trawl Surveys

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

A specialized software query and lookup tables have been developed to address cases where classification has varied among years, vessels, cruises, or hauls. For a user-selected set of years, the tool accesses data in the Division's Oracle database and groups the aggregate weights and numbers of invertebrate caught by the lowest accountable inclusive taxon (LAIT). As an example, inconsistent classification of the neptunid snails as *Neptunea heros, Neptunea pribilofensis*, and *Neptunea* spp. over three survey years would be consolidated as *Neptunea* spp. for reporting purposes.

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

Miscellaneous projects

Bibliography on the applicability of sonars for habitat mapping:

A great variety of biotic and abiotic factors define the habitats of marine species such that knowledge of their spatial and temporal variability can be used to understand biological patterns of distribution and abundance. The importance of habitats for the sustainable management of fishery stocks was formally acknowledged in the US with passage of the Sustainable Fisheries Act in 1996. At that time, the Magnuson-Stevens Fishery Conservation and Management Act was amended to include new requirements to identify and protect essential fish habitat (EFH). By legal definition, EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Using the best scientific information, federal fishery management plans must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. In so doing, the plans should explain the physical, biological, and chemical characteristics of EFH and must also identify the specific geographic location or extent of habitats described as EFH.

The broad scope of the EFH mandate requires an efficient process for describing and mapping the habitats of federally managed species. Factors such as temperature, salinity, and depth are generally accepted as habitat-defining characteristics for marine fish and invertebrates, and synoptic data sets are frequently available. Research also indicates that surficial sediments are an important habitat factor for many species, with both direct and indirect effects on survival and growth. Traditional sampling with grabs and cores is, however, impractical over large areas and the availability of geo-referenced data is usually limited as a result. Acoustic methods, on the other hand, are suitable for large-scale surveying and show great promise as a substitute for direct-sampling methods, but they are still at a "nascent"stage of development [13] and have not been proven for EFH purposes.

The complex relationship between acoustic returns and seafloor sediments has been actively studied for decades. According to Holliday [14], as many as 80 different parameters have been used to describe the physical and material properties of the seafloor, of which six to 12 of these may have major influence on acoustic returns from the seabed. However, many of these parameters are confounded such that an area of seabed has a characteristic return but that acoustic return is not unique to that particular seabed type. Known as the "inverse problem", various combinations of grain size, surface roughness, and slope, for example, may be indistinguishable. In actual practice, the situation is even more complex, given the seabed frequently is not static due to time-varying forces such as waves, currents, certain fishing activities, and natural biological processes.

The primary focus of this bibliography is benthic habitat characterization using backscatter and bathymetric data from single-beam echo sounders, multibeam echo sounders, and side-scan sonars. The coverage ranges from methods for acquiring and processing data, data extraction and synthesis from imagery, production and use of habitat maps for fishery management and other purposes, modeling species distributions using processed data, and some relevant theoretical treatments. The bibliography was compiled from extensive searches of online

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[13] Anderson, J. T., D. V. Holliday, R. Kloser, and D. Reid [ed.] 2007. Acoustic seabed classification of marine physical and biological landscapes. ICES Cooperative Research Report no. 286. Copenhagen. 185 p.

[14] Holliday, D. V. 2007. Theory of sound-scattering from the seabed. Pages 7-28 *in* J. T. Anderson, D. V. Holliday, R. Kloser, and D. Reid [ed.] Acoustic seabed classification of marine physical and biological landscapes. ICES Cooperative Research Report no. 286. Copenhagen.

literature databases, as well as secondary reviews of literature cited in the selected references. The collection includes peer-reviewed articles, as well as state and federal reports, conference papers, conference presentations, bulletins, and books. The abstracts and keywords for each reference were obtained from the original source whenever possible. If one or the other was not available for use, a brief summary and/or keywords were added.

This bibliography will be published as a NOAA Technical Memorandum and posted on the AFSC web site as a searchable, dynamic database.

Benthic Mapping Specialist billet

In June 2014, NOAA Corps hydrographer LTJG Theresa Smith reported to the HRG for a three-year assignment as a Benthic Mapping Specialist. This is the first such cross-over billet between NOAA hydrography and fisheries. She replaced LTJG Adam Pfundt, who returned to sea duty on NOAA Ship *Rainier.*

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 Alaska's marine environment. During 2014, AFSC personnel analyzed the stomach contents of more than 40 species sampled from the eastern Bering Sea, the Aleutian Islands, the Gulf of Alaska, the northern Bering Sea, and the Chukchi Sea regions. The contents of 16,326 stomach samples were analyzed including 3,636 stomach samples analyzed at sea during the Aleutian Islands groundfish survey. This resulted in the addition of more than 53,000 records to AFSC's Groundfish Food Habits Database in 2014. In addition to stomach samples from groundfish, we analyzed bill-load samples from 129 Tufted Puffins and 28 Horned Puffins collected from breeding colonies on Buldir and Aitak Islands for the Alaska Department of Fish and Game.

Collection of additional stomach samples was accomplished through resource survey, special studies comparing stomach contents with prey-sampling, and Fishery Observer sampling. Over 5,800 stomach samples were collected from large and abundant predators during the eastern Bering Sea bottom trawl survey of the continental shelf. At-sea analysis of stomach contents was conducted on almost 1,500 groundfish during the Aleutian Islands bottom trawl survey. These samples were supplemented by the collection of 1,674 stomach samples from Alaskan fishing grounds by Fishery Observers. Rockfish stomachs and zooplankton tows were sampled during a special study examining habitats around Kodiak Island by the RACE Division.

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.

Comparisons of At-Sea vs In Lab Stomach Content Analysis
Quantifying food web linkages is essential to understanding energy flow in the ecosystem and how external forces such as fishing and climate change may cause unanticipated shifts in ecosystem composition. For several years, REEM conducted Stomach Content ANalysis at Sea (SCANS) in addition to regular collection and preservation of groundfish stomach samples (to be analyzed in the laboratory) during surveys of the Gulf of Alaska and Aleutian Islands regions. During some surveys, stomach samples from the same predator species were analyzed both in the laboratory and at sea, thus providing the opportunity to examine how our ability to identify key prey types may differ between the two methods.

Identification of coelenterates (Cnidaria and Ctenophora) and pelagic urochordates (pelagic Tunicata and Larvacea) differs between the two methods for some zooplanktivores. SCANS more frequently detected coelenterates in the diets of Dark rockfish, Dusky rockfish, Prowfish and Sablefish, but not in the diets of Walleye pollock or Atka mackerel. Dissolution of coelenterate tissues during the preservation process is likely the main factor in the differences observed. Neither method of analysis commonly detected coelenterates in the diets of Walleye pollock or Atka mackerel. Pelagic urochordates were more frequently identified in the preserved and laboratory examined stomachs of Walleye pollock. Unlike coelenterates, pelagic urochordates have some tissues that do not dissolve during the preservation process, and their small size makes them more easily detected with the aid of a microscope in the laboratory.

The identification level of prey-fish was also found to differ between the two analysis methods for some piscivores. Identification of fish to species was higher using SCANS of Pacific cod, Arrowtooth flounder, Pacific halibut, and Walleye pollock (Fig. 1). One factor that contributes to this result is the greater ability to detect hard to identify larval-stage fishes and residual hard parts from fully digested fishes by using a microscope in the laboratory, and visual identification of digested prey to narrow taxonomic categories often proves difficult. Another contributing factor is the ability to freeze the visually unidentifiable prey-fish for genetic identification when SCANS is being performed. Numerically, large percentages are not identified to species, but these are mostly well digested fish with few parts remaining in the stomach, so when weight is considered, the percentages that are identified to species is larger for both methods (Fig. 1). The exception to this appears to be Walleye pollock that are analyzed in the laboratory, and may be due to greater uniformity in size of the (mostly larval and juvenile) prey-fish regardless of the level of digestion.

Conducting SCANS during groundfish surveys results in lower sample sizes due to the greater time required on the vessel to process each sample compared to collection and preservation, and possibly also results in lower precision regarding the composition of each stomach's contents. However, conducting SCANS results in faster delivery of the data for use in management models, reduced chemical usage and transportation, and the ability to coordinate genetic analyses of some prey-fish. The later benefit has allowed evaluation of some of our standard visual identification practices. Genetic analysis of prey-fish that could not be visually identified at least to family (to order, non-gadoid or unidentified teleost categories) indicated that these fish were in fact different species than the prey-fish that were visually identified. Several common forage fish can be identified to species at all levels of digestion because of distinctive bones and otoliths that remain intact throughout the digestion process, while other fishes become indistinguishable through visual means after very little digestion occurs. When diet composition data is being aggregated for ecosystem energy-flow models, the assumption that the unidentified fish portion of the diet can be represented by the composition of the identified prey-fishes is unlikely to be true.

Using both stomach content analysis methods will result in better descriptions of the marine foodweb linkages in Alaskan waters than using either method alone. SCANS can better identify consumption of soft-bodied prey, and, coupled with genetic identification techniques, poorly described portions of the diet may be more precisely described. Standard preservation and analysis practices can better detect small prey (or small parts of prey), allow for greater samples sizes across regions with heterogeneous habitat, and provide greater precision for the weight composition of each sample.

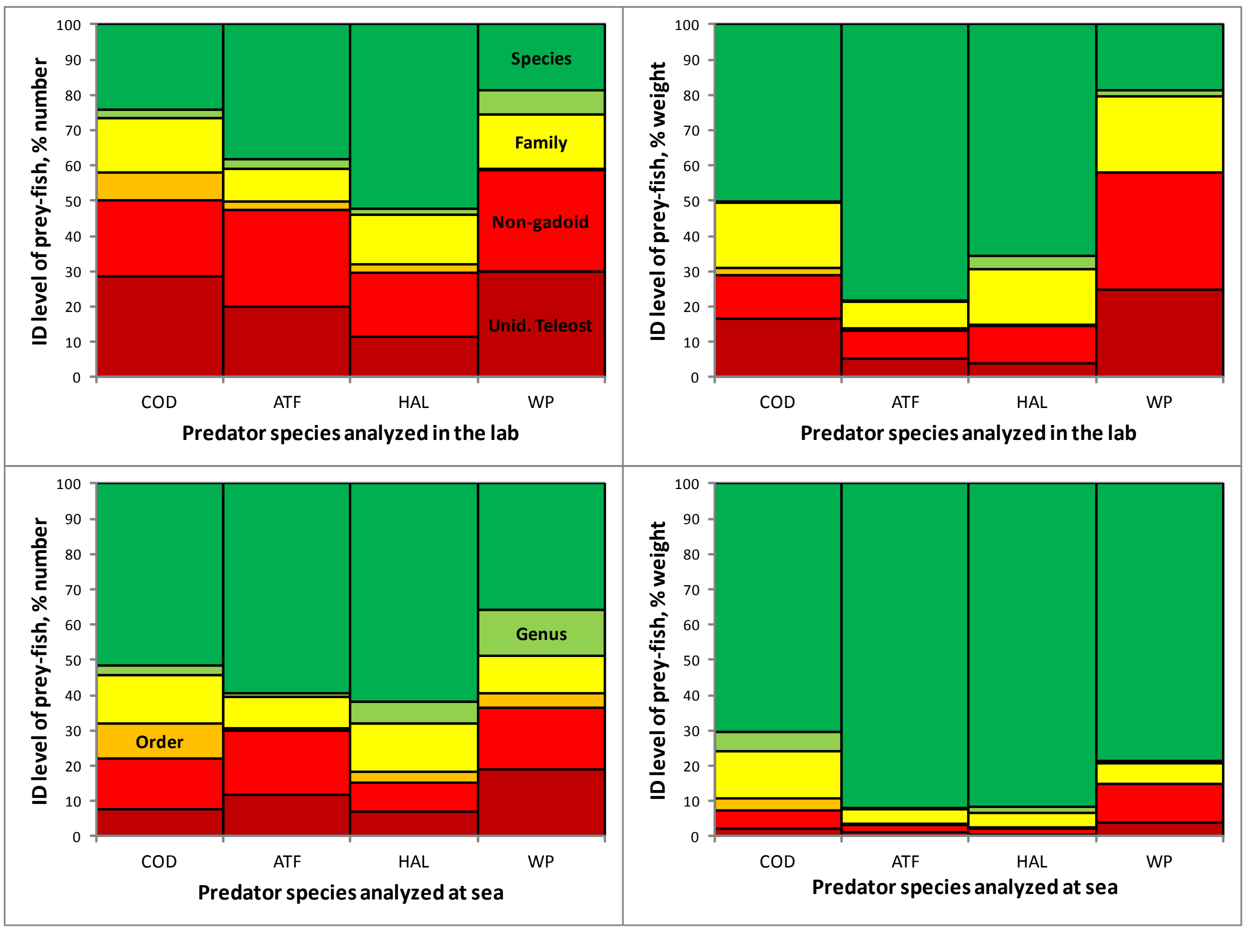


Figure 1. Identification levels of prey-fish in the diets of four predators, Pacific cod (COD), Arrowtooth flounder (ATF), Pacific halibut (HAL) and Walleye pollock (WP) averaged from three surveys where stomach content analyses were performed both in the laboratory (upper panels) and at sea (lower panels). The numeric distribution of the prey-fish among the identification levels is shown in the two panels on the left side, and the weight distribution of the prey-fish among the identification levels is shown in the two panels on the right side.

Seabird Bycatch Estimates for Alaskan Groundfish Fisheries, 1993-2013

In 2013 the restructured observer program expanded coverage, including vessels less than 60 feet overall and vessels in the halibut fleet. Despite this expansion, the total seabird mortality associated with the fleet was the lowest we have recorded, at 4,730 birds overall (Table 1, Fig. 2). As was expected, however, the bycatch of albatross did increase, to 438, the second highest recorded number since 2007 and well above the average of 347.6 throughout this time period. Overall bycatch remains low when compared to the years prior to 2002, when the cod freezer longline fleet and other longline vessels began extensive use of paired streamer lines (Fig. 2). These numbers include all gear types, but do not include mortality from the trawl fleet where mortality occurs due to warp, net wing, or third wire interactions. Current estimates, beginning in 2007, are produced from the Alaska Regional Office Catch Accounting System. A report of seabird bycatch, 2007-2013 with more detailed information, including information by fishery, can be found on the AFSC website's seabird page, at http://www.afsc.noaa.gov/refm/reem/Seabirds/Default.php

Table 1. Total estimated seabird bycatch in Alaskan federal groundfish fisheries, all gear types and Fishery Management Plan areas combined, 2007 through 2013.

Species/ Species Group	Year						
	2007	2008	2009	2010	2011	2012	2013
Unidentified Albatross	23	0	0	0	0	0	0
Short-tailed Albatross	0	0	0	15	5	0	0
Laysan Albatross	17	226	148	233	205	135	189
Black-footed Albatross	208	314	56	48	221	141	249
Northern Fulmar	4,806	3,334	8,200	2,452	6,214	3,022	3,268
Shearwater	3,587	1,224	622	653	195	514	191
Storm Petrel	1	44	0	0	0	0	0
Gull	1,360	1,551	1,335	1,145	2,158	890	556
Kittiwake	10	0	16	0	6	5	3
Murre	6	6	13	102	14	6	3
Puffin	0	0	0	5	0	0	0
Auklet	0	3	0	0	0	7	4
Other Alcid	0	0	105	0	0	0	0
Other Bird	0	0	136	0	0	0	0
Unidentified	522	541	696	240	306	285	267
Total	10,540	7,243	11,325	4,894	9,324	5,005	4,730

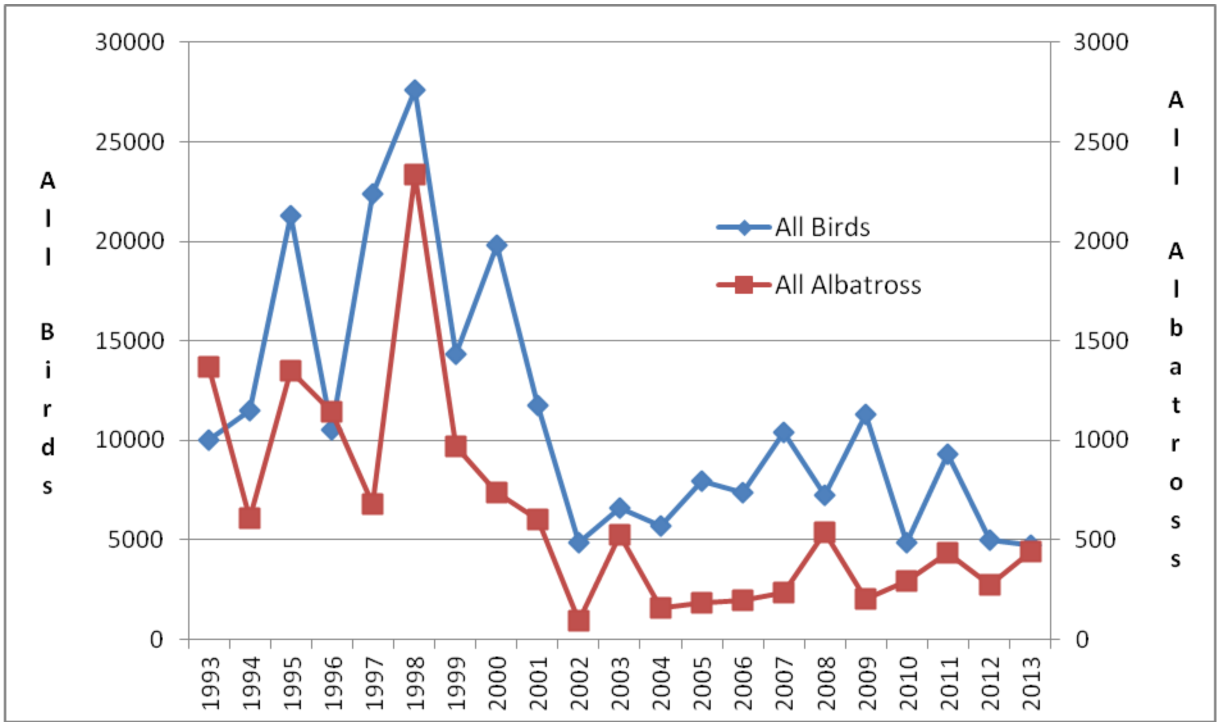


Figure 2. Total estimated bycatch of all seabirds and all albatross in Alaskan Groundfish fisheries, all gears combined -- 1993 to 2013.

In September 2014, there was an incidental take of an endangered Short-tailed albatross in the hook-and-line groundfish fishery of the Bering Sea/Aleutian Islands, and the take of a second unidentified albatross in the same haul. The last three documented Short-tailed Albatross takes in Alaska were in August 2010, September 2010, and October 2011. A response to the latest incident was coordinated with the NMFS Alaska Regional Office, the North Pacific Groundfish Observer Program, and the U.S. Fish and Wildlife Service. The confirmed Short-tailed albatross had a leg band identifying its natal breeding colony in Japan, and was five years old.

BSIERP FEAST 6 Year Project Wrap-up and Future Work

Delivery of the final report for the Forage Euphausiid Abundance in Space and Time (FEAST) model – part of The Bering Sea Project – concluded a 6 years multi-disciplinary project that produced 12 peer reviewed publications (several currently in review) and 31 presentations at international meetings. FEAST has been used to focus fieldwork and started a collaborative framework between field researchers and modelers, a process that has now been implemented at the AFSC across several Divisions, research teams as well as PMEL. FEAST will also be a centerpiece of this strategy developing an Integrated Ecosystem Assessment (IEA) for the Alaska region. NOAA's national IEA program (http://www.noaa.gov/iea) will include regular updates to FEAST, but will also use the model as a focus for collaborative fieldwork from disciplines from physics through biology, economics, and social sciences. As IEAs focus on delivering management results, this will serve as a direct conduit for bringing process-oriented fieldwork into the management arena via management strategy analyses, ecosystem indicator development and improved prediction capabilities both in the short and long term.

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

The report includes additional new and updated sections, including the 2014 Eastern Bering Sea and Aleutian Islands Report Cards and ecosystem assessments. This year, the Hot Topics section includes topics from most ecosystems. In the Arctic, a large phytoplankton bloom observed beneath the sea ice suggests that primary production pathways may be changing in the Chukchi Sea. The hot topic for the eastern Bering Sea was the observed mortalities of two endangered short-tailed albatross in association with a longline fishing vessel. The hot topics for the Gulf of Alaska include the "warm blob" of record high sea surface temperatures that developed in early 2014 and persisted through the end of summer and the exceptionally high reproductive success across several seabird species in the western Gulf. The section in the report that describes ecosystem and management indicators includes updates to 44 individual contributions and presents 6 new contributions. These include contributions on temporal trends in Pacific sand lance as revealed by puffins; using ecosystem indicators to develop a Chinook salmon abundance index for southeast Alaska; an eastern Bering Sea pollock recruitment index that incorporates sea temperature and salmon; occurrence of mushy halibut syndrome; and two on groundfish condition in the Aleutian Islands and Gulf of Alaska.

Additional regional 2014 ecosystem highlights include the warm summer conditions in the eastern Bering Sea, including the early break up of sea ice, a reduced cold pool of bottom water, and warm surface air conditions. This was the first warm year following a sequence of seven cold years in the eastern Bering Sea. The Aleutian Islands also experienced warm temperatures; survey biomasses of most fish species increased compared with the last survey in 2012. In addition, a review of Gulf of Alaska indicators suggests that there was a shift in ecosystem state in 2006. The report is available online at the Ecosystem Considerations website at: http://access.afsc.noaa.gov/reem/ecoweb/index.cfm

For more information on the REEM program, contact Kerim Aydin (206) 526-4225

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

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

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

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

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

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

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

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

MARVLS (Maturity Assessment Reproductive Variability and Life Strategy) – REFM, RACE, ABL

The MARVLS group was created by reproductive fish biologists at the AFSC in 2013 to 1) share work accomplishments and challenges, 2) discuss literature, 3) increase collaboration, and 4) bring reproductive biology needs to the attention of the AFSC. Throughout 2014 this quickly bloomed into a national group including stock assessment and reproductive biologists from all five NMFS science centers and other agencies. In 2014, the MARVLS group at AFSC created a white paper that describes the AFSC's reproductive biology needs to support stock assessments and presents ideas for future sampling on surveys and fisheries. For the first time an AFSC activity plan was developed for fiscal year 2015 for reproductive work (at NMFS activity plans direct the work for the coming year). From November 6-8th MARVLS held their first workshop at the AFSC in Seattle. Biologists from around the country met to present research, ask each other questions, and share cutting edge technologies. The enthusiasm from this meeting inspired a session at the AFS meeting in Portland in 2015, chaired by Susanne Mcdermott and a second MARVLS workshop is tentatively planned for spring 2016.

For more information contact Susanne Mcdermott at 206-526-4417, Susanne.mcdermott@noaa.gov

C. By Species

1. Pacific Cod

a. Research

Coastal Age-0 Pacific Cod Survey– Gulf of Alaska - RACE FBEP
The Fisheries Behavioral Ecology Program conducts research on the early life-history habitat requirements of commercially important Alaskan fish and crab species. Age-0 stages of Pacific cod are often restricted to surface waters or coastal nursery habitats where they are not available to the stock assessment trawl survey. As such, there are few direct measures of age-0 abundance data to fit stock-recruitment models and examine recruitment processes at this

important early life stage. The Newport laboratory has been conducting an annual summer beach seine and camera survey of two coastal nurseries in Kodiak, AK across 16 sites since 2006. The survey samples are focused on age-0 and age-1 stages of juvenile Pacific cod, but also samples co-occurring juvenile walleye pollock and saffron cod. The Newport laboratory is examining this time-series and its efficacy of predicting year class strength locally (inshore) and more broadly (offshore) across the Gulf of Alaska. Models are also examining variance of sequential year class prediction as a function of habitat (e.g., structure, unstructured), spatial scale (within bay, across bay, regional), time of year (newly vs. late-settled fish) and environment (e.g., temperature, salinity). Mechanisms of such relationships will be examined using available seasonal and annual vital rate information for each species in each system

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

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

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

To investigate vertical availability of Pacific cod to the BT, this study used a side-by-side BT experiment and analysis of acoustic data collected during the side-by-side experiment and from other BT surveys. The side-by-side experiment was used to test the null hypothesis that there was no difference in the vertical availability of Pacific cod between a low-opening (2.5 m) and a high-opening (7.0 m) BT. If results from the archival tag study are a typical representation of the vertical structure of Pacific cod from across the Bering Sea shelf, and if vertical availability of Pacific cod to the BT is unaffected by bottom-trawling activity (i.e., diving response), the expectation would be that the low-opening trawl would have approximately half the catch rate of

Pacific cod compared to the high-opening trawl. Acoustic data from the experiment and from other historical BT survey tows were also analyzed to investigate whether the vertical structure of Pacific cod and their availability to the BT changed by area, during different times of day, or at different bottom depths. Abundance estimates from the acoustic analyses and the proportion of Pacific cod between the seafloor and 2.5 m and between 2.5 and 7.0 m were compared to corresponding BT abundance estimates to determine if vertical availability of Pacific cod to the BT varies during general survey operations conducted in different areas on the shelf and at different bottom depths. Possible mechanisms for non-varying vertical availability of Pacific cod to the BT survey are also discussed.
For more information, contact Bob Lauth, e-mail: bob.lauth@noaa.gov

Local Adaptation in Puget Sound Pacific Cod (*Gadus macrocephalus*): Phenotypic and geneomic differentiation and the conservation of a depleted population in a warming environment

RAD sequencing and SNP discovery

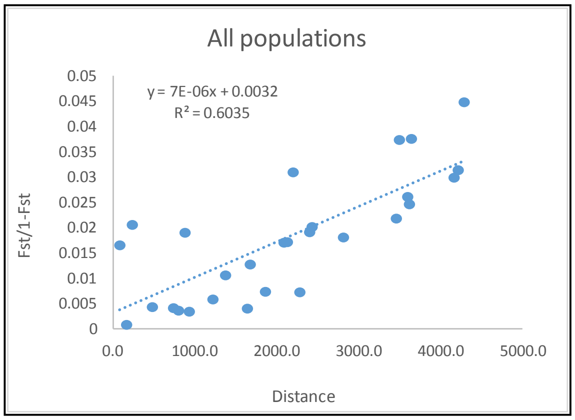
Fin clip samples were collected from spawning and pre-spawning aggregations of Pacific cod at eight locations across the northeastern Pacific Ocean Collection sites included the Washington State coast in 2005 (WC05); Salish Sea region in 2012 and 2013 (JDF12, SS12/13); Hecate Strait in 2004 (HS04); Prince William Sound in 2012 (PWS12); Kodiak Island in 2003 (KOD03), Unimak Pass in 2003 (UP03), and Adak Island in 2006 (AD06). DNA was extracted from up to 48 individuals from each sample (WC05: n = 48, JDF12: n = 21, SS12/13: n = 42, HS04: n = 48, PWS12: n = 48, KOD03: n = 48, UP03: n = 48, and AD06: n = 48) for a total of 351 fish. RAD-tagged libraries were submitted to the University of Oregon Genomics Core Facility (UOGCF) for next-generation DNA sequencing. Compressed data were downloaded and raw reads were quality filtered to minimize physical linkage and sequencing errors and to retain markers in Hardy-Weinberg equilibrium.

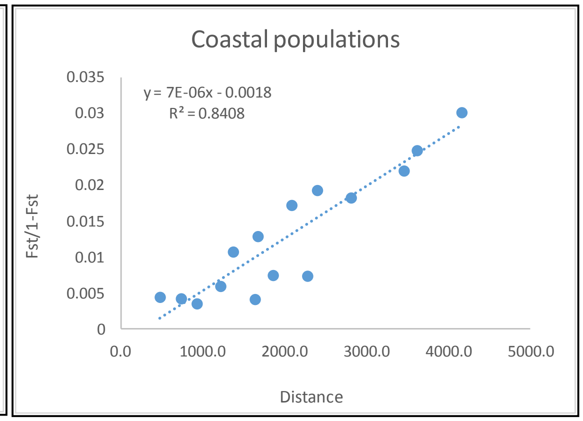
Population genetic analyses

A total of 6,756 loci were retained after filtering. Locus-specific allele frequencies, expected heterozygosity (H_E); Hardy–Weinberg equilibrium (HWE) P-values; F_{IS}, F_{ST}, and F_{IT}; and population pairwise F_{ST} were estimated. Global F_{IS}, F_{ST} and F_{IT} were 0.011, 0.017, and 0.027, respectively. Pairwise F_{ST} values were largely significant, where red indicates significance at the P = 0.05 level:

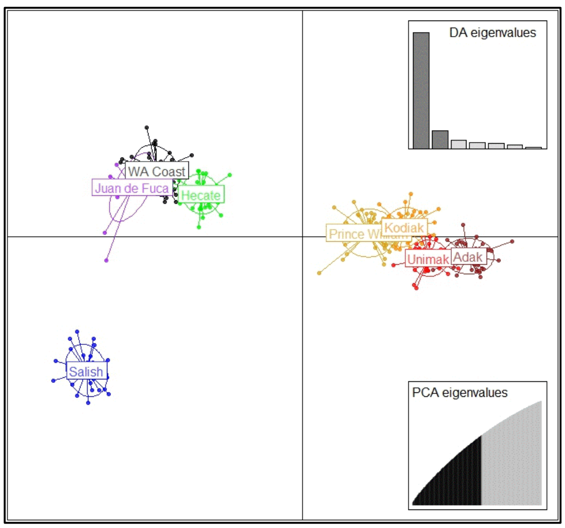
	JDF12	SS12/13	WC05	HS04	PWS12	KOD03	UP03	AD06
JDF12	0							
SS12/13	0.0168	0						
WC05	0.0003	0.0196	0					
HS04	0.0035	0.0188	0.0034	0				
PWS12	0.0156	0.0310	0.0150	0.0095	0			
KOD03	0.0206	0.0372	0.0193	0.0132	0.0022	0		
UP03	0.0225	0.0369	0.0199	0.0138	0.0036	0.0011	0	
AD06	0.0297	0.0450	0.0276	0.0189	0.0065	0.0042	0.0035	0

Isolation by distance (IBD) was assessed among sampling locations. Results were significant both over all populations (P = 0.005) and just the coastal populations (P = 0.002), excluding JDF12 and SS12/13. Graphs are below:





Several individual-based methods, including cluster analysis, PCA, DAPC, and PCoA, were performed. Results were supportive on a large scale of two clusters, with a north/south split between Hecate Straight and Prince William Sound. The Salish Sea sample, which was the only fjord-based population, also tended to separate from the remaining samples as also found in earlier research. PCA is below:

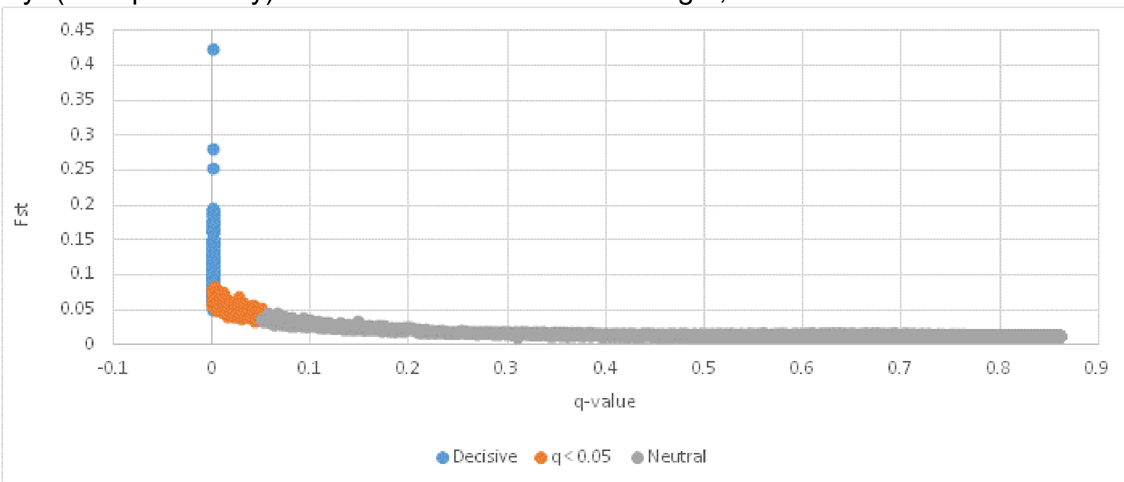


Based on the results from the clustering and multivariate analyses, analyses of molecular variance (AMOVA) were performed on three different population groupings. The first split the populations into two groups, representing the northern and southern populations of the sample range, including 1) PWS12, KOD03, UP03, and AD06 and 2) WC05, JDF12, HS04, and SS12/13. The second split the populations into three groups, representing the northern, southern, and fjord populations, including 1) PWS12, KOD03, UP03, and AD06; 2) WC05, JDF12, and HS04; and 3) SS12/13. The third reflected a potential split within the northern samples and included 1) PWS12 and KOD03; 2) UP03 and AD06; 3) WC05, JDF12, and HS04; and 4) SS12/13.

Individual assignment tests were performed to assess the power of the SNP dataset to correctly assign individuals to their population of origin. A Bayesian method unambiguously assigned 85.6% of individuals, whereas the frequencies-based method assigned 86.3%. The strong performance of SNPs in assignment tests forms the basis for a current proposal to the North

Pacific Research Board to track cod movements using genetic tags (SNPs) rather than physical tags.

Finally, a test to identify putative candidate loci under selection was performed. A total of 365 loci exhibit at least "strong" evidence for selection ($q < 0.05$), with 218 of these loci listed as "decisively" (99% probability) under selection. The remaining 6,391 loci were deemed neutral:



Contributed by Lorenz Hauser (UW) and Mike Canino (FOCI)

Pacific cod Dispersal Patterns and Nursery Habitat Use in the Bering Sea - RACE FBEP
The Fisheries Behavioral Ecology program is collaborating with the RACE-Recruitment Processes Program, ABL-Ecosystem Monitoring and Assessment Program, and Oregon State University to examine the dispersal patterns of larval and juvenile Pacific cod and their use of coastal nursery habitats. In 2014, data analysis continued on the basin-wide distribution of age-0 Pacific cod, with future work examining spatial variation in diet and growth rates.

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

further clarify larval sources and dispersal, identify juvenile nursery habitats, and estimate the contributions of juvenile nursery habitats to the adult population within the southeastern Bering Sea.

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

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS - REFM
Bering Sea-This is the second year in which separate assessments and OFL/ABC specifications have been made for the Eastern Bering Sea and Aleutian Islands Status and catch specifications (t) of Pacific cod. In prior assessments both regions were combined. Biomass for each year corresponds to the projection given in the SAFE report issued in the preceding year. The OFL and ABC for 2015 and 2016 are those recommended by the Plan Team.

All survey and commercial data series on CPUE, catch at age, and catch at length were updated for the current assessment. The 2015 specifications were based on the same model used in 2011-2013 and is thus a rerun of last year's accepted model (Model 1, the same as the 2011 accepted model) with updated data files. However, the Plan Team expressed serious reservations about this model's poor retrospective performance and continued reliance on a fixed value of survey catchability that is no longer very credible. A different model was requested for next year.

Survey biomass was higher again in 2014, continuing an upward trend that began around 2006 and has been sustained by several good year classes. Spawning stock biomass is now estimated to be at the B40% level, or 330,000 t and projected spawning biomass in 2015 is 409,000 t. The stock is therefore assigned to Tier 3a. The maximum 2015 ABC in this tier is 295,000 t, but the author and
Team recommend that ABC be held at the 2014 level of 255,000 t to compensate for the poor retrospective behavior of the standard model. The Team recommends the same value for the preliminary 2016 ABC. The corresponding OFLs are 346,000 t and 389,000 t.
EBS Pacific cod is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Aleutian Islands- For some years there has been concern that a disproportionate share of the BSAI TAC was being taken from the Aleutians. The separate specification of EBS and AI OFL/ABC for the AI region, begun last year, is a response to that concern. Both age-structured (Tier 3) and survey-based (Tier 5) assessments have been considered for this area, but the working assessment is Tier 5 for Pacific cod in the Aleutian Islands.

In this region, the survey biomass index has been flat and below the long-term average for the last ten years. The present Tier 5 assessment was reviewed and two age-structured alternatives, both of which displayed poor retrospective performance and estimated biomass on the order of three times the trawl survey swept-area values, which is very high. Thus the Tier 5assessment was again used for 2015 (ABC=17,600 t, OFL=23,400 t) while continuing work on the age-structured models with the aim of moving this assessment up to Tier 3. This stock is not being subjected to overfishing.

GULF OF ALASKA

The 2014 stock assessment updated the fishery catch data series for 1997-2014 (projected for 2014 expected total year catch) and updated the 1997-2012 seasonal and gear-specific catch-at-length. The fishery length composition data were updated for 1997-2014 (preliminary for 2014).

The 2014 GOA Pacific cod assessment evaluated four models. Model 1 is identical to the final model configuration from 2013. Model 2 is identical to Model 1 but uses the recruitment variability multiplier. The two new models (S1a and S1b) also use the recruitment variability multiplier. In addition, these models treat the bottom trawl survey as a single source of data instead of splitting the sub 27 and 27-plus data for lengths and ages, include survey age data as conditional age-at-length data. Instead of incorporating 12 blocks of logistic survey selectivity, Model S1a uses 3 blocks of non-parametric survey selectivity and Model S1b uses cubic spline based survey selectivity.

According to Model S1a, $B_{40\%}$ for this stock is estimated to be 126,600 t, and projected spawning biomass in 2015 is 155,400 t. Estimated age-0 recruitment has been relatively strong since 2005 with the 2008 and 2012 year classes being the strongest over the entire time series since 1978. Stock abundance is expected to be stable in the near term. Models S1a and S1b were preferred over Models 1 and 2 because S1a and S1b used all the survey data instead of only the 27 plus portion. Model S1a was selected by the author as the preferred model primarily because it fit the data better than S1b. The Plan Team agreed with the author's recommendation to use Model S1a as the preferred model. Since 2015 spawning biomass is estimated to be greater than $B_{40\%}$, this stock is in Tier 3a. The estimates of $F_{35\%}$ and $F_{40\%}$ are 0.626 and 0.502, respectively.

The maximum permissible ABC estimate (117,200 t) is a 32% increase from the 2014 ABC. However, The Plan Team recommended that a value lower than the maximum permissible be used for 2015 for the following reasons: Additional age-composition data (2013 GOA bottom trawl survey) was provided after the assessment was completed and a comparative analysis was done by the author to evaluate the impact of these data on results. When incorporated, these data reduced the estimated abundance at age (~ 8% of biomass) relative to the selected model in the assessment without the 2013 survey age data. A retrospective pattern indicates a consistent downward adjustment for the recent years as more data are added. This suggests that estimates tend to be biased high. Therefore, as an intermediate step, the Team recommends that ABC for 2015 be set at a value half way between the maximum permissible ABC in the assessment and the 2014 ABC which is 102,850 t. The approximate F_{ABC} at this level is 0.441.

The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition. In the 2013 assessment, the random effects model (which is similar to the Kalman filter approach, and was recommended in the Survey Average working group report which was presented to the Plan Team in September 2013) was used to apportion the ABC to the geographic regions of the GOA to spread the harvest over the range of Pacific cod.

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

2. Walleye Pollock

a. Research

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

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

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

Our survey results have been used to document the rapidly changing marine conditions in the EBS during the past ten years and provide baselines and analogues for different climate regimes. The EBS SST's underwent large-scale warming from 2002-2005 followed by substantial cooling in 2006-2012. These shifts altered fisheries distributions and have the potential to affect the overall ecology of this region. Coincident with changes in the SST we have observed changes in the energy density (kJ/g) of age-0 pollock. For example, age-0 pollock energy density was low during 2002 to 2005, but significantly increased during 2006 to 2012. These data during the cool period suggest that age-0 pollock have maximized their energy content. Recent warming during 2014 and into 2015 indicate a switch back to lower energy content and higher overwinter mortality for age-0's. 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.

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

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

Pollock recruitment was highly variable within the 10-year time series, 2001-2010 (Figure 1). A slight alternating year pattern was observed in the time series, with higher recruitment in odd-numbered years at age-1 that corresponds with higher age-0 recruitment in even-numbered years. The lower age-0 recruitment in odd-years may be associated with higher abundances of adult pink salmon (a predator and competitor) in odd-years.

In a multiple regression model, age-1 pollock recruitment was negatively related to spring sea temperatures during their age-1 stage and positively related to chum salmon growth during the pollock age-0 stage (R^2 = 0.77; p –value = 0.012). Model residuals had an alternating year pattern. Therefore, we added pink salmon abundances (harvest and escapement) from Asia and North America to the model. The pink salmon abundance predictor variable had a significant negative coefficient and explained an additional 15% of the variation in age-1 pollock recruitment (R^2 = 0.92; p-value = 0.004) (Figure 1).

The model parameters (2001-2010) and biophysical indices (2013and 2014) were used to predict the recruitment of Bering Sea pollock in 2014. The 2013 and 2014 biophysical indices (chum salmon growth = 0.969 kg, spring sea temperature = 3.95°C, pink salmon = 493 million) produced a forecast of 6,569 million (3,837 standard error, c.v. = 0.22) age-1 pollock in 2014.

The 2013 and 2014 biophysical indices indicated average ocean productivity (chum salmon growth), warm spring sea temperatures (less favorable), and above average predator abundances (pink salmon). These factors are expected to result in below average age-1 pollock recruitment in 2014.
For more information contact ellen.yasumiishi@noaa.gov.

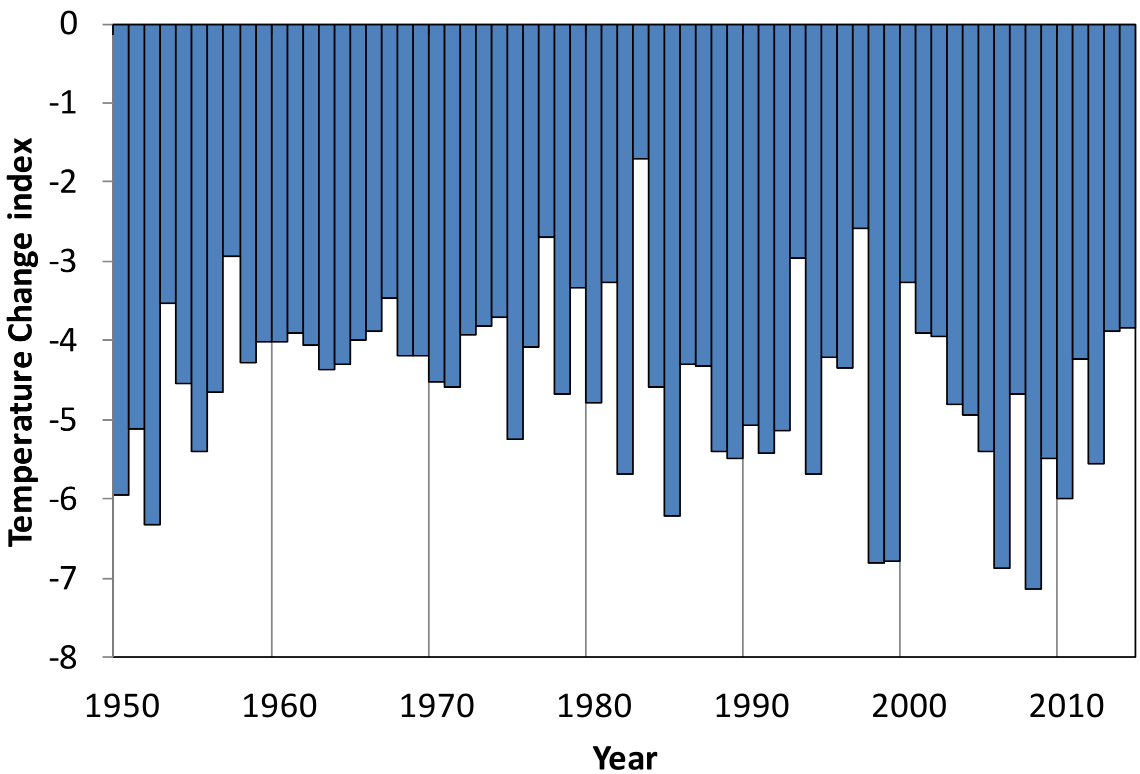


Figure 1: The Temperature Change index values from 1950 to 2014.

Walleye Pollock Ichthyoplankton Dynamics in the Bering Sea - RACE Recruitment Processes

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

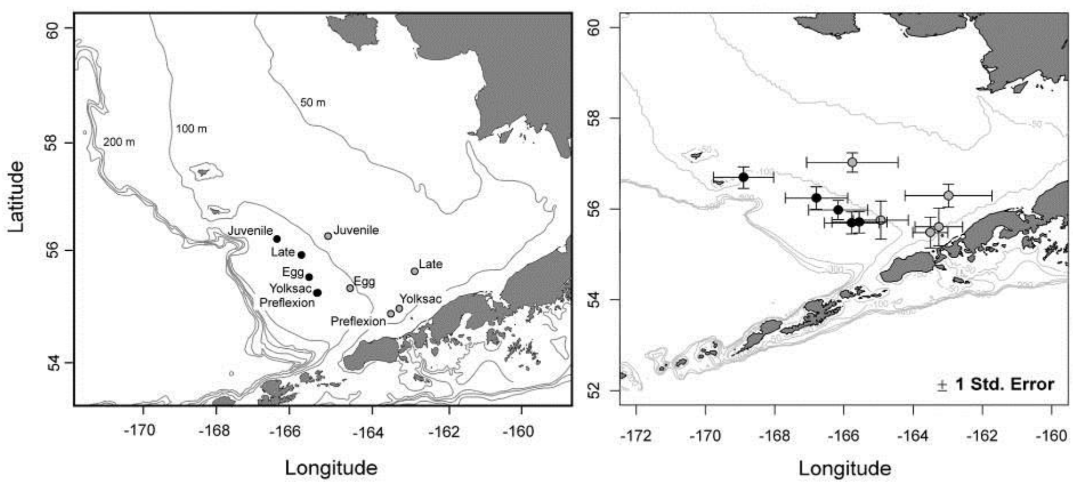


Figure 1. Early life stages of walleye pollock are distributed over the outer shelf during cold periods (filled circles) and over the middle shelf during warm years (open circles). Error bars denote 1 STD.

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

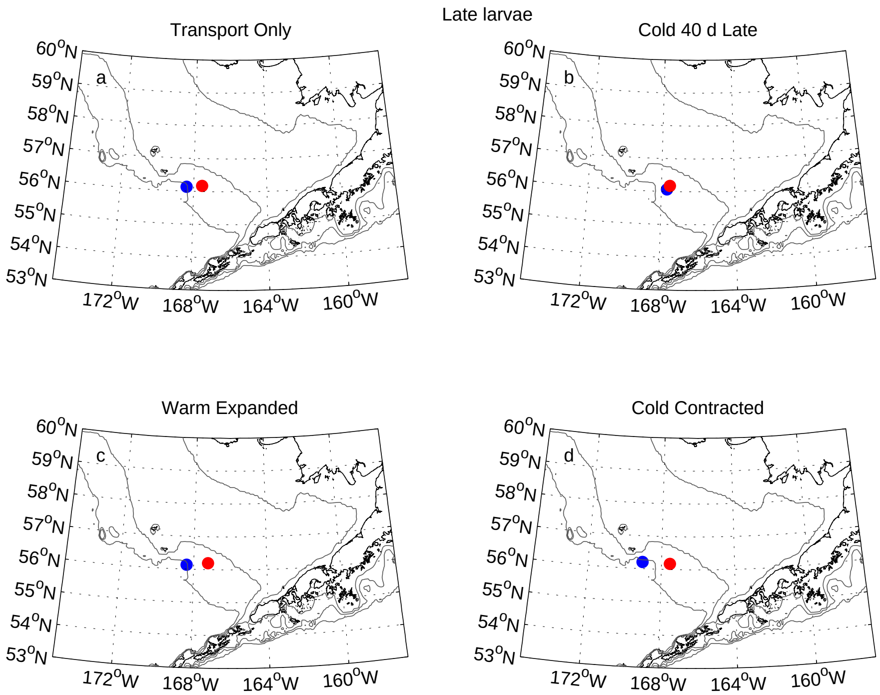


Figure 2. Modeled centers of gravity of pollock larvae (10-40 mm SL) in cold (blue) and warm (red) years for all model scenarios. Transport Only = interannual variations in advection, Cold 40 d Late = spawning delayed by 40 days under cold conditions, Warm Expanded = spawning distribution expanded eastward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

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

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

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

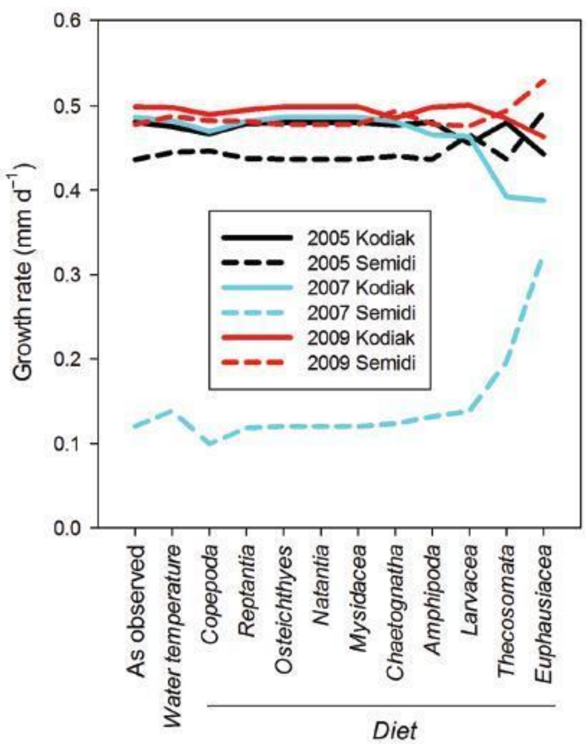


Figure 1. Bioenergetics model-based estimate of growth rate of a 70-mm SL age-0 walleye pollock with the observed weight-based diet at observed water temperatures. Lines show how growth rate estimates were affected when water temperature or the proportion of each dietary component was, in turn, equated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

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

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

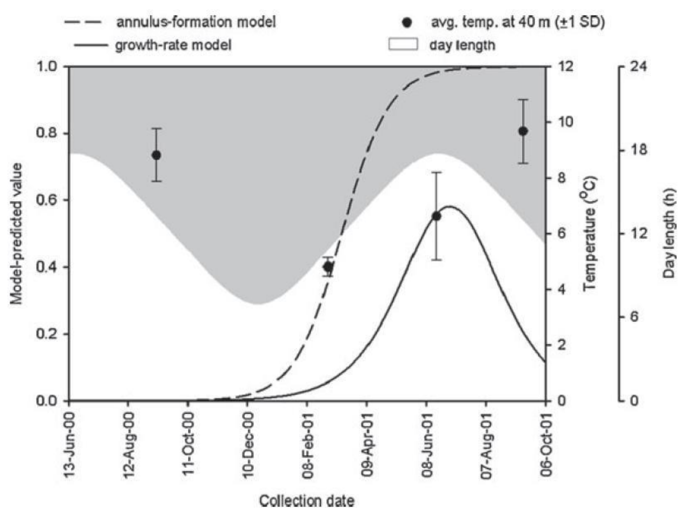


Figure 2. For age-0+ juvenile walleye pollock in the Gulf of Alaska, empirically derived models of first annulus formation and post-annulus growth rate are compared to time series of observed water temperature at 40-m depth and predicted day length.

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

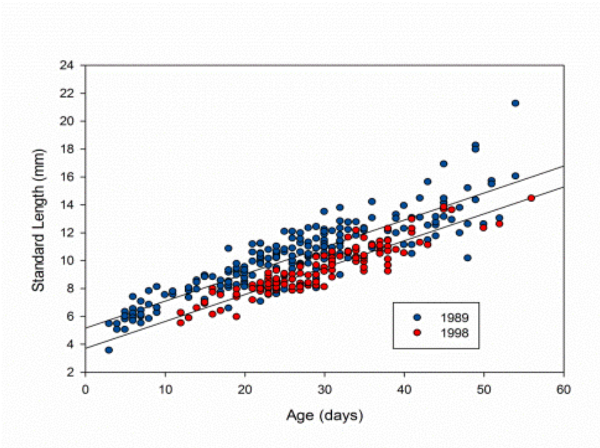
The survey conducted by Eco-FOCI during August-October 2013 to survey neritic fish populations, zooplankton, and physical oceanography encompassed an unprecedented geographic extent in the Gulf of Alaska from Unimak Pass to, but not including, Prince William Sound. Although the data and samples are currently being prepared for analysis and archival, preliminary results indicate that the 2013 year class of walleye pollock is likely to be large relative to those observed since 2000. This “early alert” has been included in presentations to the Plan Team on the Gulf of Alaska ecosystem status.

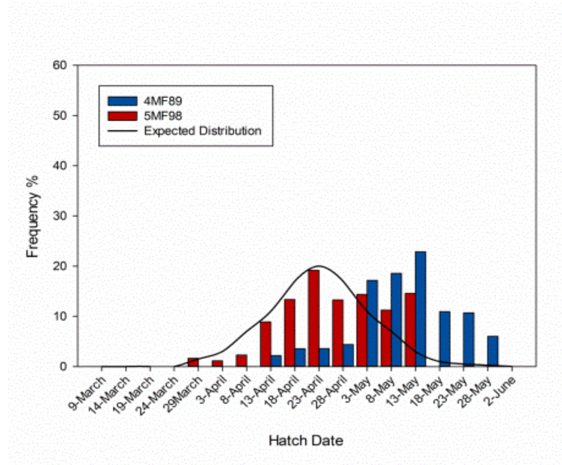
Recently, Eco-FOCI researchers have been tasked with examining the suitability of surface and midwater trawls to conduct assessment surveys of age-0 walleye pollock. Goals are threefold: to compare catch per unit effort of YOY among the gear types, to compare the size ranges of walleye pollock collected,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

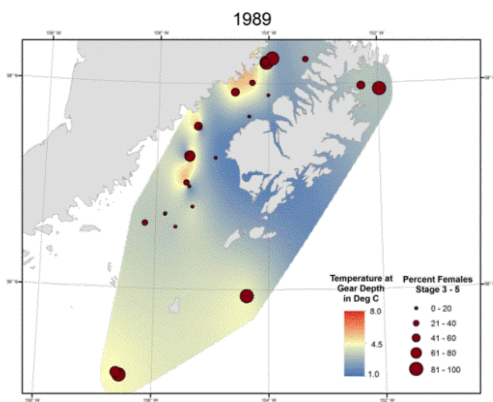
Temperature Effects on Larval Walleye Pollock (*Gadus chalcogramma*) in the Gulf of Alaska (1987-2010) and Potential Consequences on Recruitment into the Population

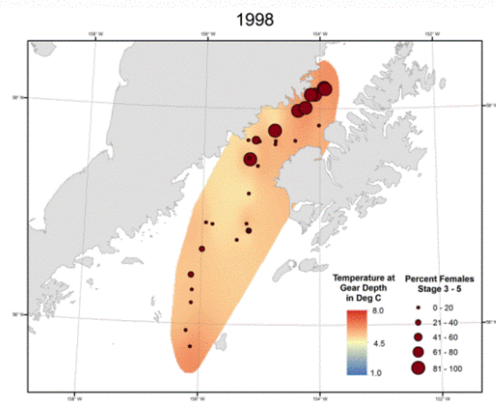
Surveys conducted from 1987-2010 by Recruitment Processes/RACE Division in the western Gulf of Alaska sampled late larval walleye pollock (*Gadus chalcogrammus*) whose otoliths were used for age and growth analyses. These analyses revealed shifts in larval length ranges and hatch date distributions, as well as significant differences in growth equations. Temperatures close to and above mean temperatures in March, such as those seen in 1998, resulted in hatch date distributions ranging over a longer time period. Years with temperatures one standard deviation below the mean in March resulted in later hatch date distributions. Cold years such as 1989 resulted in increased survival of larval walleye pollock to the age-1 life stage, which was consistent with MACE/RACE Division acoustic stock assessments and the REFM 2013 SAFE document. Although the complex biological and environmental mechanisms resulting in survival of larval pollock toward their first year are not fully understood, a shift towards later hatching may have given the larvae an initial survival advantage since a delay in development would allow larval fish more time to become in sync with the production of their preferred prey items (copedites).

Contributed by Annette Dougherty , Tiffany Vance, Kathy Mier FOCI; Darin Jones MACE









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

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

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

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

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

b. Stock Assessment

GULF OF ALASKA - REFM
The age-structured assessment model used for the GOA (west, central and western Yakutat areas) pollock assessment implemented several model changes relative to the model used for the 2013 assessment based on the 2012 CIE review, SSC, and Plan Team comments, and other considerations. The 2014 model implemented the following changes, each added to sequential models in a cumulative manner 1) starting the model in 1970 rather than 1964 and removing fishery length composition data for 1964-1971, 2) removing summer bottom trawl surveys in 1984 and 1987 and Shelikof Strait acoustic surveys in 1981-1991, 3) estimating summer bottom trawl catchability using a prior rather than fixing catchability and modeling selectivity with an asymptotic curve, 4) using a random walk for changing fishery selectivity parameters rather than time blocks, 5) using an age-specific mortality schedule with higher juvenile mortality, and 6) modeling age-1 and age-2 pollock in the winter acoustic surveys as separate indices. All composition data sets were “tuned” so that input sample sizes were close

to the harmonic mean of effective sample size. Many of these changes were implemented following SSC and Plan Team recommendations, including age-specific mortality, removing older data that had been difficult to fit, and estimating summer bottom trawl catchability. To obtain an age-specific natural mortality schedule, an ensemble approach was used which averaged the results for six methods, three multispecies models and three “theoretical empirical” methods, and then rescaled the age-specific values so that natural mortality for fish greater than or equal to age 5 was equal to 0.3, the value of natural mortality used in previous pollock assessments. The Plan Team accepted the authors’ recommended final model configuration that incorporated all of these changes. The authors also explored using a net selectivity correction for acoustic surveys calculated from field experiments using pocket nets. However, additional model exploration is needed before this model can be implemented. In addition, the method for making the net selectivity correction to the historical surveys needs to be reviewed prior to incorporating the revised estimates in the model.

This year’s pollock assessment features the following new data: 1) 2013 total catch and catch-at-age from the fishery, 2) 2014 biomass and age composition from the Shelikof Strait acoustic survey, 3) 2013 age composition from the NMFS bottom trawl survey, 4) 2014 biomass from the ADFG crab/groundfish trawl survey, 5) total catch for all years was re-estimated from original sources, and 6) fishery catch at age and weight at age were re-estimated for 1975-1999. Model fits to fishery age composition data are adequate in most years. The largest residuals tended to be at ages 1-2 of the NMFS bottom trawl survey due to inconsistencies between the initial estimates of abundance and subsequent information about year class size. Model fits to biomass estimates are similar to previous assessments, and general trends in survey time series are fit reasonably well. It is difficult for the age-structured model to fit the rapid increase in the Shelikof Strait acoustic survey and the NMFS survey in 2013. In contrast, the model expectation is close to the ADFG survey in 2013 and 2014. The fit to the age-1 and age-2 acoustic indices appeared adequate though variable. There is an indication of non-linearity in the fit to age-1 index that needs to be explored further.

The model estimate of spawning biomass in 2015 is 309,869 t, which is 39.7% of unfished spawning biomass (based on average post-1977 recruitment) which is just below the $B_{40\%}$ estimate of 312,000 t. The 2014 biomass estimate for Shelikof Strait is 842,138 t, which is a 6% decrease from 2013, but is still larger than any other biomass estimate in Shelikof Strait since 1985. The ADFG crab/groundfish survey 2014 biomass estimate is close to the 2013 estimate (2% lower). The estimated abundance of mature fish is projected to remain stable near $B_{40\%}$ or to increase over the next five years. From 2009-2013 the stock has shown an upward trend from 24% to 47% of unfished stock size, but declined to 38% of unfished stock size (spawning biomass) in 2014.

The assessment author recommended to reduce F_{ABC} from the maximum permissible using the “constant buffer” approach (first accepted in the 2001 GOA pollock assessment). Since the model projection of female spawning biomass in 2015 is below $B_{40\%}$, the W/C/WYAK Gulf of Alaska pollock stock is in Tier 3b. The projected 2015 age-3+ biomass estimate is 1,883,920 t (for the W/C/WYAK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock being below $B_{20\%}$ will be negligible in the near future.

The 2015 ABC for pollock in the Gulf of Alaska west of 140° W lon. (W/C/WYAK) is 191,309 t. This is an increase of 14% from the 2014 ABC. In 2016, the ABC based on an adjusted $F_{40\%}$ harvest rate is 250,824 t. The OFL is 256,545 t in 2015 and 321,067 t in 2016. The 2015 Prince

William Sound (PWS) GHL is 4,783 t (2.5% of the 2015 ABC of 191,309 t); the 2016 PWS GHL is 6,271 t (2.5% of the 2016 ABC of 250,824 t).

For pollock in southeast Alaska (East Yakutat and Southeastern areas), the ABC for both 2015 and 2016 is 12,625 t and the OFL for both 2015 and 2016 is 16,833 t. These recommendations are based on a Tier 5 assessment using the estimated biomass in 2015 and 2016 from a random effects model fit to the 1990- 2013 bottom trawl survey biomass estimates in Southeast Alaska, and are unchanged from last year. The Gulf of Alaska pollock stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

The assessment was updated to include the most recent data available for area apportionments within each season (Appendix C of the GOA pollock chapter) and are most likely to represent the current biomass distribution.

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

EASTERN BERING SEA - REFM

Spawning biomass in 2008 was at the lowest level since 1980, but has increased by 75% since then, with a 3% decrease projected for next year. The 2008 low was the result of extremely poor recruitments from the 2002-2005 year classes. Recent and projected increases are fueled by above average recruitment from the 2006 year class and very strong recruitment from the 2008 year class, along with reductions in average fishing mortality (ages 3-8) from 2009-2010. Spawning biomass is projected to be 39% and 32% above *BMSY* in 2015 and 2016, respectively.

New data in the 2014 assessment included the following: 1) 2014 summer bottom trawl survey abundance at age. 2) 2014 summer acoustic-trawl survey abundance at age. 3) updated 2013 summer acoustic-trawl survey abundance at age (data using an age-length key from that survey replaced those in last year's assessment that were based on an age-length key from the bottom trawl survey). 4) updated catch at age and average weight at age from the 2013 fishery. 5) updated total catch, including a preliminary value for 2014. There were no changes in the authors' recommended assessment model.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are reliable estimates both for *BMSY* and the probability density function for *FMSY*. The Plan Team concurred with the SSC's conclusion that the Tier 1 reference points continue to be reliably estimated. The updated estimate of *BMSY* from the present assessment is 1.948 million t, down 8% from last year's estimate of 2.122 million t. Projected spawning biomass for 2015 is 2.714 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 0.512, up 9% from last year's value of 0.469. The harvest ratio of 0.512 is multiplied by the geometric mean of the projected fishable biomass for 2015 (5.669 million t) to obtain the maximum permissible ABC for 2015, which is 2.9 million t, up 15% and 19% from the maximum permissible ABCs for 2014 and 2015 projected in last year's assessment.

However, as with other recent EBS pollock assessments, the authors recommend setting ABCs well below the maximum permissible levels. They list three reasons for doing so in the SAFE chapter:

1) A single year class (2008) accounts for more than half of the spawning biomass. 2) In 2014, the fleet achieved good catch rates and low salmon bycatch with an ABC far below the maximum permissible level. 3) Current low roe recovery rates may be indicative of reduced reproductive potential. During the period 2010-2013 the ABC recommendations were based on the most recent 5-year average fishing mortality rate. This year, the authors instead based their 2015 and 2016 ABC recommendations on a “replacement yield” strategy, giving a value of 1.35 million t for both years. The Team agreed that an ABC well below the maximum permissible value is appropriate, but felt that stock conditions had improved sufficiently that an increase in the ABC harvest rate was appropriate. Specifically, basing the 2015 and 2016 ABCs on the harvest rate associated with Tier 3, the stock’s Tier 1 classification notwithstanding, giving values of 1.637 million t and 1.554 million t, respectively.

The OFL harvest ratio under Tier 1a is 0.587, 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 2015 determines the OFL for 2015, which is 3.33 million t. The current projection for OFL in 2016 given a 2015 catch equal to the Team’s recommended ABC is 3.319 million t. The walleye pollock stock in the EBS is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Aleutian Islands - REFM

The new data in the model consist of updated catch information and the addition of 2014 Aleutian Islands survey data. There was one minor change in the assessment methodology, the inclusion of age one pollock in the model. This year’s assessment estimates that spawning biomass reached a minimum level of about *B29%* in 1999 and then has generally increased, with a projected value of *B34%* for 2015. The increase in spawning biomass since 1999 has resulted more from a marked decrease in harvest than from good recruitment, as there have been no above-average year classes spawned since 1989. Spawning biomass for 2015 is projected to be 70,012 t.

The SSC has determined that this stock qualifies for management under Tier 3and last year’s model was used for evaluating stock status and recommending ABC. The model estimates *B40%* at a value of 83,042 t, placing the AI pollock stock in sub-tier “b” of Tier 3. The model estimates the values of *F35%* as 0.40 and *F40%* as 0.31. Under Tier 3b, with the adjusted value of *F40%*=0.25, the maximum permissible ABC is 29,659 t for 2015. The Team recommended setting the 2015 ABC at this level. Following the Tier 3b formula with the adjusted value of *F35%*=0.32, OFL for 2015 is 36,005 t. If the 2015 catch is 1,237 t (i.e., equal to the five year average for 2009-2013), the 2016 maximum permissible ABC would be 31,900 t and the 2016 OFL would be 38,699 t. The walleye pollock stock in the Aleutian Islands is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

Bogoslof District

A Bogoslof pollock acoustic-trawl survey was conducted in 2014. The 2014 Bogoslof pollock acoustictrawl survey resulted in a biomass estimate of 112,070 t, which was an increase from the 2012 estimate of 67,100 t. The 2012 estimate was the lowest since the survey began in 1988.

Survey biomass estimates since 2000 have all been lower than estimates prior to 2000, ranging from a low of 67,063 t in 2012 to a high of 301,000 t in 2000.

The SSC has determined that this stock qualifies for management under Tier 5. The maximum permissible ABC value for 2014 would be 15,900 t (assuming M = 0.2 and $FABC$ = 0.75 x M = 0.15): ABC = B2014 x M x 0.75 = 106,000 x 0.2 x 0.75 = 15,900 t. The projected ABC for 2016 was also set at 15,900 t. Following the Tier 5 formula with M=0.20, OFL for 2015 is 21,200 t. The OFL for 2016 was set at the same level. 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. Dusky Rockfish

a. Stock Assessment

GULF OF ALASKA - ABL
Dusky rockfish, *Sebastes variabilis*, have one of the most northerly distributions of all rockfish species in the Pacific. They range from southern British Columbia north to the Bering Sea and west to Hokkaido Is., Japan, but appear to be abundant only in the Gulf of Alaska (GOA). Rockfish in the GOA are assessed on a biennial stock assessment schedule to coincide with the availability of new AFSC biennial trawl survey data. In 2014, a projection model was used with updated catch data. For the 2015 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 5,109 t. This ABC is a 7% decrease from the 2014 ABC of 5,486 t. 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

Long-term Survival and Healing of a Deep-water Rockfish After Barotrauma and Subsequent Recompression in Pressurized Tanks - ABL
Movement patterns and stock structure of deep-water rockfish (*Sebastes spp*.) are difficult to study because rockfish are physoclystic, i.e. their gas bladders are closed off from the gut, and so they often suffer internal injuries from rapid, internal air expansion when caught. From 2011-2013, we tagged and released 184 blackspotted rockfish fish at ~150-225 m and 60 others were recompressed in portable pressure tanks and slowly brought back to surface pressure. All fish exhibited some signs of barotrauma including exophthalmia ("pop-eye") (89%), everted esophagus (95%), subcutaneous emphysema (gas bubbles under the skin) (57%), ocular emphysema (air bubble under the cornea) (83%), and emphysema in the pharyngeal-cleithral membrane (99%). After re-pressurization in the tanks, the great majority of fish no longer had any external signs of barotrauma.

In 2011, 50% of fish recompressed survived long term in the lab, 60% in 2012, and 78% in 2013. This increase in survival was likely related to experience with tanks and a longer decompression schedule in 2013. When using pressurized tanks to recompress fish, it is important that adequate time is taken to depressurize fish back to surface pressure. This is species specific. For blackspotted rockfish, acute observations of fish health post-barotrauma would not be adequate. Mortalities typically occurred while fish were being recompressed (70% within 2-4 days) but 30% of mortalities occurred afterward; 17% were within a week after recompression and 13% died 3-12 months later. Of fish that survived long-term in the lab (61.6%), 41% had evidence of a previously ruptured swim bladder. This indicates that gas was released into the body cavity through ruptures in other tissues. For example, following the path of least resistance, it has been reported that gas often first fills the orbital space behind the eye. Overall, mortality increased with increasing fish length. This may be related to changes in body morphology with growth.

In 2013 a cage equipped with video capability was used to release fish at 75 m. Fish were all oriented downward when released and were capable of swimming: 33% drifted away in the current and 67% swam away. In March, 2014 a fish was recaptured in the Pacific halibut fishery 59 km away from the release location a year and a half later, demonstrating that fish can survive in the wild post capture. Since all dissected fish were immature and caught and released in inside waters, they may be less likely to be intersected by fisheries. It is possible that recaptures will increase in the coming years as fish mature. A paper is being prepared for publication.

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

Deepwater Rockfish Tagging – ABL

In the Gulf of Alaska, Aleutian Islands, and Bering Sea, commercial rockfish (*Sebastes* spp.) landings have exceeded 43,500 t annually since 2002. A large percentage of these landings are attributed to Pacific ocean perch (POP) *S. alutus*, northern rockfish *S. polyspinis*, dusky rockfish *S. variabilis*, rougheye rockfish *S. aleutianus*, and shortraker rockfish *S. borealis*. These species occupy deep water on the continental shelf and slope and are taken in directed fisheries as well as in non-directed fisheries as bycatch. Both fixed and mobile gears, including longlines and bottom trawls, are used to catch rockfish in these fisheries. Despite the value of these fisheries, many life history and biological characteristics of the fish remain poorly understood by scientists and managers.

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

The objective of this project is to investigate vertical and horizontal movement patterns, distribution, stock structure, and life history parameters of three deep-water rockfish species — Pacific ocean perch, northern rockfish, and dusky rockfish. We propose to trawl in the Gulf of Alaska near Kodiak Island with a livebox (aquarium codend) attached to a midwater trawl. Rockfish caught in the trawl will pass into the livebox and will be shunted into a calm, water-filled compartment. This compartment will protect the fish from being crushed while the net is pulled through the water and while the livebox is retrieved onto the deck of the vessel. Once on deck, rockfish will be removed from the livebox, quickly measured and tagged. Tagged fish will be loaded into a release cage, lowered to a depth at which they will be sufficiently recompressed and negatively buoyant, approximately 80 m, and the fish will be released at depth. All fish will be tagged with numbered external spaghetti tags and a subset will be tagged with either archival tags or pop-off satellite tags. Data for spaghetti- and archival-tagged fish will be recovered within the fishery, whereas, data from satellite-tagged fish will be uploaded autonomously after a preprogrammed pop-off date. This work will be completed in areas that receive substantial commercial fishing effort near Kodiak Island. By tagging in these areas, the probability of recovering spaghetti and archival tags, and thus data, will be maximized.

In 2015, we plan to tag up to 5,000 rockfish with spaghetti tags. Tag recovery data will allow us to describe rockfish movements between release and recapture locations and will elucidate distribution and migration patterns. This information is critical for understanding stock composition and habitat requirements. Additionally, spaghetti tag recoveries will allow for growth calculations which are important for stock assessments. Pop-off satellite and archival tag recoveries will provide detailed information, including time and date, temperature, depth, and location, thereby allowing a thorough description of vertical and horizontal movements and greatly enhancing our ability to describe rockfish distribution and habitat utilization.

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

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

In addition, there is a need to examine the variability of rockfish reproductive parameters over varying temporal and spatial scales. It remains unknown if there is variability in rockfish reproductive parameters at either annual or longer time scales however, recent studies suggest variation may occur for the three most commercially important species, Pacific ocean perch, *Sebastes alutus,* northern rockfish, *S. polyspinis,* and dusky rockfish *S. variabilis.* Researchers at the AFSC Kodiak Laboratory will be examining annual differences in reproductive parameter estimates of Pacific ocean perch and northern rockfish in the upcoming years. Sampling for this study was initiated in 2012 and additional samples will be collected through at least the 2015 reproductive season.

Rougheye and Blackspotted Rockfish-GAP Kodiak

The recent discovery that rougheye rockfish are two species, now distinguished as 'true' rougheye rockfish, *Sebastes aleutianus*, and blackspotted rockfish, *Sebastes melanostictus* further accents the need for updated reproductive parameter estimates for the members of this species complex. Current estimates for age and length at maturity for this complex in the GOA are derived from a study with small sample sizes, few samples from the GOA, and an unknown mixture of the two species in the complex. A critical step in improving the management of this complex is to understand the reproductive biology of the individual species that comprise it, as it is unknown if they have different life history parameters. This study re-examines the reproductive biology of rougheye rockfish and blackspotted rockfish within the GOA utilizing histological techniques to microscopically examine ovarian tissue. Maturity analyses for these species and other deepwater rockfish species within this region are complicated by the presence of mature females that are skip spawning. Preliminary results from this study indicate age and length at 50% maturity for rougheye rockfish are 15.5 years and 43.9 cm FL with 36.3% of mature females not developing or skip spawning. Samples of blackspotted rockfish were also collected and analyzed during this time period. Preliminary results indicate length at 50% maturity for blackspotted rockfish is 44.3 cm FL with 94% of mature females collected for this study skip spawning. The analyses of these data is complicated by the presence of both skip spawning individuals within the sample as well as a large number of large and/or old immature individuals. More samples are needed to clarify the reproductive parameters of this species.

These updated values for age and length at maturity have important implications for stock assessment in the GOA.

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

Shortraker rockfish (in collaboration with Charles Hutchinson, AFSC age and growth laboratory)

Currently stock assessments for shortraker rockfish, *Sebastes borealis* utilize estimates of reproductive parameters that are problematic due to limited sample sizes and samples taken during months of the years that may not be optimum for reproductive studies. The current study results indicate a length of 50% maturity of 49.5 cm which is a larger than the value currently used in the stock assessment of this species (44.5 cm). In addition this study found a skip spawning rate of over 50% for this species during the sampling period. Length at maturity data for this species were later utilized to derive an indirect age at 50% maturity for this species based on converting the length at maturity to an age at maturity. However, the ages used for this conversion were considered experimental, and additional samples are needed for updated, direct determination of the age at 50% maturity when the aging methodology for shortraker rockfish becomes validated. Researchers at the AFSC Age and Growth lab have initiated a study to initiate the aging of shortraker rockfish. Due to difficulties with aging this species which attains very old ages, additional collaborative work with other agencies is being pursued to develop a consistent methodology for aging this species.

Blackspotted and rougheye rockfish field identification project – ABL in collaboration with RACE

There is difficulty in accurate at-sea field identification between the two species. Previous studies have found that, when compared to genetic identifications, field scientists had a misidentification rate of approximately 46% (samples in eastern GOA near Yakutat), while the expert (Jay Orr) had misidentification rates of 9%. In addition, if differences in growth and maturity exist, one species may be at greater risk to overfishing than the other.

In response to these concerns, special projects were initiated during the 2009 and 2013 GOA bottom trawl survey. The goals of these projects were to collect relevant biological and genetic data to improve at-sea identification, adjust the species-specific biomass estimates based on misidentification rates, and examine differences in life history characteristics between the two species. Field scientists collected length, weight, and muscle tissue (2009) or fin clips (2013) from most rougheye and blackspotted rockfish sampled for otoliths. Additionally, most of the unidentified rougheye/blackspotted specimens were sampled for genetics.

For the 2009 survey, 895 fish were genetically identified in the lab. Overall (not including hybrids or fish unidentified in the field) these results show a 23% misidentification rate. This is a substantial improvement over previous studies. Of the genetically identified rougheye rockfish (n=307), only 6% were incorrectly identified in the field as blackspotted rockfish and 1% were unidentified. Of the genetically identified blackspotted rockfish (n=577), 31% were incorrectly identified in the field as rougheye rockfish and 3% were unidentified. Hybrids existed between the two species (n=11). These hybrids were mostly identified as rougheye rockfish in the field (82 %).

Trawl survey data were adjusted for species misidentification rates to compute species specific biomass estimates and age compositions. For the 2009 survey the adjusted data indicated that 47%, 51%, and 2% of the estimated biomass was comprised of rougheye, blackspotted, and hybrids, respectively. Prior to this adjustment the estimated biomass was 63% rougheye and 37% blackspotted rockfish.

Data from the 2013 trawl survey have been analyzed for species misidentification rates, but ages have not been determined. Preliminary analysis of the 2013 survey data show that there have been some continued improvements in species identification with overall misidentification rates of 13% compared to 23% from the 2009 survey. The identification of blackspotted rockfish improved substantially compared to 2009. Of the genetically identified blackspotted rockfish (n=424), only 15% were incorrectly identified in the field as rougheye rockfish compared to 31% in 2009. The identification of rougheye rockfish somewhat worsened compared to 2009. Of the genetically identified rougheye rockfish (n=429), 11% were incorrectly identified in the field as rougheye rockfish compared to 6% in 2009.

Trawl survey age compositions for 2009 corrected for misidentification rates indicated that the average age was 20 years for blackspotted rockfish and 15 years for rougheye rockfish (see figure below). The majority of the age composition for rougheye rockfish was less than 20 years old whereas blackspotted rockfish had a more uniform age composition. The 2009 genetically identified and aged fish (n=878, hybrids=11) found differences in growth between the two species. Rougheye rockfish grow faster and typically attain a greater maximum size than blackspotted rockfish (Figure 1).

The estimated Von Bertalanffy growth parameters for the two species based on the samples taken in the 2009 bottom trawl survey were as follows (Figure 2):

	Rougheye	Blackspotted
Sample Size	298	570
L_∞ (mm)	536	519
κ	0.109	0.065
t_0	0.250	0.250

In the future, we would like to extend this sampling to commercial fisheries as a special project requested of the Observer Program. When combined with accurate species-specific catch and survey data, such information will help determine the utility of a split-species complex model or separate species models for examining if one species may be at greater risk to overfishing. At present, the area-specific harvest rates for RE/BS rockfish have been on average low and catches have consisted of approximately half the ABC in recent years.

For further information please contact Jon Heifetz (907) 789-6054 or jon.heifetz@noaa.gov

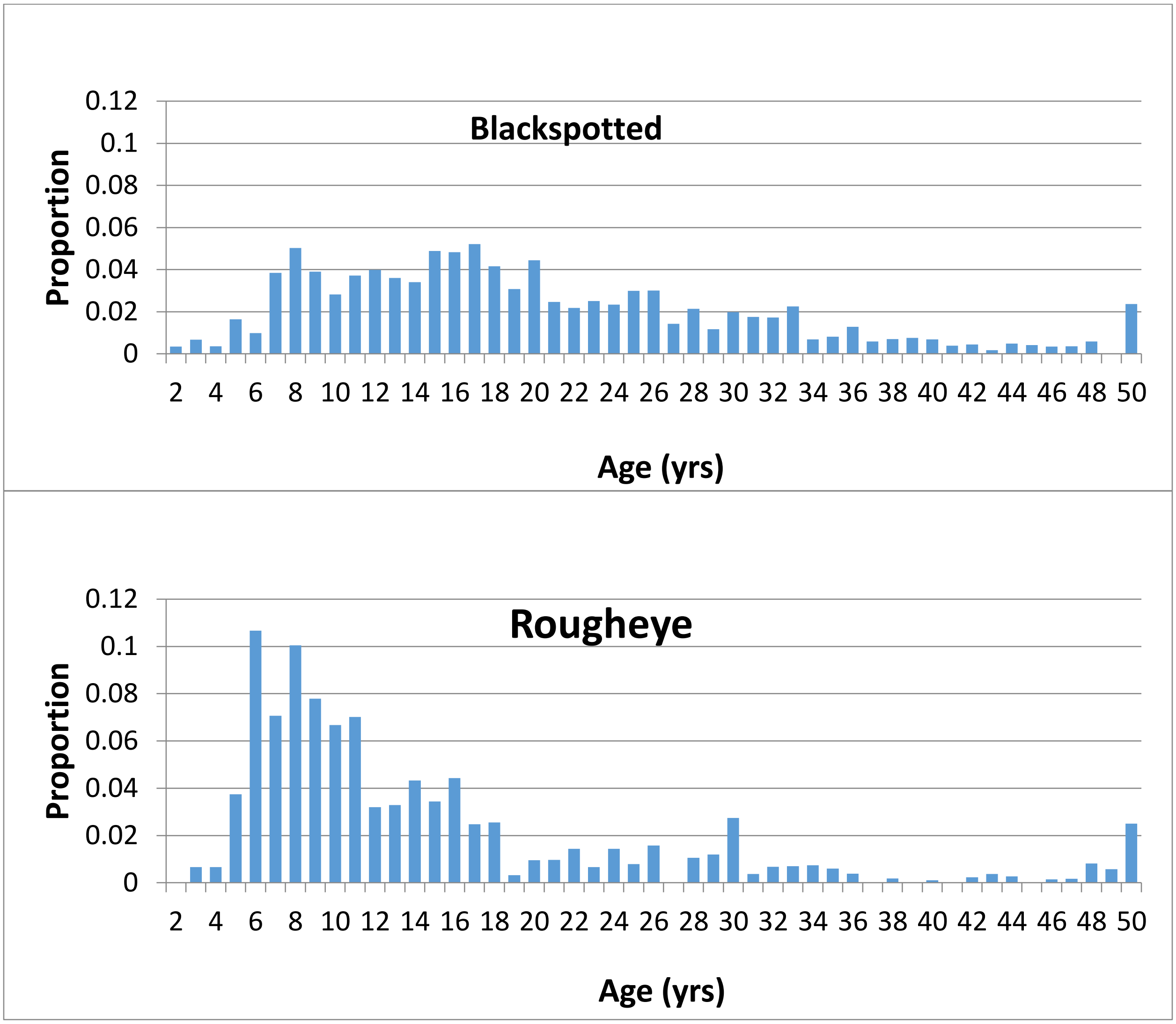


Figure 10. Age composition of rougheye and blackspotted rockfish from the 2009 trawl survey.

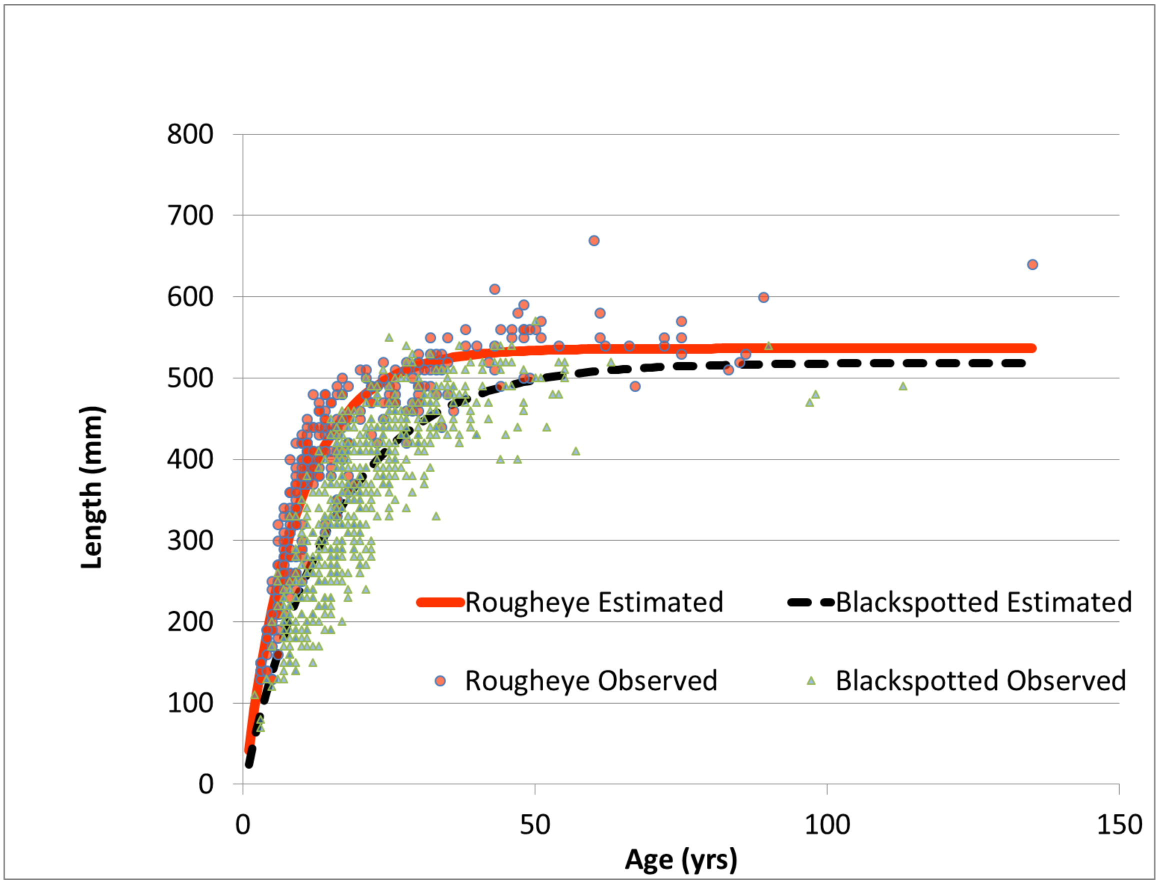


Figure 2. Estimated Von Bertalanffy growth curves for genetically identified rougheye and blackspotted rockfish from the 2009 trawl survey.

b. Stock Assessment

Pacific Ocean Perch (POP)

BERING SEA AND ALEUTIAN ISLANDS - REFM

Pacific ocean perch (POP) assessments are conducted on a two-year cycle to coincide with planned Aleutian Islands surveys. Since the Aleutian Islands were surveyed in 2014, a full assessment was conducted to determine the 2015 harvest.

The survey biomass estimates and age composition data from the U.S.-Japan cooperative survey in 1980, 1983, and 1986 were removed from the assessment. The 2014 AI survey biomass estimate and length composition were included in the assessment as well as the 2012 AI survey and 2013 fishery age compositions and the 2012 fishery length composition. The length-at-age, weights-at-age, and age-to-length conversion matrix were updated based on data from the NMFS AI trawl survey beginning in 1991.

The 2014 AI survey biomass is large and consistent with the survey biomass estimates in 2010 and 2012, and the size composition data continue to show relatively strong cohorts from 1994 to 2000. A bicubic spline model was used to estimate fishery selectivity as a function of year and age. The multinomial input sample sizes for the age and length composition data were changed using an iterative reweighting procedure that ensures that the standard deviation of the normalized residuals for each composition data type is 1.

Spawning biomass is well above the *B40%* reference point and projected to be 234,426 t in 2015 and to decline to 223,744 t in 2016. Large recruitments in the late 1990s have driven up recent estimates of stock abundance. The SSC has determined that reliable estimates of *B40%, F40%,* and *F35%* exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of *B40%, F40%,* and *F35%* are 169,203 t, 0.089, and 0.0109 respectively. Spawning biomass for 2015 (234,426 t) is projected to exceed *B40%*, thereby placing POP in sub-tier "a" of Tier 3. The 2015 and 2016 catches associated with the *F40%* level of 0.089 are 34,988 t and 33,550 t, respectively, and were the authors' and Plan Team's recommended ABCs. The 2015 and 2016 OFLs are 42,558 t and 40,809 t.

A random effects model was used to regionally set ABC based on the proportions of model-based estimates of ending year survey biomass that were for 2015: BS = 8,771 t, Eastern Aleutians (Area 541) =8,312 t, Central Aleutians (Area 542) = 7,723 t, and Western Aleutians (Area 543) = 10,182 t. The recommended OFL for 2015 and 2016 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 - ABL
Pacific ocean perch (POP), *Sebastes alutus*, is the dominant fish in the slope rockfish assemblage and has been extensively fished along its North American range since 1940. Since 2005, Gulf of Alaska rockfish have been moved to a biennial stock assessment schedule to coincide with the biennial AFSC trawl survey that occurs in this region. In even years (such as 2014's assessment for the 2015 fishery) there is no new trawl survey data available, and usually a projection model is run to provide forecast estimates of abundance. However, in 2014 a full assessment was performed in order to include new maturity data into the assessment. This new information indicated a younger age at 50% maturity than in previous assessments. For the 2015 fishery, we recommended the maximum permissible ABC of 21,012 t. This ABC was a 9% increase from the 2014 ABC of 19,309 t. Overfishing was not occurring, the stock was not overfished, and it was not approaching an overfished condition.

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

Northern Rockfish

BERING SEA AND ALEUTIAN ISLANDS - REFM
Northern rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. Since the Aleutian Islands were surveyed in 2014, a full assessment was presented for catch advice in 2015.

Catch was updated through October 11, 2014. The survey biomass estimates and age composition data from the U.S.-Japan cooperative surveys in 1980, 1983, and 1986 were removed from the assessment. The 2014 AI survey biomass estimate and length composition were included in the assessment. The 2012 AI survey age composition was included in the assessment. The 2012 and 2013 fishery length compositions were included in the assessment. The length-at-age, weights-at-age, and age-to-length conversion matrix were updated based on data from the NMFS AI trawl surveys beginning in 1991. The multinomial input sample sizes for the age and length composition data were obtained by an iterative reweighting procedure that ensures that the standard deviation of the normalized residuals for each composition data type is 1.

The 1980s cooperative surveys had low biomass estimates relative to the remainder of the time series, and removal of these data increased the estimated population size. Spawning biomass has been increasing slowly and almost continuously since 1977 until recent years, where it appears to be leveling off. Female spawning biomass is projected to be 94,873 t and 93,540 t in 2015 and 2016, values well above *B40%.*. Recent recruitment has generally been below average.

The Plan Team agreed with the author's recommended changes to the model. The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for *B40%* (57,768 t), *F40%* (0.070), and *F35%* (0.088). Because the projected female spawning biomass of 94,873 t is greater than *B40%*, sub-tier "a" is applicable, with maximum permissible *FABC* = *F40%* and *FOFL* = *F35%*. Under Tier 3a, the maximum permissible ABC for 2015 is 12,488 t, which was the recommendation for the 2015 ABC. Under Tier 3a, the 2014 OFL is 15,337 t for the Bering Sea/Aleutian Islands combined. The Plan Team recommended setting a combined BSAI OFL and ABC. The Team recommendation for 2016 ABC is 12,295 t and the 2016 OFL is 15,100 t.

Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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

GULF OF ALASKA-ABL

The northern rockfish, *Sebastes polyspinis*, is a locally abundant and commercially valuable member of its genus in Alaskan waters. As implied by its common name, northern rockfish has one of the most northerly distributions among the 60+ species of *Sebastes* in the North Pacific Ocean. Since 2005, Gulf of Alaska (GOA) rockfish have been moved to a biennial stock assessment schedule to coincide with the AFSC trawl survey. An age-structured assessment (ASA) model is used to assess northern rockfish in the GOA; the data used in the ASA model includes the trawl survey index of abundance, trawl survey age and length composition, fishery catch biomass, and fishery age and length composition. Updated catch data is the only data available in even years, while in odd years a full assessment is run that includes both updated survey and catch data since the last full assessment. In 2014 a projection model was performed with new catch data implemented to determine ABC. The result was a recommended ABC for 2015 of 4,999 t; this ABC was 6% less than the 2014 ABC of 5,324 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

A full assessment was made for shortraker rockfish in 2014 due to the completion of the Aleutian Islands survey. The 2014 biomass estimate is based on the Aleutian Island survey data through 2014 as well as the 2002-2012 eastern Bering Sea slope survey data. The EBS slope survey data had not been included in previous biomass estimates for this species. Catch data have been revised and updated through October 31, 2014. For estimation of biomass, the assessment methodology was changed from a Kalman filter version of the Gompertz-Fox surplus production model to a simple random effects model.

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

The SSC has previously determined that reliable estimates of only biomass and natural mortality exist for shortraker rockfish, qualifying the species for management under Tier 5. The Plan Team recommended basing the biomass estimate on the random effects model. The recommended *FABC* 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 *maxFABC* value of 0.0225. The ABC is 518 t for 2015 and 2016 and the OFL is 690 t for 2015 and 2016.

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

GULF OF ALASKA - ABL
Rockfish in the Gulf of Alaska (GOA) are assessed on a biennial assessment schedule to coincide with new data from the AFSC biennial trawl surveys in the GOA. A straightforward update of the assessment was presented in an executive summary because the GOA survey was not conducted in 2014. Catch data were updated.

Shortraker rockfish has always been classified into “tier 5” in the North Pacific Fishery Management Council’s (NPFMC) definitions for ABC and overfishing level, in which the assessment is mostly based on averaging the exploitable biomass from the three most recent trawl surveys (presently the 2009, 2011, and 2013) to determine the recommended ABC. For an off-cycle year, there is no new survey information for shortraker rockfish; therefore, the 2013 estimates are rolled over. Estimated shortraker biomass is 58,797 mt, which is identical to the 2013 assessment biomass estimate. The NPFMC’s “tier 5” ABC definitions state that $F_{ABC} \leq 0.75M$, where *M* is the natural mortality rate. Using an *M* of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 1,323 t for the 2015 fishery. Gulfwide catch of shortraker rockfish was 730 t in 2013 and estimated at 559 t in 2014. Shortraker rockfish in the GOA is not being subjected to overfishing, It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

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

Blackspotted/rougheye Rockfish Complex

BERING SEA AND ALEUTIAN ISLANDS - REFM

A full stock assessment was completed for 2014, the first since 2012. The assessment features an age-structured statistical model for the Aleutian Islands (Tier 3) and a Tier 5 assessment for the Bering Sea component of the stock. New data in this assessment included: updated catch for 2013 and catch for 2014 through October 11, 2014 fishery length composition data were included for 2012 and 2013 the 2014 AI survey biomass estimate and length composition was included the 2012 AI survey age composition was included. The survey biomass estimates and age composition data from the U.S.-Japan cooperative survey in 1980, 1983, and 1986 were removed from the assessment. The length-at-age, weights-at-age, and age-to-length conversion matrices were updated based on data from the NMFS AI trawl survey beginning in 1991. Two major changes were made in the age-structured model for the AI component of this stock complex: After evaluating several alternative methods of parameterizing selectivity, the recommended model uses a double logistic curve to model fishery selectivity. Multinomial input sample sizes for the age and length composition data were obtained by an iterative reweighting procedure that ensures that the standard deviation of the normalized residuals for each composition data type is 1.

A simple random effects model was used to estimate current biomass for the EBS component of this stock complex. Total biomass for the AI component of the stock in 2015 is projected to be 40,327 t which is an increase from last year's projected 2014 value of 29,087 t. For the period 1977-2014, the current (2014) estimate of female spawning biomass is the all-time high. Female spawning biomass is projected to increase further to 7,921 t in 2015 and 8,993 t in 2016. These projected increases are fueled by extremely large year classes spawned in 1998, 2002, and 2006.

Application of the random effects model produces an estimated biomass for the SBS area of 1,339 t for 2015, a small decrease from last year's estimate of 1,389 t.

As was the case with the two most recent full assessments in 2010 and 2012, there was a concern about the appropriate range of year classes to use when estimating average recruitment. This year, the authors recommended using year classes up through 1998, but the Team recommends using year classes up through 1996 only, as this would correspond to the result of the formula recommended by the recruitment working group. The difference in the recommended range of year classes causes the Team's *B40%* estimate to differ from that of the authors, which in turn affects the recommended ABCs. The values listed in this summary correspond to the Plan Team's estimate of *B40%*. For the Aleutian Islands, this stock qualifies for management under Tier 3 due to the availability of reliable estimates for *B40%*, *F40%* , and *F35%*. Because the projected female spawning biomass for 2015 of 7,921 t is greater than *B40%*, (5,535 t) the stock qualifies as Tier 3a and the adjusted *FABC* = *F40%*values for 2015 and 2016 are 0.047 and 0.058, respectively. The maximum permissible ABC for the Aleutian Islands is 615 t, which is the authors' and Team's recommendation for the AI portion of the 2015 ABC.

Under Tier 3a, the 2015 OFL is 799 t for the combined BSAI region. The apportionment of 2015 ABC to subareas is 445 t for the Western and Central Aleutian Islands and 203 t for the Eastern Aleutian Islands and Eastern Bering Sea. The Team recommends an overall 2016 ABC of 702 t and a 2016 OFL of 865 t. Given on-going concerns about fishing pressure relative to biomass in the Western Aleutians, the SSC requested that the potential apportionment by sub-area be calculated and presented. The blackspotted and rougheye rockfish complex is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OFALASKA - ABL

Rougheye (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*) have been assessed as a stock complex since the formal verification of the two species in 2008. We use a statistical age-structured model as the primary assessment tool for the Gulf of Alaska rougheye and blackspotted rockfish (RE/BS) stock complex which qualifies as a Tier 3 stock. Rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. However, due to the 2013 government shutdown, we presented an executive summary in 2013, similar to an off-cycle year, to recommend harvest levels for the next two years. Because of the availability of new longline survey data and additional aging data in 2014, we conducted a full assessment for the 2015 fishery. New and updated data added to this model include updated catch estimates for 2011-2013, new catch estimates for 2014-2016, new fishery ages for 2009 and 2012, new fishery lengths for 2010 and 2011, a new trawl survey estimate for 2013, updated trawl survey ages for 2009, new trawl survey ages for 2011, and fully revised longline survey abundance estimates and length frequencies (1993-2014). We now use the time series of relative population numbers (RPNs) rather than relative population weights (RPWs) to represent the longline survey abundance. Use of the RPNs follows what is done for the sablefish assessment model. New biological data on growth and aging error were used to update the weight-at-age estimates, the size-at-age conversion matrix, and the aging error matrix. For the 2015 fishery, we recommended the maximum allowable ABC of 1,122 t from the updated projection model. This ABC is 10% less than last year's ABC of 1,244 t and similarly less than last year's projected 2015 ABC of 1,262 t. The stock is not overfished, nor is it approaching overfishing status.

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

Other Rockfish Complex

BERING SEA AND ALEUTIAN ISLANDS - REFM

New data in the 2014 assessment included updated catch and fishery lengths for 2014. Biomass estimates, CPUE, and length frequency compositions were also included from the 2014 Aleutian Island trawl survey, and the 2013 and 2014 eastern Bering Sea shelf survey. There was no Bering Sea slope survey in 2014. Of the new data, only the survey biomass estimate is used in computing recommended ABCs and OFLs. In previous assessments, a 4-6-9 weighted average of three most recent surveys for each region (Aleutian Islands, Bering Sea shelf, and Bering Sea slope) had been used to calculate the BSAI other rockfish biomass estimate. To remain consistent with other Tier 5 assessments, a random effects model was used for each region to calculate the biomass estimate for the entire BSAI area.

Trends in spawning biomass are unknown for the species of the "Other rockfish" complex. The 2014 assessment reported that biomass of other rockfish was at an all-time high in both the most recent EBS slope survey (2012) and this year's AI survey. *FABC* was set at the maximum allowable under Tier 5 (*FABC* = 0.75*M*). The accepted values of *M* for species in this complex are 0.03 for shortspine thornyheads and 0.09 for all other species. Multiplying these rates by the best biomass estimates of shortspine thornyhead and other rockfish species in the "other rockfish" complex yields 2015 and 2016 ABCs of 695 t in the EBS and 555 t in the AI. The Team recommends that OFL be 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 1,667 t for 2015 and 2016.

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 ALAKSA - ABL
The Other Rockfish complex in the Gulf of Alaska (GOA) is comprised of 25 species, but the composition of the complex varies by region. The species that are included across the entire GOA are the 15 rockfish species that were previously in the “Other Slope Rockfish” category together with yellowtail and widow rockfish, formerly of the “Pelagic Slope Rockfish” category. Northern rockfish are included in the Other Rockfish complex in the eastern GOA and the Demersal Shelf rockfish species are included west of the 140 line (i.e. all of the GOA except for NMFS area 650). The primary species of “Other Rockfish” in the GOA are sharpchin, harlequin, silvergray, and redstripe rockfish; most of the others are at the northern end of their ranges in Alaska and have a relatively low abundance here. Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the AFSC biennial trawl surveys in the GOA. The next full assessment will be completed in the fall of 2015.

All species in the group are classified into “tier 5” or “tier 4” (only sharpchin rockfish is “tier 4”) in the NPFMC definitions for acceptable biological catch (ABC) and overfishing level (OFL), in which the assessment is mostly based on biomass estimates from trawl surveys, instead of modeling. As in previous assessments since 1994, an average of the Gulf-wide biomass from the three most recent trawl surveys (presently the 2009, 2011, and 2013 surveys) is used to determine current exploitable biomass. This results in a current exploitable biomass of 83,383 t for Other Rockfish. Applying either an $F_{ABC} \leq F_{40\%}$ rate for sharpchin rockfish or an $F_{ABC} \leq 0.75M$ (M is the natural mortality rate) for the other species to the exploitable biomass for Other Rockfish results in a recommended ABC in the GOA of 4,079 t for 2014 and 2015. This is an increase of 1% compared to the 2013 ABC of 4,045 t for Other Rockfish. While the overall survey biomass was similar to the previous survey (85,774 t in 2011), the composition of the species included changed. The Demersal Shelf Rockfish species had not previously been included in the biomass calculations. With the inclusion of the new species, the large decline in biomass observed for silvergray rockfish did not impact the overall exploitable biomass substantially. Gulfwide catch of Other Rockfish was 818 t and 988 t in 2013 and 2014, respectively. Other rockfish is not considered overfished in the Gulf of Alaska, nor is it approaching overfishing status. However, the apportioned ABC for the Western GOA has often been exceeded. Beginning in 2014, the Western and Central GOA apportioned ABCs were combined. This was not deemed a conservation concern because the combined catch of the Western and Central GOA does not always exceed the combined ABC of the two areas, nor is the catch of Other Rockfish approaching the complex ABC.

Catch composition is quite different from survey composition. There are three species which are poorly sampled by the survey, but occur in the catch, and ABC was exceeded in the last two years (harlequin, widow, and yelloweye). Widow rockfish is a species with relatively low biomass in the complex and the ABC = 2 t, but annual catch averages ~ 16 t. Catch of harlequin and yelloweye rockfish average ~ 450 t and 156 t, respectively, exceeding the ABCs of 365 t and 20 t, respectively. These species tend to inhabit untrawlable habitat, and thus, the biomass indices are likely an underestimate. Yelloweye rockfish is mostly caught in hook and line fisheries, as well as Alaska state fisheries, thus catch in the federal assessment may not capture all sources of catch. Harlequein, on the other hand, are the major species caught in the Other Rockfish complex and are mostly caught in the rockfish trawl fishery. This could be a conservation concern because it unknown to what degree the trawlable/untrawlable habitat impacts the survey biomass estimates. Species specific ABCs are not used for management, they are summed to create a complex ABC/OFL, which is used for management.

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

5. Thornyheads

a. Stock Assessment

GULF OF ALAKSA - ABL

Gulf of Alaska thornyheads (*Sebastolobus* species) are assessed as a stock complex under Tier 5 criteria using the assessment methodology introduced in 2003. We use the exploitable biomass from the most recent trawl survey to determine the recommended ABC for thornyheads. This complex is assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For Gulf of Alaska thornyheads, 2014 was an even year that has no new survey data available, so we presented an executive summary that rolls over the same recommendations from the 2013 assessment. The total estimated biomass of 81,816 t results in a recommendation of maximum allowable ABC of 1,841 t for thornyhead rockfish. Catch levels remain below the TAC and the stock was not being subjected to overfishing last year.

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

6. Sablefish

a. Research

Sablefish Tag Program - ABL

The ABL MESA Program continued the processing of sablefish tag recoveries and administration of the tag reward program and Sablefish Tag Database during 2014. Total sablefish tag recoveries for the year were around 700. Twenty nine percent of the recovered tags in 2014 were at liberty for over 10 years. About 40 percent of the total 2014 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 34 percent within 100 – 500 nm, 17 percent within 500 – 1,000 nm, and 9 percent over 1,000 nm from their release location. The tag at liberty the longest was for approximately 36 years, and the greatest distance traveled of a 2014 recovered sablefish tag was 1,998 nm. Two adult sablefish and two juvenile sablefish tagged with archival tags were recovered in 2014. Data from these electronic archival tags, which will provide information on the depth and temperature experienced by the fish, are still being analyzed.

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, and rougheye and blackspotted rockfish are also maintained in the Sablefish Tag Database. Twenty four thornyhead, one blackspotted rockfish, and one archival Greenland turbot tag were recovered in 2014.

Releases in 2014 totaled 2,778 adult sablefish, 123 juvenile sablefish, 738 shortspine thornyheads, and five greenland turbot. Pop-up satellite tags (PSAT) were implanted on 43 sablefish and three blackspotted rockfish. 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 2014. A total of 123 juvenile sablefish were caught and tagged and released in St John Baptist Bay near Sitka, AK over 4 days (July 15th – July 18th) with 90 rod hrs. A biologist from the Alaska Department of Fish and Game participated for one of the days. Total catch-per-unit-effort (CPUE) equaled 1.36 sablefish per rod hour fished. This was down significantly from 2013 (2.29) and lower than the 5-year average. Juvenile sablefish had a mean length of 33 cm fork length (95% CI, 29-36 cm). The St. John Baptist Bay juvenile sablefish tagging cruise will likely be conducted again in 2015 at the end of May. Due to reports of high young of the year presence reported in 2014, tagging may also be conducted in other areas in summer 2015 such as Prince William Sound or Kodiak.

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

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

It is preferable to gauge maturity status (if a fish will spawn in the future spawning season) just prior to spawning when oocytes are easily discernable. Sablefish were sampled in December of 2011, immediately before the spawning season nearby Kodiak Island, which is near the center of their Alaska distribution. Skipped spawning was documented in sablefish for the first time. These could be identified by the combination having only immature oocytes and a much thicker ovarian wall than immature fish, measured from histological slides (Figure 1). These characteristics indicated that sablefish exhibit the resting type of skipped spawning, where vitellogenic oocytes (containing yolk) are not produced. Age at maturity estimates were heavily influenced by whether these skipped spawners were classified as mature or immature; the age at 50% maturity when skipped spawners were classified as mature was 6.8 years and 9.9 when classified as immature. Skipped spawning fish were identified primarily on the shelf (19 of 22 skip spawning fish were on the shelf, total study sample size = 394). Weight specific fecundity was not related to fish size or age, indicating that relative reproductive output stays constant, verifying the assumption made in the stock assessment that total egg productions is linearly related to female spawning biomass. Four satellite tags were deployed during the cruise and programmed to pop-off after a month to two months. Despite being highly migratory throughout their lives, all four of the sablefish exhibited sight fidelity within the spawning season; the two tagged on the slope remained on the slope and the two caught on the slope and released on the shelf, moved back to where they were caught on the slope.

This year a project was funded to sample the same area that was sampled in 2011 during the summer and winter of 2015. Since skipped spawning sablefish did not produce vitellogenic oocytes, they can be identified during the summer when fish that will spawn have developed vitellogenic oocytes. It is currently unknown when during the summer this occurs. Energy reserves are linked to skipped spawning in other species. The liver synthesizes vitellogenin and so the ratio of liver weight to body weight may be a good predictor of whether a female sablefish will spawn. Goals of this project include acquiring more data on the distribution and prevalence of skipped spawning, relating energy reserves to whether a fish will spawn, improving determinations of maturity during the summer, and evaluating methods to incorporate skipped spawning into maturity ogives for sablefish.

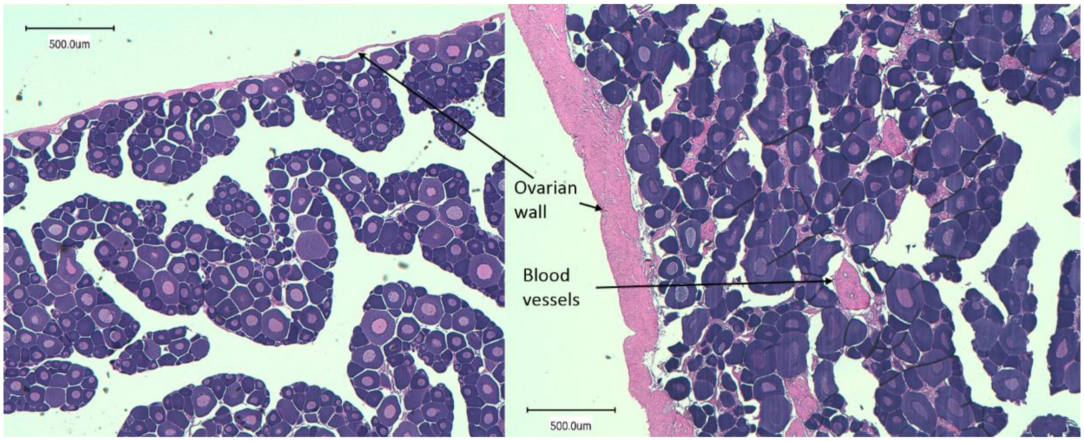


Figure 1. Images of histology slides made from an ovarian section from an immature female sablefish (left) and a skipped spawning female (right).

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

Juvenile Sablefish Ecology – ABL and UAF
Juvenile sablefish are commonly found in nearshore waters; however, the characteristics that make this habitat preferable are not well understood. This joint study between ABL and UAF investigated the diet composition of juvenile sablefish, quantified seasonal and ontogenetic shifts in diet, and assessed nearshore habitat use.

Pulsed resources create an influx of energy that can provide individual and population level benefits to their consumers. As consumers, sablefish experience strong seasonal pulses in prey resources during their period of juvenile growth in the nearshore marine environment. This study described temporal patterns in diet composition of sablefish (N=1,081) ranging in size from 226 mm to 455 mm FL during summer and fall, 2012-2013, in St. John Baptist Bay, Alaska. Juvenile sablefish exploited a large variety of prey taxa characteristic of a generalist predator, with significant diet shifts among sampling periods revealing seasonal and interannual variation in resource use (ANOSIM; Global R=0.278, p<0.001). Diets were more diverse in 2012, when more invertebrate taxa were consumed, compared to 2013, when diets were dominated by Pacific herring and salmonid offal. In September of 2012 and 2013, spawning pink salmon (*Oncorhynchus gorbuscha*) were observed within the study area and juvenile sablefish capitalized on this high energy subsidy, with salmon carcasses among the top contributors to their diets by weight. However, sablefish also exploited lower energy in situ prey, such as benthic invertebrates, suggesting that they are not entirely reliant on seasonally pulsed, high energy prey. This study emphasizes the significance of salmon as a vector of energy across ecosystems and is one of the first to document a marine teleost species scavenging on adult salmon carcasses in coastal marine waters.

Describing fine-scale movements of juvenile sablefish can provide insight into their mechanisms for survival in nearshore habitats. Juvenile sablefish have been found to eat benthic and pelagic prey, implying potential vertical migration off the bottom to forage, however little is known about their fine-scale movement. This study assessed the vertical movement patterns of juvenile sablefish in relation to daylight and tidal cycles using acoustic telemetry. Thirteen juvenile sablefish were implanted with acoustic transmitters and monitored by 2 acoustic receivers from 5 Oct to 14 Nov 2003 within St. John Baptist Bay, Baranof Island, Alaska. The six fish that remained within range of the receivers spent the majority of time near the bottom, but made periodic vertical excursions. Generalized linear mixed models were used to determine the relationship between excursion frequency and environmental factors. Excursions were influenced by tide and diel conditions, with a higher excursion frequency at dawn and during slack and flood stages and a lower excursion frequency at night. Flood and slack tide may create an influx of pelagic prey resources, which could lead to the more frequent vertical movement of juvenile sablefish during these tide stages. Higher probability of excursions at dawn may be due to factors such as predator avoidance or increased prey movement at crepuscular periods. To date, this is the first study describing vertical migration of juvenile Sablefish in the wild and reveals that environmental conditions have the potential to affect the fine-scale movements of juvenile sablefish within nearshore habitats.

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

Sablefish Archival Tagging Study - ABL

During the 1998, 2000, 2001, and 2002 AFSC longline survey, 600 sablefish were implanted and released with electronic archival tags that recorded depth and temperature. These archival tags provide direct insight into the vertical movements and occupied thermal habitat of a fish. 127 of these tags have been recovered and reported from commercial fishing operations in Alaskan and Canadian waters. Analysis of these data began in 2011 continued in 2012 and 104 of these tags have been analyzed to date. Temporal resolution of depth and temperature data ranged from 15 minutes to one hour, and data streams for an individual fish ranged from less than a month to greater than five years. After a hiatus during 2013-2014, data analysis will resume in 2015 or 2016. For more information, contact Mike Sigler mike.sigler@noaa.gov or Pete Hulson pete.hulson@noaa.gov.

Sablefish Satellite Tagging - ABL

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

We had about a 50% success rate of the 2014 released PSATs, the highest of all three years of sampling. Success means that the tag stayed on the fish until the programmed release date, and successfully reported the pop-off location as well as archived data collected while on the fish. Tags were on the fish anywhere from 6 – 9 months, depending on when the fish was tagged on the LL survey in the summer. Data is still being processed and analyzed, but both long and short migrations were observed within the 6 - 9 months of tracking. For more information, contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

Sablefish – Whale depredation research -ABL

Sperm whales in the Gulf of Alaska depredate (remove or damage fish caught on fishing gear) on the annual National Marine Fisheries Service Alaska longline survey. Sperm whale depredation can reduce sablefish catch rates and increase the uncertainty of estimates of sablefish abundance and biomass derived from the longline survey. Prior studies that estimated the effect of sperm whale depredation were all fixed-effects models. However, the occurrence of whale depredation is sporadic – creating unbalanced data – and analysis of unbalanced designs using fixed-effects models can results in poor estimation and inference compared to mixed-effects models. In addition, the data within and among longline survey stations is likely correlated, which is also better handled with random effects. We compared inferences across several fixed effects and mixed-effects models of sperm whale depredation. We used these results and simulations to select an appropriate model for inference. We evaluated approaches for improved accounting of whale depredation in the sablefish stock assessment and sablefish management.

From 1998-2012, a total of 1154 year/station combinations were examined in sperm whale depredation models. Overall, 241 (21%) combinations were flagged for depredation based on sperm whale sightings as a proxy for depredation, while only 149 (13%) were flagged based on depredation evidence (damaged fish). Mixed effects models to estimate the sperm whale depredation effect performed better (based on simulations and comparison of point estimates and standard errors) than fixed effects models, likely due to the unbalanced nature and variation in the depredation data. Area-specific model results for sperm whale depredation varied by area; the greatest reductions in sablefish catch rates were generally seen in the West Yakutat and East Yakutat/Southeast areas (~17% - 23% reductions, $p < 0.05$). Models did not perform as well in regions with fewer data points, such as the Western Gulf of Alaska; therefore, mixed effects across-area models were selected as the most effective method for application in the annual sablefish stock assessment. Using the results of the area-wide model estimated expansions of catches at longline stations with sperm whales present by 1.14 and by 1.18 at stations where there was evidence of depredation. Because there were fewer incidents of evidence of depredation than presence, the effect on the all Alaska abundance index was similar for both variables and was an increase of 1-5% from 1998-2012. Compared to previous fixed effect studies, the use of mixed effect modelling and the longer time series of data showed that the effect of both presence and evidence of depredation had a significant effect on catch rates of sablefish on the Alaska longline survey.

Correcting for sperm whale depredation in the stock assessment resulted in an increase in estimated female spawning biomass of 3-4% in the terminal year which would yield an 8% higher quota recommendation. However, accounting for sperm whale depredation in the assessment should be done in concert with estimating the increase in mortality caused by depredation in the fishery. Current work is focused on estimating additional mortality caused by sperm whale depredation in the fishery.

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

Southeast Coastal Monitoring Survey Indices and the Recruitment of Sablefish - ABL

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

Age-2 sablefish recruitment was described as a function of late August sea temperature, late August chlorophyll *a*, and juvenile pink salmon productivity index during the age-0 stage (based on adult salmon returns to southeast Alaska during the age-1 stage) in a multiple regression model (Figure 1; Table 1). Chlorophyll *a* during the age-0 phase was most strongly correlated with sablefish recruitment ($R^2 = 0.80$; p-value = 0.00003) with a three-fold increases in chlorophyll *a* in 2000 and recruitmentin 2002. Sea temperature and pink salmon productivity explained an additional 15% of the variation in sablefish recruitment ($R^2 = 0.950$; p-value = 0.00001).
Warmer sea temperatures were associated with high recruitment events in sablefish. Higher chlorophyll *a* content in sea water during late summer indicate higher primary productivity and a possible late summer phytoplankton bloom. Higher pink salmon productivity, a co-occurring species in near-shore waters, was a positive predictor for sablefish recruitment to age-2. These conditions are assumed more favorable for age-0 sablefish, overwintering survival from age-0 to age-1, and overall survival to age-2.

The model parameters (2001-2012) and biophyscial indices (2011-2013) were used to predict the recruitment of Gulf of Alaska sablefish (2013-2015). Below average recruitment events for age-2 sablefish are expected in 2013 and 2015, and a slightly above-average recruitment event is expected in 2014 due to the high juvenile pink salmon productivity in 2013.

For more information contact Ellen Yasumiishi at ellen.yasumiishi@noaa.gov

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA - ABL
A full sablefish stock assessment was produced for the 2015 fishery. We added relative abundance and length data from the 2014 AFSC longline survey, relative abundance and length data from the 2013 longline and trawl fisheries, age data from the 2013 longline survey and 2013 fixed gear fishery, updated historical catches from 2006 – 2013, and projected 2014- 2016 catches.

The fishery abundance index decreased 13% from 2012 to 2013 (the 2014 data are not available yet). The longline survey abundance index increased 15% from 2013 to 2014 following a 25% decrease from 2011 to 2013. Spawning biomass is projected to decrease from 2015 to

2018, and then stabilize. Sablefish are currently slightly below the spawning biomass limit reference point and well below the target, which automatically lowers the potential harvest rate. We recommend a 2015 ABC of 13,657 t. The maximum permissible ABC for 2015 is very similar to the 2014 ABC of 13,722 t. The 2013 assessment projected a 10% decrease in ABC for 2015 from 2014. This smaller decrease is supported by a moderate increase in the domestic longline survey index from the all-time low in 2013 that offset the lowest value of the fishery abundance index seen in 2013. The fishery abundance index has been trending down since 2007. The 2013 IPHC GOA sablefish index was not used in the model, but also declined 21% from 2012. The 2008 year class showed potential to be above average in previous assessments based on patterns in the age and length compositions. However the estimate in this year's assessment is only average because it is heavily influenced by the recent large overall decrease in the longline survey and trawl indices.

Spawning biomass is projected to decline through 2018, and then is expected to increase; assuming average recruitment is achieved in the future. ABCs are projected to decrease in 2016 to 12,406 t and 12,292 t in 2017 (see Table 3.18). Projected 2015 spawning biomass is 35% of unfished spawning biomass. Spawning biomass has increased from a low of 32% of unfished biomass in 2002 to 35% of unfished biomass projected for 2015 but is trending downward in projections for the near future. The 1997 year class has been an important contributor to the population; however, it has been reduced and is predicted to comprise less than 7% of the 2015 spawning biomass. The 2000 year class is still the largest contributor, with 16% of the spawning biomass in 2015. The 2008 year class is average and will comprise 10% of spawning biomass in 2015 even though it is only 60% mature.

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

7. Yellowfin sole

a. Stock Assessment

BERING SEA - REFM

The 2014 EBS bottom trawl survey resulted in a biomass estimate of 2.51 million t, compared to the 2013 survey biomass of 2.28 million t (an increase of 10 percent). The stock assessment model indicates that yellowfin sole have slowly declined over the past twenty years, although they are still at a fairly high level (63% above B_{MSY}), due to recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 1970s. The time-series of survey age compositions indicate that only 8 of the past 26 year classes have been at or above the long term average. However, the 2003 year class appears to be as strong as any observed since 1983 and is a contributor to the reservoir of female spawners. The 2014 catch of 156,700 t represents the largest flatfish fishery in the world and the five-year average exploitation rate has been 6% for this stock (consistently less than the ABC).

New data for this year's assessment include:
2013 fishery and survey age compositions
2014 trawl survey biomass point estimate and standard error
estimates of the discarded and retained portions of the 2013 catch
estimate of total catch through the end of 2014.

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 2015 is 644,200 t. Projected spawning biomass for 2015 through 2020 indicates an increasing trend and a slow decline thereafter. The upward trend in the population biomass is due to strong recruitment from the 2003 year class.

The SSC has determined that reliable estimates of B_{MSY} and the probability density function for F_{MSY} exist for this stock. Accordingly, yellowfin sole qualify for management under Tier 1. The estimate of B_{MSY} from the present assessment is 391,000 t. Corresponding to the approach used in recent years, the 1978-2006 stock-recruitment data were used this year to determine the Tier 1 harvest recommendation. This provided a maximum permissible ABC harvest ratio (the harmonic mean of the F_{MSY} harvest ratio) of 0.117. The current value of the OFL harvest ratio (the arithmetic mean of the F_{MSY} ratio) is 0.125. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2015 biomass estimate produced 2015 ABC of 248,800 t recommended by the author and Team, and the corresponding product using the OFL harvest ratio produces the 2015 OFL of 266,400 t. For 2016, the corresponding quantities are 245,500 t and 262,900 t, respectively.

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

8. Northern Rock Sole

a. Research

Habitat availability for age-0s as a leading indicator of northern rock sole recruitment? RACE Recruitment Processes

Recruitment Processes and GAP researchers from the AFSC studied the relationships between annual spatial distribution and relative abundance of small (≤ 11 cm FL) juvenile Northern Rock Sole and summer bottom temperatures using data from a time series of eastern Bering Sea summer trawl surveys from 1982 through 2012. Latitudinal distributions of age-2 and age-3 fish were correlated most strongly with eastern Bering Sea mean summer bottom temperatures (range of 0.8–3.8 °C) two and three years prior to the survey year, during the time that the fish would have been age-0. Thus, temperature in the age-0 year may affect spatial distribution for the first few years of life. Distribution of small juveniles shifted northwards two years following the beginning of a warming trend from 1999 to 2003, and shifted southwards two years following a cooling trend from 2004 through 2010. Northerly distributions were correlated with high abundances (Figure 1). Density dependence was ruled out as a reason for northward shifts in distribution given a lack of correlation between annual latitudinal centers of distributions and the annual abundances within the southern part of the distribution. The vast spatial extent of age-0 nursery habitat in the north may produce large cohorts of Northern Rock Sole that contribute disproportionately to the recruiting population, and temperature related use of this habitat during the age-0 year may regulate recruitment to the overall population. Bottom temperature in the age-0 year may affect later adult distribution and abundance in the eastern Bering Sea. Results suggest that availability of nursery habitat during the age-0 year could be a useful leading indicator of Northern Rock Sole recruitment.

Contributed by Dan Cooper (FOCI) and Dan Nichol (GAP)

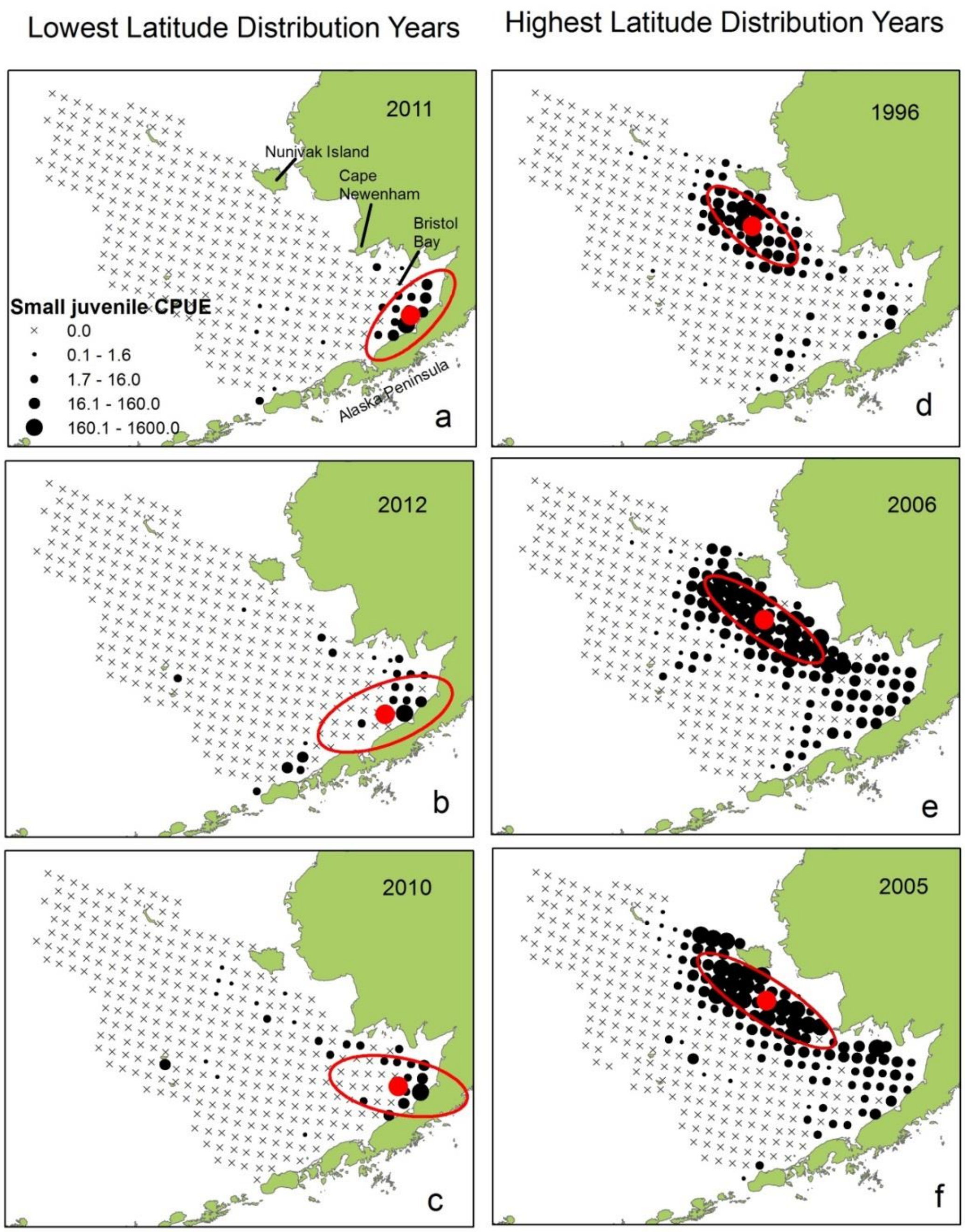


Figure 1. Variability in latitudinal distribution of Northern Rock Sole small juveniles (≤11 cm) for six years with the three highest and three lowest latitudinal centers of distribution from the summer AFSC EBS trawl survey. Catch per unit effort (CPUE) at each survey station (number of fish per hectare) are shown with variably sized black circles. Mean geographic center of

distribution weighted by CPUE for each year is shown with a solid red circle. Red ellipses encompass the area of approximately 68% of the catch in each survey year. a-c) The three years with the lowest latitude centers of distribution and d-f) the three years with the highest latitude centers of distribution from 1982–2012.

Age-0 yr Northern Rock Sole Habitat Studies Around Kodiak, Alaska - RACE FBEP
The Fisheries Behavioral Ecology Program, located in Newport Oregon, in cooperation with staff members from the Kodiak Laboratory, conduct research and test hypotheses designed to better understand annual recruitment of juvenile northern rock sole to coastal nursery areas in the Gulf of Alaska around Kodiak using a combination of field and laboratory studies. Laboratory studies focus upon specific habitat features which promote settlement and survival in these species, while field research focuses the recruitment of juvenile northern rock sole and their distribution among habitats. In addition, the program continues an annual survey (11-years in 2014) of juvenile recruitment that may ultimately prove useful in understanding annual variability in habitat features that control nursery production, subsequent year-class strength, and eventual adult recruitment to the fishery. In 2013 a study was completed that documented inter-annual variability in the depth distribution of juvenile northern rock sole on their nursery grounds around Kodiak Island, Alaska. This study evaluated whether this variability was a response to inter-annual changes in the availability of habitat created by polychaete tubes; principally *Sabellides sibirica*. Worm tubes may constitute an alternative refuge and/or feeding habitat for juvenile flatfish. Accordingly, it was hypothesized that during years of low worm abundance, fish would concentrate in the shallows (< 10 m depth) where they would find refuge from predation, but would move to greater depths (> 15 m, where the worms occur) during years when the worms were abundant. Using data on worm abundance and fish density over 5 yr, this hypothesis was tested at 2 Kodiak nursery embayments. Whether worms were abundant in a given year or embayment had no influence on overall fish abundance, however, worm abundance did influence juvenile flatfish depth distributions. At one site, where worms tended to be scarce, fish were typically concentrated in shallow water. However, during the 1 year when worms were abundant, fish were concentrated in deeper water. At another site, where worms are more regularly found, fish tended to concentrate in deeper water, the exception being the one year when worms were nearly absent. Regression analysis for both sites and all years indicated that the percent of fish occupying shallow water (< 10m) decreased with increasing worm abundance. When worms were prevalent, fish were most commonly found on bottom with sparse to moderate worm cover, but avoided bottom where the worms were so dense as to form a ‘turf’. These results demonstrate that the geographic and inter-annual variation in worm tube abundance has significant influence over the distribution of juvenile northern rock sole.

b. Stock Assessment

BERING SEA - REFM
The northern rock sole stock is currently at a high level due to strong recruitment from the 2001, 2002 and 2003 year classes which are now contributing to the mature population biomass. The 2014 bottom trawl survey resulted in a biomass estimate of 1.86 million t, 6% higher than the 2013 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 at a high level and is projected to decline in the near future due to the lack of good observed recruitment since 2003. The stock is currently estimated at over twice the B_{MSY} level.

New information for the 2014 analysis include:
1) 2013 fishery age composition. 2) 2013 survey age composition. 3) 2014 trawl survey biomass point estimate and standard error. 4) updated fishery discards through 2014. 5) fishery catch and discards projected through the end of 2014.

Northern rock sole are managed as a Tier 1 stock using a statistical age-structured model as the primary assessment tool. Model results indicate that spawning biomass increased almost continuously from a low of 54,981 t at the beginning of the model time series in 1975 to a peak of 758,648 t in 2001. Spawning biomass then declined to 491,611 t in 2009, but has increased continuously since then, reaching 632,502 t in 2014. The 2000-2005 year classes are all estimated to be above average, with the 2002 year class estimated to be at about twice the long-term average. The stock assessment model projects a 2015 spawning biomass of 622,300 t. This was slightly less than the 2015 value projected in last year's assessment. The projected spawning biomass for 2016 is 589,800 t.

The SSC has determined that northern rock sole qualifies for management under Tier 1. Spawning biomass for 2015 is projected to be well above the *BMSY* estimate of 260,000, placing northern rock sole in sub-tier "a" of Tier 1. The Tier 1 2015 ABC harvest recommendation is 181,700 t (*FABC* = 0.143) and the 2015 OFL is 187,600 t (*FOFL* = 0.152). The 2016 ABC and OFL values are 164,800 t and 170,100 t, respectively. Recommended ABCs correspond to the maximum permissible levels.

This is a stable fishery that lightly exploits the stock because it is constrained by PSC limits and the BSAI optimum yield cap. Usually the average catch/biomass ratio is about 3.5 percent of the northern rock sole stock. Northern rock sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALASKA Shallow Water Complex - REFM
Shallow-water and deep-water flatfish are assessed on a biennial schedule to coincide with the timing of survey data. An executive summary for shallow water flatfish was presented which included updated 2013 catch and the partial 2014 catch as well as projections using the updated results from the northern and southern rock sole assessment. 2014 catches of southern rock sole were substantially lower than catches in 2013.

The shallow water complex is comprised of northern rock sole, southern rock sole, yellowfin sole, butter sole, starry flounder, English sole, sand sole and Alaska plaice. Northern and southern rock sole are assessed with an-age structured model. Changes to the rock sole assessment model input data included updating the fishery catches for 2013 and 2014, including catch-at-length for 2014, adding GOA bottom trawl survey age compositions data from 2013 and compiled survey age data by length to accommodate the option for model fitting based on conditional age-at-length. The fishery catch data was portioned 50% to each of the northern and southern analyses (rather than 60% for both assessment models in 2013). Several changes were made to the technical implementations of the rock sole stock assessment models in response to SSC and Team recommendations from 2013. These included estimation of natural mortality rates separately for males (females were fixed at 0.2), a change in both models from using selectivity-at length to selectivity-at-age and using the number of trips or hauls as the primary input sample size (rather than the number of fish). Both models internally estimated the growth and selectivity parameters.

The rock sole species assessment model estimates are used for trend and spawning biomass estimates whereas the remaining species in this complex are based on the NMFS bottom trawl surveys. The most recent survey was 2013. Survey abundance estimates for the entire shallow-water complex were lower in 2013 compared to 2011; decreasing by 35,156 t. Model estimates of northern and southern rock sole spawning biomass have also shown slight declines in recent years.

Northern and southern rock sole are in Tier 3a while the other species in the complex are in Tier 5. An updated projection model for northern and southern rock sole was run this year; the remaining shallow water flatfish biomass estimates are from the 2013 survey. The Team noted that changes in the growth parameter estimates (relative to the externally estimated values used in the previous assessment) led to large changes in the *F* reference points for northern rock sole, as well as the total biomass in the southern rock sole assessment.

For the shallow water flatfish complex, ABC and OFL for southern and northern rock sole are combined with the ABC and OFL values for the rest of the shallow water flatfish complex. This yields a combined ABC of 44,205 t and OFL of 54,207 t for 2015. For 2016, the combined ABC is 39,205 t and the OFL is 48,407 t. The assessment authors recommended the maximum permissible ABC for 2015. Information is insufficient to determine stock status relative to overfished criteria for the complex. For the rock sole species, the assessment model indicates they are not overfished nor are they approaching an overfished condition. Catch levels for this complex remain below the TAC and below levels where overfishing would be a concern.

9. Flathead Sole

a. Stock Assessment

BERING SEA - REFM

The flathead sole assessment also includes Bering flounder, a smaller, less abundant species with a more northern distribution relative to flathead sole. The 2014 shelf trawl biomass estimate increased 6% from 2013 for flathead sole. Survey estimates indicate high abundance for both stocks for the past 30 years. The 2007 year class is estimated to be above average, but it follows 3 years of poor recruitment. The assessment employs an age-structured stock assessment model.

New for the 2014 assessment are 1) 2014 catch biomass was added to the model, 2) 2013 catch biomass was updated to reflect October – December 2013 catches, 3) 2012 fishery age composition data were added and 2011 fishery age composition data were updated to reflect changes made to the observer database, 4) 2013-2014 fishery length composition data were added to the model, 5) 2013-2014 Eastern Bering Sea (EBS) shelf survey biomass and 2014 Aleutian Islands (AI) survey biomass were added to the linear regression used to determine estimates of AI survey biomass in years when no AI survey occurred, which resulted in updating the entire time series,6) 2013-2014 survey bottom temperatures were added to the model, 7) 2013 survey age composition data were added to the model, 8) 2014 survey length composition data were added to the model, and 9) Minor changes in the historical survey catch were made to the eastern Bering

Sea shelf bottom trawl survey database, as a result of Pacific halibut data reconciliation between RACE and the IPHC. The most common error was an incorrect application of an expansion factor to the Pacific halibut catch sample. In hauls where the catch was subsampled, this change in expansion for halibut affected the catch proportion of the other species in the catch to a minor degree. No changes were made to the assessment methodology.

Model estimates indicated that spawning biomass increased continuously from a low of 17,654 t in 1979 to a high of 319,400 t in 1997, and has been quite stable since 2005, with biomasses ranging between 234,130 t and 252,320 t. The 1998, 2001-2003, and 2011 year classes are all estimated to be well above average. The projected spawning stock biomass for 2015 is 233,736 t. Flathead sole are abundant and only lightly exploited.

The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock, thereby qualifying flathead sole for management under Tier 3. The current values of these reference points are *B40%*=127,682 t, *F40%*=0.28, and *F35%*=0.35*.* Because projected spawning biomass for 2015 (233,736 t) is above *B40%*, flathead sole is in sub-tier "a" of Tier 3. ABCs for 2015 and 2016 were set at the maximum permissible values under Tier 3a, which are 66,130 t and 63,711 t, respectively. The 2015 and 2016 OFLs under Tier 3a are 79,419 t and 76,504 t, respectively. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

GULF OF ALASKA - REFM

Flathead sole are assessed on a biennial schedule to coincide with the timing of survey data. This year is an off-year thus an executive summary of the assessment was presented. The projection model was run using updated 2013 catch and new estimated total year catches for 2014-2016.

The 2015 spawning biomass estimate (83,818 t) is above $B_{40\%}$ (35,532 t) and projected to be stable
through 2016. Total biomass (3+) for 2015 is 254,602 t and is projected to slightly increase in 2016.

Flathead sole are determined to be in Tier 3a. The 2015 ABC was set at the maximum permissible ABC of 41,349 t from the updated projection. The F_{OFL} is set at $F_{35\%}$ (0.61) and gives an OFL of 50,792 t.

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

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

10. Alaska Plaice

a. Stock Assessment - REFM

The Alaska plaice resource continues to be estimated at a high and stable level with very light exploitation. The 2014 survey biomass was 451,600 t is a 10% decrease over 2013 and is largely consistent with estimates from resource assessment surveys conducted since 1985. The combined results of the eastern Bering Sea shelf survey and the northern Bering Sea survey indicate that 38% of the Alaska plaice biomass was found in the northern Bering Sea in 2010.

The stock is expected to remain at a high level in the near future due to the presence of a strong year class estimated from 2002. Exploitation occurs primarily as bycatch in the yellowfin sole fishery and has averaged only 1% from 1975-2014.

The last full assessment was in November 2012, therefore changes to input data in this analysis include: 1) Estimated 2014 fishery catch and updated 2013 fishery catch, 2) 2013 and 2014 trawl survey biomass estimate and standard error, 3) 2014 survey length composition, 4) 2012 and 2013 survey age composition, 5) 2013 fishery length composition, 6) 1975 and 1979-1981 survey biomass data were excluded, 7) New maturity schedule estimated from histological analysis of samples collected in 2012. The assessment methodology was unchanged.

The stock assessment model estimates a 2015 spawning biomass of 215,300. This was slightly less than the 2015 value of 246,300 projected in last year's assessment. The projected spawning biomass for 2016 is 201,300. Above average recruitment strength in 1998 and exceptionally strong recruitment in 2001 and 2002 have contributed to recent highs level of female spawning biomass.

Reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock, therefore qualifying it for management as a Tier 3 stock. The updated point estimates are *B40%* = 142,100 t, *F40%* = 0.143, and *F35%* = 0.175. Given that the projected 2015 spawning biomass of 215,300 t exceeds *B40%*, the ABC and OFL recommendations for 2015 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the *F40%* level gives a 2015 ABC of 44,900 t and a 2016 ABC of 42,900 t. The OFL was determined from the Tier 3a formula, which gives a 2015 value of 54,000 t and a 2016 value of 51,600 t. Alaska plaice is not being subjected to overfishing, is not overfished, and is not approaching an
overfished condition.

11. Greenland Halibut (Turbot)

a. Stock Assessment

The 2014 Greenland turbot assessment was updated as follows: 1) updated 2014 catch data, including a 433 t decrease in the catch estimate for 2003 from last year, 2) 2014 EBS shelf survey biomass, 3) 2014 ABL longline survey RPN 4) 2014 EBS shelf survey and ABL longline age and length composition estimates, 5) Shelf survey age and length composition data now include the expanded northern strata from 1987 onward, 6) Updated fishery catch-at-length data for longline and trawl gear from 2014, 7) For Model 2 (see below), the 2006 and 2007 trawl fishery length composition data were removed as the sample sizes were deemed too small, 8) Updated fishery catch-at-length data for longline and trawl gear from 2014, 9) Length of females at 50% mature was changed from 55 to 60 cm per D'yakov (1982).

Two models (Models 1 and 2) were presented for review with Model 2 accepted for use in the 2014 assessment. Model 1 was identical to Model 1 from 2013 except for the addition of new female maturity parameters. Model 2 differed from Model 1 (from 2014) by the addition of a recruitment autocorrelation parameter, fixing of catchability for shelf and slope surveys at 0.62 and 0.57, respectively; and inclusion of an additional selectivity bin (2010 - 2014) for the longline fishery length composition data.

The projected 2015 female spawning biomass is 30,853 t. This is a 12% increase from the 2015 spawning biomass of 27,624 t projected in last year's assessment. Spawning biomass is projected to increase to 38,848 t in 2016. While spawning biomass continues to be near historic lows, increases have been estimated or are projected for the years following 2013, and large 2008 and 2009 year classes are being observed in both the survey and fishery size composition data. These year classes are both estimated to be stronger than any other year class spawned since the 1970s.

The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock. Greenland turbot therefore qualifies for management under Tier 3. Updated point estimates of *B40%*, *F40%*, and *F35%* from the present assessment are 52,049 t, 0.176, and 0.218, respectively. The stock remains in Tier 3b. The maximum permissible value of *FABC* under this tier translates into a maximum permissible ABC of 3,172 t for 2015 and 5,248 t for 2016, and an OFL of 3,903 t for 2015 and 6,453 t for 2016. These are the accepted ABC and OFL recommendations.

The authors' and Team's recommended 2015 and 2016 ABCs in the EBS are 2,448 t and 4,050 t, respectively. The authors' and Team's recommended 2015 and 2016 ABCs in the AI are 724 t and 1,198 t, respectively. Area apportionment of OFL is not recommended. Greenland turbot is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

12. Arrowtooth Flounder

a. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS- REFM

The following new data was included in the model: 1) Survey size compositions from the 2013 and 2014 Eastern Bering Sea shelf surveys and the 2014 Aleutian Islands survey, 2) Biomass point estimates and standard errors from the 2013 and 2014 Eastern Bering Sea shelf surveys and the 2014 Aleutian Islands survey, 3) Fishery size compositions for 2012, 2013, and 2014. Fishery size composition data were also added for 1992-1999, which were not previously included, 4) Estimates of catch through October 10, 2014, 5) Age data from the 2010 Bering Sea shelf and 2010 Aleutian Islands surveys, as well as the 2004 shelf survey, which also was not previously included.

The age-structured assessment model is similar to the model used for the 2012 and 2013 assessments. The 2014 model implemented the following changes based on Plan Team and SSC comments: 1) Fishery selectivity is estimated non-parametrically rather than using a 2-parameter logistic function, and 2) An additional likelihood component was added to incorporate the Aleutian Islands age data.

The projected age 1+ total biomass for 2015 is 908,379 t, a decrease from the value of 995,494 t projected for 2015 in last year's assessment. The projected female spawning biomass for 2015 is 533,731 t which is a decrease from the previous estimate of 632,319 t. The recommended 2015 ABC is 80,547 t based on a *F40%*=0.153 harvest rate and the 2015 overfishing level is 93,856 t based on a *FOFL*=0.180 harvest rate.

The SSC has determined that reliable estimates of *B40%*, *F40%*, and *F35%* exist for this stock. Arrowtooth flounder therefore qualifies for management under Tier 3. The point estimates of *B40%* and *F40%*, from last year's assessment were 231,015 t and 0.156, respectively; from this year's assessment, they are 222,019 t, 0.153, respectively. The projected 2015 spawning biomass is far above *B40%* in both last year's and this year's assessments, thus ABC and OFL recommendations for 2015 were calculated under sub-tier "a" of Tier 3. The authors and Team recommend setting *FABC* at the *F40%* level, which is the maximum permissible level under Tier 3a, which results in 2015 and 2016 ABCs of 80,547 t and 78,661 t, respectively, and 2015 and 2016 OFLs of 93,856 t and 91,663 t.

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

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

GULF OF ALASKA - REFM

There were no changes in assessment methodology since this was an off-cycle year. Parameter values from the previous year's assessment model, projected catch for 2014, and updated 2013 catch were used to make projections for ABC and OFL estimates.

Female spawning biomass in 2015 was estimated at about 2 million t and is expected to decrease slightly in 2016. The 2014 catch of arrowtooth was the highest on record. This is partially due to recent changes to regulations (Amendment 95) of the halibut trawl prohibited species catch (PSC) limits. For the Amendment 80 fleet in the GOA, unused halibut PSC limits are now allowed to be rolled from one season to the next, which allows catcher processors to spend more time targeting arrowtooth flounder without constraints due to halibut PSC. In addition, new regulations have moved the deep-water flatfish fishery closure date later in the year for all trawl vessels. These changes will likely result in continued higher arrowtooth flounder catches than previous years, similar to the current year.

Arrowtooth flounder is estimated to be in Tier 3a. Projections are based on an estimated 2014 catch (39,744 t) that is also used for 2015 and 2016. The 2015 ABC ($F_{40\%}$=0.172) is 192,921 t, which is a slight decrease from the 2014 ABC of 195,358 t. The 2015 OFL ($F_{35\%}$=0.204) is 226,390 t. The 2016 ABC is 185,352 t and OFL is 217,522 t. The stock is not overfished nor approaching an overfished condition. Catch levels for this stock remain below the TAC and below levels where overfishing would be a concern.

13. Other Flatfish

a. Stock Assessment

BERING SEA - REFM

The "other flatfish" complex currently consists of Dover sole, rex sole, longhead dab, Sakhalin sole, starry flounder, and butter sole in the EBS and Dover sole, rex sole, starry flounder, butter sole, and English sole in the AI. Starry flounder, rex sole, and butter sole comprise the vast majority of the species landed. Starry flounder, rex sole and butter sole comprise the majority of the fishery catch with a negligible amount of other species caught in recent years. In 2014 Starry flounder continued to dominate the shelf survey biomass in the EBS and rex sole was the most abundant "other" flatfish in the Aleutian Islands. The biomass of the other flatfish complex on the eastern Bering Sea shelf was relatively stable from 1983-1995, averaging 54,274 t, and then increased from 1996 to 2003, averaging 84,137 t. Since 2003, the biomass estimates have been at a higher level, averaging 125,800 t. The 2014 shelf and Aleutian Islands (slope survey not conducted in 2014) surveys combined estimate of 143,000 t is at the highest level of the past 7 years and third highest overall for the time-series. The estimated increases from the past five years are primarily due to the higher estimates of starry flounder on the Eastern Bering Sea shelf. Sakhalin sole biomass, which has no pattern in fluctuation, had a high of 1,410 t in 1997 and a low of 37 t in 2012. Sakhalin sole are primarily found north of the standard survey area. Distributional changes, onshore-offshore or north-south, might affect the survey biomass estimates of other flatfish.

The SSC has classified "other flatfish" as a Tier 5 species complex with harvest recommendations calculated from estimates of biomass and natural mortality. Natural mortality rates for rex (0.17) and Dover sole (0.085) in the GOA SAFE document are used, along with a value of 0.15 for all other species in the complex. For 2014, a random effects model was used to estimate the complex biomass for ABC purposes. Projected harvesting at the 0.75 *M* level (average *FABC* = 0.093) gives a 2015 ABC of 13,250 t for the "other flatfish" complex. The corresponding 2015 OFL (average *FOFL* = 0.124) is 17,700 t. This assemblage is not being subjected to overfishing. It is not possible to determine whether this assemblage is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

GULF OF ALASKA Deep-water flatfish - REFM
The deepwater flatfish complex is comprised of Dover sole, Greenland turbot, and deepsea sole. This complex is assessed on a biennial schedule to coincide with the timing of survey data. This year is an off-year thus an executive summary of the assessment was presented. Dover sole are assessed as a Tier 3a species and the projection model was run using updated 2013 catch and new estimated catches for 2014- 2016. Greenland turbot and deepsea sole fall under Tier 6. ABCs and OFLs for Tier 6 species are based on historical catch levels and therefore these quantities are not updated. ABCs and OFLs for the individual species in the deepwater flatfish complex are determined as an intermediate step and then summed for the purpose of calculating complex-level OFLs and ABCs.

The model estimate of 2015 spawning stock biomass for Dover sole is 67,156 t, which is well above $B_{40\%}$ (28,218 t). Spawning stock biomass and total biomass are expected to remain stable through 2016. Stock trends for Greenland turbot and deepsea sole are unknown.

Since the Dover sole stock has been assessed using an age-structured model and $B_{2015} > B_{40\%}$, it is determined to be in Tier 3a. Both Greenland turbot and deepsea sole are determined to be in Tier 6. The 2015 and 2016 Dover sole ABCs are 13,151 t and 12,994 t, respectively. The Tier 3a 2015 and 2016 OFLs are 15,749 t and 15,559 t, respectively. The Tier 6 calculation (based on average catch from 1978–1995) for the remaining species in the deepwater flatfish complex ABC is 183 t and the OFL is 244 t for 2015 and 2016. The GOA Plan Team agreed with the authors' recommendation to use the combined ABC and OFL for the deepwater flatfish complex for 2015 and 2016. This equates to a 2015 ABC and OFL of 13,334 t and 15,993 t respectively for deepwater flatfish. The ABC is equivalent to the maximum permissible ABC.

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

14. Sharks and Skates

a. Research

Spiny Dogfish Ecology and Migration - ABL

A total of 183 satellite pop-off tags have been deployed on spiny dogfish since 2009. Data has been successfully recovered from 153 tags. Five tags have been physically recovered and complete data sets are being downloaded from them. Six spiny dogfish tagged in Puget Sound were tagged with acoustic tags in addition to the pop-off tags, to attempt to compare the light based geolocation with known positions from the acoustic receivers. Recovered data from the pop-off tags, which includes temperature, depth, and geographic location, are still being analyzed. Preliminary results suggest that spiny dogfish can undertake large scale migrations rapidly and that they do not always stay near the coast (e.g. a tagged fish swam from near Dutch Harbor to Southern California in 9 months in a mostly straight line, not following the coast). Also, the spiny dogfish that do spend time far offshore have a different diving behavior than those staying near shore, with the near shore animals spending much of the winter at depth and those offshore having a significant diel diving pattern from the surface to depths up to 450 m. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Spiny Dogfish Improved Aging Methods - ABL

Staff from ABL, AFSC REFM Division, and the University of Alaska Fairbanks are wrapping up a North Pacific Research Board funded project to investigate alternative ageing methods for spiny dogfish. The project objectives were to compare the previous method of ageing the dorsal fin spines with a new technique developed that uses the vertebrae. Sample processing and ageing criteria were standardized and a manual has been created which is currently under review for peer review publication. Preliminary results suggest that the vertebrae may be suitable for ageing, however, more research is necessary before that method can be supported (e.g., validating ages). This project has been discussed at workshops at the last two CARE meetings (2013 and 2015), and presented at many scientific conferences. The NPRB final report has been submitted, and manuscripts are in preparation (one submitted). For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

Population Genetics of Pacific Sleeper Sharks - ABL

Two species of the subgenus *Somniosus* are considered valid in the northern hemisphere: *S. microcephalus*, or Greenland shark, found in the North Atlantic and Arctic, and *S. pacificus*, or Pacific sleeper shark, found in the North Pacific and Bering Sea. The purpose of this study was to investigate the population structure of sleeper sharks in Alaskan waters. Tissue samples were opportunistically collected from 141 sharks from British Columbia, the Gulf of Alaska, and the Bering Sea. Sequences from three regions of the mitochondrial DNA, cytochrome oxidase c- subunit 1 (CO1), control region (CR), and cytochrome b (cytb), were evaluated. A minimum spanning haplotype network separated the sleeper sharks into two divergent groups, at all three mtDNA regions. Percent divergence between the two North Pacific sleeper shark groups at CO1, cytb, and CR respectively were all approximately 0.5%. Greenland sharks were found to diverge from the two groups by 0.6% and 0.8% at CO1, and 1.5% and 1.8% at cytb. No Greenland shark data was available for CR. The consistent divergence from multiple sites within the mtDNA between the two groups of Pacific sleeper sharks indicates a historical physical separation. There appears to be no phylogeographic pattern, as both types were found throughout the North Pacific and Bering Sea. Development of nuclear markers (microsatellites) is currently underway and will allow for a better understanding of the level of introgression, if any, between these two 'populations' of sharks. For more information, contact Cindy Tribuzio at (907) 789-6007 or cindy.tribuzio@noaa.gov.

b. Stock Assessment

Sharks - ABL

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

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 2003-2014 were updated from the NMFS Alaska Regional Office's Catch Accounting System. In the GOA, total shark catch in 2014 was 1,525 t, which is down from the 2013 catch of 2,169 t (the greatest catch of the full time series). Substantial changes to the observer program (referred to as "observer restructuring") likely affected the catch estimates for shark species. Smaller vessels are now subject to observer coverage, and this includes vessels fishing halibut IFQ, which were previously exempt from coverage. The increase in 2013 can be attributed mostly to an increase in the catch estimate of spiny dogfish in the Pacific halibut target fishery, which was 675 t, up ~450 t from the average catch from 2003 – 2012, but was still within the range of catches from this target fishery. An additional impact of observer restructuring was that estimated shark catches in NMFS areas 649 (Prince William Sound) and 659 (Southeast Alaska inside waters) for Pacific sleeper shark and spiny dogfish by the halibut target fishery has increased. In the last two years, the average Pacific sleeper shark and spiny dogfish catch in NMFS areas 649 and 659 has been 87 t and 79 t, respectively, compared to the historical average of < 1 t and ~14 t average (SD = 23), respectively. There was approximately 2 t of salmon shark and other shark catch estimated in these areas as well. The catch in NMFS areas 649 and 659 does not count against the federal TAC, but if it were included the total catch of sharks in 2014 would be 1,703 t, which is still below the recommended acceptable biological catch (ABC) for the shark complex.

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

In the BSAI, estimates of shark catch from the Catch Accounting System from 2014 were 137 t which exceeded the TAC, but not the ABC. Pacific sleeper shark are the primary species caught. These catch estimates do incorporate the restructured observer program, but the impact appears to be minimal for BSAI sharks. The survey biomass estimates on the BSAI are highly uncertain and not informative for management purposes.

For the GOA assessment, spiny dogfish are a “Tier 6” species, but a “Tier 5” calculation is used (this is due to the “unreliable” nature of the biomass estimates) and all other sharks a “Tier 6” species. The GOA-wide ABC and OFL for the entire complex is based on the sum of the ABC/OFLs for the individual species, which resulted in ABC=5,989 t and OFL= 7,986 t for 2014. In the BSAI, all shark species are considered “Tier 6” with the 2015 ABC = 1,020 t and OFL = 1,360 t.

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

15. Other Species

a. Research

Otolith Morphology, Speciation, Stock Structure, and Microchemistry of Giant Grenadier – ABL (MESA and Genetics), REFM (Age and Growth)

Three very different shapes of otoliths have been observed in giant grenadier. A review of the literature and world-wide experts revealed that such variability in otolith shape is highly unusual for an individual fish species. Otolith morphology differences could be related to speciation or stock structure. Tagging studies are a traditional way to determine migration patterns and spatial stock structure for fish. However, these studies are not possible for giant grenadier because the fish do not survive the pressure difference when caught at depth and brought to the surface. Genetic and otolith microchemistry studies are an alternative means for examining stock structure and speciation, i.e. if giant grenadier are actually two or more species. In 2013, tissue and otoliths samples were collected on the AFSC longline survey in the eastern, central, and western Gulf of Alaska, and the Bering Sea. Otoliths have been measured for a quantitative comparison of shapes in relation to genetic differences. Ageing will be completed in spring of 2015. Samples of each otolith shape in each area are being sequenced at the cytochrome c oxidase subunit 1 (COI) mitochondrial region to look for genetic variation. Additionally, microsatellite markers are being employed to look for stock structure.

It is unknown where juvenile giant grenadier reside; the youngest fish that has been aged is 14 years old. This spring, an undergraduate student at the University of Washington is examining otolith microchemistry in a small number of samples to determine if giant grenadier make large migrations (geographically or depth) at certain times during their long lives (maximum age is at least 58 years and age at 50% maturity for females is 22). Adults are found at depths from 600-1,000+ in great abundance.

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

Octopus Delayed Discard Mortality - RACE GAP

Octopus are caught incidentally in trawl, longline, and pot fisheries; however, the majority of the catch comes from Pacific cod pot fisheries. There is concern that the establishment of annual catch limits (ACLs) for this group may unnecessarily constrain this and other commercial fisheries. During 2011, in the Bering Sea/Aleutian Islands regions the total allowable catch (TAC) for octopus was reached in August 2011 and octopus retention was prohibited starting September 1, 2011. The overfishing limit (OFL) for octopus was reached October 21, 2011 and directed fishing for Pacific cod pot gear was closed for the remainder of the year. Due to the lack of reliable abundance estimates and life history information about octopus in the Gulf of Alaska it is appropriate that they be managed conservatively, however better scientific data will ensure the most appropriate values are used for discard mortality rates for this assemblage.

Observer data have documented the short term mortality of octopus captured within these pot fisheries is very low. Data on delayed or long-term mortality of this species will enable scientists to develop a gear-specific discard mortality factor. During three fishing seasons 60 octopus were collected for long term mortality studies from commercial fishing vessels utilizing pot gear. To date these octopus have exhibited low mortality rates and these data support the development of a gear specific discard mortality factor. Field collections for this project are completed and data analyses will be completed within the next year.

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

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

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

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

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

Distribution and Migration of Morphometrically Mature Male Snow Crab in the Eastern Bering Sea - RACE GAP
Tagging of adult male snow crab (*Chionoecetes opilio*) in the eastern Bering Sea, using pressure and temperature recording data storage tags, was conducted during 2010 and 2011 in an effort to determine the occurrence and extent of seasonal migrations. The research was

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

A total of 277 adult males were tagged and 33 were recovered by the fishery between 2011 and 2012. Analyses of the tag depth records indicated that most of these males underwent some limited inshore movements during spring, but that the timing and extent of these movements were highly variable among individuals. Comparisons of tag depth records with distributions of adult female snow crab during the two years in which tagged males were at liberty, indicated that inshore movements were likely made for the purpose of mating. However, the timing and extent of these migrations were such these males could only mate with females that had already released a brood in a prior years (multiparous), and not with those that were holding their first brood (primiparous).

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

b. Assessment

Grenadiers - ABL

The Secretary of Commerce approved Amendments 100/91 on August 6, 2014, which added the grenadier complex into both FMPs as Ecosystem Components. Under this rule, they are not allowed to be targeted, but there is an 8% Maximum Retainable Allowance (MRA). There are no OFL, ABC, and TACs. It is recommended that an Ecosystem Component be monitored for overfishing, but no definition of overfishing exists for this group and a SAFE report is not required. The only other Ecosystem Component is forage fish. An unofficial assessment has been conducted annually since 2006. An abbreviated full SAFE was prepared in 2014 that presented unofficial ABC and OFL values using tier 5 calculations. A random effects model was used for an updated estimate of GOA biomass. The great majority of grenadier biomass is below 700 m and no trawl surveys have sampled from 700-1,000 m since 2009. The model is used to estimate biomass in three depth strata separately and then three are summed for a total biomass estimate. Since there was no trawl survey in the GOA in 2014, the estimate for 2013 is used as the most recent value of exploitable biomass. There was no EBS slope trawl survey in 2014 and so the biomass estimate remained the same. Estimated catch is not close to approaching unofficial ABCs and so we conclude that overfishing is not occurring in the BSAI or the GOA. The Plan Team and the Scientific and Statistical Committee of the NPFMC have requested an abbreviated assessment, like the one prepared in 2014, every other year with no executive summary report in off years.

Cara Rodgveller at (907) 789-6052 or cara.rodgveller@noaa.gov

D. Other Related Studies

Fisheries Resource Pathology Program – RACE

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

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

For further information, contact Dr. Pam Jensen, (206) 526-4122.

Systematics Program - RACE GAP

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2014. A taxonomic revision, based on molecular and morphological data, of the sandlance genus *Ammodytes* of the North Pacific was published (Orr et al., 2015), recognizing two species in the eastern North Pacific (*A. hexapterus* in the Bering Sea and north; *A. personatus* in the southern Bering Sea and south) and describing and naming a new species from Japan. We (Orr and Wildes) are continuing our work on sandlances by including Atlantic species in a global analysis and conducting more detailed population-level studies in the eastern Pacific. A paper documenting the genetic diversity of lumpsuckers (Cyclopteridae) across the North Pacific and marginal seas (Kai et al., 2014) was published, as well as a range extension documenting the presence of two species of manefishes (Caristiidae) in Japanese waters (Okamoto et al., 2014) and a manuscript clarifying the taxonomy and distribution of sculpins of the genus *Malacocottus*, including recognition of *M. aleuticus* as a juvenile form of *M. zonurus* and *M. kincaidi* (Stevenson, 2015). A guide to cods and cod-like fishes (Gadiformes) is complete and being formatted for distribution (Hoff, Orr, and Stevenson, in press). A taxonomic revision of snailfishes in the *Careproctus rastrinus* species complex, including the description of a new species from the Beaufort Sea, was completed and tentatively accepted (Orr et al., in review). An additional study testing the hypothesis of cryptic speciation in northern populations of the eelpout genus *Lycodes* (Stevenson) is underway. Also in progress are studies examining identifications of rockfishes (*Sebastes aleutianus* and *S. melanostictus*) off the West Coast (Orr, with NWFSC); morphological variation related to recently revealed genetic heterogeneity in rockfishes (*Sebastes crameri*; Orr, with NWFSC) and flatfishes (*Hippoglossoides*; Orr, Paquin, Raring, and Kai); and a partial revision of the lumpsucker genus *Eumicrotremus* (Stevenson). A description of two new species of snailfishes from the Aleutian Islands is in preparation (Orr) and work on the morphology of the pectoral girdle (Orr, with UW), and other new species continues. In addition to taxonomic revisions, descriptions of new taxa, and guides, RACE systematists have collaborated with molecular biologists at the University of Washington and within AFSC to identify snailfish eggs in king crabs (Gardner, Orr, Stevenson, Somerton, and Spies, in review) and to examine population-level genetic diversity in the skates *Bathyraja parmifera*, related to its nursery and undertaken with NPRB support (Hoff, Stevenson, Spies, and Orr). Molecular and morphological studies on *Bathyraja interrupta* (Stevenson, Orr, Hoff, and Spies), *Eumicrotremus* (Kai and Stevenson), and *Lycodes* (Stevenson and Paquin) are also underway. In addition to systematic publications and projects, RACE systematists have been involved in works on the zoogeography of North Pacific fishes, including collaborations with the University of Washington on a checklist of the fishes of the Salish Sea (Pietsch and Orr, in press) and notes on new records and range extensions of other fishes (Paquin et al., in press).

With the support of NPRB and JISAO, an annotated checklist of the marine macroinvertebrates of Alaska comprising over 3500 species has been tentatively accepted (Drumm et al., in review). As a result of this checklist and following Stevenson and Hoff's (2009) for the Bering Sea shelf, a processed report providing species-level confidence identification matrix for the Gulf of Alaska and Aleutian Islands and another on species of the Bering Sea slope were published (Orr et al., 2014a,b). A report on a pilot study to collect coral bycatch data from the Alaska commercial fishing fleet was also completed (Stone et al., in press).

Salmon Excluders – RACE Conservation Engineering (CE)

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

Develop Alternative Trawl Designs to Effectively Capture Pollock Concentrated Against the Seafloor While Reducing Bycatch and Damage to Benthic Fauna – RACE CE

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

Provide Underwater Video Systems to Fishermen and Other Researchers to Facilitate Development of Fishing Gear Improvements – RACE CE

We have continued to provide underwater video systems to be used by the fishing industry to allow them to directly evaluate their own modifications to fishing gear. Beyond their direct use, exposure to NMFS systems has motivated many companies to procure similar systems for dedicated use on their vessels. Either way, the goal of better understanding of fishing gear operation and quicker development of improvements is being realized. While the existing camera systems have been maintained, a significant advance in this area has been the development and testing of much more compact and inexpensive camera systems for use on commercial fishing gear. All camera system components are enclosed in a single 3.5 inch diameter acrylic tube mounted on a plastic plate. The entire system measures 21 x 9 x 5 inches and is of nearly neutral buoyancy in water. These systems have been in use for about 2 years now and have proven to be very easy to use, durable and flexible. Six new systems will be built for our use and as replacements of the older loaner systems. While this design is so inexpensive and functional that many vessels have acquired their own systems, there is still a need for loaner systems.

APPENDIX I - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS
Published January 2014 through December 2014 (AFSC authors in bold text)

BAKER, **M. R.**, and **A. B. HOLLOWED**.
2014. Delineating ecological regions in marine systems: Integrating physical structure and community composition to inform spatial management in the eastern Bering Sea. Deep-Sea Res. II 109:215-240.

BARBEAUX, **S. J.**, **J. K. HORNE**, and **J. N. IANELLI**.
2014. A novel approach for estimating location and scale specific fishing exploitation rates of eastern Bering Sea walleye pollock (*Theragra chalcogramma*). Fish. Res. 153:69-82.

BOGRAD, S. J., E. L. HAZEN, E. A. HOWELL, and **A. B. HOLLOWED**.
2014. The fate of fisheries oceanography: Introduction to the special issue. Oceanography 27(4):21-25.

BUSBY, **M. S.**, **J. T. DUFFY-ANDERSON**, **K. L. MIER**, and **L. G. De FOREST**.
2014. Spatial and temporal patterns in summer ichthyoplankton assemblages on the eastern Bering Sea shelf 1996–2007. Fish. Oceanogr. 23:270-287.

CAHALAN, **J.**, J. GASPER, and J. MONDRAGON. 2014. Catch sampling and estimation in the federal groundfish fisheries off Alaska, 2015 edition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-286, 46 p. Online. (.pdf, 664 KB).

CONN, **P. B.**, **D. S. JOHNSON**, **L. W. FRITZ**, and **B. S. FADELY**.
2014. Examining the utility of fishery and survey data to detect prey removal effects on Steller sea lions (*Eumetopias jubatus*). Can. J. Fish. Aquat. Sci. 71:1229-1242.

CONRATH, **C. L.**, and **M. E. CONNERS**.
2014. Aspects of the reproductive biology of the North Pacific giant octopus (*Enteroctopus dofleini*) in the Gulf of Alaska. Fish. Bull., U.S. 112:253-260. Online. (.pdf, 1 MB).

De FOREST, **L.**, **J. T. DUFFY-ANDERSON**, **R. A. HEINTZ**, **A. C. MATARESE**, **E. C. SIDDON**, **T. I. SMART**, and **I. B. SPIES**.
2014. Taxonomy of the early life stages of arrowtooth flounder (*Atheresthes stomias*) and Kamchatka flounder (*A. evermanni*) in the eastern Bering Sea, with notes on distribution and condition. Deep-Sea Res. II 109:181-189.

De ROBERTIS, **A.**, and **K. TAYLOR**.
2014. *In situ* target strength measurements of the scyphomedusa *Chrysaora melanaster*. Fish. Res. 153:18-23.

De ROBERTIS, **A.**, **D. McKELVEY**, **K. TAYLOR**, and **T. HONKALEHTO**.
2014. Development of acoustic-trawl survey methods to estimate the abundance of age-0 walleye pollock in the eastern Bering Sea shelf during the Bering Arctic Subarctic Integrated Survey (BASIS). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-272, 46 p. Online (.pdf, 2.39 MB).

FAUNCE, **C.**, **J. CAHALAN**, J. GASPER, **T. A'MAR**, **S. LOWE**, **F. WALLACE**, and R. WEBSTER.

2014. Deployment performance review of the 2013 North Pacific Groundfish and Halibut Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-281, 74 p. Online (.pdf, 4.15 MB).

FELTHOVEN, **R.**, J. LEE, and K. SCHNIER.
2014. Cooperative formation and peer effects in fisheries. Mar. Resour. Econ. 29:133-156.

FISSEL, **B. E.**
2014. Economic indices for the North Pacific groundfish fisheries: Calculation and visualization. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-279, 47 p. Online (.pdf, 756 KB).

FOWLER, **C. W.**, and S. M. LUIS.
2014. We are not asking management questions. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-267, 48 p. Online (.pdf, 1.26 MB).

FOWLER, **C. W.**, R. D. REDEKOPP, V. VISSAR, and J. OPPENHEIMER.
2014. Pattern-based control rules for fisheries management. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-268, 116 p. Online (.pdf, 1.6 MB).

GODDARD, P., **R. LAUTH**, and **C. ARMISTEAD**.
2014. Results of the 2012 Chukchi Sea bottom trawl survey of bottomfishes, crabs, and other demersal macrofauna. U. S. Dep. Commer., NOAA-TM-AFSC-278, 110 p. Online (.pdf, 8.74 MB).

GUYON, **J. R.**, **C. M. GUTHRIE III**, A. R. MUNRO, J. JASPER, and W. D. TEMPLIN.
2014. Extension of genetic stock composition analysis to the Chinook salmon bycatch in the Gulf of Alaska walleye pollock (*Gadus chalcogrammus*) trawl fisheries, 2012. U. S. Dep. Commer., NOAA-TM-AFSC-285, 26 p. Online. (.pdf, 725 KB).

HAWKYARD, M., **B. LAUREL**, and C. LANGDON.
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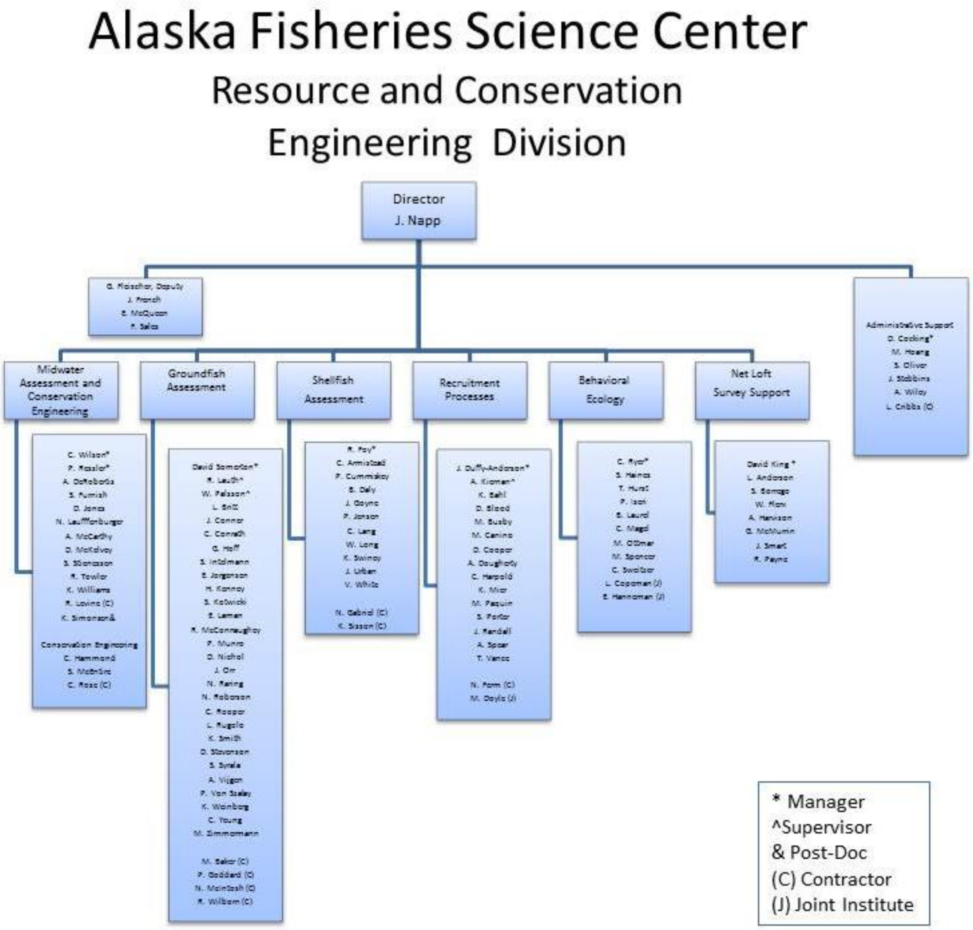
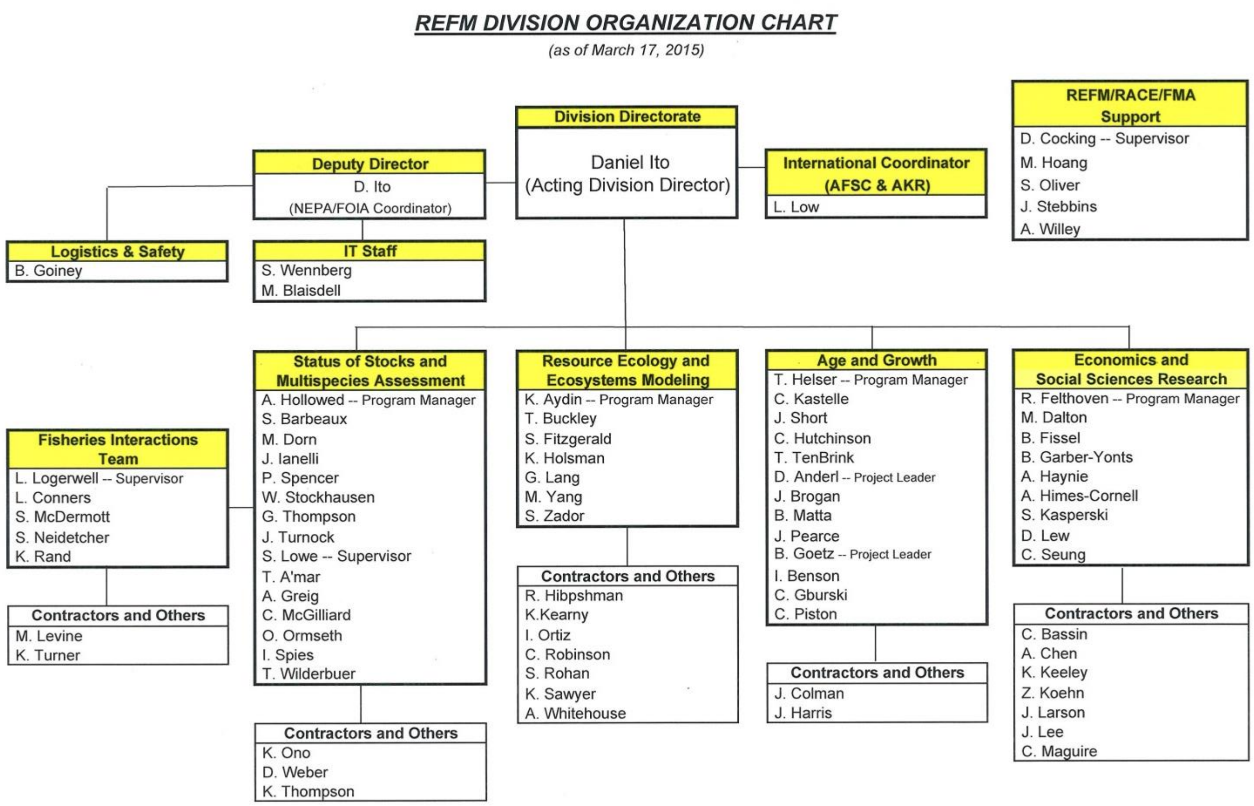
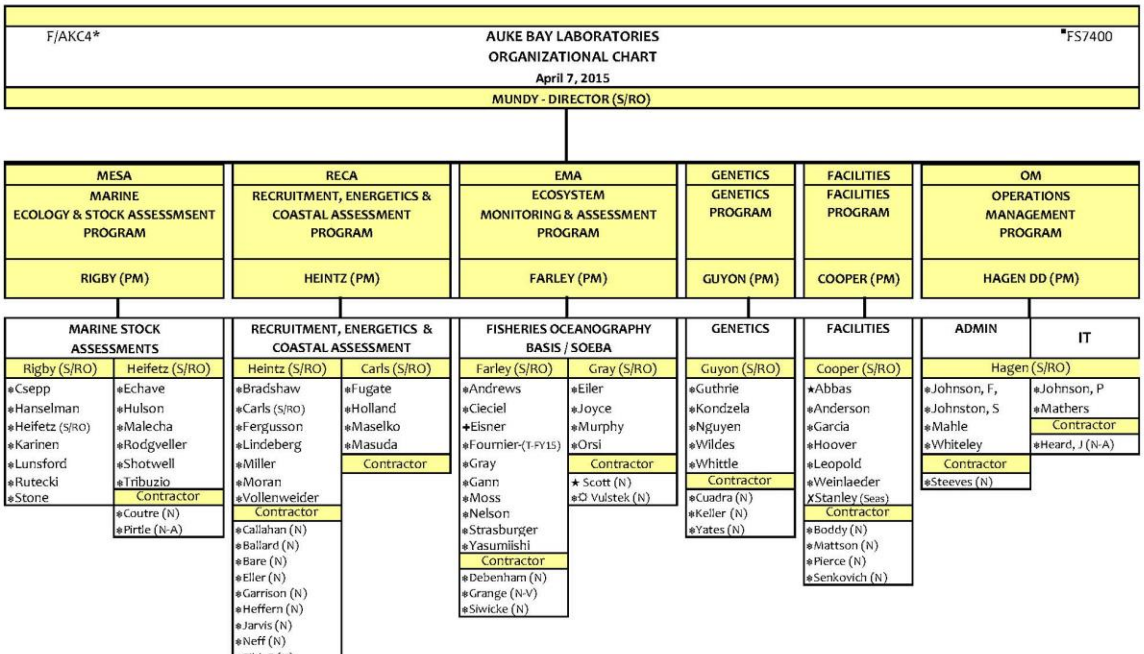
APPENDIX II. RACE ORGANIZATION CHART



APPENDIX III. REFM ORGANIZATION CHART



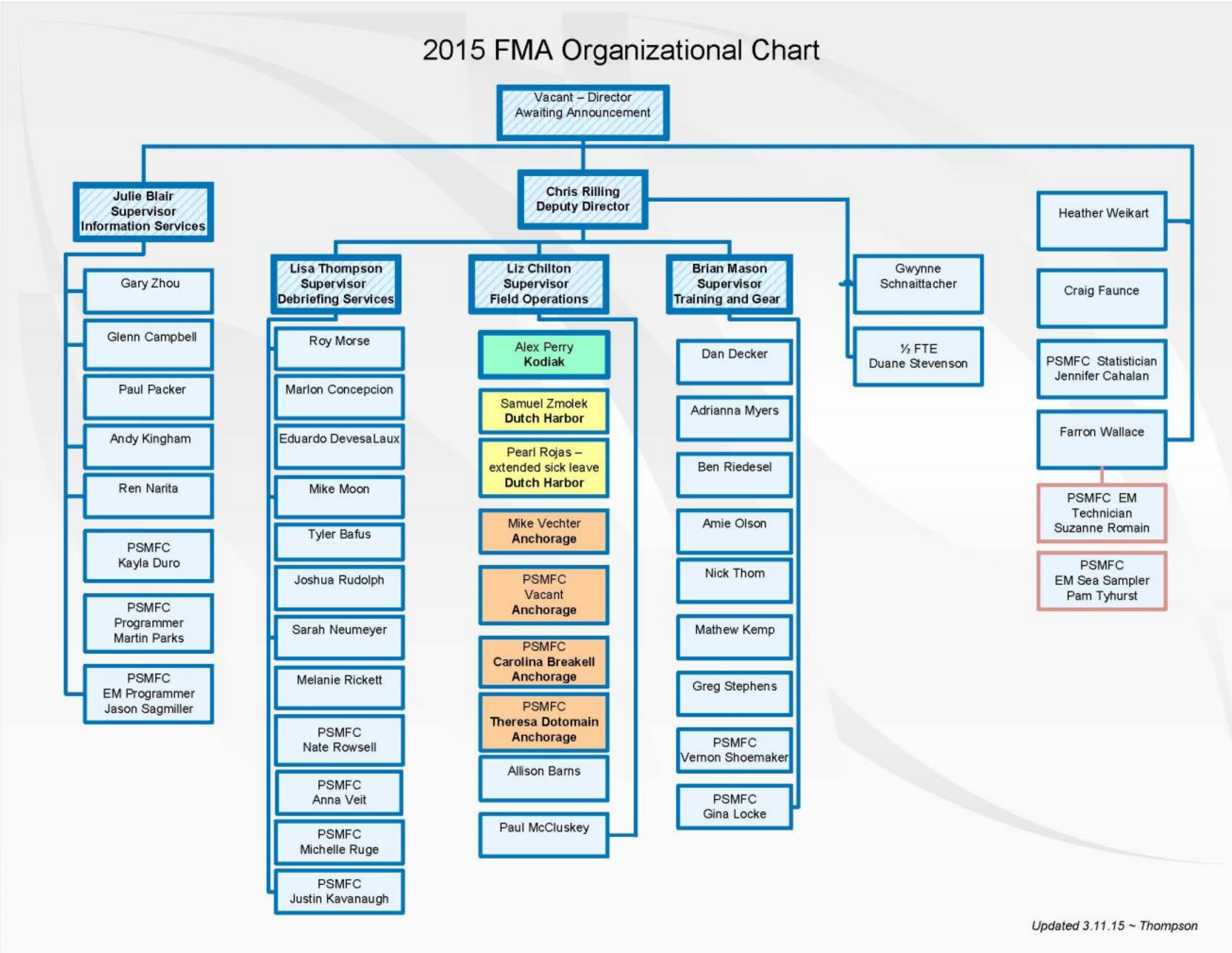
APPENDIX IV – AUKE BAY LABORATORY ORGANIZATIONAL CHART



ABL Organization Totals	
FTE	62
Term	1
Associate	4
Contractors	26
Students	0
Volunteer	1
TOTAL Active	94

ABBREVIATIONS	FACILITIES
PM = Program Manager	*TSMRI
A = Associate	♦Auke Bay Marine Station
N = Non-NOAA	★Little Port Walter Marine Station
RO = Rating Official	☼ Auke Creek Research Station
S = Supervisor	✗ Pribilof/St Paul /St. George Islands
St = Student Appointme	✚ Bldg 4, Sand Point, Seattle
T = Term Appointment	Juneau Subport
V = Volunteer	**CODES**
	F/AKC4 = ABL Routing Code
	* Organization Code
	▪Operating Unit Number

APPENDIX V – FMA ORGANIZATIONAL CHART



CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2014

April 2015

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Compiled by
K. L. Yamanaka
Fisheries and Oceans Canada
Science Branch
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

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. Carmel Lowe is the new Regional Director of Science. The Divisions and Sections are as follows:

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

Canadian Hydrographic Service	Mr. David Prince
Ocean Science	Ms. Miriam O (Acting)
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. Dennis Rutherford (Acting)
Pelagic Fish Research & Conservation Biology	Dr. Nathan Taylor (Acting)
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 2016 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 Regional Manager (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 which is headed by Mrs. Marilyn Hargreaves. The Groundfish Section has at least two review meetings per year, in which stock assessments or other documents undergo scientific peer review (including external reviewers who are often from NOAA). The resulting Science Advisory Report summarizes the advice to Fishery Managers, with the full stock assessment becoming a Research Document. Both documents can be viewed on the Canadian Stock Assessment Secretariat website: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm

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 2015 Groundfish Integrated Fisheries Management Plan can be viewed at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.htm#Groundfish.

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 were no longer possible. Larocque Relief Funding, to replace fish allocations, was provided in 2007 and continued to fund surveys through March 2013. Recent legislative changes grant the Minister of Fisheries and Oceans the authority to allocate fish or fishing gear for the purpose of financing scientific and fisheries management activities that are described in a joint project agreement entered into with any person or body, or any federal or provincial minister, department, or agency. Some of the Larocque Relief funded projects transitioned to the new Fisheries Act provisions for the 2013-14 fiscal year, where stakeholders were willing.

Allocations of fish for financing scientific and management activities are identified in the Groundfish Integrated Fisheries Management Plan. Joint Project Agreements (JPAs) were developed for 2014-15 between Fisheries and Oceans Canada and several partner organisations to support groundfish science activities through the allocation of fish to finance the activities. These JPAs will be updated for 2015-16.

B. Multispecies or ecosystem models and research

1. Development of a tiered approach to the provision of harvest advice for B.C.'s groundfish.

Many species of groundfish in B.C. are data deficient where the available data are inadequate to support complex stock assessment models. However, DFO's Sustainable Fisheries Framework (http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/overview-cadre-eng.htm) requires the provision of science advice on the status of, or risks to, species of groundfish affected by fishing activities. A tiering framework would define guidelines for assessing the adequacy of data for stock assessment and recommend assessment approaches for species with limited information. Similar frameworks have been developed for Alaskan, Australian, and European fisheries.

2. Implementing Ecosystem Approaches to Management in the Pacific Groundfish Stock Assessment Process Post-Doctoral Research Fellow Dr. Jean-Baptiste Lecomte

In 2011, the DFO Sustainable Aquatic Ecosystems Strategic Outcome Committee identified the need for a DFO National policy regarding Ecosystem Approach to Management (EAM). This project first investigates mechanistic ecosystem processes (ecosystem considerations) and their use in the provision of science advice for Pacific groundfish. Secondly, it will provide recommendations to groundfish science on how its operational advice can be best structured within a regional EAM framework.

During the past year, a Bayesian approach aimed at identifying relationships between climatic and environmental variables and the productivity of Pacific groundfish species has been developed. This approach accounts for all uncertainties in productivity estimates provided by age-structured or surplus production Bayesian models already used for science advice. This method allows drawing mechanistic ecosystem processes that affect groundfish species. In particular, this approach was applied to the Pacific Ocean Perch (*Sebastes alutus*, POP) stock in the Queen Charlotte Sound (BC, Canada). POP recruitment estimates, number of age 1 fish, are provided by a Bayesian catch at age model used for the stock assessment of this species for the period 1940 to 2010, and are used to identify relationships between environment and POP productivity. Key climatic and environmental variables (i.e. PDO, NPGO, Sea level at Prince Rupert) impacting POP recruitment were identified and illustrated a conceptual mechanism of the ecosystem processes that affect POP productivity.

The next step of this project is to build a decision-based framework with a priori rules and harvest strategies incorporating the mechanistic ecosystem processes previously identified. The objective is to have a suite of harvest strategies that can accommodate multiple states of productivity and uncertainty inherent in ecosystems, monitoring and assessment modelling.

3. Summary of research surveys in 2014

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 2014, please see Appendix 2. Other research surveys conducted in 2014 include longline and trap surveys. These surveys are described under their respective species programs below.

C. By species

1. Pacific Cod

i. Research program in 2014

Statistical analyses were developed in 2014 to investigate alternative drivers of productivity and abundance of Pacific Cod (*Gadus macrocephalus*) in British Columbia. Simulation models and linear regression analyses were used to evaluate fishing, climate drivers and density-dependent mortality as possible contributors to large apparent cycles in recruitment and abundance of Pacific Cod since the 1950s. Unfortunately, the work was mostly inconclusive. Estimates of recruitment from the 2013 stock assessment were highly uncertain and confounded with large changes in fishery practices. Length data proved inadequate for estimation of recruitment, due to uncertainty in selectivity and inconsistencies in the sampling program throughout the time series. Previously-identified correlates with recruitment (e.g., Prince Rupert sea level) were no longer significantly related to recruitment. Feedback simulation modelling was used to search for management procedures that are robust to uncertainty in underlying drivers of abundance and productivity, including performance of alternative fishery reference points. Results of this work were presented at several meetings, including the 2014 PICES Annual Meeting in Yeosu, South Korea, and the Western Groundfish Conference in Victoria, BC. Results of the feedback modelling component are currently being developed into a primary paper.

Genetic tissue was collected during 2014 Synoptic Surveys in the Strait of Georgia and the West Coast of Vancouver Island. Genetic samples were also collected by a commercial vessel during the 2015 spring spawning season. These samples are intended to be used in studies on stock structure in British Columbia. In addition, otoliths were collected, along with dorsal fins during the 2014 synoptic surveys. Pacific Cod are notoriously difficult to age, especially in British Columbia, and are currently aged using dorsal fin rays. The otoliths will be used in a new age-validation project due to begin in 2015, in collaboration with the PBS Sclerochronology Laboratory.

ii. Stock Assessments

A stock assessment for Areas 5CD (Hecate Strait) and 5AB (Queen Charlotte Sound) was reviewed in January 2014. The stock assessment applied a Bayesian delay-difference model to catch, survey and biological data from 1956-2013. Following the discovery of some problems in the data used to calculate mean weight in the commercial fishery in Area 5AB, this portion of the stock assessment was re-done and reviewed in December 2014. For both areas, there was large uncertainty in the estimates of natural mortality, and consequently in estimates of fishery reference points and stock status, especially for Area 5AB. Alternative reference points based on estimated historical biomass and fishing mortality were used as an alternative to MSY-based reference points. Performance of alternative reference points was evaluated using feedback simulation modelling.

2. <u>Rockfish – inshore</u>

i. Research programs in 2014 and planned for 2015

1. Surveys on the Inside (PMFC Area 4B)

A research longline survey was designed and initiated in 2003 to survey hard bottom (non-trawlable) areas over the Inside waters east of Vancouver Island. Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records, and fishermen consultations. The hard bottom 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. The Inside waters are divided into two regions; Northern and Southern and one region is surveyed in each year. Twenty-one days of DFO ship time are allocated in August for this longline survey. In 2014, the Northern region was surveyed, hence, in 2015 the Southern region is planned for a survey.

2. Surveys on the Outside (PMFC Areas 3CD, 5ABCDE)

Since 2003, the International Pacific Halibut Commission (IPHC) has allowed a third technician onboard charter vessels during the 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 was supported by DFO and the Halibut and Sablefish commercial industry between 2003 and 2006 and Larocque funds between 2007 and 2012. A transition to other funding mechanisms was not completed in time for a survey program in 2013, however, a survey program was conducted under a "Use-of-Fish" policy and Joint Project Agreement (JPA) with the Pacific Halibut Management Association (PHMA) in 2014. This JPA is scheduled for renewal for 2015.

In collaboration with the PHMA, 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. Similar to the IPHC survey, alternative funding was not secured for this program in 2013 but a survey program was conducted for the southern portion of BC in 2014 under a "Use-of-Fish" policy and JPA with the PHMA. This JPA is scheduled for renewal for 2015.

3. Assessment of Rockfish Conservation Areas (RCAs) using visual surveys.

Late in 2014, competitive funding was granted to continue the analysis of the visual data to assess inshore rockfishes within and adjacent to RCAs. Documentation of survey and video review methods is underway, as well as, the analysis of reef-fish species within and adjacent to RCAs.

ii. Stock assessment

There were no stock assessments prepared in 2014. An outside population stock assessment for Yelloweye Rockfish is underway with a proposed data review with industry in May and assessment review in September 2015.

iii. Management

Subsequent to public consultations in 2012, the Minister of Environment has not made a decision on whether to list Quillback Rockfish as *threatened* under Canada's *Species At Risk Act* (SARA). Quillback Rockfish remain unlisted in 2014. If listed as *threatened,* DFO must create recovery strategies and action plans within a year of listing.

Yelloweye Rockfish was listed as *Special Concern* under the SARA in 2011. DFO is developing a SARA management plan in 2015.

3. <u>Rockfish – shelf</u>

Research Programs in 2014

There was no directed biological research work on shelf rockfish in 2014 with the exceptions that (a) biological samples are routinely collected from the commercial trawl fishery and from the four multi-species synoptic bottom trawl surveys off the west coast of Vancouver Island, the west coast of Haida Gwaii, Queen Charlotte Sound, and Hecate Strait, and (b) genetic material is collected on all major groundfish surveys for species identification of the Rougheye Rockfish/Blackspotted Rockfish sibling species complex.

Stock assessments in 2014

In 2014, the first stock assessment of Yellowtail Rockfish (YT, Sebastes flavidus) in BC waters since 1998 was conducted (DFO 2015). This work was completed in collaboration with an analyst from the Canadian Groundfish Research and Conservation Society. The primary challenge to the assessment of YT in both Canadian and US waters is the lack of reliable indices of stock abundance. This species usually resides near the bottom but is often found in the water column and, therefore, may not be reliably represented in the various bottom trawl surveys conducted coastwide. Survey sampling error for relative biomass estimates is typically large, with coefficients of variation often exceeding 50% and reaching as high as 90%.

Alternative survey gears (e.g., longline hook and trap) are inefficient for catching YT, and there is no available midwater trawl survey or time-series derived from acoustic measurements suitable for indexing the abundance of this species.

An annual, two-sex statistical catch-at-age (SCA) model was applied to (i) reconstructed catches starting in 1940, (ii) fishery-independent indices of relative biomass derived from six bottom trawl surveys spanning 48 years from 1967 to 2014, and (iii) proportion-at-age data from commercial and survey sources spanning 34 years from 1980 to 2013. A Bayesian approach was used to allow the modelled uncertainty to be characterized by a Markov Chain Monte Carlo (MCMC) approximation to the posterior probability distribution of leading and derived model parameters. The leading parameters estimated by the model include stock-recruitment parameters, natural mortality (independently for females and males), catchability coefficients for the six survey series, and sex-specific selectivity parameters for the commercial fishery data and for the three survey series for which age data are available. Fixed inputs to the model include growth and maturity information and the selectivity parameters for the remaining three survey series.

Estimates of the leading model parameters were used to reconstruct derived quantities annually from 1940 to 2014, including the vulnerable biomass (the biomass that is vulnerable to capture by the fishery), the spawning stock biomass (mature females only), the mid-year exploitation rate, and the population age structure. Reference points related to the unfished equilibrium biomass, current stock biomass, minimum stock biomass and the biomass at maximum sustainable yield (MSY) were used to evaluate current and future stock status. Forecasts from 2016 to 2025 (10 years) were performed for a fixed range of constant annual catches to estimate the probabilities that the spawning biomass will exceed the reference points in each future year. The uncertainty associated with parameter estimates and forecast performance was calculated using 1000 draws from five million MCMC samples from the Bayes posterior probability distribution, and presented as the median and a 90% credible interval (i.e., the 5th, 50th and 95th percentiles).

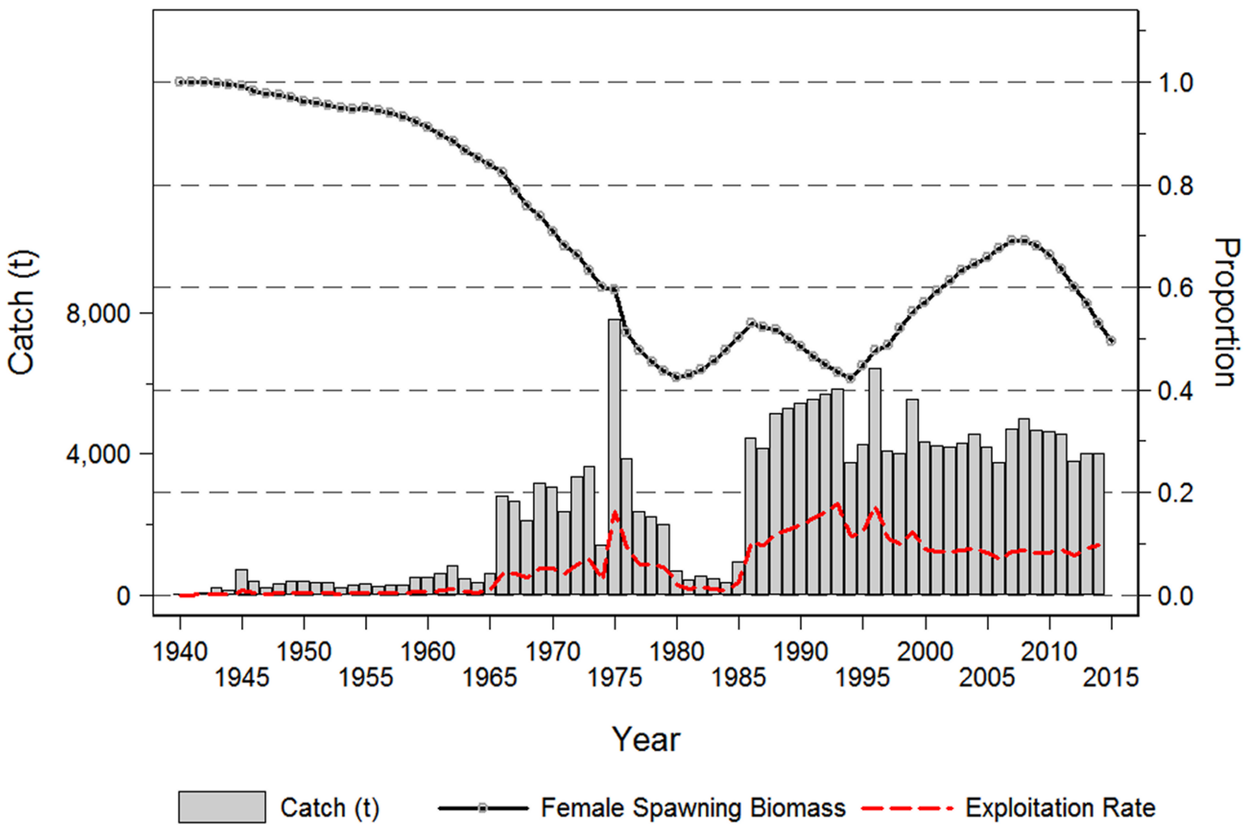

Figure 1. Annual commercial catch (tonnes, vertical bars scaled to left-hand axis) and median estimates for Bt/B0 (female spawning biomass in year t relative to that in 1940) and exploitation rate ut (ratio of total annual catch to the vulnerable biomass in the middle of the year) scaled to the right-hand axis. These results are based on the reference case. Source: DFO 2015.

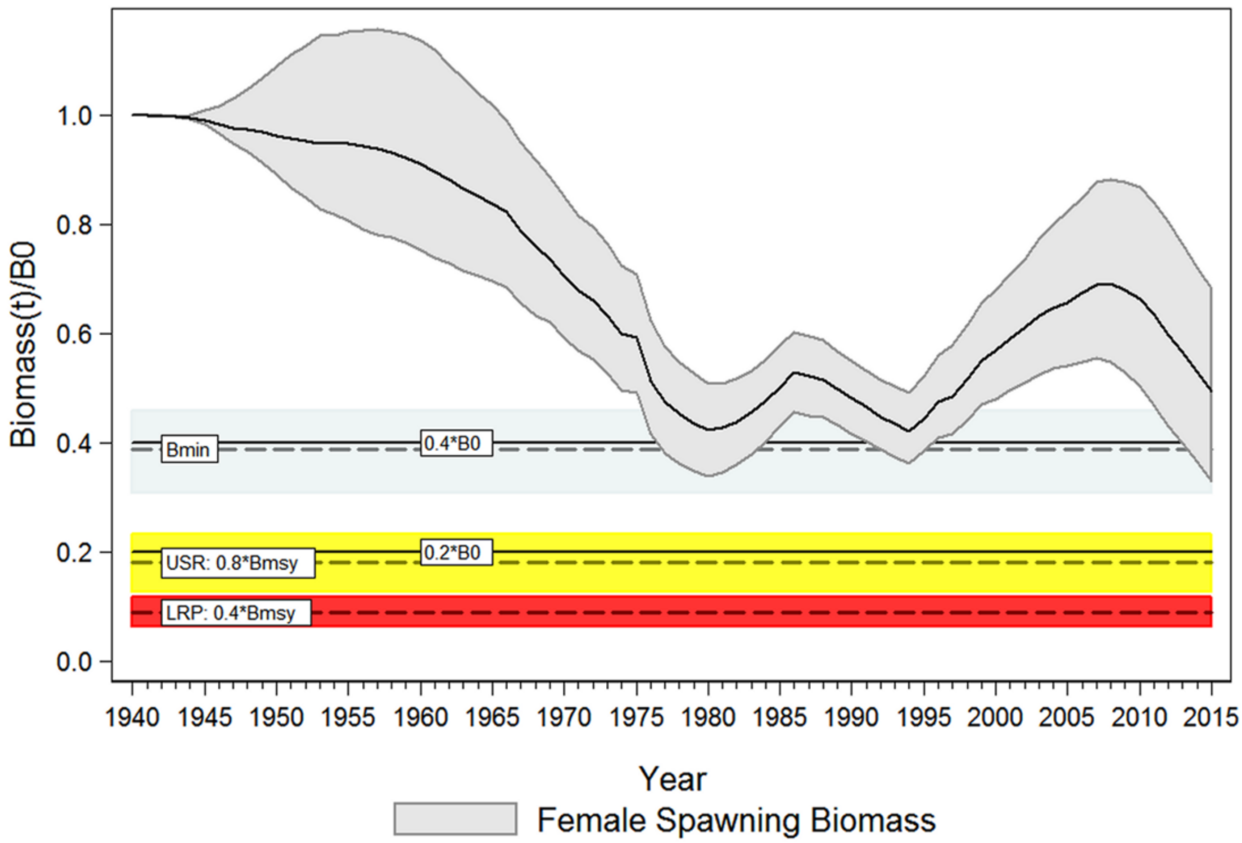

Figure 2. Posterior median estimates and 80% credibility intervals for female spawning biomass (Bt) by year relative to B0 for Yellowtail Rockfish (grey envelope with black line median). Also shown relative to B0 are posterior median estimates (dashed lines) and 80% credibility intervals for the MSY-based reference points (LRP: Limit Reference Point = 0.4BMSY in red; USR: Upper Reference Point = 0.8BMSY in yellow) and the minimum biomass reference point (Bmin) from the MCMC posterior of Bt. The reference levels of 0.2B0 and 0.4B0 appear as solid black lines in B0 space. Source: DFO (2015).

The interpretation of YT stock status that can be derived from the reference case (single gear, six groundfish bottom trawl survey indices) is of a population that has declined from a median spawning stock depletion of about 0.7 to about 0.49 of the unfished state over the last eight years, as a relatively strong 2001 year class is removed by fishing and natural mortality (emigration is not explicitly accounted for in the model and will appear as a higher natural mortality). Estimated spawning stock biomass remains above historical lows that occurred in 1980 and 1994, when the median depletion was below 0.4B0. Median exploitation rates have been near 0.1 since 1990, ending with u2014=0.10 by the terminal year in the reconstruction. The population is forecast to decline modestly over the next 10 years at current harvest levels to a median depletion of about 0.4B0.

Research activities planned for 2015

DFO staff continues to collect genetic material from the Blackspotted and Rougheye Rockfish species complex. Tissue samples from these species are collected from all major surveys and analysed for species identification. Joint work is underway with colleagues from Simon Fraser

University to map the spatial distribution of the two species and identify scenarios for partitioning the historical catch, which was recorded simply as “Rougheye Rockfish”.

Stock assessments planned for 2015

No shelf rockfishes are scheduled for assessment in 2015.

References

DFO. 2015. Yellowtail Rockfish (*Sebastes flavidus*) Stock Assessment for the Coast of British Columbia, Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/010.

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 (Committee on the Status of Endangered Wildlife in Canada) 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, Nanaimo BC) 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. The program retains 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.

Work was completed on the first phase of an International Governance Strategy (IGS) project entitled *Ocean Acidification and Impacts on Marine Ecosystems* headed by Debby Ianson at the Institute of Ocean Sciences (IOS, Sidney BC). The project explored the potential effects of ocean acidification on BC fisheries and temperate marine ecosystems. A manuscript was submitted to PLOS ONE on Jul 29, 2014. It was accepted on Dec 23, 2014 and the paper was published on Feb 11, 2015 (Haigh et al. 2015).

All PBS packages on CRAN were updated to comply with the ever-changing R environment – PBSmapping 2.68.68 published Jan 14, 2015; PBSmodelling 2.67.266 published Jan 23, 2015; PBSddesolve 1.11.29 published Jun 16, 2014; PBSadmb 0.68.104 published Apr 9, 2014. The DFO packages not on CRAN were also maintained and rebuilt (see PBS Software). Additionally, collaboration started on a new package *PBSsatellite* initiated by Lyse Godbout from DFO’s Salmon Assessment and Freshwater Ecosystems (SAFE) division and implemented by Nicholas Boers (MacEwan University, Edmonton AB).

Work started in collaboration with Jackie King (PBS) on a project called “Implementing Ecosystem-based Fisheries Management in the Groundfish Stock Assessment Process” funded by the Strategic Program for Ecosystem-Based Research and Advice (SPERA). The objectives are (i) to identify mechanisms linking climate-ocean variability to groundfish recruitment, and (ii) to construct and test the decision-based framework for commercially important groundfish species. A postdoctoral fellow, Jean-Baptiste Lecomte, was recruited from France to work on this (see above B. Multispecies or ecosystem models and research).

ii. Stock assessment

In 2014, our group presented an updated stock assessment (since 2006) for the Redbanded Rockfish (RBR, *Sebastes babcocki*) stock along the BC coast. There was an attempt to fit a statistical catch-age model (specifically Awatea, a version of Coleraine); however, the ageing data were sparse and inconsistent, and the model fits proved to be unstable. It became clear after some discussion with the Sclerochronology Laboratory that ageing RBR is difficult and that estimated ages are likely inaccurate and imprecise.

The RBR assessment team tried running Awatea without the age data, fitting only to the survey indices. Such a model run should behave similarly to a surplus production model, with the main difference being the formulation of the productivity assumptions. Unlike a surplus production model where productivity is embodied in a single estimable parameter, this model formulation fixed natural mortality, steepness of the stock-recruitment function and all the selectivity parameters using the means of the informed priors for these parameters. This model run was characterized by enormous uncertainty, particularly at the upper end of possible biomass levels, and would require considerable more work before being suitable for providing advice to management.

In the end, the RBR team fitted unweighted linear regressions to each survey series (each survey series independently). All of the fitted trends for all the surveys had $p > 0.05$. The smallest p-value was 0.06 for the IPHC survey (Figure 11). The 95% confidence intervals for the slopes all overlapped 0, except for the IPHC longline survey where the upper bound equaled 0. Thus, none of the fitted trends appeared to be significantly different to 0 (at the 0.05 level). By definition, this analysis ignored any structure in the series; for example, the IPHC survey (Figure 11) showed an increase in the late 1990s followed by a drop to a lower level.

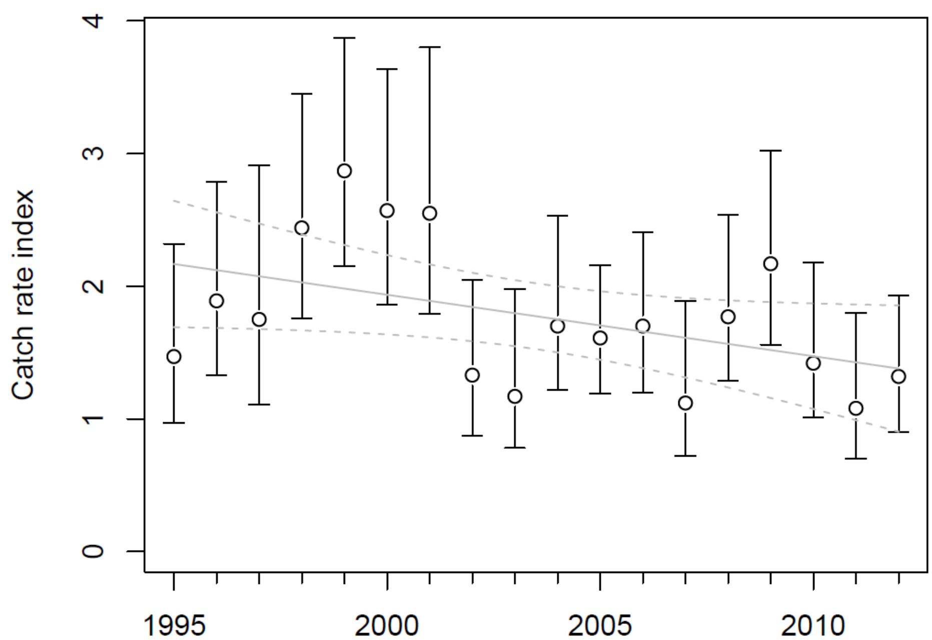

Figure 11. Relative catch rate index (numbers per effective skate) for the IPHC Longline series, shown as mean values (circles) and bootstrapped 95% confidence intervals (bars). Unweighted linear regression fit shown as solid lines (with 95% confidence intervals as dashed lines), but in light grey to indicate that the trend is not significantly different from 0 (p=0.06).

iii Research activities for 2015

Rowan will be chairing regional peer review meetings in May for stock assessments on Arrowtooth Flounder (*Atheresthes stomias*). The quality control work conducted on the IPHC longline survey data will be written up in more detail, and methods will be explored to properly consider the zero observations in such data.

Collaboration continues with Jackie King (PBS) and Jean-Baptiste Lecomte (postdoctoral fellow, PBS) on the aforementioned project "Implementing Ecosystem-based Fisheries Management in the Groundfish Stock Assessment Process" (see above B. Multispecies or ecosystem models and research).

Collaboration continues on a new R package, tentatively called *PBSsatellite*, which will provide support for reading and manipulating satellite data from NetCDF files. This project is lead by Lyse Godbout (DFO, SAFE) and incorporates the technical expertise of Dr. Nicholas Boers (MacEwan University) and student(s). In 2015, this project hopes to build on the capabilities of *PBSsatellite* to develop applications that will use satellite data (e.g., chlorophyll, temperature) to facilitate or complement fisheries stock assessments.

Work continues with international colleagues on developing methods for calculation biomass size spectra, with a view to applying them in future to data on the groundfish community.

5. Sablefish

i. Research activities in 2014 and planned for 2015

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 2011-2014 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, discontinued)

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** (2003-2014)

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** (1995-2014)

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 2014 contingent on adequate resources from DFO and the Sablefish industry, but will include only the randomized program (c) and the inlets program (d).

A new introduction to the surveys in 2013 was the deployment of “trap camera” system consisting of (1) tri-axial accelerometers that produce measurements of quasi-continuous 3-axis motion and orientation of fishing traps, (2) deep-water autonomous cameras affixed to traps that produces motion-activated and fixed-interval high definition video of benthic substrate type, gear interaction with the substrate, and biological communities; and (3) standard oceanographic probes that measure in-situ depth and temperature data needed for gear mobility (depth) and habitat suitability modeling (both). Developmental work on the camera system in 2014/15 includes provision of a graphical user interface for camera configuration, and replacement of the existing “stand-alone” accelerometers with new units capable of higher temporal resolution. The “trap-camera” system is deployed on most Sablefish survey sets and has been deployed on three commercial fishing trips to northern seamounts (including Bowie Seamount) when fishery-independent at-sea observers were on-board.

ii. Stock assessment activities in 2014 and planned for 2015

In 2013, fishing industry stakeholders proposed a TAC floor of 1,992 t, because lower quotas may increase economic risks. The existing management procedure was revised to implement this TAC floor and simulation analyses were conducted to determine whether the revised management procedure would continue to meet agreed conservation objectives. The revised procedure provides conservation performance that is comparable to the existing procedure. Applying the revised procedure to updated landings and biomass index data resulted in a harvest recommendation of 2,129 t for the 2013/14 fishing year, which was above the proposed TAC floor. A lower survey index in 2014 resulted in the catch floor being invoked, i.e., a catch recommendation of 1,992t for the 2015/16 fishing year.

Development of the Sablefish operating model used for feedback simulations was delayed from 2014 to 2015. Consequently, an updated management strategy evaluation will not be conducted until 2015/16. Recent publications related to BC Sablefish reviewed evidence for stock structure, documented the revised management procedure, and described the use of biological reference points and operational control points for the BC Sablefish fishery.

6. Flatfish

i. Research program in 2014

Ongoing data collection in support of the flatfish research program continued in 2014 through the Groundfish Synoptic Surveys, port sampling, and at-sea observer sampling.

ii. Research activities planned for 2015

A review and summary of biological and abundance information collected from multiple flatfish species during Groundfish Synoptic Surveys between 2003 and 2014 is planned for 2015 – 2016.

An evaluation of management procedures for Rock Sole stocks that differ in the approach used to estimate reference points is also planned for 2015; this evaluation will be contrasted with a similar analysis for Pacific Cod stocks.

iii. Stock assessments planned for 2015

A coastwide assessment of Arrowtooth Flounder in BC will be delivered in May 2015 and an assessment of Petrale Sole stocks in BC is anticipated in November 2015.

7. Lingcod

i. Research programs in 2014

Ongoing data collection in support of the lingcod research program continued in 2014 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

ii. Stock assessments in 2014

A stock assessment for the Inside Strait of Georgia Lingcod stock was completed in 2014 that updated stock status for Minor Statistical Areas 13-19, 28 and 29 within Major Statistical Area 4B. The assessment focussed on characterizing how stock status had changed since the current management regime for recreational fisheries was introduced in 2006, as well as how current spawning biomass compared to biomass-based reference points. Nine stock assessment scenarios were used to characterize a range of stock status estimates in 2014. All scenarios were weighted equally when characterizing stock status and a model-averaging approach, in which estimated Bayesian posterior distributions from all nine scenarios were combined with equal weights, was used to represent structural uncertainty across scenarios. All scenarios estimated a continued recovery in Strait of Georgia spawning biomass to 2014 from historically low levels in the late 1980's. Spawning biomass in 2014 was estimated with 100% certainty to be greater than spawning biomass at the start of the current management regime in 2006. Results from the model-averaging approach estimated that spawning biomass in 2014 was most likely in the cautious zone based on the provisional reference points identified in the DFO Fishery Decision-Making Framework Incorporating the Precautionary Approach (i.e., cautious zone = spawning biomass between $0.4B_{MSY}$ and $0.8B_{MSY}$). The median estimate of the model-averaged posterior distribution for the ratio of B_{2014} / B_0 was 0.23 (5^{th} and 95^{th} percentiles = 0.17, 0.30).

8. Pacific Hake

i. Research program

Triennial (until 2001), then biennial acoustic surveys, covering the known extent of the Pacific Hake stock have been run since 1995. An acoustic survey, ranging from California to northern British Columbia was run in 2013, to continue the biennial time series. The estimated biomass from the 2013 survey was 2.423 million metric tonnes with a CV of 0.0433. This estimate is approximately 1.75 times the 2012 survey estimate and 4.66 times the 2011 survey estimate. The survey catch was dominated by three-year olds at 76.2% of the total number. Nearly all the three-year olds were found in United States (US) waters, only 4.6% of the overall biomass was in Canadian waters at the time of the survey.

Being an off-survey year, 2014 ship time for Canada was used for research of Pacific Hake. The research included haul representativeness, which was done by performing a series of tows across single hake aggregations at different depths and spatial locations. This was done to determine the efficacy of performing a single tow on an aggregation of Hake during the survey and attributing the length frequency from the single tow to the entire aggregation for biomass estimate purposes. Age-1 hake aggregations were also insonified and measured for target strength, which will be used to improve the target strength/length relationship which is applied to the acoustics in the biomass estimation procedure.

ii. Stock Assessment in 2015

The majority of the Canadian Pacific Hake catch for the 2014 season was taken from the Southwest coast of Vancouver Island in the third quarter (July-Sept). The recent (2008-2013) shift in temporal and spatial distribution of Pacific Hake Northward was not apparent in 2014.

The Joint Venture (JV) fishery did not receive any quota in 2014. The total Canadian TAC including carryover for 2014 was 111,357 metric tonnes (mt). The domestic sector was allocated all of this and caught 34,784 mt (31% of total allocation).

Management of Pacific Hake has been under a treaty (The Agreement) between Canada and the United States since 2011. As in previous years, and as required by The Agreement, The 2015 harvest advice was prepared jointly by Canadian and US scientists working together, collectively called the Joint Technical Committee (JTC) as stated in the treaty. A single assessment model was used; Stock Synthesis 3 (SS3). The SS3 model was selected as the base model by the JTC, and endorsed by the SRG. The 2015 model was the same model used in 2014, with time series updates (catch and age compositions) but without a new acoustic biomass index, because it was a non-survey year.

The final decision on catch advice for the 2015 fishing season was made at the meeting of the International Pacific Hake Joint Management Committee in Lynnwood, Washington on March 18-19, 2015. A coastwide TAC of 440,000 mt for 2015 was established, which includes any carryover from 2014. As laid out in the treaty, Canada will receive 26.12% of this, or 114,928 mt.

The final assessment document and other treaty-related documents are posted at:
http://www.nwr.noaa.gov/fisheries/management/whiting/pacific_whiting_treaty.html

9. Elasmobranchs

i. Research programs in 2014

Active programs for Basking shark (*Cetorhinus maximus*), big skate (*Bathyraja binoculata*), longnose skate (*Raja rhina*), blue shark (*Prionace glauca*), salmon shark (*Lamna ditropis*) and spotted ratfish (*Hydrolagus colliei*).

ii. Stock assessment in 2014

The stock assessment for Pacific spiny dogfish (*Squalus suckleyii*) was cancelled upon request from fisheries management for Nov 2014. The IUCN Red List Reassessment for big skate was completed through the Shark Specialist Sub-group of IUCN.

iii. Management

Code of Conduct for sharks captured in commercial and recreational fisheries were released in 2014. The Code of Conduct provides instruction for identification, reporting and sampling (by onboard observers). The shark sightings network was fully launched in 2014 with online or phone in reports (www.pac.dfo-mpo.gc.ca/SharkSightings; 1-877-507-4275). Reward badges and postcards are provided for reported shark sightings.

iv. Research activities for 2014.

1. Habitat modelling of critical habitat on basking shark based on satellite chlorophyll and SST, coupled to field samples of zooplankton density.
2. NPRB funded collaborative research with NMFS and MLML for bomb radiocarbon age validation of big skate and longnose skate.
3. Development of microsatellite markers for salmon shark.

D. Other related studies

1. <u>Statistics and Sampling</u>

i. Biological sampling and database work in 2014

Principal Statistics and Sampling activities in 2014 included the ongoing population of the groundfish biological database (GFBio). This database now includes over 10,045,000 specimens. Data entry activities continued to concentrate on the input of current port sampling and observer biological data and recent research cruises. There was also further targeted effort towards the entry of historic research cruises and the scanning of original documents to electronic format.

The groundfish trawl fishery continues to be covered by 100% dockside and virtually 100% observer coverage. These observers also provided 252 length/sex/age samples and 80 length samples in 2014. Port samplers provided an additional 33 samples, all except one sample with ageing structures (length/sex/age/weight). The focus of their sampling efforts continued to be from those fisheries not covered by at-sea observers with the bulk of the samples (21) coming from sablefish tag recoveries and frozen samples from seamount trips. In addition, there were 26 samples collected in Ucluelet from the domestic hake fishery; 22 of the samples had ageing structures.

The GFBio database tag release module underwent a major revision in 2014. This was necessary to enable individual tagged fish that were captured and subsequently re-released with a new tag to be properly connected to all of its related information (e.g., length, weight, previous tag number). It was also necessary to modify GFBioField to facilitate the changes in the tagging module.

Development of “GFCatchAll” as a comprehensive database that will include all known sources of groundfish catch (1900-present) is still on hold but work was initiated in 2014 to enter known sources of catch information from historic catch reports published in the 1960s and 1970s.

The statistics group continued to field a large number of internal and external data requests in 2014 and worked on methods to streamline the responses. This included the development of standardized tables for release to the public that respected confidentiality issues of commercial fisheries data.

ii. Catch monitoring in 2014

Staff continued to be being actively involved in the Recreational Catch Monitoring Working Group.

iii. Field work in 2014

Staff participated on various bottom trawl surveys (see Summary of Groundfish Surveys below) including the west coast Vancouver Island and west coast Haida Gwaii groundfish trawl surveys, the west coast Vancouver Island, and Queen Charlotte Sound shrimp trawl surveys, as well as the Pacific Hake hydroacoustic survey. This group also included the port sampling activity (1 person-years) in the Vancouver area. Staff continued to enhance GFBioField, the integrated (paper-less) data capture system for surveys.

iv. Proposed field and database work for 2015

Port sampling in the Vancouver area will continue in 2015.

Staff will participate in groundfish bottom trawl surveys to the Strait of Georgia, Hecate Strait and Queen Charlotte Sound, the shrimp trawl survey off the west coast of Vancouver Island, and the Pacific Hake hydroacoustic survey.

Development of “GFCatchAll” as a comprehensive database that will include all known sources of groundfish catch (1900-present) will continue in 2015 to identify all possible sources of catch information and to work on the documentation of various fishery sectors through time.

APPENDIX 1. REVIEW OF CANADIAN GROUNDFISH FISHERIES

1. Commercial fisheries

All catch figures for the 2013 calendar year are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut) in 2013 were 89,761 t, a decrease of 12% from the 2012 catch. The major species in the trawl landings were Pacific Hake (60%), Arrowtooth Flounder (9%), Pacific Ocean Perch (5%), Yellowtail Rockfish (4%), and Walleye Pollock (4%). Trawl production was distributed amongst areas 3C (35%), 3D (26%), 5A (16%), 5B (6%), 4B (6%), 5D (4%), 5E (4%), and 5C (1%).

Canadian landings of groundfish caught by gear other than trawl in 2012 totalled 5,746 t. Landings of Sablefish by trap and longline gear accounted for 2,212 t, approximately 58% by trap gear, 40% by longline gear and 2% by unspecified. Landings of species other than Sablefish by trap, longline, handline and troll gear accounted for 3,266 t (49% rockfish, 27% Lingcod, 12% North Pacific Spiny Dogfish, and 11% 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 2013, the estimates were generated from a combination of creel surveys and fishing lodge reports and covered the months of March to October. Provisional estimates of 2013 catches, landings and releases, for this 8-month period were 17,312 fish for Lingcod, 18,856 fish for all rockfish species, 581 fish for Pacific Halibut, 3,814 fish for Rock Sole, 1,511 fish for Starry Flounder, 2,057 fish for other flatfish species, 25,404 fish for North Pacific Spiny Dogfish, 2,231 fish for greenlings, 1,364 fish for Pacific Cod and 1,710 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 March to October. Provisional estimates for this 8-month period are 7,750 fish for Lingcod, 14,689 for all rockfish species, 8,108 fish for Pacific Halibut, 3,039 fish for all flatfish species, 17,248 fish for North Pacific Spiny Dogfish, 4,481 fish for greenlings, and 3,324 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 September. Provisional estimates of 2013 catches were 14,826 fish for Lingcod, 19,307 fish for all rockfish species, 27,583 fish for Pacific Halibut, 1,313 fish for North Pacific Spiny Dogfish, 172 fish for greenlings, 1,136 for all flatfish species, and 495 fish for other groundfish species.

Fisheries and Oceans Canada (DFO) has also implemented an internet survey (iRec) of people who hold a Tidal Waters Sport Fishing Licence to collect data on recreational fishing activity and catch in the tidal waters of British Columbia. The information collected will be used, in combination with data from other sources, to provide estimates of catch and effort in recreational fisheries. Random samples of people with Tidal Waters Sport Fishing Licences will be selected monthly. Selected licence holders will be asked to summarize all of their fishing activity and catch during that month.

The estimates from the iREC surveys won't be used for management purposes until two specific actions have been completed:

1.) Independent science review of the survey design, analysis methods and results to date.
2.) A review of iREC results against local knowledge in the recreational sector.

3. Joint-venture fisheries

There were no joint-venture fisheries conducted off British Columbia in 2013.

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific Hake off British Columbia in 2013.

APPENDIX 2. SUMMARY OF BOTTOM TRAWL SURVEYS IN 2014

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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 to the survey. 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 rates are useful indicators 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. Groundfish staff provides assistance in catch sorting and species identification and also collect biological samples from selected species. From 2010 through 2013 the goal was to collect biological 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 was focused on length by sex data as opposed to collecting ageing structures. In 2014 the sampling program was rationalized to only include species where the survey is expected to provide a useful index of abundance. Up until 2013, the groundfish section routinely placed two staff on board for the duration of the survey. Recent staffing reductions resulted in only one person being available to participate in the 2014 survey. In addition, the sampling program was further reduced so that the single person from the groundfish section could accomplish all the work.

Starting in 2013, the survey included locations in Barkley Sound that were surveyed by the CCGS Neocaligus in previous years. In 2014, the Queen Charlotte Sound portion of the survey was not conducted due to the limited number of vessel days available for the program.

The 2014 survey was conducted onboard the W.E. Ricker and ran from May 2 to 25. A total of 133 tows were completed. The total catch weight of all species was 69,977 kg. The mean catch per tow was 530 kg, averaging 26 different species of fish and invertebrates in each. Over the entire survey, the most abundant fish species encountered were Eulachon (*Thaleichthys pacificus*) followed by Spotted Ratfish (*Hydrolagus colliei*), Walleye Pollock (*Theragra chalcogramma*) and Arrowtooth Flounder (*Reinhardtius stomias*). The number of tows where the species was captured, total catch weight, estimated biomass, and relative survey error for the top 25 fish species by weight are shown in Table 1 for the West Coast Vancouver Island set locations. Abundance indices have not been calculated for the Barkley Sound set locations as these locations have not yet been used for any groundfish assessments.

Biological data were collected from a total of 10,445 individual fish from 20 different groundfish species (Table 2). Most biological samples included fish length and sex but age structures were also collected for Lingcod (*Ophiodon elongatus*) and both age structures and tissue samples for DNA analysis were collected from Rougheye Rockfish (*Sebastes aleutianus*). More than half of all the individual fish measured during the survey were Eulachon (*Thaleichthys pacificus*). Although we include this species in these summaries, the groundfish section staff typically does not collect the biological data from this species.

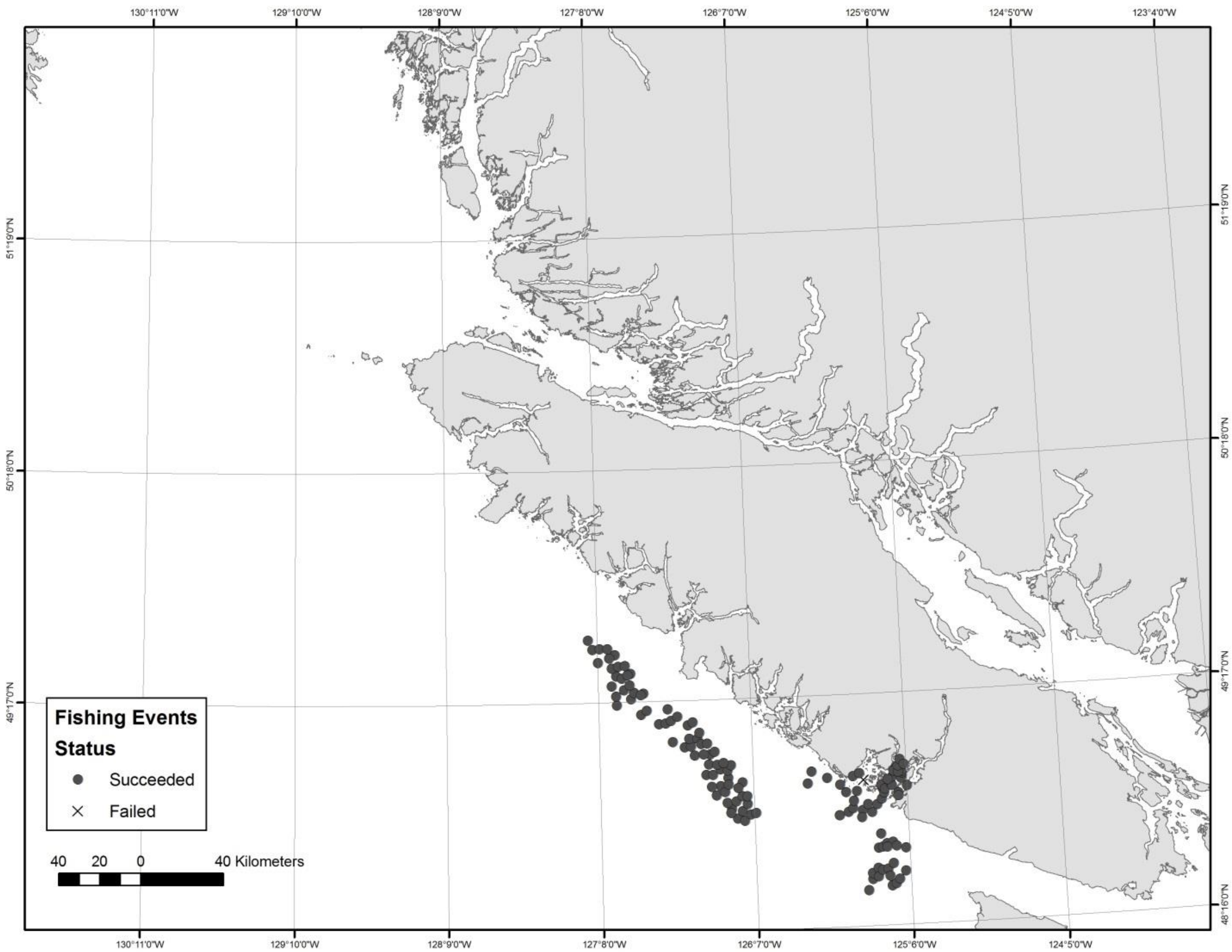

Figure 12. Barkley Sound and West Coast Vancouver Island set locations of the 2014 Multi-species Small Mesh Bottom Trawl Survey

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 2014 Multi-species Small Mesh Bottom Trawl Survey.

Species	**Scientific Name**	**Num. Tows**	**Catch (kg)**	**Biomass (t)**	**Rel. Error**
Arrowtooth Flounder	*Reinhardtius stomias*	68	4193	3871	0.10
Eulachon	*Thaleichthys pacificus*	69	4034	3897	0.12
Walleye Pollock	*Theragra chalcogramma*	40	3195	2721	0.36
Pacific Herring	*Clupea pallasii*	58	2221	1961	0.38
Pacific Cod	*Gadus macrocephalus*	60	1428	1295	0.32
Rex Sole	*Glyptocephalus zachirus*	67	1136	1068	0.09
Flathead Sole	*Hippoglossoides elassodon*	59	868	759	0.14
Dover Sole	*Microstomus pacificus*	68	742	662	0.10
Slender Sole	*Lyopsetta exilis*	69	588	525	0.11
Spotted Ratfish	*Hydrolagus colliei*	61	564	502	0.12
Lingcod	*Ophiodon elongatus*	47	478	469	0.13
North Pacific Spiny Dogfish	*Squalus suckleyi*	29	466	402	0.31
English Sole	*Parophrys vetulus*	49	390	337	0.21
Pacific Halibut	*Hippoglossus stenolepis*	34	351	354	0.18
Blackbelly Eelpout	*Lycodes pacificus*	56	207	191	0.23
Sablefish	*Anoplopoma fimbria*	42	190	156	0.22
Longnose Skate	*Raja rhina*	48	182	164	0.16
Pacific Sanddab	*Citharichthys sordidus*	10	159	128	0.78
Whitebait Smelt	*Allosmerus elongatus*	3	134	117	1.01
Petrale Sole	*Eopsetta jordani*	29	101	94	0.26
Yellowtail Rockfish	*Sebastes flavidus*	18	44	45	0.29
Big Skate	*Raja binoculata*	2	20	14	0.93
Darkblotched Rockfish	*Sebastes crameri*	25	18	20	0.46
Sandpaper Skate	*Bathyraja interrupta*	15	17	15	0.24
Pacific Ocean Perch	*Sebastes alutus*	22	12	10	0.52

Table 2. Number of fish sampled for biological data during the 2013 Multi-species Small Mesh Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	**Scientific Name**	**Lengths Collected**	**Age Structures Collected**
North Pacific Spiny Dogfish	*Squalus suckleyi*	242	0
Big Skate	*Raja binoculata*	3	0
Sandpaper Skate	*Bathyraja interrupta*	3	0
Longnose Skate	*Raja rhina*	98	0
American Shad	*Alosa sapidissima*	127	0
Eulachon	*Thaleichthys pacificus*	5548	0
Pacific Cod	*Gadus macrocephalus*	255	0
Pacific Hake	*Merluccius productus*	30	0
Walleye Pollock	*Theragra chalcogramma*	1123	0
Rougheye Rockfish	*Sebastes aleutianus*	31	31
Pygmy Rockfish	*Sebastes wilsoni*	99	0
Sablefish	*Anoplopoma fimbria*	166	0
Lingcod	*Ophiodon elongatus*	149	121
Arrowtooth Flounder	*Reinhardtius stomias*	885	0
Petrale Sole	*Eopsetta jordani*	95	0
Rex Sole	*Glyptocephalus zachirus*	918	0
Flathead Sole	*Hippoglossoides elassodon*	19	0
Pacific Halibut	*Hippoglossus stenolepis*	95	0
Dover Sole	*Microstomus pacificus*	243	0
English Sole	*Parophrys vetulus*	316	0

2. Multi-species Synoptic bottom trawl surveys

Fisheries and Oceans, Canada (DFO) together with the Canadian Groundfish Research and Conservation Society (CGRCS) have implemented a comprehensive 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 2014 the West Coast Vancouver Island and West Coast Haida Gwaii surveys were conducted.

2.1. West Coast Vancouver Island Synoptic Bottom Trawl Survey

The West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between May 28 and June 21. We assessed a total of 193 blocks (Table 3). We conducted a total of 153 tows; 147 were successful survey sets and 6 were failures due to hang ups or insufficient bottom time. Note that some blocks are only successfully fished following more than one attempt.

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

The total catch weight of all species was 138,217 kg. The mean catch per tow was 903 kg, averaging 27 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (R*einhardtius stomias*), Pacific Ocean Perch (*Sebastes alutus*), Splitnose Rockfish (*Sebastes diploproa*), and North Pacific Spiny Dogfish (*Squalus suckleyi*). The number of tows where the species was captured and total catch weight from usable tows as well as the estimated biomass and relative survey error for the 25 most abundant species are shown in Table 4. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 30,198 individual fish of 49 different species (Table 5). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 3. 2014 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl 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 to 125	3	16	2	55	2	78
125 to 200	3	5	1	49	1	59
200 to 330	2	0	0	29	0	31
330 to 500	2	9	0	14	0	25
Total	**10**	**30**	**3**	**147**	**3**	**193**

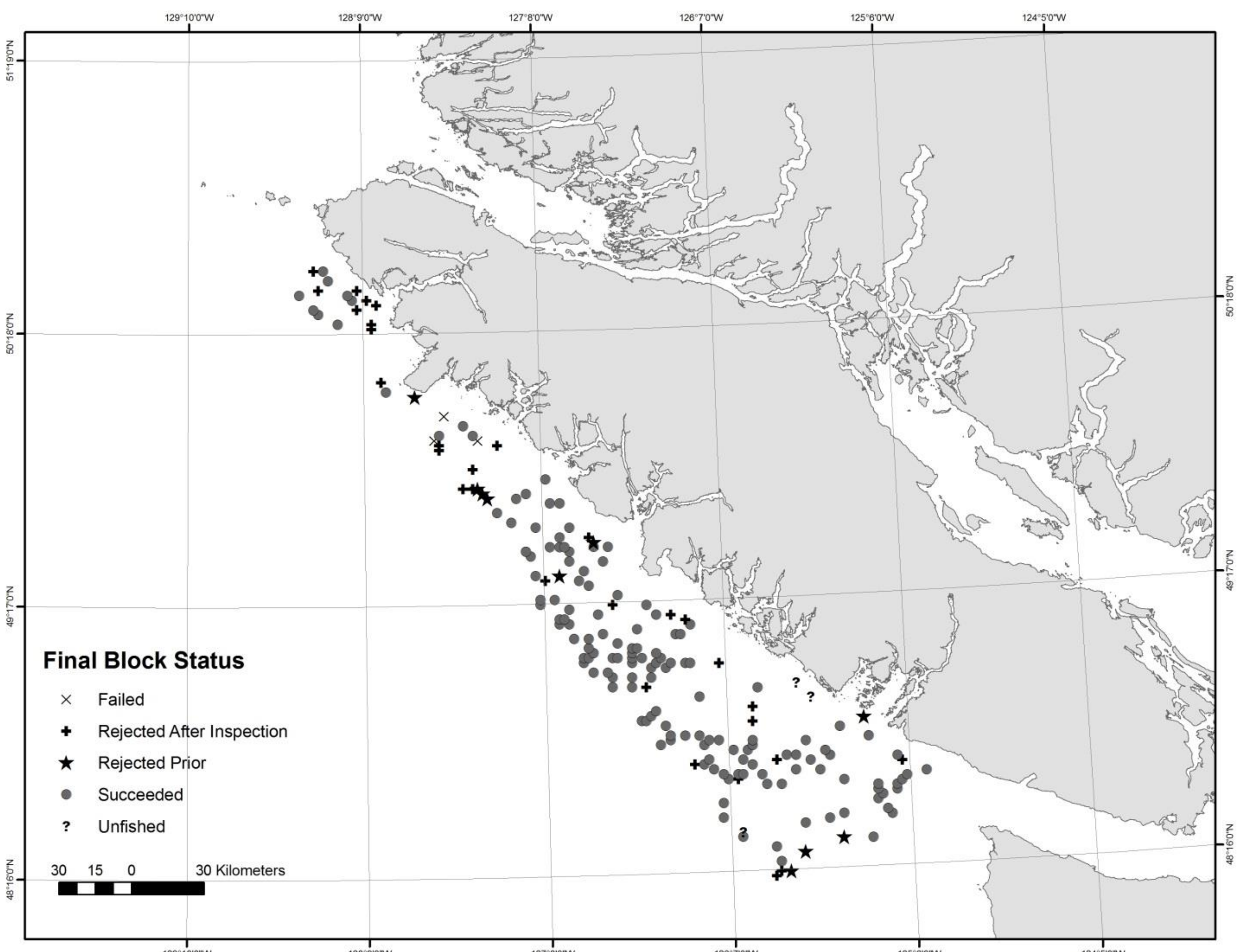

Figure 13. Final status of the allocated blocks for the 2014 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey.

Table 4. Number of catches and total catch weight from usable tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2014 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey.

Species	**Scientific Name**	**Num. Tows**	**Catch (kg)**	**Biomass (t)**	**Rel. Error**
Arrowtooth Flounder	*Reinhardtius stomias*	142	24850	14124	0.11
Pacific Ocean Perch	*Sebastes alutus*	57	19684	5334	0.36
Splitnose Rockfish	*Sebastes diploproa*	36	12931	3007	0.52
North Pacific Spiny Dogfish	*Squalus suckleyi*	98	10922	4762	0.26
Sharpchin Rockfish	*Sebastes zacentrus*	58	9233	2856	0.42
Yellowtail Rockfish	*Sebastes flavidus*	72	8317	5281	0.35
Redstripe Rockfish	*Sebastes proriger*	43	5952	2209	0.35
Rex Sole	*Glyptocephalus zachirus*	136	5396	3211	0.07
Dover Sole	*Microstomus pacificus*	135	4293	2144	0.08
Sablefish	*Anoplopoma fimbria*	97	3285	1109	0.19
Silvergray Rockfish	*Sebastes brevispinis*	41	3210	793	0.36
Pacific Cod	*Gadus macrocephalus*	110	2889	2197	0.21
English Sole	*Parophrys vetulus*	104	2418	2187	0.14
Spotted Ratfish	*Hydrolagus colliei*	132	2117	1712	0.18
Flathead Sole	*Hippoglossoides elassodon*	66	1581	1360	0.21
Canary Rockfish	*Sebastes pinniger*	58	1548	992	0.72
Lingcod	*Ophiodon elongatus*	88	1496	1045	0.2
Greenstriped Rockfish	*Sebastes elongatus*	76	1493	736	0.18
Petrale Sole	*Eopsetta jordani*	99	1465	1260	0.16
Walleye Pollock	*Theragra chalcogramma*	61	1418	1132	0.48
Eulachon	*Thaleichthys pacificus*	70	1359	1090	0.21
Pacific Hake	*Merluccius productus*	39	1302	370	0.3
Redbanded Rockfish	*Sebastes babcocki*	43	1160	265	0.3
Pacific Halibut	*Hippoglossus stenolepis*	89	1067	848	0.14
Yellowmouth Rockfish	*Sebastes reedi*	7	901	191	0.64

Table 5. Number of fish sampled for biological data during the 2014 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	**Scientific Name**	**Lengths Collected**	**Age Structures Collected**
Brown Cat Shark	*Apristurus brunneus*	4	0
North Pacific Spiny Dogfish	*Squalus suckleyi*	898	177
Skates	*Rajidae*	3	0
Big Skate	*Raja binoculata*	14	0
Sandpaper Skate	*Bathyraja interrupta*	18	0
Longnose Skate	*Raja rhina*	142	0
Spotted Ratfish	*Hydrolagus colliei*	775	0
Green Sturgeon	*Acipenser medirostris*	4	0
Eulachon	*Thaleichthys pacificus*	1403	0
Pacific Cod	*Gadus macrocephalus*	1196	1008

Species	Scientific Name	Lengths Collected	Age Structures Collected
Pacific Hake	*Merluccius productus*	366	77
Pacific Tomcod	*Microgadus proximus*	81	0
Walleye Pollock	*Theragra chalcogramma*	549	76
Rougheye Rockfish	*Sebastes aleutianus*	268	268
Pacific Ocean Perch	*Sebastes alutus*	959	534
Redbanded Rockfish	*Sebastes babcocki*	439	427
Shortraker Rockfish	*Sebastes borealis*	4	4
Silvergray Rockfish	*Sebastes brevispinis*	234	185
Darkblotched Rockfish	*Sebastes crameri*	145	30
Splitnose Rockfish	*Sebastes diploproa*	502	122
Greenstriped Rockfish	*Sebastes elongatus*	1226	22
Puget Sound Rockfish	*Sebastes emphaeus*	24	0
Widow Rockfish	*Sebastes entomelas*	78	25
Yellowtail Rockfish	*Sebastes flavidus*	766	379
Rosethorn Rockfish	*Sebastes helvomaculatus*	325	68
Quillback Rockfish	*Sebastes maliger*	19	0
Bocaccio	*Sebastes paucispinis*	22	22
Canary Rockfish	*Sebastes pinniger*	232	192
Redstripe Rockfish	*Sebastes proriger*	867	362
Yellowmouth Rockfish	*Sebastes reedi*	67	35
Yelloweye Rockfish	*Sebastes ruberrimus*	30	30
Stripetail Rockfish	*Sebastes saxicola*	59	0
Pygmy Rockfish	*Sebastes wilsoni*	35	0
Sharpchin Rockfish	*Sebastes zacentrus*	833	256
Shortspine Thornyhead	*Sebastolobus alascanus*	1073	211
Sablefish	*Anoplopoma fimbria*	1063	412
Kelp Greenling	*Hexagrammos decagrammus*	15	0
Lingcod	*Ophiodon elongatus*	385	273
Pacific Sanddab	*Citharichthys sordidus*	610	0
Arrowtooth Flounder	*Reinhardtius stomias*	2711	848
Petrale Sole	*Eopsetta jordani*	1046	905
Rex Sole	*Glyptocephalus zachirus*	3227	486
Flathead Sole	*Hippoglossoides elassodon*	923	125
Pacific Halibut	*Hippoglossus stenolepis*	259	0
Southern Rock Sole	*Lepidopsetta bilineata*	344	322
Slender Sole	*Lyopsetta exilis*	1788	0
Dover Sole	*Microstomus pacificus*	2671	821
English Sole	*Parophrys vetulus*	1463	623
Curlfin Sole	*Pleuronichthys decurrens*	33	22

2.2. West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey

The West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey was conducted on the F/V E.J. Safarik between Aug 25 and Oct 2. Of those days, fishing operations were conducted on only 12. The other days were lost either to inclement weather conditions or mechanical breakdowns and repairs. We conducted a total of 64 tows; 54 were successful and 10 were failures due to hang ups or insufficient bottom time. Note that some blocks are only successfully fished following more than one attempt. The survey design called for 125 blocks to be assessed but we were only able to assess a total of 55 blocks (Table 6). Further, all the completed blocks are clustered in two parts of the survey grounds (Figure 14). Unfortunately, it is unlikely that the catch rate indices that could be generated from this survey will be meaningful due to the low number and pattern of the assessed blocks.

A total of four different DFO staff and two contract science staff from Archipelago Marine Research participated in the survey.

The total catch weight of all species was 98,232 kg. The mean catch per tow was 1534 kg, averaging 20 different species of fish and invertebrates in each. The most abundant fish species encountered were Pacific Ocean Perch (*Sebastes alutus*), Sharpchin Rockfish (*Sebastes zacentrus*), Arrowtooth Flounder (*Reinhardtius stomias*), Silvergray Rockfish (*Sebastes brevispinis*), and Redstripe Rockfish (*Sebastes proriger*). The number of tows where the species was captured and total catch weight from usable tows as well as the estimated biomass and relative survey error for the 25 most abundant species are shown in Table 7. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 7,307 individual fish of 71 different species (Table 8). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 6. 2014 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl 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-assessed blocks per survey stratum.

Depth Stratum (m)	Rejected Prior	Rejected Inspected	Failed	Success	Total Assessed	Not Assessed
180-330	0	0	1	39	40	33
330-500	0	0	0	7	7	23
500-800	0	0	0	5	5	6
800-1300	0	0	0	3	3	8
Total	**0**	**0**	**1**	**54**	**55**	**70**

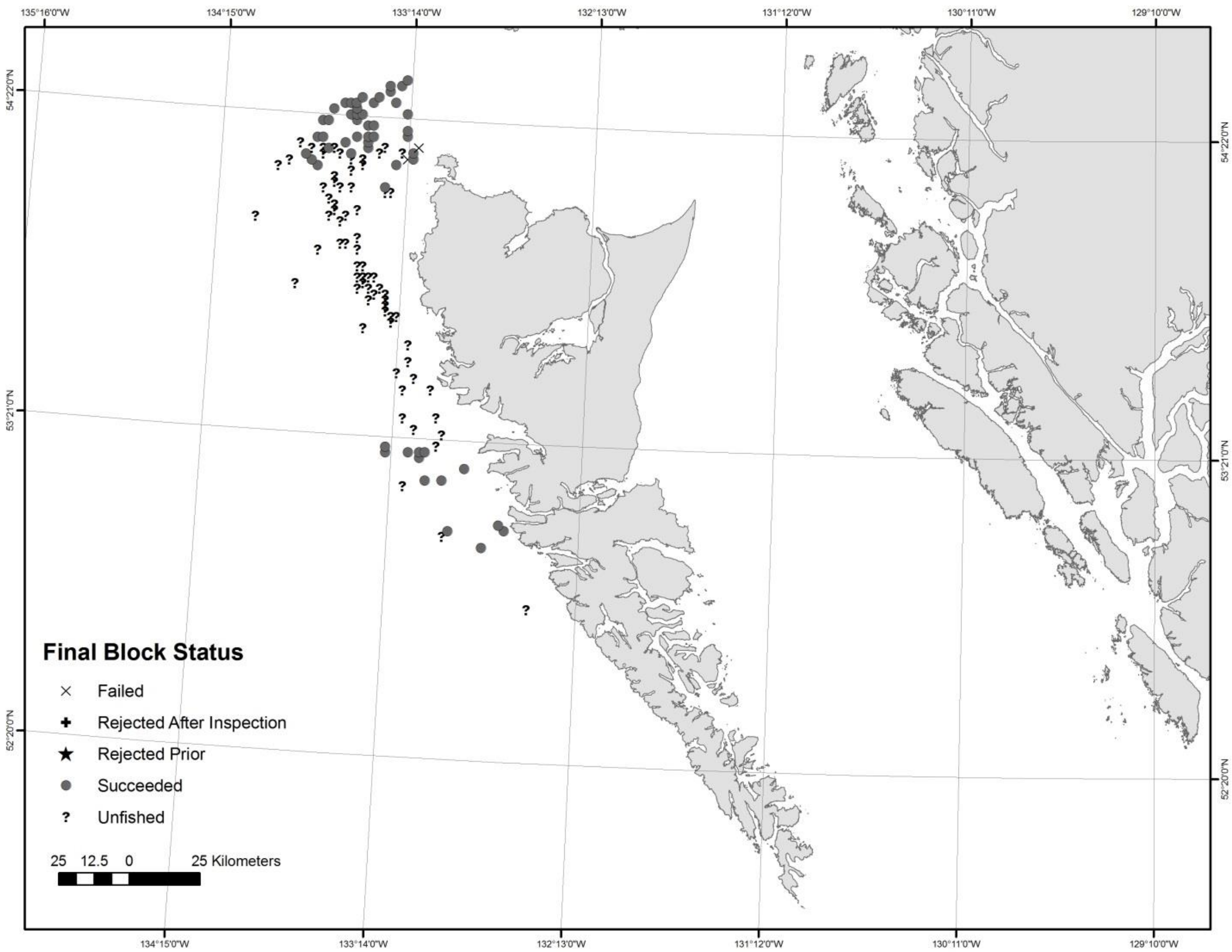

Figure 14. Final status of the allocated blocks for the 2014 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey.

Table 7. Number of catches and total catch weight from usable tows, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2014 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey.

Species	**Scientific Name**	**Num. Tows**	**Catch (kg)**	**Biomass (t)**	**Rel. Error**
Pacific Ocean Perch	*Sebastes alutus*	38	46848	8838	0.29
Sharpchin Rockfish	*Sebastes zacentrus*	31	8903	2058	0.47
Silvergray Rockfish	*Sebastes brevispinis*	34	5323	988	0.35
Arrowtooth Flounder	*Reinhardtius stomias*	43	5275	4318	0.71
Redstripe Rockfish	*Sebastes proriger*	22	3601	706	0.44
Yellowmouth Rockfish	*Sebastes reedi*	15	3018	542	0.7
Rougheye Rockfish	*Sebastes aleutianus*	22	2695	514	0.33
Shortspine Thornyhead	*Sebastolobus alascanus*	48	2649	919	0.28
Dover Sole	*Microstomus pacificus*	44	1662	1225	0.58
Widow Rockfish	*Sebastes entomelas*	11	884	65	0.54
Sablefish	*Anoplopoma fimbria*	27	831	410	0.28
Redbanded Rockfish	*Sebastes babcocki*	33	694	177	0.51
Harlequin Rockfish	*Sebastes variegatus*	16	682	180	0.92
Rex Sole	*Glyptocephalus zachirus*	42	649	227	0.19
Spotted Ratfish	*Hydrolagus colliei*	38	550	155	0.21
Pacific Halibut	*Hippoglossus stenolepis*	28	537	136	0.3
Pacific Cod	*Gadus macrocephalus*	32	439	113	0.28
Rosethorn Rockfish	*Sebastes helvomaculatus*	32	305	60	0.2
Longnose Skate	*Raja rhina*	17	282	213	0.22
Shortraker Rockfish	*Sebastes borealis*	9	247	30	0.44
Pacific Hake	*Merluccius productus*	7	214	245	0.51
Lingcod	*Ophiodon elongatus*	12	206	112	0.68
Walleye Pollock	*Theragra chalcogramma*	26	193	19	0.29
Yelloweye Rockfish	*Sebastes ruberrimus*	2	153	41	0.91
Dusky Rockfish	*Sebastes variabilis*	3	49	12	0.77

Table 8. Number of fish sampled for biological data during the 2014 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey showing the number of lengths and age structures that were collected by species.

Species	Scientific Name	Lengths Collected	Age Structures Collected
Brown Cat Shark	*Apristurus brunneus*	8	0
Aleutian Skate	*Bathyraja aleutica*	7	0
Roughtail Skate	*Bathyraja trachura*	3	0
Sandpaper Skate	*Bathyraja interrupta*	17	0
Longnose Skate	*Raja rhina*	33	0
Pacific Flatnose	*Antimora microlepis*	15	0
Pacific Cod	*Gadus macrocephalus*	63	0
Pacific Hake	*Merluccius productus*	56	0
Walleye Pollock	*Theragra chalcogramma*	98	0
Popeye	*Coryphaenoides cinereus*	31	0
Pacific Grenadier	*Coryphaenoides acrolepis*	54	0
Giant Grenadier	*Albatrossia pectoralis*	36	0
Rougheye Rockfish	*Sebastes aleutianus*	269	268
Pacific Ocean Perch	*Sebastes alutus*	1063	869
Redbanded Rockfish	*Sebastes babcocki*	168	161
Shortraker Rockfish	*Sebastes borealis*	46	46
Silvergray Rockfish	*Sebastes brevispinis*	461	199
Dusky Rockfish	*Sebastes variabilis*	27	0
Splitnose Rockfish	*Sebastes diploproa*	12	0
Greenstriped Rockfish	*Sebastes elongatus*	12	0
Widow Rockfish	*Sebastes entomelas*	34	0
Rosethorn Rockfish	*Sebastes helvomaculatus*	367	0
Bocaccio	*Sebastes paucispinis*	6	6
Canary Rockfish	*Sebastes pinniger*	8	0
Redstripe Rockfish	*Sebastes proriger*	265	131
Yellowmouth Rockfish	*Sebastes reedi*	94	81
Yelloweye Rockfish	*Sebastes ruberrimus*	29	29
Harlequin Rockfish	*Sebastes variegatus*	80	0
Sharpchin Rockfish	*Sebastes zacentrus*	570	47
Shortspine Thornyhead	*Sebastolobus alascanus*	1077	182
Longspine Thornyhead	*Sebastolobus altivelis*	224	152
Sablefish	*Anoplopoma fimbria*	202	57
Lingcod	*Ophiodon elongatus*	26	19
Arrowtooth Flounder	*Reinhardtius stomias*	661	67
Petrale Sole	*Eopsetta jordani*	5	0
Rex Sole	*Glyptocephalus zachirus*	505	31
Pacific Halibut	*Hippoglossus stenolepis*	70	0
Slender Sole	*Lyopsetta exilis*	15	0
Dover Sole	*Microstomus pacificus*	590	191

APPENDIX 3. PARTIAL LIST OF GROUNDFISH RELATED REPORTS WITH 2014 PUBLICATION DATES.

PRIMARY

King, J.R. and R.P. McPhie. 2014. Preliminary age, growth and maturity estimates of spotted ratfish (Hydrolagus colliei) in British Columbia. Deep Sea Research II (doi:10.1016/j.dsr2.2013.11.002).

McFarlane, G.A., and J.R. King. 2014. History of the Fisheries. In: R.J. Beamish and G.A. McFarlane (eds.), The Sea Among Us: the Amazing Strait of Georgia, Harbour Publishing.

Okamura, H., McAllister, M. K. Ichinokawa, M., Yamanaka, K. L., and Holt, K.. 2014. Evaluation of the sensitivity of biological reference points to the spatio-temporal distribution of fishing effort when seasonal migrations are sex-specific. Fisheries Research 158 (2014) 116-123. doi:10.1016/j.fishres.2013.10.022

OTHER PUBLICATIONS

DFO. 2014. Performance of a revised management procedure for Sablefish in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014 /025.

Taylor, I.G., C. Grandin, A.C. Hicks, N. Taylor, and S. Cox. 2015. *Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2015.* Prepared by the Joint Technical Committee of the U.S. and Canada Pacific Hake/ Whiting Agreement; National Marine Fishery Service; Canada Department of Fisheries and Oceans. 159 p.

Edwards, A.M., Haigh, R. and Starr, P.J. (2014). Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the north and west coasts of Haida Gwaii, British Columbia. DFO Canadian Science Advisory Secretariat Research Document 2013/092. vi + 126p.

Edwards, A.M., Haigh, R. and Starr, P.J. (2014). Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, British Columbia. DFO Canadian Science Advisory Secretariat Research Document 2013/093. vi + 135p.

APPENDIX 3. GROUNDFISH STAFF IN 2014

Greg Workman	Section Head
Schon Acheson	Technician, Pacific Hake, port sampling and surveys
Kristina Anderson	Technician, Sablefish and surveys (maternity leave until Jan 2015)
Karina Cooke	Technician, Database support and surveys, Inshore Rockfish
Andrew Edwards	Program Head, Statistical & mathematical modelling, stock assessment
Robyn Forrest	Program Head, Pacific Cod, Pacific Halibut, stock assessment
Chris Grandin	Program Head, Pacific Hake stock assessment and Port sampling
Lorri Granum	Technician, Database support
Rowan Haigh	Statistical & exploratory data analysis, stock assessment, R packages
Kendra Holt	Program Head, Lingcod, Flatfish stock assessment
Jackie King	Program Head, Elasmobranchs, Climate studies
Brian Krishka	Biologist, Database support and analysis, Flatfish
Rob Kronlund	Program Head, Sablefish, Analytical programs
Lisa Lacko	Biologist, GIS and database, Sablefish
Jean-Baptiste Lecomte	Post-doctoral Fellow (France)
Sandy McFarlane	Emeritus scientist
Wendy Mitton	Technician, Sablefish (retired April 2014)
Melissa Nottingham	Technician, Groundfish surveys
Norm Olsen	Program Head, Groundfish Surveys, Programmer/GIS and Statistics
Kate Rutherford	Biologist, Database manager, Groundfish Statistics
Jon Schnute	Emeritus scientist
Maria Surry	Technician, Elasmobranchs
Kathryn Temple	Technician, Groundfish surveys
Daniel Williams	Technician, Groundfish surveys
Malcolm Wyeth	Biologist, Groundfish surveys
Lynne Yamanaka	Program Head, Inshore rockfish research and stock assessment

2015 IPHC Research Report for TSC

Review of 2014 Projects and Proposals for 2015
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 2014, and the third section presents the preliminary staff research proposals for 2015 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.

SECTION I:

Staffing Updates

In 2014 the IPHC hired Stephanie Hart (Administrative Assistant). Throughout 2014 and into 2015 efforts have been ongoing to fill the Biological and Ecosystem Science Program Head (Gregg Williams – ret'd) position. This is in addition to some standard turnover seen in both the port and sea sampling seasonal positions.

Stephen Kaimmer (Research Biologist) and Heather Gilroy (Fisheries Statistics Program Manager) are retiring from the Commission in May 2015. Claude Dykstra (current Survey Manager) was hired for the Research Biologist position and will transition into that role over the next few months. The Commission is in the process of hiring for the Survey Manager position. The Fisheries Statistics Program Manager will be filled in the interim as an acting role by Kirsten MacTavish.

The current contract for the Commission's Executive Director, Dr. Bruce Leaman, expires in early 2016. During 2015, the Commission will be searching for a new Executive Director to succeed Dr. Leaman.

SECTION II:

Review of 2014 - Project Summaries

This section provides a brief recap of projects conducted in 2014. Full reports on most projects can be found in the 2014 RARA.

Research is conducted within four areas of study which connect to the IPHC mission and support the assessment and management objectives of the Commission. These four areas are 1) assessment and stock identification; 2) management strategy; 3) biology; and 4) ecology.

Assessment and stock identification

Project 2014-02: Estimating hooking success for large halibut
Priority: Medium
Start: 2014
Anticipated Ending: 2014
Personnel: S. Kaimmer, I. Stewart

The study attempted to observe hook attacks by halibut in the 110 to 150+ cm range, i.e., 40-80 lb fish, to estimate hooking success. Previous camera studies (Kaimmer 1998) demonstrated an increasing hooking success with increasing size for halibut ranging from about 70 to 110 cm. Our Didson1 studies in 2006 and 2007 (Kaimmer and Wischniowski 2008 and 2009) used a much larger pool of observations to refine this curve. Although these investigations estimated an increasing relationship between hooking success and fish size, which would be indicative of an asymptotic cure, neither had enough observations of large fish (over 100 cm) to estimate whether this relationship might be dome shaped with a decreasing hooking success for very large fish. It was expected that observing an additional 50 attacks from halibut spread throughout the 110 to 150+ cm range would allow the estimation of the form of the relationship between hooking success and fish length for these larger fish. The form of this curve has very important implications for stock assessment assumptions (Clark and Kaimmer 2006).

A GoPro camera was used to observe hook attacks on a single baited hook off Afognak Island near Alaska's Kodiak Island. The number of large halibut observed was not enough to generate this parameter. However, large numbers of smaller halibut were observed which confirmed the earlier estimates of hooking success for halibut with fork lengths ranging between 60 to 100 cm and validated the technique for estimating hooking parameters.

Biology

Project 636.00: Evaluation of Pacific halibut macroscopic maturity stage assignments

Priority: High

Start: 2004

Anticipated Ending: Continuing

Personnel: K. MacTavish, other staff as needed

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 2014, a sampling protocol was determined and histological slides were prepared from all the gonad samples that were available. A technician was hired for 3 months to help with processing of the slides. The goal is to measure individual oocyte diameters from all the slides and to assign reproductive maturity stages from the slides to compare with those assigned in the field. Work on these goals will continue in 2015.

Project 621: Development of protocols for dockside monitoring of harvested sex ratios

Start Date: 2006

Anticipated ending: 2016

Personnel: T. Loher, I. Stewart, M. Woods, O. McCarthy, J. Marx; volunteer fleet members; L. Hauser, H. Galindo, and I. Jimenez-Hidalgo (UW-SAFS)

Declines in size at age of Pacific halibut, in concert with sexually-dimorphic growth and a constant minimum commercial size limit, have led to the expectation that the sex composition of commercial catches should be increasingly female-biased. Sensitivity analyses suggest that variance in sex composition of landings may be the most influential source of uncertainty affecting current understanding of spawning stock biomass. In the absence of derived fishery sex-ratio 'data', the 2013 stock assessment was found to be very sensitive to the assumption that the relative selectivity-at-age of males and females is equivalent in the survey and fishery. A 20% range in fishery-selectivity sex ratios translated into a roughly 50 million pound range in estimates of female spawning biomass (i.e., ~25% of the total estimated spawning biomass). Without direct observations of fishery sex ratio at age, there is no way to determine the magnitude of uncertainty and/or bias that exists in current assessment results due to this source. Unfortunately, there is currently no reliable way to determine the sex of commercially-harvest halibut at landing, because all individuals must be eviscerated at sea.

The current project represents a suite of integrated studies that are designed to obtain reliable sex data from eviscerated commercial landings. The project is composed of the following components: 1) comparison of the survey-based statistical method and genetic (microsatellite) sexing accuracy; 2) examination of methods to mark fish at sea, in a survey setting; 3) development of an unequivocal genetic sexing assay using single nucleotide polymorphisms (SNPs); 4) pilot testing of chosen marking methods in a commercial setting; 5) examination of spatial and temporal variance within and among the sex ratios of commercial landings, as determined via at-sea marking, and validated by genetic assays, and; 6) development of at-sea marking and genetic validation protocols that can provide fleet wide (by IPHC Regulatory Area and year) estimates of sex ratio for direct use in the stock assessment.

Components 1 and 2 represented summer internships conducted by Monica Woods and Orion McCarthy, respectively, and were completed in 2011 and 2014. Components 3 and 4 will be initiated this spring. The former will be executed via collaboration with the University of Washington (Dr. Lorenz Hauser, principal investigator), and is expected to produce by 2017 a SNP-based test of sex that can be conducted in-house, by the IPHC. Component 4 will rely upon collaboration with commercial IFQ holders landing their catch in Seward, Alaska. This will test a single method of sex-marking during six commercial fishing trips, in order to determine the marking method's feasibility from a fleet perspective, evaluate the additional workload that processing sex-marked catch is likely to have upon the IPHC's port sampling program, and generate a small tissue archive that can be subjected to subsequent genetic analysis, as an element of Project Component 5. Components 5 and 6 are expected to occur from 2016-2018.

Project 621: Examining population connectivity between the southern Salish Sea and the outer continental shelf via Pop-up Archival Transmitting (PAT) tagging

Start Date: 2014

Anticipated ending: 2015

Personnel: T. Loher, survey team; B. Starkhouse (Lummi Nation), R. Svec and J. Peterson (Makah Fisheries Management Department), S. Bass (Point No Point Treaty Council)

A research paper published in the journal *Environmental Biology of Fishes* called into question whether Pacific halibut harvested from the inside waters of Area 2A (i.e., the southern Salish Sea) belong to the larger outer-coast population, or represent a unique inside-waters stock that should be managed independently. Thus, a tagging experiment was conducted during the summer of 2014 to examine whether halibut that reside in the US waters of the southern Salish Sea during the summer remain there or, alternatively, mix with spawning population(s) to the west and the north, thereby representing component(s) of a more broadly-ranging stock. The experiment will also assess interannual fidelity to summer feeding grounds by determining fish locations the summer after tagging, in addition to inferring potential spawning locations based on fish locations during the winter of 2014-2015.

Using refurbished satellite-transmitting archival tags, six halibut were tagged on May 27 and 28, 2014, during the IPHC's setline survey, and another six halibut tagged on October 11 and 12, during a dedicated charter. Six fish were tagged in each of two general regions: 1) north of the San Juan Islands, in the southern Strait of Georgia and Boundary Pass; 2) in the eastern Strait of Juan de Fuca, between Port Angeles and the San Juan Islands. All tagged fish were females, and ranged from 94-131mm in length. Eight tags were programmed to report final fish locations and environmental data (temperature, depth, and light-level; the latter used to infer at-liberty locations) on January 15, 2015; four tags were programmed to release and report between May 27 and June 1, 2015. To date, nine tags have detached and reported to passing satellites. Seven of those produced endpoint location data. Upon reporting, five fish were located near their deployment locations in the southern Salish Sea, on dates ranging from July 10, 2014 to March 20, 2015. The two remaining fish were located in Area 2B on their reporting dates (October 27, 2014 and January 15, 2015), at deep-water locations consistent with known halibut spawning grounds.

Project 650: Electronic archival tagging: preparation for coastwide deployment

Start Date: 2006

Anticipated ending: 2016

Personnel: T. Loher, J. Forsberg, T. Geernaert, R. Rensmeyer, S. Stephens, survey team; P. O'Flaherty (Lotek Wireless), J. Nielsen (UAF Juneau), F. Broell (Dalhousie University)

This project is composed of several components, first initiated in 2006 and expected to culminate in the deployment of electronic archival tags throughout the managed range of the eastern Pacific halibut stock. Electronic archival tags represent a powerful tool for studying fish migration, behavior, and physiology, at resolutions that cannot be achieved using conventional tags. Whereas conventional tagging produces, at best, two data points per fish –geographic location at deployment and recovery - archival tags can produce millions of data points per year, providing information not only on tagging and recovery locations, but also the potential for at-liberty position estimates using light data, geomagnetism, or tidal amplitude estimation; remote tag detection via a variety of telemetry methods; and depth, temperature, and acceleration data throughout deployment. The IPHC has been planning a large-scale deployment that will examine relationships between growth rates and water temperature, age- and sex-specific ontogenic migration, and seasonal migration patterns coastwide. However, advances in battery power and data storage capacity have increased the operable lifespan of modern archival tags to the point of allowing relatively fine-scale data collection (e.g., every 15-30 seconds) for periods in excess of five years. Such long tag life requires that new methods be developed that will optimize tag retention and recovery rates, in order to maximize data recovery from our deployments.

To this end, the IPHC has conducted two captive holding experiments to refine surgical implantation techniques and develop ultrasonic techniques for non-lethal sex identification (2006-2008), and develop external attachment protocols (2009-2015). Based largely upon these results, a suite of five at-sea tag deployments have been conducted, designed to test hard-on-body external attachment (2008), examine relative recovery rates of surgically-implanted versus hard-mount external tags (2009), identify potential fishery-specific deployment locations in the Aleutian Islands region (2010), field-test tags designed to record the earth's magnetic field strength (2011), and compare the effectiveness of three different external dart-and-tether designs (2013). At this juncture, we feel that sufficient information has been obtained from these experiments to allow tag deployments to begin during the summer of 2016. Given the scale of the currently-proposed deployment design (i.e., ~1,000 tags distributed among IPHC regulatory areas), we expect to conduct these deployments over a roughly 3-year window, using the IPHC survey as the primary deployment platform.

Project 664.11: Otolith increment study

Priority: High

Start Date: 2013

Anticipated ending: 2014

Personnel: B. Leaman, T. Loher, Ian Stewart, S. Martell, J. Forsberg

This research focuses on the decrease in size at age, and the desire to examine similar metrics in previous time periods of the halibut stock. The project is part of a broad-based study of changing size at age in halibut, involving food web and ecosystem drivers, bioenergetics, fisher effects, and analytic modeling. The study, in collaboration with NMFS, UW, and ADF&G, is partially funded by NPRB. Primary work by IPHC staff will include the use of the otolith archives to examine growth patterns and size at age in earlier time periods. Thus far, the IPHC staff has re-aged subsets of otoliths from each decade from the 1920s to the 1980s by both the surface and break-and-bake technique and compared original surface ages to the ages made in 2014 (surface and bake). Additionally, systematic subsamples of otoliths collected in 1992, 1993, and 1998 that were previously only surface-aged were re-aged by break-and-bake and included in this analysis. Results indicated that historical samples contained very few fish aged older than 15 years by either method. Based on simultaneous estimation of bias and imprecision for up to four unique ages per otolith, the properties of historical surface ageing methods were found to be very similar to current methods, becoming increasingly biased and imprecise beyond 15 years.
Otolith increment measurements were made on subsamples of 15-year-old halibut from birth years 1977 and 1992. Analyses of increment data indicate a decline in Pacific halibut size-at-age between 1977 and 1992, with larger Pacific halibut found in the eastern Aleutian Islands (4B) than west (3A) in both years.

We intend to extend this study by looking at samples by decade, back to the 1920s. Stomach and relative abundance samples for halibut and co-occurring groundfish species were also collected for the larger project during the 2013 NMFS Gulf of Alaska survey.

Project 665.11: Estimate of length/weight relationship and head/ice/slime adjustment

Priority: High

Start: 2013

Anticipated Ending: open ended

Personnel: R. Webster, L. Erikson, K. MacTavish, H. Gilroy

The purpose of this study is to reexamine the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight. The current length-net weight relationship was estimated in 1926. Using 1989 data, Clark (1992) re-estimated the relationship's parameters and found good agreement with the earlier curve. However, when Courcelles (2012) estimated the relationship data collected in 2011, she found significant differences between her estimated curve and that derived from the 1989 data, although inference was limited to a relatively small part of Area 3A and to the time of the setline survey. IPHC staff has always known that the relationship varies seasonally and likely regionally. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or WPUE derived from length measurements. Seasonal variation could affect weight estimates that are made from data collected during only a small part of the year. Therefore, we are collecting data coastwide throughout the season in order to estimate spatial and seasonal variation in the length to weight relationship.

The current relationship used by IPHC between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime: gross landed weight (gutted, with head, ice and slime) is assumed to include 12% head weight and 2% ice and slime, which combine to give a multiplier of 0.8624 to convert gross to net weight. However, the industry standard for head, ice and slime deduction is a total of 12%. Therefore as a secondary goal, we also plan to collect data to provide direct estimates of adjustment factors to compare with the currently assumed values, and to assess variability in the weight of heads and ice and slime. To achieve this, we plan to record multiple weights on at least a subsample of fish.

In 2013, a pilot phase of the project was implemented that tested the equipment and methods at a selection of ports (Bellingham, Port Hardy, Prince Rupert, Petersburg, Sitka, Juneau, and Homer). The need to carefully test potential scales prior to full implementation, and the fact that the scales we used were far more expensive than those considered within the 2013 project budget, meant that the scope of the project in 2013 was more limited than initially proposed. In 2014, scales were provided to most port samplers and thus length and weight data were collected in most staffed ports, except for Dutch Harbor, St. Paul, and Sand Point, Alaska. The data were collected throughout the entire length of the commercial fishing season to determine whether seasonal or area-specific L-W relationships are warranted. This project will continue in 2015.

Ecology

Project 610.13: Oceanographic monitoring of the north Pacific and Bering Sea continental shelf with water column profilers

Priority: Medium

Start date: 2009

Anticipated ending: Continuing

Personnel: L. Sadorus, P. Stabeno (NMFS PMEL)

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 coastwide deployment. A total of 1,267 successful casts were made in 2014 out of a possible 1,394.

Project 642.00: Assessment of mercury and contaminants in Pacific halibut

Priority: Medium

Start Date: 2002

Anticipated ending: Continuing

Personnel: C. Dykstra, B. Gerlach (ADEC)

Our collaboration with the Alaska Department of Environmental Conservation (ADEC) continued in 2014, collecting halibut tissue samples for analysis of heavy metal and organic pollutant loading from the California, Puget Sound, Fairweather, and 4A Edge S charter regions. To date 2,284 samples have been tested by ADEC. The mean level of total mercury for these samples has been 0.311 ppm (for comparison the FDA limit of concern is based on methyl mercury (~85% of total mercury) levels of 1.000 ppm, the EPA and CFIA level of concern is 0.500 ppm) ranging from non-detectable to 2.0 ppm. Results from analysis of persistant organic pollutants (POP's - pesticides, selected PCB congeners, dioxins, and furans etc) found that in general these compounds are either undetectable in halibut or well below other marine fish species. This is a positive finding and is likely attributable to the lower fat content in halibut compared to these other species.

In 2014 the Alaska Section of Epidemiology (a division of the Alaska Department of Health and Social Services) issued new guidance for women of child bearing age (WCBA) and young children with regards to fish over 0.400 ppm methyl mercury. This guidance includes lingcod, yelloweye rockfish, salmon shark, spiny dogfish shark and halibut which are more than 40 lbs. This is not considered a concern for the commercial fishery where average weights coming out of the fishery are in the 25-26 lb range. Reporting in 2014 included joint analyses with ADEC staff in presentations at the International Flatfish Symposium and the 2014 EPA National Forum on Contaminants in Fish.

Project 661.11: *Ichthyophonus* prevalence in halibut

Priority: Medium

Start Date: 2012

Anticipated ending: ongoing

Personnel: C. Dykstra, J. Gregg (USGS), P. Hershberger (USGS)

Ichthyophonus is a protozoan parasite from the class Mesomycetozoea, a highly diverse group of organisms having characteristics of both animals and fungi. It has been identified in many marine fish, and is considered a causative agent in herring fishery collapses world-wide and there is concern over its effects on the success of salmon spawning on major rivers such as the Yukon.

During 2011-2014, samples were collected from halibut caught on the IPHC setline assessment survey over a broad geographic range, with a goal of describing the spatial and temporal distribution of *Ichthyophonus* prevalence. Limited sampling of small (<50 cm) halibut from the NMFS trawl survey recorded a very low prevalence rate of 2.4%, suggesting that infections establish after some ontogenetic shift in diet, habitat, or behavior. Sampling of larger, adult halibut have shown a wide range of rates, with Prince William Sound showing some of the highest observed in marine fish. The prevalence of infection is higher than that which has been observed in studies of other sympatric fish species, including other pleuronectids, suggesting that either susceptibility and/or infection pressures are higher in halibut. While *ichthyophoniasis* has been shown to reduce growth rate, decrease swimming stamina, and cause mortality in other fish hosts, its effects on Pacific halibut are unknown. Results to date were presented, in conjunction with USGS co-authors, at the International Flatfish Symposium in the fall of 2014.

Other

Project 618.00: Undergraduate Internship

Start Date: 2002

Anticipated duration: Continuing

Personnel: L. Sadorus, other staff support as needed

The IPHC's 2014 summer intern, Orion McCarthy, worked on a pilot study to develop a marking technique that can be carried out by fishers and used by port samplers to identify commercially-landed halibut by sex (as gonads are not present upon arrival at port because halibut are dressed at sea). Successful marks must be cost effective, easily executed, identifiable, and not damaging to the fish. Distinct male and female knife cuts were developed, the female cut consisting of two incisions in the dorsal fin and the male cut consisting of an incision in the gill plate. The sex ratio of the catch marked by fishers and assessed by the port sampler did not differ significantly from the true biological sex ratio of the catch, indicating the marking method may be useful to represent the sex ratio of halibut stocks. Fisher participation is crucial if the IPHC truly wishes to gauge the sex ratio of commercial halibut stocks, and it is recommended a voluntary program be established before regulations are implemented. Future research should address the limitations of the current study, namely the small size of the offload, lack of repetition, limited geographical scope, and port sampler limitations.

Remote Data Entry Development

In 2014, the IPHC worked on developing software applications for data entry of commercial and survey data into tablets with the intent of replacing the pencil and paper method currently used in both programs. IPHC's programmers created and are still developing two applications: eLogs and eSurvey.

The eLogs application was finalized for testing in the field and tablets were deployed with port samplers in Alaskan ports at the start of the commercial halibut season (March 2014). Port samplers are using Panasonic Toughpads on which the eLog application was installed. Testing was ongoing throughout the season with fixes to the programming. Port samplers are still collecting paper logs until they pass a strict set of criteria, at which point, the samplers will enter the log data directly into the eLog application during the skipper interviews.

The eSurvey application was also developed to replace the paper data forms that are currently used on the survey. In 2014 the eSurvey application was pilot tested in the field on two different operations. Development continued throughout the fall, and a larger scale pilot project will occur in 2015, with the goal of full deployment cycle in 2016.

SECTION III:

Ongoing and Proposed for 2015

Research proposed by IPHC staff goes through an internal review process by a staff Science Board. This year, the Board met in mid-October to review staff proposals for 2015 research. For each proposal, the Board discussed the merits, objectives, design, and coherence with the

Commission's research goals and objectives. The Principal Investigator (PI) subsequently joined the Board for a broad discussion of the project. Concerns, questions and need for refinements or revisions, if any, about the proposal were communicated to the PI at that time. Following a full review of all proposals, the Board assigned a priority rating to each project, based on the following criteria:

High – Research which has a direct bearing on the assessment or its inputs, harvest policy, or current management structure. Postponement of a high priority project would have a significant and immediate impact on management or IPHC operation.

Medium – Research which addresses an assessment issue or management question/need. Postponement will not have an immediate significant impact on fishery management or IPHC operation but may impact future analyses.

Low – Research which addresses current issues of any subject but is not considered having a timely need or being crucial to current IPHC management or operation.

For the past several years, two primary topics have been at the forefront of discussions about the halibut resource. The first has been the continuing decline in size at age, with the resulting effects and impacts on the harvest policy and stock status. The IPHC staff is continuing with an externally-funded (NPRB) project examining multiple influences on halibut size at age. Allied with this is the need to accurately estimate the removals from the stock through conversion of landed fish weight into the quantities required for the stock assessment. The second issue has been the migratory behavior of the stock, specifically seasonal and ontogenetic migration, including sex and age-specific differences in spawning migration timing and duration. Understanding migration patterns is the overarching goal of the archival tag program, which has several aspects examining tag type, location, tag shedding, and resolution of geomagnetic location data (projects 650.xx).

Research into both areas is of high priority for the Commission and staff. In the following section, studies for 2015 will be presented which address both topics. In addition, the staff proposes to undertake a genetic study designed to establish a validation procedure for estimating the sex ratio of the commercial catch. Sensitivity analyses have shown that the estimate of stock biomass is very sensitive to the estimated sex ratio.

Based on the Science Board discussions and the topics previously outlined, the following sections describe the upcoming work by IPHC staff and also provide descriptions of recommended research studies for funding in FY2015.

OBJECTIVE 1: STOCK IDENTIFICATION, MONITORING AND ASSESSMENT

Research in this area focuses on stock identification, monitoring, assessment, forecasting, and incorporation of uncertainty in both data and processes into management advice. The staff seeks to understand the underlying Pacific halibut stock structure and the influence of age, size, and sex on movement as they relate to stock components. Additionally, monitoring occurs through the IPHC Port Sampling program (fishery removals), standardized setline stock assessment survey (fishery-independent stock indices), and trawl surveys (pre-recruits).

The most significant work is the annual stock assessment, which produces estimates of abundance based on a comprehensive suite of fishery-dependent and -independent variables. The assessment also forecasts short-term trends in the stock to support the IPHC decision-making process. Assessment staff also works at determining and reducing the level of uncertainty associated with stock assessments through advanced analytical techniques. Where needed, improved data collection or other studies are recommended.

For 2015, in addition to the annual assessment, the staff is proposing studies to address the accurate determination of both the sex ratio of the catch, and the spawning biomass of the stock, as well as a cooperative project on hooking behaviour.

<u>Funded research – Proposed</u>

Project 2015-01: Genetic Sexing via Single Nucleotide Polymorhpisms (SNPs)
Priority: High
Start: 2015
Anticipated Ending: 2016
Personnel: T. Loher, L. Hauser (UW)

The work will allow for direct and reliable monitoring of sex ratios within the commercial catch in the face of potentially changing sex ratios due to decreasing size at age relative to the commercial minimum size limit (MSL). Proposals to reduce the MSL have also been advanced to reduce handling mortality on currently-sublegal fish, to theoretically bring a larger proportion of males into the exploited stock fraction, and to increase the economic efficiency of the harvest. At present, the sex composition of the catch is estimated from IPHC survey data but there is a critical need to directly monitor changes in sex composition of the catch should such actions be invoked.

The sequencing of Restriction site Associated DNA (RAD tags), has revolutionized genetics by allowing the discovery and genotype-calling of thousands of SNPs (Single Nucleotide Polymorphisms) in multiple individuals at relatively low cost. The technique takes advantage of the large number of sequences (millions of reads per run) produced by the Illumina HiSeq 2000 sequencer. Briefly, RAD tag sequencing focuses on sequencing the regions (tags) directly adjacent to specific restriction sites genome-wide. It is therefore possible to sequence a large and reproducible subsection of the genome in many individuals. Given the high success in sexing halibut with microsatellites, we expect to identify several dozens of sex specific SNPs that will allow the development of rapid assays for large samples. Once SNPs highly diagnostic for sex have been identified, we will develop high-throughput assays to allow the screening of larger samples. We will identify about 20 SNPs and re-sequence them in additional individuals. We will optimize these SNPs for use with low quality DNA, allowing the elimination of costly and laborious DNA extraction methods in routine sex surveys. In addition, we will minimize the number of SNPs necessary for 100% sex identification by picking highly discriminatory SNPs from our panel.

Project 2015-02: Commercial Sex Marking Pilot
Priority: High
Start: 2015
Anticipated Ending: 2016
Personnel: T. Loher, I. Stewart, J. Marx

This project has three primary objectives: a) test a single method of sex-marking aboard a small sample of commercial fishing trips in order to determine its feasibility from a fleet perspective; b) evaluate the additional workload that processing sex-marked catch, and obtaining tissue samples for subsequent genetically-based QA/QC of the physical marking process, is likely to have upon the IPHC's port sampling program; c) generate a small tissue archive that can be subjected to subsequent genetic analysis, as an element of Project 2015-01, above. We plan to sample six offloads from Area 3A, equally distributed amongst spring, summer (during the survey period), and fall. The study will use volunteer vessel captains who are willing to mark fish during selected commercial trips, and we will also work with interested RAB members during the selection process. We will attempt to identify vessels and trips that plan relatively small landings (preferably in the 2000-3000-pound range), with an eye toward scaling the process upwards in the future. We expect that obtaining a broad temporal distribution of landings for each area may require collaboration from two, or even three, vessels in one or more areas.

Participating vessels will be briefed on the appropriate method for marking males and females during dressing, and asked to mark every fish retained during the designated fishing trip(s). The initial plan is to use the marks identified by McCarthy (2015), which consisted of two vertical cuts in the dorsal fin for females and one vertical cut in the white-side operculum for males. For each sampled offload, the port sampler will record the length and marked sex of each fish (including unmarked individuals) and collect and preserve a tissue sample. Analysis will include:

- A post-participation 'debrief' with each harvester regarding the marking process, time requirements, ideas for alternate marks and general willingness to participate again in the future.
- A comparison of the sex-ratio at age among the sampled trips with the sex-ratio at age among survey legs during the same year.
- Genetic samples will be stored, pending the development of SNIP assays when they can be assigned a sex and the accuracy of fishermen's marks can be tested directly following the approach used by McCarthy (2015).

Tissue samples will be archived until such time as a definitive genetically-based indicator of sex has been developed and is ready for use. When ready, the samples will be subjected to analysis and the resultant sex ratios compared to those obtained by at-sea catch-marking.

Project 2015-03: čibu·d hook research
Priority: Low
Start: 2015
Anticipated Ending: 2016
Personnel: E. Henry

In 2014, Makah Fisheries Management performed a study on the čibu·d, a traditional halibut hook used in the past by the Makah tribe. They were testing whether the traditional hooks could both fish effectively (maintain a similar catch-rate) and reduce the rate of non-halibut bycatch relative to commonly used circle hooks. Though it was shown from the Makah's original study that the čibu·d was not as effective at catching halibut in a commercial longline operation using circle hooks, there was a significant reduction in the observed rate of bycatch. A major uncertainty in the study was the actual fishing configuration and hooking process, which may have resulted in lower halibut catch rates. Although the mechanism of hooking can be inferred from the design of the čibu·d and location of the hook in captured fish, there are no recorded observations of halibut behavior when encountering the čibu·d, or of a halibut actually being hooked by one. Also, there is no information on the hooking success of čibu·d in comparison to circle hooks when deployed in a manner consistent with recreational rather than longline fisheries. The purpose of this study would be to record video of čibu·d hooking behavior, and to compare hooking behavior differences between čibu·d and circle hooks in a controlled aquarium setting. This could improve the understanding of the results already obtained by the Makah Fisheries Management program and help to better identify promising avenues for use of the čibu·d in future halibut fisheries.

This project has two primary goals: 1) establish the first video record of hooking behavior for halibut encountering metal čibu·d. This will include qualitative analysis of how the hook is attacked, where it becomes embedded in the jaw, and how many interactions are required for successful hooking, and 2) compare the rate of hooking success for metal čibu·d with modern 14/0 circle hooks.

OBJECTIVE 2: HARVEST POLICY AND MANAGEMENT

Work to support this objective involves annual evaluations of IPHC's harvest policy with regard to the current stock dynamics and management goals. The staff develops stock projection procedures which incorporate a realistic range of alternative hypotheses about stock behavior, environmental influences, and fishing effects on stock abundance and halibut characteristics. The staff also provides harvest management advice to the Commission and user groups in a form which allows the consideration of uncertainty in the assessment and forecasting processes.

In 2013 the Commission approved the formation of the MSAB to oversee the MSE process and to advise the Commission and Staff on the development and evaluation of candidate objectives and strategies for managing the fishery. The MSAB has been working with staff over the past 18 months to develop candidate management objectives, procedures to achieve these objectives, and performance metrics with which to measure success. The Board has developed five overarching objectives and a number of specific stock and fishery objectives. Progress and results of the Board's meetings are posted on the MSAB website (http://www.iphc.info/msab). The group is currently working on a coastwide operating model of the halibut stock and in the future will develop more spatially explicit modelling.

OBJECTIVE 3: BIOLOGY, PHYSIOLOGY AND MIGRATION

Staff research within this objective seeks to collect and monitor primary biological characteristics of all sizes of halibut throughout the species' range. This includes directed studies but also involves incorporating studies monitoring the size at age of halibut within ongoing data programs wherever possible. IPHC also collaborates with other institutions and agencies to obtain biological and ecosystem information on halibut not otherwise available through IPHC programs and to incorporate that information into understanding and prediction of halibut population dynamics. Specific migration research objectives focus on the impacts of ontogenetic and seasonal movements on long-term yield, spatial distribution of spawning biomass, impact of fishing seasons on interceptions, and temporal variations in fish movement.
Research specific to halibut migration and movement was requested by the Commission in 2001 (Leaman et al., 2002). Dr. T. Loher of the IPHC staff has designed a tag study to provide information on seasonal migration of halibut that can provide input for discussing appropriate fishing seasons with four objectives. These objectives will be accomplished by quantifying, for the eastern Pacific halibut population, on regional bases:

1) the active spawning season for Pacific halibut, defined as the period over which eggs are released into the water column;

2) depth-specific spawning habitat, defined as the range of bottom depths over which halibut initiate active spawning behavior;

3) the fall and spring migratory periods, including estimates of the proportion of stock in a state of seasonal migration by date; and

4) where possible, timing of seasonal movement among regulatory areas, and the proportion of the spawning stock likely to be located out-of-area, by date.

Since 2009, the IPHC staff has been actively engaged in studies explicitly designed to establish protocols for the proposed work. This includes selection of appropriate tag type, tagging attachment and location protocols on the fish, and reliable, cost-effective tag technology. The ongoing studies outlined below support this work.

Also, in 2013 the IPHC embarked on an extensive set of studies to examine the recent decline in halibut size at age. The work encompasses several focused pieces of research, including those being conducted by IPHC staff and others in a collaborative study with the National Marine Fisheries Service (NMFS), the University of Washington (UW), and the Alaska Department of Fish and Game (ADF&G). Work will continue in 2015 as the decadal samples are identified and extracted from the archives, and aging/measuring of the growth increments begins.

The staff has also initiated a study of halibut movements within the southern Salish Sea (Puget Sound) in response to proposed hypotheses from Washington tribes about the nature of the population in that region. There has been a suggestion that the fish in this region are isolated and may require unique management. A demonstration of the movement of halibut from inside and outside waters will address the hypotheses.

Funded Research - Ongoing

Project 636.00: Evaluation of Pacific halibut macroscopic maturity stage assignments

Priority: High

Start: 2008

Anticipated Ending: 2016

Personnel: K. MacTavish, other staff as needed

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 2015, research will include:

- Determining the maximum precision for oocyte diameter measurements by oocyte maturation stage.
- Conducting assessment of the prepared slides from the archived gonads using the sampling protocols developed in 2014.
- Developing the sampling plan required to characterize seasonal maturation, including determination of the value of current summer assessment of halibut maturity stages.

Project 650.13: Archival tags: mounting protocols (OCA)

Priority: High

Start Date: 2009

Anticipated ending: 2015

Personnel: T. Loher

For 2015, the staff intends to terminate the captive holding of halibut in tanks at the Oregon Coast Aquarium (OCA) in Newport, OR. Staff believes that we have obtained all the necessary information from this study with the finding that neither the dart-and-tether nor the surgical implantation methods show signs of shedding. This portion of the project will be terminated in late fall, although the fish may be used for project 2015-03 prior to sacrificing.

Project 650.16:   Archival tags: Area 4B site selection

Priority: High

Start date: 2010

Anticipated ending: 2015

Personnel: T. Loher, J. Forsberg, survey team

In 2009, a total of 773 fish were tagged in Area 4B to evaluate tag recovery rates in preparation for 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 suggested that if archival tags were deployed in the Aleutians, we would likely recover relatively few of those tags. This project deployed tags on four sites, and recoveries to date (41 with 70% from two sites) indicate that the two sites would provide suitable locations for subsequent recoveries. The requested budget for 2015 is to cover the rewards for the anticipated recoveries.

Project 650.18:   Archival tags: tag attachment protocols

Priority: High

Start Date: 2013

Anticipated ending: 2017

Personnel: T. Loher

Recovery rates of archival tags affixed to halibut using four different external mounting protocols (three dart-and-tether configurations; one wired to the operculum) are being tested in a field release of “dummy” archival tags. During the summer of 2013, a total of 900 fish were tagged off northern Kodiak Island (Area 3A), with an equal number of fish tagged with each tag attachment type. Fish carrying a dart-and-tether tag were also tagged with a bright pink cheek tag, and rewards of $100 will be given for all tags recovered.

Project 665.11:   Estimate of length/weight relationship and head/ice/slime adjustment

Priority: High

Start: 2013

Anticipated Ending: open ended

Personnel: R. Webster, L. Erikson, K. MacTavish, H. Gilroy

The purpose of this study is to reexamine the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight. The current length-net weight relationship was estimated in 1926. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or WPUE derived from length measurements. Seasonal variation could affect weight estimates that are made from data collected during only a small part of the year. Therefore, we are collecting data coastwide throughout the season in order to estimate spatial and seasonal variation in the length to weight relationship. Data will be collected in 2015 from ports staffed with IPHC samplers throughout the fishing season. The goal is to determine whether seasonal or area-specific L-W relationships are warranted, or whether the effect of any variation can be incorporated via variation about the existing relationship.

The current relationship used by IPHC between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime: gross landed weight (gutted, with head, ice and slime) is assumed to include 12% head weight and 2% ice and slime, which combine to give a multiplier of 0.8624 to convert gross to net weight. However, the industry standard for head, ice and slime deduction is a total of 12%. Therefore we are also collecting data to provide direct estimates of adjustment factors to compare with the currently assumed values, and to assess variability in the weight of heads and ice and slime.

Project 646.13: Archival tags: Salish Sea PAT tags
Priority: Low
Start: 2014
Anticipated Ending: 2015
Personnel: T. Loher

This study is a test of several hypotheses regarding halibut movements within Area 2A. Specifically, that halibut found in the southern Salish Sea, i.e., Puget Sound, are an isolated stock component requiring management independent of the larger outer coast population. Six of the tags (at sites south of the San Juan Is.) were deployed in June from the IPHC survey platform. During July we attempted to formalize collaboration with a Lummi Nation vessel to deploy the remainder of the tags but this was unsuccessful and the six remaining tags were deployed from an alternate vessel in early October. The tags are programmed to pop up in January 2015 and June 2015.

Funded Research - Proposed

Project 2015-04: Length-weight relationship at sea
Priority: High
Start: 2015
Anticipated Ending: 2016
Personnel: E. Soderlund

This project integrates with the 665.11 port sampling project and obtains the two missing pieces of information on length-weight relationships: estimating shrinkage factors from fresh at-sea lengths and weights, to landed lengths and weights. It is particularly important for estimating removals from bycatch, recreational, and subsistence fisheries where no storage process occurs from capture to weight estimation.

The purpose of this study is to collect data on IPHC's SSA Survey for use in estimating the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight, as well as estimation of shrinkage (potentially occurring in both length and weight) from time of capture to time of offload. This project will complement an ongoing project (665.11), in which samples from commercial deliveries are measured and weighed at the dock, by providing length to weight data that is not available at commercial offloads: from U32 fish, round fish, and freshly killed and dressed fish, as well as measurements of shrinkage from the time of capture to final weighing at the offload. The current length to net weight relationship was estimated in 1926. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or WPUE derived from length measurements. The current relationship between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime. We also plan to collect data to provide direct estimates of adjustment factors to compare with the currently assumed values, and to assess variability in the weight of heads and ice and slime to supplement data collected in project 665.11.

OBJECTIVE 4: ECOSYSTEM INTERACTIONS AND ENVIRONMENTAL INFLUENCES

Research on this objective seeks to advance the understanding of the ecological context for halibut, including predation and competition, as well as fishing and environmental effects on recruitment and distribution. This also includes understanding the relationship between environmental influences and halibut distribution and behavior. This is primarily accomplished with broad-scale monitoring programs, some of which can occur on IPHC research platforms. Additionally, IPHC seeks to share its environmental data set with other researchers and institutions. Collaborative research is sought out whenever possible.

IPHC is actively involved in a large-scale monitoring program from the setline assessment survey using water column profilers. The program is making environmental data available to other researchers through a public access portal with the Pacific Marine Environmental Laboratory (PMEL). Other monitoring is occurring from the survey platform, including an appraisal of contaminants in halibut and the prevalence of *Ichthyophonus*. These three programs are proposed to continue in 2015, and are discussed below.

Funded research – Ongoing

Project 610.13: Oceanographic monitoring of the north Pacifi c and Bering Sea continental shelf with water column profilers
Priority: Medium
Start date: 2009
Anticipated ending: Continuing
Personnel: L. Sadorus, J. Walker, P. Stabeno (NMFS PMEL)

The goal of this project is to measure oceanic properties in the waters over the Alaskan, B.C., and the U.S. west coast continental shelf that can be correlated to catch per unit effort (CPUE) of halibut as well as incidence of other groundfish species. The IPHC operates a survey that covers the area, and water column profilers that measure temperature, salinity, dissolved oxygen, pH, and florescence are deployed at each station. These data provide an annual snapshot of near shore oceanic conditions as well as valuable observational data for studying halibut distributions in relation to environment, addressing environmentally-related catchability in the survey, modeling and biological studies on recruitment and growth variability.

Since 2009, a NOAA grant has provided for the complete outfitting of all chartered survey vessels, resulting in a complete coastwide deployment. Annual costs are directed towards maintenance and calibration of the profilers, and data preparation necessary for submission to the National Ocean Data Center.

Funding in 2015 includes replacing one profiler, upgrading an older profiling unit to come into compliance with the newer units, the replacement of four profiler control/recording units, as well as maintenance and calibration of all units. An ancillary element of the proposal includes the construction of an environmental database, including the profiler and other data, at the IPHC for direct use by IPHC staff.

Project 642.00: Assessment of mercury and contaminants in Pacific halibut
Priority: Medium
Start Date: 2002
Anticipated ending: Continuing
Personnel: C. Dykstra, B. Gerlach (ADEC)

The staff proposes to continue IPHC's collaboration with the Alaska Department of Environmental Conservation (ADEC), collecting halibut tissue samples for analysis of heavy metal and organic pollutant loading. This work has been ongoing since 2002. In 2015 sampling will focus on the Shelikof, Adak, and St. Matthew charter regions, and will expand to include sub-legal halibut to better understand the accumulation dynamics over the animals' lifespan.

Project 661.11: *Ichthyophonus* prevalence in halibut
Priority: Low
Start Date: 2012
Anticipated ending: ongoing
Personnel: C. Dykstra, G. Williams, J. Gregg (USGS), P. Hershberger (USGS)

Ichthyophonus is a protozoan parasite from the class Mesomycetozoea, a highly diverse group of organisms having characteristics of both animals and fungi. It has been identified in many marine fish, and is considered a causative agent in herring fishery collapses world-wide, and there is concern over its effects on the success of salmon spawning on major rivers such as the Yukon.

Sampling of Pacific halibut aboard IPHC setline surveys has been ongoing since 2011. Results to date show that adult halibut have a wide range of infection rates, with Prince William Sound showing some of the highest observed in marine fish. Samples will continue to be collected in 2015 at three sentinel sites (OR, PWS, and northern Bering Sea) to monitor variability in prevalence and intensity of infections.

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Northwest Fisheries Science Center

National Marine Fisheries Service

NOAA Fisheries

Agency Report to the Technical Subcommittee

of the Canada-U.S. Groundfish Committee

April 2015

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. Four divisions, Conservation Biology, Environmental and Fisheries Sciences, Fish Ecology, and Fishery Resource Analysis and Monitoring, conduct applied research to resolve problems that threaten marine resources or that deter their use. 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 Charleston, North Carolina.

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 2014, FRAM continued to: implement a West Coast observer program; conduct a coast wide survey program that includes West Coast groundfish acoustic, hook and line, and trawl surveys; develop new technologies for surveying fish populations; 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 and Fisheries Sciences Division conducts research to assess and reduce natural and human-caused impacts on environmental and human health, and to improve methods for fisheries restoration and production in conservation hatcheries and in aquaculture. Environmental health and conservation research examines environmental conditions and the impacts of chemical contaminants, marine biotoxins, and pathogens on fishery resources, protected species, habitat quality, seafood safety, and human health. Fisheries restoration and aquaculture includes research on the challenges associated with captive rearing, nutrition, reproduction, behavior, disease control, engineering, hatchery technology and larval/juvenile quality for protected, depleted and commercially valuable species.

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.

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) 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, 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. The analysis was updated in 2014 to include additional trawl survey data from 2011-2013.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

b)_Feeding ecology of select groundfish species captured in the Northwest Fisheries Science Center's (NWFCS) West Coast Bottom Trawl Survey, using gut contents and stable isotopes

Investigators: K.L. Bosley, J. Buchanan, A.C. Chappell, K.M. Bosley

The authors are examining the diets of multiple groundfish species as an ongoing component of the NWFSC's West Coast Bottom Trawl Survey. This research was initiated to address a need frequently cited in the "Research and Data Needs" section of groundfish stock assessments to better understand trophic dynamics. The goal of the ongoing study is to gather information on diets of many important groundfish species and provide needed information to stock assessors and managers. Stomachs and muscle tissue samples are collected at sea and preserved for gut content determination and stable isotope analysis. In the laboratory, stomachs are assessed for fullness and the contents removed for examination. Prey species are identified to the lowest taxonomic level possible then individually weighed and enumerated. Yellowtail, darkblotched, canary, sharpchin and stripetail rockfishes are largely zooplanktivorous, with euphausiids composing 48.0 to 84.7% of total prey weight. Darkblotched and canary rockfishes also feed on shrimp, which were 34.2% and 39.5% by weight, respectively. Sablefish, yelloweye rockfish, chilipepper and bocaccio are piscivorous, with fish making up 50.7% to 91.4% of total prey weight. Greenstriped and rosethorn rockfishes show a strong preference for benthic prey; various shrimp species make up 80.8% of greenstriped diets by weight, while rosethorn consumed 52.1% shrimp and 20.3% galatheid crab species. Finally, widow rockfish and Pacific ocean perch exhibit a more omnivorous feeding strategy, eating a variety of zooplankton including euphausiids (14.3% and 30.9%), amphipods (4.3% and 3.4%), shrimp (0.87% and 5.3%) and gelatinous organisms (2.6% and 60.94%). These results demonstrate that groundfishes are significant consumers in both benthic and pelagic habitats feeding across multiple trophic levels. The results of stable isotope analysis will show whether the gut contents represent recent or long-term trends.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov or John Buchanan at John.Buchanan@noaa.gov

c) Occurrence of demersal fishes in relation to near-bottom oxygen levels within the California Current large marine ecosystem

Investigators: A.A. Keller. L. Ciannelli, W.W. Wakefield, V. Simon, J. Barth, S. Pierce

Various ocean-climate models driven by increased greenhouse gases and higher temperatures predict a decline in oceanic dissolved oxygen (DO) as a result of greater stratification, reduced ventilation below the thermocline, and decreased solubility at higher temperatures. Since spreading of low oxygen waters is underway and predicted to increase, understanding impacts on higher trophic levels is essential. Within the California Current System, shoaling of the oxygen minimum zone (OMZ) is expected to produce complex changes. Onshore movement of the OMZ could lead to habitat compression for species with higher oxygen requirements while allowing expansion of species tolerant of low bottom DO. As part of annual groundfish surveys, we sampled catch across a range of conditions from the upper to the lower limit of the OMZ and shoreward across the continental shelf of the US west coast. DO ranged from 0.02 to 4.25 $mL\ L^{-1}$ with 642 stations (of 1020 sampled) experiencing hypoxic conditions in 2008 – 2010 (Figure 1). Catch and species richness exhibited significant and positive relationships with near-bottom oxygen concentration. Probability of occurrence was estimated for four species (spotted ratfish, petrale sole, greenstriped rockfish and Dover sole) using a binomial Generalized Additive Model. The models for each species included terms for position, day of the year, salinity, near-bottom temperature and the interaction term between depth and near-bottom DO. Spotted ratfish and petrale sole were sensitive to changes in near-bottom oxygen, while greenstriped rockfish and Dover sole show no changes in probability of occurrence in relation to changes in oxygen

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

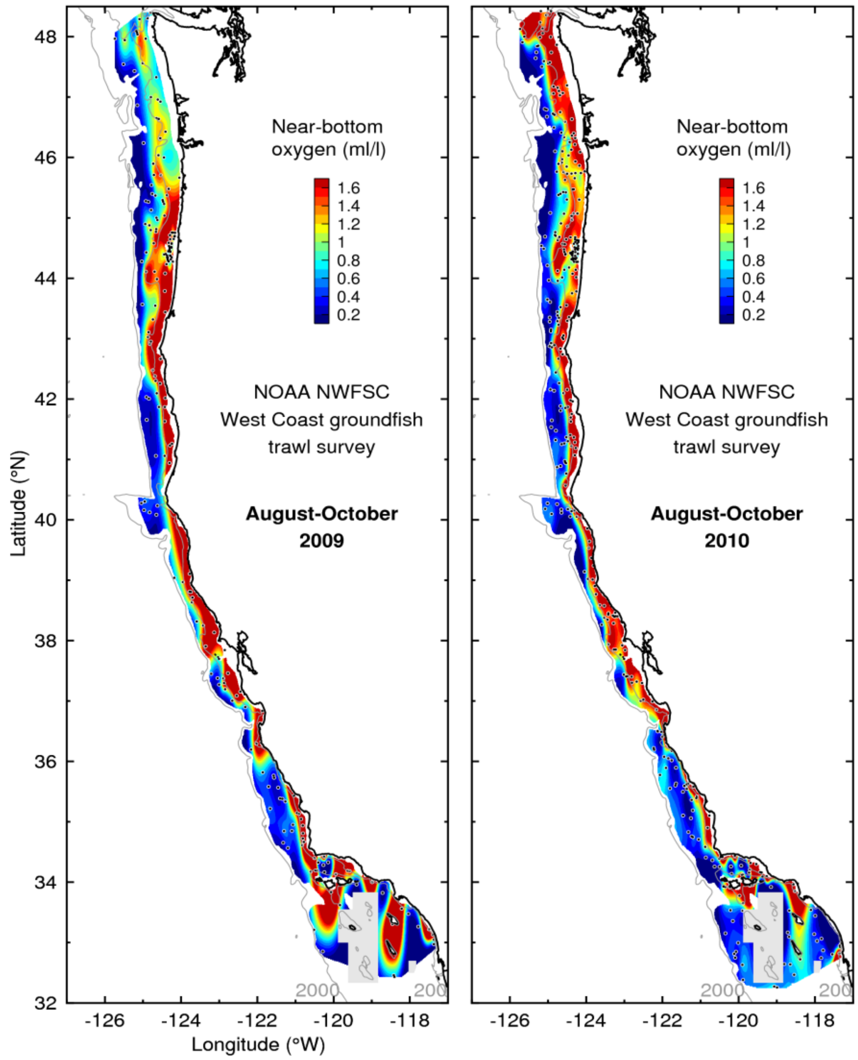


Figure 1. Contour plots of near-bottom oxygen concentrations (mL L^{-1}) along the U.S. west coast at depths of 55 – 1280 m in: a) 2009; and b) 2010 (August – October).

d) Impact of light on catch rate of four demersal fish species during the 2009 - 2010 U.S. west coast groundfish bottom trawl survey

Investigators: M. Bradburn, A.A. Keller

To determine the influence of light on catch of demersal fish, we examined the relationship between near-bottom light levels, catch rates, and catch probability for four abundant groundfish species well represented in annual bottom trawl surveys on the U.S. west coast: arrowtooth flounder (*Atheresthes stomias*), greenstriped rockfish (*Sebastes elongatus*), longnose skate (*Raja rhina*), and Pacific hake (*Merluccius productus*). Relative downward irradiance was measured with net-mounted archival tags during annual trawl surveys along the U.S. west coast in 2009 and 2010. Near-bottom light levels were recorded for 818 hauls at depths less than 400 m. Significant linear relationships were observed between catch per unit effort (CPUE, kg ha-1) and near-bottom light ($P < 0.05$). CPUE of arrowtooth flounder, longnose skate, and Pacific hake was negatively related to near-bottom light. For these species, CPUE decreased 16 - 22% per unit increase in log10 light (μE m-2 s-1). CPUE of greenstriped rockfish increased 39% per unit increase in log10 light. Light, depth, and latitude explained 15 - 47% of the variance in CPUE for the four species. Catch probability was significantly related to light, depth, latitude, and relative time of day ($P < 0.05$). For all species, catch probability varied inversely with light when depth was less than 200 m. At depths of 200 to 300 m, catch probability increased with light for arrowtooth flounder and greenstriped rockfish. Catch probability for Pacific hake decreased slightly at depths greater than 200 m while longnose skate was relatively unaffected by light at these depths. We used these relationships to explain the variability in catch rates for individual species within bottom trawl surveys. By influencing the density and distribution of these groundfish species, light can alter catch rates. Furthermore, we found possible herding of greenstriped rockfish, and trawl avoidance by arrowtooth flounder, Pacific hake, and longnose skate.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

e) Enzyme activities of demersal fishes from the shelf to the abyssal plane

Investigators: J. Drazen, J.R. Friedman, M. Gerringer, E. Aus, N. Condon, A.A. Keller, M.E. Clarke

The present study examined metabolic enzyme activities of 61 species of demersal fishes (331 individuals) trawled from a 3000 m depth range. Citrate synthase, lactate dehydrogenase, malate dehydrogenase, and pyruvate kinase activities were measured as proxies for aerobic and anaerobic activity and metabolic rate. Fishes were classified according to locomotory mode, either benthic or benthopelagic. Fishes with these two locomotory modes were found to exhibit differences in metabolic enzyme activity. This was particularly clear in the overall activity of citrate synthase, which had higher activity in benthopelagic fishes. Confirming earlier but less comprehensive studies, enzyme activities declined with depth in benthopelagic fishes. For the first time, patterns in benthic species could be explored and these fishes also exhibited depth-related declines in enzyme activity, contrary to expectations of the visual interactions hypothesis. Trends were significant when using depth parameters taken from the literature as well as from the present trawl information, suggesting a robust pattern regardless of the depth metric used. Potential explanations for the depth trends are discussed, but clearly metabolic rate does not vary simply as a function of mass and habitat temperature in fishes as shown by the substantial depth-related changes in enzymatic activities.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

f) Size at maturity for grooved Tanner crabs (*Chionoecetes tanneri*) along the U.S. west coast (Washington to California)

Investigators: A. Keller, J. Buchanan, E. Steiner, D. Draper, A. Chappell, P. Frey, M. Head

We conducted a multiyear study (2012 -2014) to examine interannual variability in the size (carapace width, mm), growth, and depth (m) for mature and immature grooved Tanner crab (*Chionoecetes tanneri*, Rathbun, 1893) along the U.S. west coast (lat. 32°30'N to 48°30'N). An additional goal was to provide updated, coast-wide estimates of size at 50% maturity (W50) for male and female Tanner crabs and assess changes in W50 over time. Our randomly selected samples came from fisheries independent bottom trawl surveys undertaken annually by the Northwest Fisheries Science Center at depths of 55 to 1280. We used allometric relationships between carapace width and either abdominal width (females) or chela length (males) to determine functional maturity for each sex. We subsequently evaluated maturity by fitting logistic regression models to the proportion mature. W50 varied significantly between males (125.2 mm) and females (89.1 mm) but interannual differences were slight and unlikely biologically significant. Annual mean carapace widths (CW), of mature crabs measured from 2012 to 2014 were always greater for males (139.9–143.4 mm) relative to females (98.8–100.4 mm). Similarly, average sizes of immature crabs varied between sexes with males (75.7 – 84.6 mm) larger than females (66.7 – 71.9 mm). Size frequency distributions indicated little overlap in size of mature male and female grooved Tanner crabs but considerable overlap between subadults. The best model expressing the complexity in growth incorporated width, sex, and stage but not year, implying interannual differences were slight. Grooved Tanner crabs were partially segregated by depth and stage. Depth (m) ranged from 195 – 1254 m with the average depth of mature Tanner crabs (females, 737 m; males, 767 m) significantly shallower than subadult (females, 949 m; males, 918 m) crabs.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

g) The Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey: survey history, design, and description

Investigators: A. Keller, J. Wallace, R. Methot

Scientists from the Northwest Fisheries Science Center (NWFSC) Fisheries Resources Analysis and Monitoring (FRAM) division annually conduct a bottom trawl survey of groundfish resources. The purpose of the West Coast Groundfish Bottom Trawl Survey (WCGBTS) is to provide fisheries-independent indices of stock abundance to support stock assessment models for commercially and recreationally harvested groundfish species. The survey produces annual biomass estimates that are calculated using the area swept by the trawl to estimate fish density. These estimates are expanded to the full survey area to produce species-specific biomass indices. The WCGBTS collects data on 90+ species contained in the Fisheries Management Plan (FMP) to fulfill the mandates of the Magnuson-Stevens Sustainable Fisheries Act. Fishery managers on the West Coast of the United States rely on fishery stock assessments to provide information on the status of groundfish stocks. Stock status determinations directly influence decisions regarding harvest levels. Here we provided a detailed description of the groundfish survey's history, design and current description.

Prior to 1998, surveys conducted by the Alaska Fisheries Science Center (AFSC) were the principal source for fishery-independent data about groundfish resources along the upper continental slope and shelf of the U.S. west coast. The AFSC triennial shelf surveys used chartered Alaska fishing vessels (19.8–52.1 m) while slope surveys were conducted with the NOAA R/V Miller Freeman during most years (1988 and 1990–2001). A review of the earlier surveys reveals that both the AFSC's west coast shelf and slope surveys varied considerably among years both in the timing of the surveys and the geographical extent (longitudinally and by depth). Survey timing varied between years as the focus of the surveys shifted among different groundfish species. Spatial coverage varied between years due to constraints imposed by annual budget levels and/or availability of NOAA ship time. The various configurations of these surveys are described since they provide insights into the design of the current NWFSC's annual groundfish survey. The NWFSC survey has utilized a consistent survey extent and design since 2003 except for the changes to geographic strata and station allocations in 2004.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

h) Distribution of demersal fishes along the U.S. west coast (Canada to Mexico) in relation to spatial fishing closures (2003 – 2011)

Investigators: A.A. Keller, W.W. Wakefield, C.E. Whitmire, B.H. Horness, M.A. Bellman, K.L. Bosley

A temporally and spatially variable Rockfish Conservation Area (RCA) was established as a marine protected area along the U.S. west coast in 2002 to protect stocks of rockfishes (*Sebastes* spp.) by restricting commercial trawling in regions where depleted stocks were most abundant. Since the RCA falls within the region sampled annually by the Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey (32º30′ – 48º10′ N Lat.), data collected from 2003 to 2011 were utilized to evaluate if establishment of the RCA influenced catch per unit effort (CPUE, kg ha^{-1}), species richness, and size distribution of demersal fishes. Catch and species richness were compared among three management areas (continuously closed, periodically closed, and open to commercial bottom trawling) using analysis of covariance models that account for variability due to area, year, and depth. The most appropriate models for catch (35 species treated individually and aggregated into six subgroups) and species richness were selected using Akaike's information criteria (AIC). All of the best fit models were highly significant ($P < 0.0001$), explaining 3 to 76% of the variation in catch and the majority (19 of 35) included both area and depth. For 27 species and five subgroups of demersal fishes, the mean CPUE (based on Tukey's multiple comparison test) was significantly greater within the area continuously closed to commercial bottom trawling relative to areas periodically closed or open. The most appropriate model for species richness included area and year and mean richness was greatest in the area continuously closed to commercial bottom trawling. Species-specific length composition distributions were calculated from subsampled individual lengths which were available for 31 species. Significant differences in length frequency distributions (Kolmogorov-Smirnov asymptotic test statistic, $P < 0.001$) were observed for these 31 demersal fish species, with a higher proportion of larger fish most often (~65%) present in areas continuously closed to commercial bottom trawling (20 of 31 species) relative to other areas. The data suggest that the RCA is an effective management tool for conserving not only rockfishes, but other demersal fish species. Although no increases in CPUE occurred over the time examined, both catch and species richness were greater in the closed portion of the RCA and a higher proportion of larger fish occurred within the RCA boundaries.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

i) Pelagic and demersal fish predators on juvenile and adult forage fishes in the Northern California Current: spatial and temporal variations

Investigators: R. Brodeur, R. Emmett, J. Buchanan

A requisite for reliable food web models and ecosystem-based management in regions such as the California Current is the availability of diet information on key predators. In upwelling ecosystems, much of the lower trophic level energy may be transferred through a relatively small set of very abundant pelagic forage fish taxa, such as anchovies, sardines, smelts, and herring. In addition the pelagic juvenile stages of some important midwater and demersal fishes (Pacific hake and rockfishes) may act as forage fishes during a more limited time period each year. In this paper, we review what is known about the utilization of these forage species by larger fish predators and elasmobranchs in the Northern California Current (NCC) from northern Washington to northern California (Cape Mendocino) to examine spatial and temporal variations in the kinds and sizes of forage fishes consumed. We found that predation on forage fishes was highly variable in space and time, and was often dependent on the size of the prey available as well as the predator. Pacific hake and spiny dogfish have the potential to be dominant forage fish predators due to their high biomass but other species such as arrowtooth flounder and Pacific halibut can be important due to their high proportion of forage fish in the diet. We also highlight where diet information is poor or lacking, and areas where regular fish diet monitoring could be useful for ecosystem-based management.

For more information, please contact John Buchanan at John.Buchanan@noaa.gov

j) Cryptic population structure near Pt Conception, CA in the severely depleted cowcod, *Sebastes levi*

Investigators: J. Hess, P. Chittaro, A. Elz, E. Gilbert-Horvath, V. Simon, J. Garza

Cowcod (*Sebastes levis*) is a member of a northeastern Pacific Ocean species flock that experienced extensive fishery exploitation. Factors that could produce structure in cowcod include a major biogeographic boundary within cowcod's geographical distribution; severe declines in abundance, potentially, resulting in reductions in effective population size and divergence owing to genetic drift; and dependence on patchily distributed habitat. We examine the following two questions: (i) is there subdivision present and, if so, is it concordant with the two marine biogeographic region separated by Point Conception, and (ii) have cowcod experienced loss of genetic variation owing to population size reduction? Coarse-scale genetic and otolith analyses indicated regional structure across Point Conception. However, analysis of 24 microsatellite DNA loci revealed as many as three cryptic, divergent lineages (FCT = 0.194) that meet south of Point Conception. The two southern lineages had higher growth rate than the northerly distributed lineage. In general, cowcod is the least genetically diverse of 10 rockfishes surveyed with the same markers, but the recent substantial declines in abundance were not reflected by recent genetic bottleneck analyses.

For more information, please contact Victor Simon at Victor.Simon@noaa.gov

k) Can we increase our confidence about the locations of biodiversity 'hotspots' by using multiple diversity indices?

Investigators: N. Tolimieri, A.O. Shelton, B.E. Feist, V. Simon

Some have suggested that targeting conservation efforts on biodiversity hotspots—areas of exceptionally high diversity—is the most efficient way to use limited resources to protect the most or rarest species. Moreover, the preservation of biodiversity is a focus for resource management and conservation because of the links between biodiversity and ecosystem function. However, biodiversity is a complex concept, and there are many ways to define biodiversity and a plethora of diversity indices. Do these indices agree on where biodiversity hotspots are, and by extension, where conservation should take place? Here we use a habitat modeling approach to map spatial and temporal patterns in five metrics of diversity for the demersal fish community in the California Current Large Marine Ecosystem: species density, species evenness, taxonomic distinctness, functional divergence and total biomass. Depth, bottom temperature, sediment grain size, and distance to hard substratum were included as covariates in the model. All indices showed strong spatial patterns and relationships with depth. Spatial patterns for functional divergence and total biomass varied among years, but other indices did not show temporal variation. We identified hotspots as cells where at least one index was in the top 5% and 10% of its range. There was minimal spatial overlap among hotspots for the five indices. Over 40% of the study area was classified as a biodiversity hotspot by at least one metric. However, no area was identified as a hotspot by all five metrics and only slightly more than 1% of the coast was identified as within a hotspot for three or more metrics. Since different indices represent diverse aspects of diversity, our results caution against the uninformed use of diversity metrics in the identification of biodiversity hotspots. Instead we must define our objectives and then choose the relevant metrics for the problem.

For more information, please contact Nick Tolimieri at Nick.Tolimieri@noaa.gov

l) Maturity and growth of sablefish, *Anoplopoma fimbria*, along the U.S. West Coast

Investigators: M.A. Head, A.A. Keller, M. Bradburn

Life history parameters such as growth and reproductive processes are dynamic, and shift with environmental and anthropogenic influences. Providing up-to-date life history information is critical for population dynamic models that are used to manage fisheries. Sablefish, *Anoplopoma fimbria*, are a valuable groundfish species that support commercial fishing throughout the North Pacific Ocean, including off the U.S. West Coast. Ovaries were histologically assessed for maturity status, intensity of atresia, and the presence of post-ovulatory follicles. We evaluated coast-wide length and age at maturity for 477 female sablefish by fitting a logistic regression model to the proportion mature. We also examined length-at-age data for 525 female sablefish based on the von Bertalanffy growth model. Since maturity and growth are important components of models used to assess the status of sablefish, we explored variation in these life history parameters among three regions along the West Coast separated by major biogeographic features at Cape Mendocino, CA (40◦26’N) and Pt. Conception, CA (34◦27’N). Coast-wide estimates of length (L_{50}) and age (A_{50}) at 50% maturity were 54.64 cm and 6.86 years, respectively. Differences in L_{50} were found north and south of Cape Mendocino, CA, and by depth (range 55–1280 m). Length at 50% maturity decreased from north to south and with increasing depth within each region. Age at 50% maturity also differed north and south of Cape Mendocino, CA, with female sablefish maturing at a younger age further north. Growth of female sablefish demonstrated similar differences among geographic areas and by depth. Asymptotic size (L_∞, cm) tended to increase at higher latitude and decrease with depth, while growth rates (k, $year^{-1}$) were elevated north of Point Conception, CA, and generally at depths ≤550 m. For female sablefish, the larger size and younger age at 50% maturity, as well as larger asymptotic sizes and somewhat elevated growth rates, were associated with regions within the California Current Ecosystem characterized by elevated productivity and cooler water temperature.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

m) Robust estimation of maturity ogives and skipped spawning rates in U.S. West Coast groundfish using double-reads and measurement error models

Investigators: G.L. Stokes, M.A. Head, J.T. Thorson, A.A. Keller

The reproductive output of a population depends upon physiological factors, including maturation rates and fecundity at size and age, as well as the rate at which post-maturation females fail to spawn (i.e. skipped spawning). These rates are increasingly included in stock assessment models, and are thought to change over time due to harvest and environmental factors. Thus, it is important to accurately estimate maturation and skipped spawning rates while also including information on imprecision. For this task, we developed a new double-read and measurement-error modeling protocol for estimating maturity that is based on the use of multiple histological reads of ovaries to account for reader error caused by poorly prepared slides, nuclear smear, and possible drops of yolk. Application to three West Coast groundfishes (Pacific hake *Merluccius productus*, darkblotched rockfish *Sebastes crameri*, and canary rockfish *Sebastes pinniger*) indicates that reader uncertainty is strongly predictive of reader error rates. Results also show large differences in rates of skipped spawning among species, with higher rates exhibited by short-lived species. We recommend that future maturity studies use multiple reads and record reader certainty. This improved protocol will help improve life history, environmental, and anthropogenic effects on maturity. Furthermore, we recommend examining multiple slides from the same fish to see if there is inherent variability within individuals.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

n) Maturity and growth of darkblotched rockfish, *Sebastes crameri,* along the U.S. West Coast

Investigators: P.H. Frey, M.A. Head, A.A. Keller

Changes in the reproductive biology of fish stocks over time can affect the accuracy of recruitment estimates used by fisheries managers to determine harvest levels. For heavily depleted species, shifts in parameters such as age and size at maturity may occur over a relatively short time period in response to changes in selective pressure or population density. We examined the reproductive biology of darkblotched rockfish (*Sebastes crameri*), a commercially and ecologically important groundfish in the California Current ecosystem along the West Coast of North America. The National Marine Fisheries Service currently lists darkblotched rockfish as “rebuilding” after years of intense overfishing in the 1980s and 1990s. We examined ovaries and age structures collected in 2011 and 2012 for oocyte development stage and maturity. Length and age at 50% maturity were estimated as 30.0 cm fork length and 6.0 years, respectively, indicating a 12% and 29% decrease compared to the length and age at 50% maturity previously reported for this stock. This reduction increased the estimate of spawning stock biomass in a recent darkblotched rockfish stock assessment. Our study also revealed spatial patterns in darkblotched rockfish maturity along the U.S. West Coast, including a notable decrease in the proportion of mature fish encountered south of central Oregon. Our findings demonstrate the importance of periodically updating life history data used in stock assessment models, and also highlight the potential value of spatial management toward sustainable fishing of rockfish species.

For more information, please contact Peter Frey at Peter.Frey@noaa.gov

o) Assessing the quality of life history information in publicly available databases

Investigators: J.T. Thorson, J. Cope, W.S. Patrick

Single-species life history parameters are central to ecological research and management, including the fields of macro-ecology, fisheries science, and ecosystem modeling. However, there has been little independent evaluation of the precision and accuracy of the life history values in global and publicly available databases. We therefore develop a novel method based on a Bayesian errors-in-variables model that compares database entries with estimates from local experts, and we illustrate this process by assessing the accuracy and precision of entries in FishBase, one of the largest and oldest life history databases. This model distinguishes biases among seven life history parameters, two types of information available in FishBase (i.e., published values and those estimated from other parameters), and two taxa (i.e., bony and cartilaginous fishes) relative to values from regional experts in the United States, while accounting for additional variance caused by sex- and region-specific life history traits. For published values in FishBase, the model identifies a small positive bias in natural mortality and negative bias in maximum age, perhaps caused by unacknowledged mortality caused by fishing. For life history values calculated by FishBase, the model identified large and inconsistent biases. The model also demonstrates greatest precision for body size parameters, decreased precision for values derived from geographically distant populations, and greatest between-sex differences in age at maturity. We recommend that our bias and precision estimates be used in future errors-in-variables models as a prior on measurement errors. This approach is broadly applicable to global databases of life history traits and, if used, will encourage further development and improvements in these databases.

For more information, please contact James Thorson at James.Thorson@noaa.gov or Jason Cope at Jason.Cope@noaa.gov

p) Distribution and life history characteristics for vermilion rockfish (*Sebastes miniatus*) and its cryptic pair, 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, 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. NWFSC researchers are analyzing tissue samples taken from specimens captured during the survey to taxonomically separate vermilion rockfish and its cryptic twin, the sunset rockfish, to compare depth and distributional patterns between the two species. In addition, this research is developing separate life history parameters for each species including age at length, annual growth estimates, length-weight relationships, and age at maturity. This information can be combined with species-specific abundance indices using the methods described in Harms et al. (2010) to determine whether separate stock assessments for vermilion and sunset rockfish are warranted.

For more information, please contact John Harms at John.Harms@noaa.gov

q) A fishery-independent multi-species examination of recent population trends for key species of shelf rockfish (Genus: *Sebastes*) in Southern California

Investigators: A.C. Hicks, J.H. Harms, J.A Benante, R.M. Barnhart

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 121 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 annual 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.

For more information, please contact John Harms at John.Harms@noaa.gov

r) Recent developments: Southern California shelf rockfish hook and line survey

Investigators: R.M. Barnhart, J.H. Harms, 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 time series of catch-per-unit-effort data and associated biological data 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 55% 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 survey has prioritized the collection of ovary specimens to support research aimed at estimating size at maturity for vermilion rockfish, sunset rockfish, greenspotted rockfish, cowcod, and bocaccio. Efforts to collect video habitat information via the deployment of an underwater camera sled 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.

For more information, please contact John Harms at John.Harms@noaa.gov

s**) Classification of benthic habitats in the Southern California Bight**

Investigators: A. Chappell, R.M. Barnhart, J.H. Harms, J.A. Benante, C.E. Whitmire.

The Southern California Shelf Rockfish Hook and Line Survey uses rod and reel gear to sample hard bottom habitats within the Southern California Bight (SCB) that are not effectively sampled during trawl surveys. Information collected during the survey is used to generate abundance indices and estimate biological parameters to support stock assessments for demersal rockfishes (*Sebastes* spp.). The survey, initiated in 2004, is conducted annually aboard vessels chartered from the local sportfishing industry. The survey design consists of 121 fixed stations sampled annually spanning from Pt. Arguello (34.6^0 N) to the Mexican border (32.1^0 N) in a depth range of 37 – 229 m.

Benthic habitat observations are also collected during the survey via opportunistic deployment of a towed video sled consisting of a low-light analog color camera and a mini-DV recording system. Video is analyzed using established protocols to classify bottom type into major and minor substrata comprising eight habitat categories: mud, sand, pebble, cobble, boulder, continuous flat rock, diagonal rock ridge and vertical rock-pinnacle top. Our primary objective is to compare the proportion of each habitat type within the survey's sampling frame relative to their composition in the SCB as a whole as determined by available habitat maps. To date, approximately 82 sled dives have occurred producing informative footage during 51 dives representing 46 unique stations. Preliminary findings suggest some smaller hard-bottom habitat features may not be adequately resolved within available maps. If these features support significant abundances of fish and invertebrates, this may have implications for coastwide biomass estimates for these species. Longer term objectives include: incorporating habitat type as a covariate in population abundance models; identifying species and assemblage associations with specific habitat types; and ground-truthing habitat maps.

For more information, please contact Aaron Chappell at Aaron.Chappell@noaa.gov

t**) The role of environmental drivers on the distribution of vermilion (*Sebastes miniatus*) and sunset rockfishes (*S. crocotulus*) in the Southern California Bight.**

Investigators: A. Hughes, A.C. Hicks, J.H. Harms

Recent genetic research revealed that the vermilion rockfish, previously thought to be a single species, actually comprises two species that diverged 2-3 million years ago (Hyde et al. 2008). This research coined the newly-identified cryptic species the sunset rockfish (*S. crocotulus*). Survey observations suggest depth segregation between vermilion rockfish and sunset rockfish may be somewhat more ambiguous than the100 m threshold proposed by Hyde et al. (2008), at least within the SCB, suggesting other factors may also play a role in defining the two species distributions. Using data collected from the NOAA Hook and Line survey, logistic regression models were used to determine the importance and predictive ability of environmental covariates to determine if an observation was a Vermilion Rockfish or a Sunset Rockfish.

The NOAA Hook and Line Survey employed standard hook and line gear deployed by rod and reel aboard chartered sportfishing vessels in the Southern California Bight. All rockfish encountered during the survey are identified to species and processed for length, weight, sex, age (via otoliths), and genetic information (via fin clip). The survey deployed a Conductivity-Temperature-Depth (CTD) sensor array at each site to collect environmental and oceanographic data including temperature, salinity, dissolved oxygen, chlorophyll, and turbidity.

Three categories of logistic regression models were created with different combinations of variables, including interactions between the variables, using 1) only environmental data (sea-surface temperature, dissolved oxygen, salinity, and steepness of the bottom), 2) only spatial data (Northings and Eastings), and 3) environmental and spatial observations. Every model set included Depth in meters as a covariate. The best model for each set was selected using the

Akaike Information Criterion (AIC). Furthermore, models were tested using cross-validation, where a randomly selected 80% of the data were used as a training data set and the remaining 20% were used as a test case. This was repeated 1000 times with random subsets of data, and models were compared using Mean Squared Error (MSE) to assess their bias and variance in predictions. Using the model in each set that performed the best in the cross-validation, the depth that predicted 50% vermilion rockfish was calculated.

Cross-validation showed that the environmental model with covariates for depth, temperature, salinity, depth: temperature, and temperature: salinity, where a ':' indicates an interaction between the variables, exhibited the lowest mean squared error (MSE).

Previous studies including Hyde et al. (2008) suggest a distinct depth partitioning, with a majority of vermilion rockfish found shallower than 100 meters and a majority of sunset rockfish found deeper than 100 meters. These results show that vermilion and sunset rockfish do not have a sharp depth partitioning, with the proportion of vermilion rockfish declining with deeper depths but the two species co-occurring at depths even as deep as 200 meters. The 100 m partition was found to be a good indicator for the occurrence of vermilion rockfish, as the environmental model predicts greater than 90% proportion of vermilion rockfish shallower than 100 meters. However, this model found the depth at which the proportion of vermilion rockfish reaches 0.5 to be 126 m, indicating that vermilion rockfish seem to persist deeper than this 100 m division as well, with the proportion not reaching 10% until down to 150 m.

This work was done by Austen Hughes, a 2014 Hollings scholar, under the mentorship of John Harms (FRAM/NWFSC/NOAA) and Allan Hicks (FRAM/NWFSC/NOAA). A poster was presented by Austen Hughes in Silver Spring, MD as part of the Hollings scholar program.

For more information, please contact Allan Hicks at Allan.Hicks@noaa.gov or John Harms at John.Harms@noaa.gov

u) Fishing vessel-based survey of young-of-the-year (YOY) groundfishes along the Newport hydrographic line

Investigators: W.W. Wakefield, M. Yergey, L. Ciannelli

The Northwest Fisheries Science Center (NWFSC) Fishery Resource Analysis and Monitoring Division conducts a comprehensive groundfish bottom trawl survey encompassing the U.S. west coast between the borders with Canada and Mexico and water depths of 50 – 1280 m. This survey does an excellent job of quantifying adult fishes in the study area, but was not designed to quantitatively sample the young-of-the-year (YOY) life history stage. Limited research has been conducted on YOY groundfishes off Oregon since the pioneering work during the late 1970s and early 1980s. A recent Oregon Sea Grant funded project on the effects hypoxia on pelagic larval and benthic juvenile groundfishes has allowed for sampling in nearshore waters (30 – 80m) during the summer months, but there has been no systematic seasonal sampling across the entire continental shelf since the early 1980s. In 2012 a project was initiated to conduct a fishing vessel-based survey of YOY groundfishes along the NH-Line synoptically with a separate and ongoing plankton/physical oceanography sampling program (Figure 2).

A 2-m wide by 0.5-m high video beam trawl system, equipped with a high-definition video system and scaling lasers is being used to collect fish samples as well as video of fish habitat and behavior (Figure 3). On board, scientists work with the fishing crew to collect fish from the trawl, measuring and returning the large juveniles and adults (anything greater than 150 mm SL), and freezing the juvenile and YOY groundfish. These frozen fish are brought back to the lab, where they are classified to lowest possible taxonomic group possible (usually species), measured, and weighed. These fish are then preserved to allow for future research that may look at the diets or growth rates. The video that is collected on each deployment of the beam trawl is also analyzed back in the laboratory, where each fish in the video is classified to the lowest possible taxonomic group possible, and their behavior is quantified. This information is then used to better understand how the behavior of these YOY fishes changes with a changing environment. A total of 132 tows have been conducted as a part of this project, with 34 in 2012, 56 in 2013, and 42 in 2014. The fish samples collected from the first full year (July 2012 – July 2013) have been fully processed with fishes identified to lowest taxonomic level (species in most cases), and cataloged into our database (Fisheries Oceanography Information System or FOIS). Analysis of the data from the first complete year of sampling was recently presented at the 9th International Flatfish Symposium in Cle Elum, Washington.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

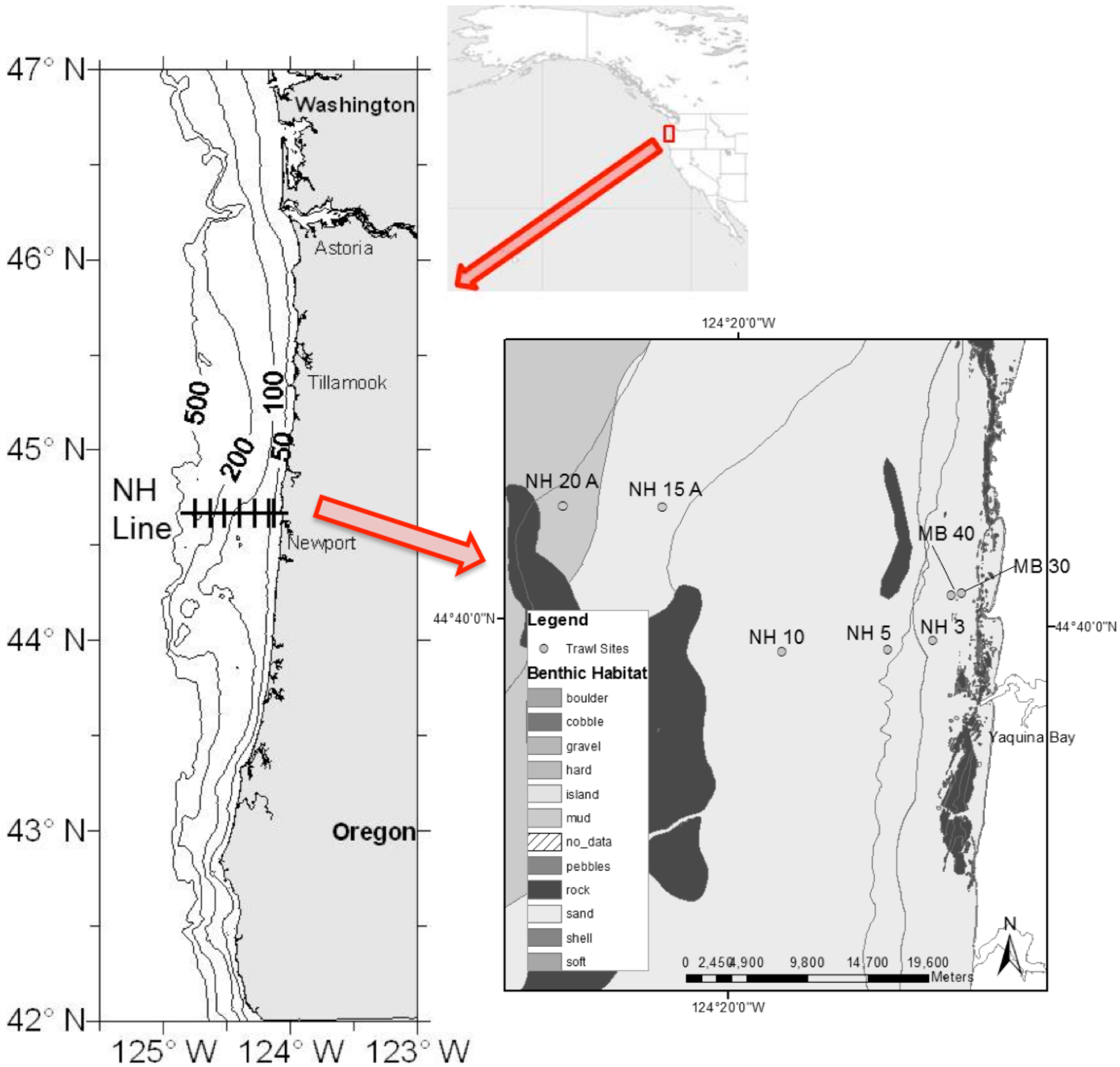


Figure 2. Hydrography/zooplankton/ichthyoplankton stations sampled along the Newport Hydrographic Line at biweekly intervals by the NWFSC Estuarine and Ocean Ecology Program (left). Detailed view of beam trawl stations off Moolack Beach and along the Newport Hydrographic Line.

Figure 3. NMFS and PSMFC researchers and the crew of the F/V Miss Yvonne look on during a deployment of the beam trawl system equipped with HD camera and scaling lasers. F/V Miss Yvonne, off Newport OR, July 30th 2012.

v) A review of essential fish habitat (EFH) for Pacific coast groundfishes

Investigators: W.W. Wakefield, K. Griffin

A review of Essential Fish Habitat (EFH) for 91 species of Pacific coast groundfish was ongoing in 2014. The review of the key products developed for this review are now available to the public. Initial EFH designations were based on best available data developed from 2002 to 2005; NOAA's National Marine Fisheries Service (NMFS) implemented these designations in May 2006. Beginning in 2010, the Pacific Fisheries Management Council (PFMC), Northwest and Southwest Fisheries Science Centers, and the NMFS Regions initiated the next 5-year review for EFH provisions of the groundfish Fishery Management Plan. In Phase I of this process, new and relevant information were compiled and summarized for the review. Sources of information included published scientific literature and unpublished scientific reports, solicitation of data from interested parties, and the review of previously unavailable or inaccessible data sets. Coast-wide maps were updated for (1) bathymetry and interpreted groundfish habitat types, (2) the distribution and extent of commercial fishing effort (as potential impact to EFH), (3) the distribution and relative abundance of biogenic habitat (i.e., sponges and corals), and (4) spatial management boundaries (as potential mitigation of impacts). This complete body of information, in the form of a written report and supporting Internet data catalog, was presented to the PFMC, its advisory bodies and the public at the Council's September 2012 meeting (Phase I Report: http://www.pcouncil.org/2013/05/25450/rfp-gf-efh-may2013/; online data catalog: http://efh-catalog.coas.oregonstate.edu/overview/). NMFS conducted an analysis of the information in the Phase I Report, and delivered a Synthesis Report to the Council in April 2013 (http://www.pcouncil.org/2013/05/25450/rfp-gf-efh-may2013/). During Phase II of the process, the Council solicited proposals to modify EFH and Habitat Areas of Particular Concern (HAPC). The Council accepted the EFHRC Phase 2 report, thus formally ending the Phase 2 process. Towards the next step in Phase 3 the Council requested that the Northwest and Southwest Fisheries Science Centers investigate the question of essential fish habitat effectiveness, accuracy, and completeness, and present their findings at the September 2014 Council meeting. At the September meeting, the Council is tentatively scheduled to initiate a fishery management plan amendment, including alternatives for refining elements of groundfish EFH as warranted by new information, the Science Center evaluation, and proposals received. If the Council decides to amend EFH, Phase III of the process will begin and may require an amendment to the groundfish Fisheries Management Plan. This 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 associated with EFH.

For more information, please contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or Kerry Griffin at Kerry.Griffin@noaa.gov

w) Historical reconstruction of Oregon's commercial fisheries landings

Investigators: Karnowski, M., V. V. Gertseva, A. Stephens.

On the West Coast of the United States, recent catch data are available from the Pacific Fisheries Information Network (PacFIN). Historical catch information, however, is sparse, scattered about various incongruous sources, and there is no database analogous to PacFIN to house it. Therefore, reconstruction of historical catch time series in stock assessments has been conducted for each state individually, and assessment authors have often approached the problem differently, using different data sources and a variety of methods. This contributes an additional source of uncertainty to assessment results, as well as duplication of effort among assessment authors. We reconstructed historical catches of fish species commercially landed in Oregon, from the beginning of West Coast rockfish fisheries to the present, using best available data sources and standardized methods, for use in stock assessments.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

x) Estimating uncertainty in historical catch of rockfish on the West Coat of the United States

Investigators: V. V. Gertseva, S.E. Matson.

Historical catch information is essential for fishery stock assessment. Without accurate catch history, it becomes difficult to reveal how a stock responds to exploitation. Historical catch estimates however, are associated with some (often significant) degree of uncertainty. Understanding this uncertainty enables the evaluation of model sensitivity to different assumptions about historical removals. We identified historical periods with different degrees of uncertainty in catch estimates, and formally estimated this uncertainty for each of these periods, using historical species composition samples and proportions of different species that comprise multi-species market categories. Our results are of immediate benefit for stock assessors on the U.S. West Coast as they help stock assessors use more realistic catch scenarios to formulate their alternative sets of model specifications. This study also provides an example of an approach to estimate uncertainty in historical catch that can be emulated elsewhere.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

y**) Spine-based ageing methods in the spiny dogfish shark*, Squalus suckleyi*: How they measure up?**

Investigators: I.G. Taylor, V.V. Gertseva, S.E. Matson

The second dorsal spine has historically been used for age determination in the spiny dogfish shark. The dorsal spines are located on the external surface of the body and are subjected to natural wear and breakage. Two methods have been developed to account for the worn portion of the spine and extrapolate the lost annuli. We compared the performance of these methods using a large data collection assembled from multiple sources, and evaluated their utility for stock assessment and management of the spiny dogfish shark *Squalus suckleyi* in the Northeast Pacific Ocean. Our results showed that the two methods produced very different age estimates for older fish with worn spines. Both methods raised significant questions about some aspects of the age estimates produced, and further exploration of techniques to account for worn spine annuli is needed. It is therefore important to develop alternative methods for shark age determination, including those using stained vertebrae.

Presented in 2014 at NWFSC Seminar Monster Jam and UW/NMFS quantitative fisheries workshop (Fish Think Tank)

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

z**) Bomb radiocarbon age validation for California Current (CC) rockfish**

Investigators: M.A. Haltuch, O.S. Hamel, P. McDonald, J. Field, C. Kastelle

Otolith-derived ages provide an informative piece of data in fisheries stock assessment in regard to estimating recruitments, growth, and exploitation rates (e.g. Haltuch et al. 2013). The research and data needs sections of NWFSC stock assessments routinely identify the need for age-determination and age-validation studies (e.g. Gertseva and Thorson 2013). Historical otolith collections that include fish caught by commercial vessels fishing out of northern California ports during the 1960’s until present are available at the SWFSC. These historical samples are ideal for the application of bomb radiocarbon age validation methods that require fish with birth years during the late 1950s through the 1970s (e.g. Haltuch et al. 2013).

Rockfish are the focus of the proposed bomb radiocarbon analyses due to longevity, and thus the likelihood of large ageing bias and variability at older ages. Archived samples are available for splitnose, canary, black, copper, and brown rockfish, all of which would benefit from age validation. The last full assessment for splitnose rockfish directly identified a need for age validation. Black rockfish is scheduled to for a full assessment during 2015. Copper and brown rockfish are currently data moderate stock assessments but will likely have full assessments in the future due to stakeholder demand and uncertain stock status that may be near or below limit reference points (pers. comm. J. Cope). Canary rockfish have a complimentary bomb radiocarbon age validation study in the north (Piner at al. 2005) but this age validation used the northeast Pacific halibut reference chronology, which came from a much different environment than the reference chronology developed for the west coast of the US (Haltuch et al, 2013). CC petrale sole radiocarbon data suggests that it may be necessary to revisit the canary rockfish age validation using a species specific CC reference chronology (Haltuch et al. 2013). If species specific reference chronologies are not able to be developed for the above rockfish species, the petrale sole reference chronology, which is more environmentally representative of the canary rockfish distribution, will be used for age validation.

This study proposes to use bomb radiocarbon age validation of CC rockfish to produce more reliable ageing error matrices that will improve stock assessment's ability to model age imprecision and bias, reducing assessment uncertainty.

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

aa) A state-space approach for measuring growth variation and application to North Pacific groundfish

Investigators: C.C. Stawitz, T.E. Essington, T.A. Branch, M.A. Haltuch, A.B. Hollowed, P.D. Spencer

Understanding demographic variation in recruitment and somatic growth is key to improving our understanding of population dynamics and forecasting ability. Although recruitment variability has been extensively studied, somatic growth variation has received less attention, in part because of difficulties in modeling growth from individual size-at-age estimates. Here we develop a Bayesian state-space approach to test for the prevalence of alternative forms of growth rate variability (e.g. annual, cohort-level, or during early life-history) in size-at-age data. We apply this technique to twenty-nine Pacific groundfish species across the California Current, Gulf of Alaska, and Bering Sea/Aleutian Islands marine ecosystems. A significant proportion of stocks (15/37) exhibited substantial growth variability. Most commonly (18/37 stocks), growth trends fluctuated annually across ages in single year, suggesting that either there are shared environmental features that dictate growth across multiple ages, or some temporally-fluctuating observation error remains in the estimate of growth process. This method represents a novel way to use size-at-age patterns from fishery-dependent or -independent data to test hypotheses about growth dynamics while allowing for annual variation and measurement error.

For more information contact Christine C. Stawitz: cstawitz@uw.edu

bb) The importance of spatial models for estimating the strength of density dependence

Investigators: J.T. Thorson, H. Skaug, K. Kristensen, A.O. Shelton, E.J. Ward, J.H. Harms, J.A. Benante

Identifying the existence and magnitude of density dependence is one of the oldest concerns in ecology. Ecologists have aimed to estimate density dependence in population and community data by fitting a simple autoregressive (Gompertz) model for density dependence to time series of abundance for an entire population. However, it is increasingly recognized that spatial heterogeneity in population densities has implications for population and community dynamics. We therefore adapt the Gompertz model to approximate local densities over continuous space instead of population-wide abundance, and allow productivity to vary spatially using Gaussian random fields. We then show that the conventional (nonspatial) Gompertz model can result in biased estimates of density dependence (e.g., identifying oscillatory dynamics when not present) if densities vary spatially. By contrast, the spatial Gompertz model provides accurate and precise estimates of density dependence for a variety of simulation scenarios and data availabilities. These results are corroborated when comparing spatial and nonspatial models for data from 10 years and ~100 sampling stations for three long-lived rockfishes (*Sebastes* spp.) off the California Coast. In this case, the nonspatial model estimates implausible oscillatory dynamics on an annual time scale, while the spatial model estimates strong autocorrelation and is supported by model selection tools. We conclude by discussing the importance of improved data archiving techniques, so that spatial models can be used to re-examine classic questions regarding the existence and magnitude of density dependence in wild populations.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

cc) Advances in ageing techniques and age interpretation for U.S. West Coast groundfish

Investigators: O.S. Hamel, J.M. Cope, M.A. Haltuch

Because growth patterns of many west coast groundfishes limit the informational value of length data, fish ages are very important inputs to our age-structured stock assessments. At the Northwest Fisheries Science Center, we conduct a variety of ageing studies, and we review three recent avenues of research: age validation, alternative ageing methods, and understanding ageing error. Age validation: We developed the first bomb radiocarbon reference chronology for the California Current, using known-age petrale sole (*Eopsetta jordani*). Petrale sole spend a substantial portion of their first year of life in areas subject to variable upwelling. This variable environment illustrates the importance of using reference curves for age validation that are region- and species-specific, whenever possible. Alternative ageing methods: Traditional age-reading methods are time-consuming for long-lived species. Based on initial success with two groundfishes, we explore the use of otolith weights for rapid age determination of long-lived groundfishes. We also explore the consistency of these relationships over time and space. Ageing error: The Pacific hake (*Merluccius productus*) stock is characterized by infrequent, strong year-classes, surrounded by average and below-average cohorts. Ageing is conducted annually, such that readers routinely know the year of collection. Ageing error is typically assumed to be largely consistent across years in stock assessments, however, we hypothesized that readers are more likely to assign uncertain hake reads to predominant ages. We conducted a double-blind study wherein previously read otoliths from many years were reread without readers knowing the collection year. Results confirmed that strong year classes experienced less effective ageing error in the regular course of ageing otoliths. Accounting for this tendency improved model fits to age data. Each of these research avenues has improved our understanding and is enabling us to develop more reliable population models and management guidance.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

dd) Developing partnerships for enhanced data collections of West Coast Groundfish

Investigators: J. Field, S. Sogard, S. Beyer, S. Rienecke, M. Gleason, M.A. Haltuch

Accurate information on basic life history traits such as age at maturity, growth rates, and fecundity are vital to assessing population health and productivity. These traits are rarely static over space and time, and understanding the importance of geographic (as well as temporal) variability in life history traits is a frequent research priority in stock assessments. Moreover, in California waters, age data for most species are increasingly less available for assessment purposes. Similarly, collection of reproductive ecology data (maturity, fecundity, condition) and genetic data (fin clips) has traditionally not been a component of port samplers data collection, due to the reluctance of most processors to cut fish (a voluntary, not mandatory, requirement in California) and the time consuming nature of sampling reproductive tissues (particularly subsamples of eggs or larvae) for such studies. In this study, we propose to develop a pilot study with a key fisheries stakeholder, The Nature Conservancy (TNC), and the fishermen partners they work with as part of the California Groundfish Collective (CGC), that will enable a localized data collection effort to complement existing port sampling efforts run by the Pacific States Marine Fisheries Commission (PSMFC). The idea will be to develop a proof-of- concept study that initially focuses on three key species (petrale sole, chilipepper rockfish and bocaccio), but could later be expanded to enhance data collection of other species of interest. These species were selected as they are of high commercial value, are constraining to larger scale fisheries on the West Coast (petrale sole and bocaccio are currently rebuilding, and anticipated to be rebuilt in 2015), and have either been subject to ongoing studies related to reproductive ecology (chilipepper and bocaccio) or have had explicit research recommendations to collect improved information on maturity, fecundity, age and spatial variability in life history patterns (petrale sole). A small number of samples have been processed in the 2014-2015 reproductive season in an effort to refine practical and logistical considerations.

For more information, contact John Field at John.Field@noaa.gov

2. Stock Assessment

a) Stock assessment model development

Investigator: R.D. Methot

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 3.24u as of August 2014.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

b) Accounting for marine reserves using spatial stock assessments

Investigators: C. McGilliard, A.E. Punt, R.D. Methot, and R. Hilborn

Some fish stock assessments are conducted in regions that contain no-take marine reserves (NTMRs). NTMRs are expected to lead to spatial heterogeneity in fish biomass by allowing a buildup of biomass inside their borders while fishing pressure occurs outside. Stock assessments do not typically account for spatial heterogeneity caused by NTMRs, which may lead to biased estimates of biomass. Simulation modeling is used to analyze the ability of several stock assessment configurations to estimate current biomass after the implementation of a single, large NTMR. Age-structured spatial operating models with three patterns of ontogenetic movement are used to represent the "true" population dynamics. Results show that assessing populations as a single stock with use of fishery catch-rate data and without accounting for the NTMR results in severe underestimation of biomass for two of the movement patterns. Omitting fishery catch-rate data or allowing time-varying dome-shaped selectivity after NTMR implementation leads to improved estimates of current biomass, but severe bias in estimated trends in biomass over time. Performing separate assessments for fished areas and NTMRs leads to improved estimation performance in the absence of movement among assessment areas, but can severely overestimate biomass otherwise. Performing a spatial assessment with estimation of movement parameters among areas was found to be the best way to assess a species, even when movement patterns were unknown. However, future work should explore the performance of spatial assessments when catchability varies among areas.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

c) Future direction for stock assessment models

Investigator: R.D. Methot

Stock assessment models estimate the dynamics of a single species in response to a time series of catch and an indicator of the trend in stock abundance over time. More complete assessments also include size/age composition data which provides direct information on the level of total mortality being experienced by the stock. Where there are sufficient data, the models estimate the time series of absolute stock abundance and fishing mortality and productivity parameters that determine sustainable harvest rates. These estimates are conditioned on simplifying assumptions about the constancy of parameters that govern the productivity and natural mortality of the stock. From an ecological perspective, a stock's carrying capacity, productivity and natural mortality are not just functions of the stock's characteristics. These factors are functions of a stock's interactions with its predators, prey, competitors, habitat and environment. In a fished ecosystem, many stocks are fished and reduced in abundance, so these interactions will change over time. From this perspective, the need for coordination of single species models and ecosystem models emerges. Ecosystem models can provide more comprehensive evaluation of the effects of fishing and sustainable rates, single species models can provide better estimation and short-term forecasting of stock abundance.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

d) Evaluating methods for setting catch limits in data-limited fisheries

Investigators: T.R. Carruthers, A.E. Punt, C.J. Walters, A.D. MacCall, M.K. McAllister, E.J. Dick, J.M. Cope

The majority of global fish stocks lack adequate data to evaluate stock status using conventional stock assessment methods. This poses a challenge for the sustainable management of these stocks. Recent requirements to set scientifically based catch limits in several countries, and growing consumer demand for sustainably managed fish have spurred an emerging field of methods for estimating overfishing thresholds and setting catch limits for stocks with limited data. Using a management strategy evaluation framework we quantified the performance of a number of data-limited methods. For most life-histories, we found that methods that made use of only historical catches often performed worse than maintaining current fishing levels. Only those methods that dynamically accounted for changes in abundance and/or depletion performed well at low stock sizes. Stock assessments that make use of historical catch and effort data did not necessarily out-perform simpler data-limited methods that made use of fewer data. There is a high value of additional information regarding stock depletion, historical fishing effort and current abundance when only catch data are available. We discuss the implications of our results for other data-limited methods and identify future research priorities.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

e) Evaluating a prior on relative stock status using simplified age-structured models

Investigators: J.M. Cope, J.T. Thorson, C.R. Wetzel, J. DeVore

Fisheries management aimed to support sustainable fisheries typically operates under conditions of limited data and analytical resources. Recent developments in data-limited analytical methods have broadened the reach of science informing management. Existing approaches such as stock reduction analysis and its extensions offer simple ways to handle low data availability, but are particularly sensitive to assumptions regarding relative stock status. This study develops and introduces a prior on relative stock status using Productivity-Susceptibility Analysis vulnerability scores. Data from U.S. west coast groundfish stocks (n = 17) were used to develop and then test the performance of the new relative stock status prior. Traditional simulation testing via an operating model was not possible because vulnerability scoring could not be simulated; we instead used the "best available scientific information" (BASI) approach. This approach uses fully-realized stock assessments (deemed the best available scientific information by management entities) and reduces data content available to simpler models. The Stock Synthesis statistical catch-at-age framework was used to nest within the full assessment two simpler models that rely on stock status priors. Relative error in derived estimates of biomass and stock status were then compared to the BASI assessment. In general, the new stock status prior improved performance over the current application of stock status assumed at 40% initial biomass. Over all stocks combined, stock status showed the least amount of bias, while initial biomass was better estimated than current biomass. The BASI approach proved a useful and possibly complimentary approach to simulation testing with operating models in order to gain insight into modelling performance germane to management needs, particularly when system components (e.g., susceptibility scoring) cannot be easily simulated.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

f) BMSY/B0 and FMSY/M

Investigators: A.E. Punt, J.M. Cope

Simple Stock Synthesis (SSS) and Depletion-Based Stock Reduction Analysis (DB-SRA) are two methods for calculating overfishing limits for data-poor fish stocks. Both methods are Bayesian in that priors are imposed on the parameters of the underlying population dynamics model (although there is no information to update the priors). DSB-SRA is based on a generalized production function which allows independent priors to be imposed on BMSY/B0 and FMSY/B0. However, SSS is based on the Beverton-Holt stock-recruitment relationship so there is a functional relationship between BMSY/B0 and FMSY/B0 as expressed in the steepness parameter (h). We outline two stock-recruitment relationships (the Shepherd and Generalized Ricker) which if incorporated in Stock Synthesis may allow the goal of independent priors to be imposed on BMSY/B0 and FMSY/B0 to be achieved. We show for some example species how well these stock-recruitment relationships achieve this goal and compare DB-SRA and SSS when they are applied to some example rockfish stocks.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

g) The dids, dos, don'ts, and developments of data-limited catch limits

Investigators: J. Berkson, J.M. Cope

Limitations in the application of fully realized statistical catch-at-age models are the rule, not the exception, when trying to inform stock management. While this is a global challenge, several advances in data-limited resource management have been developed within the United States over the past 5+ years. Most of this development was instigated by the 2008 reauthorization of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA), the main piece of fisheries legislation in the US. The MSA focuses mainly on sustainable yields, thus most data-limited methods ultimately seek to provide guidance in setting levels of total stock removals in order to avoid/eliminate overfishing. Here we give an overview of what has been developed, how it has been applied, and what we have learned from these methods and applications. From this synthesis, we are in a better position to evaluate where we go next, both in method development and application. There is unlikely a time in the near future that these data-limited approaches will not be an essential fisheries management tool. To that end, consistent terminology, linkage of methods to control rules, and understanding how to facilitate a continuum of methods across various data-availability scenarios are important considerations for future advances.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

h) Lengthening our stride: evaluating the inclusion of length compositions in the development of data-limited stock assessments.

Investigators: J.M. Cope, J.T. Thorson, C.R. Wetzel, J. Hastie

The application of stock assessments to fisheries management on the west coast of the United States has been greatly enhanced by the ongoing development of Stock Synthesis, a flexible statistical catch-at-age framework. While this framework has been enhanced to incorporate more data and parameters, recent develops have also demonstrated its use in data-limited situations. Both catch-only and catch-index only modelling exercises have proven useful in obtaining management and/or biological quantities. This work attempts to expand the catch-index applications by incorporating current year length or age compositions so as to define selectivity curves and improve biomass and status estimation. This work is applied to several west coast groundfish stocks and compared to both the full assessments and the simpler applications in order to identify the use of such data. The results aim to improve our understanding of modelling under data-constraining situations, as well as offer insight in data collection and stock assessment prioritization.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

i) Evaluating sustainability of fisheries bycatch mortality for marine megafauna: a review of conservation reference points for data-limited populations

Investigators: J.E. Moore, K.A. Curtis, R.L. Lewison, P.W. Dillingham, J.M. Cope, S.V. Fordham, S.S. Heppell, S.A. Pardo, C.A. Simpfendorfer, G.N. Tuck, S. Zhou

Fisheries bycatch threatens populations of marine megafauna such as marine mammals, turtles, seabirds, sharks and rays, but fisheries impacts on nontarget populations are often difficult to assess due to factors such as data limitation, poorly defined management objectives and lack of quantitative bycatch reduction targets. Limit reference points can be used to address these issues and thereby facilitate adoption and implementation of mitigation efforts. Reference points based on catch data and life history analysis can identify sustainability limits for bycatch with respect to defined population goals even when data are quite limited. This can expedite assessments for large numbers of species and enable prioritization of management actions based on mitigation urgency and efficacy. This paper reviews limit reference point estimators for marine megafauna bycatch, with the aim of highlighting their utility in fisheries management and promoting best practices for use. Different estimators share a common basic structure that can be flexibly applied to different contexts depending on species life history and available data types. Information on demographic vital rates and abundance is required; of these, abundance is the most data-dependent and thus most limiting factor for application. There are different approaches for handling management risk stemming from uncertainty in reference point and bycatch estimates. Risk tolerance can be incorporated explicitly into the reference point estimator itself, or probability distributions may be used to describe uncertainties in bycatch and reference point estimates, and risk tolerance may guide how those are factored into the management process. Either approach requires simulation-based performance testing such as management strategy evaluation to ensure that management objectives can be achieved. Factoring potential sources of bias into such evaluations is critical. This paper reviews the technical, operational, and political challenges to widespread application of reference points for management of marine megafauna bycatch, while emphasizing the importance of developing assessment frameworks that can facilitate sustainable fishing practices.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

j) Catch curve stock-reduction analysis: An alternative solution to the catch equations

Investigators: J.T. Thorson, J.M. Cope

Abstract: Legislative changes in the United States and elsewhere now require scientific advice on catch limits for data-poor fisheries. The family of stock reduction analysis (SRA) models is widely used to calculate sustainable harvest levels given a time series of harvest data. SRA works by solving the catch equation given an assumed value for spawning biomass relative to unfished levels in the final (or recent) year, and resulting estimates of recent fishing mortality are biased when this assumed value is mis-specified. We therefore propose to replace this assumption when estimating stock status by using compositional data in recent years to estimate a catch curve and hence estimating fishing mortality in those years. We compare this new “catch-curve stock reduction analysis” (CC-SRA) with an SRA or catch curve using simulated data for slow or fast life histories and various magnitudes of recruitment variability. Results confirm that the SRA yields biased estimates of current fishing mortality given mis-specified information about recent spawning biomass, and that the catch curve is biased due to changes in fishing mortality over time. CC-SRA, by contrast, is approximately unbiased for low or moderate recruitment variability, and less biased than other methods given high recruitment variability. We therefore recommend CC-SRA as a data-poor assessment method that incorporates compositional data collection in recent years, and suggest future management strategy evaluation given a data-poor control rule.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

k) Giants’ shoulders 15 years later: lessons, challenges and guidelines in fisheries meta-analysis

Investigators: J.T. Thorson, J.M. Cope, K.M. Kleisner, J.F. Samhouri, A.O. Shelton, E.J. Ward

Meta-analysis has been an integral tool for fisheries researchers since the late 1990s. However, there remain few guidelines for the design, implementation or interpretation of meta-analyses in the field of fisheries. Here, we provide the necessary background for readers, authors and reviewers, including a brief history of the use of meta-analysis in fisheries, an overview of common model types and distinctions, and examples of different goals that can be achieved using meta-analysis. We outline the primary challenges in implementing meta-analyses, including difficulties in discriminating between alternative hypotheses that can explain the data with equal plausibility, the importance of validating results using multiple lines of evidence, the trade-off between complexity and sample size and problems associated
with the use of model output. For each of these challenges, we also provide suggestions, such as the use of propensity scores for dealing with selection bias and the use of covariates to control for confounding effects. These challenges are then illustrated with examples from diverse subfields of fisheries, including (i) the analysis of the stock–recruit relationship, (ii) fisheries management, rebuilding and population viability, (iii) habitat-specific vital rates, (iv) life-history theory and (v) the evaluation of marine reserves. We conclude with our reasons for believing that meta-analysis will continue to grow in importance for these and many other research goals in fisheries science and argue that standards of practice are therefore essential.

For more information, please contact James Thorson at James.Thorson@noaa.gov

l) Examining the 10-year rebuilding dilemma for U.S. fish stocks

Investigators: W.S. Patrick, J.M. Cope

Abstract: Worldwide, fishery managers strive to maintain fish stocks at or above levels that produce maximum sustainable yields, and to rebuild overexploited stocks that can no longer support such yields. In the United States, rebuilding overexploited stocks is a contentious issue, where most stocks are mandated to rebuild in as short a time as possible, and in a time period not to exceed 10 years. Opponents of such mandates and related guidance argue that rebuilding requirements are arbitrary, and create discontinuities in the time and fishing effort allowed for stocks to rebuild due to differences in productivity. Proponents, however, highlight how these mandates and guidance were needed to curtail the continued overexploitation of these stocks by setting firm deadlines on rebuilding. Here we evaluate the statements made by opponents and proponents of the 10-year rebuilding mandate and related guidance to determine whether such points are technically accurate using a simple population dynamics model and a database of U.S. fish stocks to parameterize the model. We also offer solutions to many of the issues surrounding this mandate and its implementation by recommending some fishing mortality based frameworks, which meet the intent of the 10-year rebuilding requirement while also providing more flexibility.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

m) Random effect estimation of time-varying parameters in Stock Synthesis

Investigators: J.T. Thorson, A.C. Hicks, R.D. Methot

Biological processes such as fishery selectivity, natural mortality, and somatic growth can vary over time, but it is challenging to estimate the magnitude of time-variation of demographic parameters in population dynamics models, particularly when using penalized-likelihood estimation approaches. Random-effect approaches can estimate the variance, but are computationally infeasible or not implemented for many models and software packages. We show that existing models and software based on penalized-likelihood can be used to calculate the Laplace approximation to the marginal likelihood of parameters representing variability over time, and specifically demonstrate this approach via application to Stock Synthesis. Using North Sea cod and Pacific hake models as case studies, we show that this method has little bias in estimating variances for simulated data. It also provides a similar estimate of variability in hake recruitment (log-SD = 1.43) to that obtained from Markov chain Monte Carlo (MCMC) methods (log-SD = 1.68), and the method estimates a non-trivial magnitude (log-SD = 0.07) of variation in growth for North Sea cod. We conclude by discussing the generality of the proposed method and by recommending future research regarding its performance relative to MCMC, particularly when estimating multiple variances simultaneously.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

n) Standardizing compositional data for stock assessment

Investigator: J.T. Thorson

Stock assessment models frequently integrate abundance index and compositional (e.g. age, length, sex) data. Abundance indices are generally estimated using index standardization models, which provide estimates of index standard errors while accounting for: (i) differences in sampling intensity spatially or over time; (ii) non-independence of available data; and (iii) the effect of covariates. However, compositional data are not generally processed using a standardization model, so effective sample size is not routinely estimated and these three issues are unresolved. I therefore propose a computationally simple "normal approximation" method for standardizing compositional data and compare this with design-based and Dirichlet-multinomial (D-M) methods for analysing compositional data. Using simulated data from a population with multiple spatial strata, heterogeneity within strata, differences in sampling intensity, and additional overdispersion, I show that the normal-approximation method provided unbiased estimates of abundance-at-age and estimates of effective sample size that are consistent with the imprecision of these estimates. A conventional design-based method also produced unbiased age compositions estimates but no estimate of effective sample size. The D-M failed to account for known differences in sampling intensity (the proportion of catch for each fishing trip that is sampled for age) and hence provides biased estimates when sampling intensity is correlated with variation in abundance-at-age data. I end by discussing uses for "composition-standardization models" and propose that future research develop methods to impute compositional data in strata with missing data.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

o) Spatial semiparametric models improve estimates of species abundance and distribution

Investigators: A.O. Shelton, J.T. Thorson, E.J. Ward, B.E. Feist

Accurate estimates of abundance are imperative for successful conservation and management. Classical, stratified abundance estimators provide unbiased estimates of abundance, but such estimators may be imprecise and impede assessment of population status and trend when the distribution of individuals is highly variable in space. Model-based procedures that account for important environmental covariates can improve overall precision, but frequently there is uncertainty about the contribution of particular environmental variables and a lack of information about variables that are important determinants of abundance. We develop a general semiparametric mixture model that incorporates measured habitat variables and a nonparametric smoothing term to account for unmeasured variables. We contrast this spatial habitat approach with two stratified abundance estimators and compare the three models using an intensively managed marine fish, darkblotched rockfish (*Sebastes crameri*). We show that the spatial habitat model yields more precise, biologically reasonable, and interpretable estimates of abundance than the classical methods. Our results suggest that while design-based estimators are unbiased, they may exaggerate temporal variability of populations and strongly influence inference about population trend. Furthermore, when such estimates are used in broader meta-analyses, such imprecision may affect the broader biological inference (e.g., the causes and consequences of the variability of populations).

For more information, please contact Jim Thorson at James.Thorson@noaa.gov or Ole Shelton at Ole.Shelton@noaa.gov

p) Accounting for vessel effects when standardizing catch rates from cooperative surveys

Investigators: J.T. Thorson, E.J. Ward

Interpretation of fishery-dependent and independent-survey data requires accounting for changes in the proportion of local individuals that are caught by fishing gear ("catchability"). Catchability may be influenced by measured characteristics of fishing gear, and even standardized fishing techniques may experience changing catchability over time due to changes in fishing vessel characteristics and personnel. The importance of vessel power has long been recognized in the analysis of fishery dependent catch per unit effort data, but less-studied in the analysis of fishery independent data collected by research vessel surveys. Here we demonstrate how differences in catchability among vessels ("vessel effects"), as well as random variation in vessel-specific catchability over time ("vessel-year effects") can be incorporated into generalized linear mixed models through their treatment as random effects. We apply these methods to data for 28 groundfish species caught in a standardized survey using contracted fishery vessels and personnel in the Northeast Pacific. Model selection shows that vessel, vessel-year, and both effects simultaneously are supported by available data for at least a few species. However, vessel-year effects generally have a larger effect on catch rates than vessel-effects and hence abundance indices estimated using both vessel- and vessel-year effects are generally similar to estimates when using just vessel-year effects. Additionally, models indicate little support for the hypothesis that characteristics such as length and displacement of the contracted vessels used in this survey have a substantial impact on catch rates. Finally, inclusion of vessel- or vessel-year effects generally results in wider estimates of credible intervals for resulting indices of abundance. This increased credible interval width is consistent with statistical theory, because vessel effects will result in non-independence of different sampling occasions, thus decreasing effective sample sizes. For this reason, we advocate that future analyses include vessel- and/or vessel-year effects when standardizing survey data from cooperative research programs.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

q) Rigorous meta-analysis of life history correlations by simultaneously analyzing multiple population dynamics models

J.T. Thorson, I. Taylor, I.J. Stewart, A.E. Punt

Correlations among life history parameters have been discussed in the ecological literature for over 50 years, but are often estimated while treating model estimates of demographic rates such as natural mortality (*M*) or individual growth (*k*) as "data." This approach fails to propagate uncertainty appropriately because it ignores correlations in estimation errors between parameters within a species and differences in estimation error among species. An improved alternative is multi-species mixed-effects modeling, which we approximate using multivariate likelihood profiles in an approach that synthesizes information from several population dynamics models. Simulation modeling demonstrates that this approach has minimal bias, and that precision improves with increased number of species. As a case study, we demonstrate this approach by estimating *M*/*k* for 11 groundfish species off the U.S. West Coast using the data and functional forms on which pre-existing, peer-reviewed, population dynamics models are based. *M*/*k* is estimated to be 1.26 for Pacific rockfishes (*Sebastes* spp.), with a coefficient of variation of 76% for *M* given *k*. This represents the first-ever estimate of correlations among life history parameters for marine fishes using several age-structured population dynamics models, and it serves as a standard for future life history correlation studies. This approach can be modified to provide robust estimates of other life history parameters and correlations, and requires few changes to existing population dynamics models and software input files for both marine and terrestrial species. Specific results for Pacific rockfishes can be used as a Bayesian prior for estimating natural mortality in future fisheries management efforts. We therefore recommend that fish population dynamics models be compiled in a global database that can be used to simultaneously analyze observation-level data for many species in life history meta-analyses

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

r) Assessing the future effects of climate change trends on U.S. west coast sablefish productivity and on the performance of alternative management strategies

Investigators: M.A. Haltuch, T. A'mar, N.A. Bond, J.L. Valero

The U.S. west coast sablefish fishery is a valuable commercially targeted species, making assessing and understanding the interaction between climate change and fishing a priority for (1) forecasting future stock productivity and (2) for testing the robustness management strategies to climate variability and change. The horizontal-advection bottom-up forcing paradigm describes large-scale climate forcing that drives regional changes in alongshore and cross-shelf ocean transport, directly impacting the transport of nutrients, mass, and organisms. This concept provides a mechanistic framework through which climate variability and change alter sea surface height (SSH), zooplankton community structure, and sablefish recruitment, all of which are regionally correlated. This study assesses future trends in sablefish productivity as well as the robustness of harvest control rules to climate driven changes in recruitment by conducting a management strategy evaluation of the currently implemented harvest control rule as well as an alternative. We use 50 year ensemble forecasts of sablefish productivity under a suite of future climate variability and change scenarios. Future recruitments are generated under two scenarios (1) the fit of a Beverton-Holt stock-recruitment curve based on historical data and (2) recruitments driven by a SSH-recruitment relationship that is treated as an age-0 survey of abundance with associated uncertainty. Multi-decadal forecasts of sablefish productivity could provide long term strategic advice to allow fishers and managers to plan for and respond to shifts in productivity.

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

s) Improving ecosystem-based stock assessment and forecasting by using a hierarchical approach to link fish productivity to environmental drivers

Investigators: T. Essington, T. Branch, M.A. Haltuch, A. Hollowed, P. Spencer, N. Mantua

We investigated the hypothesis that synchronous recruitment is due to a shared susceptibility to environmental processes using stock-recruitment residuals for 52 marine fish stocks within three Northeast Pacific large marine ecosystems: the Eastern Bering Sea and Aleutian Islands (BSAI), Gulf of Alaska, and California Current. There was moderate coherence in terms of exceptionally strong and weak year classes and significant distributions of across stock correlation. Based on evidence of synchrony from these analyses, we used Bayesian hierarchical models to relate recruitment to environmental covariates for groups of stocks with similar susceptibility to environmental processes. There were consistent relationships among stocks to the covariates, especially within the Gulf of Alaska and California Current. The best Gulf of Alaska model included Northeast Pacific sea surface height data as predictors of recruitment, and was particularly strong for stocks dependent on cross-shelf transport during the pelagic larval phase for recruitment. In the California Current the best-fit model included San Francisco coastal sea level data as predictors, with higher recruitment for many stocks corresponding to anomalously high sea level the year before spawning and low sea level the year of spawning. The best BSAI model included several environmental variables as covariates and there was some consistent response across stocks to these variables. Future research may be able to utilize these across stock environmental influences, in conjunction with an understanding of ecological processes important across early life history stages at appropriate temporal and spatial scales, to improve identification of environmental drivers of recruitment.

For more information, contact Megan Stachura at mstachur@u.washington.edu

t) A comparison of parametric, semi-parametric, and non-parametric approaches to selectivity in age-structured assessment models

Investigators: J.T. Thorson and I.G. Taylor

Integrated assessment models frequently track population abundance at age, and hence account for fishery removals using a function representing fishery selectivity at age. However, fishery selectivity may have an unusual shape that does not match any parametric function. For this reason, previous research has developed flexible ‘non-parametric’ models for selectivity that specify a penalty on changes in selectivity as a function of age. In this study, we describe an alternative ‘semi-parametric’ approach to selectivity, which specifies a penalty on differences between estimated selectivity at age and a pre-specified parametric model whose parameters are freely estimated, while also using cross-validation to select the magnitude of penalty in both semi- and non-parametric models. We then compare parametric, semi-parametric, and non-parametric models using simulated data and evaluate the bias and precision of estimated depletion and fishing intensity. Results show that semi- and non-parametric models result in little decrease in precision relative to the parametric model when the parametric model matches the true data-generating process, but that the semi- and non-parametric models have less bias and greater precision when the parametric function is misspecified. As expected, the semi-parametric model reverts to its pre-specified parametric form when age-composition sample size is low but performs similarly to the non-parametric model when sample size is high. Overall, results indicate few disadvantages to using the non-parametric model given the range of simulation scenarios explored here, and that the semi-parametric model provides a selectivity specification that is intermediate between parametric and non-parametric forms.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

u) A method for calculating a meta-analytical prior for the natural mortality rate using multiple life-history correlates

Investigator: O.S. Hamel

The natural mortality rate M is an extraordinarily difficult parameter to estimate for many fish species. The uncertainty associated with M translates into increased uncertainty in fishery stock assessments. Estimation of M within a stock assessment model is complicated by the confounding of this parameter with other life history and fishery parameters which are also uncertain and some of which are typically estimated within the model. Ageing error and variation in growth, which may not be fully modeled, can also affect estimation of M, as can assumptions, including the assumed form of the stock recruitment function (e.g., Beverton-Holt, Ricker) and the level of compensation (or steepness), which may be fixed (or limited by a prior) in the model. To avoid this difficulty, stock assessors often assume point estimates for M derived from meta-analytical relationships between *M* and more easily measured life history characteristics. However, these relationships depend upon estimates of *M* for a great number of species, and those estimates are also subject to errors and biases (as are, to a lesser extent, the other life history parameters). Therefore, at the very least, some measure of uncertainty should be calculated and used for evaluating uncertainty in stock assessments as well as in fishery management evaluations. Given error-free data on *M* and the covariate(s) for the meta-analysis, prediction intervals provide the appropriate measure of uncertainty in *M*. In contrast, if the relationship between the covariate(s) and *M* is exact and the only error is observation error in *M*, confidence intervals are appropriate. In this talk I will describe both types of intervals, develop priors based upon multiple published meta-analyses of various life history correlates using the prediction interval calculation, and discuss some caveats and considerations when deciding which meta-analyses to use in developing priors.

For more information, please contact Owen Hamel at Owen.Hamel@noaa.gov

v) Bootstrapping of sample sizes for length- or age-composition data used in stock assessments

Investigators: I.J. Stewart, O.S. Hamel

Integrated stock assessment models derive estimates of management quantities by fitting to indices of abundance and length and age compositions. For composition data, where a multinomial likelihood is often applied, weights are determined by input sample sizes, which can be an important contributor to model results. We used a generic bootstrap method, verified through simulation, to calculate year-specific maximum realized sample sizes from the observation error inherent in fishery biological data. Applying this method to length-composition observations for 47 groundfish species collected during a standardized trawl survey, we found maximum realized sample size to be related to both the number of hauls and individual fish sampled from those hauls. Sampling in excess of 20 fish from each haul produced little increase in most cases, with maximum realized sample size ranging from approximately 2-4 per haul sampled. Utilizing these maximum realized sample sizes as input values for stock assessment (analogous to minimum variance estimates), appropriately incorporates interannual variability, and may reduce over-emphasis on composition data. Results from this method can also help determine sampling targets.

For more information, please contact Owen Hamel at Owen.Hamel@noaa.gov

w) Biology, fisheries, assessment and management of Pacific hake (*Merluccius productus*)

Investigators: O. S. Hamel, P.H. Ressler, R. E. Thomas, D.A. Waldeck, A.C. Hicks, J.A. Holmes, G.W. Fleischer

Pacific hake (*Merluccius productus*), also known as Pacific whiting, is the most abundant commercial fish species in the California Current Large Marine Ecosystem (CCLME) and is an important part of the ecosystem as both predator and prey. A large migratory population occurs off California, Oregon, and Washington in United States waters and off British Columbia in Canadian waters. Smaller distinct non-migratory populations of Pacific hake occur in major inlets of the northeast Pacific Ocean, including the Strait of Georgia and Puget Sound. The coastal Pacific hake population has supported a fishery averaging 222 thousand tonnes per year since 1966. Coastal Pacific hake migrate to northern feeding areas in the summer and southern spawning areas in the winter. The extent of the northern migration and the distribution along the coast are related to the population age and size composition and to varying ocean-climatic conditions, which also influence growth and location of spawning aggregations. Pacific hake have a lifespan of around 20 years, reach maturity around age 4, and achieve an average asymptotic size of 53 cm.

Coastal Pacific hake are managed under the auspices of a treaty between the United States and Canada, and the two countries jointly conduct acoustic surveys of the resource, stock assessments, stock assessment reviews and management meetings. Prior to the treaty there were independent and competing stock assessments from the United States and Canada. The Hake Treaty established a default harvest policy, a fixed harvest allocation for each country, and a Joint Management Committee that determines the annual coastwide Total Allowable Catch based on the best available science, the treaty's default harvest policy, and input from industry advisors. Regulation and management of the individual fisheries continues to rest within each country.

The fishery is executed by four sectors in the United States: vessels that deliver to shore-based processors, vessels that deliver to at-sea processors (motherships), vessels that both catch and process at-sea (catcher-processors), and a tribal fishery. The Canadian fishery is prosecuted by vessels that deliver to shore-based processors, with a joint-venture mothership sector in some years. The Pacific hake fishery in the United States and Canada is jointly certified by the Marine Stewardship Council as a sustainable fishery. Pacific hake must be frozen or processed soon after harvest to achieve a marketable product. Currently, most Pacific hake is marketed as fillets or headed and gutted products, although previously a large portion of the harvest was turned into surimi. While none of these products demand a high price, the total revenue to the industry is in the tens of millions of U.S. dollars.

For more information, please contact Owen Hamel at Owen.Hamel@noaa.gov

x) Addressing cohort-strength correlated ageing error in fishery stock assessment

Investigators: O.S. Hamel, I.J. Stewart

Age data are important in stock assessment for estimation of parameters such as growth rate, age of maturity, fecundity at age, and the natural mortality rate. However, even modern otolith annulus counting techniques are subject to uncertainty and error, as seen in double and cross-reads and through the use of various validation techniques. Ageing uncertainty (and bias) is accounted for in stock assessments via lab-, era-, and/or reader specific ageing error matrices, which generally result in improved parameter estimation and statistical fit to age data. In the Pacific hake (*Merluccius productus*) assessment, however, ageing error matrices did not resolve poor fits to age data for strong year classes. The Pacific hake stock is characterized by infrequent strong year classes, typically surrounded by average and below average cohorts. Ageing is conducted on a yearly basis such that readers know the year of collection. We hypothesized that readers are more likely assign uncertain reads to predominant ages. In order to test the hypothesis that strong year classes effectively experience less ageing error, we conducted a double-blind study wherein previously read otoliths across years were reread without readers knowing the collection year. Results confirmed that strong year classes experienced less effective ageing error in the regular course of ageing otoliths. Fits to age data and estimation of year-class strength improved greatly when cohort-specific ageing error was accounted for in the assessment. The "strong cohort effect" is a potential problem for any species with appreciable ageing imprecision and a high degree of recruitment variability.

For more information, please contact Owen Hamel at Owen.Hamel@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 to be conducted in 2015, along with the 2014 Hake Scientific Review Group meeting, is shown in Table 1.

Table 1. 2014 and 2015 Review Schedule for Full Groundfish Assessments

STAR PANEL	STOCK	AUTHOR(S)	REVIEW PANEL DATES	STAR PANEL LOCATION
Hake SRG* Panel	Pacific hake/ whiting	Allan Hicks Nathan Taylor Chris Grandin Ian Taylor Sean Cox	February 18-21, 2014	Seattle, WA
1	Canary rockfish Darkblotched rockfish	Jim Thorson Vlada Gertseva	April 27-May 1, 2015	Seattle, WA
June SSC	Arrowtooth data moderate review	TBD	June 10-12, 2015	Spokane, WA
2	Bocaccio China rockfish	Xi He EJ Dick	July 6-10, 2015	Santa Cruz, CA
3	Black rockfish	Jason Cope	July 20-24, 2015	Newport, OR
3	Widow rockfish Kelp greenling (OR)	Allan Hicks Aaron Berger	July 27-31, 2015	Newport, OR

*****Scientific Review Group – for international review of Pacific hake under treaty with Canada
**Accepted for status determination but not for management (scale of population not accepted)
*** Not accepted for management or status determination at the STAR panel

1. Shelf Rockfish - West Coast

a) Stock Assessments

No shelf rockfish species were assessed in 2014.

Data moderate rockfish: Full assessments of data moderate rockfish species brown, china, copper, sharpchin, stripetail (status only), and yellowtail from 2013 are available from: http://www.pcouncil.org/groundfish/stock-assessments/by-year/gf2013

For more information on data-moderate rockfish assessments, contact Jason Cope at Jason.Cope@noaa.gov or E. J. Dick at Edward.Dick@noaa.gov

Cowcod: The complete version of the 2013 stock assessment of cowcod, *Sebastes levis*, can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/by-species/cowcod/

For more information on the cowcod assessment, contact E. J. Dick at Edward.Dick@noaa.gov

Bocaccio: The complete version of: Status of bocaccio, *Sebastes paucispinis*, in the Conception, Monterey and Eureka INPFC areas as evaluated for 2013 can be viewed online at:

http://www.pcouncil.org/wp-content/uploads/Bocaccio_2013_Assessment_Update..pdf
For more information on the bocaccio assessment, contact John Field at John.Field@noaa.gov

Canary rockfish: A data report showing that overfishing has not been occurring was conducted for canary rockfish in 2013. For more information on the canary rockfish data report, contact John Wallace at John.Wallace@noaa.gov

Yelloweye rockfish: A data report showing that overfishing has not been occurring was conducted for yelloweye rockfish in 2013. For more information on the yelloweye rockfish data report, contact John Wallace at John.Wallace@noaa.gov

2. Slope Rockfish

a) Stock assessments

No slope rockfish species were assessed in 2014.

Full assessments of aurora, darkblotched, and rougheye and blackspotted rockfish (the latter two as a complex), and a data report on Pacific ocean perch were conducted in 2013.

Aurora rockfish: The complete version of “Stock assessment of aurora rockfish in 2013” can be found online at:
http://www.pcouncil.org/wp-content/uploads/AURORA_Assessment_2013_Final.pdf

For more information on the aurora rockfish assessment, contact Owen Hamel at Owen.Hamel@noaa.gov

The complete version of “Status of the Darkblotched Rockfish Resource off the Continental U.S. Pacific Coast in 2013” can be found online at: http://www.pcouncil.org/wp-content/uploads/Darkblotched_2013_Assessment.pdf

For more information on the darkblotched rockfish assessment, contact Dr. Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

Pacific ocean perch: A data report showing that overfishing has not been occurring was conducted for Pacific ocean perch in 2013. For more information on the Pacific ocean perch data report, contact John Wallace at John.Wallace@noaa.gov

Rougheye and blackspotted rockfishes: The 2013 assessment of Rougheye Rockfish (*Sebastes aleutianus*) and Blackspotted Rockfish (*S. melanostictus*) can be found online at: http://www.pcouncil.org/wp-content/uploads/Rougheye_and_Blackspotted_2013_Assessment.pdf

For more information the rougheye and blackspotted rockfish assessment, contact Allan Hicks at Allan.Hicks@noaa.gov

3. Thornyheads

a) Stock Assessments

No thornyhead species were assessed in 2014.

Full assessments of both shortspine and longspine thonyhead from 2013 can be viewed online at:

www.pcouncil.org/wp-content/uploads/Longspine_Assessment_2013.pdf

http://www.pcouncil.org/wp-content/uploads/Shortspine_2013_Assessment.pdf

For more information on the longspine thornyhead assessment, please contact Andi Stephens: Andi.Stephens@noaa.gov.

For more information on the shortspine thornyhead assessment, please contact Ian Taylor at Ian.Taylor@noaa.gov.

4. Sablefish

a) Stock Assessments

No sablefish assessment was conducted in 2014. The complete version of: Status of the U.S. sablefish resource in 2011 can be viewed online at: http://www.pcouncil.org/wp-content/uploads/Sablefish_2011_Assessment.pdf

For more information on sablefish, contact James Thorson at James.Thorson@noaa.gov.

5. Flatfish

a) Stock Assessments

No flatfish species assessments were conducted in 2014.

Full assessments of Pacific sanddab (accepted for status determination only) and petrale sole and data moderate assessments for English and rex sole were conducted in 2013.

Pacific sanddab: The 2013 assessment of Pacific sanddab can be found online at: http://www.pcouncil.org/wp-content/uploads/Sanddab_2013_Assessment.pdf

For more information on the Pacific sanddab assessment, contact Xi He at Xi.He@noaa.gov.

The complete version of: Status of the U.S. petrale sole resource in 2012 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

English and Rex Soles: The data moderate assessment document for English and rex soles can be found at: http://www.pcouncil.org/groundfish/stock-assessments/by-year/gf2013/
For more information on the 2013 data-moderate assessments, contact Jason Cope at Jason.Cope@noaa.gov

6. Pacific Hake

This stock assessment for 2014 reported the collaborative efforts of the official U.S. and Canadian JTC members in accordance with the Agreement between the government of the United States and the government of Canada on Pacific hake/whiting. The assessment reported the status of the coastal Pacific hake (or Pacific whiting, *Merluccius productus*) resource off the west coast of the United States and Canada. The Agreement between the United States and Canada establishes U.S. and Canadian shares of the coast-wide TAC at 73.88% and 26.12%.

Coast-wide fishery landings of Pacific hake averaged 223 thousand mt from 1966 to 2013, 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 2008–2013 have been above the long term average. 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. Of the 2013 total coast-wide catch, 67% came from the 2010 year class. However, catch age-composition differed between the U.S. and Canada: in 2012, U.S. fisheries caught mostly 4 and 2-year old fish from the 2008 and 2010 year classes, while the Canadian fisheries caught older fish from the 2005, 2006, and 2008 year classes. In 2013, more than 70% of the U.S. catch was from the 2010 year class whereas Canadian catches were dominated by older fish from 2008, 2006, 2005, and 1999 year classes.

Data were updated for the 2014 assessment with the addition of new ages into the 2012 age distribution, the addition of a new age distribution from the 2013 fishery and acoustic survey, and addition of the 2013 acoustic survey biomass estimate to the abundance index. The assessment used Bayesian methods to incorporate prior information on two key parameters (natural mortality, *M*, and steepness of the stock-recruit relationship, *h*) and integrated over parameter uncertainty to provide results that can be probabilistically interpreted. The exploration of uncertainty was not limited to parameter uncertainty as structural uncertainty was investigated through sensitivity analyses. 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 resulting in time-varying selectivity, and little data to inform incoming recruitment until the cohort is age 2 or greater, will, in most circumstances, continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Uncertainty in this assessment is largely a function of the potentially large 2010 year class being observed twice in the acoustic survey and three times in the fishery, although with low and uncertain selectivity. However, with recruitment being a main source of uncertainty in the projections and the survey not quantifying hake until they are 2 years old, short term forecasts are very uncertain.

The base model estimates indicate that since the 1960s, Pacific hake female spawning biomass has ranged from well below to near unfished equilibrium biomass. The model estimates that the stock was below the unfished equilibrium in the 1960s and 1970s, increased toward the unfished equilibrium after two or more large recruitments occurred in the early 1980s, and then declined steadily through the 1990s to a low in 2000. This long period of decline was followed by a brief peak in 2003 as the large 1999 year class matured and subsequently supported the fishery for several years. Estimated female spawning biomass declined to an all-time low of 0.479 million mt in 2009 because of low recruitment between 2000 and 2007, along with a declining 1999 year class. Spawning biomass estimates have increased since 2009 on the strength of a large 2010 cohort and above average 2008 and 2009 cohorts. The 2014 female spawning biomass is estimated to be 81.8% of the unfished equilibrium level (B_0) with 95% posterior credibility intervals ranging from 41.6% to 168%. The median of the forecast for 2014 female spawning biomass is 1.72 million mt.

Estimates of historical Pacific hake recruitment indicate very large year classes in 1980, 1984, 1999, and 2010. The U.S. fishery and acoustic age compositions both show the 2010 year class comprised a very large proportion of the observations in 2013. Uncertainty in estimated recruitments is substantial, especially for 2010, 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 and was substantially below the $F_{40\%}$ target in 2012 and 2013. 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 two of the last 10 years (2008 and 2011). Recent catch and levels of depletion are presented in Figure 4.

A management strategy evaluation (MSE) was conducted for Pacific hake to test 1) the benefit of more frequent survey data, 2) differences in the accuracy of the assessment when modeling time-varying selectivity, and 3) investigating the population and catch differences when setting catches less than the default harvest rate suggests. More frequent survey observations (annual surveys) slightly improved stock status metrics, and resulted in a slightly higher catch with a lower inter-annual variability. However, the introduction of time-varying selectivity with a biennial survey had a greater benefit to stock status and catch than an annual survey with time-invariant selectivity. Therefore, the 2014 stock assessment incorporated time-varying selectivity. Finally, the introduction of ceilings to the TAC of 375,000 mt and 500,000 mt resulted in reduced risk to stock status, increased average catch, and lower inter-annual variability in catches in the long-term. Including a TAC Floor of 180,000 mt along with a ceiling of 375,000 mt resulted in a high probability that the stock status could fall below 10% of unfished equilibrium biomass.

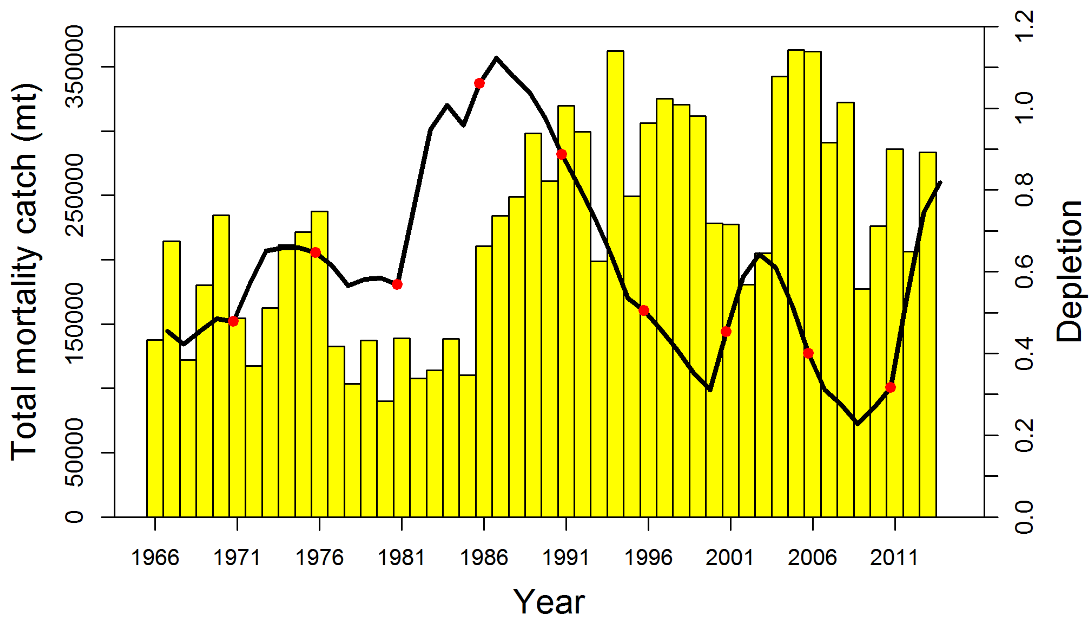


Figure 4. Total catch (mt; bars; 1966–2013) and depletion (relative to average unexploited equilibrium level; line; 1966–2014) for Pacific hake

The complete document: “Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2014 with a management strategy evaluation” can be viewed online at: http://www.westcoast.fisheries.noaa.gov/publications/fishery_management/groundfish/whiting/2014-stock-assess.pdf

For more information on the Pacific hake assessment, please contact Allan Hicks at Allan.Hicks@noaa.gov

7. Other species

No species in the ‘other’ category were assessed in 2014.

D. Other Related Studies

1. Bycatch Reduction Research

a) Recent conservation engineering work in U.S. West Coast groundfish fisheries

Beginning in 2004, the NOAA Fisheries Northwest Fisheries Science Center (NWFSC) initiated a fisheries conservation engineering program within its Fisheries Resource Analysis and Monitoring Division. Through key regional collaborations with the Pacific States Marine Fisheries Commission, Oregon Department of Fish and Wildlife, Alaska Fisheries Science Center, and the fishing industry, the NWFSC has been able to pursue a wide-ranging array of conservation engineering projects relevant to reducing bycatch in the west coast groundfish and ocean shrimp trawl fisheries. In the past several years, these projects included: 1) Reducing Chinook salmon, eulachon, rockfish, and Pacific halibut bycatch in midwater and bottom trawl fisheries using BRDs, 2) Providing loaner video camera systems to the fishing industry, and 3) Examining selectivity characteristics of codends that differ in mesh size and configuration in the bottom trawl fishery, 4)

Developing and testing selective flatfish sorting grid bycatch reduction devices in the bottom trawl fisheries. Much of our current work has been in response to the fishing industries concerns over catches of overfished rockfishes and Pacific halibut IBQ (Individual Bycatch Quota) allocated in the Pacific coast Groundfish Trawl Rationalization Catch Share Program. The trawl rationalization program, starting in January 2011, established formal Annual Catch Limits (ACLs) and individual catch share quotas. In addition to ACLs, fishing opportunities may also be limited by hard caps or IBQs for non-groundfish species (e.g., Chinook salmon, and Pacific halibut). Bycatch of overfished, rebuilding, and prohibited species in the West Coast groundfish trawl fishery has the potential to constrain the fishery such that a substantial portion of available harvest may be left in the ocean.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

b) Testing of Pacific halibut bycatch reduction devices in two U.S. West Coast Bottom Trawl Fisheries

The U.S. West Coast limited entry (LE) groundfish trawl fishery is managed under a catch share program and operates under annual catch limits and individual fishing quotas along with individual bycatch quotas (IBQs) for Pacific halibut, a prohibited species. For many fishermen participating in the bottom trawl component of this fishery, bycatch of Pacific halibut is a concern because limited IBQ is available. Individual fishermen could reach their Pacific halibut IBQ before reaching their catch share quota of healthier stocks, thereby ending their fishing season or forcing them to purchase limited and expensive quota. In separate studies, we examined two industry-designed Pacific halibut flexible sorting grid bycatch reduction devices (BRDs): one was developed for the deepwater Dover sole/thornyhead/sablefish (DTS) complex fishery, while the second was developed for the nearshore flatfish fishery. Fish retention (by weight) was quantified using a recapture net. For the BRD tested in the DTS fishery, retention of marketable-sized Dover sole, thornyheads, and sablefish was 99.0%, 96.9%, and 90.0% respectively. Pacific halibut bycatch was reduced by 83.7%. In the nearshore flatfish fishery, the BRD examined retained 85.1% of the marketable-sized flatfishes encountered. Retention was highest for petrale sole (93.3%), and Dover sole (89.4%). Bycatch of Pacific halibut was reduced by 93.7%, while catches of rockfishes and roundfishes were reduced by 72.1% and 96.5%, respectively. Results demonstrated the capability of flexible sorting grids to improve trawl selectivity in the U.S. West Coast LE groundfish bottom trawl fishery while maintaining catches for several target species. This work was presented at the 2014 Alaska Sea Grant Lowell Wakefield Symposium, “Fisheries Bycatch: Global Issues and Creative Solutions”.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or Mark Lomeli at MLomeli@psmfc.org or visit http://www.nwfsc.noaa.gov/research/divisions/fram/habitat.cfm

c) Size selectivity of T90 mesh and diamond mesh codends on five groundfish species commonly caught over the upper continental slope of the U.S. West Coast

The U.S. West Coast limited entry (LE) groundfish bottom trawl fishery operates under a catch share program (initiated in 2011) that allocates individual fishing quotas (IFQ) and establishes annual catch limits (ACLs). Reducing catches of IFQ constraining species, and juvenile and unmarketable-sized groundfishes would allow fishermen to more effectively utilize their IFQs, increase their net economic benefits, and increase their fishing opportunities. We examined the size-selection characteristics of two experimental T90 mesh codends (conventional diamond mesh that has been turned 90o in orientation) and the conventional diamond mesh codend and evaluated their efficacy at reducing catches of unmarketable-sized fishes in the U.S. West Coast LE groundfish bottom trawl fishery. The codends tested were 114 mm and 140 mm T90 mesh, and 114 mm diamond mesh. Tests occurred off Oregon during 2012 aboard a commercial trawler during daytime hours. We measured codend selectivity using the covered codend method. Fifteen valid tows were completed for each codend. Selection curves and mean L50 values for two flatfish species (rex sole, and Dover sole), and three roundfish species (shortspine thornyhead, longspine thornyhead, and sablefish) were estimated using a non-linear mixed-effects model. Mean L50 values for rex sole and Dover sole were smaller in the 114 mm T90 codend than the 114 mm diamond codend. The opposite was observed for shortspine thornyhead, longspine thornyhead, and sablefish, with larger mean L50 values occurring in the 114 mm T90 codend than the 114 mm diamond codend. The selectivity of the 140 mm T90 codend differed significantly from the 114 mm T90 and 114 mm diamond codends for the five groundfish species evaluated. The 140 mm T90 codend was most effective at reducing the retention of unmarketable-sized fishes, however, selectivity showed a considerable loss of marketable-sized fishes. While there may be clear benefits for using T90 codends in this mixed-stock groundfish fishery, other mesh sizes and/or codend circumferences other than those used in this study may improve results for trawl fishermen. Further evaluation of T90 codends over a range of mesh sizes, circumferences, and under various fishing conditions would provide important information to better determine their potential efficacy in this fishery.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or Mark Lomeli at MLomeli@psmfc.org or visit http://www.nwfsc.noaa.gov/research/divisions/fram/habitat.cfm

d) Evaluation of a selective flatfish sorting grid bycatch reduction device in the West Coast bottom trawl fishery

The U.S. West Coast limited entry (LE) groundfish trawl fishery is managed under an Individual Fishing Quota (IFQ) program that establishes annual catch limits for 39 groundfish managed units (stocks, stock complexes, and geographical subdivisions of stocks), and individual bycatch quotas for Pacific halibut (*Hippoglossus stenolepis*). For many fishermen engaged in this fishery and targeting flatfishes, catches of overfished and rebuilding rockfishes (*Sebastes* spp.), sablefish, and Pacific halibut can be a concern because quota is limited relative to flatfish quotas. Individual fishermen could reach their quota for one of these “lower-quota” species before reaching their catch share quota of more abundant and productive flatfishes, thereby ending their fishing season unless they can lease or purchase additional quota. In this study, we evaluated a selective flatfish sorting grid bycatch reduction device (BRD) designed to reduce catches of rockfishes, sablefish, and Pacific halibut, while retaining flatfishes. A recapture net was used to quantify fish escapement and retention by weight. Generalized linear mixed modeling was used to compare the proportion of fish catch at length to determine if retention was length-related. The mean retention of flatfishes (five species evaluated) ranged from 68.1% to 92.3%. Petrale sole (the highest valued flatfish) displayed the highest percent retention, whereas arrowtooth flounder (the lowest valued flatfish) exhibited the lowest percent retention. Catches of shelf rockfishes, slope rockfishes, sablefish, and Pacific halibut were reduced by 80.3%, 64.0%, 97.0%, and 90.3%, respectively. Catch comparison analyses using GLMM showed retention was significantly length-related in three of the five flatfish species evaluated. Flatfishes <57 cm in length were retained in the trawl in significantly greater proportions. Shelf rockfishes >29 cm in length, slope rockfishes >32 cm in length, and sablefish >42 cm in length were retained in the trawl in significantly lower proportions. Significantly fewer Pacific halibut were retained in the trawl across all lengths.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or Mark Lomeli at MLomeli@psmfc.org or visit http://www.nwfsc.noaa.gov/research/divisions/fram/habitat.cfm

e) Providing direct observation video camera systems to fishermen for use in evaluating industry-designed approaches to reducing bycatch and impacts to benthic habitats

Since 2010, the NWFSC, working in collaboration with PSMFC, has operated an underwater video camera loaner to make 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 two additional video systems to the pool (Figures 5 and 6). These camera systems have been used extensively across the Pacific hake midwater trawl fishery, groundfish bottom trawl fishery, and the pink shrimp trawl fishery.

Figure 5. One of four autonomous direct observation video camera systems developed at the NWFSC.

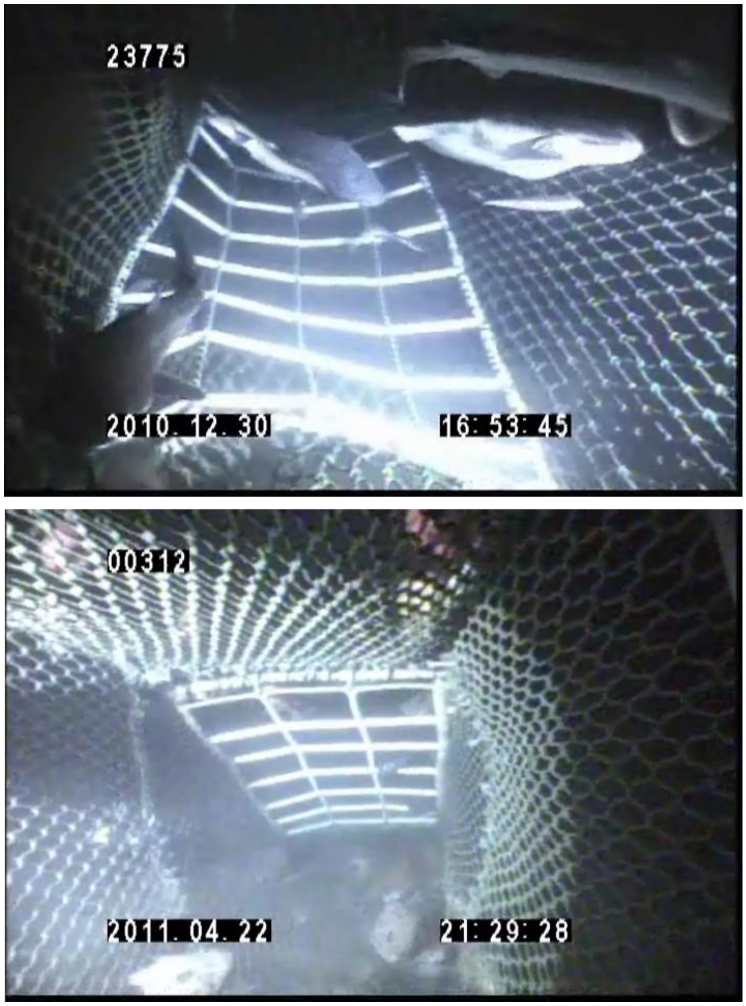


Figure 6. Video frame grabs showing flexible sorting grates developed by the fishing industry to reduce Pacific halibut bycatch in the groundfish bottom trawl fishery. Information gained from the videos was used to improve the performance of the grates.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov or Mark Lomeli at MLomeli@psmfc.org 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 2014, CAP aged more than 29,900 otoliths. Ages were produced to support the 2015 assessments on for petrale sole, black rockfish, canary rockfish, china rockfish, darkblotched rockfish, widow rockfish, Pacific hake and sablefish. Widow rockfish age reading was taken over from the SWFSC in 2014. China and black rockfish were species that previously had never been aged by CAP before. Throughout 2014, 6,545 hake otoliths were aged for use in the 2015 joint hake assessment with Canada. CAP also completed over 1,000 training age reads during the year. CAP continued the practice of recording otolith weights prior to breaking and burning, in support of research into alternative methods of age determination. They are also collaborating with a NW Center engineer in Seattle to explore alternative light-based means of counting annuli.

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 seventeenth annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2014 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 *Last Straw, Noah's Ark, Ms. Julie,* and *Excalibur* 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 charter was for a period of 11-12 weeks with the *Last Straw* and *Noah's Ark* surveying the coast during the initial survey period from May to July. The *Excalibur,* and *Ms. Julie* 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 2014, 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) echinoderm adaptations to hypoxia across the Southern California continental margin - Scripps Institution of Oceanography, UC San Diego; 2) collection of tissue samples from grenadiers: *Coryphaenoides acrolepis* (Pacific grenadier), *Coryphaenoides cinereus* (popeye grenadier), *Albatrossia pectoralis* (giant grenadier), *Nezumia stelgidolepis* (California grenadier), *Nezumia liolepis* (smooth grenadier), *Coryphaenoides filifer* (filamented grenadier), and *Coelorinchus scaphopsis* (shoulderspot grenadier) – Northwest Fisheries Science Center; 3) collection of otoliths for shortspine thornyhead by depth strata (0-273 fm, 273-547 fm and >547 fm – Northwest Fisheries Science Center; 4) a study on the life history of the pygmy rockfish, *Sebastes wilsoni* – Marine Science Institute, University of California, Santa Barbara; 5) record all sightings of basking sharks – Moss Landing Marine Laboratories; 6) collection of all thornback rays, *Platyrhinoidis triseriata* – Moss Landing Marine Laboratories; 7) collection of 25 big skate (*Raja binoculata*) egg cases – Moss Landing Marine Laboratories 8) collection of eastern North Pacific softnose skates, genus *Bathyraja* – Moss Landing Marine

Laboratories; 9) collection of 25 Pacific spotted spiny dogfish, *Squalus suckleyi* between San Francisco, CA and Morro Bay, CA – Moss Landing Marine Laboratories; 10) collection of any Pacific black dogfish, *Centroscyllium nigrum* – Moss Landing Marine Laboratories; 11) 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; 12) collection of all unusual or unidentifiable sharks including small sleeper sharks, *Somniosus pacificus* and velvet dog shark (*Zameus squamulosus*) – Moss Landing Marine Laboratories; 13) collection of any chimaera that is not *Hydrolagus colliei*, including: *Harriotta raleighana*, *Hydrolagus* spp. and *Hydrolagus trolli* – Moss Landing Marine Laboratories; 14) collection of voucher specimens for multiple fish species – Northwest Fisheries Science Center; 15) collection of voucher specimens for multiple fish species – Oregon State University; 16) collection of DNA and/or whole specimens of rougheye rockfish (S*ebastes aleutianus*), blackspotted rockfish (S*ebastes melanostictus*), darkblotched rockfish (S*ebastes crameri*) and blackgill rockfish (S*ebastes melanostomus*) to reduce uncertainty in the assessment of morphologically-similar west coast rockfish – 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; 4) collection and identification of cold water corals; 5) fish distribution in relation to bottom dissolved oxygen concentration in the oxygen minimum zone; 6) composition and abundance of benthic marine debris collected during the 2014 West Coast Groundfish Trawl Survey; and 8) collection of ovaries from Pacific ocean perch, Pacific hake, aurora rockfish, shortspine thornyheads, and canary rockfish to assess maturity; 9) maturity of grooved Tanner crabs.

For more information please contact Aimee Keller at Aimee.Keller@noaa.gov

b) Southern California shelf rockfish hook-and-line survey

In early fall 2014, FRAM personnel conducted the 11th 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*), cowcod (*S. levis*) and the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*) within the SCB.

The F/V *Aggressor* (Newport Beach, CA), F/V *Mirage* (Port Hueneme, CA), and F/V *Toronado* (Long Beach, CA) were each chartered for 10 days of at-sea research, with 15 biologists participating during the course of the survey. The three vessels sampled a total of 162 sites ranging from Point Arguello in the north to 9 Mile Bank and the U.S.-Mexico EEZ boundary in the south. For the first nine field seasons, sampling was conducted aboard two chartered vessels, however a third vessel was added to the survey in 2013 in response to internal and external peer reviews recommending additional research into the role the vessel platform plays in abundance modeling. 2014 marked the first year of sampling within the Cowcod Conservation Areas (CCAs). Approximately 42 sites over several areas of the CCAs were sampled as part of a pilot monitoring project and in response to research needs identified by the PFMC and stock assessment scientists. It is anticipated that monitoring at these sites will continue and new sites in other areas of the CCAs will be sampled during the 2015 survey.

Approximately 5,794 sexed lengths and weights, 5,529 fin clips, and 5,367 otolith pairs were taken during the course of the entire survey representing 39 different species of fish. Several ancillary projects were also conducted during the course of the survey. Approximately 554 ovaries were collected from 11 different species to support the development of 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 also deployed an underwater video sled to capture visual observations for habitat analysis, species composition, and fish behavior studies.

For more information, please contact John Harms at John.Harms@noaa.gov

c) 2014 joint U.S.-Canada integrated acoustic and trawl research cruise of Pacific hake

The joint U.S.–Canada integrated acoustic and trawl research cruise was conducted by NWFSC/FRAM on the NOAA ship *Bell M. Shimada* (U.S. waters) from 28 August 2014 to 14 September 2014, and by a Canadian team (DFO/Pacific region) on the CCGS *W.E. Ricker* (Canadian and U.S. waters) from 19 August 2014 to 15 September 2014. The overall goal of the cruise was to conduct research into topics suggested by hake stock assessment scientists and/or panel members of the international Scientific Review Group (SRG) for improving hake biomass estimates. By testing new equipment and methods, the NWFSC and DFO strive to continue using the best available science while conducting biennial hake acoustic surveys.

- To investigate hake school structure and ecosystem components over time (e.g., tide), the Shimada acoustically sampled a fixed area thirty-two times.
- To improve the understanding of patterns and rates of hake migration, six short lines (“reference transects”), spaced along the coast between the 100- and 800-m isobaths (except for the Newport Oceanographic Line), were run during the course of the research cruise, four of which were run repeatedly.
- To investigate what is not being caught by the codend of an Aleutian wing trawl (AWT) midwater net, four pocket nets with a mesh size of 11 mm (versus the 32-mm mesh size of the AWT codend) were attached to each side of an AWT. Differences in the proportions of organisms caught by the two types of nets are being looked at, with the goal of developing a target strength complex for the hake/myctophid mix (see below).
- To improve an understanding of hake and ecosystem ecology, Methot trawls were conducted to assist with acoustic identification of krill.
- Trawl metrics of the AWT were quantified since its update with new rigging.
- Techniques for near-field calibration were investigated (Tables 2 and 3).

We investigated the applicability of calibrating a broadband acoustic system in the near field. The calibration was performed on a single transducer with a mono-static configuration using a single standard target, a 25-mm tungsten carbide sphere in the nearfield of both the transducer and the sphere. A theoretical model was developed to quantify the nearfield effect. Numerical simulations revealed that the frequency responses at different distances varied significantly, the null positions were essentially invariant - a unique characteristic for determination of the compressional and shear wave speeds in the calibration sphere. The calibration curves obtained in the near field could be applied to farfield once the nearfield effects were accounted for. Since the transducer was located in the near field, the signal-to-noise ratio was high, resulting in a much wider useable bandwidth than the nominal bandwidth. The resultant calibration uncertainty, i.e. root-mean-square uncertainty over the entire usable frequency band was 1.03 dB and reduces to 0.32 dB when the regions corresponding to nulls were excluded. The methods reported here could potentially be applied to the calibration of multibeam and broadband echosounder/sonar systems since it is difficult to meet the farfield condition for outermost beams when shipboard calibrations are needed.

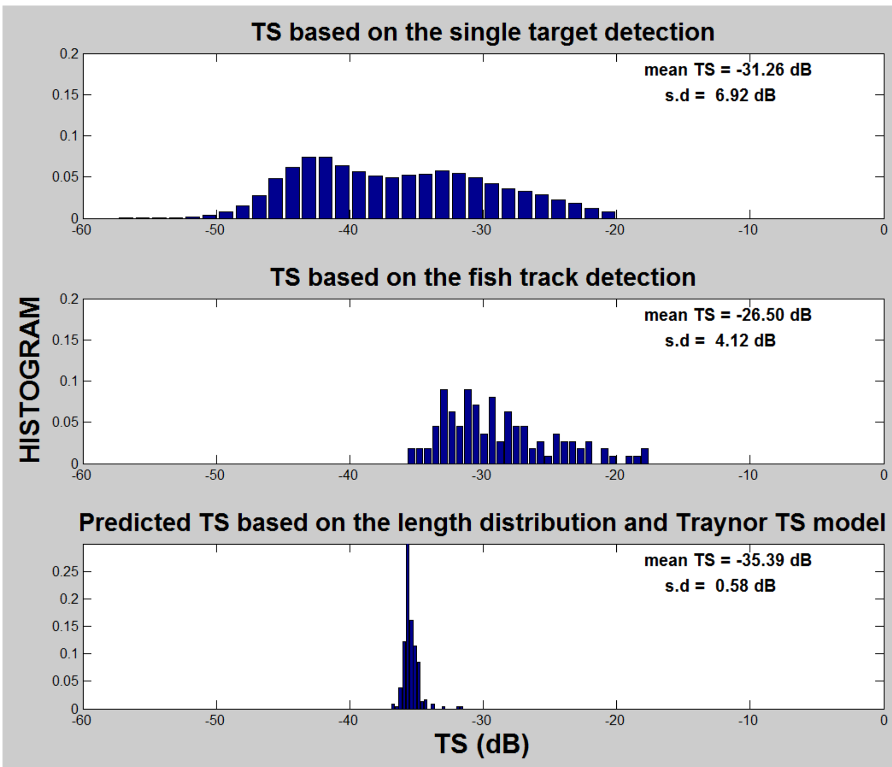
Table 2. Nearfield calibration - Target Strength Difference, ΔTS, between the TS_{FF} (farfield) and TS_{NF} (nearfield) for a 38.1 mm WC sphere before applying nearfield compensation. Note that $R_F = D^2/2\lambda$, where *D* is the diameter of the transducer and is the wave length, and $4R_F$ corresponds to the Fraunhofer distance. For 38 kHz echosounder mounted on NOAA FSVs, the R_F is 1.39 m.

Freq. (kHz)	18	38	70	120	200
$1R_F$	-1.829	-1.818	-1.840	-2.038	-1.872
$2R_F$	-0.455	-0.450	-0.456	-0.509	-0.451
$4R_F$	-0.114	-0.112	-0.114	-0.127	-0.111
$5R_F$	-0.073	-0.072	-0.073	-0.081	-0.071
$10R_F$	$-1.819E^{-02}$	$-1.794E^{-02}$	$-1.819E^{-02}$	$-2.036E^{-02}$	$-1.776E^{-02}$

Table 3. Target Strength Difference, $\delta(TS)$ or $\delta(\Delta TS)$ after applying nearfield compensation

Freq. (kHz)	18	38	70	120	200
$1R_F$	-0.002	-0.006	-0.005	-0.001	-0.022
$2R_F$	0.001	0.001	0.001	$1.95E^{-04}$	0.005
$4R_F$	$8.27E^{-05}$	$2.05E^{-04}$	$1.71E^{-04}$	$2.00E^{-05}$	$7.89E^{-04}$
$5R_F$	$2.47E^{-05}$	$6.17E^{-05}$	$5.09E^{-05}$	$4.96E^{-06}$	$2.51E^{-04}$
$10R_F$	$-1.95E^{-05}$	$-4.80E^{-05}$	$-4.01E^{-05}$	$-5.14E^{-06}$	$-1.77E^{-04}$

- During the cruise, midwater trawls equipped with a camera system were conducted to verify species composition of observed backscatter layers and to obtain biological information (i.e., size distribution, age composition, sexual maturity). A total of 11 successful midwater trawls, equipped with pocket nets, conducted by the *Shimada* resulted in a total hake catch of 3,394 kg. Ten Methot tows were successfully conducted.
- In a study area off the central Oregon coast, the *Shimada* investigated the target strength (TS) of Pacific hake (Figure 7) and other species (Figure 8) by drifting over aggregations of hake—during select times at night and day—while collecting single target data.

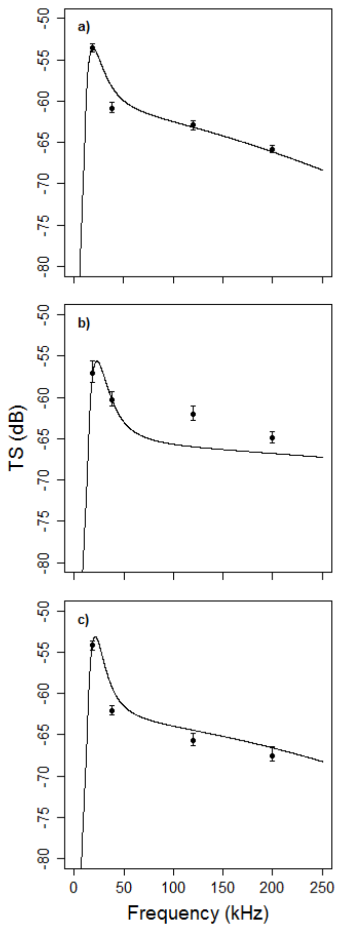


1. Pings on a single target (daytime behavior)

2. Following a single target through time (daytime behavior)

3. Predicted TS from the Traynor model (nighttime behavior)

Figure 7. Target strength for Pacific hake (day and night)



Target Strength for myctophids: a) *Maurolicus muelleri* mean length = 35.2 mm, b) *M. muelleri* mean length = 23.2 mm, c) *Benthosema glaciale* mean length = 55.60 mm versus frequency. Black circles are the mean *in situ* TS collected with the Simrad EK60 echosounders for appropriate hauls. The black line shows the resonance scattering model output, and error bars show the upper and lower 95% confidence intervals of the mean estimates. Viscosity = 6, 2 and 3 cal. kg m^{-1} for large and small myctophids, respectively.

Figure 8. Target strength for small *Maurolicus muelleri* and large *Benthosema glaciale* myctophids.

5. NOAA Program: FATE - fisheries and the environment

a) Incorporating climate driven growth variability into stock assessment models: a simulation-based decision table approach

Investigators: Lee Qi, J. T. Thorson, A.E. Punt and V.V. Gertseva

This is a collaborative project between the Northwest Fisheries Science Center (NWFSC) and University of Washington funded by the NOAA Fisheries and the Environment (FATE) Program. Biological characteristics of managed fishes are likely to vary with time due to environmental variability. Growth of splitnose and yelloweye rockfishes has been previously found to be highly correlated with several productivity indicators in the California Current Ecosystem, and time-series of climate-growth indices have been developed for these two species, using otolith band reading techniques. These indices, however, have not been used to inform stock assessments, due to a lack of guidance for when and how to incorporate indices of time-varying individual growth into an assessment model. This project uses a generic decision table approach to evaluate the effects of incorporating climate-driven time-varying growth into stock assessment models. Values in the decision table represent management outcomes (i.e. lost yield and the probability of overfishing) and are generated using simulation modeling, while existing data for splitnose and yelloweye rockfishes used to estimate the prior probability of time-varying growth. This simulation-based decision table approach provides guidance on whether and how to include the environmental indices in future splitnose and yelloweye rockfish assessments. It could also be used generically to help evaluate the utility of including environmental data in stock assessment models.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

6. Ecosystem Studies

a) Integrated Ecosystem Assessment of the California Current

Investigators: C.J. Harvey, N. Garfield, E.L. Hazen, G.D. Williams, eds.; numerous contributors from the NWFSC, SWFSC and partner institutions

An integrated ecosystem assessment (IEA) is a science support element for ecosystem-based management (EBM); the IEA process involves synthesizing and analyzing information through steps that include scoping, indicator development, risk analysis, and evaluating management strategies. The primary goal of the California Current IEA is to inform the implementation of EBM by melding diverse ecosystem components into a single, dynamic fabric that allows for coordinated evaluations of the status of the California Current ecosystem. We also aim to involve and inform a wide variety of stakeholders and agencies that rely on science support for EBM, and to integrate information collected by NOAA and other federal agencies, states, non-governmental organizations, and academic institutions. The essence of IEAs is to inform the management of diverse, potentially conflicting ocean-use sectors. As such, a successful California Current IEA must encompass a variety of management objectives, consider a wide-range of natural drivers and human activities, and forecast the delivery of ecosystem goods and services under a multiplicity of scenarios. This massive undertaking will evolve over time.

The Phase III iteration of the California Current IEA, which covers up to 2013, builds on earlier reports by adding habitat and human dimensions components to a body of work that already included physical/climate drivers, coastal pelagic species, salmon, groundfish, seabirds, marine mammals, human activities from fisheries and non-fisheries sectors, and broader indicators of ecological integrity. Phase III also includes risk assessment work and several model-driven management strategy evaluations.

For more information please contact Dr. Chris Harvey at NOAA's Northwest Fisheries Science Center, Chris.Harvey@noaa.gov

b) California Current IEA Phase III report: ecological integrity

Investigators: G.D. Williams, K.S. Andrews, J.F. Samhouri, N. Tolimieri, C. Barcelo, R.D. Brodeur, J. Field, B. Peterson, A. Thompson.

Ecological integrity is "the ability of an ecological system to support and maintain a community of organisms that has a species composition, diversity, and functional organization comparable to those of natural habitats within a region" (Parrish et al. 2003). We identified and evaluated potential indicators of ecological integrity across a variety of species and foraging guilds, using the ecological literature as a basis for their rankings. We selected the mostly highly ranked indicators to track two aspects of the California Current Large Marine Ecosystem (CCLME):

• Trophic structure: mean trophic level, scavenger biomass ratio, biomass of gelatinous zooplankton, and the northern copepod biomass anomaly

• Biodiversity: Simpson's diversity, species richness or species number for multiple taxa.

The indicators reported in this section are designed to be integrative, community-based measures that draw information from across the taxonomic spectrum. Indicators derive from monitoring time series through recent years (2011-2013, depending on the time series). Indicators specific to individual ecological components, such as coastal pelagic species, groundfishes, and protected species (marine mammals, seabirds, and Pacific salmon), also provide information that can influence ecological integrity and are covered in other sections in this report.

The spatial extent of CCLME data coverage varies among taxa. The groundfish data span the U.S. West Coast (~32 to 48°N, ~50-1200 m depths) and conclusions related to this dataset (mean trophic level, scavenger biomass, species richness, species density, and Simpson diversity) are applicable to the full CCLME. Note, however, that the trawl survey does not adequately sample complex, rocky habitats and any conclusions are limited to trawlable areas. Data for ichthyoplankton are drawn from southern California and Oregon survey transect lines, while those for gelatinous zooplankton are taken from surveys conducted off central California and the Oregon/Washington coasts. Data for coastal pelagic fishes are also drawn from the Oregon/Washington survey, whereas the copepod data are limited to survey stations in waters off of central Oregon. Thresholds and targets are not currently set for indicators of ecological integrity, and time series are evaluated based on internal statistical properties.

For more information, please contact Greg Williams at Greg.Williams@noaa.gov

c) California Current IEA Phase III report: human dimensions of the CCIEA

Investigators: S. Breslow, D. Holland, P. Levin, K. Norman, M. Poe, C. Thomson, R. Barnea, P. Dalton, N. Dolsak, C. Greene, K. Hoelting, S. Kasperski, R. Kosaka, D. Ladd, A. Mamula, S. Miller, B. Sojka, C. Speir, S. Steinbeck, N. Tolimieri.

A conceptual model of the California Current Large Marine Ecosystem (CCLME) socio-ecological system highlights the "social" within the socio-ecological system and demonstrates that any particular management strategy can affect human wellbeing through at least two major pathways: through alterations in environmental conditions, which in turn affect human wellbeing, and through direct effects on human wellbeing. In addition to broad conceptualizations of the coast-wide system in both natural and social terms, and discussions of relevant social science approaches and frameworks, we include 5 major indicator efforts within the CCLME. These indicators cover levels of human coastal community vulnerability, vessel-and port-level fisheries diversification trends and effects, "personal use" of fisheries as a preliminary proxy for possible subsistence practices among commercial operators, the relationship between water supply and agricultural production in Central California, and a survey of marine-oriented recreational expenditures.

For more information, please contact Sara Breslow at Sara.Breslow@noaa.gov

d) California Current IEA Phase III Report: fishery income diversification

Investigators: D. Holland and S. Kasperski

Catches and prices from many fisheries exhibit high inter-annual variability leading to variability in the income derived by fishery participants. Our analysis indicates that income variability is reduced on average if individuals diversify their income by participating in several different fisheries. The annual variability of aggregate revenues for ports is also reduced by diversification. We utilize the Herfindahl-Hirschman Index (HHI) to measure diversification of West Coast and Alaskan entity's gross revenues across species groups and regions. HHI theoretically ranges from zero when revenues are spread amongst an infinite number of fisheries to 10,000 for an entity that derives all revenue for a single fishery. Thus, the less diversified an entity's revenue sources are, the higher the HHI. We evaluate how diversification measured at the vessel level has changed over time for various fleet groups. We also track diversification of aggregate revenues for various port groups over time.

For more information please contact Dan Holland at Dan.Holland@noaa.gov

e) New target fisheries lead to spatially variable food web effects in an ecosystem model of the California Current

Investigators: K.N. Marshall, I.C. Kaplan, and P.S. Levin

Growing human populations put increasing demands on marine ecosystems. Studies have demonstrated the importance of large biomass forage groups in model food webs, but small biomass contributors are often overlooked. Here, we predict the ecosystem effects of three potential future fisheries targeting functional groups that make up only a small proportion of total ecosystem biomass using the California Current Atlantis Model: deep demersal fish such as grenadier (*Albatrossia pectoralis* and *Coryphaenoides acrolepis*), nearshore fish such as white croaker (*Genyonemus lineatus*), and shortbelly rockfish (*Sebastes jordani*). Using a spatially explicit ecosystem model, we explored fishing scenarios for these groups that resulted in abundance levels of 75, 40, 25, and 0 percent of the status quo fishing scenario. We evaluated the effects on coast-wide biomass and describe variation in affected groups by region. Results indicate that developing fisheries on the proposed targets would have low coast-wide effects on other species. However, effects varied significantly within the ecosystem, with higher impacts concentrated in the central California region of the model. This work provides a framework for evaluating effects of new fisheries and suggests that regional effects should be evaluated within a larger management context.

For more information, please contact Kristin Marshall at Kristin.Marshall@noaa.gov

f) Finding the accelerator and brake in an individual quota fishery: linking ecology, economics, and fleet dynamics of US West Coast trawl fisheries

Investigators: I.C. Kaplan, D.S. Holland, and E.A. Fulton.

In 2011, the Pacific Fisheries Management Council implemented an individual transferrable quota (ITQ) system for the U.S. West Coast groundfish trawl fleet. Under the ITQ system, each vessel now receives transferrable annual allocations of quota for 29 groundfish species, including target and bycatch species. Here we develop an ecosystem and fleet dynamics model to identify which components of an ITQ system are likely to drive responses in effort, target species catch, bycatch, and overall profitability. In the absence of penalties for discarding over-quota fish, ITQs lead to large increases in fishing effort and bycatch. The penalties fishermen expect for exceeding quota have the largest effect on fleet behaviour, capping effort and total bycatch. Quota prices for target or bycatch species have lesser impacts on fishing dynamics, even up to bycatch quota prices of \$50 kg(-1). Ports that overlap less with bycatch species can increase effort under individual quotas, while other ports decrease effort. Relative to a prior management system, ITQs with penalties for exceeding quotas lead to increased target species landings and lower bycatch, but with strong variation among species. The model illustrates how alternative fishery management policies affect profitability, sustainability and the ecosystem.

For more information, please contact Isaac Kaplan at Isaac.Kaplan@noaa.gov

g) The legacy of a crowded ocean: indicators, status, and trends of anthropogenic pressures in the California Current ecosystem

Investigators: K.S. Andrews, G.D. Williams, J.F. Samhouri, K.N. Marshall, V. Gertseva, P.S. Levin

As human population size and demand for seafood and other marine resources increase, the influence of human activities in the ocean (e.g., fishing and shipping activity) and on land (e.g., pollutants and runoff from industrial and agricultural activities) is increasingly critical to the management and conservation of marine resources. In order to make management decisions related to anthropogenic pressures on marine ecosystems, we need to understand the links between pressures and ecosystem components, and we cannot draw those linkages unless we know how pressures have been changing over time. We developed indicators and time series of indicators for 22 anthropogenic pressures at the scale of the U.S. portion of the California Current ecosystem. Time series suggest that seven pressures have decreased and two have increased over the short term, while five pressures were above and two pressures were below long-term means. Cumulative indices of anthropogenic pressures suggest a slight decrease in pressures in the 2000's compared to the preceding few decades. Dynamic factor analysis revealed four common trends that sufficiently explained the temporal variation found among all anthropogenic pressures. Using this reduced set of time series will be useful when trying to determine whether links exist between individual or multiple pressures and various ecosystem components.

For more information, please contact Kelly Andrews at Kelly.Andrews@noaa.gov

h) Comparing the movements of spiny dogfish *Squalus suckleyi* in the north Pacific with satellite and acoustic tracking technology

Investigators: C. Tribuzio, K.S. Andrews

Spiny dogfish (*Squalus suckleyi*) are a small species of shark, common in coastal waters of the eastern North Pacific Ocean. Previous tagging studies have shown that they have the potential to undertake large scale migration and that there are seasonal patterns to their movement. This study aims to investigate movement on an even finer scale. The miniaturization of pop-off satellite archival tags (PSATs) has enabled smaller species to be tagged. Since 2009 we have deployed 184 PSATs on spiny dogfish at locations across the Gulf of Alaska, British Columbia (Canada) and Puget Sound (Washington, USA) waters. To date, 145 tags have been recovered, with 31 still outstanding and the remainder failed to report. As well, 6 spiny dogfish were double tagged with acoustic tags and deployed in Puget Sound. Preliminary results such as pop-off location are already elucidating surprising movement patterns. While most spiny dogfish were tagged in the Gulf of Alaska, many fish moved as far south as southern California. Further, the fish that undertook the large scale migrations, tended to have a different daily movement pattern from those that remained. A great deal of analysis remains on this project, but early results are intriguing and suggest that spiny dogfish are more highly mobile than previously believed.

For more information please contact Kelly Andrews at Kelly.Andrews@noaa.gov

i) Developing ecological indicators for Washington State's marine spatial planning process

Investigators: K.S. Andrews, J.M. Coyle, C.J. Harvey, and P.S. Levin

In March 2010, the Washington State legislature enacted a new state law on marine spatial planning (MSP; Substitute Senate Bill 6350). One of the primary objectives of this law was to develop a comprehensive marine management plan for the state's marine waters. The law stipulated that the "plan must include an ecosystem assessment that analyzes the health and status of Washington marine waters including key social, economic, and ecological characteristics. This assessment should seek to identify key threats to plan goals, analyze risk and management scenarios, and develop key ecosystem indicators." In support of Washington State's MSP process, we are developing conceptual models and corresponding ecosystem indicators that describe the important ecological components, oceanographic drivers, and human pressures in Washington State waters. The conceptual models serve as the basic frameworks for the development of ecosystem indicators and assessing the status and trends of key components of the ecosystem in Washington marine waters. We are focusing on non-human ecological components, oceanographic drivers and human pressures in major types of habitat found along and off the coast: coastal estuaries, rocky intertidal shores, sandy beaches, kelp forests, seafloor, and the pelagic zone. Key components of each habitat (e.g., focal species, oceanographic drivers, and human pressures) were linked within each conceptual model based on reviews of the literature and expert opinions of how the ecological systems worked. We then used an evaluation framework to select and evaluate potential indicators that could be tracked for each of the key components of each habitat's conceptual model. Future research will focus on integrating social, economic and cultural characteristics into the conceptual models.

For more information, please contact Kelly Andrews at Kelly.Andrews@noaa.gov

j) Does Puget Sound represent a distinct population segment for yelloweye and canary rockfish?

Investigators: K.S. Andrews, K.M. Nichols, A. Elz, C.J. Harvey, N. Tolimieri, D. Tonnes, D. Lowry, R. Pacunski, and K.L. Yamanaka

Yelloweye *Sebastes ruberrimus* and canary *Sebastes pinniger* rockfish populations in Puget Sound, WA were listed as "threatened" under the U.S. Endangered Species Act in 2010. However, considerable uncertainty characterizes the designation of these "distinct population segments" (DPS) due to limited genetic and demographic information. Much of the evidence for delineating these DPSs was based on genetic evidence from other species in Puget Sound, general life history characteristics of the listed species, and the geographic isolation of Puget Sound. The objectives of this project were (1) to collect new biological and genetic information to determine whether ESA-listed Puget Sound rockfish populations are genetically similar to or distinct from their respective coastal populations and (2) to create working relationships with the recreational fishing community in order to develop sustainable management practices. In 2014, we worked with local recreational charter boat captains to collect fin clips from 40 yelloweye and 33 canary rockfish inside the Puget Sound DPS. These genetic samples are being compared with samples from the outer coasts of U.S. and Canada and the Strait of Georgia. Data collection and analyses will continue through 2015, but we will present preliminary genetic analyses, biological data and interactions with the recreational fishing community.

For more information, please contact Kelly Andrews at Kelly.Andrews@noaa.gov

k) Sibling rivalry: do sixgill sharks (*Hexanchus griseus*) co-occur in kin-structured pairs within nursery habitat of an inland estuary?

Investigators: K.S. Andrews, S. Larson

The association of individuals in the animal kingdom is based on several life-history, reproductive and behavioral processes. Some taxa, such as mammals, have relatively small litters, care for their young and form close-knit family units that remain together for several years and in some instances for their entire lives. However, many fishes broadcast spawn millions of eggs or release thousands of larvae into the water column, provide no subsequent parental care and never come in contact with offspring or siblings. In order to determine whether sixgill sharks move in kin-structured groups, we monitored the movement of 24 individuals from 2006 to 2009 in Puget Sound, WA. Using tissue samples from each shark, we were able to calculate the relatedness of all sharks collected. Using kinship coefficient values, pairs of sharks that were more closely related to each other were more likely to be detected at the same location during the same week than pairs of sharks that were not closely related to each other.

For more information, please contact Kelly Andrews at Kelly.Andrews@noaa.gov

l) How does the definition of 'home range' affect predictions of the efficacy of marine reserves?

Investigators: N. Tolimieri, K.S. Andrews, 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

m) Learning to review end-to-end marine ecosystem models for management applications

Investigators: I.C. Kaplan, K.N. Marshall

In recent years, the shift toward ecosystem-based management of marine resources has led to the development of new analytical tools that simultaneously consider multiple human impacts and multiple species. End-to-end marine models are one type of modelling tool that simulates full ecosystems from oceanography to food webs and fisheries. End-to-end models differ from single species models in some key aspects (e.g., external parameter estimation, long run times, complex and uncertain mathematics to describe ecological interactions) that ultimately lead to different criteria for model review and application. We draw on recent experience with an end-to-end model of the California Current Ecosystem to address how, despite these challenging properties, end-to-end models can nonetheless be subject to rigorous external peer review.

For more information, please contact Isaac Kaplan at Isaac.Kaplan@noaa.gov

n) Variability in rockfish (*Sebastes* spp.) fecundity: species contrasts, maternal size effects, and spatial differences

Investigators: S.G. Beyer, S.M. Sogard, C.J. Harvey, J.C. Field

Over 60 species of rockfish (*Sebastes* spp.) reside off the coast of California, many of which are economically important to both recreational and commercial fisheries. Rockfish are live-bearers with a diverse array of reproductive strategies. Understanding the reproductive potential of an exploited stock is critical to assessing the health and status of a fishery. We investigated the reproductive ecology of four rockfish species to examine species contrasts and to determine spatial and maternal-size effects on reproductive potential. Females were sampled during the winter parturition season (November through March) of 2009 through 2012. Maternal length and somatic weight were positively correlated with relative fecundity (larvae per g somatic weight) in all four species, indicating a disproportionately greater reproductive output by larger, older females. Fecundity estimates in chilipepper, *S. goodei*, and yellowtail rockfish, *S. flavidus*, varied regionally, but did not significantly differ over time within the years sampled (sample sizes for speckled, *S. ovalis*, and blackgill rockfish, *S. melanostomus*, were too small to allow spatiotemporal comparisons). Two reproductive strategies were evident as yellowtail and blackgill rockfish produced a relatively highly fecund, single brood of smaller-sized larvae annually, in contrast to chilipepper and speckled rockfish, which produced larger-sized larvae with lower fecundity. In some regions multiple broods were common, complicating estimates of annual fecundity for these two species. There was some evidence that egg production was positively correlated with female condition, indicating that environmental variability in oceanographic conditions and productivity may drive changes in fecundity and reproductive strategy (i.e., single versus multiple broods).

For more information, please contact Sabrina Beyer at Sabrina.Beyer@noaa.gov.

o) Exploration into oceanographic effects on growth and fecundity in rockfishes (*Sebastes* spp.)

Investigators: S.G. Beyer, S.M. Sogard, D.M. Stafford, R.B. MacFarlane, C.J. Harvey, J.C. Field

Climate effects on ecosystem productivity are well established for the California Current, and climate variability is reflected in bottom-up effects on fish growth and productivity. Stock assessments have begun to include these important effects in estimating critical metrics such as growth, spawning biomass, spawning output and recruitment, however, such variability is often difficult to quantify and typically even more difficult to appropriately account for in assessment models. In this study, we explored the consequences of variable oceanographic conditions on female bioenergetic allocation patterns, fecundity and growth. From 2009 through 2015, rockfish were collected during the winter reproductive season by hook-and-line methods off Central California. We combined our results with two published datasets to create a time series of female condition and egg production for chilipepper rockfish (2005-2008) and yellowtail rockfish (1985-1991, 2005-2008). Additionally, we aged nearly 10,000 chilipepper rockfish otoliths collected by fishery-independent bottom trawl surveys from 1983 to 2014, and utilized over 50,000 age estimates from otoliths collected from commercial fisheries from 1978-2014, to assess time-varying growth in mean length-at-age. The results of this study will be used to incorporate effects of variable oceanographic conditions on growth and reproduction into West Coast rockfish stock assessments.

For more information, please contact Sabrina Beyer at Sabrina.Beyer@noaa.gov

p) The legacy of a crowded ocean: indicators, status, and trends of anthropogenic pressures in the California Current ecosystem

Investigators: K.S. Andrews, G.D. Williams, J.F. Samhouri, K.N. Marshall, V.V. Gertseva, P.S. Levin

As human population size and demand for seafood and other marine resources increase, understanding the influence of human activities in the ocean and on land becomes increasingly critical to the management and conservation of marine resources. In order to account for human influence on marine ecosystems while making management decisions, linkages between various anthropogenic pressures and ecosystem components need to be determined. Those linkages cannot be drawn until it is known how different pressures have been changing over time. This paper identifies indicators and develops time series for 22 anthropogenic pressures acting on the USA's portion of the California Current ecosystem. Time series suggest that seven pressures have decreased and two have increased over the short term, while five pressures were above and two pressures were below long-term means. Cumulative indices of anthropogenic pressures suggest a slight decrease in pressures in the 2000s compared to the preceding few decades. Dynamic factor analysis revealed four common trends that sufficiently explained the temporal variation found among all anthropogenic pressures. This reduced set of time series will be a useful tool to determine whether links exist between individual or multiple pressures and various ecosystem components.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

7. Acoustic Modeling and Research

a) A high resolution acoustic imaging system to map interior fish morphology: Acoustic Imaging Microtome System (AIMS)

Investigators: D. Chu, J. M. Jech, S. D. Tomich, and L. C. Hufnagle Jr.

An Acoustic Imaging Microtome System (AIMS) was constructed to map the internal structure of fish (Figure 9). The system consists of two pairs of high-frequency (4.5 MHz) transmit and receive planar arrays, with one pair in the vertical plane and the other in the horizontal plane. AIMS provides a series of acoustic images, analogous to microtome slices, along the length of a fish by combining electronically controlled sequential acoustic transmissions and receptions over 224 channels and a computer-controlled mechanical device that moves the acoustic arrays lengthwise along the fish. AIMS measures the acoustic attenuation (extinction) along the direct ray paths of each transmit/receive channel pair that penetrates the fish body in a bistatic configuration. This results in a 2-D image of the interior morphology with 4-5 mm resolution. The images can provide morphological information on the fish's cheekbone, backbone, rib bone, skull, fins, stomach, and swimbladder, which is important for accurately modeling fish acoustic target strength, especially for non-swimbladder-bearing fish species.

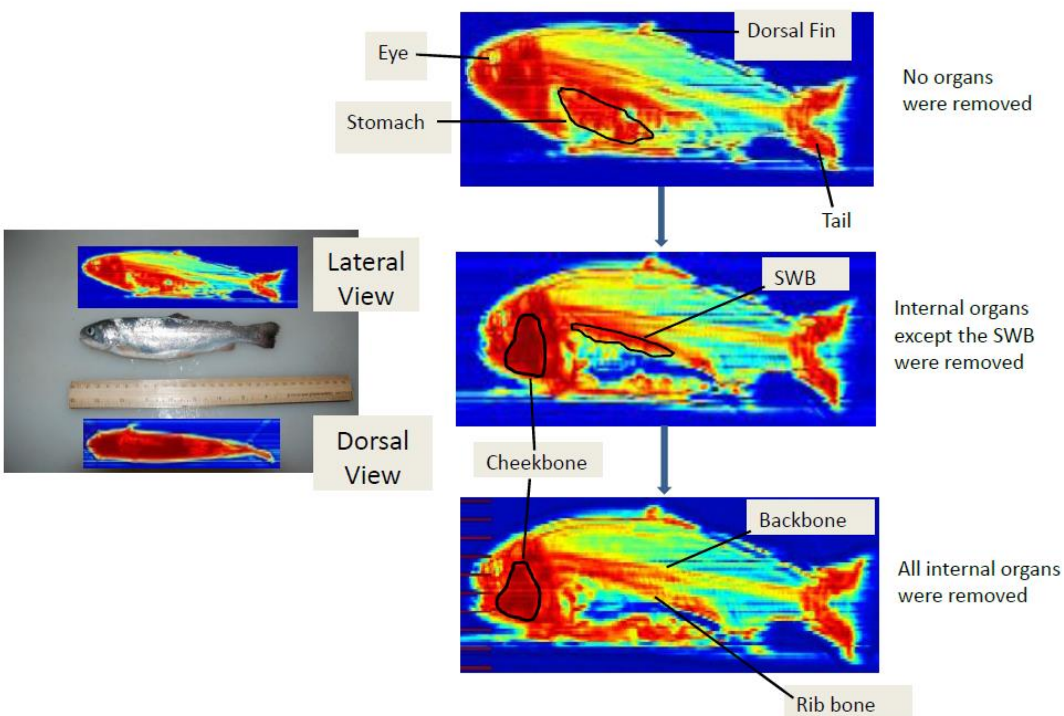


Figure 9. AIMS images of a ~20 cm juvenile steelhead (*Oncorhynchus mykiss)*. Left: photo of the specimen with ruler, and the lateral and dorsal views corresponding AIMS images; Top right: AIMS image of the live fish with on organs removed; Mid right: AIMS image of the fish with its internal organs except the swimbladder were removed; Bottom right: AIMS image of the fish with all of its internal organs including swimbladder removed.

For more information, please contact Dezhang Chu at Dezhang.Chu@noaa.gov

8. Advance Technologies

a) National Marine Fisheries Service, untrawlable habitat strategic initiative (UHSI)

The National Marine Fisheries Service, Untrawlable Habitat Strategic Initiative (UHSI) team conducted a pilot multi-tiered field experiment in the Gulf of Mexico during August 2014. The object of the experiment is to evaluate tools and sampling methods appropriate for estimating the sampling efficiency of imaging systems mounted on stationary-arrays, ROV, AUV, and towed vehicles used to count fish within a measureable sampling path. Three modular underwater sampling systems (MOUSS) that coupled stereo cameras and digital imaging sonars (DIDSON) were deployed along a transect line approximately 50 m apart to create a sampling corridor that was constantly observed for between 7-10 hours. Following two hours of deployment of the MOUSS systems the vehicles navigated through the corridor to measure species specific changes to those stimuli. Proof-of-concept was demonstrated in that species showed an initial startle response following MOUSS deployment and within 15 m had settled back into what appears to be regular habits. Additionally all three vehicles were successfully observed by the stationary MOUSS systems during transit. Ongoing analyses are being conducted for the stereo and DIDSON imaging systems, as well as the mobile platforms. As second Gulf of Mexico project is planned for summer 2015.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

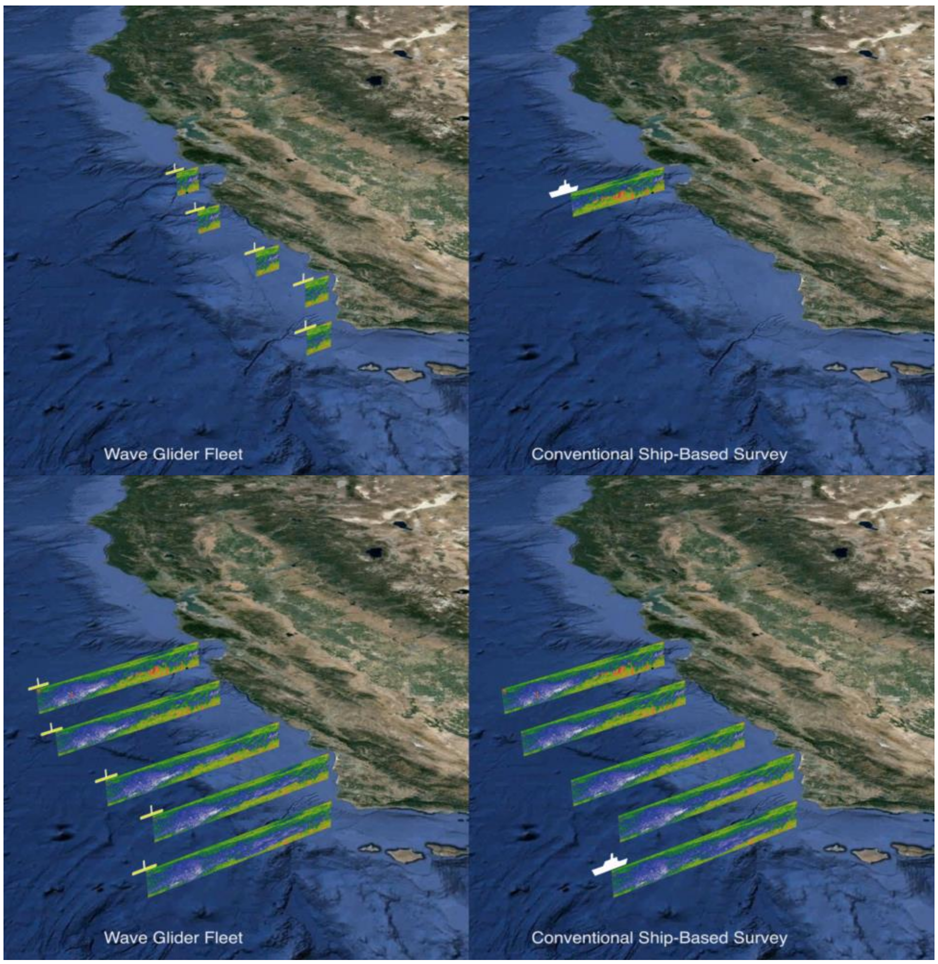
b) A wave glider approach to fisheries acoustics: transforming how we monitor the Nation's commercial fisheries in the 21st century

Investigators: C. H. Greene, E. L. Meyer-Gutbrod, L. P. McGarry, L. C. Hufnagle Jr., D. Chu, S. McClatchie, A. Packer, J.-B. Jung, T. Acker, and H. Dorn

Possessing the world's largest Exclusive Economic Zone (EEZ), the United States enjoys the benefits of a multi-billion dollar commercial fishing industry. Along with these benefits, comes the enormous task of assessing the status of the nation's commercial fish stocks. At present, many of the most valuable commercial fish stocks are assessed with acoustic surveys conducted from manned survey vessels. The expense and limited availability of ship time often compromise the quantity and quality of the acoustic stock assessment data being collected.

Here, we describe our vision for how an unmanned mobile platform, the Liquid Robotics Wave Glider, can transform fisheries acoustics into a science more consistent with the new ocean-observing paradigm. Wave Gliders harness wave energy for propulsion and solar energy to power their communications, control, navigation, and environmental-sensing systems. This unique utilization of wave and solar energy allows Wave Gliders to collect ocean environmental data sets for extended periods of time.

Recently, we developed new technology for Wave Gliders that enable them to collect multi-frequency, split-beam acoustic data sets comparable to those collected with manned survey vessels. A fleet of Wave Gliders collecting such data would dramatically improve the synoptic nature as well as the spatial and temporal coverage of acoustic stock assessment surveys. With improved stock assessments, fisheries managers would have better information to set quotas that maximize yields to fisherman and reduce the likelihood of overfishing. Improved observational capabilities also would enable fisheries scientists and oceanographers to more closely monitor the responses of different fish stocks to climate variability and change as well as ocean acidification.



(A)

(B)

Figure 10. A) Five wave gliders, each running their survey lines at 1.5 knots, can complete five transect lines in the same amount of time that a single manned survey vessel completes the same five transect lines; B) With a fleet of wave gliders, each one running a survey transect line, a full acoustic stock assessment of the west coast EEZ can be completed in one week, the same amount of time that a manned vessel would need to complete ~12.5% of the survey.

For more information, contact Dezhang Chu at Dezhang.Chu@noaa.gov

b) Southern California shelf rockfish hook-and-line survey external review

In April 2012, the design, methods, and analytical techniques associated with the hook and line survey were reviewed through the Center for Independent Experts (CIE). The CIE provided 2 reviewers, and one independent reviewer served as chair of a panel that evaluated the survey. The survey's design and methods received generally favorable remarks, and several new approaches were suggested for generating indices of abundance and addressing issues associated with gear saturation and inter-specific competition for hooks. Survey staff developed a formal response to the recommendations provided by the review panel which is available to the public.

For more information, please contact John Harms at John.Harms@noaa.gov

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

9. Observer Data Collection and Analysis

The FRAM West Coast Groundfish Observer Program (WCGOP) continued collecting fishery-dependent data during 2014 on groundfish fleets along the entire U.S. west coast. The groundfish fishery is broken down into two main categories the catch share fisheries and the non-catch share fisheries. The catch share fishery can be further broken down into the shorebased fleet and the at sea fleet. The at sea fleet includes catcher-processors (CPs) and motherships. The catch share fisheries require 100% observer and shore side monitoring. The non-catch share fisheries require observer coverage upon request and coverage is randomly assigned by fishery and port group.

Table 4. Number of observers that were deployed by the WCGOP in 2014

2014	Shorebased	CPs and Motherships
Number of catch share observers	**76**	**46**
Number of non-catch share observers	**27**	**-**

a) Catch Shares

There are three sectors in the catch share program: shorebased, motherships (includes motherships and mother ship catcher-vessels), and catcher-processors. All vessels participating in the shorebased sector or acting as mother ship 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 shore side processors. Catch shares regulations allow the shorebased sector to use trawl, longline, or pots to harvest IFQ species. The mother ship 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. Table 5 below provides information on observer activities in the catch share fishery.

Catch Share observers are deployed in the following catch share fisheries:

- All vessels participating in the Shore-based Individual Fishing Quota (IFQ) program including hake and non-hake groundfish trawl and fixed gear vessels
- All motherships participating in the at-sea hake fishery
- All mother ship catcher-vessels participating in the at-sea hake fishery

- All catcher-processors participating in the at-sea hake fishery

Table 5. Summary of observer coverage and sea days in the catch share fisheries

DESCRIPTION	SS IFQ Trawl	SS IFQ Fixed Gear	SS Hake	MSCV	CPs and Motherships
Number of vessels	64	22	25	19	14
Number of trips*	1,050	145	996	53	76
Number of Sea days*	4,203		2,255	726	1,652**
Number of Observers	76				46

*Includes trips and/or sea days where no fishing activity occurred
**Includes both Lead and Second observers

Note: Totals as of 3/10/2015. Since data have not been finalized, these could change in the future.

SS IFQ trawl: vessels targeting non-hake groundfish with trawl gear and landing at shore based processors.
SS IFQ Fixed Gear: vessels targeting non-hake groundfish using longlines or pots and landing at shore based processors.
SS Hake: vessels targeting hake using trawl gear and landing at shore based processors.
MSCV: mother ship catcher-vessel targeting hake with trawl gear
CPs and Motherships: mother ships and catcher-processors targeting hake using trawl gear

b) Non-catch shares

The observer program collects data in other west coast fisheries that are not part of the catch share program. The program had 1,611 sea days in the non-catch share fisheries in 2014 aboard vessels ranging in size from skiffs to larger fixed gear vessels and depths ranging from less than 20 ft. to more than 300 ft.

Table 6. Non-Catch Share sea day summary by fisheries/sectors:

NCS Sea Days

FISHERY DESCRIPTION	SEA DAYS*
CA Emley-Platt EFP	9
CA Fosmark EFP	2
CA Halibut	51
CA Nearshore	206
CA Pink Shrimp	71
Limited Entry Sablefish	350
Limited Entry Zero Tier	105
OR Blue/Black Rockfish	47
OR Blue/Black Rockfish Nearshore	130
OR Pink Shrimp	425
WA Pink Shrimp	138
WC Open Access Fixed Gear	77

*Includes sea days where no fishing activity occurred.

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.

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.

All WCGOP reports can be obtained at:
http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/index.cfm.

For more information, please contact Jon McVeigh at Jon.McVeigh@noaa.gov

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NMFS Southwest Fisheries Science Center

Draft Agency Report to the Technical Subcommittee

of the Canada-U.S. Groundfish Committee

April 2015

Edited by Xi He and John Field

With contributions from John Hyde,
Susan Sogard, Cindy Thomson, William Watson, and Mary Yoklavich

A. AGENCY OVERVIEW

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 Marine Mammal and Turtle Division (formerly the Protected Resources Division, led by Dr. Lisa Ballance), and the Fisheries Resources Division (led by Gerard DiNardo). 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 Fisheries Research Division 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 FRD 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 Dr. Toby Garfield and has researchers located in both Monterey and Santa Cruz. 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

B1. Effects of hypoxia on embryonic development, larval mortality and growth in rockfishes

Investigators: Neosha Kashef (UCSC), David Stafford (UCSC), & Susan Sogard (FED, SWFSC)
Viviparous rockfishes (*Sebastes* spp.) are exposed to varying oxygen levels during gestation in the dynamic oceanographic environment of the California Current. For species reproducing in spring, upwelling drives productivity by delivering nutrient rich water to nearshore habitat paired with low levels of oxygen. With climate change upwelling may vary in timing, frequency and intensity with the potential for rockfishes to have increased exposure to hypoxic waters both temporally and spatially. To learn more about the effects of hypoxia on rockfish reproduction we exposed female fishes with unfertilized eggs to 2, 4 and 8 mg/l oxygen levels – levels known to occur in their natural environment. Exposure continued for the duration of gestation and embryonic development was monitored every three days. After parturition larvae were placed in treatment tanks at the same three oxygen levels to evaluate depletion rates of lipid reserves, growth and mortality rates. Mothers in low dissolved oxygen treatments had higher incidence of embryo mortality and deformity. Preliminary results suggest that 50% mortality occurs sooner for post-parturition larvae reared in lower oxygen water. These data indicate that exposure to low oxygen concentrations during gestation and in early life stages may be both detrimental to larval production and survival. Information about the effects of oxygen on early life history of rockfishes will be valuable in informing future fisheries management.

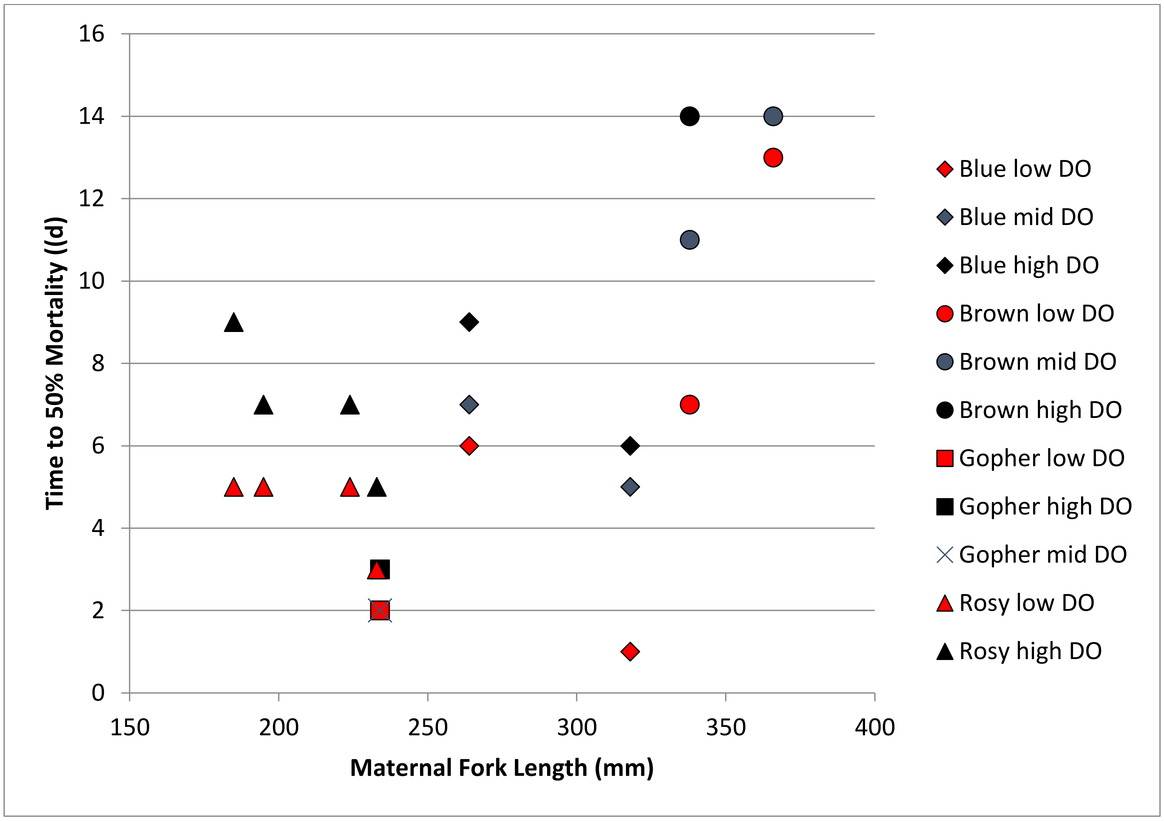


Figure B1. Time until 50% mortality of post-parturition rockfish larvae held in 3 dissolved oxygen levels; low = 2 mg L^{-1}, mid = 4 mg L^{-1}, and high = 8 mg L^{-1}. Sample sizes included 2 blue rockfish, 2 brown rockfish, 1 gopher rockfish, and 4 rosy rockfish females. Larvae were held in groups of 500.

B2. Ecosystem indicators for the Central California Coast, May-June 2014

Investigators: John Field and Keith Sakuma, Fisheries Ecology Division, SWFSC

The Fisheries Ecology Division of the SWFSC has conducted an annual midwater trawl survey for juvenile rockfish (Sebastes spp.) and other pelagic micronekton along the Central California coast in late spring (May-June) since 1983. Along with oceanographic information, the survey targets pelagic juvenile (young-of-the-year, YOY) rockfish and the micronekton forage assemblage (including other juvenile fishes, krill, coastal pelagic species, and mesopelagic species) for fisheries oceanography studies and stock assessments (Ralston et al. 2014). The data for the 2014 survey are preliminary. The SWFSC portion of the 2014 survey began on May 2nd, 2014 and ran through June 17th, 2014, onboard the R/V Ocean Starr, a research vessel under contract from Stabbert Maritime. A NWFMC survey team continued the survey into the waters off of Oregon and Washington at that time, however those results are not reported here.

The standardized anomalies from the mean of the log (x+1) catch rates are shown by year for six key YOY groundfish and forage groups (Figure 1), including all YOY rockfish, market squid (*Doryteuthis opalescens*), krill (primarily *Euphausia pacifica* and *Thysanoessa spinifera*), YOY Pacific sanddab (*Citharichthys sordidus*), Pacific sardine (*Sardinops sagax*) and Northern anchovy (*Engraulis mordax*). Notably, 2013 and 2014 had among the highest ever observed catches of juvenile rockfish, sanddab and market squid in the core, southern and northern areas, following an unusually stable trend of high krill abundance and very low abundance of Pacific sardine and northern anchovy in preceding years. The longer time series for juvenile rockfish suggests that 1984 and 1985 were years of comparable high abundance for juvenile rockfish (Ralston et al. 2013). In both 2013 and 2014, these observations were consistent with high reported catches of YOY rockfish and other groundfish in power plant impingement surveys, scuba surveys, commercial and recreational fishermen, and from food habits studies of seabirds and other predators in this region. Trends from the southern (Southern California Bight) and northern (north of Point Reyes to Cape Mendocino) areas, which have been sampled only since 2004, were highly consistent with these "core area" trends for Central California for most species. The observed dynamics of the YOY groundfish and high turnover invertebrates is thought to largely represents shifts in productivity associated with higher survival of early life history stages for these species, while the trends observed for coastal pelagic and mesopelagic species are thought to be more likely related to shifts in their distribution.

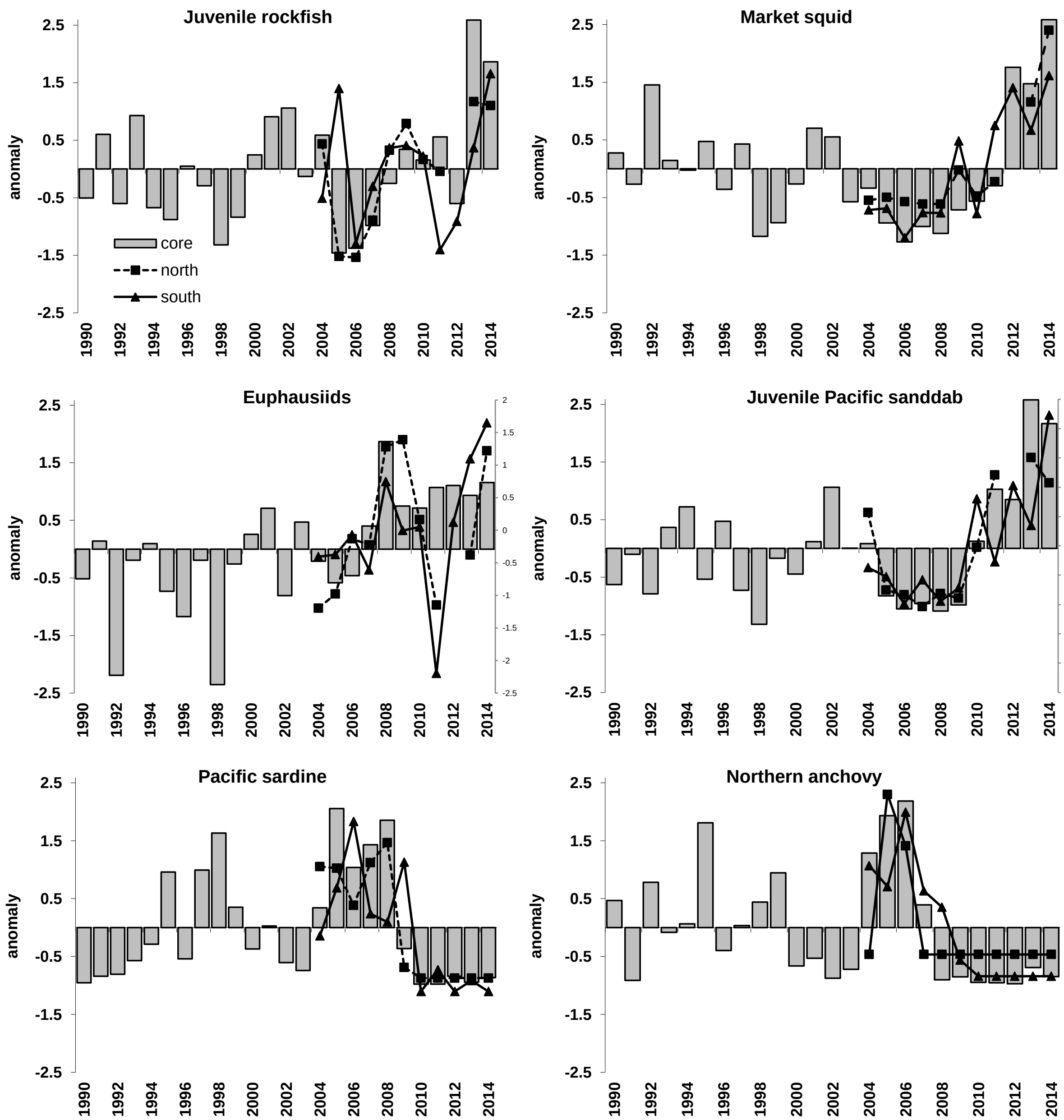


Figure B2: Long-term standardized anomalies of several of the most frequently encountered pelagic forage species from rockfish recruitment survey in the core (Central California) region (1990-2014) and the southern and northern California survey areas (2004-2014, excluding 2012 for the northern area).

B3. Research on larval rockfish at the SWFSC

Over the past year (2014-15) the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division in La Jolla continued to conduct molecular identification on larval rockfishes collected from CalCOFI cruises. The overall aim of this research is to develop species-specific larval rockfish time-series and then use these data to evaluate how spawning patterns of different rockfishes responded to environmental factors and the presence of rockfish conservation areas in Southern California between 1997 and the present. Methodologically, the project involves sorting rockfishes (which can mostly only be identified to genus based on morphology) from ethanol-preserved plankton samples, sequencing mitochondrial DNA from individual larvae and matching larval sequences to those from adults that have previously been identified to the species level. We are focusing on winter CalCOFI cruises because rockfish larvae are more abundant then relative to other seasons. During the past year we completed soring all ethanol-preserved winter samples between 1998 and 2013 and those from spring 2013. We also completed genetic identification of samples from 1998-2001, 2004-05, and 2011-2013. We anticipate that all genetic identifications will be completed by July 2015. Much of this work was made possible by funding from NOAA's Fisheries and the Environment program.

In addition to the molecular identification-based research, we have continued updating larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from mid-1965 through 2011, and by the end of this year expect to complete samples collected during the first half of 1965 in addition to completing all 2012 samples. This provides a nearly 50 year time series of larval abundances of the rockfish species visually identifiable as larvae (*S.aurora, S. diploproa, S. goodei, S. jordani, S. levis, S. paucispinis*).

C. BY SPECIES, BY AGENCY

C1. Nearshore rockfish stock assessments

The Pacific Fishery Management Council requested a full assessment of China rockfish in 2015, which will be used to inform harvest guidelines for the 2017-18 management cycle. Assessment scientists at the NMFS SWFSC (E. Dick and M. Monk) are working with co-authors from the NWFSC (I. Taylor and M. Haltuch), as well as staff from state agencies, to complete the revised assessment. The previous assessment, completed in 2013, was based on a new "data-moderate" assessment format, and found that the northern subpopulation (from Cape Mendocino, California, to the US-Canada border) was below target biomass with a declining trend in abundance. The subpopulation south of Cape Mendocino was above target biomass with an increasing trend in recent years.

The revised, "full" assessment will consider additional data sources including age and length composition data and new indices of abundance, namely a trip-based index of recreational catch and effort from Washington's Ocean Sampling Program, and a nearshore commercial logbook index for Oregon. The assessment will also examine data sources to inform assumptions about stock structure in the model, as this was a point of extensive discussion during the 2013 assessment.

C2. Shelf Rockfish

C2.a. Rockfish barotrauma and survival research at SWFSC Lo Jolla Lab

The SWFSC Genetics and Physiology program continues to evaluate post-release survival of rockfish (Sebastes spp.) suffering from barotrauma and released using recompression devices. This work relies upon the use of externally attached acoustic tags equipped with depth and accelerometer sensors to send data to a receiver array that allows us to determine survival and behavior of released fish. Building upon previous work we expanded our receiver array at the 43 fathom bank to allow us to incorporate 3D tracking of individual fish in addition to the basic behavior and survival data that we were previously collecting. These tracking data will provide a rare insight into natural movements (horizontal and vertical) at fine temporal (~ 4min data points) and spatial (+/- a few meters) scales, allowing us to better understand habitat and foraging behavior which ultimately will inform capture probabilities in visual and acoustic based surveys. In addition to fish tracking, multiple oxygen as well as temperature & depth loggers are deployed between 80 and 200m to characterize the seasonal incursion of hypoxic water into this important depth habitat for rockfishes in southern California and allow us to monitor behavior of fish in relation to oxygen saturation.

In FY14/15 we deployed 40 accelerometer and depth sensor tags on bocaccio (*S. paucispinis*) and 14 on cowcod (*S. levis*). Twelve of the 40 bocaccio were also fitted with dissolved oxygen sensor tags to monitor fine-scale oxygen preferences. An additional 15 bocaccio have been brought into captivity for measurement of both $O_{2critical}$ and $O_{2lethal}$ with evaluation of how acclimation to normoxic and hypoxic conditions affect these measures. Planned lab experiments using hyperbaric respirometery chambers will evaluate the effect of simulated capture and recompression on these values. Together the lab and field data will be used to better understand post-release survival of rockfishes and whether there may be seasonal variation in these estimates due to shoaling of hypoxic water masses.

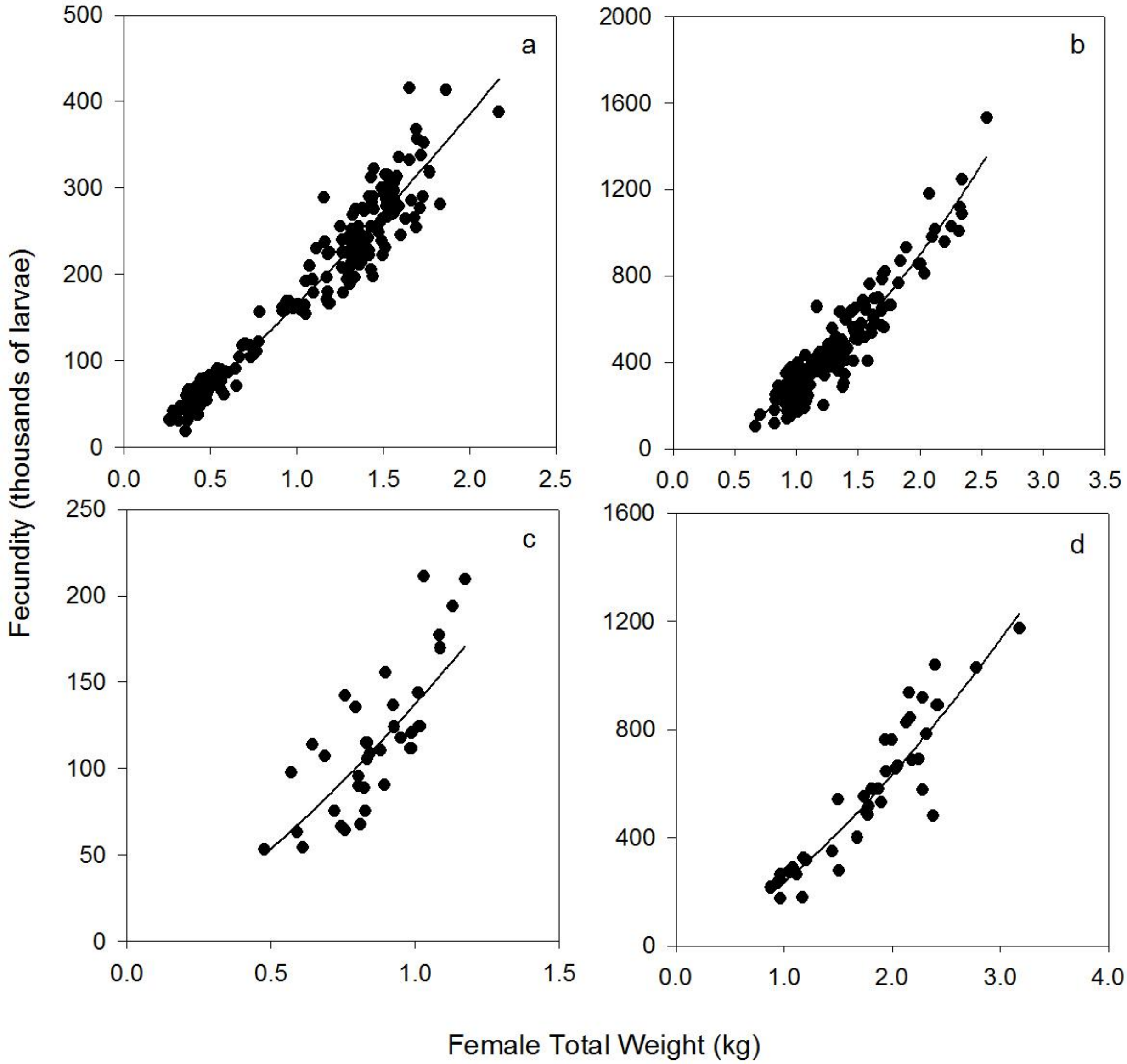
C2.b. Stock assessments

FED staffs are conducting two shelf rockfish stock assessments (Bocaccio and Chilipepper Rockfish) in 20015. The Bocaccio assessment model is to be a full assessment and will be reviewed by a STAR Panel in July 2015, while the Chilipepper is an assessment update (updates include new data but do not change the data inputs or basic model structure) of the 2007 stock assessment. The 2007 update found the Chilipepper rockfish stock to be above target levels, with catches and harvest levels far below the target levels due to area closures implemented to rebuild co-occurring species (such as Bocaccio and Canary rockfish). As catches have remained low since that time, and survey indices have continued to indicate high recruitment (juvenile indices) and high abundance levels (bottom trawl surveys), the stock is anticipated to continue to be above target levels.

For the Bocaccio stock assessment, a comprehensive study has been undertaken since 2014 to age Bocaccio since no age data were used in Bocaccio stock assessments in the recent stock assessments and were recommended by the last stock assessment reviews. The ageing process included development of ageing criteria, ageing validation, and analysis of ageing errors (Pearson et al. in review). Over 10,000 Bocaccio otoliths have been aged, and a simulation study to examine effects of numbers of age data on estimations of fish growths in stock assessment models was also conducted (He et al. in review). The Bocaccio stock assessment will be conducted using the latest available Stock Synthesis (SS) program.

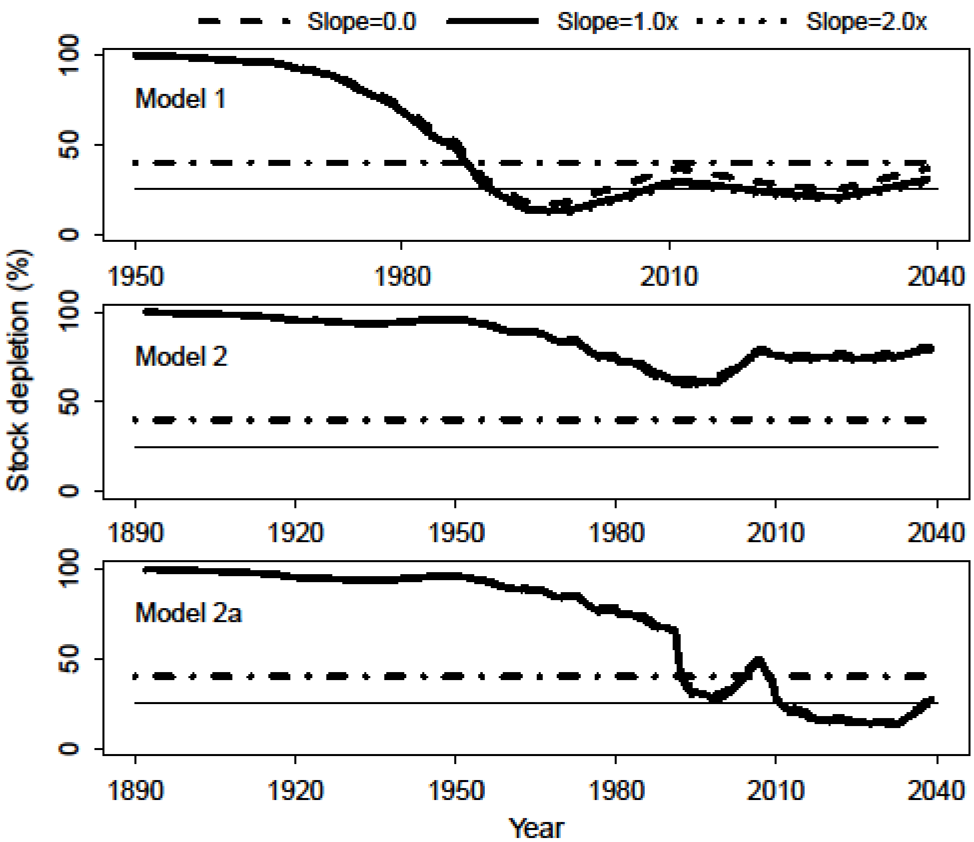
C2.c. Relative fecundity of rockfish and their effects in fishery stock assessments

A study was conducted to investigate the reproductive ecology of four rockfish species residing in the California Current: Chilipepper, *Sebastes goodei*; Yellowtail rockfish, *S. flavidus;* Speckled rockfish, *S. ovalis*; and Blackgill rockfish, *S. melanostomus* (Beyer et al. 2015). Females were sampled from Northern to Southern California during the winter parturition season (November through March) of 2009, 2010, 2011 and 2012 to assess spatiotemporal trends in fecundity. Maternal length and weight were positively correlated with relative fecundity (Φ_{rel}, larvae per g somatic weight) in all four species, indicating a disproportionately greater reproductive output by larger, older females. Yellowtail rockfish had the highest absolute fecundity and Φ_{rel}, the greatest maternal size effect, and produced the smallest sized eggs. For Yellowtail rockfish and Chilipepper, fecundity varied spatially among sampling locations, but did not significantly vary over time within the years sampled (sample sizes for Speckled and Blackgill rockfish were too small to allow spatiotemporal comparisons). Two reproductive strategies were evident as Yellowtail rockfish and Blackgill rockfish produced a single brood of larvae annually in contrast to Chilipepper and Speckled rockfish, which both produced multiple broods in Southern California and to a lesser extent in Central California, complicating estimates of annual fecundity. There was some evidence that egg production was positively correlated with female condition, indicating that environmental variability in oceanographic conditions and productivity may drive changes in fecundity and reproductive strategy (i.e., single versus multiple broods) in these species.



Figuer C2c.1. Relationship of absolute fecundity (Φ) with maternal size (weight; kg) for Chilipepper (a), Yellowtail rockfish (b), Speckled rockfish (c), and Blackgill rockfish (d)

A study was conducted to examine effects of misspecifications of size-specific fecundity (Φ_{rel}) functions on estimated stock assessment parameters and related management quantities using two stocks (Chilipepper and Blackgill rockfish) as case studies and three sets of simulation models, chosen to represent wide ranges of life and fishing histories (He et al. 2015). The results showed that misspecification effects were relatively small when stocks were less depleted (e.g. 75% of virgin spawning output), but could lead to more substantive misspecifications in more depleted stocks with slower growth and lower mortality rates. For example, we found that stock was estimated to be as much as 20% less depleted if a strong size-specific Φ_{rel} exists in a population, but no size-specific Φ_{rel} is used in the model. This represents a non-trivial shift in the perception of status for most stocks. The results also showed that overestimating the strength of the size-specific Φ_{rel} function in stock assessment models led to smaller estimation errors in assessment outputs compared to underestimating the size-specific Φ_{rel}. The results are insightful with respect to the importance of gathering data on size-dependent Φ_{rel} and other aspects of reproductive ecology, as well as with respect to the nature of assumptions that are made with regards to reproductive ecology in data limited situations.



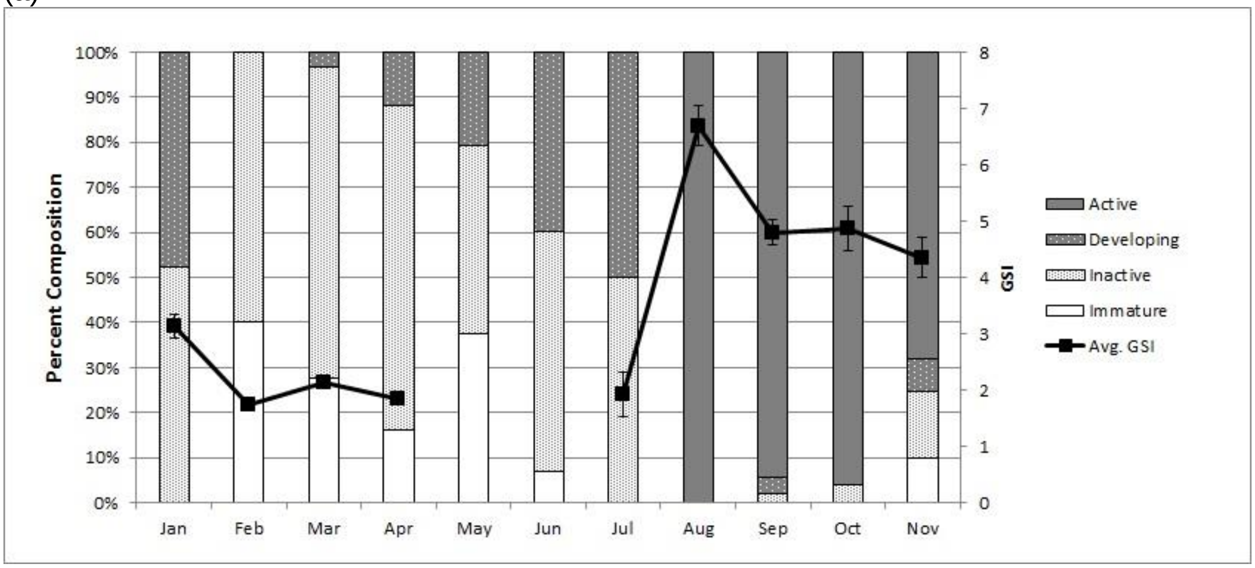
Figuer C2c.2. Time series of median stock depletion from three individually simulated assessment runs with three slopes of weight-specific relative fecundity (Φ_{rel}) functions for three simulated operating models, each with a base run slope of 1x. Two horizontal lines are management references (solid = overfished limit; dotdash = management target).

C2.d. Reproductive biology of Pacific Sanddab

A manuscript is in review (first presented at the International Flatfish Symposium in 2014) which reports the results of a series of studies were initiated in 2012 to evaluate the reproductive dynamics of female Pacific sanddab (*Citharichthys sordidus*) initially in support of a 2013 stock assessment of that species (Levebvre et al. in review). The study presents data on the annual reproductive cycle (based on both macroscopic and histological observations); length at maturity; batch fecundity; spawning fraction and spawning interval, based on both field collected

and captive female Pacific sanddabs. Results suggest that during the reproductive season (from approximately May through January) the fraction of spawning females ranged from 42 to 98%, indicating that females were spawning on a near daily basis throughout much of the season. A comparison of the size at maturity from historical studies relative to this study also suggested a downward shift in the size at maturity since the 1940s, although the magnitude and cause of this shift remain unknown. Pacific sanddab were determined to have asynchronous oocyte development and indeterminate fecundity. Absolute batch fecundity was variable, and significantly related to maternal length, while relative batch fecundity was weakly but significantly related to maternal length. Studies of captive fish demonstrated that females were capable of spawning on successive days, and values of fecundity and I were similar to those estimated from
wild-caught fish.

(**a**)



(**b**)

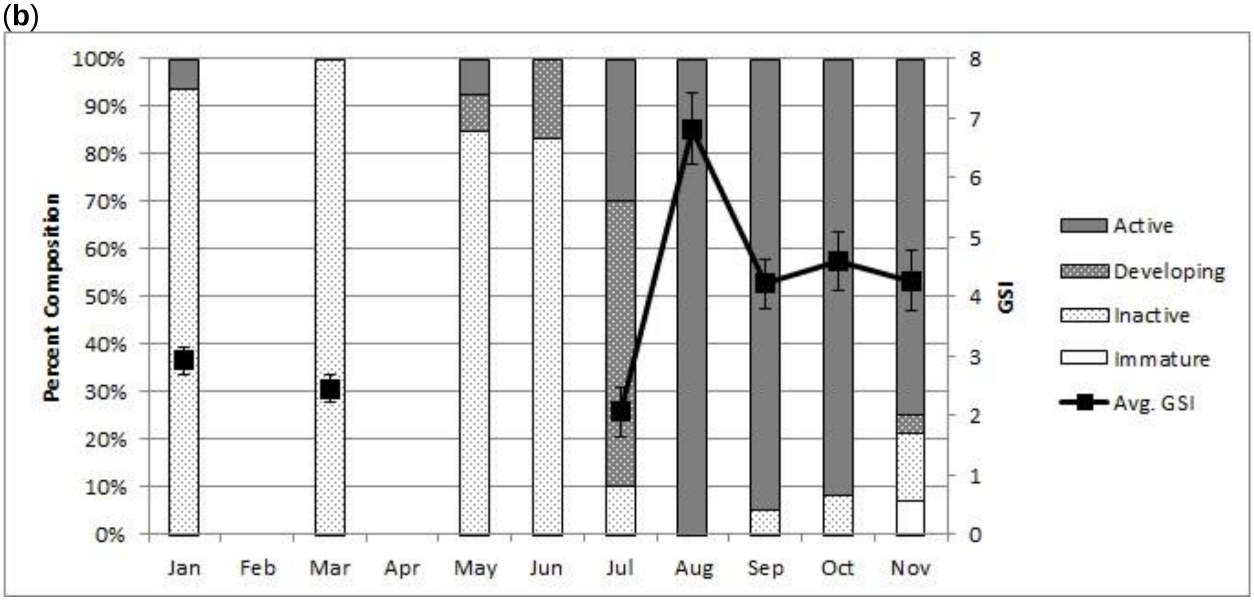


Figure C2.d. Percent composition of females in gross maturity categories and average GSI values for Pacific sanddab (*Citharichthys sordidus*) collected March 2012-April 2013 for (a) all females collected (n=312), with gross maturity based on macroscopic staging and (b) females examined histologically (n=97).

D. OTHER RELATED STUDIES

D1. Estimating unfished potential of Cowcod abundance off central and southern California

Investigators: Mary Yoklavich and David Huff

We are developing models to predict cowcod (*Sebastes levis*) abundance using data collected during visual surveys conducted from a human-occupied submersible off central and southern California and from data on a number of habitat variables. Potential model covariates have been extracted from a regional oceanographic modeling system (ROMS) via a data-assimilated, 8-day overlapping analysis spanning the period 1980-2011. This analysis provides estimates of salinity, temperature, and ocean currents at 1/10-degree resolution. A coupled biological model provides estimates of diatoms, NO3, particulate organic nitrogen, predatory zooplankton, meso- and microzooplankton, nanophytoplankton, dissolved organic nitrogen, irradiance, NH4, Chlorophyll a, and SiOH4. All values were extracted for depths near the seafloor at sample locations and were time-averaged over a one-month period corresponding to sample date. The data also have been extracted for the spatial extent of the study area over the entire sampling period to develop climatologies that may be used for model predictions and to display the quantity and extent of available habitat. We estimated surface productivity from spatial extents that correspond to persistent positive temporal deviations from a 10-year climatology developed with remotely sensed chlorophyll concentrations. A digital elevation model (DEM) provided depth, slope, and other derived seafloor features at 90-meter resolution.

Cowcod are designated as overfished, and consequently occupancy in their rocky habitat is very low. We are developing generalized additive models to estimate ‘unfished potential abundance’ within cowcod depths and bottom types. Selected models included bottom temperature and current velocity and primary productivity as predictors. We are identifying a reference condition to calibrate our statistical model, using data from sites with the greatest number of ‘fishable’ sized rockfishes of any species. With this approach we try to avoid the pitfall of developing a model in which the number of individuals observed might not represent all suitable habitat because of the depleted condition of the stock. Potential cowcod abundance can be compared between Southern California Bight and the Central Coast. Comparisons can be made with more traditional assessments that are based on fishery data. Our results also can help in understanding affects of climate change on fish distributions.

Contact: mary.yoklavich@noaa.gov

D2. Habitat-based predictive mapping of rockfish density and biomass off the central California coast

Investigators: Mary Yoklavich and Lisa Wedding

Understanding the association between components of habitat and fish distribution and abundance is important in order to achieve accurate stock assessments. We developed generalized additive models (GAM) and spatially predictive maps of rockfish abundance at the individual species level using habitat descriptors collected from visual surveys and fine-scale bathymetry. We advanced beyond presence/absence and presence only models to create predictive maps of density (number of fish/100 m^2) and biomass (kg of fish/100 m^2) for *Sebastes* *rosaceus* (Rosy rockfish) and *S. constellatus* (Starry rockfish), both common species in commercial and recreational fisheries along the central coast of California. Selected models included co-variables of seafloor depth, complexity, substratum type, and heterogeneity. Predicted density and biomass of both species were highest in areas of complex rock on the continental shelf off Point Lobos and Point Sur in 50-90 m (*S. rosaceus*) and 80-120 m (*S. constellatus*) water depth. We estimated absolute abundance of these species in our entire central California study area. Our results will be useful both in stock assessments of these data-poor species as well as in allocation of fishing effort, catches, and other space-based management decisions.

Contact: mary.yoklavich@noaa.gov

D3. A Comparative Assessment of Visual Survey Tools: Results of a workshop and user questionnaire

Investigators: Mary Yoklavich, Jennifer Reynolds, Dirk Rosen

Visual surveys of seafloor habitats and associated organisms are being used more commonly in marine science, and yet researchers and resource managers continue to struggle in choosing among available underwater tools and technologies. In this report, we present the results of a comprehensive questionnaire and a corresponding workshop that address the capabilities, limitations, operational considerations, and cost for five mobile, visual, survey tools: remotely operated vehicles (ROV) used in both shallow and deep water; autonomous underwater vehicles (AUV); human-occupied vehicles (HOV); towed camera sleds (TCS); and human divers recording data (scuba). These tools were considered specifically in the context of their use during systematic surveys of benthic organisms (i.e., fishes, megafaunal invertebrates) and components of their seafloor habitats. This information represents the knowledge, interests, and expertise of a broad group of marine scientists, engineers, and resource managers, and provides specific, practical guidance as well as insight on what is needed to advance the use of these tools and improve data collection for a variety of science and management applications.

Contact: mary.yoklavich@noaa.gov

D4. A summit on the role of deep-sea corals and sponges as habitat for managed species off the West Coast and Alaska.

Investigators: Mary Yoklavich, Steve Copps, Jon Heifetz, Tom Hourigan, Milton Love, Sean Rooney, Chris Rooper, John Stadler, Bob Stone, Brian Tissot, Fan Tsao, Waldo Wakefield, and Curt Whitmire

Understanding the function of deep-sea corals and sponges (DSC&S) as groundfish habitat is fundamental to the review and management of groundfish essential fish habitat (EFH) for the Pacific Fishery Management Council (PFMC), the North Pacific Fishery Management Council (NPFMC), and other Councils. Whereas the vulnerability of DSC&S may evoke strong calls for conservation, there is limited information on the distribution, abundance, and ecological function of DSC&S taxa. The role of DSC&S as a component of groundfish EFH, in particular, is not well established. Strong associations between rockfishes and DSC&S have been documented from visual surveys conducted in Alaska (e.g., Aleutian Islands and parts of the Gulf of Alaska) and between rockfishes and sponges in Grays Canyon off Washington, but not from other similar surveys off the West Coast. A key consideration is whether similar levels of association of DSC&S and groundfishes along the West Coast can be inferred from visual surveys conducted in areas of Alaska with similar habitats.

To improve our understanding of the role of DSC&S as habitat (particularly EFH) for groundfishes, NMFS convened a web-enabled series of 8 seminars from August 2014 to February 2015. These science-based seminars were presented by researchers with expertise in associations and functions of DSC&S as habitat and attracted significant interest and discussion nationwide. To download the seminars, go to https://swfsc.noaa.gov/DeepseaCoralSeminars/. Following the webinar series, a core group met at an in-person Summit at NOAA's Sand Point facilities in Seattle, Washington 3–5 March 2015. The Summit brought together 13 researchers and other subject-matter experts from NMFS Alaska Fisheries Science Center, Northwest Fisheries Science Center, Southwest Fisheries Science Center, West Coast Region, Office Habitat Conservation, and academia to summarize the scientific understanding of the association and functions of DSC&S as habitat for groundfishes off the West Coast and Alaska. A white paper on Summit outcomes has been submitted to the PFMC in the context of their deliberations related to Pacific Coast groundfish EFH; this document will be submitted to the NPFMC in the coming months. A review paper on this topic is forthcoming.

Contact: mary.yoklavich@noaa.gov

D5. SWFSC FED Economics Team Activities

In 2014 the FED's Economics Team completed an economic survey of California groundfish anglers. The main objective of the survey was to assess the effects of recreational groundfish regulations on angler preferences and behavior. The survey was designed in coordination with the California Department of Fish and Wildlife and groundfish biologists at FED and the University of California, Santa Barbara. Analysis of survey data is currently underway.

The Economics Team completed two manuscripts that are in internal review.

- Thomas-Smyth, A., A. Mamula and C. Speir. Assessing the accuracy of high spatial resolution effort data: comparing VMS and logbook data in the California groundfish trawl fishery.
  This paper develops a feasible GIS-based method of integrating trawl logbook data with high-resolution spatial data from Vessel Monitoring Systems (VMS). This work includes use of a speed-based criteria for inferring fishing activity from VMS data, and tow path reconstruction based on bathymetric interpolation of fishing locations between the start and end coordinates of tows reported in logbooks.
- Mamula, A. and T. Collier. Multifactor productivity, environmental change, and regulatory impacts in the US West Coast groundfish trawl fishery, 1994-2013.
  This paper estimates multifactor productivity for vessels participating in the West Coast Limited Entry Groundfish Trawl Fishery from 1994 to 2013. The paper focuses on the impact of regulatory changes (including the 2003 vessel buyback and 2011 catch share program) on productivity, and analyzes productivity dynamics across spatial, behavioral and scale dimensions.

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STATE OF ALASKA
GROUNDFISH FISHERIES

ASSOCIATED INVESTIGATIONS IN 2014

Prepared for the Fifty-fifth 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.
Kenneth J. Goldman, Kristen Green, Lee Hulbert, Mike Jaenicke,
Kevin McNeel, Scott Meyer, Jan Rumble, Elisa Russ, Gail Smith,
Mark Stichert, Maria Wessel, and Carrie Worton

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ALASKA DEPARTMENT OF FISH AND GAME
DIVISION of COMMERCIAL FISHERIES & DIVISION of SPORT FISH
Capital Office Park
1255 W. 8th Street
Juneau, AK 99802-5526

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STATE OF ALASKA GROUNDFISH FISHERIES AND ASSOCIATED INVESTIGATIONS IN 2014

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 nautical 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 140º W. longitude. The North Pacific Fisheries Management Council (Council) 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 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 fisheries. 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 (EEZ) equidistant line boundary in Dixon Entrance north and westward to 144º 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 where the groundfish project leader, a fisheries biologist, and one full-time fisheries technician are located. Two full-time biologists are based in Douglas. Seasonal technicians and port samplers are employed in Petersburg, Ketchikan and Sitka. In addition, one seasonal biologist will be hired in Petersburg in the spring of 2015. The project also receives biometric 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 Council Gulf of Alaska Groundfish Plan Team and produces the annual stock assessment for DSR for consideration by the Council.

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 2014. An additional assessment survey was planned aboard the ADF&G vessel the R/V *Solstice*; however, was cancelled due to weather. The ADF&G vessel the R/V *Medeia* is home ported in Juneau and is used to conduct a biennial sablefish marking survey that was last conducted in 2013.

b. Central Region

The **Central Region** groundfish staff is headquartered in Homer and consists of a regional groundfish/shellfish management biologist, a regional groundfish/shellfish research project leader, a groundfish port sampling and age reading coordinator, who also serves as an assistant area management biologist, a groundfish fish ticket processing and data analysis position, two groundfish/shellfish research biologists, one GIS analyst, three to four seasonal technicians, and one seasonal commercial groundfish sampler, who also serves as the primary groundfish age reader. An assistant area management biologist and a seasonal commercial groundfish sampler are also located in Cordova and a seasonal groundfish sampler in Seward. Regional support is located in Anchorage. The regional groundfish management biologist serves as a member of the Council's Gulf of Alaska Groundfish Plan Team, and the research project leader serves on the Council Non-Target Species Committee and as a member of the Kasitsna Bay Lab Science Board. The age reading coordinator is the current Chair of the Committee of Age Reading Experts (CARE), a Working Group of the Technical Subcommittee (TSC). 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 staff responsibilities include research and management of groundfish species harvested in state waters of **Central Region,** which includes Cook Inlet (CI) and Prince William Sound (PWS) areas, as well as in federal waters for black, blue, and dark rockfishes, and lingcod. Within Central Region, groundfish species of primary interest include sablefish, Pacific cod, walleye pollock, lingcod, rockfishes, skates, sharks, and flatfishes. Data are collected through commercial groundfish sampling, fishermen interviews, logbooks, onboard observing, and through ADF&G trawl, pot and remotely operated vehicle (ROV) surveys. Commercial harvest information (fish tickets) is 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 into local databases to provide additional information, including catch composition, catch per unit effort, depth, and location 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 15,000 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 interviews and biological data collections from commercial groundfish landings; and a number of research projects. In addition, the Westward Region has a member on the Council Bering Sea/Aleutian Island Groundfish Plan Team (Dave Barnard) and the Gulf of Alaska Groundfish Plan Team (Mark Stichert).

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 the collection, 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 are 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 personnel, 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 personnel 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 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. Age determination is 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 Council, 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 (BOF), NMFS, Council 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 Council 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 Council 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 Council, 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 2014, ADF&G AKFIN personnel processed 19,069 groundfish fish tickets, collected 17,817 groundfish biological samples and measured 11,821 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 personnel 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 2014

ADF&G Region	
1 - Southeast	3,167
2 - Central	4,210
4 – Westward (Kodiak, AK Pen.)	10,411
4 – Westward (BSAI)	1,281
Total	19,069

Groundfish Biological Data Collection - Calendar Year 2014

ADF&G Region	AWL Samples Collected	Age Estimates Produced by Regional Personnel	Age Estimates Produced by the Age Determination Unit
1 - Southeast	4,196	none	4,140
2 - Central	10,990	1,460	1,078
4 - Westward	6,827	5,143	N/A
Total	17,817	6,603	5,218

Interagency 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. Data are transferred annually to the Commercial Fisheries Entry Commission, where additional license and value information is merged with all fish ticket records. Once completed, the data are provided to the Alaska Fisheries Information Network (AKFIN) support center.

Beginning in 2001, the agencies tasked with commercial fisheries management in Alaska (ADF&G, NMFS, IPHC) began development of consolidated landing, production, and IFQ reporting from a sole source – the Interagency Electronic Reporting System (IERS). The goal is to move all fisheries dependent 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 groundfish and salmon tender vessels. The application and the landings reports are stored on a portable thumb drive and are 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 implementing an electronic logbook application, ***eLogbook***, currently used by groundfish catcher processors. The ***eLogbook*** has expanded to be used with groundfish longline and crab catcher vessels. The IERS has been in successful operation in Alaska's commercial fisheries since August 2005. To date, more than 500,000 landing reports have been submitted to the eLandings repository database.

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 tendered salmon fishery fleet by the end of the 2015 season. Statewide shellfish and herring fisheries will be addressed in 2016.

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 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 2014, the IERS recorded more than 106,250 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, 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 vessel operators.

Within the confines of confidentiality agreements, detailed data are distributed to the State of Alaska Commercial Fisheries Entry Commission (CFEC) annually. Detailed groundfish data are available to the National Marine Fishery Service NMFS-AK Region from the eLandings respository database. The AKFIN Support Center receives groundfish data on a monthly schedule, which is summarized and provided to the Pacific States Fisheries Information Network (PACFIN). 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 Council and summarized data to 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 BOF, the 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 ADF&G's statewide groundfish and invertebrate age reading program, the Mark, Tag, and Age Laboratory's Age Determination Unit (ADU), continued to provide age data to regional managers in 2014. The ADU received 8,484 specimens representing 11 groundfish species from statewide commercial and survey sampling efforts. The ADU distributed 5,218 groundfish ages to region managers, which included data from samples received in previous years but processed in 2014. Sablefish and yelloweye rockfish (4,158 and 1,060 ages released, respectively) were the only groundfish processed in 2014 due to the availability of calibrated age readers. Age data quality was assessed through precision testing of approximately 30% of reads along with comparing measured fish lengths and otolith weights at age to estimated ranges for 100% of age data produced. Quality control processes resulted in 3,853 age estimates in 2014. Additionally, 1,732 specimens were processed as part of training and calibration procedures. With training, quality control, and data production, ADU age readers evaluated 10,803 groundfish specimens in total. To increase the rate and complexity of age structure processing, the ADU acquisitioned new sectioning and polishing equipment to develop serial and mounted thin sections.

To collect objective data used in quality control procedures, a minimum of one age structure from each groundfish was measured for length, height, and weight. Measurements were used to identify errors arising from specimen handling, data entry, species misidentifications, or age assignments. The derivation of morphometric-age models and evaluation of measurement data utility was presented at the 2014 Western Groundfish Conference. To further develop the ADU's ability to take precision age structure measurements, four ADU members attended a two day training on image analysis using Image Pro Premier® software. In total, 7,509 age structures were measured as part of production procedures in 2014.

To evaluate, standardize, and advance age estimation processes for both commercial and sport State fisheries, the ADU hosted a two day meeting with the four State of Alaska groundfish age labs. This meeting initiated several important conversations about standardizing processes, provided a mass review of age criteria and methodology for commercially important species, initiated two lingcod age structure exchanges (from Region 4 to the ADU and Region 2 Sport), and discussed differences between the labs.

The ADU continued to participate in CARE, a Working Group of the TSC, throughout 2014. The ADU exchanged data and specimens regarding radiometric bomb carbon validation studies and the identification of signature years with other CARE agencies, and was involved in additional age structure exchanges including shortraker rockfish. The ADU was also involved in planning the 2015 CARE meeting and processing workshop.

Approximately 30% of funding for this project was provided by AKFIN, and the majority of funding (70%) was provided by the State of Alaska. The ADU employed five people throughout 2014 for approximately 47 work months to age groundfish and invertebrates, process samples, enter data, maintain sample archives, measure samples, and complete other support tasks.

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 BOF 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 that 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 or responds to 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 144º 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 regionwide Chinook salmon harvest studies project. The project leader, the project biometrician, and the project research analyst are based in Juneau. Beginning in 2014, the Area Management Biologists in Yakutat, Juneau, Sitka, Petersburg, Ketchikan, and Craig were responsible for the onsite daily supervision of the field technicians. 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 rockfish lengths and species composition; halibut length; lingcod length and sex; and sablefish length. No otoliths or other age structures were collected. Data summaries were provided to the Alaska BOF, other ADF&G staff, the public, and a variety of other agencies such as the Council, IPHC and NMFS.

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, sharks, sablefish, and Pacific cod, 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 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 were forwarded to the IPHC for age reading.

Southcentral Region staff is responsible for management of groundfish fisheries in state and federal waters. The lack of stock assessment information for state-managed species has prevented 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. Stock status is evaluated by examining times series data on age, size, and sex composition. The lack of stock assessments, coupled with increasing effort and harvest in several groundfish sport fisheries, accentuate the need for developing comprehensive management plans and harvest strategies.

Typical duties included providing sport halibut harvest statistics to IPHC and Council, assisting in development and analysis of the statewide charter logbook program and statewide harvest survey, providing information to the Alaska BOF, advisory committees, and local fishing groups, drafting and reviewing proposals for recreational groundfish regulations, and dissemination of information to the public.

B. By Species

1. 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** discontinued the cod-tagging program in 2011 that was initiated in 1997 in the Central, Western, and Eastern Gulf of Alaska. A total of 18,670 tags have been released. Tagged cod continue to be captured from earlier years, with five recovered in 2014. 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 have occurred. 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 Unalaska 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 2014.

c. Management

Regulations adopted by the Alaska BOF 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 acceptable biological catch (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 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. Guideline harvest levels (GHL) are allocated by gear type; however, the one exception was longline gear in PWS until 2014. In 2011 the BOF adopted thresholds 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, and in 2014 the BOF adopted regulations to allocate pot and jig to a combined 15% of the GHL with a step up and step down provision.

The Council established sector allocations for the federal Central Gulf of Alaska (CGOA) Pacific cod fisheries implemented in 2012. The Council'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 was prosecuted independently of other Pacific cod federal gear sectors, 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 BOF 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.

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 feet overall length (OAL) 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 ADF&G considered these changes manageable. The annual GHLs are based on the estimate of acceptable biological catch (ABC) of Pacific cod as established by the Council. Current GHLs are set at 25% of the Central Gulf ABC, apportioned between the Kodiak, Chignik, and Cook Inlet Areas and 25% of the Eastern Gulf ABC for the Prince William Sound Area. Historically 25% of the Western Gulf ABC was reserved for the South Alaska Peninsula Area. In October 2013, the BOF increased the South Alaska Peninsula Area ABC apportionment from 25% to 30% of the Western Gulf Pacific cod ABC.

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 foot OAL vessel size limit in the Chignik and South Alaska Peninsula Areas. The BOF also adopted a harvest cap for vessels >58 feet that limited harvest to a maximum of 25% of the GHL in the Cook Inlet Area and 50% of the GHL in the Kodiak Area. The fishery management plans also provided for removal of restrictions after October 31 on exclusive area registrations, vessel size, and gear limits to increase late season harvest 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 BOF 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 of the acceptable biological catch (ABC) of Pacific cod as established by the Council 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 BOF 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 feet or less OAL for pot vessels, 100 feet or less OAL for trawl vessels and 58 feet or less OAL for longline and jig vessels. In 2009, vessels participating in the B season were restricted to under 60 feet OAL for all legal gear types. In 2010, this regulation was once again changed to allow pot vessels 125 feet or less OAL 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 feet OAL.

As of 2012, the state-waters A season opens January 1 in waters between 175° W long and 178° W long to vessels 60 feet OAL or less using trawl, pot, and jig gear, and vessels 58 feet OAL or less using longline gear. Harvests between 175° W long and 178° W long accrue toward the GHL, while harvest in state waters east of 175° W long and west of 178° W long are initially managed under parallel fishery regulations with harvest accruing toward federal TAC. If the state-waters A season GHL has not been taken by April 1, when the federal catcher-vessel trawl B season opens, the state-waters A season in waters east of 175° W long and west of 178° W long will close and a parallel fishery will immediately open in those waters.

Within state waters from 175° W long to 178° W long, the state-waters A season remains open to vessels 60 feet OAL or less using trawl, pot, and jig gear, and vessels 58 feet OAL or less using longline gear. If state-waters A season GHL remains when the federal catcher-vessel trawl B season closes, the state-waters A season reopens in all waters west of 170° W long until the state-waters A season GHL is reached, or through June 9. During this time trawl vessels may not be greater than 100 feet OAL, pot vessels may not be greater than 125 feet OAL, and vessels using mechanical jig or longline gear not greater than 58 feet OAL.

In October 2013, the BOF created a state-waters Pacific cod fishery management plan in waters of the Bering Sea near Dutch Harbor. The Dutch Harbor Subdistrict Pacific cod season is open to vessels 58 feet or less OAL using pot gear, with a limit of 60 pots. The season opens seven days after the federal Bering Sea–Aleutian Islands pot/longline sector's season closure, and may close and re-open as needed to coordinate with federal fishery openings. The fishery was not opened to jig gear because the federal jig season typically occurs year-round

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). The Southcentral Region creel sampling program also collects data on cod catch by stat area (on a vessel-trip basis), and lengths of sport-caught Pacific cod. 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 (CI)** and longline gear the dominant gear in recent **Prince William Sound (PWS)** fisheries. Pot gear is still the dominant gear during the state-waters season in CI, longline is not a legal gear type for this fishery, and longline gear is dominant during the parallel fishery. The total harvest during the parallel fishery since 2000 peaked during the 2012 fishery and decreased in 2013 and then again in 2014. In the most recent 5 parallel seasons, longline took the largest percentage in 2013, 74% of the harvest. In PWS longline gear has taken over 99% of the total harvest during the past five seasons. In 2014 in the **Westward Region** parallel Pacific cod fisheries, pot gear vessels take over 70% of the total harvest, with the remainder divided between trawl, jig, and longline gear. Pot and jig gear are the only legal gear types during state-waters fisheries in the Kodiak, Chignik, and South Alaska Peninsula Areas. Pot gear vessels take approximately 75% of the total Pacific cod catch annually. In the Aleutian Islands trawl gear took 24% of the harvest and pot gear took 76%. Trawl and pot gear were used only during the A season. There was no harvest in the B season.

Prior to 1993 much of the cod taken in **Southeast Alaska** commercial fisheries 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 2014, 12% 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. A total of 345 mt of Pacific cod were harvested in Southeast state-managed (internal waters) fisheries during 2014 with 317 mt harvested from the directed fishery.

The 2014 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and Prince William Sound Areas of the **Central** Region were 1,991 mt and 664 mt, respectively. 2014 harvest from the Cook Inlet Area state-waters Pacific cod fishery totaled 369 mt and the Prince William Sound Area harvest totaled 628 mt. In Cook Inlet in 2014, GHLs were not achieved and there was no harvest by jig gear due to the parallel season remaining open for the entire year. In the PWS state-waters season, the harvest was exclusively by longline, 628 mt. In 2014, Cook Inlet received 3.75% of the CGOA ABC, and the PWS allocation was 25.0% of the EGOA ABC.

In the **Westward** Region, the Kodiak Area state-waters Pacific cod GHL is based on 12.5% of the annual CGOA Pacific cod ABC while the Chignik Area GHL is based on 8.75% of the annual CGOA ABC. The 2014 South Alaska Peninsula Area state-waters Pacific cod GHL was based on 30% of the WGOA Pacific cod ABC. Legal gear is limited to pot and jig gear during state-waters Pacific cod fisheries in these three areas. The 2014 Pacific cod GHLs were 6,638 mt in the Kodiak Area, 4,646 mt in the Chignik Area and 9,524 mt in the South Alaska Peninsula Area. Total state-waters Pacific cod catch in the Kodiak, Chignik and South Alaska Peninsula was 5,548 mt, 4,352 mt and 9,947 mt respectively. In the Aleutian Islands District state-waters Pacific cod GHL is based on 3% of the annual BSAI Pacific cod ABC. Legal gear is limited to non-pelagic trawl, pot, longline and jig gear during state-waters the Pacific cod fishery in this area. The 2014 total state-waters Pacific cod catch in the Aleutian Islands District was 4,496 mt. The Dutch Harbor Subdistrict state-waters Pacific cod GHL is based on 3% of the annual BSAI Pacific cod ABC and is open to pot gear only. In 2014, the total state-waters catch for the Dutch Harbor Subdistrict was 8,013 mt.

Estimates of the 2014 recreational harvest of Pacific cod are not yet available from the statewide harvest survey, but the 2014 estimates were 10,631 fish in **Southeast** and 27,161 fish in **Southcentral Alaska**. The average estimated annual harvests for the prior five-year period (2008–2012) were 10,722 fish in **Southeast** Alaska and 26,764 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. Thornyhead, *Sebastolobus* species are defined separately.

a. Research

In the **Southeast Region** biological samples of rockfish are collected from the directed DSR fishery; sampling effort was 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 fishery was not opened. Fishery data is also collected from the logbook program, which is mandatory for all groundfish fisheries. The logbook program is designed to obtain detailed information regarding specific harvest location. In 2014, the directed fishery for DSR opened in the East Yakutat (EYKT) area of the Southeast Outside District (SEO). Length, weight and age structures were collected from 1,238 yelloweye rockfish caught in the directed and halibut commercial longline fisheries. The Central Southeast Outside (CSEO), Southern Southeast Outside (SSEO), and Northern Southeast Outside (NSEO) sections did not open to directed fishing because the portion of the TAC allocated to that area was not large enough to support an orderly fishery. Directed fishing for DSR was also opened in internal waters. No biological samples of yelloweye rockfish were collected from the internal waters fishery.

Rockfish habitat mapping projects continue in the **Southeast Region.** Seafloor mapping is performed to identify rockfish habitat in this important fishing ground. To date, ADF&G has mapped approximately 3,058 km^2 of seafloor within SEO. More importantly, over 1,264 km^2 of rocky habitat has been mapped. The last mapping survey was conducted in 2010, and an upcoming project is scheduled for the summer of 2015, which will be jointly conducted with the U.S. Geological Survey. An age-structured assessment model for yelloweye rockfish has been submitted to the Gulf of Alaska Groundfish Plan Team for review (Contact Kristen Green).

Skipper interviews and port sampling of commercial rockfish deliveries in **Central Region** during 2014 occurred in Homer, Seward, Whittier, Kodiak, 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. Limited fishing effort drastically reduced sampling opportunities from 2006 to 2009 until an increase in effort resulted in additional sampling opportunity. However, with only 20 landings in 2013, sampling opportunity was limited and sampling goals were not achieved. Although there were only 23 landings during the 2014 fishery, a more targeted sampling effort resulted in achieving sampling goals (n=550) for the directed CI jig rockfish fishery. Additional rockfish samples were collected from bycatch fisheries in CI and PWS with the sampling goal achieved or nearly achieved for PWS quillback, yelloweye, and shortraker rockfish. Sample data collected included date and location of harvest, species, length, weight, sex, gonad condition, and otoliths. Homer staff determined ages of pelagic and demersal shelf rockfish otoliths, and otoliths from slope and thornyhead rockfish species were sent to the Age Determination Unit. Additional sampling occurred during the CI and PWS research trawl surveys (Contact Elisa Russ).

Seafloor mapping efforts continued in Central Region. We expanded the area mapped at the southwestern PWS lingcod / DSR index site by mapping much of Cape Cleare Bank to the south of the existing NOAA multibeam coverage. Cape Claire Bank together with Elrington / Latouche Bank and the southwestern PWS island passages to the north are important harvest areas for lingcod, DSR, and other groundfish. By mapping Cape Claire bank, a more comprehensive map of detailed seafloor features was obtained and will be used for delineating habitat type for conducting lingcod and DSR surveys. A collaborative seafloor mapping project with the United States Geological Survey USGS was conducted in May 2014. USGS provided all of the MBES survey equipment, all hydrographic personal during data collection, processed and cleaned the data, and produced the final products. ADF&G provided the R/V *Solstice* as the survey platform, which resulted in a very cost effective survey.

USGS was motivated to learn about the detailed structure of the Patton Bay fault system which runs east and west though Cape Cleare Bank. They're purpose of collecting the multibeam and seismic data was to better image and understand megathrust splay faults. Ultimately information derived from this survey will be used to improve seismic hazard maps for Alaska, which are used for developing safer buildings and structures.

The Patton Bay fault system extends west of Cape Cleare Bank through Junken Trough and up onto Junken Bank. Junken Trough and the seafloor directly surrounding the Patton Bay fault was of interest to USGS. While we had less interest in Junken Trough we had high interest in all of the seafloor on Cape Cleare Bank including that associated with the fault. A compromise was struck with USGS to satisfy both agencies' needs. USGS would collect full bottom coverage multibeam bathymetry on Cape Cleare Bank to address ADF&G interests while the deeper waters of Junken Trough would be mapped to address USGS interests. There were 638 km^2 of seafloor mapped during this survey. Of this, 207 km^2 were completed with the proposed Cape Cleare Bank mapping area while another 365 km^2 were completed in the Junken Trough area. An additional 66 km^2 were mapped in the inside waters of PWS south of Chenega Island.

Resolution of the historical NOAA single beam \ smoothsheet bathymetry was exceptionally low for Cape Cleare Bank. Additionally, there were large vertical shifts in the seafloor following the 1964 Good Friday earthquake. The detail in seafloor texture from the multibeam bathymetry collected during this survey is a marked improvement over the historical data (Contact Mike Byerly or Dr. Kenneth Goldman).

The **Westward Region** continued port sampling of several commercial rockfish species and Pacific cod in 2014. Rockfish sampling concentrated on black and dark rockfish with opportunistic sampling of 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 2014 season. Pacific cod otolith aging is ongoing.

The **Westward Region** also continued to conduct hydroacoustic surveys of black and dark rockfish in the Northeast, Eastside, and Southeast districts of the Kodiak Management Area in 2014 in an effort to generate biomass estimates for both black and dark rockfish. Surveys of the Afognak and Northeast districts in the Kodiak Management Area will continue in 2015 (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) length composition and average weight, and 3) biomass of total sport removals (harvest and release mortality).Primary species harvested in Southeast Alaska included yelloweye, black, copper, and quillback rockfish. Approximately 9,792 rockfish were sampled from the sport harvests at Ketchikan, Craig, Klawock, Wrangell, Petersburg, Juneau, Sitka, Gustavus, Elfin Cove, and Yakutat in 2014 (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 port. The 2014 total sample size from the sport harvests at Seward, Valdez, Whittier, Kodiak, and Homer was 5,013 rockfish (Contact Barbi Failor).

The Division of Sport Fish continued research in Prince William Sound on survival of rockfish following recompression. In 2014, northern, dusky, copper, quillback, and silvergray rockfish were caught using sport fishing gear over a range of depths, and held for two days at capture depths of at least 35 m to evaluate survival. Eighty-seven percent of held fish survived, which is consistent with results from other studies indicating high survival for yelloweye and quillback rockfish in Prince William Sound and for other species in the Pacific Northwest. This study will be continued through 2017 to achieve sample sizes that are adequate to estimate post-recompression survival for as many demersal rockfish species as possible in Prince William Sound (Contact Mike Thalhauser).

b. Stock Assessment

The **Southeast Region** performs multi-year stock assessments 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. 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 DSR in NSEI and SSEI management areas, and no surveys for non-DSR species (e.g. black rockfish) have been conducted since 2002.

Prior to 2012, line transect surveys were conducted using a submersible; after that time, visual surveys have been conducted using an ROV. The last submersible surveys were conducted in 2009 in EYKT, 2005 in SSEO, 2007 in CSEO, and 2001 in NSEO; density estimates were derived from each of these surveys with the exception of the NSEO management area where data were too limited to obtain a valid density estimate. Consequently, the most recent valid density estimate for NSEO is from 1994. Density estimates by area for the most recent submersible surveys ranged from 765 to 1,930 yelloweye rockfish per km^2 with CV estimates of 12–33%. ROV surveys were performed in collaboration with Central Region staff in 2012 in CSEO and 2013 in SSEO. An ROV survey was planned for EYKT in 2014; however, was canceled due to inclement weather. We plan to complete a survey in this area in 2015. Yelloweye rockfish density was 752 yelloweye per km^2 (CV=14%) for CSEO in 2012 and 986 yelloweye per km^2 (CV=22%) in SSEO in 2013. In addition from ROV video data, we are able to measure fish lengths for yelloweye rockfish, lingcod, and halibut using stereo camera imaging software (SeaGIS, Ltd).

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 bordered by land masses, deep fjords, and/or expanses of deeper soft substrates. An ROV survey at Nuka Bank and Pye Reef in the Central Region NGD was planned and attempted in July, 2014. This was the first survey attempted using the R/V *Solstice*. Problems with the vessels location of the pole mounted tracking system forced an early termination of the survey. The R/V *Solstice* crew relocated the pole mount to the port side of the vessel to correct the issue. There were 24 of the planned 150 transects completed during this survey. All the video and tracking data have been reviewed an completed but no population estimate could be produced due to the small sample size (Contact Mike Byerly or Dr. Kenneth Goldman).

In the **Westward Region** rockfish surveys using hydroacoustic equipment were deployed in an effort to assess black and dark rockfish stocks in the Kodiak Management Area. Surveyed areas included the Northeast, Eastside, and Southeast districts of the Kodiak 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) based 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 five-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 BOF meeting in early 2006 the season for the directed DSR fishery in SEO was changed to occur only in the winter 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 BOF 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 2014 ABC for DSR was 274 mt, which resulted in a TAC of 224 mt to commercial fisheries and 43 mt to sport fisheries, and the 2015 ABC is set at 225 mt, resulting in a

TAC of 182 mt for commercial and 35 mt for sport fisheries. The TACs are set after deducting the subsistence catch, 7 mt for 2014 and 8 mt for 2015 . A significant portion of the total commercial harvest is taken as bycatch 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 estimate bycatch rate by depth and apply this to the commercial catch to estimate DSR bycatch. Since 2012, commercial landing data has been 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, because six years of DSR full retention landings were available for analysis and 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.

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 with a total GHL of 147 mt for all of SEO. A series of open and closed areas was also created in order for managers to better understand the effects of directed fishing on black rockfish stocks. Halibut and groundfish fishermen are required to retain and report all black rockfish caught. Shortspine thornyhead, shortraker rockfish, rougheye rockfish and redbanded rockfish may be taken as bycatch only (no directed fishing). (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 BOF formalized the 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 BOF adopted a directed rockfish season opening of July 1 for the Cook Inlet Area and restricted legal gear to jigs to target pelagic shelf rockfish species. At the spring 2000 BOF meeting, the BOF 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 BOF 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 the sablefish fishery, 5% during the state-waters Pacific cod season and 10% during other directed fisheries. In 2010 the BOF 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. In 2014, the BOF adopted regulations to adjust rockfish bycatch levels during the parallel Pacific cod season in PWS to 5%, for consistency with the state-waters season. Proceeds from rockfish landed in excess of allowable bycatch levels and over the GHL are surrendered to the State of Alaska (Contact Jan Rumble).

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 2.3 mt 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 2014, 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 2014, 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 in 2014. 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 Mark Stichert).

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 2014 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:

<u>Southeast Alaska Outside Waters</u>: 1) all non-pelagic rockfish caught must be retained until the bag limit is reached; 2) 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; 3) 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; and an annual limit of one yelloweye rockfish.

<u>Southeast Alaska Inside Waters</u>: 1) all non-pelagic rockfish caught must be retained until the bag limit is reached; 2) 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; 3) 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; and an annual limit of two yelloweye rockfish.

For the entire Southeast Alaska region, charter operators and crewmembers could not retain non-pelagic rockfish while clients were on board the vessel. In addition, anglers fishing from charter vessels were required to release non-pelagic rockfish to the depth of capture or at least 100 feet, whichever is shallower, using a deepwater release device. Charter vessels were required to have at least one functional deep water release device on board and available for inspection (Contact Bob Chadwick).

Rockfish regulations in **Southcentral Alaska** have been designed to discourage targeting of rockfish yet allow and mandate retention of incidental harvest. As in Southeast Alaska, bag limits are more restrictive for non-pelagic species to account for their lower natural mortality rates. The open season for rockfish was year-round in all areas. 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 in Prince William Sound 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 2014. Effort in the directed black rockfish fishery was low with two vessels participating; consequently, directed harvest is confidential. A total of 4.1 mt of black rockfish were harvested in all groundfish, halibut, and salmon troll fisheries in SEO. The 2014 directed DSR fishery in outside waters was opened in EYKT for a total harvest of 33.0 mt. There was also a directed DSR fishery in internal waters in 2014 (SSEI and NSEI); the total harvest in SSEI and NSEI combined was 26.9 mt.
An additional 63.1 mt of DSR was taken as bycatch in SEO and 15 mt in internal waters with 90% in SEO and 91% in internal waters from the IFQ halibut fishery. Slope, PSR, and thornyhead rockfish were also taken as bycatch in internal waters with 67.8 mt harvested in 2014.

In the **Central Region**, total rockfish harvest in 2014 was just under 99 mt. The 2014 Cook Inlet Area directed rockfish fishery opened July 1 and closed December 31 with a harvest of 17.8 mt of pelagic shelf rockfish. Total rockfish harvest in the Cook Inlet Area including bycatch to longline, pot and jig fisheries was 27.6 mt. Total rockfish harvest for the PWS Area bycatch-only fishery was 71.4 mt from pot, trawl, and longline fisheries, which exceeded the guideline harvest level and profits from rockfish delivered after this GHL was achieved were forfeited to the State of Alaska. This included 31.2 mt incidental catch of rockfish from the walleye pollock trawl fishery and a 40.2 mt incidental harvest of demersal and slope rockfish primarily from the sablefish, Pacific cod, and halibut longline fisheries.

Overall **sport harvest** (guided and unguided) is estimated primarily through the Statewide Harvest Survey (SWHS). Charter vessel logbooks provide reported harvest for the guided sector only. 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 estimates are for the general category of “rockfish” (all species combined), and the charter vessel logbooks require reporting of rockfish harvest in three categories - pelagic, yelloweye, and other non-pelagics. Recreational rockfish harvest is typically estimated in numbers of fish. Estimates of the 2014 harvest are not yet available from the SWHS, but the 2014 estimates for all species combined were 139,909 fish in Southeast and 116,176 fish in Southcentral Alaska. The average estimated annual harvest for the prior five-year period (2008–2012) was 111,178 rockfish in Southeast Alaska and 108,929 fish in Southcentral Alaska.

3. Sablefish

a. Research

In 2014, 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 cost of these surveys is offset by the sale of the fish landed, but in 2014 three commercial fishermen that participated in the surveys were allowed to sell their Personal Quota Share (PQS) from the total testfish harvested in the survey, thus reducing the total testfish harvest impact on the quota by approximately 30%. The department plans to allow permit holders to harvest their PQS aboard the 2015 survey as well.

The survey CPUE for NSEI increased in 2014 to1.46 lb/hook from 1.40 lb/hook in 2013. In the SSEI stock assessment, analyses revealed a decline in the overall longline survey CPUE index (round lb/hook) from 2013 (0.67) to 2014 (0.61). There is a high proportion of immature fish in the longline and pot fisheries (>60% from 2012–2014) and in the survey (>73% from 2012–2014). In 2013, the survey was redesigned to expand survey station coverage in Dixon Entrance as well as increase the minimum spacing between survey stations. The Dixon Entrance area is an important area to the commercial fishery (40 to 60% of the annual commercial harvest), yet this area had been underrepresented in the department survey. The new survey design was used for the 2013 and 2014 SSEI longline surveys.

Since 2012, ADF&G has conducted our mark/recapture study in NSEI on the ADF&G *R/V Medeia.* In May and June 2013, 7,961 fish were marked and released in NSEI over the course of the pot tagging survey. Over the 23 day survey, 34 longline pot sets were made. Sablefish were targeted by area and depth in proportion to the commercial catch using logbook data from the three previous years. The mark-recapture results serve as the basis of our NSEI stock assessment. No pot tagging survey occurred in 2014 due to budget reductions; however, a survey is scheduled for May 2015 (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 lack of funding, 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. Sablefish tagging surveys were conducted in PWS in 2011 and 2013 using pot longline gear. There were 1,203 and 318 fish tagged in 2011 and 2013, respectively. CPUE was very low in 2013 with an average of 0.60 fish per pot. To date, 241 fish have been recaptured from the 2011 survey and 22 were captured from the 2013 survey. From the 2011 tagged releases, 79% were recaptured within PWS and 19% outside in the GOA with the remainder of unknown location. A PWS sablefish tagging survey is planned for March, 2015.

Short-terms goals are to determine whether the portion of the GOA sablefish stock that resides in and used PWS is well- or poorly-mixed with the larger GOA population. If well-mixed, there would be no need for a PWS sablefish stock assessment as the Federal assessment could be used to apportion catch for the PWS sablefish fishery. If poorly-mixed, there would be a need to conduct more tagging work in PWS to provide an assessment of the abundance within those waters from which to set harvest limits and manage the fishery. The department will continue to conduct more sablefish tagging as funding allows, and work towards addressing the mixing question via tag-recapture analysis. If data results indicate that a PWS assessment needs to be conducted, the department would continue its tagging study potentially in combination with an age-structured model to accomplish the goal of providing information with which to best manage the fishery (Contact Mike Byerly or Dr. Kenneth Goldman).

Skipper interviews and port sampling occurred in Cordova, Whittier, 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 2014 recommended ABC of 356 mt was calculated by applying the 2013 fishery mortality at age (based on a harvest rate of 6.9% using the $F_{50\%}$ biological reference point (BRP)) to the 2014 forecast of total biomass at age and summing across all ages. The 2014 ABC was a 26% reduction from the 2013 ABC (547 mt), which was also based on the $F_{50\%}$ BRP (the harvest rate was 7.8% for 2013). Since 2009 BRPs have become more conservative, i.e. $F_{45\%}$ in 2009 and $F_{50\%}$ since 2010.

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 GHLs. In the Cook Inlet Area there is a state-managed open access sablefish fishery with a separate GHL.

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 were 78 permit holders eligible to fish in 2014 in NSEI and 23 permit holders eligible to fish in SSEI.

The SSEI quota was set at 243 mt for 2014.

During the February 2009 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 sport fishery. At the 2012 BOF meeting, a regulation was passed to require personal use and subsistence use sablefish permits, and at the 2015 BOF meeting, limits were defined for personal use sablefish fisheries for the number of fish, number of permits per vessel, and number of hooks. No changes were made to sablefish subsistence fisheries in 2015.

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 relative change to the ABC in the federal CGOA. The 2014 fishery GHL was 25.4 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 PWS fishery GHL was set at 110 mt, which is the midpoint of the harvest range set by a habitat-based estimate, and has not changed since 1996. PWS 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 BOF adopted regulations which included a registration deadline, logbooks, and catch reporting requirements. In 2009, new season dates were also adopted by the BOF for PWS sablefish, 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 sole **Westward Region** sablefish fishery occurs in the Aleutian Islands. The GHL for the Aleutian Islands is set at 5% of the combined Bering Sea Aleutian Islands 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 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. In 2013, the BOF changed the season opening and closing dates to revert back to coinciding with the federal IFQ season.

The Southeast Alaska **sport fishery** for sablefish was regulated for the first time in 2009. Sport limits in 2014 were four fish of any size per day, four in possession, with an annual limit of eight fish applied to nonresidents only in lower Lynn Canal and Chatham Strait. In 2014 a total of 180 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 2014, with no bag, possession, or size limits. Port samplers in Southcentral Alaska measured six sablefish from the sport harvest, again suggesting relatively small harvests.

d. Fisheries

In the **Southeast Region** the 2014 NSEI sablefish fishery opened August 15 and closed November 15. The 78 permit holders landed a total of 350.3 mt of sablefish. The fishery is managed by equal quota share; each permit holder was allowed 4.3 mt. In the NSEI fishery, the overall CPUE (adjusted for hook spacing expressed in round lb/hook) increased slightly with 0.84 lb/hook in 2014 and 0.81 in 2013. The 2014 SSEI sablefish fishery opened June 1 and closed November 15. Twenty-two permit holders landed a total of 224.5 mt of sablefish, each with an equal quota share of 10.6 mt. In SSEI, 20 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 2014. Longline fishery CPUE declined slightly in 2014 from 2013 (0.33 lb/hook in 2013to 0.30 lb/hook in 2014) (Contact Kristen Green).

In the **Central Region** the 2014 open access sablefish fishery in the Cook Inlet North Gulf District opened at noon July 15 and was open through the remainder of the calendar year. Five vessels participated and harvested 23.0 mt, the second year that the GHL (25.4 mt) was not achieved. The 2014 PWS harvest totaled 43.9 mt and was the lowest harvest on record, less than half of the historical average and a decrease of 26.6 mt from 2013 (Contact Jan Rumble).

Within the **Westward Region**, only the Aleutian Islands have sufficient habitat to support mature sablefish populations of enough 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 2014 Aleutian Island fishery opened on May 8 with only pot, longline, jig and hand troll gear allowed. Additional requirements for the fishery include registration and logbook requirements. The GHL was set at 157 mt for the state-waters fishery. The harvest from the 2014 Aleutian Islands sablefish fishery was 74 mt. The season remained open until the November 7 closure date (Contact Heather Fitch).

The most recent sablefish recreational harvest estimates from the SWHS are for 2013. The estimated harvest was 12,395 fish in Southeast Alaska and 5,593 fish in Southcentral Alaska. SWHS estimates are suspected to be biased high due to misidentification and misreporting. Sablefish are not commonly taken by anglers, and relatively high catches were reported from some areas where sablefish are rarely or never observed by creel survey crews. Charter logbooks indicated guided-only harvests of 7,423 sablefish in Southeast Alaska and 154 sablefish in Southcentral Alaska in 2013 (Contact Bob Chadwick, Dan Bosch).

4. Flatfish

a. Research

There was no research on flatfish during 2014.

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

Very little effort has occurred in the **Southeast** fishery in recent years. Only one vessel since the 1998–1999 season has applied for a Commissioner's permit to participate in this fishery; this vessel made a single flatfish landing in 2013. Due to limited participation, harvest information is confidential for this landing. 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. In state waters of the **Westward Region**, the State of Alaska adopts most NMFS regulations and the flatfish fishery is managed under a parallel management structure. No commissioner's permits to harvest flatfish were issued in **Central Region** during 2014.

5. Pollock

a. Research

Pollock continue to be a dominant species in the **Central Region** ecosystem. Skipper interviews and biological sampling of PWS commercial pollock deliveries during 2013 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 1,150 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 2014 (Contact Dr. Kenneth Goldman).

c. Management

Prince William Sound pollock pelagic trawl fishery regulations were amended by BOF in 2009 and 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. In 2013, new management measures were implemented to set the PWS pollock GHL at 2.5% of the federal Gulf of Alaska ABC. For **Cook Inlet,** directed fishing for pollock is managed under a "Miscellaneous Groundfish" commissioner's permit. In Central Region, pollock is also retained as bycatch to other directed groundfish fisheries, primarily Pacific cod (Contact Jan Rumble).

d. Fisheries

The 2014 Prince William Sound fishery opened on January 20 with a GHL of 3,891 mt. Total pollock harvest was 2,368 mt, and the fishery was closed early because of bycatch limits being exceeded. Total bycatch during the PWS pollock fishery was 120 mt, 65% of the bycatch total was dominated by squid at 78 mt. The rockfish bycatch exceeded the department's 0.5% limit, 30.6 mt was harvested. In the Cook Inlet Area in 2014, a commissioner's permit seine pollock fishery was opened on December 1st. For this fishery, 99.8 mt of pollock was available and 5.2 mt was harvested. There were 5 permits issued for the fishery but only 2 of them participated. In addition, pollock was harvested as bycatch to the Pacific cod longline and jig fisheries, 0.7 mt (Contact Jan Rumble).

6. Sharks

a. Research

In 2009, **Central Region** Commercial Fisheries Division began tagging all sharks with spaghetti-type external tags, but discontinued that work after the 2012 field season. A recent collaboration between ADF&G and NOAA/NMFS staff resulted in the publication of a paper strongly indicating that salmon sharks have a biennial reproductive cycle and a gestation period of no longer than 10 months (Conrath et al. 2014). Another research project on the reproductive biology of salmon sharks via blood hormone concentrations, which was initiated in the summer of 2010, continues with the goal of providing more precise information on the timing and frequency of reproductive activity. Another research project examining the energetics of salmon sharks was initiated in the summer of 2012, which includes the concurrent application of temperature/depth transmitters and accelerometers. The department hopes to continue that work in 2016. A collaborative effort led by the National Institute of Polar Research in Japan with collaborators at ADF&G, the University of California at Santa Barbara, the Institute for Ocean Conservation Science at Stony Brook University and the Scottish Oceans Institute's School of Biology at the University of St Andrews, has resulted in a forthcoming publication on the ecological significance of endothermy in fishes (Contact Dr. Kenneth 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. Three salmon sharks were reported harvested by any interviewed anglers in 2014, and once fish was measured. Twenty-one spiny dogfish were reported harvested by interviewed anglers in over 13,800 angler-days of effort. Eight length measurements were obtained from spiny dogfish in 2014. 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. Kenneth Goldman).

c. Management

The Alaska BOF prohibited all directed commercial fisheries for sharks in 1998. In 2000 the BOF increased the commercial 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 had been set by the maximum allowable retention amount in regulation at 20% of the round weight of the directed species on board a vessel; however, beginning in 2014, allowable bycatch levels were set at 15% by emergency order. Additionally, 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. Directed fishing for dogfish is also allowed in Southeast Alaska under the terms of a Commisioner's permit.

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 sharks continued to be low in 2014.

d. Fisheries

Sharks (which include spiny dogfish) can be harvested as bycatch with limits to target species in Cook Inlet and PWS. Commissioner's permits can also be issued but no applications were received in 2014 in the **Central** or **Southeast Region**. In Cook Inlet, there was no harvest of spiny dogfish in 2014 and in PWS 0.2 mt was harvested.

Recreational shark harvest in 2014 (the most recent year for which estimates are available) was estimated at 152 sharks of all species in Southeast Alaska and 559 sharks in Southcentral Alaska. The precision of these estimates is low; the Southeast estimate has a CV of 48% and the Southcentral estimate has a CV of 39%. 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 2013 reported charter harvest from logbooks was three salmon sharks in Southeast Alaska and four salmon sharks in Southcentral Alaska.

7. Lingcod

a. Research

Since 1996, 9,189 lingcod have been tagged and 497 fish recovered in the Southeast Region. Length, sex and tagging location are recorded for all tagged fish. Dockside sampling of lingcod caught in the commercial fishery continued in 2014 in Sitka, Juneau, and Yakutat with 916 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, Seward, and Homer. Data obtained included date and location of harvest, length, weight, sex and age. There were 365 lingcod samples collected and 77% were from the Prince William Sound Area, as there was 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).

In the **Westward Region**, no directed lingcod effort occurred during 2014. All lingcod were harvested incidental to other federal and state managed groundfish fisheries. The 2014 harvest totaled 66 mt in the Kodiak Area and 4 mt in the Chignik Area.

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 2014 included Juneau, Sitka, Craig/Klawock, Wrangell, Petersburg, Gustavus, Elfin Cove, Yakutat, and Ketchikan. Length and sex data were collected from 1,500 lingcod in 2014, 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 802 lingcod were sampled from sport harvest at Seward, Valdez, Whittier, Kodiak, Deep Creek, and Homer in 2014. 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. After reductions in GHRs, CPUE increased in CSEO until around 2007; since then CPUE has decreased. CPUE in

NSEO has been generally stable since reductions in GHRs. In SSEOC, CPUE was highly variable from 1994 to 2003; since then, limited participation in this fishery is too erratic to characterize CPUE. In EYKT, after the GHR was reduced, CPUE was fairly stable; however, in last three years CPUE has been the lowest since 2000. Yet, CPUE in EYKT remains high relative to other management areas, likely because fishing is concentrated in smaller areas with typically higher abundances of lingcod. The CPUE in IBS was stable between 2004 and 2009 and increased from 2010 to 2014, possibly due to increases in stocks or changes in fishery dynamics–vessel participation has decreased with experienced fishermen remaining in this area.

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 bordered by land masses, deep fjords, and/or expanses of deeper soft substrates. An ROV survey at Nuka Bank and Pye Reef in the Central Region NGD was planned and attempted in July 2014. This was the first survey attempted using the R/V *Solstice*. Problems with the vessels location of the pole mounted tracking system forced an early termination of the survey. The R/V Solstice crew relocated the pole mount to the port side of the vessel to correct the issue. There were 24 of the planned 150 transects completed during this survey. All the video and tracking data have been reviewed and completed but no population estimate could be produced due to the small sample size (Contact Mike Byerly or Dr. Kenneth 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 year 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 is required and trip limits are utilized by ADF&G staff, when needed, for the fleet to stay within its 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.

The **Central Region** has directed commercial fisheries for lingcod in Cook Inlet and PWS. Regulations for the 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 and a jig only gear requirement for the directed lingcod fishery in the Cook Inlet Area. Guideline harvest levels are 24 mt for Cook Inlet and 3.3 mt in the Inside District of PWS and 11.5 mt for the PWS Outside District. Resurrection Bay, near Seward, is closed to commercial harvest of lingcod. In 2009, a new BOF regulation permitted retention of lingcod at a 20% bycatch level in PWS waters following closure of the directed season.

In **Southeast Alaska**, sport harvests of lingcod are incorporated into a regionwide lingcod management plan. This plan 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.

The sport fishery lingcod season for 2014 was May 16-November 30. Charter vessel operators and crew members were prohibited from retaining lingcod while guiding clients. For resident anglers, the limits regionwide were one fish per day and two in possession, and there was no size limit. Additional restrictions were put into place for nonresidents to keep harvest from exceeding allocations specified by the Alaska Board of Fisheries. Nonresidents were allowed one fish daily and one in possession. In the Yakutat and Southern Southeast districts, nonresidents were allowed to harvest fish 30-45 inches in length, or fish 55 inches and greater in length. In the Northern Southeast District, nonresidents were only allowed to harvest fish that were 30-35 inches in total length, or fish 55 inches and greater in length. In all areas, nonresidents were limited to two lingcod annually, only one of which could be 55 inches or greater in length. In addition, the Pinnacles area near Sitka has been closed to sport fishing year-round for all groundfish since 1997 (Contact Robert Chadwick).

A suite of regulations was established in 1993 for recreational lingcod fisheries in **Southcentral Alaska** in light of the lack of quantitative stock assessment information. Resurrection Bay remained closed to lingcod fishing year-round to rebuild the population, although there is no formal rebuilding plan. The season was closed region-wide from January 1 through June 30 to protect spawning and nest guarding lingcod. Daily bag limits in 2014 were two 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 Dan Bosch or Matt Miller).

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 BOF 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. The directed fishery landed 94.7 mt of lingcod in 2014. An additional 51.0 mt was landed as bycatch in halibut and other groundfish fisheries and 6.4 mt in the salmon troll fishery.

Central Region commercial lingcod harvests have primarily occurred in the North Gulf District of Cook Inlet and PWS. Lingcod harvests in 2014 totaled 4.6 mt in Cook Inlet and 7.2 mt in PWS. Approximately 74% of the lingcod harvest in Cook Inlet resulted from directed jig effort. In PWS, approximately 94% of lingcod harvest was from directed longline effort. In both areas, the remaining harvest resulted from bycatch to other directed (primarily halibut) longline fisheries. Cook Inlet and PWS fisheries remained open through December 31 (Contact Jan Rumble).

No directed effort occurred for lingcod in the **Westward Region** during 2014. Most lingcod are taken as bycatch to federally managed bottom trawl fisheries. Incidental take by trawl vessels peaked in 2008 when 250 mt of lingcod were harvested in 2008. In response, ADF&G reduced bycatch limits in 2009 from 20% to 5%. Incidental take of lingcod had ranged between 30 to 106 mt per year since 2009. Most Lingcod are harvested in federal waters northeast of the Port of Kodiak.

Recreational lingcod harvest estimates from the statewide mail survey for 2013 (the most recent year available) were 14,333 lingcod in Southeast Alaska and 19,958 lingcod in Southcentral Alaska. The average estimated annual harvest for the prior five-year period (2008–2012) was 10,440 fish in Southeast Alaska and 22,969 fish in Southcentral Alaska.

8. Other species

In 1997 the BOF approved 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" if they wish to participate in a directed fishery for all species that do not already have regulations in place for such. Permits do not have to be issued if there are management and conservation concerns. 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. In the past, commissioner's permits have been submitted for directed fishing of hagfish in Southeast Alaska; however, no applications were made for hagfish in 2014.

Currently in the **Central Region**, skates are harvested as bycatch, and had been allowed up to 20% during other directed fisheries for groundfish until that allowable amount was reduced to 15% in 2014 and set by emergency order. A directed fishery in the Prince William Sound Area for big and longnose skates was prosecuted under commissioners permit authority in 2009 and 2010. However, the fishery was deemed unsustainable, and no permits were issued thereafter. The permit stipulated fishing depth, seasons, areas, allowable sizes of harvested fish, gear, and logbooks. In Cook Inlet, big and longnose skates harvested as bycatch was 24.4 mt in 2014, a decrease from 51.4 mt in 2013. In PWS, skate harvest was 54.6 mt in 2014, half of what was harvested in 2013, 107.8 mt. Because bycatch limits are set as a percentage of the targeted species, harvest levels of the target species can affect amount of bycatch that are legally harvested. Big skate closed to retention by emergency order on February 6, 2014 in response to the federal CGOA closure due to the TAC being achieved.

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 (Contact Dr. Kenneth 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 the annual stock assessment, and to the North Pacific Fishery Management Council. The council's Scientific and Statistical Committee has periodically reviewed the state's estimation and projection methods. ADF&G annually provides an analysis that is used to select annual management measures for the charter fishery, 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** currently houses all data in an MS Access database format. Queries are complete for calculating CPUE, abundance, and biomass estimates from most surveys. All data are additionally captured in a GIS for spatial analysis.

ADF&G manages state groundfish fisheries under regulations set triennially by the BOF.

ADF&G 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 groundfish statistical areas 325431, 315431, 325401, and 315401). The table below lists the catch by species group from 1988 through 2014 rounded to the nearest mt. Landings with only halibut catch are excluded.

Year	# Permits	# Landings	DSR	Other Rock	Sablefish	Other Groundfish	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	37	2	17	107	2	128
2011	31	41	<1	16	112	2	130
2012	21	26	<1	18	116	4	139
2013	25	27	<1	14	115	2	132
2014	24	23	5	12	89	5	158

2. **Marine Reserves**

In September of 1997 the ADF&G submitted proposals to both the BOF and the Council 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 the reserve and the Council approved the reserve at their June 1998 meeting. The Council 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. Statistical Area Charts

Digital groundfish and shellfish statistical area charts are available. Digital are available in Abode PDF and can be viewed or downloaded at
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps
(Contact Cathy Tide)

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.

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
2012	67	67	closed	127	117	15	0	closed
2013	66	84	closed	129	87	4	1	closed
2014	28	68	closed	125	55	2	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 2014, 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 (contact Bob Powers).

WEBSITES

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 Fisheries home page: http://www.adfg.alaska.gov/index.cfm?adfg=fishingSport.main

Rockfish Conservation page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportFishingInfo.rockfishconservation

Age Determination Unit Home Page: http://tagotoweb.adfg.state.ak.us/

Region I, Southeast Region, Groundfish Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareasoutheast.groundfish

Region II, Central Region, Groundfish Pages:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingcommercialbyarea.southcentral

Westward Region, Groundfish Pages:
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/2014/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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Sigurdsson, D. and B. Powers. 2014. Participation, effort, and harvest in the sport fish business/guide licensing and logbook programs, 2013. Alaska Department of Fish and Game, Fishery Data Series No. 14-23, Anchorage.

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Appendix 1. Alaska Department of Fish and Game Full-time Groundfish Staff During 2014

COMMERCIAL FISHERIES DIVISION

HEADQUARTERS, P.O. Box 25526, Juneau, Alaska 99802-5526

Chief, Computer Services Kathleen Jones (907) 465-4753	Age Determination Unit Kevin McNeel Box 115526 Juneau, AK 99811 (907) 465-3054	Elandings Program Coordinator II Gail Smith (907) 465-6157
Alaska Fisheries Information Network (AKFIN) Program Coordinator Lee Hulbert (907) 465-6109		

SOUTHEASTERN REGION

Groundfish Project Leader Kristen Green 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-2683	Fishery Biologist II Jennifer Stahl Box 240020 Douglas, AK 99824-0020 (907) 465-4071	Fishery Biologist II Mike Vaughn 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-6688
Project Biometrician Kray Van Kirk Box 240020 Douglas, AK 99824-0020 (907) 465-4216	Fishery Biologist I Aaron Baldwin Box 240020 Douglas, AK 99824-0020 (907) 465-3896	Fishery Technician IV Kamala Carroll 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-6688
Research Analyst II Martina Kallenberger Box 240020 Douglas, AK 99824-0020 (907) 465-4209	Fishery Technician IV Jennifer Dupree P.O. Box 667 Petersburg, AK 99833-0667 (907) 772-5231	Fishery Technician III Jessica Acker 304 Lake St. Rm. 103 Sitka, AK 99835 (907) 747-6831

CENTRAL REGION

CI/PWS Groundfish & Shellfish Research Project Leader Dr. Kenneth J. Goldman 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	CI/PWS Area Management Biologist Jan Rumble 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	Groundfish Sampling and Ageing Coordinator Elisa Russ 3298 Douglas Place, Homer AK 99603-7942 (907) 235-8191
Fish Ticket Processing/ Data Analyst Chris Russ 3298 Douglas Place, Homer, AK 99603-7942 (907) 235-8191	Fishery Biologist Mike Byerly 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	PWS Management Biologist Maria Wessell PO Box 669 Cordova, AK 99574-0669 (907) 424-3212

GIS Analyst Josh Mumm 3298 Douglas Place Homer, AK 99603-7942 (907) 235-8191	Fishery Biologist Martin Schuster 3298 Douglas Place Homer, AK 99603 (907) 235-8191	

WESTWARD REGION

Shellfish/Groundfish Biologist Wayne Donaldson 351 Research Ct Kodiak, AK 99615-6399 (907) 486-1840	Area Management Biologist Mark Stichert h 351 Research Ct., Kodiak, AK 99615-6399 (907) 486-1840	Groundfish Research Biologist Carrie Worton 351 Research Ct Kodiak, AK 99615-6399 (907) 486-1849
Groundfish Sampling Coordinator Kally Spalinger 351 Research Ct Kodiak, AK 99615 (907) 486-1840	Assistant Area Management Biologist Trent Hartill 351 Research Ct Kodiak, AK 99615 (907) 486-1840	Area Management Biologist Heather Fitch P.O. Box 920587 Dutch Harbor, AK 99692 (907) 581-1239
Assistant Groundfish Research Biologist Philip Tschersich 351 Research Ct Kodiak, AK 99615-6399 (907) 486-1871	Assistant Area Management Biologist Miranda Westphal P.O. Box 920587 Dutch Harbor, AK 99692 (907) 581-1239	

SPORT FISH DIVISION

STATEWIDE, P.O. Box 25526, Juneau, Alaska 99802-5526

Deputy Director Tom Brookover 333 Raspberry Road Anchorage, AK 99518-1599 (907) 465-6187	Statewide Bottomfish Coordinator Scott Meyer 3298 Douglas Place Homer, AK 99603-8027 (907) 235-1742	Logbook Program Coordinator Bob Powers 333 Raspberry Road Anchorage, AK 99518-1565 (907) 267-2299

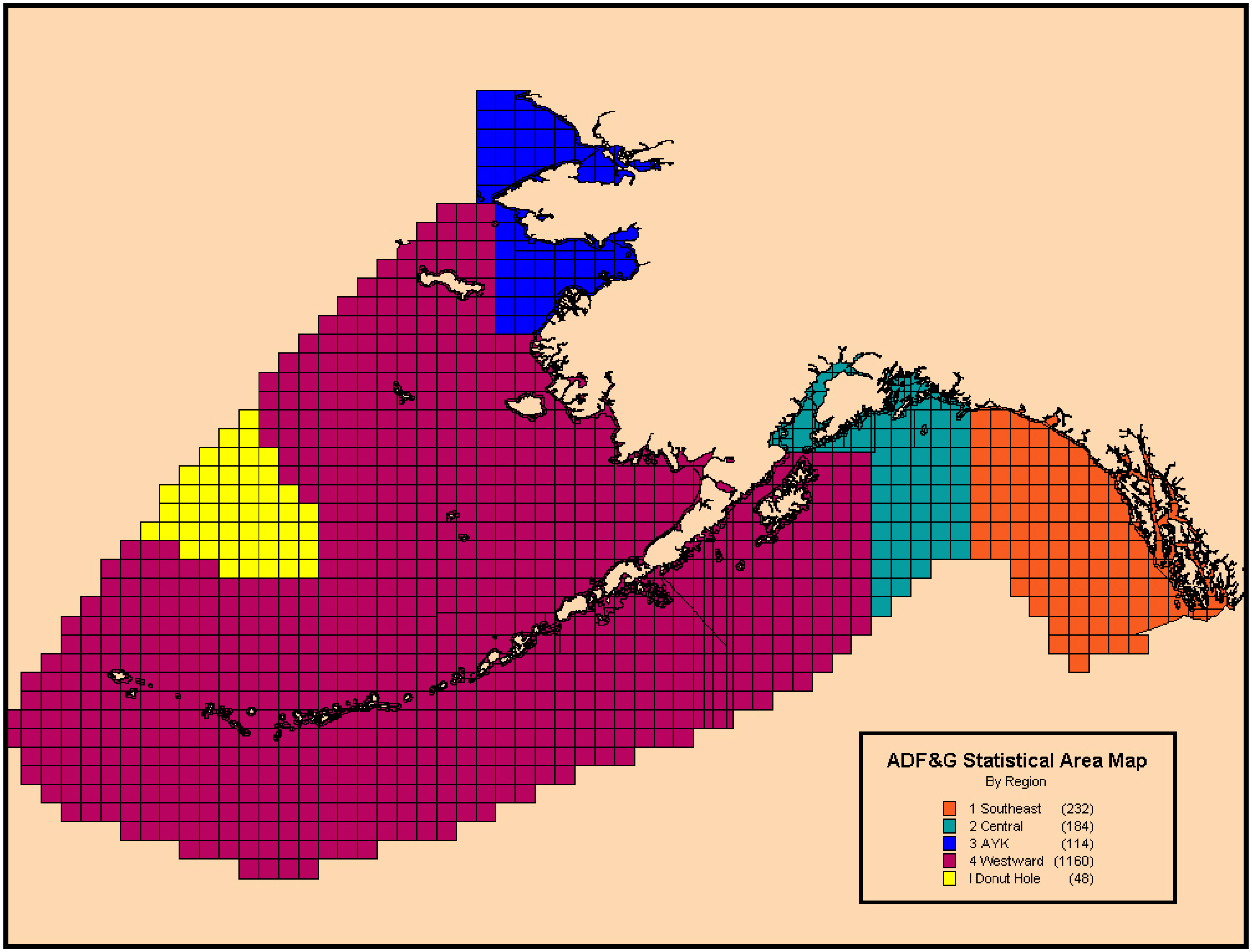
SOUTHEAST REGION

Project Leader, Marine Harvest Studies Michael Jaenicke PO Box 110024 Juneau, AK 99811-0024 (907) 465-4301	Regional Management Biologist Robert Chadwick 304 Lake St., Room 103 Sitka, AK 99835-7563 (907) 747-5551	Regional Research Biologist Jeff Nichols P.O. Box 110024 Juneau, AK 99811-0024 (907) 465-4398
Yakutat Area Management Biologist Brian Marston P.O. Box 49 Yakutat, AK 99689-0049 (907) 784-3222	Haines/Skagway Area Mgmt. Biol. Richard Chapell P.O. Box 330 Haines, AK 99827-0330 (907) 766-3638	Juneau Area Management Biologist Daniel Teske PO Box 110024 Juneau, AK 99811-0024 (907) 465-8152

Sitka Area Management Biologist Troy Tydingco 304 Lake St., Room 103 Sitka, AK 99835-7563 (907) 747-5355	Petersburg/Wrangell Area Mgmt. Biologist Patrick Fowler P.O. Box 667 Petersburg, AK 99833-0667 (907) 772-5231	Prince of Wales Area Management Biologist Craig Schwanke P.O. Box 682 Craig, AK 99921 (907) 826-2498
Ketchikan Area Mgmt. Biologist Kelly Piazza 2030 Sea Level Drive, Suite 205 Ketchikan, AK 99901 (907) 225-2859	Biometrician Sarah Power Division of Sport Fish-RTS PO Box 110024 Juneau, AK 99811-0024 (907) 465-1192	

SOUTHCENTRAL REGION

Halibut/Groundfish Project Leader Barbi Failor 3298 Douglas Place Homer, AK 99603 (907) 235-8191	Regional Management Biologists Dan Bosch, Matthew Miller 333 Raspberry Road Anchorage, AK 99518-1565 (907) 267-2218	Regional Research Biologist Tim McKinley 333 Raspberry Road Anchorage, AK 99518-1565 (907) 267-2218
Lower Cook Inlet Mgmt. Biol. Vacant 3298 Douglas Place Homer, Alaska 99603-8027 (907) 235-8191	PWS and North Gulf Mgmt. Biol. Mike Thalhauser 333 Raspberry Road Anchorage, AK 99518-1599 (907) 267-2153	Kodiak, Alaska Pen., and Aleutian Islands Management Biologist Donn Tracy 211 Mission Road Kodiak, AK 99615-6399 (907) 486-1880
	Biometrician Adam Craig Division of Sport Fish-RTS 333 Raspberry Road Anchorage, AK 99518-1599 (907) 267-2272	



Appendix II. Map Depicting State of Alaska Commercial Fishery Management Regions.

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
	Whittier	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
	Valdez	2001	50	fin
	Whittier	2000	16	fin
	Whittier	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
	Sitka	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 *Gadus chalcogrammus*				
	Exact location unknown; see comments	1997	402	fin
	Bogoslof Island	1997	120	muscle, liver, heart
	Bogoslof Island	1998	100	muscle
	Bogoslof Island	2000	100	muscle, liver, heart
	Eastern Bering Sea	1998	40	muscle, liver, heart

Middleton Island	1997	100	fin
Middleton Island	1998	100	muscle, liver, heart
Middleton Island	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
Port Bainbridge	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	unknown
Shelikof Strait	1997	104	muscle, liver, heart, eye, fin
Shelikof Strait	1998	100	muscle, liver, heart
Shelikof Strait	2000	100	muscle, liver, heart

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.

California Department of Fish and Wildlife
Agency Report
to the
Technical Subcommittee
of the
Canada-United States Groundfish Committee

April 2015

Prepared by

Adam Frimodig
Joanna Grebel
Traci Larinto
Caroline Mcknight
Michael Prall
Connie Ryan

Edited by:
Traci Larinto
California Department of Fish and Wildlife
Marine Region
4665 Lampson Avenue, Suite C
Los Alamitos, CA 90720

A. AGENCY OVERVIEW

Within the California Department of Fish and Wildlife (CDFW), 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 CDFW 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 140 permanent and 100 seasonal staff that provide technical expertise and policy recommendations to the CDFW, 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 (Traci.Larinto@wildlife.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 CDFW staff to provide current information on groundfish fisheries and the status of the stocks. California's primary commercial landings database is housed in CDFW'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.

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, *Sebastes paucispinis,* 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. Table 1 lists the commercial groundfish landings for 2013 and 2014 along with the number of lengths and otoliths taken by samplers.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

Table 1. Commercial landings (m tons) and samples collected in 2014.

Market category[1]	m tons[2]	2014 lengths	otoliths
Rockfish:			
Chilipepper rockfish	214	1207	374
Brown rockfish	191	85	
Gopher rockfish	177	117	
Grass rockfish	120	104	
Black-and-yellow rockfish	82	67	
Black rockfish	72	1172	
Blackgill rockfish	65	675	154
Vermilion rockfish	64	696	
Bank rockfish	50	169	45
Copper rockfish	37	80	
Bocaccio	18	459	28
Group slope rockfish	13		
Blue rockfish	13	310	
Treefish	11	14	
Yellowtail rockfish	11	243	111
China rockfish	10	3	
Group red rockfish	7		
Group shelf rockfish	5		
Widow rockfish	4	377	78
Splitnose rockfish	4	340	21
Olive rockfish	4	5	
Greenspotted rockfish	4	104	4
Kelp rockfish	4	3	
Quillback rockfish	3	5	
Darkblotched rockfish	3	667	110
Aurora rockfish	3	533	116
Canary rockfish	2	202	78
Starry rockfish	2	35	
Flag rockfish	1	9	
Rosy rockfish	0[4]	41	
Unspecified rockfish	0		
Speckled rockfish	0	6	
Redbanded rockfish	0	246	54
Group bolina rockfish	0		
Greenblotched rockfish	0	4	
Rosethorn rockfish	0	4	
Cowcod	0	54	21
Group small rockfish	0		
Squarespot rockfish	0	5	
Pinkrose rockfish	0		
Greenstriped rockfish	0	77	7
Honeycomb rockfish	0		
Pacific ocean perch	0	46	14
Mexican rockfish	0	10	5
Rockfish (continued)			

Table 1. Commercial landings (m tons) and samples collected in 2014.

Market category[1]	m tons[2]	2014 lengths	otoliths
Group nearshore rockfish	0		
Yelloweye rockfish	0	1	
Stripetail rockfish	0	71	
Shortbelly rockfish	0		
Calico rockfish	0		
Copper (whitebelly) rockfish	0		
Group black/blue rockfish	0		
Group bocaccio/chilipepper rockfish	0		
Group gopher rockfish	0		
Group rosefish rockfish	0		
Rougheye rockfish[3]	--[4]	24	
Sharpchin rockfish[3]	--	11	10
Blackspotted rockfish[3]	--	8	2
Shortraker rockfish[3]	--	3	
Pink rockfish	--	2	
Freckled rockfish[3]	--	1	
Roundfish:			
Sablefish	3197	6530	
Shortspine thornyhead	1074	4087	
Longspine thornyhead	334	4857	
Cabezon	164	55	
California sheephead	137	74	
Lingcod	134	510	
Kelp greenling	32	17	
Grenadiers	20	540	56
California scorpionfish	13	51	
Starry flounder	5		
Rock sole	4		
Unspecified thornyheads	3		
Monkeyface prickleback	2		
Pacific whiting	0	1	
Rock greenling	0		
Spotted ratfish	0		
Pacific cod	0	1	
Pacific grenadier[3]	--	20	
Flatfish:			
Dover sole	971	1996	662
Petrale sole	598	2964	64
California halibut	175	8	
Unspecified sanddabs	72	27	
Rex sole	19	1446	
English sole	18	921	85
Sand sole	17	249	
Unspecified sole	14		
Flatfish (continued)			
Arrowtooth flounder	12	581	

Table 1. Commercial landings (m tons) and samples collected in 2014.

Market category[1]	m tons[2]	2014 lengths	otoliths
Starry flounder	12	244	
Hornyhead turbot	2	136	
Pacific sanddab	2	1239	
Rock sole	1	2	
Curlfin turbot	0	153	
Butter sole	0	7	
Fantail sole	0	44	
Diamond turbot	--	10	
Deepsea sole[3]	--	1	
Sharks:			
Soupfin shark	1		
Leopard shark	1		
Spiny dogfish	0	97	
Skates:			
Longnose skate	56	662	
Big skate	8	218	
Unspecified skate	5		
California skate	0		
Total	8,297	36,043	2,099

Notes:

1. Market categories can be either single species (e.g., lingcod, blue rockfish) or group categories (e.g., unspecified sole, group slope rockfish). In some instances, there were no landings reported for a species, yet lengths and otoliths were collected. These landings were likely reported in a group market category (e.g., fantail sole were probably listed as unspecified sole on the landing receipt).
2. Landings for 2014 are preliminary.
3. There are no market categories for these species, so these fish were landed under a group market category (e.g., unspecified sole, group shelf rockfish)
4. Zero (0) indicates that less than 1 metric ton was caught; -- indicates no catch was recorded.

Source: California Commercial Fisheries Information System (landings) and California Cooperative Groundfish Survey (sample data).

(b) *Recreational Fishery Monitoring*

The California Recreational Fisheries Survey (CRFS) was initiated 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 website.

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). Throughout 2014, over 70 CRFS samplers gathered recreational fishing effort and catch data statewide. The CRFS samplers interviewed nearly 68,000 anglers at more than 500 sites, and examined and identified about 245,000 fish. The contractor for the licensed angler telephone survey completed 26,000 interviews, and CDFW received, processed and used more than 36,000 CPFV logs. The high sampling levels have contributed to greater accuracy and precision in estimating catch and effort, especially for overfished species.

In addition to producing monthly catch and effort estimates, the CRFS provides weekly estimates of cowcod and yelloweye rockfish harvest (primarily due to discard mortality). Recreational anglers are prohibited from retaining cowcod and yelloweye rockfish, and both species have low harvest guidelines. This close in-season monitoring helps to ensure that California stays within the harvest guidelines.

Please visit the CRFS website for more information.

Contributed by Connie Ryan (Connie.Ryan@Wildlife.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 CDFW 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 CDFW 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 CDFW 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 canary, cowcod and yelloweye rockfish.

In 2014, the Department closed the California scorpionfish commercial fishery early (November 15, 2014) due to attaining the annual catch limit. This was due primarily to recreational anglers continuing to target scorpionfish through the summer months. There have been no inseason changes for cabezon, California sheephead and greenlings since 2008.

On the federal side, in April 2014, inseason action was taken to change the rockfish conservation area north of 40°10' North Latitude, allowing fishing to occur from 0-100 fathoms and seaward of 200 fathoms (closed 100-200 fathoms). Previously, the fishery was allowed in waters 0-20 fathoms and seaward of 100 fathoms (closed 20-100 fathoms). In May 2014, carryover for 19 of the trawl individual quota (TIQ) species was implemented, giving TIQ fishermen more opportunities. In July 2014, the limited entry sablefish trip limits were increased and in the fall there were several adjustments made to the offshore whiting sectors.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

Recreational fishery

The CFGC has given the CDFW 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 CDFW 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. Recreational catch monitoring of yelloweye rockfish, a species that significantly constrains the recreational catch of all rockfish, is available on the Inseason Tracking website.

In 2014, the Department took inseason action to close the California scorpionfish recreational fishery on November 15, 2014 due to attainment of the annual catch limit. Commercial passenger fishing vessels continued to target scorpionfish well into the summer months, increasing catch over previous years.

Contributed by Traci Larinto (Traci.Larinto@Wildlfe.ca.gov)

2. Management

(a) *2014 State Management Measures Affecting Groundfish*

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 CDFW 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 CDFW also has authority to make inseason trip limit adjustments to the commercial fisheries for cabezon, California sheephead and greenlings.

In 2014, there were no changes to the commercial fisheries for cabezon, California sheephead, and greenlings in California.

Recreational fishery

In December 2012, the CFGC adopted regulations for the 2013-2014 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 March 1, 2013. The changes included:

- Increased the number of bocaccio from 2 to 3 fish within the 10-fish RCG bag limit.
- Removed the minimum size limit for bocaccio.
- Removed the minimum fillet length for bocaccio.
- Allow retention of shelf species in the Cowcod Conservation Area (CCA) in waters less than 20 fathoms.

- Adjusted the seasons according to Table 2.

Table 2. Season structure and depth constraints for the California recreational groundfish fishery proposed for 2013 and 2014, as recommended by the Council in June 2012.

Management area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern	Closed				May 15 – October 31, < 20 fm						Closed	
Mendocino	Closed				May 15-Sept 2, 2013, < 20 fm May 15-Sept 1, 2014, < 20 fm				Closed			
San Francisco	Closed					June 1 – December 31, < 30 fm						
Central	Closed				May 1 – December 31, < 40 fm							
Southern	Closed		March 1 – December 31, < 50 fm									
CCA	Closed		March 1 – December 31, < 20 fm									

Note: See Figure 1 for groundfish management area boundaries.

In April 2013, the Council adopted depth-dependent mortality rates for the recreational rockfish fishery to account for the use of descending devices.

Figure 1. Recreational groundfish management areas for 2013-14.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

(b) *Nearshore Management*

In 2002, the CFGC adopted California's Nearshore Fishery Management Plan (FMP) for 19 species [black (*Sebastes melanops*), black-and-yellow (*S. chrysomelas*), blue (*S. mystinus*), brown (*S. auriculatus*), calico (*S. dallii*), China (*S. nebulosus*), copper (*S. caurinus*), gopher (*S. carnatus*), grass (*S. rastrelliger*), kelp (*S. atrovirens*), olive (*S. serranoides*), quillback (*S. maliger*), and treefish (*S. serriceps*) rockfishes; cabezon (*Scorpaenichthys marmoratus*); kelp (*Hexagrammos decagrammus*) and rock greenlings (*H. lagocephalus*); California scorpionfish (*Scorpeana guttata*); California sheephead (*Semicossyphus pulcher*); and monkeyface prickleback (*Cebidichthys violaceus*)]. 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 CDFW 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 2014, the only management changes to nearshore species are discussed above.

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(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 or dip net gears 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 220 permits were issued. In 2014, the number of permits had decreased to 150. The number of permits has been reduced 32 percent due to 2-for-1 permit transfers and attrition. Despite this, the number of permits is still above the capacity goal for each region.

The Nearshore Fishery Bycatch Permit program, which was started in 2003, authorizes the take, possession, and landing of shallow nearshore species by vessels using only trawl or entangling nets (gill and trammel nets). Eleven Nearshore Fishery Bycatch Permits were issued in 2014, a 58 percent reduction in the number of permits issued in 2003.

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 commercial fishing is allowed. A total of 294 permits were issued in 2003; the number of permits issued decreased to 188 in 2013, a 36 percent reduction in permits.

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C. BY SPECIES

1. Pacific Whiting

    There have been no directed Pacific whiting (*Merluccius productus*) trips since the inception of the TIQ program. Pacific whiting quota shareholders are either waiting for the Oregon season (area north of 42° 00' North Latitude) to open or are trading their whiting shares for other groundfish.

    Contributed by Traci Larinto (Traci.Larinto@Wildlife.ca.gov)

2. Chilipepper Rockfish

    Exempted fishing permits (EFP) have been granted by the Council in recent years to study the use of different gears in both commercial and recreational groundfish fisheries. One EFP was granted to commercial fishermen to study a method of commercial troll long line fishing to target chilipepper rockfish (*Sebastes goodei*) inside Rockfish Conservation Areas (RCAs). The RCAs, which are currently closed to groundfish fishing, were designed to protect overfished rockfish species such as yelloweye and canary rockfish. The inability to target healthy groundfish stocks (e.g., chilipepper rockfish) within the RCAs has resulted in underutilization of many groundfish. The goal of this study is to determine whether alternate fishing strategies (i.e., troll long line) can provide additional fishing opportunities for commercial fisheries inside the RCAs while avoiding overfished stocks. Very little fishing was conducted in 2014 and the EFP was not renewed.

    Contributed by Joanna Grebel (Joanna.Grebel@Wildlife.ca.gov)

3. Yellowtail rockfish

    A second EFP was granted to commercial fishermen to study a method of commercial jig fishing to determine whether it is possible to target yellowtail rockfish (*Sebastes flavidus*) inside the RCAs while avoiding overfished rockfish species. The goal of this study is to determine if alternate fishing strategies can provide additional fishing opportunities for the commercial fishery in the RCAs while avoiding overfished stocks. Preliminary data from five trips taken in 2013 indicate that the catch was comprised of primarily yellowtail and widow rockfish (*S. entomelas*) (57 and 30 percent of total catch, respectively). Catch of overfished species was minimal (bocaccio, canary, and yelloweye rockfish catch was 6.5, 1.4, 0.5 percent of total catch, respectively]. The remainder (4.6 percent) was a combination of shelf rockfish and other species. Fishing ceased when the participants came close to their yelloweye rockfish set aside (22 pounds). Additional work was undertaken in 2014, but no update was provided. This EFP was renewed for 2015-2016.

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4. Copper rockfish

Copper rockfish 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 copper rockfish, there is limited information available on age and growth in California waters. The CDFW's Groundfish Ecosystem Research and Management 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 was on hiatus in 2013 and has recently been restarted, with projected completion by early 2016. 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 (Caroline.Mcknight@Wildlife.ca.gov)

D. OTHER RELATED ACTIVITIES AND STUDIES

1. Implementation of the Marine Life Protection Act

Overview: The Marine Life Management Act (MLMA), Marine Life Protection Act (MLPA), and Marine Managed Areas Improvement Act (MMAIA) – passed by the California State Legislature in 1998, 1999, and 2000, respectively – provide a foundation for the design and management of MPAs. California implemented the largest scientifically designed MPA network in the United States by December 2012 (Figure 2), following an MPA design and siting process led by CDFW that spanned eight years across four coastal regions, including the central coast region (2005 – 2007), north central coast region (2007 – 2010), south coast region (2008 – 2012), and the north coast region (2009 – 2012). California's redesigned coastal MPA network covers approximately 852 square miles of state waters or about 16 percent, and approximately 9.4 percent of which in no-take MPAs.

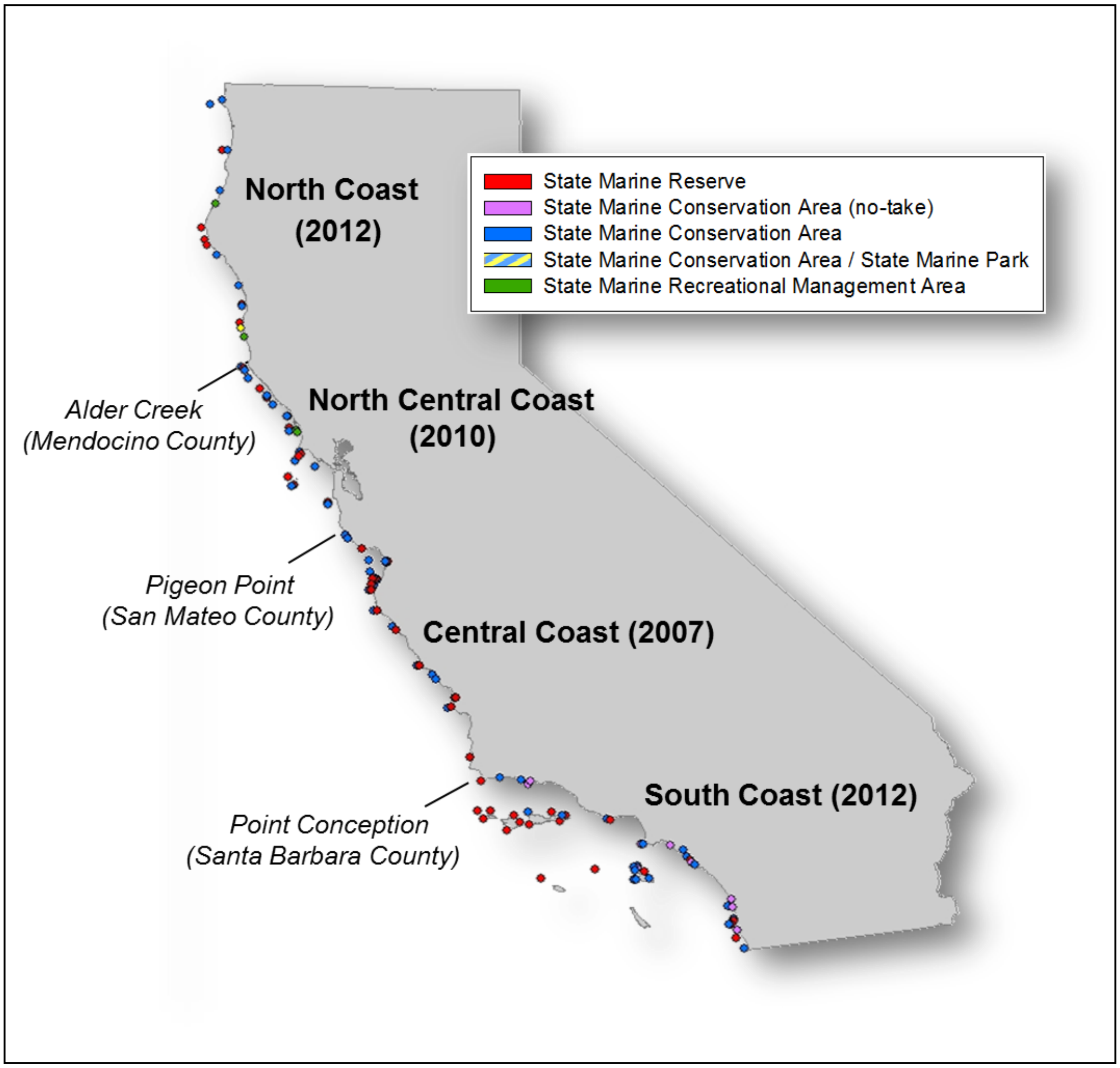

Figure 2. Locations for each MPA in California's redesigned coastal MPA network, the four MLPA coastal planning regions, and year in which each regional MPA network took effect.

2. <u>California MPA Monitoring and Research Activities</u>

Overview: CDFW currently focuses on a variety of MPA management activities, primarily aimed at meeting the goals and requirements of the MLPA, MMAIA, and MLMA; and guided by CDFW's MLPA Master Plan for MPAs and a complementary document adopted by the California Ocean Protection Council (OPC) in 2014 titled The California Collaborative Approach: Marine Protected Area Partnership Plan.

The MLPA requires monitoring, research, and evaluation at selected sites to facilitate and inform the adaptive management of MPAs. CDFW works with key partners to support and provide oversight on all aspects of MPA monitoring, research, reporting, and assessment/evaluation. CDFW also continues to explore MPA effects on California's marine fisheries, conducts field investigations such as remotely operated vehicle (ROV) projects, and administers a Geographic Information System (GIS) and an interactive marine and coastal data viewer called MarineBIOS.

MPA Monitoring Planning: In 2009, CDFW and California Ocean Science Trust (OST) created a statewide framework for MPA monitoring. The framework is designed to assess ecosystem condition and trends to inform evaluations of MPAs and management decisions, and serves as the primary basis for developing and updating regional MPA monitoring plans. To date, OST and CDFW have developed MPA monitoring plans in three of the four coastal regions to provide guidance for setting priorities, design of data collection, analysis, and reporting of monitoring projects.

Baseline MPA Monitoring Programs: Regional MPA baseline monitoring programs have been administered through a partnership among OST, CDFW, OPC, and California Sea Grant (CASG). Baseline programs are designed to establish an ecological and socioeconomic benchmark against which future MPA performance can be measured. Each regional baseline program consists of five phases: 1) secure funds and implement a process to conduct monitoring, 2) collect data, 3) analyze data, 4) report results, and 5) conduct monitoring and management reviews. Each region has between 5 to 11 baseline monitoring projects. Following data collection by the project researchers, the researchers work with the baseline partners to analyze the data and report the results. Baseline project summaries and technical reports are available on CASG's website, and the data is publicly available through an online portal at www.OceanSpaces.org. The status of regional baseline programs varies due to the staggered implementation of the regional MPA networks: 1) north coast (2014 – present), 2) north central coast (2010 – present), central coast (2007 – 2012), and south coast (2012 – present).

Sharing Baseline MPA Monitoring Results: OST, DFW, OPC, and CASG collaborate with baseline program researchers and others to share baseline results and other scientific information about the ecological and socioeconomic conditions of each region. To date, the central coast is the only baseline MPA program that has been completed. A central coast "State of the Region" baseline MPA monitoring summary report was released in 2013, coinciding with a public symposium to discuss the central coast baseline MPA program. The five-year monitoring summary and symposium proceedings reports were transmitted to the California Fish and Game Commission (Commission) to inform five-year MPA management recommendations which were delivered by CDFW to the Commission in late 2013.

Long Term MPA Monitoring: Following the completion of baseline monitoring in each region, CDFW and its partners administer cost-effective MPA monitoring programs. Efforts are underway between OST, OPC, and CDFW to develop a workplan to guide the disbursement of $3 million approved by the OPC for the next phase of MPA monitoring in the central coast region over the next 3-5 years.

MPAs and Fisheries Integration: It is expected that California's 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 fisheries may respond to the network. However, the efficacy of MPAs in terms of both their design and fisheries-based elements remains largely untested, especially on the scale of California's MPA network. The CDFW convened a MPAs and Fisheries Integration Workshop in 2011 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, and produced a workshop proceedings report. CDFW convened a second workshop in 2014 to discuss how MPA monitoring and historical data could help inform management of California's fisheries and MPAs.

ROV MPA Monitoring: Since 1999, the CDFW and its partners have performed visual surveys of fish, invertebrates, 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 size and density of fished species after MPA implementation. The CDFW program coordinates surveys with other studies funded through the MPA baseline monitoring programs as well as other projects and partners providing information for fisheries management. To date, extensive surveys have been completed at the Channel Islands (2003 – 2009), along the central coast region (2007 – 2009), and north central coast region (2009 – 2011). The CDFW recently completed surveys in southern California visiting MPA and fished rocky reefs from San Diego to Point Conception, and on the north coast from Point Arena to Point Saint George. Surveys will continue in 2015 on the north central coast between Pillar Point and Point Arena. In 2016, an ROV deployment on the central coast from Año Nuevo to Point Conception will complete a three-year statewide survey.

Geographic Information System: The CDFW's Marine Region GIS unit specializes in providing GIS marine and coastal data to support California marine science and management, such as spatial data related to California's coastline, bathymetry, fisheries, natural resources, and seafloor characteristics. Please visit the Marine Region GIS downloads website for more information.

MarineBIOS: CDFW's Marine Region GIS unit also administers a marine and coastal data viewer, MarineBIOS, which offers an interactive map for referencing relevant marine resource planning data, including boundaries and regulations of California's MPAs, marine habitats, geographic references, and points of interest.

Contributed by Adam Frimodig (Adam.Frimodig@wildlife.ca.gov) and Mike Prall (Michael.Prall@wildlife.ca.gov)

APPENDIX 1:

2014 CALIFORNIA GROUNDFISH COMMERCIAL FISHERY REVIEW

The 2014 California commercial groundfish harvest (Table 3) was approximately 6600 metric tons, with an ex-vessel value of $17.4 million. Landings were flat compared to 2013, while ex-vessel value increased 12 percent. California's top five groundfish species in 2014 were Dover sole (*Microstomus pacificus*), sablefish (*Anoplopoma fimbria*), thornyheads (*Sebastalobus spp.*), Petrale sole (*Eopsetta jordani*) and chilipepper rockfish (*Sebastes goodei*) the same as in 2013 although they made up a smaller percentage of the total landings (79 percent in 2014 vs. 83 percent in 2013).

In 2014, 73 percent of the groundfish landed were taken by bottom and mid-water trawl gear, slight decrease compared to 2013 (77 percent). Line and trap gears were the second and third most common gear types in 2014 at 20 and 7 percent, respectively; both gears saw a slight increase in use compared to 2013 (19 and 4 percent, respectively). Gill and trammel net landings were minimal, accounting for less than 0.1 percent of the groundfish catch.

The limited entry trawl individual quota (TIQ) program began in 2011, resulting in big changes for California groundfish fisheries. Prior to the TIQ program, Pacific whiting represented approximately 25 percent of the groundfish landings each year. With the advent of TIQ, California fishers traded or leased their whiting shares to Oregon and Washington fishers and Pacific whiting became bycatch in other more lucrative fisheries. Trawl gear is still the primary gear for taking groundfish, although landings in 2014 were 37 percent lower than in 2010, before TIQ. Hook-and-line landings have followed a similar trend, down 32 percent, while trap gear increased 6 percent. Despite an overall decrease in groundfish landings (34 percent between 2010 and 2014), the value of those landings is virtually the same. Pacific whiting was a low value, high volume fishery so while California lost that fishery, other more lucrative species were caught instead.

Landings of lingcod, sanddabs (all species combined) and Petrale sole have doubled since the advent of TIQ. The price paid for lingcod has increased 31 percent between 2010 and 2014, while sanddabs and Petrale sole have been steady. Bocaccio landings have increased from 4 to 25 metric tons between 2010 and 2014. Both Petrale sole and bocaccio had been declared overfished and quotas have increased in recent years as both species are recovering. Recently, markets have developed for big skate and spiny dogfish with landings totaling 39 and 38 metric tons, respectively, in 2014 compared to 2010 (1 and 6 metric tons, respectively). The ex-vessel price for big skate has more than doubled between 2010 and 2014 ($0.15 and $0.37 per pound, respectively), while the price for spiny dogfish has varied ($0.41, $0.43, and $0.21 in 2010, 2013, and 2014, respectively).

Landings of other species, such as sablefish and Dover sole have decreased (33 and 25 percent, respectively) since the TIQ program. Interestingly, thornyheads landings (all species combined) remained steady, despite the fact that they are frequently targeted with sablefish and Dover sole. Slope rockfish (all species combined) also decreased 40 percent. Many of these changes can be attributed to TIQ permittees participating in gear switching, reducing the catch of species traditionally caught with trawl gears.

Contributed by Traci Larinto (Traci.Larinto@Wildlife.ca.gov)

Table 3. California commercial groundfish landings (metric tons) for 2013-2014.

Common Name	2013	2014	2010	Percent change between 2010 and 2014
Roundfish				
Cabezon	29	31	23	34
California scorpionfish	3	1	3	-64
California sheephead	28	41	31	36
Grenadiers	83	58	95	-38
Kelp greenling	5	5	2	176
Lingcod	65	105	47	126
Monkeyface prickleback	0	0	0	617
Pacific cod	0	0	--	
Pacific whiting	6	5	2427	-100
Ratfish	0	2	0	15845
Rock greenling	0	0	--	
Sablefish	1396	1632	2450	-33
Flatfish				
Arrowtooth flounder	118	75	68	12
Butter sole	0	0	--	
Curlfin turbot	0	1	--	
Dover sole	2219	1943	2622	-26
English sole	49	59	24	146
Pacific sanddabs	2	21	0	77753
Petrale sole	472	593	213	178
Rex sole	45	43	55	-22
Rock sole	4	1	2	-66
Sand sole	15	16	8	92
Starry flounder	5	12	13	-14
Unspecified sanddabs	100	95	56	70
Unspecified sole	17	18	9	97
Sharks and skates				
Leopard shark	1	3	3	-15
Soupfin shark	1	2	3	-27
Spiny dogfish	1	38	6	586
Big skate	21	39	1	3474
California skate	0	0	--	
Longnose skate	151	165	142	16
Unspecified skate	14	19	24	-20
Rockfishes				
Shallow nearshore rockfish				
Black-and-yellow rockfish	10	11	10	8
China rockfish	1	2	2	-8
Gopher rockfish	23	26	28	-9
Grass rockfish	13	11	12	-13
Kelp rockfish	1	1	1	-25
Misc. shallow nearshore rockfish	0	0	0	-64

Table 3. California commercial groundfish landings (metric tons) for 2013-2014.

Common Name	2013	2014	2010	Percent change between 2010 and 2014
Deeper nearshore rockfish				
Black rockfish	36	40	53	-25
Blue rockfish	6	7	3	111
Brown rockfish	28	26	27	-1
Copper rockfish	7	6	3	108
Olive rockfish	1	1	1	77
Quillback rockfish	1	0	1	-49
Treefish	1	2	2	35
Misc. deeper nearshore rockfish	0	0	0	163
Shelf rockfish				
Bocaccio	17	25	4	559
Canary rockfish	2	2	0	339
Chilipepper rockfish	323	263	342	-23
Greenspotted rockfish	2	2	1	106
Starry rockfish	1	1	1	-5
Vermilion rockfish	23	26	13	99
Widow rockfish	6	4	10	-56
Yellowtail rockfish	5	6	1	458
Misc. shelf rockfish	4	7	2	216
Slope rockfish				
Aurora rockfish	5	3	0	750
Bank rockfish	52	43	7	474
Blackgill rockfish	73	59	96	-39
Darkblotched rockfish	4	4	17	-78
Splitnose rockfish	14	17	64	-74
Misc. slope rockfish	24	35	80	-56
Unspecified rockfish	0	1	0	113
Thornyheads				
Longspine thornyhead	652	608	552	10
Shortspine thornyhead	428	379	462	-18
Unspecified thornyheads	6	1	13	-92
Total	6618	6642	10,137	-34

Notes:
1. Landing data for 2014 are preliminary.
2. These are not federal groundfish but are part of the California's Nearshore Fishery Management Plan.
3. Zero (0) indicates that less than 1 metric ton was landed; -- indicates no landings occurred.
4. Longnose skate market category was added in 2009. Prior to that, longnose skates were included in the unspecified skate category.
5. Misc. rockfish contain both group market categories (e.g., group shelf rockfish) and single species market categories for species with landings less than one ton per year (e.g., greenstriped rockfish) and are a minor component of the commercial catch.
6. Unspecified rockfish and unspecified thornyhead market categories were discontinued in 2001.

Source: California Commercial Fisheries Information System.

APPENDIX 2:

2013 CALIFORNIA GROUNDFISH RECREATIONAL FISHERY REVIEW

The 2013 California recreational fishery caught approximately 2314 metric tons of groundfish and nearshore species (Table 4), 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 2013 was almost 20 percent higher than in 2012 and was due to increased catch of lingcod (*Ophiodon elongatus*) and rockfishes. In 2013, lingcod catch continued to increase as did rockfish catch (35 and17 percent, respectively, compared to 2012) due to longer fishing seasons in most regions. Changes to the sampling protocol instituted in 2004 prevent a direct comparison between 2003 and 2013 recreational catch. However, given that the recreational fishery has seen increased restrictions since 2001, much like the commercial fishery, the overall catch is likely considerably lower.

Rockfishes made up 71 percent of the recreational groundfish and state nearshore species catch in 2013, down slightly from 2012 (73 percent). The slight decline can be attributed to the large increase in lingcod catch in 2013. The same thing happened in 2012—increased lingcod and decreased rockfish catches compared to 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. Deeper nearshore rockfish accounted for 42 percent of the rockfish catch in 2013 followed by shelf and shallow nearshore (33 and 12, percent respectively); slope rockfish were rarely encountered due to the fact that fishing has been closed in deeper depths for a number of years. Black, vermilion, and bocaccio were the most frequently caught rockfish in 2013, followed by blue, copper and brown rockfishes. California scorpionfish, a closely related species in southern California, accounted for 7 percent of the rockfish catch in 2013. Of the non-rockfish groundfish, lingcod was most frequently caught (19 percent) in 2013. Lingcod was followed by sanddabs (all species combined), California sheephead (not a groundfish species, but a state nearshore species) and cabezon (4, 3 and 2 percent, respectively).

Contributed by Traci Larinto (Traci.Larinto@Wildlife.ca.gov)

Table 4. California recreational groundfish catch[1] (metric tons) for 2013-2014.

	2013	2014[2]		2013	2014[2]
Flatfish					
Butter sole	0.0[3]	--[3]	Rock sole	0.7	0.8
Dover sole	--		Sand sole	1.0	0.5
English sole	0.0	0.0	Starry flounder	0.9	1.7
Pacific sanddab	85.7	107.3	Unspecified sanddabs	5.6	12.3
Petrale sole	1.1	0.9	**Flatfish total**	**95.1**	**123.5**
Rockfish					
Shallow nearshore			*Shelf (continued)*		
Black and yellow rockfish	5.8	9.8	Flag rockfish	14.2	9.3
California scorpionfish	112.0	122.6	Greenspotted rockfish	11.1	9.8
China rockfish	10.0	10.3	Greenstriped rockfish	1.2	1.3
Gopher rockfish	41.2	55.4	Halfbanded rockfish	3.3	4.7
Grass rockfish	9.8	12.3	Honeycomb rockfish	9.2	5.6
Kelp rockfish	19.2	17.6	Rosy rockfish	5.5	4.6
Deeper nearshore			Speckled rockfish	15.5	9.5
Black rockfish	362.6	339.7	Squarespot rockfish	16.6	22.4
Blue rockfish	106.2	134.0	Starry rockfish	24.0	14.6
Brown rockfish	81.7	120.5	Vermilion rockfish	210.7	205.8
Calico rockfish	0.9	0.4	Widow rockfish	17.8	16.4
Copper rockfish	98.8	102.3	Yellowtail rockfish	55.9	59.9
Olive rockfish	20.3	31.7	Misc. shelf rockfish[4]	16.5	17.9
Quillback rockfish	2.9	2.7	*Slope*		
Treefish	13.1	9.5	Misc. slope rockfish[4]	0.3	0.6
Shelf			*Unspecified rockfish*	215.0	186.2
Bocaccio	130.8	99.5	**Rockfish total**	**1368.7**	**1639.4**
Chilipepper rockfish	7.3	10.6			
Roundfish					
Cabezon	39.3	50.8	Pacific whiting	0.0	0.1
California sheephead[5]	61.3	52.1	Ratfish	0.0	--
Kelp greenling	13.7	12.6	Rock greenling[5]	0.7	5.4
Lingcod	433.0	571.8	Sablefish	0.1	0.3
Monkeyface prickleback[5]	2.2	3.3	**Roundfish total**	**550.3**	**696.4**
Sharks and skates					
Big skate	6.6	--	Soupfin shark	0.6	0.4
California skate	0.3	0.0	Spiny dogfish	7.1	2.3
Leopard shark	14.0	14.1	Unspecified skates	0.0	--
Longnose skate	0.0	--	**Sharks and skates total**	**28.7**	**16.8**
			GRAND TOTAL	**2314**	**2484**

Notes:

1. Recreational catch includes sampler examined catch and observed discarded dead catch.
2. Catch data for 2014 are preliminary.
3. Zero (0.0) indicates that less than 1 metric ton was caught; -- indicates no catch was recorded.
4. Misc. rockfish combines species for which there was less than 1 metric ton caught per year.
5. These are not federal groundfish species but are part of California's Nearshore Fishery Management Plan.

Source: Pacific Recreational Fisheries Information Network (RecFIN).

OREGON'S GROUNDFISH FISHERIES AND INVESTIGATIONS IN 2014

OREGON DEPARTMENT OF FISH AND WILDLIFE

2015 AGENCY REPORT
PREPARED FOR THE 28-29 APRIL 2015 MEETING OF THE TECHNICAL SUB-COMMITTEE OF THE CANADA-UNITED STATES GROUNDFISH COMMITTEE

Edited by:

Alison Whitman

Contributions by:

M. Blume, T. Buell, C. Don, D. Fox, S. Jones, L. Kautzi, G. Krutzikowsky, R. Hannah, L. Mattes, P. Mirick, P. Rankin, B. Rodomsky, C. Sowell and D. Wolfe Wagman

Oregon Department of Fish and Wildlife
Marine Resources Program
2040 SE Marine Science Drive
Newport, OR 97365

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OREGON DEPARTMENT OF FISH AND WILDLIFE

A. AGENCY OVERVIEW – MARINE RESOURCES PROGRAM

MRP Program Manager:	Dr. Caren Braby
Resource Management and Assessment:	Dave Fox
Fishery Management:	Gway Kirchner
Technical and Data Services:	Maggie Sommer

The Marine Resources Program (MRP) is within the Oregon Department of Fish and Wildlife (ODFW) and has 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 cities of Astoria, Charleston, 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 60 seasonal or temporary positions. The current annual program budget is approximately $8.75 million, with about 77% 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 23% of the annual program budget.

B. MULTISPECIES STUDIES

1. Sport Fisheries Project

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2014. Starting in November 2005, major ports were sampled year-round and minor ports for peak summer-fall season. We continue to estimate catch during un-sampled time periods in minor ports based on the relationship of effort and catch relative to major ports observed during summer-fall periods when all ports are sampled. 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 collecting information on species composition, length and weight of landed groundfish species at Oregon coastal ports during 2014. 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, a portion of sport charter vessels were sampled using ride-along observers for species composition, discard rates and sizes, location, depth and catch per angler (See Section B.2).

Beginning in 2003, the recreational harvest of several groundfish species is monitored in-season for catch limit tracking purposes. Pre-season in 2014, the cabezon season was modified to July 1 through December 31. This allowed the cabezon season to proceed with no in-season actions being necessary for the first time in many years. 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 groundfish fishery was restricted pre-season to inside of 30 fathoms from April 1 to September 30. Landings in the sport Pacific halibut fisheries are 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 followed by Pacific City. Other ODFW management activities in 2014 include participation in the U.S. West Coast Recreational Fish International Network (RecFIN) process, data analysis, public outreach and education, and public input processes to discuss changes to the management of groundfish and Pacific halibut fisheries for 2015, 2016, and beyond.

Starting in July 2005, sampling of the shore and estuary fishery was discontinued due to a lack of funding. While salmon dominate estuary boat landings by weight, 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. 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.

Contact: Lynn Mattes (541) 867-0300 ext. 237 (lynn.mattes@state.or.us), Patrick Mirick (541) 867-0300 ext. 223 (patrick.p.mirick@state.or.us)

2. "No Floaters: Release At-Depth" Barotrauma Outreach Campaign

To reduce bycatch mortality of overfished rockfish species in the sport fisheries, ODFW began an outreach campaign in 2013 with the goal of increasing descending device usage among sport anglers. The effort, branded "No Floaters: Release At-Depth", has distributed over 5,000 descending devices to date, to all charter vessel owners and to the majority of sport boat owners who had previously targeted groundfish or halibut. In addition, several thousand stickers bearing an emblem of the brand (

Figure **15**) have been distributed with the goal of making rockfish conservation an innate aspect of fishing culture. The continued outreach campaign appears to be successful. Prior to the beginning of the campaign, fewer than 40 percent of anglers used descending devices. After the campaign, the percentage of users increased to greater than 80 percent. The percentage of users has remained near that 80 percent level. Additional outreach efforts include: videos are being produced that show fish successfully swimming away after release with a device and new rockfish barotrauma flyers have been produced. This outreach campaign has been the result of collaboration between ODFW, two angler groups (Oregon Coalition for Educating Anglers and Oregon Angler Research Society), Utah's Hogle Zoo, and ODFW's Restoration and Enhancement (R & E) program. As part of a new National Marine Fisheries Service (NMFS) Saltwater Recreational Policy, additional resources to continue this outreach may be available.

Figure 15: Picture of sticker provided to anglers as part of the "No Floaters" outreach campaign.

Contact: Lynn Mattes (541) 867-0300 ext. 237 (lynn.mattes@state.or.us), Patrick Mirick (541) 867-0300 ext. 223 (patrick.p.mirick@state.or.us)

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 in-season adjustments of the commercial nearshore fishery (Section B.5), which is conducted in state waters, and for participation in the Pacific Fisheries Information Network (PacFIN). Species composition sampling of rockfish and biological sampling of commercially landed finfish continued in 2014 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. Oregon's Commercial Nearshore Fishery

The commercial nearshore fishery in Oregon became a limited-entry permit-based program in 2004, following the development of the open access nearshore fishery in the late 1990's. The commercial nearshore fishery exclusively targets groundfish, including Black Rockfish, Blue Rockfish (*S. mystinus*), Cabezon, Kelp Greenling, and Oregon's "Other Nearshore Rockfish" complex. The fishery is primarily composed of small vessels (25 ft. average) fishing in waters less than 30 fathoms. Major gear types include hook-and-line, longline and fish pots. Fish landed in this fishery supply mainly live fish markets, but also provide product for fresh fish markets. Landings are regulated through two-month trip limits, minimum size limits, and annual harvest guidelines. Weekly updates on landings allow MRP staff to more effectively manage the fishery in-season.

Landings from the 2013 commercial nearshore fishery, logbook compliance, economic data, and biological data are detailed in the 2013 Commercial Nearshore Fishery Summary (Rodomsky et al. 2014; http://www.dfw.state.or.us/MRP/publications/docs/2013%20The%20Oregon%20Commercial%20Nearshore%20Fishery%20Summary.pdf). Overall, the majority of active permit holders are located on the southern Oregon coast, resulting in most of the catch consistently landed in Port Orford, Gold Beach and Brookings. Black Rockfish continued to comprise the majority of landings by weight. In-season management in 2013 included increases to two-month trip limits for Black and Blue Rockfish and Cabezon.

Fishery management staff are also working to ready data for 2015 stock assessments of nearshore species including Black Rockfish, China Rockfish and Kelp Greenling. These tasks include preparing a report on Kelp Greenling growth and length-at-maturity, and shaping nearshore logbook data for use as an index of abundance.

Contact: Brett Rodomsky (541) 867-0300 ext. 291 (Brett.T.Rodomsky@state.or.us), Troy Buell (541) 867-0300 ext. 225 (Troy.V.Buell@state.or.us)

5. Continuation of Marine Fish Ageing Project at MRP

During 2014, 3,775 age estimates were produced for recreation, commercial, and research purposes within the Marine Resource Program. For recreation and commercial programs, 1,576 kelp greenling and 805 black rockfish ages were produced, with an additional 251 and 161 test ages respectively generated. To fulfill research needs within MRP, an additional 189 black rockfish (175 tested), 260 copper rockfish (52 tested), 75 blue rockfish (15 tested), and 195 kelp greenling (21 tested) were also aged.
Contact: Lisa Kautzi (541) 867-0300 ext. 247 (Lisa.A.Kautzi@state.or.us)

6. 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. We continued work on female blue-sided rockfish and blue-blotched rockfish, as well as kelp greenling. We completed an agency Informational Report describing our findings for female copper rockfish that can be accessed at: http://www.dfw.state.or.us/MRP/publications/#Research.

Contact: Bob Hannah (bob.w.hannah@state.or.us, rockfish); Brett Rodomsky (Brett.T.Rodomsky@state.or.us, kelp greenling)

7. Movement of Rockfishes Using Acoustic Telemetry

We completed some work on the write-up of prior years' field work on yelloweye rockfish movements.

Contact: Bob Hannah, (bob.w.hannah@state.or.us), or Polly Rankin (polly.s.rankin@state.or.us)

8. Development and Testing of a Video Lander for Studying Demersal Fishes on Nearshore Rocky Reefs

We continued work developing and testing video landers as survey tools for rocky reef fishes. Field research evaluating the effect of light color on avoidance of the lander was abandoned after no apparent avoidance effect was detected. Later in 2014, we initiated a study investigating the effects of ambient light and turbidity/scattering on the effective sampling range of a stereo-video lander. This work will continue in 2015. We also published a paper describing our work evaluating the effect of bait and stereo-video on lander performance.

Contact: Bob Hannah, (bob.w.hannah@state.or.us), or Matthew Blume (matthew.blume@state.or.us)

9. Reducing the Residual Bycatch of Eulachon Smelt and Groundfish in Pink Shrimp Trawls

In July 2014, we tested the effect of adding artificial light at the bycatch reduction device (grid) and at the trawl footrope on the residual bycatch of eulachon and groundfish in a pink shrimp trawl. We used green Lindgren-Pitman® lights as the light source and changed one net on a double-rigged shrimper, using the other net as a control. Adding light on or near the grid increased eulachon bycatch by 104% and slender sole bycatch by 77%, apparently defeating the exclusion effect of the grid for these small fishes. Conversely, adding 10 green Lindgren-Pitman lights along the fishing line of the trawl (where the netting is attached, approximately 0.5 m above the seafloor on most trawls) reduced bycatch of eulachon by 91%, juvenile darkblotched rockfish by 82%, slender sole and other small flatfish by 69% and the bycatch of other juvenile rockfishes by 56%. We notified the shrimp fleet of these findings via a special mid-season newsletter, and by the end of the April-October fishing season, virtually the entire 60-boat Oregon shrimp fleet was fishing 6-15 green Lindgren-Pitman lights on each of their trawl footropes. A manuscript describing this research is currently in review.

Contact: Bob Hannah (bob.w.hannah@state.or.us), Steve Jones (steve.a.jones@state.or.us)

10. Discard Mortality of Hook-and-Line-Caught Rockfish with Barotrauma

We conducted a study to evaluate the longer-term survival and health of yelloweye rockfish experiencing capture-related barotrauma. We utilized a combination of sea-cage and laboratory holding to evaluate fish condition at 4 time intervals throughout a 30-day period. Yelloweye rockfish were captured from a depth range of 140-150m, and evaluated for injury while live, post recompression and after euthanasia at 15 and 30 days. Staff and OSU veterinarians Dr. Jerry Heidel and Dr. Tim Miller-Morgan conducted necropsies and took blood samples for analysis. All fish exhibited extensive barotrauma from initial capture, but external signs resolved post-recompression. Fish that survived to 15 and 30 days (5/6 for each trial) had severely compromised buoyancy. All necropsies on day 15, revealed blood clots or active hemorrhaging in the body cavity and within organs and extensive swimbladder injury. Necropsies on day 30 showed continued swimbladder compromise. Although its encouraging that these fish survived longer-term post-recompression, their condition indicates that serious injury remains for weeks and even a month post-capture. Of concern as well, is that lack of neutral buoyancy is a serious physical and behavioral impairment for physoclists. The condition of these fish indicated that latent mortality studies in fish captured from these deep, cold waters may need to extend beyond 30 days. We also published a paper describing our 2013 research comparing post-recompression mortality of canary and yelloweye rockfish captured at depths greater than 84 m.

Contact: Polly Rankin (polly.s.rankin@state.or.us) or Bob Hannah (bob.w.hannah@state.or.us)

11. Investigation of Shrimp Trawl Impacts on Seafloor Habitat.

We completed the write-up of a 2013 ROV-based re-survey of seafloor habitat and benthic invertebrates at 4 mud-habitat areas near Nehalem Bank, 2 that have been closed to bottom contact gear since 2007 and 2 that have remained open to shrimp trawling. The re-survey found very large increases in sea whip densities at all 4 sites in the 6-year interval, suggesting these deep mud habitats can change rapidly. The results comparing the 2007 and 2013 surveys are summarized in an Informational Report available at:

http://www.dfw.state.or.us/MRP/publications/#Research.

12. Marine Reserves in Oregon

In Oregon, marine reserves are areas of the ocean dedicated to conservation and research. There are five marine reserve sites located off the coast of Oregon at Cape Falcon, Cascade Head, Otter Rock, Cape Perpetua, and Redfish Rocks. Within the marine reserves all take of marine life and ocean development is prohibited. Adjacent to the marine reserves are marine protected areas which prohibit all ocean development, but do allow for certain fishing activities.

There are three goals of Oregon’s marine reserve sites. The first is the marine reserves are to conserve marine habitats and biodiversity. The next is the marine reserves are to serve as scientific reference areas to learn about marine reserve effectiveness and to learn about Oregon’s nearshore environment in support of nearshore resource management in general. The last is the marine reserves are to avoid significant impacts to ocean users and coastal communities.

The ODFW Oregon Marine Reserves Program is responsible for overseeing the management and scientific monitoring of Oregon’s marine reserves. Below is an overview of ecological monitoring activities that took place during 2014.

Status of sites
Harvest prohibitions took effect on January 1, 2014 for two new marine reserves at Cascade Head and Cape Perpetua, bringing the total number of implemented no-take reserves in state waters to four. Harvest prohibitions at a fifth and final marine reserve site at Cape Falcon will begin on January 1, 2016, as mandated by Senate Bill 1510 passed by the 2012 Oregon Legislature.

Site management plans have been completed and are currently being implemented for the Redfish Rocks and Otter Rock Marine Reserves. Development of site management plans for the Cape Perpetua and Cascade Head sites is currently underway, with assistance from local communities. Management plans outline site-specific strategies for outreach, reporting on monitoring activities and results, ways to improve compliance and enforcement, opportunities for community and public engagement and for addressing site specific management issues. The plans also highlight local community interests, priorities, and projects for the marine reserve site.

Monitoring Program

Survey Design: Monitoring data were collected inside the no-take marine reserves and outside the reserves in control sites, hereafter referred to as comparison areas. Comparison areas were selected based on similar depths, habitats, oceanographic conditions and fishing pressure as the associated marine reserve. Unlike the reserve however, comparison areas remain open to fishing. Long-term monitoring of the marine community will be conducted identically in both the reserve and comparison areas to discern changes due to environmental variation from changes caused by marine reserve protection. Baseline data establishes a starting point, from which future changes will be monitored in both the reserve and comparison areas through time. To detect reserve effects, the analyses will focus on comparing the magnitude of temporal change from the baseline data for response variables such as fish and invertebrate diversity, size and abundance.

Monitoring Conducted in 2014

Hook and Line Surveys: The Oregon Marine Reserves Program continued hook and line surveys in 2014 adding a fourth site, Cape Falcon Marine Reserve and its associated Cape Meares Comparison Area, to our monitoring efforts. Data collection was broken into two periods: Spring (April-May) and Fall (September-October). Combining both periods, the program sampled five days in Cape Falcon, eight days in Cascade Head, eight days in Cape Perpetua, and ten days in Redfish Rocks. In total this amounted to 31 trips led out of four different ports, with participation from 165 volunteer anglers. Although each site is unique, the 2014 survey caught a total of 5,729 fish representing 26 species between marine reserves (3,731 fishes) and comparison areas (1,998 fishes). The 26 species were distributed across five families: rockfishes—14 species, sculpins—4 species, flatfish—5 species, greenling—2 species, and surf perch—1 species. Although salmon were not included in our data, the survey did encounter at least six Coho Salmon in three different sites. Daily catches ranged from a low of 39 to a high of 431 fish measured, weighed, and released.

Honing of Sampling Methods – Trifecta Study: Oregon's five marine reserve sites host a variety of nearshore marine habitats and species. To monitor habitats and species over time, Program staff are using a suite of sampling tools. Particular sampling tools are better at sampling certain species or capturing certain measurements. To better understand the sampling biases of the tools being used to assess shallow rocky reef areas of marine reserve sites, Program staff conducted a pilot "Trifecta Study" in 2014. The Trifecta Study entailed conducting simultaneous surveys using three different sampling tools to see if they produce

similar measures of fish abundance, fish length, and species composition. The study was conducted at the Redfish Rocks Marine Reserve and looked at the differences between hook-and-line, subtidal SCUBA transects, and video lander (i.e. stationary drop camera) sampling tools. Preliminary results indicate that the video lander was slightly less effective than the other tools, although data is still being collected for this study. The video lander was limited in its ability to visually identify all fish to the species level, which reduces the overall species richness (number of different species) observed. Also, hook-and-line surveys were the only tool able to capture less common species of rockfishes including China and Quillback Rockfish. Program staff are looking at expanding the sample size of this study, to continue to hone in on the best methods to use to answer specific research questions.
More information, including copies of monitoring plans and reports, is available on the Oregon Marine Reserves website at www.oregonocean.info/marinereserves.

Contact: Cristen Don (541) 867-7701 ext. 228 (Cristen.Don@state.or.us)

13. Ocean and Estuary Shoreline Habitat Mapping

MRP staff completed a project to map and classify Oregon's ocean and estuary shorelines using the ShoreZone mapping protocol. ShoreZone is a coastal habitat mapping and classification system in which aerial imagery is collected specifically for the interpretation and delineation of geomorphic and biological features of the intertidal zone and shoreline environment. The overall goal of ShoreZone mapping is to provide a representation of the coastal and estuarine shoreline morphology and a basic framework for the biophysical characterization of the coast. This mapping protocol has been used extensively in Alaska, British Columbia and Washington, and has now extended into Oregon. The final geodatabase, aerial photos, and related products can be viewed or downloaded from http://www.coastalatlas.net/shorezone/.

Staff are now participating in a partnership with NOAA, Alaska ShoreZone, and other collaborators in Washington and British Columbia to develop an integrated, consistent ShoreZone dataset that will include all of the western North America surveys, extending for over 60,000 miles of shoreline. NOAA plans create a website that serves and displays the habitat data, photography, and videography in 2015.

Contact: Dave Fox (541) 867-0300 ext. 228 (David.S.Fox@state.or.us)

14. Surveys of Subtidal Rocky Areas in Oregon's Territorial Sea

Fishery independent data for many fish species found in Oregon's territorial sea is currently minimal or entirely lacking. Surveys of shallow (<55 m) subtidal rocky areas were undertaken in the spring of 2014 in the waters near Newport, OR. This effort focused on exploring the use of the video lander designed by ODFW (Hannah and Blume 2012) to investigate its use as a tool for fishery independent surveys of nearshore rocky reef associated fishes and invertebrates. Seawater properties were also collected during each video lander drop using a casting Seabird 19plus CTD equipped with an oxygen sensor. Initial analysis of video

data will focus on determining if there is a measurable response to the lander, either positive or negative, and exploring optimal bottom times for nearshore work to capture adequate representation of biodiversity and abundance of species observed given the tradeoff between increased bottom time and number of drops that can be done in day of field work. Analysis has been undertaken in collaboration with the ODFW marine reserves ecological monitoring project which also has interest in using a video lander as a survey tool. This is the first step in the process of investigating this tool as one method to be employed for fishery independent surveys in rocky areas throughout Oregon's territorial sea.
Contact: Greg Krutzikowsky (541) 867-0300 ext. 248 (Greg.Krutzikowsky@state.or.us), Brett Rodomsky (541) 867-0300 ext. 291 (Brett.T.Rodomsky@state.or.us)

C. BY SPECIES

1. Black Rockfish PIT Tagging

Black rockfish comprise approximately 50% of the catch in Oregon's 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 sampling bias or to changes in the fishery, such as effort distribution and regulations. The need to independently estimate exploitation rates and population abundances for black rockfish off Oregon prompted the development of a mark-recapture program using passive integrated transponder (PIT) tags. Tags are injected in the hypaxial musculature below the gill arches, determined to be the best site by a previous PIT tag retention study by ODFW. Since PIT tags are invisible to anglers, there is no tag non-reporting bias and tag detection rates can be estimated directly. The program was conducted from 2002 to 2014. The minimum size for tagging was increased from 29 centimeters (cm) to 32 cm in 2007.

In early 2014, due to the lack of federal funding, tagging operations for this project has been terminated. Tag recovery collection will continued through the end of June 2014. Because these tags will last for decades within the population, it may be possible to recover tags in the future and use this data to make further estimates if there is adequate funding and staff to continue scanning black rockfish carcasses and analyzing data.

Contact: D. Wolfe Wagman (541) 867-0300 ext. 289 (David.W.Wagman@state.or.us), Troy Buell (Troy.Buell@state.or.us)

D. PUBLICATIONS

Hannah, R.W. 2014. Length and age at maturity of female copper rockfish (*Sebastes caurinus*) from Oregon waters based on histological evaluation of ovaries. Oregon Department of Fish and Wildlife, Information Rept. Ser., Fish. No. 2014-04. 18 p.

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E. PROJECTS PLANNED FOR YEAR 2014

1. Maturity Studies

Maturity data for blue-sided rockfish will be finalized and summarized. Work will continue on tiger and redbanded rockfishes.
Contact: Bob Hannah, (bob.w.hannah@state.or.us)

2. Testing a Video Lander for Surveying Rocky Reefs

The in-progress study of how ambient light and turbidity/scattering influence the performance of a stereo-video lander will be completed.
Contact: Bob Hannah, (bob.w.hannah@state.or.us), Matthew Blume (matthew.blume@state.or.us)

3. Investigation of Hook-and-Line Surveys for Nearshore Reefs

We will be investigating the effectiveness of standardized hook-and-line surveys for nearshore rocky-reef fishes by conducting some replicate surveys comparing two different approaches for site selection.
Contact: Bob Hannah (bob.w.hannah@state.or.us), Polly Rankin (polly.s.rankin@state.or.us)

4. Discard Mortality of Rockfishes

ODFW will be investigating several aspects of the health of yelloweye rockfish that have experienced capture-related barotrauma. One experiment will utilize an on-bottom observation cage to evaluate the post-recompression behavior of yelloweye rockfish. An additional experiment will employ longer term holding and veterinarian-led necropsies of yelloweye rockfish that have experienced, and recovered or died from capture-related barotrauma.

Contact: Bob Hannah (bob.w.hannah@state.or.us), Polly Rankin (polly.s.rankin@state.or.us)

5. Nearshore Video Lander and CTD Survey

In 2014, ODFW used a high-definition video lander and a Seabird CTD to study habitat characteristics and demersal fish populations on nearshore rocky reefs. The study area ranged from Yaquina Bay to Alsea Bay, offshore to about 20 fathoms. Approximately 115 individual video lander drops of footage were collected, with 115 associated CTD casts. Observations of seabirds and marine mammals were also collected during this survey. Data were entered into a database and analyses are underway. In 2015, the survey will continue covering the nearshore area from Yaquina Bay to Cape Foulweather.

Contact: Greg Krutzikowsky (Greg.Krutzikowsky@state.or.us), Brett Rodomsky (Brett.T.Rodomsky@state.or.us)

6. Marine Finfish Ageing

Ageing of commercially and recreationally captured black rockfish otoliths will continue in 2015.
Contact: Lisa Kautzi (Lisa.A.Kautzi@state.or.us)

Washington Contribution to the 2015 Meeting of the Technical Sub-Committee (TSC) of the Canada-US Groundfish Committee

April 28th-29th, 2015

Edited by:
Dayv Lowry

Contributions by:
Dayv Lowry
Robert Pacunski
Lorna Wargo
Kurt Stick
Larry LeClair
Corey Niles
Theresa Tsou

Washington Department of Fish and Wildlife
April 2015

Review of WDFW Groundfish/Forage Fish Research, Assessment, and Management Activities in 2014

A. Puget Sound Area Activities

Staff of the Puget Sound Marine Fish Science (MFS) Unit include Dayv Lowry, Robert Pacunski, Larry LeClair, Kurt Stick, Jen Blaine, Adam Lindquist, Lisa Hillier, Andrea Hennings, Jim Beam, and Erin Wright. In addition, Courtney Adkins and Peter Sergeeff work as MFS employees during the spring bottom trawl survey. Taylor Frierson, Casey Wilkinson, and Amanda Philips joined the team in February of 2014 and serve as primary staff for ongoing surveys at U.S. Navy Facilities (see below). An additional two staff (project Bio2 and SciTech2) are currently being hired to expand these Navy surveys to include bi-monthly beach seining. The MFS unit and the Coastal Marine Fish Science Unit are overseen by Theresa Tsou.

Unit tasks are primarily supported by supplemental funds from the Washington State Legislature for the recovery of Puget Sound bottomfish populations, and secondarily by a suite of collaborative external grants. The main activities of the unit include the assessment of bottomfish and forage fish populations in Puget Sound, the evaluation of bottomfish in marine reserves and other fishery-restricted areas, and the development of conservation plans for species of interest. Groundfish in Puget Sound are managed under the auspices of the Puget Sound Groundfish Management Plan (Palsson, et al. 1998).

1. Puget Sound Groundfish Monitoring, Research, and Assessment (*Contact: Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov; Dayv Lowry 360-902-2558, dayv.lowry@dfw.wa.gov*)

a. ESA-listed Rockfish Critical Habitat Designation

In November of 2014 NOAA formally designated critical habitat for the Puget Sound/Georgia Basin distinct population segment of yelloweye, canary, and bocaccio rockfish. In an effort to act in a precautionary manner the areas designated as critical habitat were identified using very simple criteria and, as such, include a substantial degree of suboptimal habitat. Marine Fish Science Unit staff were contracted by NOAA in late 2014 to plan and execute a two-year study to groundtruth the validity of this designation using a remotely operated vehicle (ROV). Working with Chris Rooper of NOAA, staff developed a habitat suitability model based on past ROV survey records and using water depth, bottom rugosity, and slope as key habitat correlates. Taking into consideration the expected encounter rate of canary and yelloweye rockfish from past surveys, the area to be covered (Puget Sound "proper" – all waters south of Port Townsend and east of Deception Pass), funding, and other logistical factors three likelihood strata were generated and it was determined that 900+ stations could be completed. Effort was then allocated 60:20:20 (High:Moderate:Low) and sample locations were randomly selected – 450 in year one and 450 in year two. Surveys began in February of 2015 and a year-one summary is expected to be complete by the summer of 2016.

b. Participation in the Federal Rockfish Technical Recovery Team and Rockfish Working Group

In late 2012 Lowry and Pacunski were both appointed to NOAA's Rockfish Technical Recovery Team, which was charged with developing a detailed recovery plan for the three ESA-listed species in Puget Sound and the Strait of Georgia (canary, yelloweye, bocaccio). The team met in person twice in 2015 and held several conference calls focused on delisting and down-listing criteria and polishing a version of the plan for public consideration. The draft plan is currently under pre-public review by WDFW and other state agencies at large, tribal co-managers, and representatives at the Department of Fisheries and Oceans. Public review will begin in early summer of this year.

Several members of the Rockfish Technical Recovery Team are also members of a less formal, regional Rockfish Working Group. This group contains members from state and federal government, academia, the aquarium trade, and fishery organization. They meet quarterly to discuss and coordinate regional research activities and share recent technology, research, and outreach developments. In 2014 this group was formalized as an advisory technical workgroup under the auspices of the Puget Sound Partnership (PSP). In this incarnation, the workgroup advises the PSP on issues relating to the monitoring and evaluation of rockfish in Puget Sound with the ultimate goal of "recovering" the Sound by 2020. The workgroup met twice in 2014 and focused largely on the ESA recovery plan.

c. 2010 San Juan Archipelago ROV Survey Report: Stereology

Based on the success of habitat-stratified ROV surveys conducted in 2008, WDFW returned to the San Juan Islands in 2010 to conduct a survey of all habitat types. The survey design was based on stereology, which systematically surveys locations using a fixed grid with a random starting point. The survey grid for this survey included 168 stations. A report comparing the results from the 2008, habitat-stratified survey and the 2010, stereology based survey was drafted in late 2012 but, due to departure of the lead statistician for the project as well as competing program and project demands, the final report has been delayed. Redrafting of the report is currently underway and completion is expected by summer of 2015. A presentation was delivered at the Western Groundfish Conference in Victoria, B.C. in February of 2014 by Lowry comparing the results of this study with the results from the habitat-stratified survey of 2008.

d. 2012 Puget Sound-wide ROV Survey: Stereology

Building on the results of the 2008 and 2010 surveys in the San Juan Islands, WDFW embarked on a Sound-wide ROV survey based on a stereological design in April of 2012. A fixed grid of points separated by approximately 3 NM was overlaid on Puget Sound, generating 215 survey stations from the Canadian border to the Bonilla-Tatoosh line at the mouth of the Strait of Juan de Fuca, to South Sound.
To control for possible diel fish behaviors, the survey was stratified into three time periods: 0000-0759 (morning), 0800-1559 (day), and 1600-2359 (evening). Our goal was to distribute sampling effort equally among periods; however, safety and logistical considerations combined with shorter tidal sequences in the morning and evening hours resulted in a greater proportion of daytime sampling.

The field portion of the survey concluded on April 4th, 2013, with a total of 197 stations sampled out of a planned 215 stations. Several stations near Port Angeles and most stations near Point Roberts in the southern Gulf of Georgia were not sampled due to weather and logistical constraints. The final station breakdown by strata was 47 morning (24%), 110 day (56%), and 38 evening (20%). Review of recordings made during the survey was completed in June 2014, and selected videos have undergone review by a second technician as part of our QA/QC process. Preliminary population estimates for finfish encountered in this survey are provided below (Table 1).

The dominant substrates encountered in the survey were combinations of mud and sand. In contrast, rock and boulder substrates represent only a small portion of the habitat segments viewed. Excluding unidentified small fish, the dominant taxa were unidentified eelpouts, flatfish, and gadids, spotted ratfish, and English sole. Few species typically associated with rock or high-relief substrates were observed. Puget Sound rockfish (n = 269) were the most common identifiable rockfish taxa seen, followed by quillback rockfish (n = 202), with their numbers split almost evenly between rocky bottoms and soft sediment habitats. Copper rockfish and brown rockfish, the most common shallow water rockfish in Puget Sound, were seldom encountered, with only six and two individuals seen, respectively. In contrast, we encountered only five yelloweye rockfish, a species listed as Threatened under the ESA. These numbers clearly point to the deep-water bias in the survey design, indicating that the sampling frequency was not high enough to adequately capture shallow water habitats occupied by the majority of rockfish in Puget Sound. A similar Sound-wide survey will be performed again in 2017 or 2018, however the design will be habitat stratified and use data from the 2012-13 survey to “correct” occurrence observations of hard-bottom species occurring over soft bottoms, which will be undersampled in the future.

Table 1. Preliminary Puget Sound-wide Abundance Estimates for Finfish Observed in 2012-13

	ROCKFISHES								OTHER FISH SPP.		
Variable	Brown rockfish	Canary rockfish	Copper rockfish	Greenstriped rockfish	Puget Sound rockfish	Quillback rockfish	Splitnose rockfish	Yelloweye rockfish	Eelpout unid	Plainfin Midshipman	Snailfish unidentifie
Abundance	31,173	42,798	112,078	123,397	4,889,115	3,519,807	64,166	80,333	98,176,816	480,361	2,584,757
Variance	5.15E+08	9.87E+08	4.05E+09	4.55E+09	9.20E+12	6.73E+11	2.09E+09	1.30E+09	1.61E+15	2.78E+10	3.93E+11
CV	0.728	0.734	0.568	0.547	0.621	0.233	0.712	0.449	0.408	0.347	0.242
	FLATFISHES										
Variable	Arrowtooth flounder	C-O sole	Dover Sole	English sole	Pacific Sanddab	Pacific halibut	Rex Sole	Rock sole	Slender sole	Starry Flounder	
Abundance	236,548	60,102	3,627,739	14,679,418	574,449	57,741	1,637,110	374,238	2,629,174	1,986,648	
Variance	1.19E+10	2.18E+09	4.98E+11	1.01E+13	2.41E+11	1.22E+09	1.18E+11	1.42E+10	1.22E+12	7.36E+11	
CV	0.462	0.776	0.194	0.217	0.854	0.605	0.210	0.318	0.420	0.432	
	GREENLINGS AND GADIDS							POACHERS, RONQUILS, PRICKLEBACKS			
Variable	Gadidae	Hexagrammid unid	Kelp greenling	Lingcod	Pacific cod	Pacific hake	White-spotted greenling	Northern ronquil	Snake prickleback	Sturgeon poacher	
Abundance	94,902,540	69,954	2,117,650	411,827	84,497	13,332,441	56,481	80,824	11,753,311	78,176	
Variance	3.01E+14	1.22E+09	2.07E+12	3.09E+10	2.55E+09	2.19E+13	1.90E+09	2.84E+09	1.81E+13	2.13E+09	
CV	0.183	0.499	0.680	0.427	0.598	0.351	0.772	0.660	0.362	0.590	
	ELASMOBRANCHS						FORAGE FISHES				
Variable	Big Skate	Longnose Skate	Skate uniden.	Sandpaper Skate	Spiny dogfish	spotted ratfish	Baitfish unident.	Pacific Sandlance	Perch unid	Shiner perch	
Abundance	259,216	786,097	607,980	348,066	1,588,909	20,565,701	19,813,333	7,038,094	1,119,218	4,819,668	
Variance	6.11E+09	3.52E+10	2.24E+10	1.74E+10	3.26E+11	1.30E+13	2.61E+14	2.85E+12	2.03E+11	5.07E+12	
CV	0.302	0.239	0.246	0.379	0.359	0.175	0.816	0.240	0.402	0.467	

e. Genetic study on ESA-listed rockfish

In April 2014 WDFW partnered with NOAA to conduct a two-year fishing study aimed at collecting genetic samples of ESA-listed rockfish (Lowry and Pacunski are co-PI’s). The study utilizes several local charter operators with experience fishing for these species prior to the closure of rockfish fisheries in Puget Sound. To date, the survey has captured 40 yelloweye rockfish and 10 canary rockfish in the Puget Sound DPS, with most of these encounters occurring in the San Juan Island region. Many of these fish have been visibly tagged to aid in identification by divers and a remotely-operated vehicle (with one fish sighted by each method in 2015).

f. Bottom Trawl Surveys of Puget Sound

Since 1987, WDFW has conducted bottom trawl surveys in Puget Sound that have proven invaluable as a fisheries-independent indicator of population abundance for fishes living on unconsolidated habitats. These surveys have been conducted at irregular intervals and at different scales since their start. Early surveys in 1987, 1989, and 1991 were synoptic surveys of the entire Puget Sound. From 1994-1997 and 2000-2007, surveys were annual, stratified-random surveys focusing on individual sub-basins.

Starting in 2008, surveys became synoptic again, sampling annually at fixed index sites throughout Puget Sound (Figure 1). The specific objectives of the annual “Index” trawl survey are to estimate the relative abundance, species composition, and biological characteristics of groundfish species at pre-selected, permanent index stations. Key species of interest include Pacific cod, walleye pollock, Pacific whiting, English sole, spiny dogfish, and skates, but all species of fishes and invertebrates are be identified and recorded. In 2014, WDFW conducted the 7th “Index” trawl survey of Puget Sound from April 28 through May 29.

The complete “Index” survey design includes 51 stations partitioned among Puget Sound’s eight oceanographic basins: the Eastern and Western Strait of Juan de Fuca, San Juan Archipelago, Strait of Georgia, Whidbey Basin, Central Basin, South Puget Sound, and Hood Canal. Each basin was divided into two geographic subareas (north/south or east/west) except for the Central Basin, which includes a third subarea (middle) to better represent this latitudinally elongate basin. The basins were also stratified by depth as follows: 30 to 120 feet, 120 to 240 feet, 240 to 360 feet, and greater than 360 feet. Depths less than 30 feet are excluded from the survey because they are too shallow for the trawl vessel to operate. The 51 “Index” stations were selected from stations trawled prior to 2008, with each sub-basin containing one station in three of the four depth strata. Due to concerns for endangered Chinook salmon in 2012 and 2013, however, NOAA restricted the survey from operating in the shallowest depth zone (30-120 feet), eliminating 9 stations from the survey in each of those years. This restriction was lifted in 2014, once again allowing all 51 stations to be sampled.

From 2008 to 2013, two replicate trawl samples were collected at each station and were spaced several hundred meters apart to be close to each other but not directly overlapping. However, based on the similarity of catches in both tows at most stations, we altered our protocol in 2014. After the first tow was completed, the processed catch was compared to the average catch at that station from the previous 5 years. If the species comprising the majority (>75% by weight) of the tow fell within the 5-year average, no second tow was conducted at that station. If it was determined that the species composition was substantially different than expected, only then was a second tow conducted. This greatly improved the efficiency of the survey, as only 6 stations required a second tow.

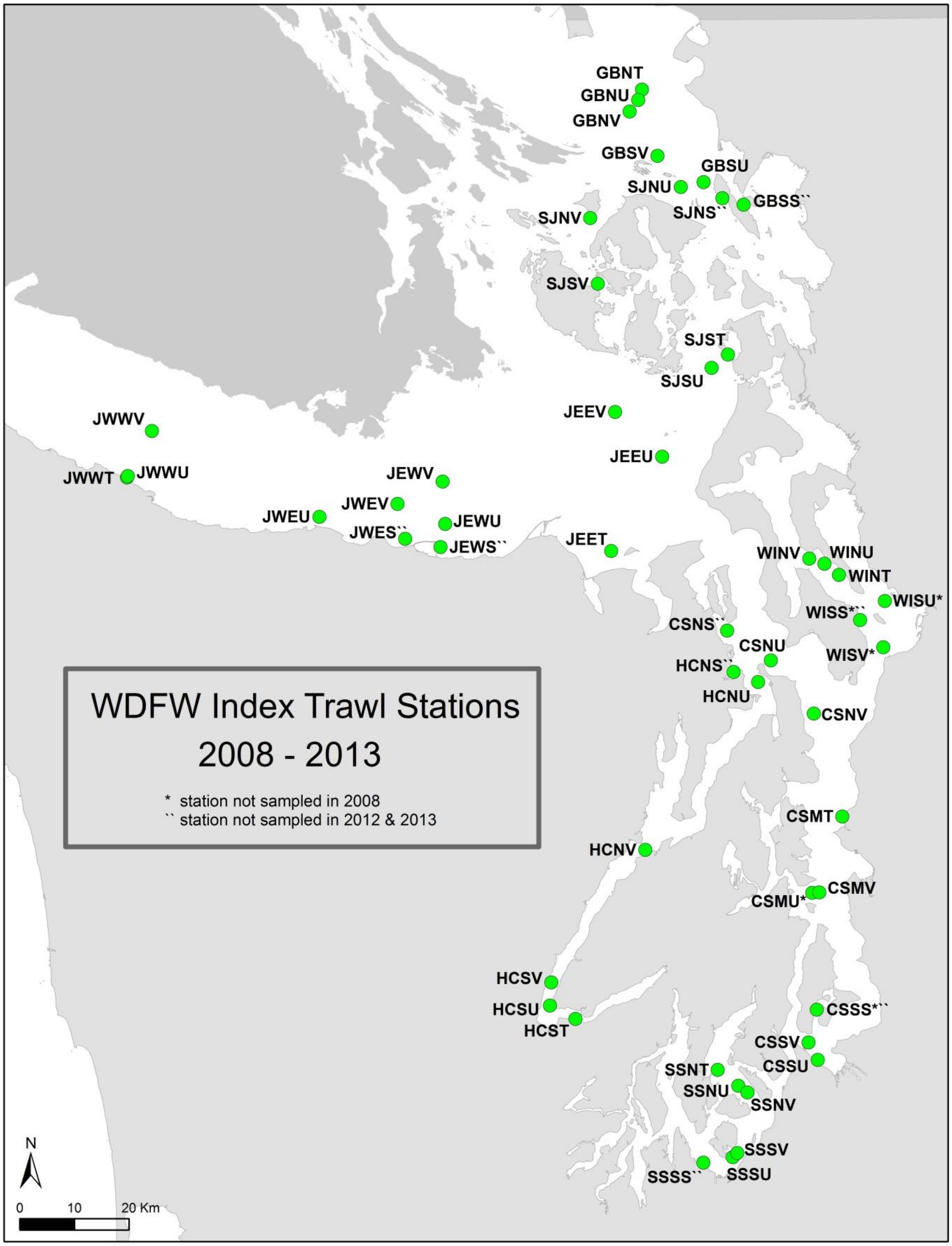
This newly gained efficiency allowed us to institute two new sampling programs: vertical plankton tows, and gastric lavage/stomach collection on large predatory species (Pacific cod, dogfish, lingcod, walleye pollock, Pacific hake). The 2014 survey also included the addition of bottom-contact sensors to the trawl warp and footrope to improve our understanding of net performance and increase the accuracy of density estimates from the trawl. Lastly, a mini-CTD was installed on the headrope to collect water quality data at each trawl station.

The trawling procedure of the 2014 survey was similar to previous WDFW trawl surveys (Palsson et al. 2002, 2003). The 57-foot F/V CHASINA was the chartered sampling vessel, and it was equipped with an agency-owned 400-mesh Eastern bottom trawl fitted with a 1.25 inch codend liner. The net was towed at each station for a distance of 0.40 nautical miles at a speed of 1-3 knots, and the tows lasted approximately 12 minutes. Net openings ranged from 8 to 14 m depending upon depth and the amount of cable towing the net. The resulting catch was identified to the lowest taxonomic level, weighed and enumerated, and most of the catch was returned to the sea. The density of fish at each station was determined by dividing the

catch numbers or weight by the area sampled by the net. Some of the catch was taken for biological samples that were sampled on deck or preserved for laboratory analysis.
During the 18 survey days in 2014, we occupied 51 stations and conducted 57 bottom trawls. An estimated 45,000 individual fish among 78 species/taxa weighing 7.8 mt were collected. By weight, spotted ratfish constituted 54% of the total fish catch, followed by English sole at 17%; by number of individuals, each of these two species constituted 24-25% of the total fish catch. The next most abundant species by weight were southern rock sole, walleye pollock, starry flounder, and big skate, each representing 2-4% of the total. By number of individuals, the next most abundant species were blackbelly eelpout, walleye pollock, Pacific hake, southern rock sole, shiner perch, slender sole, and Pacific herring (2% to 8% per species). The remaining species not listed comprised less than 2% of either total weight or total individuals caught. Catch of Pacific cod was about a third of what it was last survey, accounting for only 1.1% of the total catch by weight in 2014 compared to nearly 3% in 2013. The size distribution of Pacific cod in 2014 was slightly smaller than in 2013, measuring from 24 to 65 cm, but the average size of 56 cm in 2014 was 12 cm larger than in 2013, and thus similar to 2012. Similar to 2012 and 2013, most Pacific cod were primarily distributed in the western Strait of Juan de Fuca; a few were caught in the southern Strait of Georgia and the eastern Strait of Juan de Fuca, and one was caught in the San Juan basin. No Pacific cod were caught in the other basins. Only one ESA-listed species, Pacific eulachon, was encountered during the 2014 survey. Six individuals ranging from 17-22cm were caught, and genetic samples were collected for each in accordance with the Section 10 permit for the trawl survey.

g. Marine Reserve Monitoring: Evaluation of No-Take Refuges for Rocky Habitat Fishes
Very little reserve monitoring has occurred since 2011 due to changes in program priorities and staffing limitations associated with the 2012-13 ROV survey of Puget Sound. Due to a lack of MSF staff, and commitments to other projects, no monitoring activities were conducted at no-take refuges in 2013. A systematic evaluation of the data collected between 2000 and 2010 has begun and six sites have been identified as having data of sufficient quality and quantity to merit stand-alone evaluations of reserve efficacy. Over the next six months LeClair and Blaine will be drafting a report on this six sites that includes, as an appendix, data from other sites surveyed during the evaluation period for which data collection was more sparse.

Figure 1. Trawl Site Locations Sampled in 2014



h. Groundfish Surveys at U.S. Navy Facilities

The US Navy controls multiple restricted areas throughout Puget Sound which have been exempted from rockfish critical habitat designation by NMFS, however an Integrated Natural Resource Management Plan (INRMP) provided by the Navy is required to fulfill the obligations necessitated by these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at NBK Bremerton and NBK Keyport in 2013, WDFW entered a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and critical habitat at the following installations: NAS-Whidbey Island, NAVMAG-Indian Island, NBK-Bangor, NBK-Bremerton, NBK-Keyport. These surveys, which expand on survey conducted in 2013 at NBK Bremerton and Keyport, began in early 2014 and included ROV, SCUBA, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfishes at each installation. As of March 2015, no ESA-listed rockfish have been observed and very little rocky habitat has been recorded at these Navy installations. The dedicated project biologist and technicians will submit a final report for each installation when the surveys have concluded in 2016 which will contribute to the Navy's INRMP obligations.

WDFW has also recently entered a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed salmonids and forage fish at the following installations: NAS-Whidbey Island, NAVMAG-Indian Island, NBK-Bangor, NBK-Manchester, NS-Everett. These surveys will begin May 2015 and continue for one full year of sampling to assess the timing of migrating fish species adjacent to Navy facilities. Funds from the Navy contract were used to hire a project biologist and technician to assist with conducting the surveys and analyzing the collected data.

i. High-resolution modeling of fish habitat associations, and predictive models

In collaboration with the SeaDoc Society and Tombolo Laboratories, MFS staff are working to integrate high-resolution multibeam bathymetry data from the San Juan Islands with fish occurrence data obtained from ROV and drop camera surveys over five years. H. Gary Greene, a geologist, has spent several years mapping and typing benthic habitats in the San Juans. Leveraging visual survey work conducted by WDFW that overlaps these focal areas, a unique opportunity has arisen to groundtruth Dr. Greene's bottom typing and to use benthic terrain modeler in ArcGIS to evaluate the occurrence of fish species over particular bottom types. A cooperative agreement was established between WDFW and the SeaDoc Society in 2014 to conduct a pilot analysis in a small area of the San Juan Islands, the results of which should be available by the summer of 2015. If the pilot study is successful, it could pave the way for a Puget Sound-wide model that could be used to evaluate rockfish critical habitat designations recently made by NOAA.

j. Derelict gear reporting, response, and removal grant funding

Marine fish mortality associated with derelict fishing gear has been identified as a threat to diverse species around the world. In Puget Sound, removal of derelict fishing nets has been the focus of a concerted effort by the Northwest Straits Foundations since 2002. In late 2013 the Washington State Legislature granted $3.5 million to the Foundation to "complete" removal of all known legacy fishing nets. A portion of this money was set aside for WDFW to assist with planning of removal efforts and evaluation of the final results.

In 2012 a reporting hotline was developed, and a rapid response and removal team was formed, to prevent the accumulation of additional fishing nets. Because these nets are a direct threat to ESA-listed rockfish, in 2014 WDFW and the Foundation were able to obtain Section 6 funding to continue hotline service and ensure support for the response team. Combined with the legislative grant money mentioned above, this funding source allows the WDFW and Foundation to remove old nets, stay informed about newly lost nets, and remove new nets to minimize/eliminate this threat to rockfish, and the ecosystem at large.

k. Participation in Conferences and Workshops

In 2014-15 staff of the Puget Sound MFS Unit presented at, and/or arranged symposia at, several regional scientific meetings, and education/outreach events as indicated below.

Salish Sea Ecosystem Conference, Apr. 30-May 2, 2014. Presenters: Dayv Lowry, Andrea Hennings, Robert Pacunski.

Monster Jam Session at NOAA Montlake, Seattle. Oct. 9, 2014. Presenter: Dayv Lowry.

South Sound Science Symposium. Oct. 23, 2014. Presenter: Dayv Lowry. Also served on event steering committee.

Seattle Aquarium Lightning Talk – Discover Science Days, Nov. 7, 2014. Presenter: Robert Pacunski.

Seattle Aquarium Discover Science Days, Nov. 8-9, 2013. Presenters: Dayv Lowry, Robert Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, Adam Lindquist.

2. Forage Fish Stock Assessment and Research (*Contact: Dayv Lowry 360-95-2558, dayv.lowry@dfw.wa.gov; Kurt Stick (360) 466-4345 ext. 243, kurt.stick@dfw.wa.gov*)

a. Annual Herring Assessment in Puget Sound

Annual herring spawning biomass was estimated in Washington in 2013 using spawn deposition surveys. WDFW staff based in the Mill Creek, La Conner, and Port Townsend offices conduct these assessment surveys of all known herring stocks in Washington's inside waters annually. Stock assessment activities for the 2014 spawning season are in progress.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2014 is 9,797 tons (Table 2). The cumulative total is an increase from the 2013 total of 7,332 tons but considerably less than the mean cumulative total for the previous ten year (2004-2013) period of 11,723 tons.

The combined spawning biomass of south/central Puget Sound (including Hood Canal) herring stocks in 2014 of 4,885 tons is a slight decrease from 2013, when the cumulative spawning biomass for this region was 4,991 tons. Spawning biomass for this region in 2014 was dominated by the Quilcene Bay stock. Spawning abundance for this stock has been relatively high in recent years. A number of other stocks in the region that historically have been relatively large, are at low levels of abundance, particularly the Port Orchard-Port Madison and Quartermaster Harbor stocks.

Cumulative biomass of north Puget Sound stocks in 2014, excluding the Cherry Point stock, increase dramatically in 2014 due primarily to a large spawning event at Point Roberts. The spawning biomass of the Cherry Point stock in 2014 was a slight increase from 2013 and this stock, which is thought to be genetically distinct from other herring stocks in Puget Sound and British Columbia, continues to be at a critically low level of abundance. Estimated herring spawning activity for the Strait of Juan de Fuca region also slightly increased in 2014, with an estimated spawning biomass of 77 tons, but remains at a very low level of abundance.

Table 2. Pacific Herring Spawning Biomass Estimates, 2005-2014

PUGET SOUND HERRING SPAWNING BIOMASS ESTIMATES (SHORT TONS) BY STOCK AND REGION, 2005-2014

	YEAR									
	2014	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**
Squaxin Pass	394	554	589	565	750	817	1025	557	755	436
Purdy	84	260	135	711	500	125	496			
Wollochet Bay	39	10	31	21	50	359	45	35	27	67
Quartermaster Harbor	44	157	108	96	143	843	491	441	987	756
Elliot Bay	29	214	290							
Port Orchard-Port Madison	90	184	217	123	350	1755	1186	1589	2112	1958
South Hood Canal	112	199	264	156	150	156	223	70	244	210
Quilcene Bay	3097	2072	2626	4443	2012	3064	2531	2372	2530	1125
Port Gamble	170	273	404	1464	433	1064	208	826	774	1372
Kilisut Harbor	5	0	0	0	0	0	0	24	54	170
Port Susan	68	29	61	138	152	251	345	643	321	157
Holmes Harbor	459	585	678	3003	673	1045	686	572	1297	498
Skagit Bay	294	454	443	469	500	1027	1342	1236	2826	1169
South-Central Puget Sound Total	4885	4991	5846	11189	5713	10506	8578	8365	11927	7918
Fidalgo Bay	221	100	89	119	103	15	156	159	323	231
Samish/Portage Bay	778	693	430	387	640	320	409	348	412	218
Int. San Juan Is.	5	0	5	0	17	0	60	33	285	41
N.W. San Juan Is.	0	0	0	0	0	0	0	0	0	0
Semiahmoo Bay	2828	569	879	1605	1000	990	662	1124	1277	870
Cherry Point	1003	908	1120	1301	774	1341	1352	2169	2216	2010
North Puget Sound Total	4835	2270	2523	3412	2534	2666	2639	3833	4513	3370
Discovery Bay	5	0	105	0	26	205	248	42	1325	33
Dungeness/Sequim Bay	72	71	43	104	75	46	69	34	0	0
Strait of Juan de Fuca Total	77	71	148	104	101	251	317	76	1325	33
Puget Sound Total	9797	7332	8517	14705	8348	13423	11534	12274	17765	11321

b. Unique Herring Spawning and Pending Genetic Research

In late April of 2012 a WDFW field technician (Roy Clark) observed a herring spawning event in Elliot Bay, just offshore from Seattle. The location of this spawning event was unprecedented and the timing matched only one other known spawning population -- the high-profile Cherry Point Stock, which has been previously petitioned for ESA listing. In 2013 the fish returned again, and appeared to occupy a larger area of the Seattle waterfront (though access was limited in 2012 due to tides). In 2014 the fish only occupied a small area previously documented in 2013, and were not observed anywhere else in the area. A genetic study based on eggs collected in 2012 was complicated by low DNA amplification, but eggs and fin clips were collected in 2013 and eggs were collected in 2014. Genetic analysis suggests that these fish are not, in fact, related to the Cherry Point stock despite their spawn timing. Their closest genetic relative appears to be the geographically proximate Port Orchard-Port Madison stock. These results are currently being written up with Lorenz Hauser at the University of Washington for peer-reviewed publication.

c. Herring and smelt population-level genetic studies

Several genetic studies have been conducted on Pacific herring in Puget Sound over the last 20 years. While numerous populations have been sampled, there remain several populations that have never been included in these analyses, as well as a few populations for which poorly resolved genetic relationships still exist. In 2014, Working with the Department of Ecology and the Port Gamble Jamestown S'klallam Tribe, WDFW began collecting fin clips from spawning adults of six populations throughout Puget Sound: Port Gamble, Elliot Bay, Purdy/Henderson

Inlet, Cherry Point, Squaxin Island, and Quilcene Bay. Together this suite of populations represents the three known genetically distinct populations of herring in Puget Sound, several “unresolved” stocks, and two populations that have never been genetically evaluated. The project will continue into 2015 with results expected in June of 2015.

In 2011 the WDFW, in collaboration with the USGS, conducted a preliminary study of surf smelt genetic relationships throughout Puget Sound. The results of this study indicated that a single panmictic stock of this species ranges throughout the Sound and into southern British Columbia. Samples used in this study were eggs, and sample size was low. As an extension of this work, the WDFW has been collecting fin clips from beach seine-caught smelt at eight locations throughout Puget Sound. Samples have now been analyzed and suggest that, even with this improved sampling design, smelt in Puget Sound represent a single population. Results of this study will be presented at the annual American Fisheries Society meeting in August of 2015.

d. PSEMP’s Forage Fish and Food Webs Working Group

The Puget Sound Ecosystem Monitoring Program (PSEMP) is a multientity consortium that supports several topic-specific standing workgroups. In 2013, PSEMP added a Forage Fish and Food Webs working group, which evolved from a less formal regional forage fish research group that had been hosting seminars and meetings since 2010. As a formalized group, this entity now includes individuals who work not only on forage fish but also the relationships among forage species and other biological components of the Puget Sound ecosystem. In their new advisory capacity to PSEMP the workgroup was able to make several recommendations for the future of forage fish and food web research in Washington State, which were combined with recommendations from other workgroups to develop a strategic scientific work plan for the Puget Sound Partnership. Dayv Lowry is a co-chair of this working group.

3. Puget Sound Ecosystem Monitoring Program (PSEMP) *(Contact: Jim West 360-902-2842, James.West@dfw.wa.gov)*

The Washington Department of Fish and Wildlife is a key partner of the Puget Sound Ecosystem Monitoring Program Project (PSEMP), a multi-agency effort to assess the health of Puget Sound. WDFW’s “Toxics in Biota” group is staffed by Jim West, Jennifer Lanksbury, Laurie Niewolny, Stefanie Orlaineta, Andrea Carey, and Sandie O’Neill. This group conducts regular status and trends monitoring of toxic contaminants in a wide range of indicator species in Puget Sound, along with evaluations of biota health related to exposure to contaminants. This group has recently conducted additional focus studies on toxic contaminants in Dungeness crab (*Cancer magister*), spot prawn (*Pandalus platyceros*), blue mussels (*Mytilus* spp), as well as a field experiment testing the effects of chemicals leaching from creosote-treated wooden pilings on the health of developing Pacific herring (*Clupea pallasi*) embryos.

B. Coastal Area Activities

Staff of the Coastal Marine Fish Science (MFS - Coast) Unit includes Lorna Wargo, Brad Speidel, John Pahutski, Bob Le Goff, Brian Walker, Donna Downs, and Vicky Okimura. Seasonal and project staff include Michael Sinclair, Mariko Langness, Colin Jones, and Kristen Hinton. Unit tasks are supported through a combination of state general and federal funds. Long-standing activities of the unit include the assessment of groundfish populations off Washington coast, the monitoring of groundfish commercial landings, and the rockfish tagging project. More recently, unit activity has expanded to include forage fish management and research. The unit is completing a ESA Section 6 funded project to evaluate eulachon smelt bycatch in the Washington pink shrimp trawl fishery and beginning in 2012 undertook a survey of outer coast beaches in an effort to document seasonal and spatial pattern of spawning in surf smelt, night smelt, and sand lance to inform marine spatial planning.

Activities Related to Pacific Fishery Management and North Pacific Fishery Management Councils

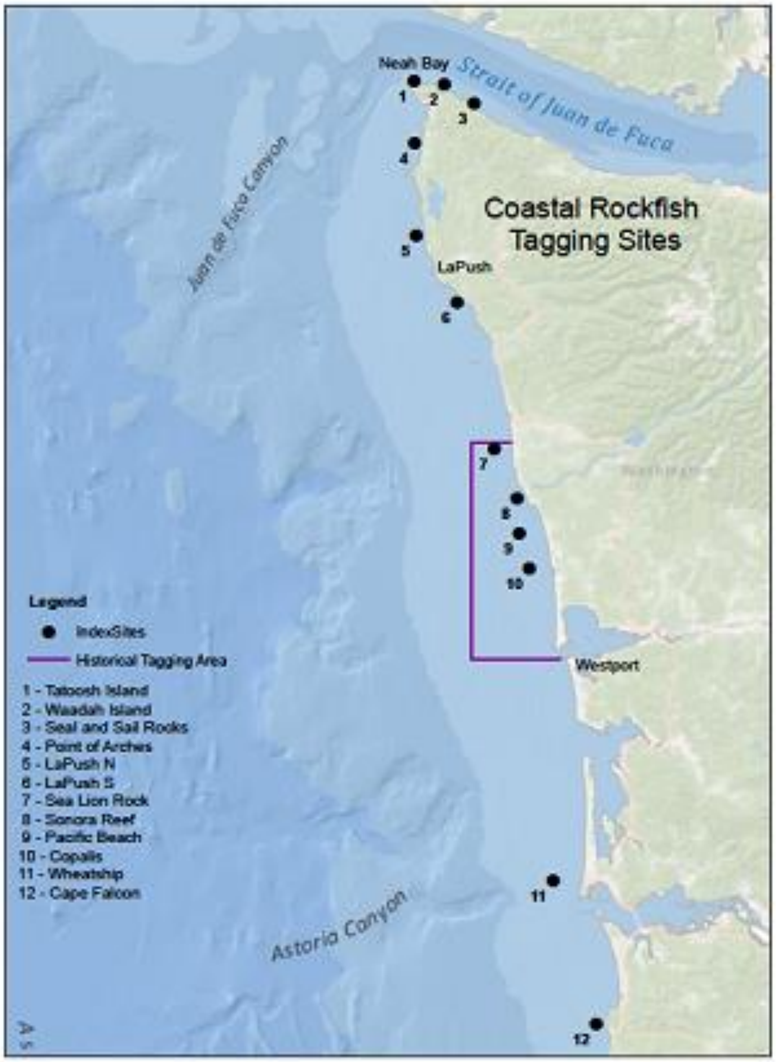
The Department contributes technical support for coastal groundfish and forage fish management via participation on the Groundfish Management Team (GMT), the Coastal Pelagics Management Team (CPSMT), the Scientific and Statistical Committee (SSC), and the Habitat Steering Group (HSG) of the Pacific Fishery Management Council (PFMC). The Department is also represented on the Scientific and Statistical Committee and Groundfish Plan Teams of the North Pacific Fishery Management Council. Landings and fishery management descriptions for PFMC-managed groundfish are summarized annually by the GMT and the CPSMT in the Stock Assessment and Fishery Evaluation (SAFE) document.

1. Coastal Groundfish Management, Monitoring, Research, and Assessment (*Contact: Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov; Lorna Wargo (360) 249-1221 Lorna.Wargo@dfw.wa.gov*; *Corey Niles, 360-249-1223, Corey.Niles@dfw.wa.gov), Intergovernmental Resource Management)*

a. Coastal Rockfish Tagging Project

In Washington, the first black rockfish tagging project began in 1981. The early tagging work concentrated on gathering biological information, such as movement and growth. Over the intervening years, the project has undergone changes as study objectives were re-defined and improvements in tagging protocols and survey locations (Figure 2) were made. The Department ended the coastal black rockfish tagging project at the end of 2013. The effort to monitor black rockfish on the coast of Washington will be incorporated into a comprehensive, fishery-independent nearshore CPUE index using hook and line gear that will include all species encountered in shallow coastal waters and address some of the concerns of past stock assessment reviews for black rockfish. Staff will still be maintaining a tag collection program in the coastal ports to recover tags deployed in black rockfish. Also, previous index locations that were established for black rockfish monitoring will be visited in future surveys at least annually.

Figure 2. Tagging Site Locations



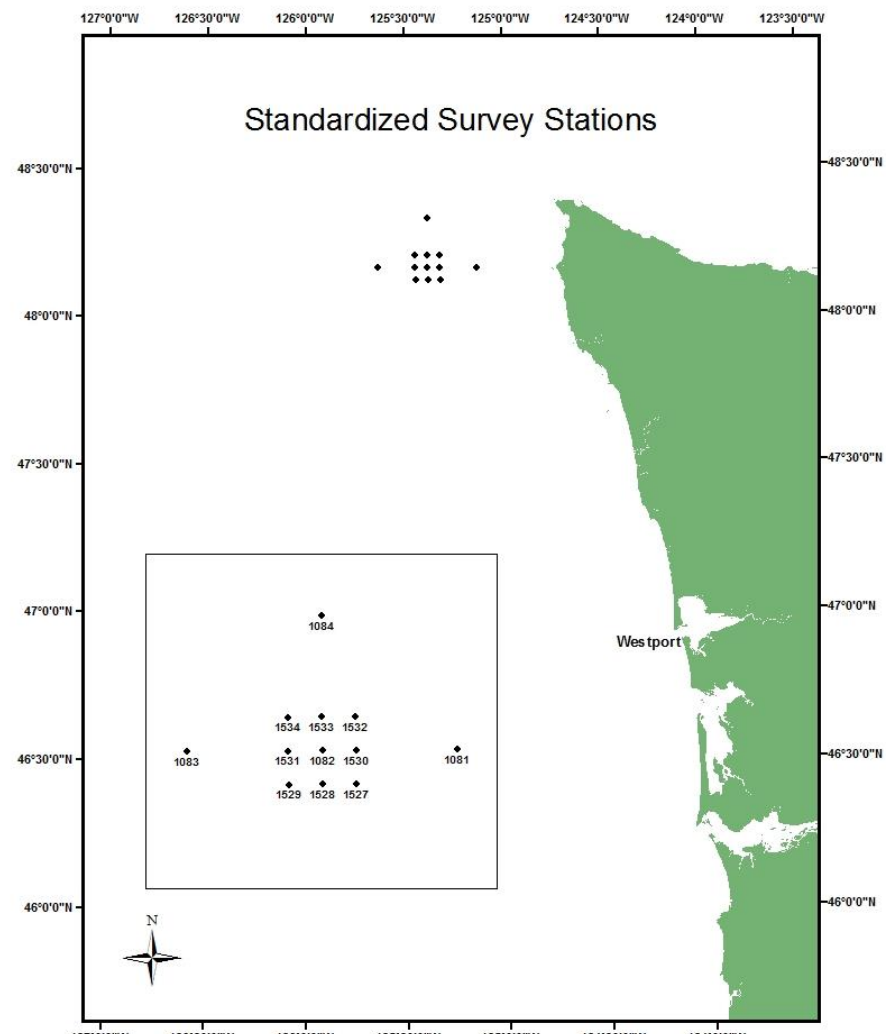
b. Rockfish Longline Survey

The Washington Department of Fish and Wildlife (WDFW) has been conducting longline surveys off the northern Washington coast to better understand seasonal changes in catch rates for rockfish that inhabit rocky habitat. Results from these research surveys will be used to improve future survey strategies to monitor and assess rockfish populations, evaluate the risk of localized depletion and survey effects, and to monitor the growth and movement of several important rockfish species.

Using IPHC survey design and data, WDFW has been refining survey strategies more specifically for rockfish that dwell in rocky habitat since 2006. The current survey design with 8 additional stations surrounding IPHC station 1082 (48^0 10' N and 125^0 23' W) in waters 50-100 fathoms in depth (Figure 3) was established in 2008. The R/V Pacific Surveyor has been chartered to complete the Yelloweye longline surveys. Due to their experience conducting summer IPHC surveys, the vessel and crew have maintained their gear and methods to IPHC survey standards for our research. Data collected include species composition, biological sampling, tag deployment, and CTD instrument deployment. WDFW biologists conduct 100 percent hook tally sampling for all stations. Biological data from non-rockfish species includes a LF sample of 20 percent of the catch. Catch from the first 20 hooks of each skate are measured. Retained rockfish are sampled for length, sex, weight, and age. Length, sex, tag numbers, and genetic samples are collected from Yelloweye rockfish. Non-rockfish species are released immediately unless they fall within the 20 percent Length Frequency (LF) sampling protocol. Rockfish, other than yelloweye, are retained on ice for biological sampling dockside and donated to a food bank. Yelloweye rockfish are tagged with external Floy tags and released at depth via a descending device.

Depending on sufficient yelloweye research set-asides, WDFW anticipates conducting surveys, both spring and fall, over the next several years to tag additional rockfish and to provide the opportunity to encounter previously tagged fish. Initially, WDFW mimicked IPHC survey methods but focused on rockfish stations. In 2012 and going forward, survey methods will diverge somewhat as IPHC conducts bait tests while WDFW has and will continue to follow the original IPHC protocols for bait. To expand survey interception of smaller rockfish, WDFW intends to test sablefish hooks with squid during surveys in 2013 and 2014. WDFW has also proposed that the summer IPHC survey include the rockfish stations around Station 1082 to improve seasonal comparisons. (The summer rockfish survey was canceled in 2010 and 2011 due to low catch limits set by the PFMC, and IPHC revising their survey.)

Figure 3. Standardized Survey Stations



c. Outreach and Education

In support of rockfish identification, and barotrauma and descending device outreach activities, coastal MFS staff expended considerable time and effort to obtain high quality photographs of rockfish, taking advantage of the access afforded through the tagging and 4B rockfish projects. Descending devices were also tested during both projects and photographed in use. These photographs now appear in agency produced barotrauma/descending device posters and brochures and in the 2013-2014 recreational fishery regulation pamphlet. Upgrades to the agency website are underway and these photographs are also being incorporated into the redesigned groundfish id webpage.

2. Forage Fish Management, Monitoring, Research, and Assessment (*Contact: Lorna Wargo (360) 249-1221 Lorna.Wargo@dfw.wa.gov; Dayv Lowry 360-95-2558, dayv.lowry@dfw.wa.gov*)

d. Outer Coast Smelt Spawning Beach Survey

As part of the first phase of a coast-wide marine spatial planning process funded by the Washington State Legislature and administered by the Washington State Department of Natural Resources, the Washington Department of Fish and Wildlife completed a 24-month survey (Oct. 2012 to Oct. 2014) in an effort to document the presence of eggs deposited by forage fishes that spawn in the intertidal (primarily surf smelt *Hypomesus pretiosus*) along the Washington coast from the mouth of the Columbia River north to Cape Flattery. Due to the local knowledge of smelt fisheries possessed by coastal Indian Tribes, and their role as co-managers of the natural resources of Washington State, surveys were collaboratively conducted with members and employees of the Hoh, Makah, Quileute, and Quinault Tribes.

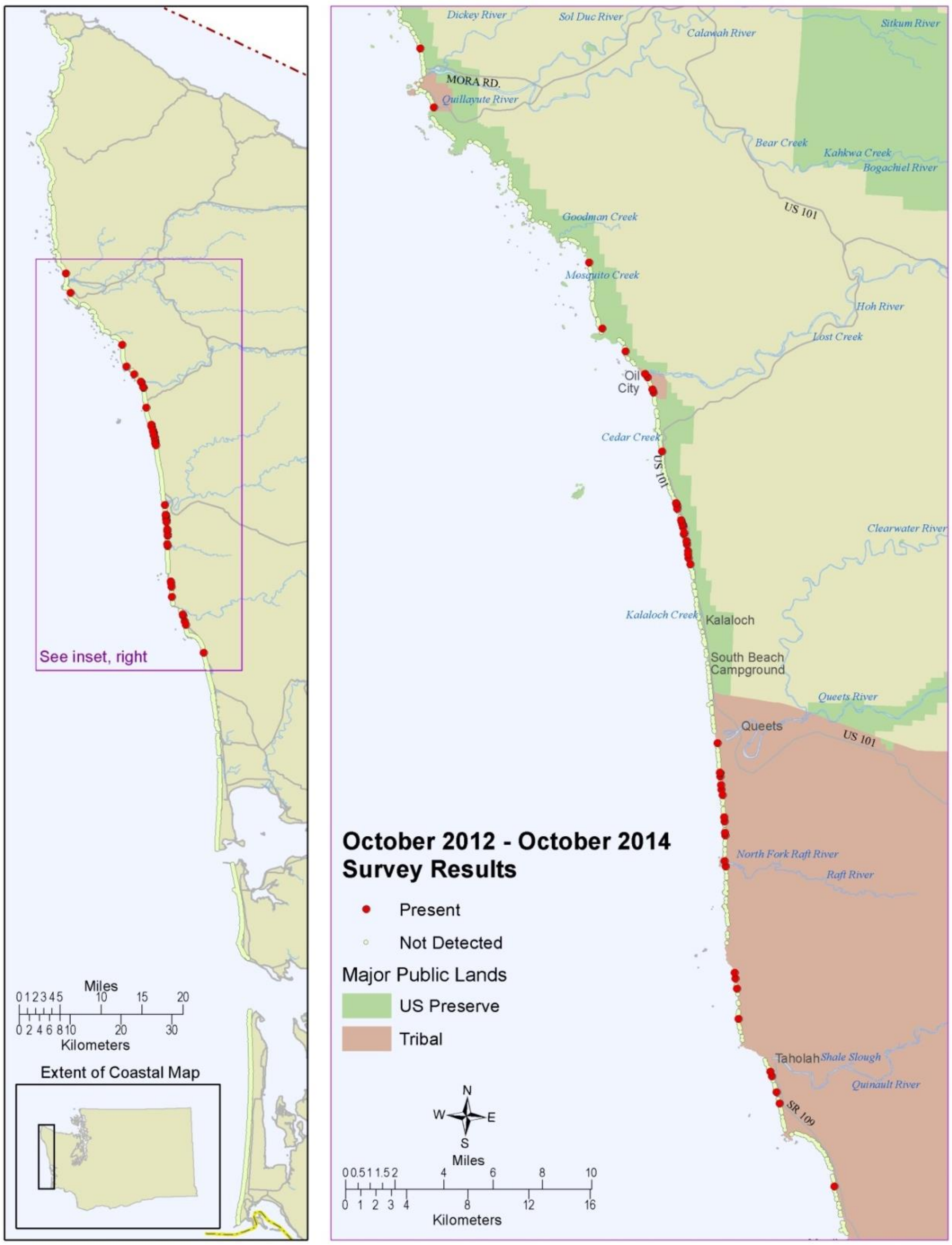
Using existing shoreline sediment composition and geoform classifications from DNR ShoreZone GIS data, a total of 158 miles of likely spawning beaches were identified. Each sampling beach was subdivided into equal 1000-ft. long beach segments/sites (831 total). A random draw of sites was allocated over each monthly sampling period and assigned to collaborating staff based on ownership, management, or ease of access to the land where sites were located. Sampling occurred on days that would allow for access near the upper tidal limit (above +6 MLLW) for an extended period of time, maximizing collection capacity for a given date. Bulk beach sediment samples were collected and pertinent habitat data were recorded. Bulk samples were condensed by sieving and winnowing methods, and then examined for forage fish egg presence/absence.

Over the two-year survey period, 89% of possible spawning beaches were sampled and 40 smelt spawning sites were documented (Figure 4). Smelt spawn was documented in each month from January through October, and peak spawn abundance occurred from May to September. Spawning sites were located in the northern central coast, ranging as far south as 47.27483, -124.23372 and as far north as 47.93226, -124.64301 (WGS84). These results expand the known spawning window 5 months and 30 miles northward of what had been documented as a result of limited survey effort prior to 2012.

The sampling design was constructed to allow use of an occupancy model to predict the likelihood of finding eggs and extrapolate the spatiotemporal patterns to the remainder of the sampling universe. The number of sites with documented spawn was low relative to the total number of sites sampled, thus model development has been delayed until a more robust data set and funding is available.

A report was published in the WDFW Technical Report series covering the complete two-year survey:
Langness M., P. Dionne, D. Masello, and D. Lowry. 2015. Summary of coastal intertidal forage fish spawning surveys: October 2012 – October 2014. Washington Department of Fish and Wildlife, Fish Program Report Number FPA 15-01.

Figure 4. Locations of all sites sampled from October 2012 – October 2014. Documented smelt spawning sites (Present = 2+ eggs) and sampled sites where eggs were not detected are indicated.



f. Washington Commercial Shrimp Trawl Observer Program – Eulachon Bycatch Study
(*Contact: Lorna Wargo (360) 249-1221 Lorna.Wargo@dfw.wa.gov*)

The ocean pink shrimp (*Pandalus jordani*) trawl fishery is a vital component of Washington's coastal commercial fisheries, providing greater stability compared to other trawl fisheries. In 2010, eulachon were listed under the ESA as a threatened species. In that listing, the Pacific Northwest trawl fishery for ocean pink shrimp was deemed a moderate threat to eulachon recovery; the Eulachon Biological Review Team (BRT) ranked bycatch second among the severity of threats impacting recovery of eulachon stocks (Gustafson, et. al., 2010). The ocean pink shrimp fishery also encounters rockfish including "overfished" species, e.g. dark blotched rockfish *Sebastes crameri* and Pacific ocean perch *S. alutus* juveniles and yelloweye rockfish S. *ruberrimus*. Prior to 2010 very limited information about bycatch composition or rates existed for the Washington shrimp trawl fishery. To close this data gap, the Washington Department of Fish and Wildlife undertook two actions: 1) implemented regulations effective in 2010 to require participation of Washington licensed shrimp trawl fishers in the West Coast Groundfish Observer Program (WCGOP); and 2) sought and received a Species Recovery Grant to implement a state-based observer program (Studies of Eulachon Smelt in Oregon and Washington, NOAA Grant No.NA1ONMF4720038. This project concludes June 30, 2013; a final report is due December 31, 2013.

MFS-coastal unit staff conducted the state-based program, deploying observers on vessels during the 2011 and 2012 shrimp fishery seasons with simultaneous coverage by the WCGOP. In 2011, the WDFW observer program observed 819 tows (23.7%) across 50 trips (24.3%). Section 6 funding cuts reduced coverage in 2012 to 666 tows (15.9%) across 41 trips (16.1%). Sampling protocols largely followed the WCGOP and estimates of bycatch for eulachon smelt, plus other species or categories of fish will be reported. While the study had enumeration of bycatch and collection of eulachon biological data (including genetic sampling) as its primary objectives, formal and informal actions to reduce bycatch were also undertaken. Regulatory changes to allow only rigid panel excluders and to reduce the maximum bar spacing on excluder panels (or biological reduction device; BRDs) to ¾ inches were adopted and effective for the 2012 season. Staff encouraged voluntary gear and fishing practice changes by skippers to reduce bycatch, and deployed underwater camera equipment to collect video to further inform and guide these changes.

Committee of Age Reading Experts

2014 Committee Report
and
Executive Summary of the
Eighteenth Biennial Meeting April 14-17, 2015

Prepared for the Fifty-sixth Annual Meeting of the
Technical Subcommittee of the Canada-USA Groundfish Committee

April 28 –29, 2015

Prepared by
Elisa Russ
2013-2015 CARE Chair
Alaska Department of Fish and Game
Central Region Commercial Groundfish
Age Determination Project Manager
3298 Douglas Place
Homer, Alaska
99603

A. CARE Overview

1. History

The Committee of Age-Reading Experts, CARE, is a subcommittee of the Canada-USA Groundfish Committee's Technical Subcommittee (TSC) charged with the task to develop and apply standardized age determination criteria and techniques and operate within the Terms of Reference, approved by the TSC in 1986, and the CARE Charter, developed in 2000 and approved by the CARE in 2004.

2. Report Period

This report covers the work period of January 1 – December 31, 2014. However, to promote timely reporting of work and recommendations occurring during the recent CARE conference, an Executive Summary of the 18th CARE conference held April 14-17, 2015 is included here as part of the TSC report. Current officers through June 30, 2015 (elected at April 2013 meeting) are:

- Chair - Elisa Russ (ADF&G)
- Vice-Chair - Chris Gburski (AFSC)
- Secretary - Lance Sullivan (NWFSC)

The Secretary will prepare a draft of the minutes from the recent CARE meeting to be distributed to CARE members for review and subsequent approval prior to the end of his term. Due to the close proximity of the TSC meeting following the CARE meeting, it is necessary to for the Chair to prepare the report to TSC to include proceedings of the recent meeting as an executive summary (since minutes were not yet available).

3. CARE Conference – Executive Summary

CARE meets biennially for a conference that usually lasts three days. Conferences typically consist of one and a half "business" days and one and a half days for hands-on calibration workshop at microscopes to review and standardize age reading criteria with any extra time scheduled for a specific focus group or workshop.

a. **Overview:** The most recent biennial CARE Conference was held in Seattle, WA, April 14-17, 2015 at the NOAA Western Regional Center at the Alaska Fisheries Science Center (AFSC) Sand Point facility, and hosted by the Age and Growth AFSC staff. As part of the 2015 CARE Conference, a crustacean age determination workshop led by Dr. Raouf Kilada was scheduled, which began on April 14 with the CARE business meeting commencing on April 15. The conference was attended by 49 CARE members (Table 1) from participating agencies ADF&G (12), AFSC (15), CDFO (6), IPHC (4), NMFS/AFSC – ABL (1), NWFSC/PSMFC (3), ODFW (1), University of New Brunswick, St. John (1), and WDFW (6). The next CARE Conference in 2017 will be held prior to the TSC meeting during the first week of April at the same location, NOAA AFSC, Sand Point facility, Seattle, WA. The following officers were elected at the April 2015 meeting and will take office July 1:

- Chair - Chris Gburski (AFSC)
- Vice-Chair - Lance Sullivan (NWFSC)
- Secretary – Kevin McNeel (ADF&G)

b. **Business Session Highlights:**

i. **Scientific presentations:**

An official Call for Presentations and Posters for the 2015 CARE Conference was sent to members on January 23 (Appendix III). Submissions were requested to address three topic sessions:

1. New techniques in age determination methods.
2. Age validation studies.
3. Age-based models for fisheries stock assessment and management.

Other presentations and posters related to the scope of CARE were also welcomed for consideration. Abstracts were due to the CARE Chair by March 13, 2015. There were eight oral presentation and seven poster abstracts submitted by the deadline. A book of Abstracts (Appendix IV) was compiled and available to members during the business meeting.

Eight oral presentations in PowerPoint format were given during the CARE meeting:

Topic Session 1: New techniques in age determination methods

1. Dr. Raouf Kilada (crustacean workshop presenter), *Finally, we can say how old this crab is.* (45 minutes)
2. Irina Benson, *Preliminary Results on the Use of Otolith Microchemistry for Developing Ageing Criteria for Eulachon (Thaleichthys pacificus).* (20 min)

Topic Session 2: Age Validation Studies

3. Thomas Helser, *Estimation of Ageing Bias Using Bomb Radiocarbon $\Delta^{14}C$ Signatures in Fish Otoliths: Beyond Plot and Cluck.* (30 min)
4. Craig Kastelle, *Use of the stable oxygen isotope, ^{18}O, in otoliths as an indicator of fish life history events and age validation.* (25 min)
5. Stephen Wischniowski, *Incorporation of bomb-produced ^{14}C into fish otoliths. An example of basin-specific rates from the North Pacific Ocean.* (15 min) – due to S. Wischniowski being absent due to a medical emergency, Thomas Helser gave the presentation.
6. Kevin McNeel, *Assessing yearly growth increment criteria used to assign ages for groundfish at the Alaska Department of Fish and Game Age Determination Unit using bomb radiocarbon.* (20 min)
7. Kristin Politano, *Using otolith measurements to refine quality control procedures.* (20min)

Topic Session 3: Age-based models for fisheries stock assessment and management

8. Dr. Kray Van Kirk, *The use of age data in contemporary fisheries stock assessment and management.* (20 min)

Eight posters were presented during a poster session with presenters held at 3:00 pm April 16. See Appendix IV for titles and abstracts.

ii. Agency Reports:

CDFO (Joanne Groot), IPHC (Joan Forsberg), AFSC (Thomas Helser), ADF&G-all sites (Elisa Russ, Kevin McNeel, Sonya El Mejjati/Joan Brodie), NWFSC/PSMFC (Patrick McDonald), WDFW (Andrew Claiborne), and ODFW (Lisa Kautzi) provided reports summarizing and updating agency activities, staffing, organization, new species and projects. Important to note was the retiring of Darlene Gillespie (CDFO); Stephen Wischniowski is the lead for the CDFO age determination program however he was unable to attend CARE due to a medical issue. There was no representative at CARE from SWFSC or CDFG. Details from agency reports will be available in the CARE minutes which will be finalized and published to the CARE website by year's end.

iii. Summary of 5th International Otolith Symposium (IOS)

The 5th IOS was held in Mallorca, Spain October 20-24, 2014. CARE members that attended and presented at the conference were Thomas Helser, Craig Kastelle and Cindy Tribuzio from AFSC. Craig Kastelle provided a summary of IOS. Over 300 scientists attended with over 300 presentations given. There were four themes that described environmental, population, community, and individual indicators. There were two workshops at IOS that focused on age validation and otolith shape analysis.

iv. Discussion of long-term storage of otoliths in glycerin-thymol:

This discussion was continued from the 2013 CARE meeting and also in response to the TSC recommendation in 2014 to develop a set of best practices for short and long term otolith preservation and storage. In 2013, Sandra Rosenfield (WDFW) reported some archived otoliths stored in glycerin-thymol solution had shown signs of deterioration and questioned the use of that medium. Delsa Anderl (AFSC) and Joan Forsberg (IPHC) volunteered to do a cursory review of samples from their archived otolith collections stored in that medium. There were some archived otoliths that had shown degradation, however, there was not consensus that the solution was the issue but instead might be attributed to cleanliness of samples, incorrect solution mixing, or possibly the age of fish sampled (e.g. young sablefish otoliths appeared to be affected after long-term storage). Although there was some affected otoliths, agencies utilizing glycerin-thymol solution for otolith storage, as well as those using ethanol or storing otoliths dry, plan to continue with current practices and therefore there was no consensus between agencies about the best method to employ.

v. Crustacean Age Determination Workshop

Interest from the CARE membership resulted in a special workshop being organized for the 2015 CARE Conference that focused on a new age determination technique developed by Dr. Raouf Kilada from the University of New Brunswick, Saint John. Dr. Joel Webb (ADF&G) assisted Elisa Russ (CARE Chair) in the organization and planning of the workshop, and also assisted Dr. Kilada in conducting the workshop. CARE members have already been involved with shellfish age determination for bivalves (e.g. geoduck clams, weathervane scallops) and TSC was consulted for approval prior to planning the crustacean workshop. The workshop focused on Dungeness crab, snow crab, and spot shrimp (prawn), and participants provided specimens. AFSC had excellent facilities and equipment to host the workshop and aspects included dissection of the age structures - eyestalks and gastric mills (crab only), embedding in resin, sectioning, and imaging. Participants in the workshop were able to successfully prepare specimens for age determination. There were a total of 20 participants from AFSC, ADF&G, CDFO, ODFW, and WDFW. Participants anticipate future age structure exchanges and calibration work as techniques are further developed and implemented. See Appendix II for workshop agenda.

vi. Hands-on Session Highlights and Demonstrations:

a) Hands-On Age Reading at Microscopes:

A total of 28 readers reviewed 13 species during the hands-on workshop, mainly for the purpose of calibration between age readers and agencies. Members aged black rockfish, canary rockfish, china rockfish, quillback rockfish, yelloweye rockfish, shortraker rockfish, Pacific cod, walleye pollock, lingcod, sablefish, rex sole, Greenland turbot, and geoduck clam. Species aged, participating members, and agencies are listed in Table 2.

b) Micro-mill demonstration:

A micro-milling demonstration was led by Craig Kastelle (AFSC). Craig demonstrated techniques for operating the micro-mill using a Pacific cod otolith and imaging software. Participants included Andrew Claiborne, Bethany Stevick

(WDFW), Joanne Groot, Barbara Campbell (CDFO), Lance Sullivan, Patrick McDonald (NWFSC), Rob Dinneford, Andrew Pollak, and Elisa Russ (ADF&G). The demonstration was particularly helpful for CDFO staff as that agency has just acquired a micro-mill.

B. CARE Subcommittee (Working Group) Reports – Executive Summary

There were five active working groups that reported at the 2015 CARE Conference.

1. **CARE Manual/Glossary Subcommittee** – The members of the manual working group are lead Elisa Russ (ADF&G), Betty Goetz (AFSC), Lisa Kautzi (ODFW), and new member Chris Gburski (AFSC). Barb Campbell (CDFO) is also a member although she was unable to attend the working group meeting at the 2015 CARE meeting due to conflict with sablefish working group.

The Manual/Glossary Committee working group members develop and update age-reading chapter sections or definitions for age-reading terms suggested by CARE members. These chapter sections and definitions are subsequently approved by CARE members and added to the CARE Manual/Glossary.

The subcommittee addressed topics discussed 2013 manual recommendations, drafted 2015 recommendations, and delegated tasks. Tasks include compiling edits and finalizing the lingcod section that ADF&G-Juneau (ADU) staff submitted, incorporate thin sectioning methods and edit rockfish ageing section (Elisa), compile information from all agencies on baking otoliths and draft section (Elisa, Betty, Lisa), revise draft of ergonomics section to be included with equipment information (Betty) [Julie Pearce (AFSC) attended manual working group committee, provided additional suggestions/information on ergonomic equipment from perspective of new age reader and will supply equipment list to Betty by end of April], and draft walleye pollock section (research and provide draft at 2017 meeting – Elisa). An Acknowledgments Section will be prepared for manual version generated after 2015 meeting and the manual subcommittee will work with the website subcommittee to post archived editions of the manual. Manual working group will review sablefish section once submitted by sablefish working group. Manual working group will work with Cindy Tribuzio (AFSC) on a new spiny dogfish section for the manual since she has draft age determination manual for that species in process of publication. After review and approval by the Manual Working Group, all revisions will be submitted to the full CARE membership for final review and approval followed by incorporation into the CARE manual. Recommendations are included in CARE to CARE 2015.

2. **CARE Website Subcommittee** – Jon Short (AFSC) lead and webmaster, Nikki Atkins (NWFSC – not present), and new members Thomas Helser (AFSC) and Dion Oxman (ADF&G).

   The CARE website working group administers to the appearance, operation, and access to the site, through the cooperation of the PSMFC website and webmaster. The CARE web page is located at http://www.psmfc.org/care/.

   J. Short requested 2014 production numbers and will update the CARE website with 2014 production numbers, 2014 age structure exchanges, and the 2015 CARE meeting minutes once approved. N. Atkins continued to maintain the CARE Forum in 2014 (link on website).

   The website subcommittee included Tim Frawley (ADF&G) by teleconference to discuss the future of the existing website. The website working group discussed the possibility of adding publications of fish ageing and validation to the website so that relevant information is more accessible to the age reading community and stock assessors. One option was to add links to the existing species information page and the ageing method table. Another option is to create a more sophisticated database back-end that would allow users to search by species, ageing technique, validation method, author, etc. Publication entries could be added by agency representatives into an online form that would populate the database back end, and automatically link to appropriate species information pages. ADF&G staff expressed interest in building the web application if they would be able to employ their expert knowledge of ASP.NET and IIS Web Services on the project. The existing web technology of Joomla that utilizes mySQL and PHP is not a technology they support.

The CARE website is on a Joomla 1.0 document management system (DMS) that was implemented in 2008 on a PSMFC server. The Joomla version is past its supported lifespan and the current version of Joomla is 3.4. It is a major undertaking to update the website to the current version of Joomla, so we discussed the possibility of converting the site and the CARE Forum to a different technology. Tim expressed willingness to support the effort to move to an ASP.NET website if that option is available on the PSMFC web server. Jon Short agreed to research options with PSMFC to see what choices are available. As of 2012, PSMFC themselves had switched from Joomla to a WordPress website, so that is one option if CARE decides to leave Joomla for another open source DMS. Both Jon and Tim expressed concern about committing to a major project such as converting the CARE website, but both are willing to assist on the project as time allows.

3. **Charter Subcommittee –** Elisa Russ (ADFG) and Betty Goetz (AFSC)

   The Charter, initiated in 2000, provides a framework in which the original intent of CARE may continue. It also familiarizes 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, and the charter was revised following the 2008 CARE meeting.

   The charter working group reviewed the charter and made recommendations to CARE to edit information on timelines including TSC report preparation following same year CARE meeting, add information on submission of production numbers (species aged table), and coordination with the Chair and host agency regarding meeting logistics. The revised charter will be submitted to the membership for approval by June 2015.

4. **Sablefish ad hoc Working Group –** Current members are Delsa Anderl (AFSC) as the lead and other members Patrick McDonald (NWFSC), Kevin McNeel (ADF&G), Barb Campbell (CDFO), Lance Sullivan (NWFSC), and John Brogan (AFSC).

   Due to some past members leaving their positions, tasks were reassigned with plans to update the sablefish section in the age determination manual with the draft complete by the end of 2015 and submission to the manual subcommittee by summer 2016, with review and approval by the membership prior to the 2017 CARE meeting. Additionally, some members of the group reviewed sablefish otolith to continue work on calibration and age determination criteria.

5. **Shortraker ad hoc Working Group –** This is a new ad hoc working group formed for the 2015 CARE meeting with exchanges completed prior to the meeting. Working group members are Charles Hutchinson (AFSC) as the lead and Kevin McNeel (ADF&G), Joanne Groot (CDFO), Delsa Anderl (AFSC), and Stephen Wischniowski (CDFO – absent).

   The shortraker rockfish working group convened in 2015 and discussed the age structure exchange (n=46; 2 exchanges GOA & Canadian stocks) that was initiated in 2014 between 5 members of the working group from AFSC, ADF&G, & CDFO. The group utilized camera microscopes and imaging software during a mini-workshop to discuss the sectioned shortraker otoliths and pattern interpretation in detail. AFSC members have the most experience ageing shortraker rockfish and the working group was utilized for calibration and training for the less experienced age readers. In addition to the members of the working group, three additional CARE members from AFSC and ADF&G participated for training on pattern interpretation. Shortraker rockfish growth patterns exhibit a lot of checks during early years up until approximately age 10 and then uneven growth increments after age 10. The shortraker rockfish working group made a recommendation to continue work on pattern interpretation through future exchanges of age structures (otoliths) and images culminating in a final shortraker rockfish workshop at the 2017 CARE meeting with the intention of developing the ageing criteria.

C. Age Structure Exchanges

Age structure exchanges occur periodically 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. There were eleven age structure exchanges initiated in 2014 which are listed in Table 3.

D. Recommendations CARE and TSC

In 2015 recommendations were made by CARE to CARE, CARE to TSC, and TSC to CARE. Some recommendations may take more than one cycle to complete. This list contains recommendations that are still pending or provide background for those made by CARE/TSC in response to prior recommendations.

1. 2015 Recommendations
   1.1. CARE to CARE recommendations 2015
      1.1.1. Recommends the Manual/Glossary subcommittee continue revision and expansion of the CARE Manual on Generalized Age Determination with the following sections:
         i. Lingcod Otolith Ageing section – finalize draft and incorporate into manual, May 2015 *(thanks ADF&G – Juneau ADU staff).*
         ii. Thin Sectioning Method – add section under General Ageing Procedures; finish draft, finalize, and submit to membership approval prior to 2017 meeting.
         iii. Rockfish Ageing Procedures – finish draft, finalize, and submit to membership approval prior to 2017 meeting.
            a. Edit to avoid redundancy with Thin Sectioning section.
            b. Revise/move some info to Otoliths Ageing Procedures where appropriate.
         iv. Add section on baking otoliths under General Ageing Procedures – research methodologies with agencies where techniques employed and submit draft for 2017 meeting.
         v. Ergonomics – section to be included with general information on equipment with included list of ergonomic equipment recommendations for age readers; finish draft, finalize, and submit to membership for approval by June 2015.
         vi. Walleye Pollock Ageing Procedures (new) – **collaborate** between agencies and submit draft at 2017 meeting (use AFSC manual as starting point).
         vii. Sablefish Ageing Procedures section – draft to update the sablefish section in the CARE manual will be completed by sablefish working group by end of 2015 then after edits/revision will be submitted to manual working group by June 2016 for finalization with submission to membership for approval prior to 2017 meeting.
         viii. Spiny Dogfish Ageing Procedures section (new) – prepare draft for 2017 meeting.
            a. (Following publication of CARE member Cindy Tribuzio's spiny dogfish age determination manuscript and use techniques described.)
         ix. Remove documentation sections regarding changes to manual (also incomplete):
            a. Add Acknowledgements Section – submit to membership for approval for 2017 meeting;
            b. See Recommendation 1.1.2 to post archived editions.
      1.1.2. Recommends the manual working group submit archived editions of the CARE Manual to the website committee for posting on the website to preserve historical records.

1.1.3. Recommends that the CARE Forum be continued.

1.1.4. Recommends the website committee research the possibility and process of adding publications of fish ageing and validation to the website so that relevant information is more accessible to the age reading community and stock assessors.

i. One option is to add links to the existing species information page and the ageing method table.

ii. Publication entries could be added by agency representatives into an online form that would populate the database back end, and automatically link to appropriate species information pages.

iii. Another option is to create a more sophisticated database back-end that would allow users to search by species, ageing technique, validation method, author, etc.

1.1.5. Additional recommendations for the website to be completed prior to 2017 meeting:

i. Add information at top of Species Info page to "Check with specific agency about changes in historical age determination techniques"; report that "Methods listed are for most recent reporting year", or adjust in conjunction with changes incorporated in 1.1.6;

ii. Edits such as consistent capitalization on Species Info page;

iii. Update agency production numbers annually,

a. Include methods for current reporting year and use appropriate codes (B&BN= Break & Burn, B&BK= Break & Bake),

b. Update Species Info page to include new codes,

iv. Add table for agency contacts with e-mail address – if possible, hyperlink from Ageing Method table (Agency field),

v. Add webpage for age structure inventories (links may be spreadsheet or links) for participating agencies, including protocol information.

1.1.6. Recommends the Website committee research the possibility of converting the site and the CARE Forum to a different technology (Joomla out of date and major undertaking to update to new version):

i. Consider moving to an ASP.NET website and research options available on the PSMFC web server, however, amount of work involved and cost will be assessed prior to implementation;

ii. Other option is to consider WordPress website (as of 2012, PSMFC had switched from Joomla to a WordPress website), if instead decide to leave Joomla for another open source DMS, load a new version of Joomla for the CARE website, or other recommended CMF (e.g. WordPress or Drupal).

1.1.7. Recommend the Charter Working Group revise charter and submit to membership for approval by June 2015. Changes to include:

i. information on timelines including preparation of TSC report following same year CARE meeting,

ii. submission of production numbers (species aged table), and

iii. Chair coordination with host agency regarding meeting logistics.

1.1.8. Recommends consideration of how to document changes in methods and age reading techniques by agencies for specific species and the process to report this information (e.g. website through species-specific methods, addendum to manual, and/or new document) – discuss at 2017 meeting by member agencies. (See recommendation 1.1.5)

1.2. CARE to TSC recommendations 2015

1.2.1. Recommend to remove the TSC to CARE 2014 recommendation for CARE to develop a set of best practices for short and long term otolith preservation and storage. There is currently no consensus on best storage protocol between or within agencies because method suitability may be dependent on species, fish age, and/or archive space availability.

i. Reports from agencies using glycerin-thymol, including recommended recipe for solution, will be included in the TSC report.

ii. Agencies will continue to research whether current methods of long-term storage are adequate for preservation of otolith integrity.

1.2.2. Recommend that new age readers are oriented to available ergonomic equipment and its proper use for minimum strain. Further recommend that implementation of ergonomic equipment continue and be supported by agency managers, and proactive standard operating procedures be in place to prevent workplace injury.

i. Reports on use of ergonomic equipment were provided by CARE member agencies in 2015 and:

a. Most upgrades were implemented after requests by age reading staff or local project managers;

b. Although some agencies have preventative and proactive protocols in place through either self-evaluation (see Appendix V for Laboratory Ergonomics Checklist) or ergonomic specialists available for evaluation of workstation, need to ensure that is available for all agencies.

1.2.3. Recommend that CARE continue to explore and develop new methods of shellfish age determination (with the support of TSC).

1.2.4. Recommend that the TSC schedule their odd-year meetings (same year as CARE meeting) no earlier than the last week of April (preferably later) in order to allow the CARE Chair adequate time to prepare the report to TSC.

Note: CARE meeting for 2017 has been scheduled for the first week of April to allow at least two weeks to prepare the CARE report to TSC (if the TSC meeting is scheduled no earlier than the last week of April).

1.3. TSC to CARE recommendations 2015

Note: These recommendations were received from the TSC following their April 2015 meeting and incorporated into this final report. The TSC to CARE recommendations directly address the CARE to TSC recommendations for 2015 listed above.

1.3.1. The TSC thanks CARE for taking time during their biennial meeting to work towards developing a set of best practices for short and long-term storage of otoliths. However, the TSC is discouraged that CARE was unable to come to agreement on this and considers this important to all member agencies. The TSC believes that CARE members are experts in the field of otolith reading and storage, and are thus best suited to develop and use best practices. The TSC asks CARE to reconsider TSC's request at their next meeting and initiate this process by documenting structures and storage methods currently in use (by species and agency) with notes on their benefits and deficits. TSC will also move this request forward to the U.S. groundfish management teams for their consideration through the SSCs to develop a study proposal to investigate best practices. TSC acknowledges the valuable work of CARE and encourages work on this problem and recognizes that this is a long term goal for agencies.

1.3.2. The TSC understands the importance of ergonomic issues for CARE members and shares their concern regarding potential ergonomic injuries to age readers. In response, the TSC voiced their concern about this issue in the 2014 Letter to Supervisors that was sent to each TAC member agency, specifically to supervisors and managers for groundfish research activities in each agency. TSC places this issue within agencies' health and safety policies and urges agencies to pursue this matter directly through lab supervisors and their agency's health and safety committees. TSC recommends that, where there are concerns in this regard, CARE send a letter to the specific agency or supervisor, with specific suggestions to alleviate the ergonomic conditions, highlighting the health and safety issue.

1.3.3. The TSC is supportive of CARE taking on non-groundfish work because it advances fisheries research. However, the TSC reminds CARE that its mandate has always been groundfish and they should be given priority within CARE. CARE does not need to include shellfish investigations in their report to the TSC.

1.3.4. The TSC understands that CARE is concerned about the short amount of time, usually less than one month, between the biennial CARE meeting and the TSC meeting which makes it difficult for the CARE Chair to prepare the CARE minutes in time for the TSC meeting. If there is not enough time to submit a full report for the TSC annual meeting, the TSC will accept a brief summary and conclusions from the CARE meeting along with any recommendations to the TSC. The full report can then be submitted at a later date when the final agency reports are due, usually the end of June.

Note from TSC: In recent years the TSC has met the last week of April, and that should not change. The TSC cannot schedule their meeting any later because many TSC members start their research season the first week of May.

2. 2014 Recommendations
   2.1. TSC to CARE
      2.1.1. Held over ergonomic injury recommendation from 2013 and TSC suggested looking at ergonomic injuries and solutions in similar assembly type work (circuit boards) and medical pathology (microscope slide reading).
      2.1.2. The TSC understands that CARE is looking into issues surrounding long-term storage of otoliths. TSC suggests that CARE researchers document their findings and develop a set of best practices for short and long term otolith preservation and storage.

3. 2013 Recommendations
   3.1. CARE to TSC
      3.1.1. At the 2013 CARE meeting, the manual working group drafted a section on Ergonomics for inclusion in the CARE Manual on Generalized Age Determination. It is important that agency leaders recognize the health risks associated with age reading and equipment options that may be available to mitigate these risks.
   3.2. TSC to CARE
      3.2.1. TSC acknowledges CARE's concerns regarding ergonomic injuries caused by extended period ageing fish and has recommended that the Parent Committee request Agencies to investigate ergonomic remedies to minimize ergonomic injuries.

4. 2012 Recommendations
   4.1. TSC to CARE
      4.1.1. 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.

CARE Response: The 2015 CARE to CARE recommendation 1.1.5.v. addresses this TSC to CARE recommendation from 2012. This was addressed in 2013, however, not all agencies agreed to participate and at the 2015 meeting it was recommended that different formats be utilized for those agencies that choose to participate based on each agency's organization of archived age structures (e.g. links or spreadsheets). Some agencies also require a specific request and a link will provide the user with the required submission documentation.

5. 2011 Recommendations
   5.1. CARE to TSC (also see 2015 CARE to CARE recommendation 1.1.5.v. and *CARE Response* to 2.1.1)
      5.1.1. 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, the 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 would consult their agencies regarding the TSC recommendation and will formulate a reply by year end.

5.2. 2011 TSC to CARE Recommendations:

5.2.1. *"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. "

1. *To clarify for CARE, TSC's 2010 information request includes the following by species:*

   Number of ageing structures collected by:

   i. *structure type*
   ii. *agency*
   iii. *year*
2. *Number of structures aged by year (already on the website)*
3. *A link to a contact person at each agency.*

5.2.2. 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?"*

5.2.3. 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."

5.2.4. 2011 CARE reply to TSC:

i. 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.
ii. Three CARE member agencies chose not to participate. Some will link the CARE website to their agency website and provide a contact name.
iii. 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.

5.2.5. CARE recommends that the 2013 agenda address the effects of long-term storage of otoliths in glycerin.

6. 2010 Recommendations

6.1. TSC to CARE

6.1.1. 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.

Table 1. Attendees of the CARE Conference, April 14-17, 2015, Seattle, Washington, U.S.A.

Last name	First name	Agency	Location	Country	Email
Russ	Elisa	ADF&G	Homer	USA	elisa.russ@alaska.gov
Pollak	Andrew	ADF&G	Homer	USA	andrew.pollak@alaska.gov
McNeel	Kevin	ADF&G	Juneau	USA	kevin.mcneel@alaska.gov
Dinneford	Rob	ADF&G	Juneau	USA	rob.dinneford@alaska.gov
Politano	Kristin	ADF&G	Juneau	USA	kristin.politano@alaska.gov
Oxman	Dion	ADF&G	Juneau	USA	dion.oxman@alaska.gov
Webb	Joel	ADF&G	Juneau	USA	joel.webb@alaska.gov
Smith	Quinn	ADF&G	Juneau	USA	quinn.smith@alaska.gov
Van Kirk	Kray	ADF&G	Juneau	USA	kray.vankirk@alaska.gov
El Mejjati	Sonya	ADF&G	Kodiak	USA	sonya.elmejjati@alaska.gov
Brodie	Joan	ADF&G	Kodiak	USA	kayla.bevaart@alaska.gov
Bevaart	Kayla	ADF&G	Kodiak	USA	kayla.bevaart@alaska.gov
Tribuzio	Cindy	AFSC/NMFS - ABL	Juneau	USA	cindy.tribuzio@noaa.gov
Anderl	Delsa	AFSC	Seattle	USA	delsa.anderl@noaa.gov
Benson	Irina	AFSC	Seattle	USA	irina.benson@noaa.gov
Brogan	John	AFSC	Seattle	USA	john.brogan@noaa.gov
Gburski	Chris	AFSC	Seattle	USA	christopher.gburski@noaa.gov
Goetz	Betty	AFSC	Seattle	USA	betty.goetz@noaa.gov
Helser	Thomas	AFSC	Seattle	USA	thomas.helser@noaa.gov
Hutchinson	Charles	AFSC	Seattle	USA	charles.hutchinson@noaa.gov
Johnston	Chris	IPHC	Seattle	USA	chris.johnston@noaa.gov
Kastelle	Craig	AFSC	Seattle	USA	craig.kastelle@noaa.gov
Matta	Beth	AFSC	Seattle	USA	beth.matta@noaa.gov
Pearce	Julie	AFSC	Seattle	USA	julie.pearce@noaa.gov
Piston	Charlie	AFSC	Seattle	USA	charlie.piston@noaa.gov
Short	Jon	AFSC	Seattle	USA	jon.short@noaa.gov
Tenbrink	Todd	AFSC	Seattle	USA	todd.tenbrink@noaa.gov
White	Vanessa	AFSC	Seattle	USA	vanessa.white@noaa.gov
Campbell	Barbara	CDFO	Nanaimo	Canada	Barbara.Campbell@dfo-mpo.gc.ca
Dunham	Jason	CDFO	Nanaimo	Canada	Jason.Dunham@dfo-mpo.gc.ca
Fong	Ken	CDFO	Nanaimo	Canada	Ken.Fong@dfo-mpo.gc.ca
Gillespie	Graham	CDFO	Nanaimo	Canada	Graham.Gillespie@dfo-mpo.gc.ca
Groot	Joanne	CDFO	Nanaimo	Canada	Joanne.Groot@dfo-mpo.gc.ca
Rutherford	Dennis	CDFO	Nanaimo	Canada	dennis.rutherford@dfo-mpo.gc.ca
Forsberg	Joan	IPHC	Seattle	USA	joan@iphc.int
Johnston	Chris	IPHC	Seattle	USA	chris@iphc.int
Gibbs	Linda	IPHC	Seattle	USA	linda@iphc.int
Rudy	Dana	IPHC	Seattle	USA	dana@iphc.int

McDonald	Patrick	NWFSC	Newport	USA	patrick.mcdonald@noaa.gov
Sullivan	Lance	NWFSC	Newport	USA	lance.sullivan@noaa.gov

Table 1. continued. Attendees of the CARE Conference, April 14-17, 2015, Seattle, Washington, U.S.A.

Whiteside	Cassandra	NWFSC	Newport	USA	cassandra.whiteside@noaa.gov
Kautzi	Lisa	ODFW	Newport	USA	lisa.a.kautzi@state.or.us
Claiborne	Andrew	WDFW	Olympia	USA	andrew.claiborne@dfw.wa.gov
Hildebrandt	Anna	WDFW	Olympia	USA	Anna.Hildebrandt@dfw.wa.gov
Jones	Colin	WDFW	Olympia	USA	Colin.Jones@dfw.wa.gov
Rosenfield	Sandy	WDFW	Olympia	USA	greenthumb51@hughes.net
Stevick	Bethany	WDFW	Olympia	USA	Bethany.Stevick@dfw.wa.gov
Topping	Jennifer	WDFW	Olympia	USA	toppijat@dfw.wa.gov

Table 2. 2015 CARE Hands-On "Scope Time" Session – Species Aged, Participants, and Agency.

Species	Participants	Agency	Comments
Walleye pollock	Chris Gburski	AFSC	Calibration, Training
	Sonya El Mejjati	ADF&G	
	Joan Brodie	ADF&G	
	Andy Pollak	ADF&G	
	Chris Johnston	AFSC	
	Elisa Russ	ADF&G	
	Betty Goetz	AFSC	
	Delsa Anderl	AFSC	
Lingcod	Sonya El Mejjati	ADF&G	Calibration
	Rob Dinneford	ADF&G	
	Sandra Rosenfield	WDFW	
	Lance Sullivan	NWFSC	
	Patrick McDonald	NWFSC	
	Lance Sullivan	NWFSC	
	Kristin Politano	ADF&G	
	Joan Brodie	ADF&G	
Sablefish	Patrick McDonald	NWFSC	Calibration
	Kevin McNeel	ADF&G	
	John Brogan	AFSC	
	Lance Sullivan	NWFSC	
	Kristin Politano	ADF&G	
Black rockfish	Andy Pollak	ADF&G	Calibration
	Lisa Kautzi	WDFW	
Canary rockfish	Andy Pollak	ADF&G	Calibration
	Patrick McDonald	NWFSC	
China rockfish	Andy Pollak	ADF&G	Calibration
	Cassandra Whiteside	NWFSC	
Quillback rockfish	Andy Pollak	ADF&G	Calibration

	Cassandra Whiteside	NWFSC	
Yelloweye rockfish	Andy Pollak	ADF&G	Calibration
	Cassandra Whiteside	NWFSC	
Shortraker rockfish	Charles Hutchinson	AFSC	Calibration, Exchange, Training
	Kevin McNeel	ADF&G	Mini-Workshop Focus
	Betty Goetz	AFSC	
	Joanne Groot	CDFO	
	Kristin Politano	ADF&G	
	Delsa Anderl	AFSC	
	Elisa Russ	ADF&G	
Rex sole &	John Brogan	AFSC	Training
Greenland turbot	Joan Forsberg	IPHC	
	Linda Gibbs	IPHC	
	Dana Rudy	IPHC	
	Chris Johnston	IPHC	
Pacific cod	Craig Kastelle	AFSC	Calibration, Training
	Lance Sullivan	NWFSC	
	Andy Pollak	ADF&G	
	Rob Dinneford	ADF&G	
Geoduck clam	Bethany Stevick	WDFW	Calibration, Training
	Colin Jones	WDFW	
	Kristin Politano	ADF&G	

Table 3. CARE age structure exchanges initiated in 2014.

Exchange ID No.	Species	Originating Agency	Coordinator	Coordinating Agencies
14-001	Rougheye Rockfish	WDFW	S. Rosenfield	NWFSC/PSMFC
14-002	Spiny Dogfish	AFSC/ABL - Juneau	C. Tribuzio	AFSC
14-003	Lingcod	ADF&G - Kodiak	S. El Mejjati	ADF&G (ADU)
14-004	Big Skate	CDFO	J. King	AFSC, PSRC*
14-005	Big Skate	CDFO	J. King	AFSC, PSRC
14-006	Longnose Skate	CDFO	J. King	AFSC, PSRC
14-007	Longnose Skate	CDFO	J. King	AFSC, PSRC
14-008	Shortraker Rockfish	CDFO	J. Groot	AFSC, ADF&G
14-009	Shortraker Rockfish	AFSC	C. Hutchinson	AFSC, ADF&G
14-010	Lingcod	ADF&G – Kodiak	S. El Mejjati	ADF&G - Homer
14-011	Black Rockfish	ODFW	L. Kautzi	WDFW

*PSRC=Pacific Shark Research Center, Moss Landing Marine Laboratories

Figure 1: Attendees of the 2015 CARE Conference, April 14-17 2015 Group Photo, Shortraker Rockfish ad hoc working group, Crustacean Age Determination workshop, hands-on session calibration microscope work, and Poster Session.

APPENDIX-I

Eighteenth Biennial Meeting of the
Committee of Age Reading Experts

Working Group of the Canada – US Groundfish Committee TSC
AFSC Sand Point Facility, NOAA Western Regional Center
7600 Sand Point Way, NE, Seattle, WA, USA
Bldg. #4, Jim Traynor Conference Room

April 14 – 17, 2015

CARE Agenda

Tuesday April 14, 2015

Crustacean age determination workshop – see workshop agenda (participation limited – workshop full)

Wednesday April 15, 2015

I. Welcome and Opening Statements for CARE 2015 Meeting (8:30 – 9:00)
   - A. Call to Order (Elisa Russ, CARE Chair)
     - 1. Minutes will be taken by Lance Sullivan, CARE Secretary
   - B. Host Statements
     - 1. Opening statements (Thomas Helser)
     - 2. Host information (Chris Gburski, CARE Vice-Chair)
   - C. Introductions
     - 1. Round-table introductions (name, agency, location)
     - 2. Attendance, address, phone, email (written list)
   - D. Approval of the 2015 agenda

II. Agency Overviews and Updates (9:00-9:45)

   *No PowerPoint; 5 minute updates (staffing, organizational, new species/projects, etc.)
   - A. CDFO (Steve Wischniowski)
   - B. IPHC (Joan Forsberg)
   - C. AFSC (Tom Helser)
   - D. ADFG (Elisa Russ, Sonya El Mejjati, Kevin McNeel)
   - E. NWFSC (Patrick McDonald)
   - F. SWFSC
   - G. WDFW (Andrew Claiborne)
   - H. ODFW (Lisa Kautzi)
   - I. CDFG

III. CARE to CARE recommendations from 2013 – Review (9:45-10:15)

A. Recommends the manual working group post archived editions of the CARE Manual on the website with a link to the year of publication.
B. Recommends the Manual/Glossary committee continue revision and expansion of the CARE Manual on Generalized Age Determination with the following sections:
    1. Lingcod Otolith Ageing – finalize draft and incorporate into manual.
    2. Thin Sectioning Method – edit updated draft
    3. Rockfish Ageing Procedures –
        a. Edit to avoid redundancy with Thin Sectioning section.
        b. Revise/move some info to Otoliths Ageing Procedures where appropriate.
    4. Add section on baking otoliths under General Ageing Procedures.
    5. Ergonomics – write short section to be included with general information on equipment.
    6. Walleye Pollock Ageing Procedures – draft new section – collaborate between agencies.
    7. Sablefish Ageing Procedures Section – revise.
    8. Remove documentation sections in beginning of manual as is incomplete:
        a. See Recommendation A to post archived editions.
        b. Add Acknowledgements Section.
C. Recommends that the CARE Forum be continued.
D. Recommends the Website committee load a new version of Joomla for the CARE website, or other recommended CMF (e.g. WordPress or Drupal).
    1. Future plans include:
        a. Edits such as consistent capitalization on Species Info page,
        b. Update agency production numbers,
        c. Add webpage for age structure inventories.
E. Recommend further study of otoliths stored long term in glycerin-thymol,
    1. Report on observations regarding the media in 2015,
    2. Provide recommendation to manual committee in 2015 regarding storage.
F. Recommend to the Charter Working Group to expand charter to include timelines for reports and meetings for possible additions to the charter pending CARE membership approval.

IV. CARE to TSC recommendations from 2013
A. At the 2013 CARE meeting, the manual working group drafted a section on Ergonomics for inclusion in the CARE Manual on Generalized Age Determination. It is important that agency leaders recognize the health risks associated with age reading and equipment options that may be available to mitigate these risks.

V. TSC to CARE recommendations from 2013
A. TSC acknowledges CARE's concerns regarding ergonomic injuries caused by extended period ageing fish and has recommended that the Parent Committee request Agencies to investigate ergonomic remedies to minimize ergonomic injuries.

VI. TSC to CARE recommendations from 2014
A. Held over ergonomic injury recommendation from 2013 and TSC suggested looking at ergonomic injuries and solutions in similar assembly type work (circuit boards) and medical pathology (microscope slide reading).
B. The TSC understands that CARE is looking into issues surrounding long-term storage of otoliths. TSC suggests that CARE researchers document their findings and develop a set of best practices for short and long term otolith preservation and storage.

Break (10:15-10:30) – Posters may be set up prior to the meeting commencement or during breaks today.

VII. Working Group Reports / Activity Since CARE 2011 (10:30-11:30)

A. 2014 TSC Meeting (Elisa Russ)

1. Replies to TSC regarding 2013/2014 recommendations.
2. Long-term otolith storage; review from 2013; glycerin-thymol observation reports.

B. Age structure exchanges (Chris Gburski)

C. Website (Jon Short)

1. Archived structures added to website - progress? Location, agency contacts, links (AFSC)

D. Forum (Nikki Atkins – written report since absent)

E. CARE Manual (Elisa Russ)

F. Charter Committee (Elisa Russ)

G. Sablefish (Delsa Anderl) – tabled until CARE 2017

VIII. Topics for Discussion / New Business (11:30-12:00)

A. Summary of 5th International Otolith Symposium 2014 (Helser)

B. Other Conferences since 2013 that members attended?

C. Species Info on the website - need Agency updates & verification

D. Additional topics

E. Non-agenda items

Lunch (12:00-1:15)

IX. Oral Presentations – 3 Topics (1:15-5:00)

A. Topic Session 1: New techniques in age determination methods

1. Dr. Raouf Kilada (crustacean workshop presenter), *Finally, we can say how old this crab is.* (45 minutes)

2. Irina Benson, *Preliminary Results on the Use of Otolith Microchemistry for Developing Ageing Criteria for Eulachon (Thaleichthys pacificus).* (20 min)

B. Topic Session 2: Age Validation Studies

1. Thomas Helser, *Estimation of Ageing Bias Using Bomb Radiocarbon $\Delta^{14}C$ Signatures in Fish Otoliths: Beyond Plot and Cluck.* (30 min)

2. Craig Kastelle, *Use of the stable oxygen isotope, ^{18}O, in otoliths as an indicator of fish life history events and age validation.* (25 min)

Break (3:15-3:30)

3. Stephen Wischniowski, *Incorporation of bomb-produced ^{14}C into fish otoliths. An example of basin-specific rates from the North Pacific Ocean.* (15 min)

4. Kevin McNeel, *Assessing yearly growth increment criteria used to assign ages for groundfish at the Alaska Department of Fish and Game Age Determination Unit using bomb radiocarbon.* (20 min)

5. Kristin Politano, *Using otolith measurements to refine quality control procedures.* (20 min)

C. Topic Session 3: Age-based models for fisheries stock assessment and management

1. Dr. Kray Van Kirk, *The use of age data in contemporary fisheries stock assessment and management.* (20 min)

Dinner at Elliott Bay Brewing Company, 12537 Lake City Way NE, Seattle (5:30-?)

Thursday, April 16, 2015

X. Working groups & Workshops (8:30 am-5:00 pm, schedule lunch as appropriate for respective groups)

A. Crustacean workshop – see workshop agenda

B. Working Groups (Traynor Room or Room 2079)

1. Meet and discuss activity since 2013

2. Formulate written recommendations and prepare for presentation Friday morning

C. Hands-on microscope work and calibration (Traynor Room)

1. Sign up for dual scope station use (time)

D. **POSTER SESSION –** posters available for viewing during breaks from other tasks all day and session at 3 pm

Friday April 17, 2015

XI. Recommendations (8:30-9:00)

A. 2015 CARE to CARE

B. 2015 CARE to TSC

XII. Concluding CARE business (9:00-10:00)

A. Administration nominations

B. Schedule and location of 2017 meeting

XIII. Working groups & Hands-on Workshop (10:00-12:00)

A. Working Groups – additional time available to meet and schedule tasks for 2017

B. Hands-on Workshop – dual microscopes available for calibration work until noon

XIV. CARE Business Meeting Adjourns (12:00 noon)

XV. Crustacean Workshop Resumes (1:00-5:00)

A. May adjourn earlier depending on student needs

APPENDIX-II

TUESDAY, APRIL 14

8:30 – 9:30 AM (Traynor Room)

- Welcome
- Introductions, schedule , Q&A
- Age determination in aquatic species with reference to crustaceans – Dr. Raouf Kilada, University of New Brunswick (St. John), New Brunswick, Canada

9:30 AM – 9:40 AM Coffee Break

- A novel age determination technique and case studies for crustaceans – Dr. Raouf Kilada

10:15 AM – 10:30 PM

- Workshop Orientation – Objectives, Groups, Rooms, Stations

10:30 AM – 12:00 PM

- Group 1 – Dissection (Observer Wet Lab) and embedding (Age and Growth/RACE Labs)
- Group 2 – Sectioning and mounting (Age and Growth Lab, Room 1114)

12:00 PM - 1:30 PM – Lunch Break

1:30 PM – 2:30 PM (continued from before lunch)
2:30 PM – 4:30 PM

- Group 1 – Sectioning and mounting (Age and Growth Lab)
- Group 2 – Dissection (Observer Wet Lab) and embedding (Age and Growth/RACE Labs)
- Viewing and imaging (Age & Growth Imaging Lab, Room 1110)

4:30 PM - 4:45 PM (Traynor)

- Debrief and Q&A

With support from:

BSFRF
Bering Sea Fisheries Research Foundation

WEDNESDAY, APRIL 15 – No workshop during CARE Meeting

THURSDAY, APRIL 16
8:30 AM – 8:45 AM (Observer Wet Lab)

- Objectives for the day

8:45 AM – 12:00 PM

- Sectioning and mounting dissected specimens (Age & Growth Imaging Lab, Room 1110)
- Open stations for dissection, embedding, sectioning, viewing/imaging

12:00 PM – 1:30 PM – Lunch Break
1:30 PM – 4:00 PM

- Imaging of mounted specimens from dissections (Age & Growth Imaging Lab, Room 1110)
- Open stations for dissection, embedding, sectioning, viewing/imaging

4:00 PM - 4:30 PM (Observer Wet Lab)

- Debrief and Q&A

Friday, April 17, 2015
1:00 PM – 4:00 PM (Traynor Room)

- Review of results by species
- Progress and future directions
- Q&A

With support from:

BSFRF
Bering Sea Fisheries Research Foundation

APPENDIX-III

CARE CONFERENCE 2015
April 14-17, 2015
NOAA Alaska Fisheries Science Center,
Sand Point facility, Seattle, WA

CALL FOR PRESENTATIONS & POSTERS

The Committee of Age Reading Experts is pleased to announce the Call for Presentations and Posters for the 2015 CARE Conference.

The topic sessions will focus on:

1. Age validation studies.
2. New techniques in age determination methods.
3. Age-based models for fisheries stock assessment and management.

Other presentations and posters related to the scope of CARE are also welcome for consideration.

Please submit abstracts by March 13, 2015 to Elisa Russ, CARE Chair at elisa.russ@alaska.gov

- Submit abstract as a Word document (preferably) and include the following information:
    - Type of presentation (oral or poster)
    - Title
    - First and Last Name of Author(s)
        - Include any preferred appellation (e.g. Dr. or Ph.D.)
        - Name of Presenter (if more than one author)
        - Include any affiliations (spell out agency), city, country, and e-mail
    - Text of abstract in 250 words or less.
    - Amount of time needed for presentation (maximum of 20 minutes).
        - More time may be available upon request & will be considered after deadline.

The CARE membership meeting including presentations, age reader calibration, and workgroup meetings will be held April 15-17, 2015 and presentations will occur on Wednesday, April 15, 2015.

The 2015 CARE Conference will also feature a 2.5 day crustacean age determination workshop led by Dr. Raouf Kilada. The workshop will begin on Tuesday, April 14, one day before the CARE meeting convenes. The workshop is full but reply with interest in the event space becomes available.

CARE Website: http://care.psmfc.org/

APPENDIX-IV

Eighteenth Biennial Meeting of the Committee of Age Reading Experts

Working Group of the Canada – US Groundfish Committee TSC
AFSC Sand Point Facility, NOAA Western Regional Center
April 14 – 17, 2015

Abstracts

Oral Presentations – 3 Topics

A. Topic Session 1: New techniques in age determination methods
   1. Dr. Raouf Kilada (crustacean workshop presenter), *Finally, we can say how old this crab is.* (45 minutes)
   2. Irina Benson, *Preliminary Results on the Use of Otolith Microchemistry for Developing Ageing Criteria for Eulachon (Thaleichthys pacificus).* (20 min)

B. Topic Session 2: Age Validation Studies
   1. Thomas Helser, *Estimation of Ageing Bias Using Bomb Radiocarbon $\Delta^{14}C$ Signatures in Fish Otoliths: Beyond Plot and Cluck.* (30 min)
   2. Craig Kastelle, *Use of the stable oxygen isotope, ^{18}O, in otoliths as an indicator of fish life history events and age validation.* (25 min)
   3. Stephen Wischniowski, *Incorporation of bomb-produced ^{14}C into fish otoliths. An example of basin-specific rates from the North Pacific Ocean.* (15 min)
   4. Kevin McNeel, *Assessing yearly growth increment criteria used to assign ages for groundfish at the Alaska Department of Fish and Game Age Determination Unit using bomb radiocarbon.* (20 min)
   5. Kristin Politano, *Using otolith measurements to refine quality control procedures.* (20min)

C. Topic Session 3: Age-based models for fisheries stock assessment and management
   1. Dr. Kray Van Kirk, *The use of age data in contemporary fisheries stock assessment and management.* (20 min)

Poster Presentations – See abstracts for author and agency info.

A. *A 200 year archeozoological record of Pacific cod life history as revealed through Ion Microprobe oxygen isotope ratios in otoliths.*
B. *Modeling Environmental Factors Affecting Assimilation of Bomb-produced Δ14C in the North Pacific Ocean: Implications for age validation studies.*
C. *Age validation of Pacific cod (Gadus macorcephalus) using high resolution stable oxygen isotope (δ 18O) signatures in otoliths.*
D. *What to do when dogfish lie about their age?*
E. *Bomb Dating and Age Estimates of Big Skate (Beringraja binoculata) and Longnose Skate (Raja rhina).*
F. *Changes in Pacific cod otolith weight over time.*
G. *Re-ageing of archived otoliths from the 1920s to the 1990s.*
H. *Preparing baked thick sections of Pacific halibut otoliths*

Direct determination of age in shrimps, crabs, and lobsters

Raouf Kilada[a], Bernard Sainte-Marie[c], Rémy Rochette[b], Neill Davis[b], Caroline Vanier[d], Steven Campana[e]

[a]University of New Brunswick (Saint John), 100 Tucker Park Road, Saint John, NB E2L 4L5, Canada; and Department of Marine Science, University of Suez Canal, Ismailia, Egypt.
[b]University of New Brunswick – Saint John, 100 Tucker Park Road, Saint John, NB E2L 4L5, Canada.
[c]Marine Invertebrate Biology and Conservation, Maurice Lamontagne Institute, Fisheries and Oceans Canada, 850 route de la Mer, C.P. 1000, Mont-Joli, QC G5H 3Z4, Canada.
[d]Institut des sciences de la mer de Rimouski (ISMER), Université du Québec à Rimouski, 300 allée des Ursulines, Rimouski, QC G5L 3A1, Canada.
[e]Bedford Institute of Oceanography, Fisheries and Oceans Canada, P.O. Box 1006, Dartmouth, NS B2Y 4A2, Canada.

Abstract
The detection and measurement of annual growth bands preserved in calcified structures underlies the assessment and management of exploited fish populations around the world. However, the estimation of growth, mortality, and other age-structured processes in crustaceans has been severely limited by the apparent absence of permanent growth structures. Here, we report the detection of growth bands in calcified regions of the eyestalk or gastric mill in shrimps, crabs, and lobsters. Comparison of growth band counts with reliable, independent estimates of age strongly suggests that the bands form annually, thus providing a direct and accurate method of age determination in all of the species examined. Chemical tags in the lobster cuticle were retained through one or two molts that occurred over the duration of an experiment, as apparently was the mesocardiac ossicle containing the growth bands in the gastric mill. Growth bands are not the previously documented lamellae of the endocuticle, and their formation was not associated with molting. Sex-specific growth curves were readily developed from growth band examination in multiple species, suggesting that routine measurement of growth and mortality in decapod crustaceans may now be possible.

Preliminary Results on the Use of Otolith Microchemistry for Developing Ageing Criteria for Eulachon (*Thaleichthys pacificus*)

Irina Benson, Craig Kastelle, Thomas E. Helser, Jon Short, Delsa M. Anderl
NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way, NE., Seattle, WA

Abstract
Laser-ablation inductively-coupled plasma mass spectrometry (LAICP-MS) was used to analyze the temporal change of Ba/Ca ratios in the otoliths of eulachon (*Thaleichthys pacificus*). Specimens were collected off the coast of Oregon, in the coastal areas and rivers of Southeast Alaska, and in the southeastern Bering Sea. Annual upwelling along the Pacific Coast causes fluctuation of barium concentration in surface water and may leave distinct chemical signatures in the otoliths. Attempts to age eulachon using otolith surfaces proved to be difficult. We used trace element analysis to help interpret otolith surface patterns and to develop ageing criteria for eulachon. For each otolith thin section, a continuous scan started at the core and proceeded to the proximal margin. The Ba/Ca ratios along this transect were plotted for each specimen. For the Oregon specimens Ba/Ca signature fluctuations appeared consistent with annuli in most but not all cases. Analysis of the Ba/Ca oscillations was not as straightforward as expected. Therefore, further studies need to be done to evaluate the usefulness of otolith chemistry as a tool for developing ageing criteria for eulachon.

Estimation of Ageing Bias Using Bomb Radiocarbon $\Delta^{14}C$ Signatures in Fish Otoliths: Beyond Plot and Cluck

Thomas E. Helser and Craig Kastelle

NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way, NE., Seattle, WA

Abstract

Atomic bomb testing during the 1950s and 1960s produced atmospheric radiocarbon, which after a slight delayed response, diffused into the marine environment and became incorporated into fish otoliths alive during that time. In recent years, measured bomb-produced radiocarbon ($\Delta^{14}C$) was developed as an age validation tool which compares the $\Delta^{14}C$ signature from test specimens to the $\Delta^{14}C$ of known age fish (reference chronology). To date, calcium carbonate structures in dozens of animals across different taxa have been measured for $\Delta^{14}C$, but only a handful of true reference chronologies have been developed with which to compare the $\Delta^{14}C$ signatures. In addition, a variety of statistical models and methods have been proposed to describe the functional form of radiocarbon chronologies and provide a quantitative means to compare them. However, none have been completely satisfactory in quantifying ageing bias and its uncertainty. We developed a multi-level Bayesian model and used Markov Chain Monte Carlo Simulation to estimate parameters of different functional response models and to derive a statistical framework for hypothesis tests concerning ageing bias. The model incorporates both observation and process errors and provides framework to estimate the probability of ageing bias overall from a given sample but also the probability conditional on the animal's age. Results presented are based on a comparison of canary rockfish (*Sebastes pinniger*) and Pacific Ocean perch (*Sebastes alutus*) $\Delta^{14}C$ data to the Gulf of Alaska halibut reference chronology. Canary rockfish showed a high probability of being under aged with as high as a 95% probability that under aging was occurring by as much as 6 years. In contrast, the mean ageing bias for Pacific Ocean perch was +1.4 years but considerable density of the marginal posterior encompassed zero suggesting the evidence was weak to conclude any bias. Finally, we extended the complexity of the Bayesian model by incorporating over a dozen different $\Delta^{14}C$ chronologies from California to the Gulf of Alaska into a hierarchically structured model and tested for the effects of different oceanographic factors on the functional response of the radiometric curves. The index of ocean upwelling was negatively related to the overall magnitude of ^{14}C measured in calcified structures of marine animals while the parameter commonly used to test bias was weakly positively correlated. This suggests the potential for age bias interpretations to be confounded when $\Delta^{14}C$ test samples are compared to reference chronologies derived from different oceanographic regions.

Use of the stable oxygen isotope, ^{18}O, in otoliths as an indicator of fish life history events and age validation

Craig Kastelle[a], Tom Helser[a], Jennifer McKay[b], Delsa Anderl[a], Beth Matta[a], Chris Collins-Larsen[c], Sukyung Kang[d]

[a]Alaska Fisheries Science Center, USA
[b]Oregon State University, USA
[c]University of Washington, USA
[d]National Fisheries Research and Development Institute, Republic of Korea

Abstract

The isotopic or elemental content of otoliths provides a view into the life history of fish. The stable oxygen isotope (^{18}O) in seawater is thought to be in equilibrium with marine calcium carbonate ($CaC0^3$) structures such as otoliths. We applied the principle that $\delta^{18}O$ variability in marine $CaC0^3$ is inversely related to water temperature. This presentation is an overview of what can be learned by microsampling otoliths and

measuring $\delta^{18}O$ by mass spectrometry. We analyzed $\delta^{18}O$ from three species of fish from three regions in the North Pacific: Pacific cod (*Gadus macrocephalus*) from the Eastern Bering Sea, saffron cod (*Eleginus gracilis*) from the Chukchi Sea, and small yellow croaker (*Larimichthys polyactis*) from the Yellow Sea. Up to 10 microsamples were extracted from any one year's otolith deposition, and up to 42 microsamples from a 5 year old otolith, representing the life history of the fish. We confirmed the relationship between water temperature and $\delta^{18}O$ in the otoliths ($r^2 = 0.74$) using otoliths with a known temperature history. In the larger body of our study, we saw evidence of seasonal temperature fluctuations, ontogenetic migrations, and possibly a tool to investigate temperature trends over time. In exploited populations of Pacific cod, the life-history $\delta^{18}O$ signal provided a method of developing a more accurate age reading criteria and an age validation. A comparison between Pacific cod and saffron cod $\delta^{18}O$ signals indicated different life history strategies in terms of temperature preference and possibly differences in habitat usage.

Incorporation of bomb-produced ^{14}C into fish otoliths. An example of basin-specific rates from the North Pacific Ocean

Stephen G. Wischniowski[1], Craig R. Kastelle[3], Timothy Loher[2], and Thomas E. Helser[3]

[1]Sclerochronology Laboratory, Fisheries & Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, B.C. Canada V9T 6N7
[2]International Pacific Halibut Commission, 2320 West Commodore Way, Suite 300, Seattle, WA 98199, U.S.A.
[3]National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way, Seattle, WA 98115, U.S.A.

Abstract
Sagittal otoliths from juvenile Pacific halibut (*Hippoglossus stenolepis*) of known age were used to create a bomb-produced radiocarbon reference chronology for the eastern Bering Sea (EBS) by fitting a coupled-function model to $\Delta^{14}C$ values from each specimen's birth year. The newly-created EBS reference chronology was then compared to a reference chronology previously created for Pacific halibut from the Gulf of Alaska (GOA). Adult Pacific halibut age-validation samples from the EBS were also analyzed for ^{14}C and modeled to validate age- estimation accuracy. A Bayesian model was developed and Markov Chain Monte Carlo simulation was used to estimate model parameters and adult Pacific halibut ageing bias. Differences in reference chronologies between ocean basins were reflected in large (deviance information criterion) (ΔDIC) between models, supporting the hypothesis that two separate coupled-function models were required to adequately describe the data, one each for the EBS and GOA. We determined that regionally specific GOA and EBS oceanography plays a considerable role in the $\Delta^{14}C$ values, and must be taken into consideration when selecting a reference chronology for bomb-produced ^{14}C age-validation studies. The age-validation samples indicated that the current ageing methodology used in Pacific halibut assessments is accurate and has provided accurate age assignments for Pacific halibut in the EBS.

Assessing yearly growth increment criteria used to assign ages for groundfish at the Alaska Department of Fish and Game Age Determination Unit using bomb radiocarbon

Kevin McNeel, Alaska Department of Fish and Game, Age Determination Unit (ADU), Juneau, Alaska

Abstract

To address the accuracy of yearly increment assignment, the Alaska Department of Fish and Game Age Determination Unit (ADU) has directed, collaborated on, and participated in several age validation studies. Published validations have addressed many high profile teleosts, but direct or indirect age validation should be conducted on all species and criteria. Rises in atmospheric ^{14}C due to atomic bomb testing between 1950 and 1960, and otolith reference curves have proven useful for estimating the birth year from otolith core samples (targeting the first year of growth). Predicted and estimated birth years can be compared to validate yearly increment criteria or suggest biases. To address unvalidated criteria and concerns regarding age estimation criteria at the ADU, approximately 220 otolith cores (representing 23 groundfish species) were sent to the Lawrence Livermore National Laboratory to be processed for carbon isotope concentrations using accelerator mass spectrometry. Otoliths were selected based on availability of known-age specimens and estimated birth years between 1958 and 1965. Corrected ^{14}C fractions for each otolith core along with the expected year at age 1 (using increment counts) were compared with known age and validated reference $\Delta^{14}C$ curves to validate age criteria, identify biases between estimated and expected ages, or highlight future research needs. Preliminary analysis shows that tested values follow trends established by reference curves and suggest that some species need further studies. These findings also stress the need to target specimens between optimal birth years and providing adequate samples to target rises in $\Delta^{14}C$ values.

Using otolith measurements to refine quality control procedures

Kristin Politano, Kevin McNeel, April Rebert; Alaska Department of Fish and Game, ADU, Juneau, AK

Abstract

Age data quality control is typically done utilizing somatic length at age correlations. For many of the species aged by the Alaska Department of Fish and Game Age Determination Unit (ADU), however, the relationship between somatic length and age is asymptotic. Therefore, as long-lived fishes get older, length is no longer a reliable proxy for age. To improve quality control procedures, we examined the relationship between age and otolith length, weight, and height for groundfish and developed a protocol to test for outlying age estimates. Our initial analysis revealed a continual change in otolith weight at age after fish reached L_∞ in sablefish (*Anoplopoma fimbria)*, yelloweye rockfish (*Sebastese ruberrimus*), rougheye rockfish (*S. aleutianus*), shortraker rockfish (*S. borealis)*, and lingcod (*Ophiodon elongatus*), suggesting it may be an appropriate parameter for use in quality control procedures. To establish a protocol for identifying outlying age estimates, data were modeled with otolith weight and somatic length using sigmoidal or exponential regression. An expected otolith weight and somatic length range for a given age and species was established using predicted mean and standard deviation. Models for a given species were separated by geographic location and gender given adequate sample size. After evaluating the models with a separate set of age data, mean ± 2SD was indicated as a reasonable cut off for the detection of gross outliers. The utility and feasibility of incorporating this process into age production needs to be evaluated, and more complex models should be tested. However, otolith weight has proven useful in improving data quality at the ADU and our findings support the further use and analysis of otolith morphometrics in a production setting to refine data quality control and identify unique or difficult growth patterns that may have been previously misidentified.

Poster Abstracts

A 200 year archeozoological record of Pacific cod life history as revealed through Ion Microprobe oxygen isotope ratios in otoliths

Thomas E. Helser[1](presenter), Craig Kastelle[1], John Valley[2], Aron L. Crowell[3], Ian Orland[2], Reinhard Kozdon[2], and Takayuki Ushikubo[4]

[1]Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way N.E., Seattle, WA
[2]WiscSIMS Laboratory, Department of Geoscience, University of Wisconsin, Madison, WI
[3] Arctic Studies Center, Department of Anthropology, National Museum of Natural History, Smithsonian Institution, 121 West Seventh Avenue, Anchorage, AK
[4] WiscSIMS Laboratory and Kochi Institute for Core Sample Research, JAMSTEC, 200 Monobe-otsu, Nankoku, Kochi 783-8502 Japan

Abstract
Fish otolith oxygen isotope ratios ($\delta^{18}O$) are considered “flight recorders,” providing records of sea water temperature and habitat use over the animal’s life span.
We measured $\delta^{18}O$ values in modern and archeological Pacific cod otoliths using a high precision ion microprobe. Values of $\delta^{18}O$ were measured in as many as eighty 10-micron spots along transects from the otolith core to its margin with high spot-to-spot analytical precision ($\delta^{18}O$ ±0.3‰). We obtained sample densities along a linear transect that were at least 2 to 3 times greater than micromilling/conventional mass spectrometry techniques. From modern Pacific cod otoliths (using *in situ* temperatures from electronic archive tags) we calibrated the fractionation equation of aragonite ($r^2 = 0.75$, $p<0.001$, $\delta^{18}O_A = 2.13 - 0.25T^oC$) to predict sea water temperature. Sinuous variability of $\delta^{18}O$ values along core-to-margin transects likely reflect seasonal temperature changes and suggest similar longevity between modern and archeological cod. Generally increasing $\delta^{18}O$ values from the otolith core to the margin revealed an ontogenetic migration from warmer near shore habitat during the first year of life to cooler deeper waters at later ages, a behavior that has not changed over the past 200 years. A decline in the average $\delta^{18}O$ of core spot samples from archeological (200+, 100+ YBP) to modern otoliths suggest increasing sea surface temperatures from the late Little Ice Age to present. Temperatures calculated from the $\delta^{18}O$ in aragonite suggest a 2-3^{o}C rise in coastal marine sea surface temperatures in the Gulf of Alaska over the last 200 years.

Modeling Environmental Factors Affecting Assimilation of Bomb-produced $\Delta^{14}C$ **in the North Pacific Ocean: Implications for age validation studies**

Thomas E. Helser[1](presenter), Craig R. Kastelle[1], and Han-lin Lai[2]

[1]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, 7600 Sand Point Way, Seattle, WA 98115, U.S.A.
[2]Office of Science and Technology, National Marine Fisheries Service, National Oceanic and Atmospheric Administration,1315 East West Highway, Silver Spring, MD 20901 U.S.A

Abstract
The bomb radiocarbon ^{14}C chronometer has become the gold standard for assessing the accuracy of age estimates of fish based on otolith growth rings. In the northeast Pacific Ocean, nearly a dozen age validation studies have been conducted, ranging from California to Alaska, most of which have relied on a single reference chronology from the Gulf of Alaska. As such, it seems quite likely that oceanographic factors affecting the uptake and assimilation of ^{14}C in marine carbonates can lead to a misinterpretation of age determination error when the test samples and reference curve are not from the same region. To explore this possibility, we developed a hierarchical Bayesian meta-analysis using bomb-produced

radiocarbon from data sets in the northeast Pacific Ocean. We investigated whether latitude and upwelling exerts an influence on the parameters that describe the rapid radiocarbon $\Delta^{14}C$ increase in marine calcium carbonates. Models incorporating both latitude and upwelling as linear covariates of a 4-parameter logistic model were favored based on ∆DIC statistics. There was substantial evidence to support that the timing of the $\Delta^{14}C$ pulse was advanced and that total $\Delta^{14}C$ uptake increased with increasing latitude. In contrast, increased oceanographic upwelling resulted in lower total radiocarbon input as well as a delay in the timing of the pulse curve, as is characteristic of the upwelling dominated California Current System. The Gulf of Alaska appears to be more tightly coupled to atmospheric radiocarbon input with greater surface mixing, and less upwelling, than other regions in the northeast Pacific, resulting in earlier timing of $\Delta^{14}C$ rise and greater total radiocarbon input into the marine environment.

Age validation of Pacific cod (*Gadus macorcephalus*) using high resolution stable oxygen isotope ($\delta^{18}O$) signatures in otoliths

Craig R. Kastelle[1](presenter), Thomas E. Helser[1], Jennifer McKay[2], Chris G. Johnston[3], Delsa M. Anderl[1], and Mary E. Matta[1].

[1]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way, Seattle, WA
[2] College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR
[3] International Pacific Halibut Commission, 2320 West Commodore Way, Suite 300, Seattle, WA

Abstract
Pacific cod (Gadus macrocephalus) is the second most important fishery in the North Pacific. However, Pacific cod age determination has historically been difficult, so uncertainty may exist in biological reference points. To address ageing inaccuracy, we conducted an age validation study using the stable isotope 18O (δ18O). This approach is based upon the principle that variability in marine carbonate δ18O is inversely related to water temperature, and thus seasonal changes in temperature would be reflected in otolith δ18O values. We sequentially microsampled Pacific cod otoliths, from the core to the margin, to measure 18O (δ18O). This provided up to ten δ18O measurements per posited annual growth zone, and approached 45 sequential samples per specimen. We developed individual life history signatures of δ18O from 40 Pacific cod otoliths with estimated ages of 2 to 5 years. Our goals were to identify the annual seasonal variation (cyclical pattern of otolith δ18O values) and determine if the number of δ18O maxima and minima was consistent with the age derived from growth zone counts. We also estimated the probability of age reading bias by treating the number of δ18O maxima and minima as an indication of “true fish age.” The relationship between δ18O in Pacific cod otoliths and known water temperature was also independently verified (r2 = 0.74). Age reading bias in specimens from ages 2 to 5 was, on average, estimated to be relatively small. The probability of an age reader assigning an age based on visual growth zone counts equal to the true age was approximately 64%, whereas the probabilities of assigning an age greater to or less than the true age by one year were approximately 19% and 17%, respectively. However, there did appear to be an age-specific bias at age 5; the probability density was non-symmetric and indicated a probability of assigning the true age was 49%, with a 51% probability of under-ageing true age by one or more years.

What to do when dogfish lie about their age?

Cindy A. Tribuzio[1](presenter), Beth Matta[2], Chris Gburski[2], Cal Blood[3], Walter Bubley[4], Gordon H. Kruse[5], William Bechtol[6]

[1]Auke Bay Laboratories, AFSC, NMFS, Juneau, Alaska

[2]Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way N.E., Seattle, WA
[3]Resource Ecology and Fisheries Management, AFSC, NMFS, Seattle, Washington
[4]South Carolina Department of Natural Resources, Marine Resources Research Institute, Charleston, SC
[5]School of Fisheries and Ocean Sciences, UAF, Juneau, Alaska, USA
[6]Bechtol Research, Homer, Alaska, USA

Abstract
Historical methods for ageing spiny dogfish (*Squalus suckleyi*) result in low precision of age estimates, particularly for older fish exhibiting spine erosion, prompting a search for improved methods of ageing. Spiny dogfish were aged by historical methods and by a new method involving vertebral thin sections obtained from the same specimens. We estimated inter-reader precision and variance associated with each structure. The two structures yielded similar ages for younger animals but not for older animals. Similar to other ageing structures, individual variability can impact thin section quality, particularly in larger older animals. Each method has advantages and disadvantages. The fin spine method was validated previously by both oxytetracycline and bomb radio carbon dating, but between-reader agreement is poor. Moreover, worn or broken fin spines require another step, where lost annuli are estimated through regression methods, which introduce an additional source of error into age estimation. In comparison, the vertebral thin section method substantially improved between-reader agreement and does not require the additional regression step, but processing of vertebrae is time consuming, the quality of the thin section impacts the age estimates, and validation of ages for larger animals has not yet been realized. In summary, the vertebrae thin section method is promising, but more work is required to examine individual variability in thin sections (i.e. quality) and ages need to be compared among the two methods from a larger sample size of large, old fish that have been age validated by bomb radio carbon dating.

Bomb Dating and Age Estimates of Big Skate (*Beringraja binoculata*) and Longnose Skate (*Raja rhina*)

Jacquelynne King[1], Thomas Helser[2], Christopher Gburski[2] (presenter), David Ebert[3], Craig Kastelle[2], and Gregor Cailliet[3]

[1] Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, V9T6N7, Canada
[2]Alaska Fisheries Science Center, Age and Growth Program, Seattle, WA, 98115, USA
[3]Pacific Shark Research Center, Moss Landing Marine Laboratories, Moss Landing, CA, 95039, USA

Abstract
Age and growth curve estimates have been produced for big skate (*Beringraja binoculata* [formerly *Raja binoculata*]) and longnose skate (*Raja rhina*) populations in the Gulf of Alaska, British Columbia and California. Age estimation for these two skate species relies on growth band counts of sectioned vertebrae. However these studies have not produced similar results for either species, highlighting the need for age validation. Archived large specimens of big skate and longnose skate collected in 1980 and 1981 had minimum age estimates old enough to suggest that radiocarbon (14C) signals from bomb testing conducted in the late-1960s could be used to establish dates of growth band formation. Accelerator mass spectrometry provided measures of Δ14C associated with a year of growth band formation based on skate age estimates. We used Bayesian statistics to compare these values to reference Δ14C a marine teleost otolith chronology produced that exists for California.

Changes in Pacific cod otolith weight over time

Rob Dinneford (presenter) and Kristin Politano

Alaska Department of Fish & Game, Age Determination Unit, Juneau, AK

Abstract
Variability of otolith weight over time merits attention as otolith measurements including weight are used in quality control procedures, specimen verification, and age studies at the Alaska Department of Fish & Game's Age Determination Unit. Sagittal otoliths of Pacific cod (Gadus macrocephalus) have a relatively high surface area to weight ratio, and are likely to highlight trends in otolith weight variability. Weekly weight measures were taken from 84 dry stored P. cod otoliths for 31 – 46 weeks on and following extraction days. Scale performance and environmental conditions including ambient temperature, in-situ temperature & humidity, were also examined. Week of measurement and environmental conditions show slight significance with otolith weight within observed weight variance; however scale performance also possibly accounts for 4% to 86% of observed variation (scale sd = 0.00037 g). Otolith weights universally decreased between 1.1% and 1.9% from extraction days to the following week over a range of 0.0041 – 0.0111 g. Samples' otolith weight varied from sd = 0.0006 g (CV = 0.10% for data set without extraction day) to sd = 0.0015 g (CV = 0.28% for data sets including extraction day). Results suggest most otolith weights are stable (excluding extraction week measures), yet small-scale variations over time and conditions should be considered in pertinent models &etc. Analyses & reporting should be limited to 0.001 g to account for scale variance beyond this resolution. Sagittal otoliths for other species and size ranges should be analyzed to see if results are similar.

Re-ageing of archived otoliths from the 1920s to the 1990s

Joan E. Forsberg (presenter) and Ian J. Stewart
International Pacific Halibut Commission, 2320 W. Commodore Way, Seattle, WA 98199

Abstract
The International Pacific Halibut Commission has collected otoliths for age determination since 1925. After otoliths are aged, they are stored and archived. The Commission's otolith collection contains samples from over 1.6 million halibut. Age determination techniques used for halibut have changed over time; prior to 1992, all otoliths were surface aged. Beginning in 1992, otoliths that met certain criteria (high surface age, difficult pattern, etc.) were also aged by break-and-burn or break-and-bake method in addition to surface aging. The break-and-burn/bake method was determined to provide more accurate ages. Therefore beginning in 2002, all otoliths collected from setline surveys or the commercial catch were aged by break-and-bake. To provide information on the bias and imprecision of historical surface ages relative to age data from the 1990s onward, subsets of otoliths from each decade from the 1920s to the 1980s were re-aged by both the surface and break-and-bake technique and original surface ages were compared to the ages made in 2014. Additionally, systematic subsamples of otoliths collected in 1992, 1993, and 1998 that were previously only surface-aged were re-aged by break-and-bake and included in this analysis. Results indicated that historical samples contained very few fish aged older than 15 years by either method. Based on simultaneous estimation of bias and imprecision for up to four unique ages per otolith, the properties of historical surface ageing methods were found to be very similar to current methods, becoming increasingly biased and imprecise beyond 15 years.

Preparing baked thick sections of Pacific halibut otoliths

Chris Johnston

International Pacific Halibut Commission, 2320 W. Commodore Way, Seattle, WA 98199

Abstract

Halibut otoliths from several different collection years were selected for an increment study looking at changes in size at age. Measurements were made on baked transverse “thick” sections of blind-side sagittal otoliths. The procedure for preparing baked thick sections is described. The posterior end of the otolith was the preferred end to bake since it leaves the anterior end for surface reading. Some otoliths had already been aged by break-and-bake technique while others had only been surface-aged. Previously-baked otolith halves were cut about 1.5 to 2 mm below the reading surface and mounted onto individual glass slides, reading surface facing up, and polished. Whole otoliths were cut transversely either side of the 1st year, baked for 10 minutes at 500° F then mounted anterior end up on individual glass slides. The sections were then polished down to expose the nucleus using the polishing procedure described above. Polishing progress was monitored using a stereomicroscope. Polished sections were submerged in water to eliminate glare and photographed under 12X to 25X magnification.

APPENDIX-V

Reducing Ergonomic Risks in Laboratories

Employee education and training is essential for prevention of laboratory injuries. Workers should have a basic understanding of ergonomic principles, and be able to recognize risk factors symptoms. The design of the job itself (work/rest schedules, job rotation), work tools and the workstation (dimension/layout) also has a direct impact on the risk of injury. Incorporating ergonomic principles into the design of laboratory tools and workstations, and reviewing work processes to maximize efficiencies can help prevent work related injuries. Periodic review of the work environment, tools and procedures helps to assure that necessary modifications are made as processes change.

Laboratory Checklist

This document will help you identify risk factors associated with laboratory environments. Designed for use by both safety specialists and laboratory workers, the checklist also includes information to help eliminate or reduce identified risks.

How to Use the Checklist

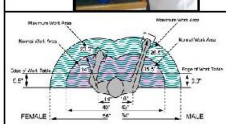
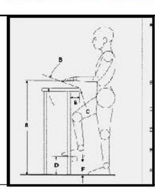
Step One: If you work with a safety specialist or safety committee, see if the following information if available for your laboratory: (1) list of musculoskeletal injuries; and (2) worker complaints or concerns about performing specific tasks.

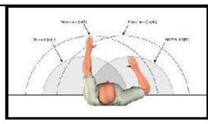
Step Two: Contact the workers and supervisor and discuss the purpose for performing the ergonomic survey. Ask the supervisors and workers if there are any issues or concerns that they have regarding laboratory work tasks.

Step Three: Complete the Laboratory Checklist for the tasks being completed in the laboratory. Answer N/A if the question does not apply to the task.
Include all meaningful comments for each area.

Step Four: *Each "NO" answer indicates a risk of injury or sub-optimal condition.* For each "NO" answer, concerning changes or modifications to the workstation or task to result in a yes response. When considering changes, obtain input from the workers, supervisors, and other safety specialists if available. Whenever possible, evaluate equipment before making purchases and before modifying the work areas or tasks. This process will help increase product acceptance, test product usability, and durability, and take advantage of worker experience.

Laboratory Ergonomics Checklist

		Yes	No	Change/Modification	Comments
	Standing Bench				
	1. Is the height of the bench appropriate for the work performed? a. Work can be positioned close to elbow height (~ 36-40") b. Work can be performed with shoulders relaxed	☐	☐	☐ Adjustable height benches ☐ Adjustable chair ☐ Temporary standing platforms ☐ Move the task to a seated bench with adjustable chair	
	2. Are primary work tools and supplies located within arm's reach (4-18") from table edge?	☐	☐	☐ Reposition tools and supplies within 18" distance ☐ Provide tool organizers, turntable workstations, turntables, storage bins, pipette holders and carousels	
	3. Is there knee and foot clearance when completing standing tasks in front of the bench? a. 4" deep knee clearance b. 4" high and 4"deep foot clearance	☐	☐	☐ Work at open bench cut outs ☐ Remove supplies and equipment from bench cut out areas ☐ Modify bench surface with clamp on cut out extensions to increase knee and foot clearance	
	4. Is a foot rail or prop available (6" from floor)	☐	☐	☐ Install rails or foot props ☐ Use footrest ☐ If bench has undersurface cabinet, open or remove door and place foot on lower shelf	
	5. Are there floor mats in areas where prolonged standing tasks are completed?	☐	☐	☐ Provide floor mats ☐ Use cushioned shoes and in-soles	

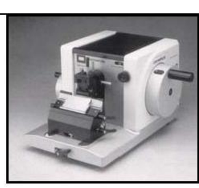
		Yes	No	Change/Modification	Comments
	6. Does the bench have rounded or padded edges to reduce contact stress?	☐	☐	☐ Add edge rests and protectors to eliminate sharp edges ☐ Use gel pads on surface to protect elbows ☐ Wear custom padded sleeves under lab coat	
	7. Is standing bench available for tasks requiring frequent movement between workstations?	☐	☐	☐ Redesign work to reduce movement between stations to optimize workflow	
	Seated Bench				
	8. Are bench cutouts available for seated workers? a. Minimum 15" depth b. Minimum 20" width	☐	☐	☐ Redesign benches to provide cut-outs for seated work ☐ Provide sit-stand chairs to improve knee clearance when working ☐ Clear out cutouts if cluttered with supplies or equipment	
	9. Are work items within close reach? a. Maximum 24"	☐	☐	☐ Reposition tools and supplies within 24" distance ☐ Provide tool organizers, turntable workstations, turntables, storage bins, pipette holders and carousels	
	10. Is seated bench available for tasks requiring precision and close inspection?	☐	☐	☐ Provide arm supports for stability if not available ☐ Provide sit-stand stools ☐ Provide adjustable work platforms to position work at optimal height	
	Laboratory Chairs				

		Yes	No	Change/Modification	Comments
	11. Can the laboratory chairs be adjusted to accommodate all workers? a. Seat height appropriate for work at height of benches? b. Feet supported on floor, ring or footrest?	☐	☐	☐ Provide chairs with adjustable height and angle seats and backrests ☐ Provide chairs with foot rings ☐ Provide footrests	
	12. Are armrests adjustable or removable if they interfere with work?	☐	☐	☐ Adjust armrests to provide support with shoulders in neutral postures ☐ Remove armrests	
	13. Are appropriate footrests or footrings provided?	☐	☐	☐ Provide industrial footrest ☐ Install foot ring on chair ☐ Install rail or platform	
	14. Do employees know how to adjust chairs?	☐	☐	☐ Train employees to adjust chair	
	Microscopes				
	15. Can employees view the eyepiece with neutral neck, shoulder and back postures? (Neck flexion < 25°, shoulders relaxed, back upright and supported by chair?)	☐	☐	☐ Reposition microscope ☐ Adjust height ☐ Adjust angle ☐ Reposition worker ☐ Adjust posture ☐ Adjust seat height ☐ Adjust seat angle ☐ use arm support/pad	

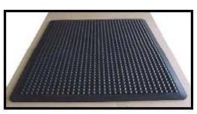
		Yes	No	Change/Modification	Comments
	16. Is the microscope positioned within easy reach of the worker? (Generally close to the edge of the workbench)	☐	☐	☐ Reposition microscope ☐ Move closer to front of counter ☐ Reposition worker ☐ Adjust posture ☐ Sit closer to bench	
	17. Can the microscope be positioned to promote neutral head, neck, shoulders and arm postures when used?	☐	☐	☐ Reposition microscope ☐ Use microscope adapters ☐ Positioning plate ☐ Ergo adapter ☐ Scopease ☐ Optical wedge ☐ Extended eyetube ☐ Eyepiece adapter ☐ Use video system	
	18. Are arms supported by worksurface, chair armrests, or pads for prolonged work?	☐	☐	☐ Use arm supports ☐ Use pads ☐ Adjust armrests ☐ Adjust worker position	
	19. Can the worker use the microscope controls with arms supported and relaxed?	☐	☐	☐ Reposition microscope ☐ Use microscope adapters ☐ Use arm supports/pads ☐ Adjust armrests ☐ Adjust worker position	
	20. Is there sufficient legroom and foot support when using the microscope?	☐	☐	☐ Work at bench cut-out ☐ Clear cut-out of clutter ☐ Provide footrest ☐ Provide foot ring	
	21. Are microscope work breaks provided?	☐	☐	☐ Institute work rotation ☐ Institute work breaks	

		Yes	No	Change/Modification	Comments
	Pipettes				
	22. Is manual pipette use limited to less than 4 hours per day?	☐	☐	☐ Institute work rotation ☐ Institute work breaks ☐ Consider use of alternative pipettes	
	23. If pipette use is more than 4 hours per day, are multi-channel, electronic or latch mode pipettes available?	☐	☐	☐ Evaluate use of alternative pipettes ☐ Electronic ☐ Latch-mode ☐ Multi-channel	
	24. Have employees been trained to select appropriate pipettes for pipetting task?	☐	☐	☐ Employee training	
 	25. Are racks, trays, beakers and supplies available and placed within easy reach?	☐	☐	☐ Provide racks and trays ☐ Position supplies within close reach ☐ Use pipette racks and organizers	
	26. Are vials, tubes and receptacles as low profile as possible?	☐	☐	☐ Provide short beakers and vials ☐ Provide short tips and tubes ☐ provide short/angled waste receptacles	

		Yes	No	Change/Modification	Comments
	27. Do workers pipette with shoulders relaxed, and arms and wrists in neutral postures?	☐	☐	☐ Employee posture training ☐ Adjust work position ☐ Adjust workstation set-up	
	28. Are rest breaks provided?	☐	☐	☐ provide work breaks or work rotation	
	Micromanipulation				
	29. If forceps are used for prolonged periods, are locking mechanisms, o-rings or other adapted aides used to reduce prolonged or static pinch forces?	☐	☐	☐ Provide adapted tweezers/forceps ☐ O-rings ☐ Pads/foam grips ☐ Self-closing ☐ Low force tools ☐ Alternate fingers/hands	
	30. Are vials easy to cap and thread?	☐	☐	☐ Provide easy opening caps ☐ Provide vials with minimal number of threads	
 	31. Are cap openers available?	☐	☐	☐ Provide decapping tools	
	32. Are clamps and holders available to support test tubes and other materials that must be help for prolonged periods?	☐	☐	☐ Provide vial clamps ☐ Provide racks, holders, shelves, or organizers	

		Yes	No	Change/Modification	Comments
	Microtome/Cryostat				
	33. Can workers operate the microtome with hands in a pistol grip position? (Wrist aligned with forearm and in handshake position)	☐	☐	☐ Re-position worker ☐ Re-position height, angle or position of microtome ☐ Employee training in work postures ☐ Use foot operated controls ☐ Modify handle position	
	34. Is equipment placed in a bench cut out allowing for adequate leg and knee clearance?	☐	☐	☐ Work at bench cut-out ☐ Clear area around microtome/cryostat of obstacles	
	35. Is an adjustable chair available at the microtome or cryostat that provides back and foot support?	☐	☐	☐ Provide adjustable chair ☐ Provide chair with head support if working in reclined position ☐ Consider mirror system to improve view of samples	
	36. Do employees have access to a motorized microtome/cryostat for high intensity/volume work?	☐	☐	☐ Consider electronic cryostat for high volume workloads	
	Laboratory Hoods and Biosafety				

		Yes	No	Change/Modification	Comments
	Cabinets				
	37. Is leg, knee clearance available to promote neutral sitting postures when using the hood or cabinet?	☐	☐	☐ Clear knee area under cabinet or hood ☐ Use sit/stand stool	
	38. Can workers work with shoulders relaxed when sitting or standing?	☐	☐	☐ Consider height adjustable hood or cabinet ☐ Use height adjustable stool/chair	
	39. Is padding available to reduce soft tissue compression (edge padding or arm pads)?	☐	☐	☐ Use elbow pads ☐ Use edge padding ☐ Use arm supports	
	40. Are materials inside the hoods and cabinets as close as possible to the worker to avoid over-reaching?	☐	☐	☐ Position receptacles within close reach ☐ Use turntables, rotating organizers, angled platforms	

		Yes	No	Change/Modification	Comments
	41. Are vials, tubes and receptacles as low profile as possible?	☐	☐	☐ Provide low profile vials, tubes and receptacles ☐ Angle receptacles to position within closer reach	
	42. Are anti-fatigue mats used if employees stand for more than 4 hours per day?	☐	☐	☐ Provide anti-fatigue mats ☐ Provide foam insoles for shoes ☐ Provide supportive shoes	
	Miscellaneous				
 	43. Are bottle dispensers and bottom dispensing carboys available to dispense liquids?	☐	☐	☐ Provide bottle dispensers ☐ Provide bottom dispensing carboys ☐ Provide bottles with handles	
	44. Is there adequate and approprpriate storage for supplies? a. Is sufficient space available for supplies? b. Are heavy bottles and boxes stored on low shelves?	☐	☐	☐ Provide storage for supplies ☐ Place heavy items on shelves between knees and chest level	

		Yes	No	Change/Modification	Comments
	45. Are cut-outs clear of storage and available for use?	☐	☐	☐ Clear cut-outs of clutter ☐ Provide cut-out areas for working at bench using work surface cut-outs or platforms	
	46. Are jars easy to open or are jar openers available?	☐	☐	☐ Provide jar openers	
	47. Are temporary platforms available for tasks that require elevting arms above chest level for prolonged periods?	☐	☐	☐ Consider standing platforms or elevated work areas (Consider safety issues and reduce fall risks before using)	
	48. Are there adequate bins and racks for frequently used items?	☐	☐	☐ Provide bins, racks and shelves for frequently used items	