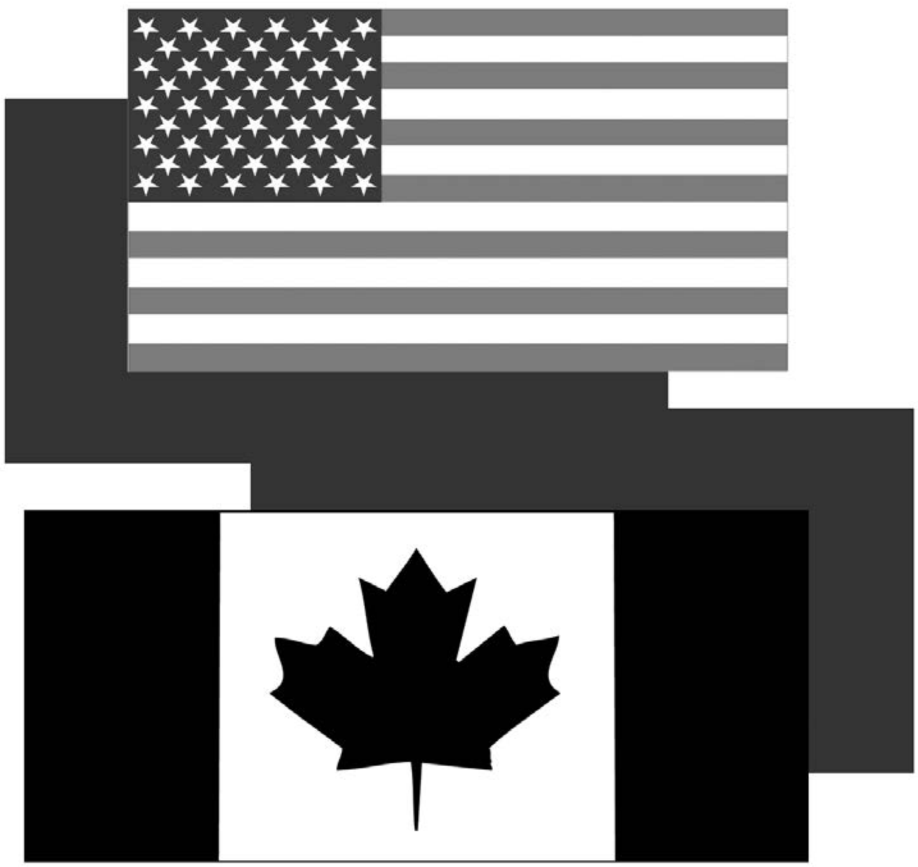
# Report of the Technical Subcommittee
# of the
# Canada-United States Groundfish Committee

## 57th Annual Meeting of the TSC

## April 26-27, 2016
## Newport, Oregon



**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, Visual Survey Methods and Developing Electronic Data Capture Systems.

***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.

October 24, 2016

## B. Executive Summary

The TSC met April 26-27, 2016 in Newport, Oregon. This year's meeting was hosted by the Oregon Department of Fish and Wildlife (list of attendees is included in the minutes). The meeting was chaired by Lynne Yamanaka, Department of Fisheries and Oceans, Canada. As is done each year at the meeting, participants review previous year (2015) research achievements and projected current year (2016) 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 discussed some few ideas for future workshops including: rockfish descenders, updates on rockfish conservation measures (ESA, SARA listing) and stock rebuilding plans, impacts of spatial management measures (MPAs and sanctuaries) on surveys and assessments (or vice versa) but no consensus was reached. Organizing another surveys workshop was also discussed but TSC members felt that when current research on selectivity and catchability become available, it might be a better time for a workshop.

Other important topics discussed at the meeting included: 1) The Maturity Assessment and Reproductive Variability of Life Stage (MARVLS) workshop was discussed and TSC members that attended reported the great work on maturities being done together with the sharing of information and samples between State agencies, IPHC, and NWFSC. Participants identified a need for cross-validation of maturity stages, similar to issues associated with age reading. The TSC is encouraged by the MARVLS initiative and supports wider invitations from MARVLS to all TSC agencies; and 2) The TSC initiated a working group on groundfish tagging data which will be led by Jon Heifetz (AFSC). TSC requests cooperation in this regard among all member agencies and hence will be included in the 2016 Letter to Supervisors. Of particular interest is the exchange of Sablefish tagging data for use in a potential coastwide Sablefish assessment conducted jointly by US State agencies, NMFS, and Canada.

Lynne Yamanaka will remain the Chair of the TSC for another year. The next TSC meeting will be held April 25-26, 2017 in Juneau, Alaska and hosted by Jon Heifetz, AFSC, Auke Bay Lab.

**Minutes**
**Fifty Seventh Annual Meeting of the Technical Subcommittee (TSC) of the Canada-U.S. Groundfish Committee**
**April 26-27, 2016**

Guin Library, Hatfield Marine Science Centre
Newport, Oregon

**Tuesday, April 26**

**I.** Call to Order: Lynne Yamanaka, Chair, called the meeting to order at 8:35 am

**II.** **Appointment of Secretary:** Alison Whitman (meeting host) and Peter Frey volunteered to take notes. The chair thanks them for acting as rapporteurs.

**III.** **Emergency preparedness:** Alison Whitman provided an orientation of the facility and explained building egress and muster stations. Alison also provided information on coffee breaks and meals.

**IV.** **Introduction of participants:** Reports were made available online before the meeting or provided at the meeting, including the 2015 TSC meeting report and the 2015 reports from the Alaska Department of Fish and Game (ADFG), Alaska Fisheries Science Center (AFSC), Fisheries and Oceans Canada (DFO), International Pacific Halibut Commission (IPHC), Washington Department of Fish and Wildlife (WDFW), Northwest Fisheries Science Center (NWFSC), Oregon Department of Fish and Wildlife (ODFW), Southwest Fisheries Science Center (SWFSC), and the Committee of Age Reading Experts (CARE). TSC members and guests introduced themselves.

**V.** **List of Participants**

Lara Erikson, International Pacific Halibut Commission, Seattle, WA, (Lara@iphc.int)

Kari Fenske, Washington Department of Fish and Wildlife, Olympia, WA, (Kari.Fenske@dfw.sa.gov) moved to AFSC in late September 2016.

Peter Frey, Northwest Fisheries Science Centre, Seattle, WA, (Peter.Frey@noaa.gov)

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

Anna Henry, International Pacific Halibut Commission, Seattle, WA, (Anna@iphc.int)

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

Andrew Olson, Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, AK (Andrew.Olson@alaska.gov)

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

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

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

Lance Sullivan, CARE vice chair, PSMFC age reader, Newport, OR, (LSullivan@psfmc.org)

Alison Whitman, Oregon Department of Fish and Wildlife, Newport, OR, (Alison.D.Whitman@state.or.us)

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)

Regrets for not being able to attend the meeting were received from:

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

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

Xi He, Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, (Xi.He@noaa.gov)

**VI. Additions to the agenda:**

- Western groundfish conference – Kari Fenske will give a summary
- TSC workshop – Ali Whitman will give a summary
- Descending devices under Item H (which agencies allow for this and how they're incorporating their use into management)
- Rockfish recovery planning – under Item H as well

**VII. Approval of the agenda** – The agenda was approved unanimously.

**VIII. Approval of 2015 report** - The 350 page report was approved unanimously. Past reports can be found at www.psmfc.org/tsc2/

## IX. Agency Overviews

**California Department of Fish and Wildlife (CDFW)** - In the marine region, there are 140 permanent and 140 seasonal staff. Six permanent staff members are dedicated to groundfish with some of these staff only working part-time on groundfish. There are 12 Pacific States Marine Fisheries Commission staff that conduct the commercial groundfish sampling program and over 100 CDFW staff dedicated to the California Recreational Fishery Survey program that sample recreationally caught groundfish as well as other species. Funding has been fairly stable. There has been lots of turnover in the Fish and Wildlife Commission with the loss of two long-time commissioners who were very involved with marine issues. The new commissioners are more environmentally minded and are not as experienced with fish and game resources. All commissioners have been around for less than two years, and the Department is doing lots of education. There has been more interaction with the tribes on the north coast, and there is a tribal representative.

**Oregon Department of Fish and Wildlife (ODFW)** - Assessment and management of state resources are conducted at six field stations. Involvement in both Pacific and North Pacific councils due to Oregon's fishing fleet's participation in Alaska fisheries. Funding is primarily from license fees and Federal funds. The new director has been with the agency a long time and has a useful background in legislative issues.

**Washington Department of Fish and Wildlife (WDFW)** - The Department consists of seven Puget Sound staff and a smaller Coastal group. Salmon port samplers report back on groundfish data but are not under direct supervision by Groundfish staff. There is a new director, James Unsworth, from Idaho with a wildlife biologist background. He is working on some education for legislators. There are salmon issues currently with the State and the tribes struggling to come to an agreement. They will likely shut down salmon fishing in the Puget Sound, so there is not much of a focus on groundfish lately. New funding was received from the legislature for the Groundfish program, specifically focusing on mid-water surveys using hydroacoustics and trawling. There is a new Fish Program Assistant Director, Ron Warren, who replaced Jim Scott, when Jim became a special assistant to the director. Jim had been the Fish Program Assistant Director for 8 years.

**Northwest Fisheries Science Centre (NWFSC)** – The Fishery Resource Analysis and Monitoring Division (FRAMD) support Groundfish research; cover five surveys. Offices for the Observer Program are in Seattle and Newport. There are a large number of contractors in this program and staff seems to be very stable. The Survey group conducts three major surveys, and is able to hire four permanent employees this year. The Assessment group has had some turnover and there are openings that they hope to fill in the next year. The Habitat group is headed up by Waldo Wakefield. The Economics group has had some program managers leave. John Stine is planning on retiring in 2017. The Center also focuses on salmon and ocean acidification, particularly the warm blob, and toxic phytoplankton as well.

**<u>International Pacific Halibut Commission (IPHC)</u>** - There are thirty full time staff in Seattle, twelve port samplers, and twenty to thirty sea samplers for the annual survey. Lots of staff transitions recently. Previous survey manager moved into the biologist position, and the database/IT person left, so they are hiring now. Quantitative scientist, Steve Martell left, but has been replaced with Allan Hicks. In the Fishery Stats Program Heather Gilroy is retiring so work on filling this position is happening. A new Research Program manager, Josep Planas, was hired. The Executive director, Bruce Leaman, is leaving in August and is being replaced by David Wilson. There is a new commissioner, Jeff Kauffman.

**<u>Department of Fisheries and Oceans, Canada (DFO)</u>** - There have been some very recent organizational changes. The Science Branch has increased from four to five divisions, making the divisions smaller and the structure more integrated between ecosystems and fisheries. The Groundfish section is being dissolved with data staff moving to a Data section, stock assessment staff going to an Assessment Methods section and the new Offshore group continuing to conduct groundfish surveys and the production of some stock status reports. Expecting some things to continue to change with the transition expected to take a year. There are twenty-nine new positions in the Science Branch within the Pacific Region. Primarily assessment positions (both salmon and groundfish positions).

**<u>Alaska Department of Fish and Game (ADFG)</u>** - Groundfish fishery offices are located in Southeast, Central and Western Alaska. Staffing in each area. Central region shares groundfish and shellfish duties. Kristen Green moved into a shellfish/assessment coordinator position, but will be leaving July 1 to pursue a PhD. There is a budget crisis, but the Groundfish Division seems to be fairly stable. They are losing legislative funding so will have to focus on federal funding to maintain surveys. The Ageing Unit is currently working on Pacific cod, as well as developing ageing techniques. ADFG also maintains AKFIN and processes data from fisheries landings. There is a dedicated sport groundfish position. ADFG conducts a statewide harvest survey to monitor harvest. Staffing varies but 4-5 people per region.

**<u>Alaska Fisheries Science Centre (AFSC)</u>** - Supports the NPFMC and conducts the large scale surveys in Alaska. There are 270 permanent staff spread amongst four divisions for Groundfish. There have been lots of retirements in the RACE division, with some of these backfilled. Major RACE activities include conducting five major bottom trawl surveys, several acoustic surveys, bycatch reduction engineering, large recruitment/ecosystem studies through the FOCI group. The REFM Division has a new Director (Ron Felthoven); personnel have been steady, and a new stock assessor is being hired. New from Auke Bay Lab’s (ABL) Marine ecology/stock assessment program, Phil Rigby is retiring and Jon Heifetz is the program manager. ABL is also hiring a MSE position. Programs that are salmon focused are expanding onto groundfish work, gear work and energetics work. FMA’s Observer program, oversee this program, reporting to TSC document now. Also 63 contractors, use a lot of contractors overall.

## X. CARE Report Summary

Lance Sullivan presented the CARE report. Chris Gburski took over as the CARE Chair, and other changes in officers also took place. The 2015 meeting occurred in Seattle, at AFSC. In addition to the meeting, a special workshop was led by Dr. Kilada on crustacean ageing. New techniques in age determination, age validation studies and age-based models for stock assessment were presented at the workshop. Also provided were agency reports with added contact information. There is a summary of the 5th Otolith Symposium (IOS). Long-term storage of otoliths was discussed, but no consensus was reached on the best technique for storage, therefore agencies will continue on with their own storage methods. In addition to the workshop, five working groups reported in, one of these, the Shortraker ad hoc working group, is new. Acknowledgements section will be prepared for the manual. CARE website subcommittee requested 2014 production numbers, will provide for exchanges, and will add officer information and meeting minutes on it. The Charter subcommittee wants to edit information on the various timelines that include the TSC report submissions. The Sablefish working group has new members, therefore tasks were reassigned and an ageing submission to the manual subcommittee is requested by summer 2016. Otoliths for calibrations and age determination characteristics were reviewed. The Shortraker working group focused on pattern interpretation and work will be done through future exchanges of otoliths and images. A final workshop will be held at the 2017 CARE meeting where age determination criteria for these two species will be determined. All exchanges are in progress, but waiting for several to come in. Will be finalized and added to the CARE website in a structure exchange table.

The 2013 and 2014 recommendations on ergonomic equipment were discussed, and 2015 recommendations were drafted by CARE to CARE, and CARE to TSC

**Recommendations from CARE to TSC:**

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.
    - Reports from agencies using glycerin-thymol, including recommended recipe for solution, will be included in the TSC report.
    - Agencies will continue to research whether current methods of long-term storage are adequate for preservation of otolith integrity.

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.

- Reports on use of ergonomic equipment were provided by CARE member agencies in 2015 and:
- Most upgrades were implemented after requests by age reading staff or local project managers;
- 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.

3. Recommend that CARE continue to explore and develop new methods of shellfish age determination (with the support of TSC).

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.

The 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).

## XI. Western Groundfish Conference 2016 report

The WGC2016 was held in Newport, Oregon from February 9$^{th}$ to 12$^{th}$, 2016. TSC sponsored a workshop "Developing Electronic Data Capture Systems" on the Monday of the conference week. There was good attendance and diverse talks. A social event was held at the aquarium. There were numerous younger attendees, and many great student talks. Good break and lunch structure. A lifetime achievement award was presented to Bruce Leaman by Rick Stanley. There was also a NMFS maturity workshop. The next conference will be organized for the Monterey area in 2018. Primarily the SWFSC and CDFW will be organizing the next meeting.

## XII. TSC workshop "Developing Electronic Data Capture Systems" report

The workshop was held on February 8$^{th}$, 2016, immediately prior to the start of the Western Groundfish Conference. A total of 38 participants from attended the day-long workshop. The first section of the workshop was presentations in electronic data capture, and the second section was small working groups. Improvements can be made to be clear about the workshop versus the conference. There was some confusion about abstract submission. Many people would like to continue having these workshops associated with the Western Groundfish Conference; however, overtime might be a concern in the future, for those attending. The venue and AV can be very expensive, so in planning for these workshops in the future, need to ask for support or bring agency equipment. Also TSC could work with the WGC steering committee.

Because of the small venue some people were wait-listed. Future workshops should consider a larger room in the future. Ali Whitman will send out a report for review and request presenters to post their talks online. Stephen (PSMFC) stated that he could post the presentations on the TSC website.

Recommendations from the workshop:

a. Recommend a core working group that convenes regularly.
b. Develop a website for users to go to for exchange of information and storage of documents, such as workshop proceedings and summaries.
c. Promote moving forward with electronic data collection systems.
d. Develop a formal forum of exchange of code, or library of systems tested, in order to document systems that worked well, or where improvements can be made.
e. Requested that funding be more flexible, because electronic data systems are typically not ready to test immediately.
f. Systems should start small to show success before rolling out to other, wider applications or situations
g. Recommend that the TSC endorse the use of electronic data collection systems, and additionally, assist with the identification of roadblocks moving forward to all groups/agencies via the working group mentioned in previous recommendations.
h. Reconvene workshop at a later date to continue discussions

## XIII. Surveys

WDFW – The Puget Sound bottom trawl survey conducts 1-2 trawls per site but they are trying to reduce the number of trawls so that there is more time for ecosystem work such as plankton tows and gut content analysis. Declines were observed in all gadids in 2015, but there were lots of Dogfish. There is a requirement to have a monitoring plan for ESA-listed species, including rockfish and their habitat in Navy waters. For these surveys they are using acoustics, traps, a remotely operated vehicle (ROV), and divers. There are no ESA-listed rockfish so far, and little adult habitat, but have found good habitat for juvenile and larval settlement (Puget Sound and Hood canal).

Annual herring assessments have found spawning populations within the Sound with several sites where no spawn observed (5 of 21), which is unprecedented. There have been lots of reports of anchovy. Surveys on the outer coast for nearshore rockfish are in the second year of sampling with a longline survey and a hook and line survey, similar to old black rockfish surveys. Some gear comparisons between the two have been done. Longline surveys seem to be promising for nearshore. A Yelloweye Rockfish offshore survey will be contracted to the IPHC to sample some of the stations, not sure if this is useful information as a long-term index.

**ODFW** - Sportfish monitoring programs at launch locations; new shore/estuary boat monitoring in Lincoln County is being conducted with effort estimated by phone/mail surveys. Commercial fishery monitoring is conducted with port biologists (now with electronic length boards). Hoping to begin fisheries-independent survey in 2-5 years, currently evaluating different methods, recently met with federal stock assessors to discuss. Will use non-extractive methods for fishery-independent surveys.  The surveys would focus on biomass estimation and not so much on longterm abundance indices.

**NWFSC** – Conduct joint Hake survey with DFO.  Hake acoustic survey showed sparse aggregations off of California, lots off Oregon and Washington and sparse again up north.  Biomass estimates were the highest seen since the survey started in 2003.  Mainly the 2010 year class which is now 5 years old, 75% is US Hake.  Also did a winter Hake survey in 2016, will be in next year's report.  There was a question about the dispersed Hake in the fishery but it was pointed out that the timing of the survey is different than the fishery and the survey showing of Hake was the strongest on record.  The Groundfish survey was conducted from May to October, it was fully funded, and the data became available two weeks ago.  Deviation of temperatures is the highest ever seen, so bottom temperature was higher than ever seen.  Near-bottom oxygen concentrations were higher than 2009 coastwide and related to depressed upwelling in 2015 (though early in the year, prior to the survey, saw low oxygen zones).  Twenty special projects were conducted; lots of maturity work.  Very unusual year oceanographically, but will want to continue maturity work over a wide range of environmental conditions.  The survey was followed around by Moss Landing and other agencies comparing video lander data with the survey trawls, and continuing to work with them in some of the rocky habitat.  They would like to survey in more untrawlable habitat.  The Southern California hook and line survey, did not get permitted to go into the federal MPAs, so lost some of their sites due to this.  They added sites in 2014 in the Cowcod Conservation Area (CCA) at request of PMFC.  Last year they added about 80 sites in the CCA, so almost doubled the survey sites.  An early look at the data showed that the size of Vermillion Rockfish and Cowcod are larger than those outside, no significant difference in Bocaccio.  Vermillion Rockfish are significantly more abundant outside the CCA.  In 2014, more Cowcod were caught outside the CCA and in 2015, more were caught inside the CCA.  Concerned that California will pull the CCA sites inside the state MPAs this year.  A continuing problem for groundfish surveys is losing sites to MPAs.  Suggest a workshop to address this issue and its potential for disrupting monitoring over the long-term.  Need to develop and test a novel descending device that can handle large numbers of rockfish at a time for use at MPA sites.  AFSC (Jon) has a cage on a winch for recompressing rockfish.  It was pointed out that these are sport boats that may not have the infrastructure.  WDFW (Dayv) has a device that can recompress a dozen rockfish relatively quickly.

**IPHC** – Conducts an annual longline survey that extends from southern OR through Alaska with 1,368 stations.  They will be rotating regional expansion of the survey, and have recently added some sites in the Eastern Bering Sea (EBS).  Most stations are on a 10 nm grid, but sampled in the EBS on a larger scale, with the last survey there in 2006.  Calibration is tracking the indices well.  Continue expansion into the Northern Bering Sea, up towards the border with Russian.  Weight per unit effort increased in most areas, with a few exceptions (2B, 3A, and 4A).  IPHC chartered 14 vessels for the survey last year.

**DFO** – One groundfish staff member has been deployed on the Shrimp trawl survey, CPUE indices from this survey are problematic and their utility needs to be investigated. There were lots of Arrowtooth Flounder and Flathead Sole in the survey in 2015. The Groundfish Section conducts a series of random depth stratified surveys annually, with coverage in any one area, every other year. Strait of Georgia survey, most abundant species were Dogfish, Rockfish, and Hake. Hecate Strait survey, most abundant species were Rockfish, Dover Sole and Rex Sole. Queen Charlotte Sound survey in the summer caught POP and Silvergray Rockfish, and Rex Sole. The data have not been fully analyzed yet. Two outer coast longline surveys are conducted. A 3rd technician goes on the IPHC survey in 2B and samples rockfishes. The other longline survey is with the halibut industry, depth stratified random design, 2015 was a northern survey and 2016 is a southern survey year. In the Strait of Georgia there is longline survey on a DFO vessel, depth stratified random design, 40 – 70 and 71 -100 meters. A Sablefish pot survey runs every year in the fall and goes into the inlets at the end of the survey. A Hake survey is conducted as well. A new internet survey of recreational fishers was reviewed by the science advisory group this year, last year's data is not yet available for publishing but preliminary looks at the data seem reasonable for some species such as halibut and rockfish species, gaps could be filled in with creel surveys.

**ADFG** - Every other year a pot survey for Sablefish is conducted. It is used for the marking portion of a mark/recapture experiment to obtain abundance estimates with the recapture portion occurring in an annual longline survey and during the commercial fishery in Chatham Strait. The longline survey is used to collect biological information on Sablefish and survey CPUE to incorporate into stock assessment for Sablefish. Longline surveys are conducted in 2 locations Chatham and Clarence Strait with the latter only having a longline survey for stock assessment. Overall, Sablefish are declining and cuts have been made to fishery quotas in two areas. For rockfish, a DSR survey is conducted in the western Gulf of Alaska (GOA). In the western region, also conduct an acoustic survey for rockfish. There is a creel survey for recreational fisheries and a statewide harvest mail survey, but the utility of this mail survey is limited for rockfish.

**AFSC** - RACE Division conducts a number of annual surveys and some biennial surveys. A bottom trawl survey on EBS shelf targets Walleye Pollock but is still a multispecies survey. Pollock estimate for 2015 is down about 14% but this is not a huge difference to the TAC. Every other year there is a Gulf of Alaska (GOA) trawl survey which occurred in 2015 and deployed a third vessel again after six years and will be using this vessel in the Bering Sea (BS) slope in 2016. The GOA bottom trawl survey is a stratified random design of known trawlable habitat stations. The "warm blob" affected distribution with some unusually low abundance for certain species but then some mixed signals depending on the species. Anne Hollowed et al. received money from NPRB to work with other west coast agencies to integrate all large scale surveys to investigate how the "warm blob" affected species, two post-docs have been hired to work on this. An acoustic trawl survey occurs every other year in the GOA and operated in 2015; this was the second biennial survey that was fully completed, targeting Pollock. In 2013, a large year class was seen coming through. Population estimates were generally up across the board, dominated by age-3 Pollock. A series of winter acoustic trawl surveys in some of the other embayments generally show good numbers of Pollock.

**AFSC, Auke Bay** – The 37th annual longline survey occurs in the GOA every year and alternates between the BS and the eastern Aleutian Islands (AI); 2015 was a BS year. Sablefish were down about 10% from the previous year, confirming a downward trend. Some enhanced maturity work on Sablefish was done, including some winter work. Some pop-up satellite tags were put out on Sablefish, as well as Floy tags on Greenland Turbot, Shortspine Thornyhead and Sablefish. Giant Grenadier is the most abundant species, followed by Sablefish. Northern BS IERS – Pollock most abundant. Southern BS IERS survey – pre-recruit Pollock are most abundant. GOA IES targets forage fish and juvenile groundfish– lots of Dogfish in a single haul and swamped the entire biomass estimates for the survey, 85% of total biomass is Dogfish, targeted forage fish. Note that these surveys saw some unusual fish, *Mola mola* etc. and lots of jellyfish and Pomfret compared to previous years. Also saw a northern mockingbird onboard a research vessel. NWFSC (Peter) asked how many satellite tags have gone out. AFSC (Jon) estimated close to 100. IPHC (Lara) asked how long they're on for. AFSC (Jon) said that it varies; some are 3 months, some 6 months, and some longer. IPHC (Lara) asked about archival tags. AFSC (Jon) said they're putting them on juvenile Sablefish, but analysis is ongoing. The North Pacific Fisheries observer program was restructured in 2013; a bias related to the 60 foot cut-off, so now it includes smaller vessels in a partial coverage category. There has been a huge effort to restructure this program with changes because of the expansion to the small fleet. IPHC (Lara) pointed out that some are opting out because they're a part of an electronic monitoring program. NWFSC (Tom) asked about EM programs on the west coast. CDFW (Traci) noted that this is moving forward through the Pacific council very quickly. CDFW (Traci) mentioned that they're doing it for fixed gear and whiting for now, in place within a year, and in 2017, the council may move towards putting it on bottom trawl. AFSC (Wayne) mentioned that Pac States are working a lot on this subject. PSFMC (Stephen) agreed that they have done a lot of work on this. CDFW (Traci) said that some of the regulations will allow for third party providers to do the video review. IPHC (Lara) said in some areas, Alaska has 100% retention of rockfish, but this is a State rule, and could overlap with EM in those areas. AFSC (Wayne) noted that most of the survey data is available on AKFIN, can get an account and access this data easily; most assessors do this. Also, lots of survey related research on untrawlable habitat, developing acoustic and trawl systems to assess untrawlable habitats. Trawl efficiency and capture efficiency is a very active area of research.

## XIV. Reserves

**CDFW** – Not all MPAs are no-take. A five year program update has been posted. Have finished the baseline surveys in MPAs and are still working in some regions; reports will be due in 2017 and 2018. The updated master MPA plan will reflect more of the ongoing monitoring. Collaborative research with some outside groups will be done.

**ODFW** - Marine reserves program has been around for 8 years now. There are five marine protected areas with the latest at Cape Falcon. Restrictions are implemented in all five areas beginning in 2016. Ecological monitoring plan includes hook and line surveys at Cape Falcon and video lander surveys at Redfish, Otter Rock, Cape Perpetua and Cascade Head and also testing a mini-video lander. Annual reports are on a new website.

**WDFW** – There has not been a lot of activity since 2009. The tribes would like to see how well the reserves are working, so most of the recent work has been to evaluate data prior to that time period. Have some dive monitoring surveys over a 15-year period and are working on a report for six sites and an appendix with all of the data. Preliminary information suggests that there are some areas with more and bigger fish, but the results are not very dramatic. Some of the fish with these results are shorter lived and faster growing, some possible effects for Lingcod, Copper Rockfish, and Quillback Rockfish, but high levels of variation among and between years appear to be masking and cut and dry effects of protection. The take-home message is that we likely still need to wait longer to see if steady incremental changes can overwhelm this variability and lead to substantial change in fish size and species composition. The recommendation is to continue monitoring. There was a strong pulse of rockfish recruitment in 2006, and at some sites there is retention of juvenile rockfish, others not. As a result, are now trying to develop some kelp bed surveys for juvenile habitat. There has been a revision to laws, and have added a section to existing construction regulations on anthropogenic artificial habitats. What is now law is what an artificial reef should look like and how they should be monitored, also rules for its removal. AFSC (Wayne) asked if all of Puget Sound is a reserve for rockfish. WDFW (Dayv) said that yes, it is no-take for rockfish but not an official MPA. NWFSC (Peter) asked if there was no-take for other species in these locations. WDFW (Dayv) said that some of sites were specifically to protect rockfish, some were to protect biodiversity, so it's difficult to evaluate as a whole. IPHC (Lara) asked if it applied to sport fishers. WDFW (Dayv) said no, no sport take and no commercial take. AFSC (Wayne) mentioned that there was no non-tribal commercial rockfish fishery since 2010. AFSC (Jon) asked if there were mandatory release methods for rockfish bycatch. WDFW (Dayv) said that there are few commercial impacts and they highly encourage sport fisheries to release and noted that you can't target bottomfish deeper than 120 feet. They might eventually push for mandatory descending devices. AFSC (Jon) asked about the tribes push for evaluating the MPAs. WDFW (Dayv) said that the tribes just wanted more information about how they worked before committing to giving up treaty fishing rights if fishing pressure wasn't a major factor influencing abundance.

**NWFSC** - One report looked at home range of Lingcod versus size of marine reserve and reserve efficacy.

**DFO** - With the change in government, the new Prime Minister (PM) appoints his Department Ministers, and in doing so also sends them a mandate letter. Previously these letters were top secret, but are now public. The DFO mandate letter outlined the PM's top priority, which was to create 5% MPAs in coastal and marine waters by 2017, and 10% by 2020. WDFW (Dayv) asked about how much is protected now? DFO (Lynne) said that it's not really known right now, because the definition of an MPA has not been settled. A broad interpretation could be "a managed area". Marine Protected Areas are designated under the Oceans Act, and the rockfish conservation areas (RCAs), were designated under the Fisheries Act. The PM's interpretation might include closures under the Fisheries Act that have some conservation benefit. In this case, RCAs could be included. For determining the % of area, the Oceans group is focusing on "Ecologically and Biologically significant areas" but it could include all of Canada's marine waters; this is all in flux.

**ADFG** – The Pinnacles are protected. HAPC's closures for various fisheries but there are still surveys allowed inside these areas.

## XV. By Species

### a. Hagfish

**ODFW** – In 2007 a fishery for human consumption developed. The longline gear used is 40 gallon traps. Landings have been stable at about 360 t/year worth 1.3 million dollars.

**DFO** – An experimental fishery has been conducted since 2013. Data collected to date are insufficient for a stock assessment.

**ADFG** – Interest in a hagfish fishery in Southeast Alaska has been developing due to the market development in Korea.

**CDFW** – There has been a hagfish fishery in California for several years. Recently regulations were developed relative to the use of barrel traps (55 gallon drum). Using the larger barrels reduces damage to the hagfish. Hagfish are being exported to Korea for human food, not their skins as happened before.

### b. Dogfish and other sharks

**WDFW** – New tribal fishery for Dogfish using gillnets and some longline in Northern Puget Sound (Lummi Tribe). Almost all big females in the catch with no bycatch reported.

**NWFSC** – Dogfish tagging studies are underway. Sixgill kinship studies in Puget Sound indicate that those fish in close proximity tend to be related.

**AFSC** – Pop-up satellite tagging studies on Dogfish have discovered that the tags give good information on latitude but not longitude. One fish tagged in Dutch Harbour popped up in Sothern California 9 months later. There is diel movement offshore but not inshore. Ageing vertebrae may be suitable but these are preliminary results.

Dogfish assessment is based on trawl survey data. Sleeper sharks appear to be two genetically distinct stocks that overlap spatially.

**ADFG** – Motion to ban shark fisheries was overturned for Dogfish. Not fished commercially, About 750 sharks harvested, largely recreationally. There was some work on Salmon Shark genetics and work on this is hoping to continue in 2017.

**c. Skates**

**NWFSC** - Aging lab is working through a backlog of Longnose Skate vertebrae that has been collected since 2008. They are working on validation methods. James Thorson (stock assessor) looked at individual Big Skate movement and this can be factored into assessment models.

**ADFG** - Lots of skate bycatch in longline fisheries but are not a valuable species to keep. No directed fishery for Dogfish but it is allowed under a commission permit.

AFSC - Working on aging studies for Longnose and Big Skates. There are reduced Maximum Retainable Allowances ( MRAs) for Big Skates in Federal management to discourage topping off. IPHC (Lara) noted that at halibut openings, the commercial fishery was landing Skates for 35 cents a pound. DFO (Lynne) noted that they were getting small Big Skates in their longline survey in the Strait of Georgia, which they haven't seen before. AFSC (Wayne) noted that trawl surveys are tracking catches of skate egg cases to document nursery areas.

**3. Pacific Cod**

**DFO** – Collecting some samples from a nursery area.

**AFSC** – No new research but will follow up on Pacific Cod population structure. IPHC will collect fin clips on their survey to help answer questions about Pacific Cod population differentiation in the Aleutian Islands. Also working on isolation by distance models; WDFW (Dayv) has collected samples for this study. There is an NPRB study on size-at-age of Pacific Cod in the EBS.

**ADFG** – No new research to report. There is an open access fishery using longline gear and in Cook Inlet they also use pot gear. There is no sport limit. In SE Alaska, Pacific Cod is mainly prosecuted as a bait fishery. Last year only about 9% was used for bait, which is different than in previous years.

**4. Walleye Pollock**

**AFSC** – Lots of research on Pollock associated with ecosystem studies. In the EBS, looking at energy content in the winter in cold years, so winter survival is higher for juvenile Pollock; a continuing study.

**ADFG** – Limited research on Pollock. A study on the genetic variation in the central region found significant differences between North American and Asian Pollock. Most areas are regulated with a commercial fisheries permit. DFO (Lynne) asked if the fishery is managed by the State within PWS? ADFG (Andrew) answered yes, but within the eastern GOA, there are exceptions.

**5. Pacific Whiting**

**NWFSC** - Annual assessment is conducted. Primary catch in the survey was the 2010 year class. Retrospective analysis may have changed past assessment biomass estimates. The fishery fell apart because there were no real concentrations of fish and catch per hour was too low to make the fishery profitable. A winter survey found fish far offshore and very dispersed.

**DFO** - Catches were about 30% of what was allotted to Canada. Survey catch was dominated by 5 year olds, and this cohort was in both US and Canadian waters. The majority of fish was taken off the coast of Vancouver Island in the third quarter of the year. NWFSC (Aimee) noted that they don't have a report from the at-sea component of the Hake fishery.

**6. Grenadiers**

**AFSC** – Grenadiers were put back into the FMP, but as an ecosystem component formal stock assessment are not required. An ongoing study on the three different shapes of otoliths of Giant Grenadiers, looking at genetic differentiation.

**7. Rockfish**

**CDFW** – Yelloweye rockfish biological samples were taken during the years that the IPHC surveyed in CA waters. Now doing the same thing with the sport survey on the party boats; biologically sampling Yelloweye Rockfish if they are accidentally taken. These otoliths will be used for the next assessment. Commercial fishermen with an EFP from PFMC conducted a study to commercial jig fishing for Yellowtail Rockfish in the RCAs without taking the bottom associated rockfish. Now have three years of data, and seems to be working well with Yellowtail and Widow Rockfishes making up almost 90% of the catch. Also have Bocaccio (about 9%) and some Yelloweye Rockfish (0.2% of total catch). The remaining species are a combination of shelf and slope species. This study was renewed for 2015/2016.

**ODFW** – Writing up studies on Yelloweye Rockfish movement and discard mortality. A site-fidelity study of Deacon Rockfish was done and it is a potential assessment candidate as a complex with Blue Rockfish. Assessment for China Rockfish indicates that it is doing well and Black Rockfish are down a bit. Commercial nearshore fisheries targeting Black, Copper, Quillback, Blue and other rockfishes have some reductions in trip limits. An annual nearshore fishery summary is available online. Yelloweye Rockfish retention is prohibited and there has been limited retention of Canary Rockfish beginning in 2015. Descending devices are used and incorporated into management practices.

**NWFSC** - Lots of information on rockfish in the agency report. There are three or four reports on Sunset and Vermillion Rockfishes. These studies are mainly associated with hook and line surveys. Five other indices of abundance. Study of Canary and Yelloweye Rockfishes in and out of Puget Sound, found that Canary might not be distinct in PS, so does not need to be listed within the Sound and Yelloweye in this study is distinct from the outside, however, the Hood canal population doesn't really mix with the rest of Puget Sound. WDFW has some information on this in their report too. Their recommendation to the Biological Review Team has been made for the five year review for the ESA listed species to de-list canary entirely, and treat yelloweye as two populations (not as a DPS but as a recovery area sub-segment). When listing occurred in 2010, very little information on Bocaccio, so used Yelloweye as a surrogate species, but now the thought is to use Canary as a surrogate due to the new population structure of Yelloweye. DFO (Lynne) asked if they've done the genetic work for Bocaccio. WDFW (Dayv) said no, because they only have three samples and they are all from the Central area, so no resolution. WDFW (Dayv) noted that they were also tagging with Floy tags hoping that they would see them again. Have found some on a ROV survey, and one was pregnant. WDFW (Dayv) the nearshore survey sends back down good Yelloweye but keep the injured ones for the NWFSC . WDFW (Dayv) Will also collect Yelloweye from the IPHC survey. NWFSC – Study ongoing on the genetic differences with Rougheye and Blackspotted. Found some interesting morphs of Darkblotched Rockfish but so far no genetic differentiation. Some work with Greenstriped Rockfish and low oxygen. They have published a report on Darkblotched Rockfish maturity. Completed a Black rockfish assessment, a Darkblotch Rockfish assessment, and updated a Canary Rockfish assessment. Lots of rockfish ecosystem studies. Stomach samples and stable isotope samples were collected by the Survey group for a diet study with stable isotopes. DFO (Lynne) asked when the next Yelloweye Rockfish assessment will be. ODFW (Ali) noted that it's on the potential list but that won't be finalized until the June PFMC meeting. The Southern California hook and line survey saw more of some rockfish species. CDFW (Traci) said that she didn't see anything else, but saw a lot of them in the 1980's as a sampler. NWFSC (Peter) noted that the hook and line data are available.

**DFO** – Competitive funding was received to write up visual surveys near RCAs and there will be a paper presented to CSAS in 2017. There are no differences in nearshore rockfish densities inside and adjacent to RCAs but the surveys only covered three years, 2009 – 2011, and only two years after the implementation of the no-take RCAs. A Yelloweye Rockfish assessment employed an age aggregated Bayesian surplus model, utilizing catches (this is total catch – all fisheries and bycatch) back to 1918 and conducted lots of sensitivity analyses. It is estimated that the 2014 biomass is about 18% of that in 1918, so there is a 65% probability that it is below the biological limit reference point. Advice to management recommended catch levels based at various harvest scenarios, and will require a large reduction in quota - will step down about 100 t over three years. Industry is concerned because it will likely limit the Halibut fishery.

Recommend a coastwide catch that is then apportioned into 4 management areas because there is insufficient data to conduct the assessment on a finer scale. The industry engaged a consultant who proposed an apportionment that reduced the TACs in all areas and varied slightly than that recommended by DFO, so this was adopted. We are working with industry and an industry paid consultant with graduate students, to investigate new assessment and management methods for rockfishes because industry is really not happy with the status quo. Recreational bag limits are reduced as well. Yelloweye Rockfish will also be reassessed by the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) in 2018 and they may recommend a 'Threatened' listing under Canada's Species at Risk Act (ESA equivalent). IPHC (Lara) asked about the reconstructions back to 1918 DFO (Lynne) said that the Canadian Bureau of Statistics compiled rockfish landings (as a complex) from 1918, and through various agencies catch has been recorded to the present. This complex was recorded differently over time until the 1990's when they started to record red snapper (Yelloweye Rockfish) in the 1990s. Catch reconstructions have allocated fishery catch by gear type. The catch of POP has also been reconstructed. The reconstructions were reviewed with fishermen in two workshops prior to the final assessment. Early on there was no trawl fishery, and catches were mainly from hook and line fisheries. Sensitivity tests on including this historical catch in the assessment were conducted. Also looked at the Yelloweye Rockfish bycatch rates in salmon troll fisheries, using the same algorithms and effort numbers as in the Bocaccio assessments. IPHC (Lara) asked about the population level at 1918 versus 1990 when the new time series started. DFO (Lynne) said catches were low and began to increase in the 1940's but were less than 100 t until the mid-1970s. The large catches in the mid-1980s to the late-1990s are the reason for the depletion. Various catch scenarios were included in the assessment model sensitivity tests. ODFW (Ali) and CDFW (Traci) noted that the west coast states are working on developing catch reconstructions. AFSC – go back to the 1960s in some species but it's not difficult to do – same assessors for each species, so it's just sorted out and that's the catch. WDFW is also running into issues with their historical reconstruction of ESA-listed species virgin biomass. AFSC (Wayne) noted that there are different criteria for ESA-listed species versus fishery targets. Do we want to have something from the TSC on this? IPHC (Lara) noted that there are apportionment challenges among all the subareas, and set the harvest policy to reflect that as much as possible.

**ADFG** - Line transects are used in the ROV survey for rockfish survey. Also do habitat mapping on this survey. Age structured assessment model to the GOA plan team for Yelloweye. In the Central region, ROV surveys are done as well. Western region conducts an acoustic survey for Black and other rockfish. Continue to research descending devices on Dusky, Tiger, Canary, and other rockfishes. Yelloweye are a multi-year assessment. For Eastern GOA, there is a Yelloweye ABC and TAC. Black rockfish there is no assessment in SE AK so use historical catch and catch rates. Black rockfish sport fishery is ramping up, and trying find funding for a survey to reevaluate. The sport fishery is taking more than the commercial fishery.

**AFSC** - Most research is focused on barotrauma. Jon Heifetz presented some of this work at the WGC2016. Chartered a boat last year to assess barotrauma in Pacific Ocean Perch, had only 5% survival in the pressure tanks, the warm blob was present so likely had thermal stress going on at the same time. Assessments: Rockfish offshore are doing well, POP in particular. Will use a geospatial estimator (time series smoother), for Dusky Rockfish, to modify the trawl survey biomass estimates. They are exploring the use of this estimator for other species as well. Habitat use and productivity in GOA rockfishes (POP, Northern and Dusky Rockfishes) study. Somatic growth and maturity patterns compared with associated habitat characteristics. Deepwater rockfish maturity patterns; Blackspotted, Rougheye and Shortraker Rockfishes, found the general estimates are similar for Blackspotted and Rougheye Rockfishes but lots of evidence for skip spawning (very high! 80-90%). Long-term study on POP, a 10-year time series of maturity to look at interannual variability. Shortraker aging study – in CARE report too. Have created a working group. Blackspotted and Rougheye can be identified using otolith shape. If you include age and growth in the model, you can separate the species with high accuracy (>95%). Jon Heifetz is working on going back historically to examine species composition in the Rougheye/Blackspotted catch. Catch in Alaska as a complex is very low. DFO (Lynne) asked about the total allowable catch for Yelloweye Rockfish in SEAK. ADFG (Andrew) couldn't find it, but noted it's in the SAFE report online. AFSC (Jon) noted that this complex is being restructured at the federal levels, and are tiered.

**DFO** (Lynne) initiated a roundtable on descender devices. DFO will review the literature but wanted information on how it's being used in management in other jurisdictions:

**CDFW** - California allows descenders and encourages using them. Received funding and sent descenders out to party boats along the coast. SWFSC also helps with this. At the Council level, California has established, for some species, depth-dependent mortality estimates with descending devices But this is only used on the charter boats in California, and only if a sampler is onboard. Have a check mark in logbook on whether it's used, but the only time they get credit for the recompression is if a sampler is onboard. DFO (Lynne) mentioned a report that the SSC produced. CDFW (Traci) noted that this is what the Council uses as a reference. CDFW (Traci) noted that you could have as much as a 50% survival rate (e.g. Yellowtail Rockfish). Also a NOAA tech memo that came out – nationwide memo on fisheries release mortality that describes how descenders are used and what the data gaps are. DFO (Lynne) asked about the non-charter sector. CDFW (Traci) said they don't get any benefits right now, but noted for Yelloweye Rockfish, this is almost completely caught on charter boats. Most of the effort is on the charter boats. DFO (Lynne) also asked about the commercial fishery. CDFW (Traci) said they are interested but not implemented yet.

**ODFW** - Most of the SSC report is based on literature from ODFW research. Descenders are not for the commercial fishery but they are voluntarily using them.

**WDFW** - Washington encourages use of descenders for rockfish and has spent considerable time working alongside the Puget Sound Anglers, to get free descenders into the hands of fishers. Most charter vessels use them now. There is a ban on fishing for bottomfish deeper than 120 feet, (the 120 foot rule) in Puget Sound because barotrauma effects are significant when fish are brought to the surface from any deeper than this. Barotrauma is not as big of an issue for species which are only found at deeper depths because of this fishing pressure refuge. Benefits of using descenders are directly applied to estimated mortality after using dock-side interviews (like Oregon) and phone interviews. Key-floats with laminated sheets for rockfish ID are given out with descending devices, so lots of fishermen are educated on descending techniques and benefits along with fish ID. Lots of fishermen take pictures to document their releases. Sport fishermen compete on how many fish they release and receive reports from WDFW staff if they are participating in the volunteer logbook program. DFO (Lynne) asked if we differentiate among devices – ODFW (Ali) and WDFW (Dayv) noted that we don't. CDFW (Traci) asked about running into people that don't know about the descending devices. WDFW (Dayv) mentioned that those people tend to be outside Puget Sound and non-residents. ODFW (Ali) agreed, noted it was the same situation in Oregon. DFO (Lynne) asked if Alaska uses them. ADFG (Andrew) said no, not really. Commercial fisheries have a bycatch allowance. The charter vessels have to have one descending device onboard. Very strict bag limits 1 Yelloweye and 2 DSR per day. AFSC (Wayne) asked if they used descenders a lot. ADFG ( Andrew) wasn't sure. He also noted that enforcement is very limited, and they cover a lot of fisheries operating at once. DFO (Lynne) asked whether the Alaska charter fleet reports through logbooks. ODFW (Ali) noted that there are logbooks for charter vessels in Alaska but couldn't remember details. DFO (Lynne) said that they will be conducting a literature review and coming up with recommendations for implementing the use of descending devices, including looking at factors (species, depths, handling time, etc.) associated with mortality. The second part of the request is how it is incorporated into management. AFSC (Jon) suggested some sort of workshop, and DFO (Lynne) agreed might be useful. WDFW (Dayv) noted that there was concern about the ability to ID rockfish species, and a student went out to study how well fishermen can ID their catches. Apparently the public is not good at fish ID. WDFW wants to replicate this study, to see if all their outreach educational efforts have been effective. CARE (Lance) suggested that community classes could be offered for the general public. WDFW (Dayv) said that each chapter group or fishing club would give talks about rockfish ID and management. The Seattle aquarium also has an annual event where we talk about this. Also trying to photograph fresh dead specimens together with underwater photos, and many of these have been posted to the WDFW webpage on a Bottomfish Identification site. IPHC (Lara) mentioned that there is a dead fish guide for the commercial fishery, and has them translated into multiple languages for plant crew and commercial fishermen. CDFW (Traci) noted that the Sportfishing Association of California helped with rockfish outreach material, in multiple languages, and also improved the photos. WDFW has created a large poster of rockfish species, because you have so many species. AFSC (Wayne) noted that NOAA has a strategic initiative to ID fish photographically, ultimately for EM. Worked on this in 2015 and will also get images this year with a new camera.

## 8. Thornyheads

**AFSC** - Best assessed by the trawl survey. The biomass is increasing. Some research on tagging in the longline survey and a maturity study in the works. Ageing has been complicated and ages are not used.

**DFO** - First Shortspine assessment done in a long time and was complicated by incidental catches with Longspine thornyheads. Most of the uncertainty in the assessment was due to growth, natural mortality and ageing. The Canadian fish tends to be younger than US fish. Eventually went with a model averaging approach. The stock is expected to decline over the next five years.

## 9. Sablefish

**WDFW** – Pacific Council initiated a coastwide assessment, noting a declining trend in Alaska, the west coast and Canada. Created a working group to do a coastwide assessment model for Sablefish (AFSC, ADFG, everybody, also hoping to work with Canada to get data for all Sablefish throughout the range)

**NWFSC** - Did a 2015 updated assessment for Sablefish and the spawning stock biomass has declined for several years. Several strong year classes, particularly 2012, but this has not translated to an increase in biomass yet. Current forecast predicts an increase, but below target biomass, and will be below overfished levels for the next few cycles. The stock is declining faster than predicted in the previous assessment. ODFW (Ali) noted that this seems to be the case in Alaska. NWFSC (Aimee) also noted that they may not be sampling deep enough to get the older year classes in the west coast. See them in the slope survey, but that only goes to 1280 m. Longline surveys found the bigger fish offshore. NWFSC (Aimee) would like to look at information from the California Bight.

**ADFG** - Mark-recapture survey in Chatham Strait, some recaptured in the commercial fishery. A longline survey to track CPUE is also done in Chatham Strait. In Clarence Strait, electronic data capture applications were implemented on the survey. This will also be implemented for the port sampling, and will help collect data more efficiently. Central region used to have a longline survey in Prince William Sound, but this ended in 2006. In Clarence and Chatham Straits, a NOAA paper noted some differences in fishery movement between these two areas, also found smaller fish in Clarence Strait. In both areas, it's a longline fishery, but also use pot gear in Clarence. Trends are declining in both areas, along with other GOA areas. Quotas have been reduced in both areas. Central region is an OA fishery with a GHL and so also for Western region. IPHC (Lara) asked whether they allow pot gear in Chatham – ADFG (Andrew) said no, there are gear conflicts and there are separate seasons in Clarence. IPHC (Lara) asked if there was interest in starting pot gear in Chatham. ADFG (Andrew) said that it would have to go through the Fish and Game commission. AFSC (Jon) noted that the federal fishery allows pot gear for black cod.  ADFG (Andrew) also noted that there was not a huge whale issue in some areas.

**DFO** - Has annual longline trap surveys for mark recapture studies.  Fishery used to be largely trap but have now switched to mostly longline.  The surveys have added accelerometers to the gear.  Assessments are through an MSE, and are conducted every other year with the operating model revisions done in the intervening years.  Also evaluate the feedback simulation portion of that model.

**WDFW** - One of port samplers was concerned about the meat recovery factor (because most fish are landed dressed), and evaluated this using two different cuts.  Found some interesting results – there is a small difference between the cuts, but you have to factor in the time of year.  More females are landed at certain times of year, and there are differences.  Current rate is 1.6, the two different cuts are 1.4 and 1.57, but they vary by quarter.  WDFW (Kari) also noted that this was a strange year oceanographically, so would prefer to have more data.  CDFW (Traci) noted that most of this information on the west coast is taken from Alaska studies, and said that it would be nice to have more data on this.  IPHC (Lara) asked when it's higher and lower.  WDFW (Dayv and Kari) are not sure, but seems that the lowest rates are in the winter.

**AFSC** - Continued tagging Sablefish.  Recovery information received is about 800 fish/year in the commercial fishery.  Also recover a lot of Canadian Sablefish too.  25% of tags recovered in 2015 were tagged 10 years ago.  High percentages had traveled large distances.  One tag was at liberty for 36 years.  Found juvenile Sablefish in St. John Baptist Bay after hearing reports from sport fishermen that they were catching lots of juveniles.  Charter boats in Kodiak and Homer tagged 100s.  This is the first tagging outside of SEAK of juveniles.  The 2014 year class appears to be strong in Alaska. Sablefish maturity manuscript documents skip spawning (10-15% were skipping).  Will continue with collecting samples this year and also continue with the satellite tagging but nothing new to report.  The longline survey has the lowest point in the time series, and a 24% decrease from the year before.  The GOA trawl survey was one of the lowest points in the time series, but there may be a couple of strong year classes coming through. Kari Fenske's PhD work is on apportionment of Sablefish by area, apportionment has now been held constant for several years, will have some recommendations soon.  A CIE review will take place in Auke Bay next month.  IPHC (Lara) noted that IPHC collects the logbook information from the IFQ Sablefish fishery. Started in 1999, and in 2002, expanded the program on a volunteer basis. Uniquely code the vessels to meet confidentiality.  AFSC (Jon) noted that they use fishery CPUE in the assessment models.  WDFW (Kari) asked about Canadian tagged fish that are recovered in Alaska – do they also send the length information to Canada?  AFSC (Jon) said that whatever they get is sent to Canada. WDFW (Kari) wanted to compare tagged fish in Canada versus what is landed.  AFSC (Jon) volunteered last year to write up a TSC agreement to encourage data sharing. Gave it to DFO (Lynne) to edit, and gave to ADFG to edit, but want to pick this back up again.  The intent is to have a coastwide assessment of Sablefish, though acknowledges that this will be difficult with the politics. DFO (Lynne) noted that it's in the recommendations from last year (sharing data for trans-boundary stocks), but also noted that it was not limited to Sablefish. IPHC (Lara) noted that all the catch limits are done in round weight, and have different recovery rates by region for the IFQ fishery. ADFG (Andrew) said that most of the state landings are whole fish.

**10. Lingcod**

**ODFW** – have commercial and recreational landings

**WDFW** - Ageing comparison between different structures (otoliths, fin rays, and vertebrae) with the best agreement among fin rays, poor agreement between rays and otoliths after age 4. ODFW (Ali) noted that we have lots of fin rays. CARE (Lance) said that they're ageing those from the federal survey and said they could take Oregon's.

**ADFG** - Conduct ROV surveys for Lingcod in the Central Region. Management is based off of GHLs, main gear is dinglebar. Typically a fast fishery that only lasts a few days. Most catch is in eastern Yakutat. DFO (Lynne) asked if the ROV survey is for the adults only. ADFG (Andrew) said that he wasn't sure. AFSC (Jon) asked if there was a commercial season for them in Washington. WDFW (Dayv) thought yes, but only on the outer coast.

**DFO** – The Lingcod Program was on hold last year because the Program Head was on maternity leave.

**11. Atka Mackerel: First time in the TSC report!**

**AFSC** – Are the number one prey item in the diet of Steller sea lions. Stock assessment is conducted every other year to coincide with the Aleutian Islands survey. Stock appears to be in good shape but limited in the western Aleutians. Lots of tagging studies occur. DFO (Lynne) noted that there was a report of an Atka Mackerel off the coast of Queen Charlotte Islands. AFSC (Jon) said that it wouldn't surprise him, see them in the GOA quite often in the sport fishery. AFSC (Wayne) noted the biological opinion (BiOp) on the impacts of commercial fishing on the Steller Sea Lions was challenged in court and had to be redone and the result is actually opening up some fishing. This activity helps keep little ports like Adak open.

**12. Flatfish**

**NWFSC** - Assessment for Petrale, last round, showed extremely low biomass levels. Now it appears to be recovered and is increasing. Conducted an Arrowtooth data-moderate assessment that shows they are also doing well.

**DFO** - Also conducted an Arrowtooth Flounder assessment and is the stock is doing well, too. Quota is 15 k tons, and catch in 2015 was 13.5 k. Working on a Petrale sole assessment, but it has been delayed.

**AFSC** – Infauna communities and habitat studies for northern rock sole in the BS looking at habitat quality. Prey does not seem to be a limiting factor, but habitat quality does vary by region. For estimating total survey catchability of rock sole in the GOA, delineation of trawlable habitat is underway to assess how well the net can catch fish. Propose to combine availability and trawl selectivity into one parameter. To fill in the holes in habitat data, using Echoview. Investigating herding and escapement of Rock Sole in bottom trawls. Tom has a paper out on Northern Rock Sole advection in the BS using ROMS model to predict larval drift. Showed that tides are very important, can go a short ways vertically but a long way horizontally. Finished maturity studies on Alaska Plaice, Yellowfin Sole and Flathead Sole. Abundance-based PSC limits for Halibut going through the NPFMC process. All assessments show strong stocks, except slight reduction in Greenland turbot.

## 13. Halibut and IPHC activities

Halibut are landed gutted. Currently the sex ratios in the commercial catch are estimated based on the IPHC survey data. Working on genetic testing for sex and have identified three different sex-specific genes. Doing commercial sex specific marking (different cuts for male and female), continued in 2015. In 2014, initially collected samples on the survey platform and wanted something simple for both survey crew and port samplers. In 2015, vessels agreed to sex mark all their fish for specific trips and those would be identified back at the dock where they would collect genetic samples. Good feedback from the vessels, but haven't processed the samples yet. In 2016, it's expanded further. Approached different fishermen associations and PHMA in BC agreed to do the marking. Currently doing a lot of outreach and Canadian port samplers are collecting fin clips to validate. AFSC (Wayne) is the intent to get a sex ratio for the assessment. IPHC (Lara) yes, it's a critical component to the assessment. Currently take survey data from the areas that closely match the commercial fleet, but still not ideal to have them only from the survey. AFSC (Tom) asked if it was a split sex assessment. IPHC (Lara) said yes.

Staff member is looking at sexual maturity to validate maturity stages, particularly for female halibut. Samples collected in 2004 for a histology study. Staff member also works with NMFS staff at Sand Point.

Have a new research program manager, and his background is in physiology. Project assessing mercury and other contaminants in halibut. Taking tissue samples from the survey, and works with ADEC labs to process data. Turned into a monitoring project and results have shown that Halibut has pretty low concentrations overall.

Continuing project started in 2013 assessing different tag protocols.

Looking at spatial and temporal distribution of ichthyophonus in Halibut with USGS and collecting samples from fish on the survey.

A reassessment of the length-weight relationship for product recovery rates is being done. There are different rates for the head (10 versus 12%) and ice and slime (1-2%). Want to apply this equitably along the west coast. Started project two years ago, port samplers got length, weight measurement in as many conditions as possible. In the RARA, range of 9-18% in head weight along the coastline, so varies dramatically by area. In 2015, every sample collected in port was also weighed, continuing to collect data in 2016 but will likely require head-on landings and weights in the future. Also doing a length-weight project at sea, taking measurements when landed on the vessel. Tagging the fish, and then repeating measurements when landing at the dock, to look at possible shrinkage.

Last year, started a pilot project to CWT tag (actually spaghetti) juvenile halibut on the trawl surveys, continuing in 2016, in the GOA, BS and the AI. WDFW (Kari) asked how they would recover them. IPHC (Lara) clarified that they are not CWTs.

Starting in 2016, are developing a condition factor scale for halibut.

Start a project with NMFS on larval halibut in ichthyoplankton surveys, focusing on connectivity between the GOA and BS.

RNA sequencing of gonads, already collected some from a subsistence fishery. RNA sequencing of liver tissue to look at growth rates.

Survey is expanding up into the northern BS, so have some pop up archival tags on adult fish in the Northern BS (will tag 32 fish).

Have an undergrad intern again. Last year's looked at depredation on the survey. Work on compiling the whale depredation survey.

The commercial fishery port sampling program is working on remote data entry applications. Testing in specific ports and then in 2014, expanded to throughout the season. In 2015, all the US port samplers were given a tablet and now have an e-logbook program. The intent is to replace the hardcover logbook for monitoring the smaller vessels. This year, they're doing both and the IPHC will assess accuracy by sampler. Field staff will still be entering two other paper logbooks.

Work on electronic data capture for the survey. Using the tablets tested last year, 3 of 14 vessels will be using this as a primary form of data collection. Next year this will be fully rolled out, if it goes well.

Future research plans include size composition of discarded fish, and a focus on physiology as well.

Work towards full catch accounting and the identification of gaps in the reporting programs. Staff is working more with the Councils and NMFS, particularly wanting to get a better idea of what those removals are.

Migration studies, particularly for undersized fish, and improving archival tag technology for smaller halibut. AFSC (Jon) noted that they already use mini-archival tags on juvenile Sablefish.

Halibut assessment in 2015: Commercial fishery landings were up from 2014. WPUE on survey was 5% higher in 2014. Age distributions from the survey and the fishery remain similar to 2011-2014, indicating a relatively stable stock, and no evidence of strong recruitment. Size-at-age remains low in the time series but has not changed much over the last few years. Four assessment models are combined in an ensemble assessment approach. Looks at proximate probability distributions to assess stock status and projects to the upcoming season. Blue line is the line in the decision table provided by the assessor and represents the current harvest policy. There is an ongoing evaluation of where this should be set.

Catch in BC is split 85:15 between commercial and recreational. Fishing dates were set for March 19th to Nov 7th at noon. 10 hour openings for the directed fishery, starting June 22nd, every two weeks on a Wednesday until the quota is taken. The reverse slot limit in 2C was changed. Changes in 3A: 1 day a week closure for charter halibut and changes in size limits. NPFMC and NMFS working on changing regulations to use longline pot gear in the longline IFQ fishery in GOA; requested IPHC to approve the gear type, which they did.

A regulation change was made to allow externally tagged halibut to be exempt from daily sport limits (i.e. anything that would prevent a tagged halibut being turned in).

Allow electronic logbook for landings in Alaska.

DMR is currently 16% for the directed fishery, and the staff is working to review this rate.

Reviewing harvest policy control rules, a confirmed priority for staff, additional resources have been allocated to this. Commission confirmed the reduction of bycatch as a priority and staff will continue to work on this issue.

The expansion of the survey into 4D north. DFO (Lynne) asked if they would go into the inside BC waters. IPHC (Anna) said yes, that's 2018. AFSC (Jon) asked about Western Alaska. IPHC (Anna) said yes, that's 2017. CDFW (Traci) asked if these expansions would be rotated, to visit them periodically. IPHC (Anna) said that it was up to the commission. IPHC (Lara) added that the intent is to visit periodically, but that no regular schedule was set up. AFSC (Wayne) mentioned that it would be nice to sync up the larger trawl surveys in the north pacific. CDFW (Traci) brought up the changes in catch sharing plan that allowed California some halibut in 2A in 2015. They implemented a catch monitoring program to do this. Monitoring with weekly reports, there were two week openers each month to allow for time to track the catch. Managed to close the fishery with less than 100 pounds left of the quota.

**14. Other groundfish**

**NWFSC** - Kelp greenling assessment by Aaron Burger, stock seems to be in good shape. Was low back in the early 1900s but has been increasing, there are no conservation concerns. A catch-only projection for California Scorpionfish was conducted. Cabazon fishery is with pots and hook and line. Working on net design studies. New book "Fishes of the Salish Sea" and a Miller and Lea update. Discover four species of sand lance. Aimee Keller has a paper out on maturity curves in Tanner crab (deep water bycatch species on the west coast); follow up paper from another manuscript, looking at carapace width and chella width. Male and females occurred at the same depth range, but the juveniles were deeper.

**ODFW** – Fishery independent studies: effects of light and turbidity on the stereo video lander. Proposing 100 stations per year in two areas but there is no analysis yet. Evaluating hook and line studies also. A maturity report on Redbanded Rockfish was completed. ROV habitat studies in Marine Reserves using video analysis.

**WDFW** – Looking at feeding biomechanics and ontogenetic changes in ratfish. Some feeding trials also but these are not going well. Collecting spines and venom sacs for researchers who are characterizing the venom and determining how it could be used for medical purposes.

**AFSC** - The Conservation Engineering group is looking at net designs to reduce seafloor impacts. Study to use halibut excluders, initial design excluded halibut well but lost lots of Pollock. Also looking at a salmon excluder, tweaked to reduce salmon bycatch and are still working on this for the Pollock fishery. Compared size selectivity with different fishing gears and found a good approach to compare between two different nets. Good information on sampling efficiency for surveys of Pollock in the Bering Sea. Now looking at the variability between stations and looking at parameters with sampling efficiency and herding, and how variation in those parameters affect the overall variation in estimates from survey. Also have a systematics group in AFSC which has produced a paper on using genetics to ID which snail fish are using king crab shells to house their eggs. Continue working on different cryptic rockfish species. Publish a list of fishes of the Salish Sea as a precursor to a book with color plates that is coming out next year. Includes 250 species of fish together with a life history information. Also working on a guidebook for codfishes of Alaska, published by NOAA as a companion to the other guides that are already out.

**CFDG** (Traci) mentioned that the Cabrillo Marine Aquarium is updating the Guide to Marine Fishes in California with the blessing of the original authors Dan Miller and Bob Lea.

**DFO** (Lynne) suggested that "other research" could be added after "other species to the report format.

## XVI. Ecosystem Science

**CDFW** - Lots of MPA work discussed earlier.

NWFSC - Lots of modeling papers (20-30). Continued work on Stock Synthesis with Rick Methot. Regression analysis, time series analyses, and integrated ecosystem work on the California current system. An initiative on non-trawlable habitat work was completed in the Gulf of Mexico. Hook and line survey and habitat work in the CA Bight.

**WDFW –** Several ecosystem projects are underway: 1) The PSEMP monitoring program (toxicity monitoring program) monitors the buildup of toxins in the food web and now includes a variety of different species. 2) Navy surveys in regards to critical habitat for ESA listed rockfish species. 3) A two-year mid-water trawl and acoustics study to fill in data gaps in the open waters of Puget Sound. The intent is to get as much seasonal variation as possible so stations are fished every other month for 12 months, starting in February 2016. Found lots of unexpected species, not finding species that we do expect and so far the largest catches include herring. All sorts of additional sampling is possible off of this platform, even bird sampling. 4) High resolution habitat data were used in modeling rockfish presence and absence with Chris Rooper. Groundtruthed the predicted high quality habitat in 2015 then refined the model and will conduct additional validation in 2016 for recommendations of critical habitat. 5) Derelict gear is a large issue in Puget Sound and there has been funding to remove it. There is a reporting network to report derelict gear. 6) Conducted ROV and habitat modeling work in the Shellfish group to evaluate urchin and CA cucumber; a comparison study between diver and ROV density estimates. 7) Work on some shark feeding studies and IUCN red list updates.

**DFO** - Implementing an ecosystem based fishery management into groundfish stock assessment methods; working to link oceanographic variability to groundfish recruitment. Developing a tiered approach to groundfish assessment in BC. Started with a literature search and will be hosting a workshop in 2016 to work with industry and to present the approach. Will produce a science response and start strategic planning. AFSC (Jon) noted that there was some information from the Wakefield Symposium last year on their website (data-limited assessment information) and they will be producing published papers from the symposium.

**AFSC** - Habitat and essential fish habitat studies. EFH models have been produced for the North Pacific, put together several types of models and trawl survey data to produce these maps for species specific maps. Also continuing work with reinterpreting the hydrographic smooth sheets; working on bathymetry and shorelines for Norton Sound. All online with several other regions completed. Long-range side scan sonar was used to map the fine scale habitat on the EBS shelf region to relate the fish species present with habitat and to look at the impacts of fishing as well. There has been a comparison of levels of trawl impacts. 2015 was the last year of fieldwork for deep water coral initiatives, and a report will be out later this year. The Bering Sea slope coral work will be completed this year too. The energetic condition of juvenile groundfish was studied; turns out different species have different trajectories. Surveying around Point Barrow for Arctic and Saffron Cod. Continue to work on recruitment to understand the processes/mechanisms. There is work on developing a new net to effectively sample larval and juvenile fish. There is still interest in increasing work in the Chukchi sea and the Arctic, but funding is difficult, and with Shell pulling out, there is a lack of BOEM and other funding. NPRB has an RFP for an integrated ecosystem assessment in the North Slope area. Food web modeling work with stomach sampling continued and analyzed lots of stomachs, mainly from the GOA. They also looked at seabirds too for the ADFG. Collected bottom grabs as well to compare the prey available with what was in the stomachs. Ecosystem considerations report is put out annually for the NPFMC. Warm blob got a lot of media attention, but mentioned that groundfish in the trawl surveys were heavier on average, and seabird productivity was high so productivity was high in 2015, but expecting these to decrease in 2016 with a cold year. About 60 publications listed.

**IPHC** - Collect oceanographic information on the setline survey, available online.

## XVII. Working Groups and potential workshops

DFO (Lynne) mentioned that she was interested in having a working group on descenders for rockfish, and solicited interest in this. AFSC (Jon) suggested sponsoring a workshop. AFSC (Wayne) asked how long it needs to be because a two day workshop should probably be separate from the Western Groundfish Conference. What's probably needed is something sooner than the next WGC anyway. DFO (Lynne) will draft a workshop agenda to distribute to TSC members, and everyone could funnel it to relevant folks to gage interest. If there is interest, could add extra time onto the TSC meeting. AFSC (Jon) pointed out that the next TSC meeting is in Alaska. CDFW (Traci) mentioned that the catch reconstruction workshop was condensed into one day and it was tough to get through everything. AFSC (Jon) said that there's really not a lot of interest from Alaska on this, or at least not a lot of activity. There was a barotrauma workshop last year. DFO (Lynne) added that the use of descenders is being considered in B.C. and management is concerned about how to account for catch, especially in the recreational fishery. So how are survival rates applied to catches and how are these monitored in the recreational fishery?

DFO (Lynne) also brought up rockfish recovery planning. AFSC (Wayne) mentioned that there are two types of recovery – ESA and overfished designations. And if it's a broader topic of recovery, Alaska may be interested. The real issue is how these two could relate to each other. AFSC (Jon) said that you could have half a day dedicated to ESA and half to rebuilding. It depends on how big you want to make it. Dayv said that they produce an annual report that says how they do these. Ali said that Oregon could come up with something similar. AFSC (Wayne) said that ESA is tightly linked to Puget Sound, and not sure we want to go down the rebuilding plan road. But a workshop on descending devices, could get information right away. Let researchers know that we're going to have a workshop in two years, and what we want is a synthesis of research of mortality rates and best practices for application.  This would be high visibility to agencies, and would be good for TSC.

WDFW (Dayv) said that an ongoing issue is estimating sport catch for rarely encountered fish.  This is especially relevant for permitted activities that impact ESA-listed species because a spurious report from the public at one site can be blown out of proportion when extrapolated to a whole spatial-temporal harvest stratum.  It's first how you get a reliable catch estimate.  CDFW (Traci) - the recovery plan stuff could be an interesting topic, NMFS just put out a press release about newly recovered stocks and some of these are the rockfish.  Workshop talks could be about how it's been working, and working well for some species.

DFO (Lynne) also brought up how spatial management affects surveys and stock assessments. NWFSC (Aimee) says that this isn't really an issue that's appropriate. DFO (Lynne) rephrased the issue; as closed areas become larger and more numerous, how does this affect our surveys in the open areas and what are the implications for stock assessment?  NWFSC (Peter) commented that this was not really a workshop, but a vital discussion about how this is handled.  Requires a discussion with assessors, and they were not on board with using descending devices on the survey, because they wanted the age data rather than releasing a couple hundred rockfish.  There must be a way to dove-tail time series research with the goals for the protected areas.  CDFW (Traci) noted that there is a lot of research that folks want to conduct in MPAs and we're working on an internal assessment tool that can evaluate each specific research request to objectively evaluate total impacts. Not ready for prime time yet.  WDFW (Dayv) we're doing the same thing for the scientific take permits.  Can't answer how much take of rockfish there is because there are no summary capabilities.  AFSC (Wayne) Oregon has a system to track permits with the Federal Agencies.  ODFW (Ali) yes, but still not easily searchable.  CDFW (Traci) the information is not easily searchable with our system.  Found a large amount of permits in an MPA and are trying to balance everyone's needs.  AFSC (Wayne) is it the Channel Islands a sanctuary? NWFSC (Aimee) actually all the MPAs and the Cordell Bank, and the Olympic national sanctuary.  So this is a struggle in every area.  Have worked with specific areas in the past, basing their decisions on a lack of understanding of the survey.

## XVIII. Recommendations

### 1. Progress on 2014 Recommendations

### A From TSC to itself

a. Redesign the TSC agency reports and meeting agenda.

*This was discussed at the 2015 meeting and Traci Larinto (TSC Chair) drafted a new format for the TSC agency reports and sent this out to agencies prior to the 2016 meeting.  The new format was adopted for the 2016 reports and meeting agenda.*

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

*Traci Larinto (TSC Chair) sent the 2015 TSC Letter to Supervisors via email, cc'ing TSC members*.

**2. Progress on 2015 Recommendations**

**A. From TSC to itself**

**1.** The TSC recognizes the potential for climate change to impact the distributions, fisheries, and biology of groundfish 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 groundfish. 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.

*TSC members chose instead to focus on the electronic data capture methods workshop. See item 5. Report to TSC from Alison Whitman, the workshop organizer.*

*At the time of writing this recommendation, the TSC was not aware of NPRB's Warm Blob project which addresses the climate change issues highlighted here. Two members of TSC are co-PIs on this project.*

**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.

*The former TSC Chair, Ms. Larinto sent a letter to Maturity Assessment, Reproductive Variability, and Life Strategies (MARVLS), a national steering committee within the National Marine Fisheries Service, that is working on fish maturity, asking that they include TSC member agencies, including DFO. They were very responsive and have included TSC members in the call for their November 3-5, 2016 workshop. TSC reaffirms the importance of sharing information on this topic and is pleased to note that there are many informal research relationships that are currently occurring.*

3. The TSC again recognized the value of the 2014 Visual Survey Methods Workshop 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.

*TSC members discussed this and recognized that there were: 1) a very well attended session on visual methods at the AFS annual meeting in August 2015; and 2) many visual methods presentations at the WGC in Feb 2016. While this remains a focused area of research with continual technological and research advances, TSC members felt that there was not a pressing need for another workshop at this time. The workshop in 2014 connected people in this field and enabled the development of research relationships that have thrived.*

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.

*TSC members agreed that the past survey methods workshops were very successful but did not feel there was a need, at this time, to convene another workshop on this topic. It was suggested that the idea of another workshop be revisited in 2021, ten years after the last one.*

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.

*TSC thanks Alison Whitman, Wayne Palsson, Traci Larinto and others who did an amazing job putting together the workshop. Many participants found the workshop very informative and especially liked that so many agencies brought their equipment to show their systems in action. Please see the Report to TSC from Alison Whitman, the workshop organizer.*

6. The TSC discussed the need to share tagging data and other associated data pertinent to the stock assessment and management of transboundary stocks. Sharing of data for species such as Sablefish, Black Rockfish, Lingcod and sharks that intermix between both countries will enhance the scientific understanding of the population dynamics of these species which may lead to

improved management. The TSC recommends sharing data for all species where transboundary intermixing may occur and urges agencies in both countries to enable data exchange. The TSC requests agencies to identify species that are tagged and the contact information for tag returns. The TSC recommends that formal data agreements be investigated to facilitate data flow, if necessary.

*Information about this issue was circulated to DFO, AFSC-Auke Bay and ADFG but was not added to the 2015 Letter to Supervisors. This item will be added to the 2016 Letter to Supervisors. In October of 2016 a two-day workshop will be held to address black rockfish tagging studies, and other aspects of stock assessment pertinent to management of this species along the west coast.*

**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 TSC 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 Wilderbuer have agreed to make the poster.

*TSC would like to thank Wayne Palsson and Tom Wilderbuer who put together a great poster for WGC. The 2015 Letter to Supervisors included information about the TSC and the website. TSC members are also encouraged to widely distribute the 2015 reports to colleagues. To make the individual agency reports more easily accessible on the website, Stephen Phillips has modified the Table of Contents of the TSC report so that each agency report can be accessed directly instead of scrolling through this very large document.*

**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 make it more interesting in an effort to entice 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.

*TSC thanks Wayne Palsson for revising the introduction in the Accomplishments document and to Stephen Phillips for posting this to the website. An item to "assign someone to update the document" has been added to the draft agenda for 2017. Another item highlighted by Rick Stanley in his work on the document was to update the working groups list. Lynne Yamanaka (TSC Chair) will add this to the 2017 agenda.*

**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.

***No action needed.***

**B. TSC to Parent Committee**

**a.** 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.

*Information about this was included in the 2015 Letter to Supervisors and will be communicated again to TSC members who sit of the Councils and are members of the GMTs. TSC recognizes the work done by CARE on this issue and agree to take it off of CARE's agenda.*

**b.** 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.

*We thank the Parent Committee for their support of the EDAS workshop.*

**c.** 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 trans-boundary 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.

*No action needed at this point.*

### C. TSC to CARE (carried over from 2015 meeting)

1. **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. **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. **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. **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 field season the first week of May.

## 3. 2016 Recommendations

## A. TSC to Itself

**a.** The TSC approved the redesigned agency reports and meeting agenda and agreed that they created a better flow to the meeting. Further additions and slight modifications will be expected in the future but for now the format worked well and the TSC recommends adopting it.

**b.** TSC members who attended the WGC and workshop agreed that they worked very well together. Associating the workshop with the WGC has travel advantages for everyone attending. In the future TSC suggests to send letters to agencies informing them of the TSC sponsored workshops for even greater participation. All recommendations from the workshop are included in the report which was received in May. The TSC will review the recommendations at the 2017 meeting.

**c.** A few ideas for future workshops were discussed and included: rockfish descenders, updates on rockfish conservation measures (ESA, SARA listing) and stock rebuilding plans, impacts of spatial management measures (MPAs and sanctuaries) on surveys and assessments (or vice versa) but no consensus was reached. Organizing another surveys workshop was also discussed but TSC members felt that when current research on selectivity and catchability become available, it might be a better time for a workshop. Carry forward this item for a discussion in 2017 with the thought towards hosting a workshop at the 2018 WGC in California. TSC members to canvas agency colleagues and develop ideas to discuss at the 2017 meeting.

**d.** The Maturity Assessment and Reproductive Variability of Life Stage (MARVLS) workshop was discussed and TSC members that attended reported the great work on maturities being done together with the sharing of information and samples between State agencies, IPHC, and NWFSC. Participants identified a need for cross-validation of maturity stages, similar to issues associated with age reading. The TSC is encouraged by the MARVLS initiative and supports wider invitations from MARVLS to all TSC agencies.

**e.** The TSC initiated a working group on groundfish tagging data which will be led by Jon Heifetz (AFSC). TSC requests cooperation in this regard among all member agencies and hence will be included in the 2016 Letter to Supervisors. Of particular interest is the exchange of Sablefish tagging data for use in a potential coastwide Sablefish assessment conducted jointly by US State agencies, NMFS, and Canada.

**f.** The TSC recognizes the valuable contributions of its working groups and as suggested by Rick Stanley, while he updated the Accomplishments document, the TSC will revisit the status of all working groups in 2017.

**B.** TSC to the Parent Committee

**a.** Just prior to the 2016 Western Groundfish Conference in Newport OR, the TSC sponsored an Electronic Data Acquisition Systems workshop. The workshop began with 9 presentations then later organized smaller work groups to discuss 5 questions. Recommendations from this workshop will be discussed at the 2017 TSC meeting. From all reports, the workshop was a success with 38 registered participants from all TSC member agencies as well as 2 Universities. The TSC thanks the Parent Committee for its support of this workshop.

**b.** At the 2016 WGC TSC members Wayne Palsson and Tom Wilderbuer presented a poster highlighting the TSC and its accomplishments. This poster was well received and helped to increase awareness of the valuable work of the TSC among the broader groundfish community attending the WGC. The TSC thanks the Parent Committee for its support.

**c.** The TSC has revised the introduction of the Accomplishments document and as suggested last year, commits to reviewing/updating this document on an annual basis. The Accomplishments document will be available on the website. The TSC thanks the Parent Committee for supporting the work to update this document.

**d.** After the 2016 TSC meeting, TSC member Jim Armstrong reported his progress towards the TSC to CARE recommendation in 2015 on the otolith storage issue:

*"Prior to every June Council meeting, the Joint Groundfish Plan Team, the Crab Plan Team, and the Scallop Plan Team review all existing research priorities. Their review considers modifications to priority category and research progress, and the possibility of eliminating or adding new priorities. As a participant in the Groundfish Plan Team review in 2016, I communicated the otolith storage issue to the Team, and it was included among their recommendations to the (North Pacific Fishery Management) Council. At the June 2016 Council meeting, the Council's SSC (Scientific and Statistical Committee), which reviews the collective plan team's recommendations, agreed with the addition of that priority item. Finally, the Council approved the addition of the otolith storage issue in its final determination of its five year (2017-2021) research priorities, which it communicated to the Secretary of Commerce, fulfilling a mandate of the Magnuson-Stevens Act."*
*The TSC is delighted to report that the otolith storage issue is approved as a 2017-2021 research priority for the North Pacific Management Council and will remove the TSC to*

*CARE recommendation pertaining to this issue. The TSC thanks the Parent Committee for their support in moving this issue forward*.

***e.*** The TSC has formed a groundfish tagging working group which will begin organizing their work in 2016. The TSC has not yet deemed that formal data sharing agreements are necessary but thanks the Parent Committee for its support should this change in the future.

**C.** TSC to CARE

a. The TSC would like to thank CARE for its ongoing reporting and research into the otolith storage issue and is delighted to report that this issue will be a 2017-2021 research priority for the North Pacific Management Council. The TSC encourages CARE and all its member agencies to support this research priority.

## XIX. Parent Committee Minutes

### Minutes of the 57th Annual Meeting of the Canada-U.S. Groundfish Committee (a.k.a. "Parent Committee")

**A** 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 12:00 pm, Wednesday, April 27, 2016.

**B** The Agenda

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

**C** The 2015 Parent Committee meeting minutes

The Parent Committee minutes were adopted as presented

**D** Progress on 2014 Parent Committee recommendations

1. The Parent Committee agrees with the TSC on updating the TSC "Agency Overview" document.

***Action:*** *The document was revised and reviewed in 2015 and the new format was adopted for the 2016 agency reports.  The agenda for the 2016 meeting was also revised to reflect the reports.*

**E** Progress on 2015 Parent Committee recommendations

**1.** The Parent Committee agrees with the long standing TSC sentiment that the proper storage of otoliths is an important issue to all agencies maintaining legacy otolith collections.  The Parent Committee understands that CARE has not come to a consensus on best practices for otolith storage and will work with TSC members who are also members of Groundfish Management Teams and sit on the North Pacific Fishery Management Council and the Pacific Fishery Management Council, to bring forward the potential issues regarding otolith storage and the long-term effects on these ageing structures and encourage work in the future to resolve this storage issue.

***Action:*** *Worked with TSC members to bring this issue forward for consideration and this was adopted as a priority for the 2017-2021 research initiative at the June 2016 North Pacific Fishery Management Council.*

**2.** The 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.

***Action:*** *A workshop on item 2) was held prior to the 2016 WGC.*

**3.** The 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.

***Action:***  *A poster was presented at the 2016 WGC.*

**4.** The 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.

***Action:***  *A working group on groundfish tagging data was created.*

F 2016  Parent Committee Recommendations

**a)** The Parent Committee thanks the TSC thanks for organizing the Electronic Data Acquisition Systems workshop (esp. Ali Whitman) held prior to the Western Groundfish Conference and for the development of the TSC poster (esp. Wayne Palsson and Tom Wilderbuer), also shown at the WGC.

**b)** The Parent Committee thanks the TSC for the work on the introduction of the “Accomplishments” document and agrees it should be updated on an annual basis.

**c)** The Parent Committee thanks the TSC for establishing the groundfish tagging working group and looks forward to seeing progress by this working group.

**XX.** 2016 Meeting Location

The Parent Committee agrees with the proposed location and schedule for the 2017 TSC and Parent Committee Meeting: Juneau, Alaska, April 25 and 26, 2016. Jon Heifetz from the AFSC will be the host.

**XXI.** Other Business

1. The Parent Committee thanks PSMFC for its ongoing support for the Annual TSC meetings.
2. The Parent Committee thanks Alison Whitman for hosting the meeting.

**XXII.** The Parent Committee meeting was adjourned at 12:45 am, Wednesday April 27, 2016.

**XXIII.** Selection of the next Chair, Schedule and Location of 2017 Meeting

Lynne Yamanaka will remain the Chair for another year. The next TSC meeting will be held April 25-26, 2017 in Juneau, Alaska and hosted by Jon Heifetz, AFSC, Auke Bay Lab.

**XXIV.** Adjourn at 12:00 p.m. on 26 April 2016.

**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

**2015 Agency Report**

**to the**

**Technical Subcommittee of the**

**Canada-US Groundfish Committee**

**April 2016**

**Compiled by Wayne Palsson, Tom Wilderbuer, and Jon Heifetz**

## VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2015

## I. 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.

### A. 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 2015 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 2015 by RACE Groundfish Assessment Program (GAP) scientists: the annual Eastern Bering Sea Shelf Bottom Trawl Survey, and the biennial Gulf of Alaska 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 Gulf of Alaska as well as winter acoustic trawl surveys in the Gulf of Alaska. Research cruises investigating bycatch issues also continued.

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

## B. REFM DIVISION

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

For more information on overall REFM Division programs, contact Division Director Ron Felthoven at (206) 526-4114.

## C. AUKE BAY LABORATORIES

The Auke Bay Laboratories (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL’s Marine Ecology and Stock Assessment Program (MESA) is the primary group at ABL involved with groundfish activities.  Major focus of the MESA Program is on research and assessment of sablefish, rockfish, and sharks in Alaska and studies on benthic habitat.  Presently, the program is staffed by 13 scientists and 2 post docs.  ABL's Ecosystem Monitoring and Assessment Program (EMA) and Recruitment Energetics and Coastal Assessment Program (RECA) also conduct groundfish-related research.

In 2015 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) age of maturity and reproductive of sablefish;  5) large-scale, integrated ecosystem surveys of Alaska Large Marine Ecosystems (LME) including the Gulf of Alaska, southeastern Bering Sea and northeastern Bering Sea conducted by the EMA Program and; 6) analysis of juvenile groundfish collected on AFSC surveys to assess their growth, nutritional condition and trophodynamics conducted by the RECA Program.

Ongoing analytic activities in 2015 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 (POP), northern rockfish, dusky rockfish, rougheye/blackspotted rockfish, shortraker rockfish, "Other Rockfish", thornyheads, and sharks and Eastern Bering Sea sharks.  Integrated ecosystem research focused on the impact of climate change and variability on Alaska LME's and response of fishes (walleye pollock, sablefish, POP, Pacific cod, arrowtooth flounder, Pacific salmon) to variability in ecosystem function.

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.

## D.  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.

## II. Surveys

**2015 Eastern Bering Sea Continental Shelf Bottom Trawl Survey – RACE GAP**
The thirty-fourth in a series of standardized annual bottom trawl surveys of the eastern Bering Sea (EBS) continental shelf was completed on 3 August 2015 aboard the AFSC chartered fishing vessels *Vesteraalen* and *Alaska Knight*, which together 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 2015 were 6.3 million metric tons (t) for walleye pollock, 1.1 million t for Pacific cod, 1.93 million t for yellowfin sole, 1.41 million t for northern rock sole, 25.2 thousand t for Greenland turbot, and 172 thousand t for Pacific halibut. There were decreases in estimated survey biomass for most major fish taxa compared to 2014 levels. Walleye pollock biomass decreased 14%, arrowtooth flounder 12%, yellowfin sole 23%, northern rock sole 24%, for Alaska plaice 21%, and Greenland turbot 10%. There was little or no change in the biomass (<1%) for Pacific cod and Pacific halibut (0.5%).

The summer 2015 survey period was warmer than the long-term average for the second consecutive year. The mean bottom temperature was 3.4°C, which was only slightly warmer than 2014 (3.2°C); however, the mean surface temperature was 7.2°C, which was a full degree lower than 2014 (8.2°C).

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

**2015 Biennial Bottom Trawl Survey of Groundfish and Invertebrate Resources of the Gulf of Alaska – 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, Cape Flattery,* and *Sea Storm* to conduct the 2015 Gulf of Alaska Biennial Bottom Trawl Survey of groundfish resources. This was the fourteenth survey in the series which began in 1984, was conducted triennially for most years until 1999, and then biennially since. Two vessels were chartered for 79 days, and the *F/V Cape Flattery* was chartered for 60 days. The cruise originated from Dutch Harbor, Alaska on May 19th and concluded at Ketchikan, Alaska on August 18th. 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 26 May. The vessels surveyed from the Island of Four Mountains (170° W longitude) proceeded eastwards through the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern management areas (Figure 1). Sampled depths range from approximately 15 to 1000

m. The cruise was divided into four legs with breaks in Sand Point, Kodiak, and Seward to change crews and re-provision.

A primary objective of this survey is to continue the data time series begun in 1984 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 2015 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. We also conducted a number of special studies and collections for investigators both from within the AFSC and from elsewhere.

The survey design is a stratified-random sampling scheme based 54 strata of depths and regions and applied to a grid of 5x5 $km^2$ cells. Stations that were previously identified as untrawlable were excluded from the sampling frame. Stations were allocated amongst the strata using a Neyman scheme weighted by stratum areas, cost of conducting a tow, past years' data, and the ex-vessel values of key species. 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 $\times$ 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.

Biologists completed 772 of 800 planned stations in the entire shelf and upper slope to a depth of 1000 m. Biologists collected 213 fish taxa that weighed 496,632 kg and numbered 885,191 individuals. There were 535 invertebrate taxa collected that weighed a total of 12,635 kg. During the 2015 survey, biologists collected 117 taxa of fish and invertebrates as 231 vouchered lots for identification, permanent storage, or other laboratory studies (see table below). Other collected samples included over 13,100 otoliths for ageing, special collections for ecological studies, and others samples for life history characterization. A validated data set was finalized on 30 September (http://dragonfish.afsc.noaa.gov/RACE/groundfish/survey_data/), and final estimates of abundance and size composition of managed species and species groups were delivered to Groundfish Plan Team of the NPFMC. The survey data and estimates are also available through the AKFIN system (www.psmfc.org). The Plan Team incorporated these survey results directly into Gulf of Alaska stock assessment and ecosystem forecast models that form the basis for groundfish harvest advice for ABCs and TAC for 2015.

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

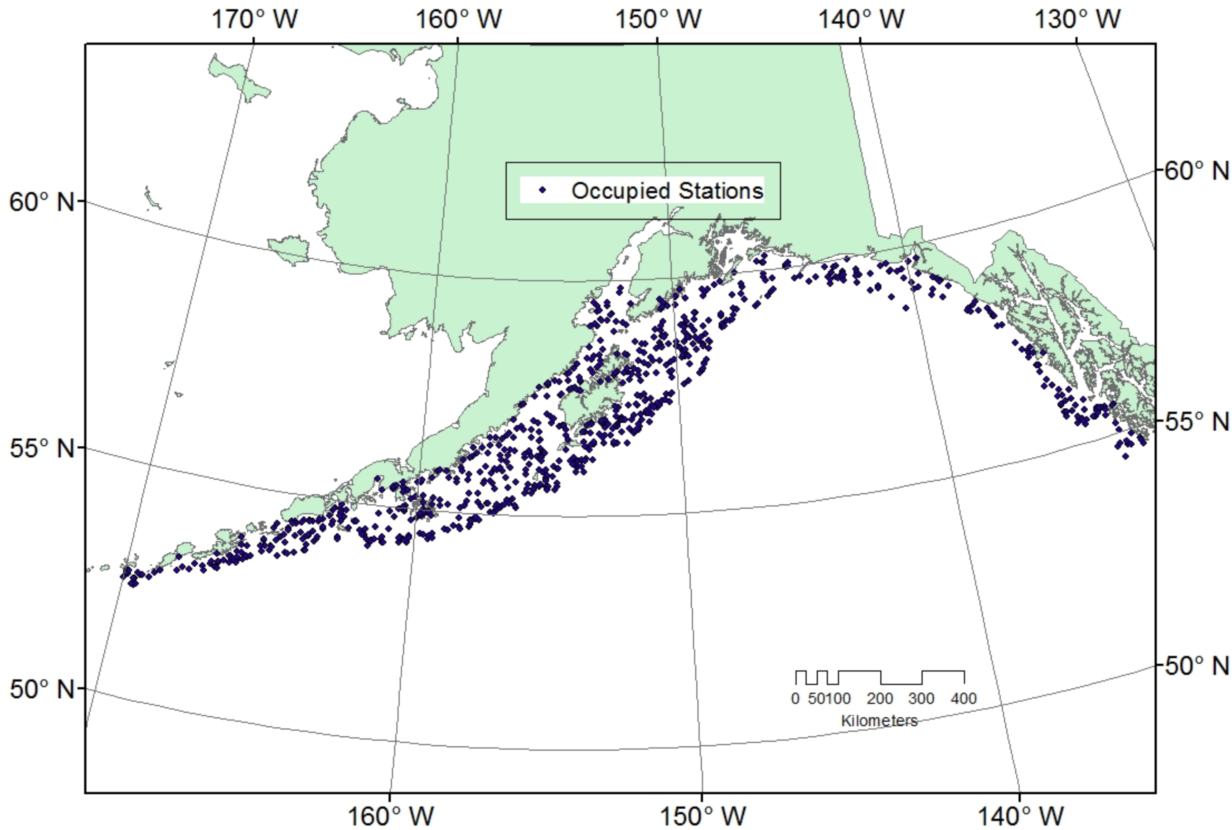


Figure 1. Occupied stations during the 2015 Gulf of Alaska Biennial Bottom Trawl Survey.

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

Two AT surveys of walleye pollock (*Gadus chalcogrammus*) were conducted. The first (cruise DY2015-02) surveyed the Shumagin Islands area (comprised of Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait), Sanak Trough, and the Kenai Peninsula Bays (i.e., Resurrection Bay, Day Harbor, Port Bainbridge, Aialik Bay, Harris Bay, Nuka Bay, Nuka Passage, Port Dick). The Shumagin Islands area and Sanak Trough were surveyed on 13, 20-24 February, and the Kenai Peninsula Bays were surveyed 27 February -1 March. The Shumagins survey was halted 13-19 February due to vessel mechanical problems. Acoustic-trawl surveys of

Morzhovoi Bay, Pavlof Bay, and Prince William Sound were planned, but were not completed due to these mechanical issues. A second AT survey (cruise DY2015-03) covered Shelikof Strait (17-23 March), Marmot Bay (15-16 March), and the Chirikof shelf break (23-24 March). Finally, three trawl-resistant bottom-mounted (TRBM) echosounders were deployed in Shelikof Strait and TRBM sounder AT survey assessment work was conducted on 11-12 February, 25-26 February, 2 March, and March 27-30.

All surveys were conducted aboard the NOAA ship *Oscar Dyson*, a 64-m stern trawler equipped for fisheries and oceanographic research. 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.

In the Shumagin Islands, acoustic backscatter was measured along 756 km (408 nmi) of transects. The survey transects were spaced 1.9 km (1.0 nmi) apart directly south and east of Renshaw Point and in the eastern half of Unga Strait, 4.6 km (2.5 nmi) apart in Stepovak Bay and West Nagai Strait, and 3.7 km (2.0 nmi) the western half of Unga Strait, and 9.3 km (5.0 nmi) apart in Shumagin Trough. The majority of walleye pollock in the Shumagin Islands were between 10 and 15 cm fork length (FL) and 20 and 45 cm FL, which is characteristic of age-1 and age-2-4 walleye pollock, respectively. Smaller fish (10-15 cm FL) made up a very small portion of the biomass (2.5%), which was similar to 2014 (3% of the total biomass), and much less than 2013 (48% of the total biomass). Large adults ( ≥ 40 cm) contributed little to overall biomass in 2015, as well. The dominance of walleye pollock with lengths representative of age-3 fish in the Shumagin Islands area (85% biomass in 2015) suggests the continued success of the 2012 year class. The maturity composition of males > 40 cm FL (n = 34) was 3% immature, 9% developing, 82% pre-spawning, 0% spawning, and 6% spent. The maturity composition of females longer than 40 cm FL (n = 105) was 0% immature, 11% developing, 86% pre-spawning, 0% spawning, and 4% spent. Age-2 and -3 walleye pollock were abundant throughout the outer portion of Shumagin Trough, off Renshaw Point, and in the West Nagai Strait area. Although adult pollock have historically been detected off Renshaw Point, only a few large adults were captured in trawl hauls in this area in 2015. The majority of the pollock (mainly age-3 fish with fewer age 1-2 year olds) formed dense layers approximately 25 m above the bottom during the day. The biomass estimate of 61,369 t, based on data and specimens collected from eight AWT hauls conducted in midwater and one on-bottom PNE haul, is nearly twice last year's estimate (37,346) and 81% of the historical mean of 75,269 t for this survey.

Sanak Trough was surveyed on 22-23 February. The majority of walleye pollock biomass for fish ≥ 40 cm was generally located in the northwestern portion of the Trough; whereas most biomass for fish < 40 cm was located along the eastern side of the Trough. Acoustic backscatter was measured along 196 km (105.5 nmi) of transects spaced 3.7 km (2 nmi) apart, and biological data and specimens were collected from three AWTs. Walleye pollock ranged between 25 and 75 cm FL with two modes at 34 and 60 cm FL.. The mode at 34 cm likely represents age-3 fish. The majority of pollock in Sanak Trough in 2014 were between 42 and 78 cm FL with a mean of 59 cm FL (mostly age-8 fish). The maturity composition for males > 40 cm FL (n = 32) was 0% immature, 6% developing, 13% pre-spawning, 3% spawning, and 78% spent. The maturity composition for females longer than 40 cm FL (n = 57) was 2% immature, 7% developing, 33% pre-spawning, 5% spawning, and 53% spent. The fact that over half of the females were already spent indicates that survey timing was likely late, and did not coincide with the onset of spawning for the majority of fish that spawn in Sanak. The biomass estimate of 17,863 t is 39% of the historic mean of 45,604 t for this survey and more than twice last year's biomass estimate (7,319 t).

The Kenai bays, specifically Port Dick, Nuka Passage, Nuka Bay, Harris Bay, Aialik Bay, Resurrection Bay, Day Harbor, and Port Bainbridge, were surveyed from 27 February to March 1. Acoustic backscatter was measured along 405.6 km (219 nautical miles (nmi)) of zig-zag transects, and biological data and specimens were collected from one PNE and eight AWTs. The majority of the adult walleye pollock biomass (FL ≥ 40 cm) was located in Aialik Bay, Resurrection Bay, and Port Bainbridge, with as much as 28% in Resurrection Bay alone. The small amount of biomass observed for fish < 40 cm FL was located in a small area of the west arm of Nuka Bay. Walleye pollock ranged between 22 and 69 cm FL with a mean of 52 cm FL, and the majority of the biomass in this region was composed of fish with lengths characteristic of fish 7-10 years old. The maturity composition for males > 40 cm FL (n = 218) was 1% immature, 1% developing, 33% pre-spawning, 61% spawning, and 4% spent. The maturity composition for females longer than 40 cm FL (n = 206) was 0% immature, 5% developing, 93% pre-spawning, 1% spawning, and 0% spent. The fact that almost all of the females were prespawning indicates that survey timing was appropriate as it coincided with the onset of spawning for the majority of the fish that likely spawn in this area.

The Shelikof Strait sea valley was surveyed from 15 to 22 March at a transect spacing of 13.9 km (7.5 nmi), acoustic backscatter was measured along 1,355 km (731.5 nmi) of transect, and biological data and specimens were collected in the Shelikof Strait area from 26 AWT hauls. As in previous years, the highest walleye pollock biomass was observed along the northwest side of the Strait near Kukak Bay, although dense aggregations of 40-60 cm FL fish also extended southward into the center of the Strait as far as Agripina Bay. Discrete, dense midwater pollock schools ("cherry balls") were occasionally encountered throughout the survey area, especially on the northern and southern transects in the Strait, consisting mostly of fish with an average FL of 30 cm. The majority of pollock biomass within Shelikof Strait was characterized by two length modes: one clear mode at 30 cm FL representing age-3 fish from the 2012 year class, and second mode consisting of fish > 40 cm FL. The maturity composition in the Shelikof Strait area for males longer than 40 cm FL (n = 690) was 5% immature, 1% developing, 6% pre-spawning, 87% spawning, and 1% spent. The maturity composition of females longer than 40 cm FL (n = 724) was 7% immature, 4% developing, 78% pre-spawning, 10% spawning, and 2% spent. The small fraction of spawning and spent females relative to pre-spawning females suggests that the survey was reasonably well-timed to coincide with the onset of spawning for the majority of fish that spawn in Shelikof. The Shelikof Strait biomass estimate of 845,306 t is the second largest reported for the region since 1985, and similar to the 2014 estimate of 842,138 t. The 2015 estimate is 1.28 times the historic mean of 659,635 t.

Marmot Bay was surveyed from 15 to 16 March along transects spaced 3.7 km (2.0 nmi) apart in the outer Bay and 1.9 km (1.0 nmi) apart in the Spruce Island Gully and inner Bay. Acoustic backscatter was measured along 315 km (170 nmi) of transects, and biological data and specimens were collected in Marmot Bay from two AWT hauls in midwater, and two PNE trawl hauls. The majority of the pollock biomass occurred in aggregations between Whale and Spruce Islands and in inner Marmot Bay. The aggregations included pollock both from 20 to 40 cm FL and pollock ≥ 40 cm FL, and were vertically stratified with smaller fish higher in the water column. Walleye pollock in the Marmot region ranged from 20 to 70 cm FL with a clear mode at 27 cm FL and two weaker modes at 46 and 60 cm FL. The maturity composition in Marmot Bay for males > 40 cm FL (n = 125) was 4% immature, 1% developing, 35% pre-spawning, 58% spawning, and 2% spent. The maturity composition of females > 40 cm FL (n = 90) was 0% immature, 1% developing, 92% pre-spawning, 3% spawning, and 3% spent. The high percentage of pre-spawning adult females suggests that peak spawning had not occurred and that survey timing was likely appropriate. The biomass estimate for Marmot Bay was 22,470 t; this estimate is the highest in the history of the Marmot survey and 11,400 t higher than the historic mean for this survey (11,049 t).

Chirikof shelf break was surveyed from 23 to 24 March along transects spaced between 7.4 km (4.0 nmi) and 11.1 km (1.0 nmi) apart, acoustic backscatter was measured along 324 km (174.5 nmi) of transects, and biological data and specimens were collected from 5 AWTs. Walleye pollock schools comprising the majority of pollock biomass in Chirikof were mixed lengths and scattered sparsely along the shelf break, they ranged from 27 to 70 cm FL with a clear mode at 31 cm FL. The maturity composition in Chirikof for males > 40 cm FL (n = 10) was 30% immature, 0% developing, 10% pre-spawning, 60% spawning, and 0% spent. The maturity composition of females > 40 cm FL (n = 27) was 15% immature, 19% developing, 67% prespawning, 0% spawning, and 0% spent. The high percentage of pre-spawning adult females suggests that peak spawning had not occurred, and that survey timing was likely appropriate. The biomass estimate for Chirikof was 12,685 t; 50,000 t less than the 2013 estimate and much less than the historic mean for this survey (40,182 t).

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

**Summer Acoustic-Trawl Survey of the Gulf of Alaska -- MACE Program**
The MACE Program completed a summer 2015 acoustic-trawl (AT) survey of walleye pollock (*Gadus chalcogrammus*) across the Gulf of Alaska (GOA) shelf from the Islands of Four Mountains eastward to Yakutat Trough aboard the NOAA ship *Oscar Dyson* (cruise DY2015-06). The summer GOA shelf survey also included smaller-scale surveys in several bays and around islands. Previous surveys of the GOA have also been conducted during the summers of 2003, 2005, 2011, and 2013 by MACE. Midwater and near-bottom acoustic backscatter was sampled using an Aleutian Wing 30/26 Trawl

(AWT), and on-bottom backscatter was sampled with a poly Nor'eastern (PNE) bottom trawl. A Methot trawl was used to target midwater macro-zooplankton, age-0 walleye pollock, and other larval fishes. Conductivity-temperature-depth (CTD) and expendable bathythermograph (XBT) casts were conducted to characterize the physical oceanographic environment. A trawl-mounted stereo camera ("Cam-Trawl") was used during the survey to aid in determining species identification and size of animals encountered by the AWT at different depths. During night operations small scale grid surveys were also performed across the shelf based on the AFSC groundfish survey's trawlability grid. Trawlable (n=19) and untrawlable (n=19) grids were surveyed using the EK60 acoustic system (18-, 38-, 70-, 120-, and 200-kHz ) and a Simrad ME70 multibeam sonar to assess the trawlability designation of the grid. Grid sampling was augmented with stereo-video drop camera deployments (n=92) to groundtruth bottom classification and estimate species abundance.

The biomass estimate for the entire survey area was 1,482,668 t. The majority of the walleye pollock observed during the survey were located on the continental shelf (64%), Shelikof Strait (19%), east of Kodiak Island in Chiniak (2%) and Barnabas Troughs (6%), and in Marmot Bay (3%). The vast majority (80%) of the biomass for the entire survey was from age-3 fish (~30-45 cm fork length). Surface water temperatures across the GOA shelf averaged 12.2° C, approximately 1.6° C warmer overall than in 2013.

The survey of the GOA shelf and shelfbreak was conducted between 11 June and 16 August 2015 and consisted of 43 transects spaced 25 nautical miles (nmi) apart. Walleye pollock distribution was patchy across the shelf. The areas of greatest walleye pollock density on the shelf transects were south of Unimak Pass, between the Shumagin Islands and Shelikof Strait, south of the Trinity Islands, and east of the Kenai Peninsula on the Northwest portion of Portlock Bank. Based on catch data from 34 AWT, 18 PNE, and two Marinovich hauls, one major length group of walleye pollock was observed on the GOA shelf which ranged from 30 to 48 cm FL with a mode of 37 cm FL. The walleye pollock biomass estimate for the GOA shelf of 946,681 t from the 1,739 nmi of trackline surveyed was approximately 64% of the total walleye pollock biomass observed for the entire survey and 3.5 times larger than the 2013 estimate.

Sanak Trough was surveyed 20 June along transects spaced 4 nmi apart. The sparse backscatter attributed to walleye pollock in Sanak Trough was patchy and scattered throughout the 47 nmi of transects surveyed. Pollock captured in the one AWT haul in Sanak Trough were primarily in the 27 to 44 cm FL with a major mode at 31 cm FL, resulting in a biomass estimate of 3,098 t, roughly three times what was seen in both 2011 and 2013.

Morzhovoi Bay was surveyed 20 June along transects spaced 4 nmi apart. Backscatter in Morzhovoi Bay attributed to walleye pollock was fairly evenly scattered throughout the bay with the greatest density located in the south east corner over the deepest part of the bay. Walleye pollock captured in 2 AWT hauls in Morzhovoi Bay ranged from 15 to 73 cm with a dominant mode of 41 cm FL. The biomass estimate for the 20 nmi of trackline surveyed in Morzhovoi Bay was 4,855 t, about 1,000 t greater than what was seen in Morzhovoi Bay in 2013.

Pavlof Bay was surveyed 21June along transects spaced 4 nmi apart. The acoustic backscatter attributed to walleye pollock in Pavlof Bay was observed throughout the survey area but primarily near the mouth of the bay. Walleye pollock captured in Pavlof Bay from 1 AWT ranged from 16 to 69 cm FL, with most fish in the 26 to 43 cm FL range and a major mode at 32 cm FL and a smaller mode at 37 cm FL. The biomass estimate in Pavlof Bay from the 20 nmi of trackline surveyed was 2,576 t, slightly higher than in 2013.

The Shumagin Islands were surveyed on 22-24 June along transects spaced 3.0 nmi apart in West Nagai Strait, Unga Strait, and east of Renshaw Point, and 6 nmi apart in Shumagin Trough. In the Shumagin Islands walleye pollock were most abundant found near the mouth of Stepovak Bay and the outer West Nagai Strait areas. Walleye pollock from 5 AWT hauls ranged in length from 12 to 68 cm FL with the majority of fish in the 35 to 45 cm FL range and a mode of 39 cm FL. The biomass estimate for the Shumagin Islands along the 151 nmi of tracklines surveyed was 15,074 t, approximately half the amount seen in 2013.

Mitrofania Island was surveyed 22-23 June along transects spaced 8 nmi apart. The majority of acoustic backscatter attributed to walleye pollock near Mitrofania Island was highest on transects to the north and west of Mitrofania Island. The vast majority of walleye pollock captured in the one AWT hau near the island ranged between 27 and 66 cm FL with a mode at 39 cm, representing age-3 fish. The biomass estimate in Mitrofania along the 47 nmi of tracklines surveyed was 14,742 t, approximately six times more than in 2013 and twice the amount seen in 2011.

Shelikof Strait was surveyed from 7-13 July along transects spaced 15 nmi apart. Walleye pollock were distributed fairly evenly throughout Shelikof Strait with more fish generally on the southern and eastern side of the trough and also along the central part of the western side of the trough. Lengths were obtained from 11 AWT hauls and ranged from 24 to 65 cm FL with a mode of 35 cm FL. The biomass estimate for the 471 nmi of trackline surveyed in Shelikof Strait was 287,804 t, which accounted for approximately 19% of the entire GOA summer survey pollock biomass and was approximately half the 2013 estimate, but still the second highest in the summer time series (since 2003). Approximately 84% of the biomass detected in Shelikof Strait were age-3 walleye pollock (89% by number).

Nakchamik Island was surveyed 12 July along transects spaced 8 nmi apart. Backscatter attributed to walleye pollock near Nakchamik Island was evenly dispersed across the 15 nmi of surveyed transects. Walleye pollock captured in the one AWT haul near Nakchamik Island from 14 and 69 cm with modes at 29 and 43 cm FL. The biomass estimate for the Nakchamik Island area was 9,147 t, approximately the same as was seen in 2013.

Alitak and Deadman Bays were surveyed 15-16 July along transects spaced 3.0 nmi apart in the outer bay, and along zig-zag transects in the inner Deadman Bay area because of the narrowness of the bay. The densest pollock aggregations in Alitak Bay occurred in the inner part of Deadman Bay. From the 3 AWT hauls conducted in the area walleye pollock ranged in length from 18 to 72 cm FL with modes at 27, 35, and 50 cm FL. The biomass estimate along the 57 nmi of trackline surveyed in Alitak/Deadman Bay area was 7,244 t, approximately half the amount that was seen in the 2013 survey. A total of 2,088 t (29%) of the overall biomass from this area was from Deadman Bay, similar to 2013 when 23% of the total biomass from this region was from Deadman Bay.

Marmot and Izhut Bays were surveyed 16-17 July along transects spaced 2 nmi apart in the inner bay and Spruce Gully, and 4 nmi apart in the outer bay. Izhut Bay was surveyed along zig-zag transects because of the narrowness of the bay. Walleye pollock were detected throughout the Bays with the greatest densities found in the outer bay and lengths from the 5 AWT hauls in Marmot Bay ranged from 18 to 67 cm FL with modes at 32 cm and 39 cm FL. The biomass estimate for Marmot Bay along the 100 nmi of trackline surveyed was 45,429 t, more than 5 times greater than the estimate in 2013. In Izhut Bay the biomass estimate along the 7 nmi of trackline surveyed was 374 t, approximately half the estimate from 2013.

Barnabas Trough was surveyed 18-20 July along transects spaced 6 nmi apart. Large aggregations of adult walleye pollock were detected in Barnabas Trough. Walleye pollock caught in 4 AWT hauls and 2 PNE hauls in Barnabas Trough ranged in size from 28 to 73 cm FL but were dominated by a single mode at 41 cm FL. The biomass estimate for the 123 nmi of trackline surveyed in Barnabas Trough was 88,906 t, approximately 6% of the entire GOA summer survey biomass estimate, and 40% greater than the amount seen in 2013, and the highest observed in the summer time series for this area (since 2003).

Chiniak Trough was surveyed 21-22 July along transects spaced 6 nmi apart. Large aggregations of adult walleye pollock were detected in Chiniak Trough. Walleye pollock caught in 4 AWT hauls in Chiniak Trough had ranged in length from 16 to 62 cm FL, with a mode at 37 cm FL. The biomass estimate for the 83 nmi of trackline surveyed in Chiniak Trough was 34,980 t, approximately 2.4% of the entire GOA summer survey biomass estimate and similar to the 2011 estimate, making the 2015 estimate the second highest in the time series (since 2003).

The Kenai Peninsula bays including Port Dick, Nuka Passage, Nuka Bay, Harris Bay, Aialik Bay, Resurrection Bay, Day Harbor, and Port Bainbridge were surveyed between 30 July and 5 Aug. All bays were surveyed using a zig-zag pattern because of the narrowness of the bays. Backscatter was relatively light but found throughout the Kenai Peninsula Bays with the densest backscatter attributed to pollock found in Harris and Resurrection Bays. Walleye pollock caught in 8 AWT and one midwater PNE haul in the Bays ranged in length from 15 to 66 cm FL and had modes at 19 cm, 25 cm, and 52 cm FL. In contrast to all other areas of the summer GOA survey, age-2 fish were most abundant by number (42%) in the Kenai Peninsula Bays and age-3 fish most abundant in biomass (23%). The biomass estimate for the 257 nmi of trackline surveyed in Kenai Peninsula Bays was 7,135 t.

Prince William Sound was surveyed 5-8 Aug along transects spaced 8.0 nmi apart. Backscatter in Prince William Sound was very sparse, with most fish located in the trough south of Montague Island. Three AWT hauls were conducted within Prince William Sound and two AWT hauls were conducted in the trough south of Montague Island from which walleye pollock ranging in length primarily from 26 to 65 cm FL with a major mode at 37 cm FL and a minor mode at 57 cm FL. The biomass estimate for the 169 nmi of trackline surveyed in Prince William Sound was 13,308 t, of which only 5,596 t was within the sound proper, roughly the same as in 2013.

Yakutat Trough was surveyed 12-13 Aug. along transects spaced 12 nmi apart. Backscatter was relatively light and diffuse in Yakutat Trough. Walleye pollock caught in the two AWT hauls in the Yakutat Trough ranged in length from 47 to 66 cm FL with a mode of 56 cm FL. The biomass estimate for the 64 nmi of transects surveyed in Yakutat Trough is 5,538 t, approximately the same amount that was seen in 2013.

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 2015. 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 2015, the thirty-seventh annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Bering Sea was conducted. One hundred-fifty-two longline hauls (sets) were completed during May 28 – August 26, 2014 by the chartered fishing vessel *Ocean Prowler*. Total groundline set each day was 16 km (8.6 nmi) long and contained 160 skates and 7,200 hooks except in the eastern Bering Sea where 180 skates with 8,100 hooks were set.

Giant grenadier (*Albatrossia pectoralis*) was the most frequently caught species, followed by sablefish (*Anoplopoma fimbria*), Pacific cod (*Gadus macrocephalus*), shortspine thornyhead (*Sebastolobus alascanus*), and Pacific halibut (*Hippoglossus stenolepis*). A total of 58,064 sablefish, with an estimated total round weight of 174,732 kg (385,218 lb), were caught during the survey. This represents a decrease of nearly 5,000 sablefish over the 2014 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 34 sablefish. Length-weight data and otoliths were collected from 1,662 sablefish. Killer whales (*Orcinus orca*) depredating on the catch occurred at nine stations in the Bering Sea and five stations in the western Gulf of Alaska. Sperm whales *(Physeter* *macrocephalus)* were observed during survey operations at 25 stations in 2015. Sperm whales were observed depredating on the gear at six stations in the central Gulf of Alaska, six stations in the West Yakutat region, and seven stations in the East Yakutat/Southeast region.

Several special projects were conducted during the 2015 longline survey. 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. Livers, ovaries, and maturity stage information were collected from all sablefish sampled for specimen data. This information will be used to help evaluate sablefish maturity and to validate visual maturity stage classifications recorded during the survey. Finally, opportunistic photo identification of both sperm and killer whales were collected for use in whale identification projects.

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

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**2015 Northern Bering Sea Integrated Ecosystem Survey – ABL**

A surface trawl survey was conducted by the Ecosystem Monitoring and Assessment program of the Alaska Fisheries Science Center from Aug 28 to Sep 21, 2016 aboard the F/V Alaskan Endeavor and included the collection of data on pelagic fish species and oceanographic conditions in the Northern Bering Sea shelf from 60°N to 65.5°N (Fig. 1). Overall objectives of the survey were to provide an integrated ecosystem assessment of the northeastern Bering Sea to support 1) the Alaska Fisheries Science Center's, Loss of Sea Ice Program and Arctic Offshore Assessment Activity Plan, 2) the Alaska Department of Fish and Game Chinook Initiative Research Initiative program, 3) the North Pacific Research Board proposal #1423, Defining critical periods for Yukon and Kuskokwim river Chinook salmon, that includes expanding the southeastern Bering Sea integrated ecosystem model to the Northeast Bering Sea shelf, and 4) sample collections within Region 2 of the Distributed Biological Observatory. Vessel support (350K) and Chinook Salmon stock composition (20K) was provided by the Alaska Department of Fish and Game as part of the Chinook Initiative Research program

(370K).  Operational support (41K), diet analysis (15K), CTD analysis (15K), and zooplankton processing (21K) was provided by by AFSC Loss of Sea Ice research program.  Participating institutions included:  1) Alaska Fisheries Science Center (AFS), Auke Bay Laboratories, Juneau, AK,  2) Alaska Department of Fish and Game (ADFG), Commercial Fisheries Division, Anchorage, AK, 3) U.S. Fish and Wildlife Servic (USFWS), Office of Migratory Bird Management, Anchorage, AK, and 4) Ocean Associates (contracting agency for AFSC).

Physical and biological data were collected from 37 surface trawl stations and oceanographic data were collected at 5 Distributed Biological Observatory stations in 2015.  Headrope and footrope depth and temperature were monitored with temperature and depth loggers (SBE39) at each station.  Average headrope depth was 1.6 m, average footrope depth was 21.3 m.  Average headrope temperature was 8.8°C, average footrope temperature was 7.6°C.  A total of 38 different species of fish and jellyfish were captured in surface trawls and included 6 species of jellyfish, 6 species of forage fish, 13 species of groundfish, 5 species of salmon, and 8 misc. fish species.

Surface trawl stations resulted in a total catch weight of 4,717, jellyfish comprised the largest catch by weight at 2,896 kg.  Jellyfish species included *Chrysaora melanaster* (2,565 kg), *Cyanea* sp. (169 kg), *Aequorea* sp. (74 kg), *Aurelia* sp. (23 kg), *Phacellophora camtschatica* (164 kg), and *Staurophora mertensi* (17 kg).  The second largest species group in surface trawl catches by biomass were forage fish species (955 kg), and included Herring (834 kg), Capelin (134 kg), Sandlance (16 kg), Rainbow Smelt (11 kg), and squid (1 kg).  Groundfish species comprised the next largest biomass at 474 kg, and included age0 Walleye Pollock (396 kg), age1 Walleye Pollock (49 kg), age0 saffron cod (25 kg), yellowfin sole (3 kg), and 10 other species each with a total catch less than 1 kg.  Salmon had the smallest catch biomass of all species groups at 396 kg, and included 125 kg of juvenile Chum Salmon, 86 kg of juvenile Pink Salmon, 42 kg of Juvenile Chinook Salmon, 36 kg of immature Sockeye Salmon, 28 kg of juvenile Coho Salmon, 16 kg of immature Chum Salmon, 4 kg of juvenile Sockeye Salmon, and 3 kg of maturing Coho Salmon.  Miscellaneous species catch (23 kg), included 12 kg of nine spine stickleback, 7 kg of Artic lamprey, 2 kg of shorthorn sculpin, and 5 other species with a total catch weight less than 1 kg.

A total catch of 258,366 individual fish and jellyfish were captured in the northern Bering Sea surface trawl stations in 2015.  Groundfish species catch were the largest at 157,138 individuals, with age 0 Walleye Pollock comprising the largest percentage at 149,043 fish, followed by age0 saffron cod at 7,887 fish.  All other groundfish species catch were below 100 individuals.  The second most abundant species group were forage fish species with a total catch of 81,196 fish, with Pacific Herring accounting for the largest catch in numbers at 57,493, followed by capelin (20,388), Pacific Sandlance (1,290), Squid sp. (1,264), and Rainbow Smelt (760).  Miscellaneous species catch (12,693) were predominately Ninespine Stickleback (12,562) and Arctic Lamprey (115), the remaining six Miscellaneous species has catches less than 10.   Salmon were the least numerically abundant species with a total catch of 4,312.  Juvenile Pink Salmon had the largest catch at 2,154, followed by juvenile Chum Salmon (1,627), juvenile

Chinook Salmon (322), juvenile Coho Salmon (84), immature Sockeye Salmon (62), immature Chinook Salmon (36) juvenile Sockeye Salmon (20), immature Chum Salmon (6), and maturing Coho Salmon (1).

Stock-specific estimates of juvenile Chinook Salmon abundance were generated from trawl catch data, genetic stock composition, and mixed layer depth expansions. A total of 4.511 million juvenile Chinook Salmon were estimated to be present in the northern Bering Sea and 44% of the juveniles were estimated to be from the Canadian-origin stock group, resulting in an abundance estimate for juvenile Canadian-origin Chinook Salmon at 1.992 million Chinook Salmon. This is an above average abundance (average abundance 1.495 million, 2003-2015) and the highest estimates of juveniles-per-spawner (70) observed since 2003 (average 34 juveniles-per-spawner). This indicates excellent early life-history survival of juvenile Chinook Salmon from the Canadian-orign stock group within the Yukon River.

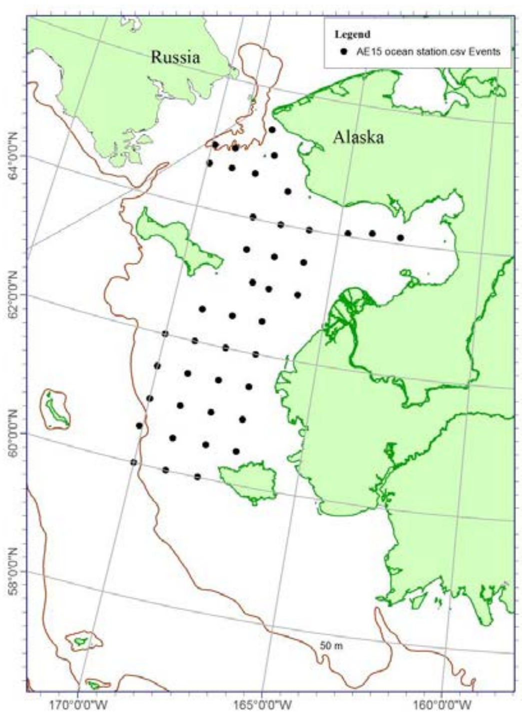


Figure 1. Stations sampled during the August 28 to September 21, 2015 integrated ecosystem survey in the northern Bering Sea.

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**2015 Gulf of Alaska Integrated Ecosystem Survey – ABL**
The Gulf of Alaska assessment is a fisheries and oceanographic survey conducted in the eastern Gulf of Alaska during the summer season (June 26 – September 4, 2015). This survey has been completed each year since 2010, and is a continuation of the monitoring efforts established by the Gulf of Alaska Integrated Ecosystem Research Project. The survey design covered the coastal and offshore eastern Gulf of Alaska in federal waters up 100 miles offshore extending roughly from Sitka Sound north to Yakutat Bay (56.5° N - 59.7° N, 136° W – 141.5° W). A Cantrawl 400/601 trawl was rigged with 6 A4 polyform bouys to fish the top 30 meters of the water column. A 250# tom weight was added to each side of the footrope to extend the vertical opening of the net. Additional sampling equipment included a Seabird Electronics CTD and associated sensors for measurement of physical water properties and water collections at depth, as well as an array of 60cm and 20cm bongo nets (zooplankton nets) equipped with 505 micron and 153 micron mesh nets, respectively. All collection locations for fish, plankton, and oceanography were made at pre-determined master station locations. A total of 66 stations were occupied and sampled, all sampling occurred during daylight hours. Approximately half way through the survey (station 36 or 66), the CTD was lost and water collections were no longer possible. The scientific objective of the survey is to assess Young of the Year (YOY) groundfish, salmon, zooplankton, and oceanographic conditions in the coastal, shelf, slope, and offshore waters of the eastern Gulf of Alaska. In 2015, the chartered fishing vessel Northwest Explorer (B&N Fisheries) was the sampling platform used to provide information on species distribution, ecosystem structure, and marine productivity in response to changes in climate patterns and temperature anomalies (i.e. the warm blob, and El Niño).

Physical and biological data and specimens were collected from all 66 trawl hauls. Samples collected included: genetic tissue, stomachs, coded wire tags, fish parasites, whole A0 groundfish for laboratory study (arrowtooth flounder, Pacific cod, Sebastes spp., and walleye pollock), zooplankton, chlorophyll a, water column nutrients, and salinity. Other physical meaurements included beam transmission, light attenuation, and dissolved oxygen. Spiny dogfish sharks (*Squalus acanthias*) accounted for 82.8% of the total biomass captured in all surface hauls. This is almost entirely due to abnormally large catches during a single day over the Fairweather Fishing Grounds. If dogfish sharks are not considered, the hydrozoan jellyfish *Aequorea* sp. accounts for nearly 36% of the total biomass captured in all surface hauls, followed by Pacific pomfret (*Brama japonica*, 20%), and adult pink salmon (*Oncorhynchus gorbuscha*, 8.5%). The hydrozoan jellyfish *Aequorea* sp. accounts for 25% of the total number of animals captured in all surface hauls, followed by spiny dogfish sharks 25%, squids 12%, and the moon jellyfish (*Aurelia* sp., 10%). Removal of the total number of dogfish sharks does not change the order of percent number captured for other species.

Water temperatures in 2015 were warmer than average, especially in surface waters. Surface temperatures near the coast were approaching 16° C and typically above 14° C at the offshore stations. In 2010 – 2012, temperatures were in the range of 10 - 12° C. The total catch of A0 pollock during the 2015 survey was 244 fish, compared to 5,586 in 2014 and and 3,965 in 2013. The 2015 catch of A0 pollock is the lowest (by an order of magnitude) than any observed since the inception of the survey in 2010. This is similar to number reported from the central and western Gulf of Alaska during summer A0 pollock surveys conducted by the Fisheries-Oceanography Cooperative Investigations program, also at AFSC.

For more information contact Wess Strasburger at **wes.strasburger@noaa.gov**

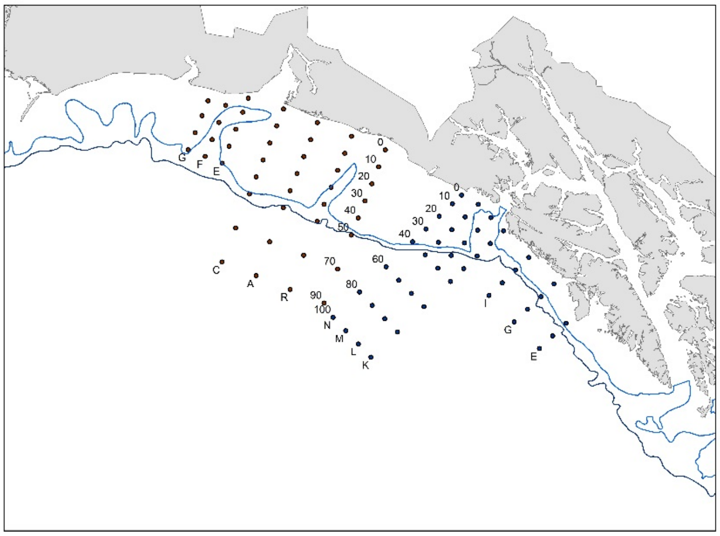

Figure 1. Station locations for the 2015 Gulf of Alaska integrated ecosystem survey conducted during July to August.

**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, rockfishes, and Pacific cod. These objectives will be addressed via 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 2015 off southeast Alaska by the F/V Northwest Explorer, a chartered commercial trawler. Fish samples were collected using a midwater rope trawl (Cantrawl model 400/601) 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, or to a maximum depth of 200 m.

We sampled a reduced sample grid that spanned from Sitka Sound north to Yakutat Bay during summer 2015 in order to accommodate other AFSC sampling. The five species of marine fish captured with the highest frequency in surface trawls during the 2015 field season were age-0 rex sole, Pacific pomfret, age-0 walleye pollock, juvenile wolf eel, and prowfish (Fig. 1-3). For more information, contact Wesley Strasburger at (907)-789-6009 or wes.strasburger@noaa.gov

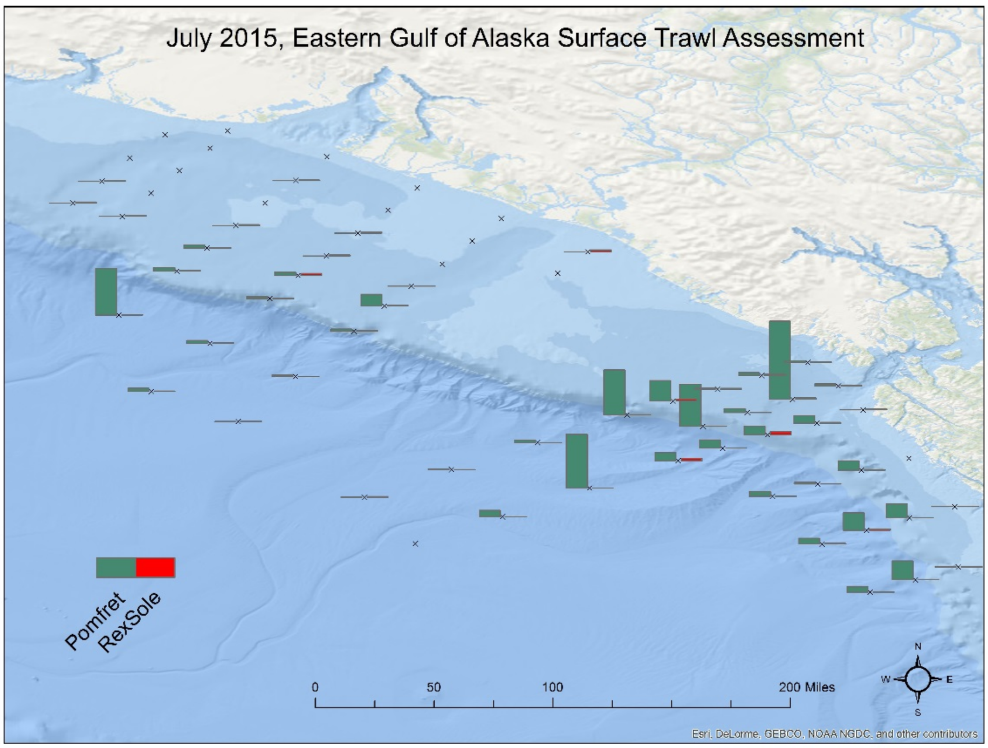


Figure 1. Catch per 30 minute net tow for age-0 rex sole and Pacific pomfret in the eastern Gulf of Alaska during July 2015.

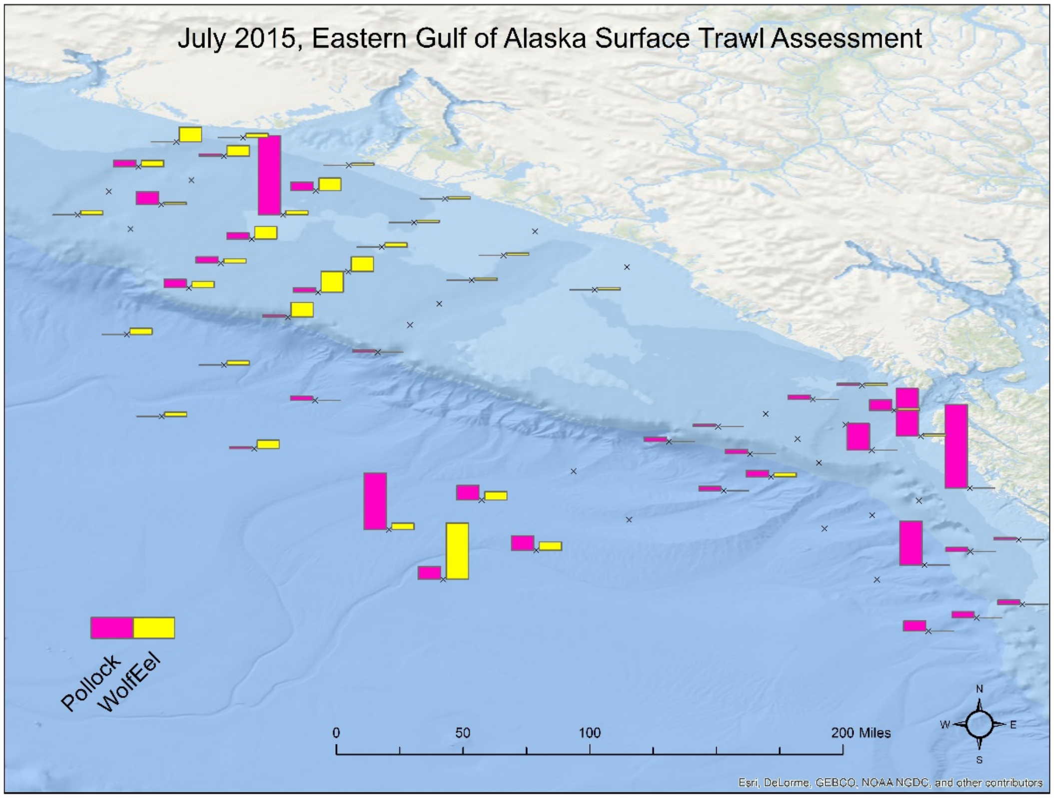


Figure 2. Catch per 30 minute net tow for age-0 pollock and juvenile wolf eel in the eastern Gulf of Alaska during July 2015.

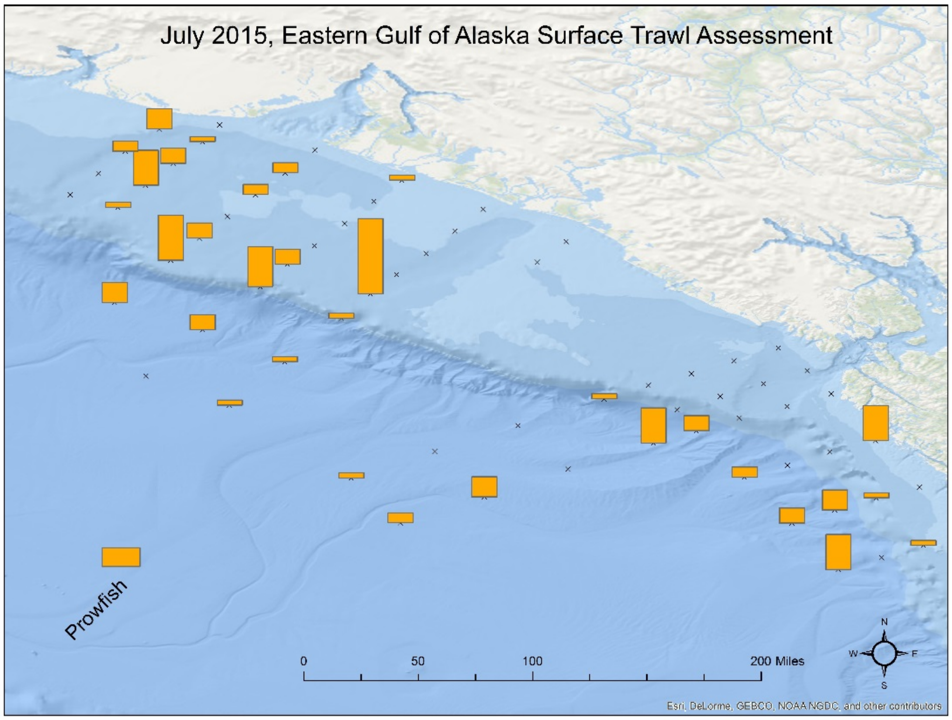


Figure 3. Catch per 30 minute net tow for prowfish in the eastern Gulf of Alaska during July 2015.

## 2015 Southeastern Bering Sea Integrated Ecosystem Survey – ABL

### Late-Summer Pelagic Trawl Survey (BASIS) in the Southeastern Bering Sea, September –October 2015

Due to an unusual warming anomaly, we requested special funding for a 2015 southeastern Bering Sea (SEBS) survey to collect ecosystem data during the second warm year (2014, 2015), following a series of cool years (2007 – 2013). Scientists from the Recruitment Processes Alliance (RPA) of the Alaska Fisheries Science Center (AFSC) conducted a fisheries-oceanographic survey in the (SEBS) during the early fall aboard the NOAA Vessel *Oscar Dyson* from September 5 to October 3 2015. The survey design covered the SEBS shelf between roughly the 50 m and 200 m isobaths, from 162º W to 171º W (Figure 1). A new midwater trawl was used to obliquely sample the entire water column (200 m maximum) for fishes and jellyfishes, in contrast to the larger midwater trawls that were used to sample the surface (top 20 m) in past years. In addition, the survey included sampling the 70 m isobath and the Distributed Biological Observatory (DBO) stations, two long-term time series describing the physical and biological properties of the Bering Sea shelf, from approximately 56.5º N to 63.5º N. Prior to the RPA surveys, fisheries-oceanographic surveys were conducted annually (2002-2012, 2014) as part of the Bering-Aleutian Salmon International Survey (BASIS) and eventually Bering Sea Project (BSP). The main objective of RPA surveys in the SEBS is to collect ecosystem data with a priority to provide mechanistic understanding of the factors that influence recruitment of walleye pollock (*Gadus chalcogrammus*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*).

Physical and biological data were collected from 49 pelagic trawl stations and at an additional 68 70 m isobath stations. Poor weather and unexpected delays resulted in the decision to not sample the DBO stations. Samples for laboratory studies of fishes, jellyfishes, and zooplankton were collected for age, diet, energetics, genetics, and isotopes. In addition, samples for physical and biological measurements were collected for chlorophyll a, water column nutrients, and salinity.

Midwater trawl station catches were comprised of over 25 fish species and over 8 jellyfish species. Jellyfish dominated the catches by weight (89.0%), followed by age-1+ pollock (9.1%) and age-0 pollock (0.8%). Jellyfish species included *Chrysaora melanaster* (60.0% by weight), *Aequorea* sp. (22.6% by weight), *Cyanea capillata* (5.3% by weight), *Aurelia* sp. (0.6% by weight), and other miscellaneous jellyfishes (0.5% by weight). Age-0 pollock was the most abundant by number (36,902), followed by *Aequorea* sp. (21,711) and *Chrysaora melanaster* (8,298). Other miscellaneous fish and invertebrate species that contributed to the catch by number were age-1+ pollock (2920), *Cyanea capillata* (2111), *Hydromedusae* sp. (1827), *Aurelia* sp. (212), squid (*Gonatus* sp., 163), eulachon (*Thaleichthys pacificus*, 82), shrimp (Caridea, 73), lantern fish (Mytophidae, 71), Pacific herring (*Clupea pallasi*, 47), yellowfin sole (*Limanda* *aspera*, 34), and capelin (*Mallotus villosus*, 31). For more information contact Wess

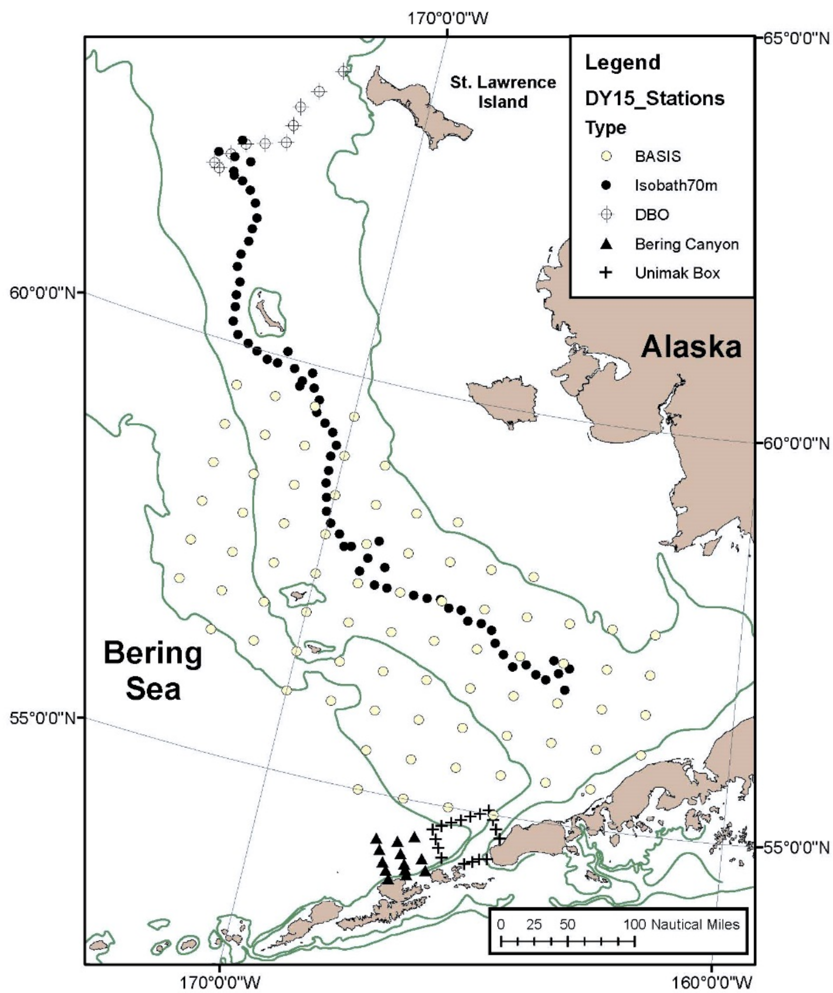


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Figure 1. Station locations for the August to October 2015 southeastern Bering Sea integrated ecosystem survey also known as BASIS.

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

The North Pacific Groundfish and Halibut Observer Program (Observer Program) provides the regulatory framework for NMFS-certified observers to obtain information necessary to conserve and manage the groundfish and halibut fisheries in the Gulf of Alaska (GOA) and the Bering Sea and Aleutian Islands (BSAI) management areas. Data collected by well-trained, independent observers are a cornerstone of management of the Federal fisheries off Alaska. These data are needed by the North Pacific Fishery Management Council (Council) and NMFS to comply with the

Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the Marine Mammal Protection Act, the Endangered Species Act, and other applicable Federal laws and treaties.

Observers collect biological samples and fishery-dependent information used to estimate total catch and interactions with protected species. Managers use data collected by observers to manage groundfish and prohibited species catch within established limits and to document and reduce fishery interactions with protected resources. Scientists use observer data to assess fish stocks, to provide scientific information for fisheries and ecosystem research and fishing fleet behavior, to assess marine mammal interactions with fishing gear, and to assess fishing interactions with habitat. Although NMFS is working with the Council and industry to develop methods to collect some of these data electronically, currently much of this information can only be collected independently by human observers.

In 2013, the Council and NMFS restructured the Observer Program to place all vessels and processors in the groundfish and halibut fisheries off Alaska into one of two categories: (1) the full coverage category, where vessels and processors obtain observers by contracting directly with observer providers, and (2) the partial coverage category, where NMFS has the flexibility to deploy observers when and where they are needed based on an annual deployment plan (ADP) developed in consultation with the Council. Some vessels and processors may be in full coverage for some of the fisheries in which they participate and in partial coverage in other fisheries. Funds for deploying observers in the partial coverage category are provided through a system of fees based on the ex-vessel value of retained groundfish and halibut in fisheries and landings that are not in the full coverage category.

The purpose of restructuring the Observer Program was to:

- reduce the potential for bias in observer data,
- authorize the collection of observer data in fishing sectors that were previously not required to carry observers,
- allow fishery managers to provide observer coverage to respond to the scientific and management needs, and
- assess a broad-based fee to more equitably distribute the costs of observer coverage.

Under the restructured Observer Program, all vessels and processors in the groundfish and halibut fisheries off Alaska are assigned to one of two observer coverage categories (1) a full coverage category; or (2) a partial coverage category.

The full coverage category includes:

- catcher/processors (with limited exceptions),
- motherships,

- catcher vessels while participating in programs that have transferable prohibited species catch (PSC) allocations as part of a catch share program,
- inshore processors when receiving or processing Bering Sea pollock.

NMFS recommended that all catcher/processors and motherships be placed in full coverage to obtain independent estimates of catch, at-sea discards, and PSC for these vessels. At least one observer on each catcher/processor eliminates the need to estimate at-sea discards and PSC based on industry provided data or observer data from other vessels.

Catcher vessels participating in programs with transferable PSC allocations as part of a catch share program also are included in the full coverage category while they are participating in these programs. These programs include Bering Sea pollock (both American Fisheries Act and Community Development Quota [CDQ] programs), the groundfish CDQ fisheries (CDQ fisheries other than halibut and fixed gear sablefish), and the Central GOA Rockfish Program.

Under the catch share programs, quota share recipients are prohibited from exceeding any allocation, including, in many cases, transferable PSC allocations. All allocations of exclusive harvest privileges create some increased incentive to misreport as compared to open access or limited access fisheries. Transferable PSC allocations present challenges for accurate accounting because these species are not retained for sale and they represent a potentially costly limitation on the full harvest of the target species. To enforce a prohibition against exceeding a transferable target species or PSC allocation, NMFS must demonstrate that the quota holder had catch that exceeded the allocation. Supporting a quota overage case for target species or PSC that could be discarded at sea from an unobserved vessel requires NMFS to rely on either industry reports or estimated catch based on discard rates from other similar observed vessels. These indirect data sources create additional challenges to NMFS in an enforcement action. In addition, the smaller the pool from which to draw similar observed vessels and trips, the more difficult it is to construct representative at-sea discard and PSC rates for individual unobserved vessels.

Inshore processors taking deliveries of Bering Sea pollock are in the full coverage category because of the need to monitor and count salmon under transferable PSC allocations.

The partial observer coverage category includes:

- catcher vessels designated on a Federal Fisheries Permit when directed fishing for groundfish in federally managed or parallel fisheries, except those in the full coverage category;
- catcher vessels when fishing for halibut individual fishing quota (IFQ) or sablefish IFQ (there are no PSC limits for these fisheries);
- catcher vessels when fishing for halibut CDQ, fixed gear sablefish CDQ, or groundfish CDQ using pot or jig gear (because any halibut discarded in these

CDQ fisheries does not accrue against the CDQ group's transferable halibut PSC allocation);

- catcher/processors that meet criteria that allows assignment to the partial coverage category;
- shoreside or stationary floating processors, except those in the full coverage category.

For more information on the North Pacific Groundfish and Halibut Observer Program contact Chris Rilling at (206) 526-4194 or chris.rilling@noaa.gov

## III. Reserves

## IV. Review of Agency Groundfish Research, Assessment, and Management

### A. Hagfish

### B. Dogfish and other sharks

***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. Seven 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 have completed a North Pacific Research Board funded project (project #1106) to investigate alternative ageing methods for spiny dogfish. Three manuscripts are in preparation, one of which has been accepted for publication to Marine Fisheries Review, as well as a final report to NPRB (available at: http://project.nprb.org/view.jsp?id=c899f0ae-4f0c-46a9-898d-757688579a1c). 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. 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. 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 is to investigate the population structure of sleeper sharks in Alaskan waters. Tissue samples have been opportunistically collected from ~200 sharks from the West Coast, 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 as part of a pilot study. 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. Continued sample collection and 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.

***Stock Assessment***

**Sharks - ABL**

The shark assessments in the Bering Sea/Aleutian Islands (BSAI) and the Gulf of Alaska (GOA) are on 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 BASI sharks and an executive summary for the GOA sharks is planned for the fall of 2016.

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 2003-2015 were updated from the NMFS Alaska Regional Office's Catch Accounting System. In the GOA, total shark catch in 2015 was 1,414 t, which is down from the 2014 catch of 1,553 t (the greatest catch of the full time series). An impact of observer restructuring (beginning in 2013) 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 75 t and 119 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 2015 would be 1,567 t, which is still below the recommended acceptable biological catch (ABC) for the shark complex.

Survey biomass was updated for the 2015 GOA assessment. The trawl survey biomass estimates are only used for spiny dogfish. The 2015 survey biomass estimate (51,916 t, CV = 25%) is about a third of the 2013 biomass estimate of 160,384 t (CV = 40%); this variability is typical for spiny dogfish. The random effects model for survey averaging was used for calculating the spiny dogfish ABC and OFL, 56,181 t.

In the BSAI, estimates of shark catch from the Catch Accounting System from 2014 were 106 t. Pacific sleeper shark are the primary species caught. These catch estimates do incorporate the restructured observer program, but the impact appears to be minimal for BSAI sharks. The survey biomass estimates on the BSAI are highly uncertain and not informative for management purposes.

For the GOA assessment, spiny dogfish are a “Tier 6” species, but 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=4,514 t and OFL= 6,020 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.

## C. Skates

1. **Research**
2. **Stock Assessment**

**Bering Sea**

This chapter was presented in executive summary format, as a scheduled “off-year” assessment. The following new data were included in this year’s assessment: Updated 2014 and preliminary 2015 catch and 2015 EBS shelf survey data. No changes were made to the assessment model. The projection model for Alaska skate was re-run with the most recent catch data (the 2015 EBS shelf survey data are not included in the projection model) and the Tier 5 random effects model was re-run for the other sharks component of the assemblage.

The 2015 biomass estimates from the shelf survey increased slightly from 2014. In the case of Alaska skates, survey biomass estimates, though variable, are basically trendless since species identification began in 1999. Model estimates of spawning biomass are also basically trendless over the 1992-2014 period covered by the model.

Since 2011, the Alaska skate portions of the ABC and OFL have been specified under Tier 3, while the “other skates” portions have been specified under Tier 5. Because projected spawning biomass for 2016 (115,378 t) exceeds $B_{40\%}$ (74,769 t), Alaska skates are managed in sub-tier “a” of Tier 3. Other reference points are $maxF_{ABC} = F_{40\%} = 0.077$ and $F_{OFL} = F_{35\%} = 0.090$. The Alaska skate portions of the 2016 and 2017 ABCs are 34,358 t and 32,167 t, respectively, and the Alaska skate portions of the 2016 and 2017 OFLs are 39,847 t and 37,306 t. The “other skates” component is assessed under Tier 5, based on a natural mortality rate of 0.10 and a biomass estimated using the random effects model that fits survey abundance estimates. The “other skates” portion of the 2016 and 2017 ABCs is 7,776 t for both years and the “other skates” portion of the 2016 and 2017 OFLs is 10,368 t for both years. For the skate complex as a whole, OFLs for 2016 and 2017 total 50,215 t and 47,674 t, respectively, and ABCs for 2016 and 2017 total 42,134 t and 39,943 t, respectively.

GOA

Skates are assessed on a biennial schedule with full assessments presented in odd years to coincide with the timing of survey data. A full assessment was completed for 2015.

New inputs this year were the biomass estimates and length composition data from the 2015 GOA bottom trawl survey, updated groundfish fishery catch data, and fishery length composition data through 2015. The random effects (RE) model was used to estimate survey biomass. In response to Plan Team and SSC requests, a separate RE model was run for each managed group, and for each regulatory area. The 2015 survey biomass estimates for big skates increased substantially, mainly due to an increase in the Central GOA estimate. This reversed a decline in Central GOA big skate biomass that began in 2003. The biomass for longnose skate and "other skates" decreased slightly relative to 2013, but in general the biomass for both groups has remained stable since 2000.

The application of the RE model to the survey data for each skate category continues to provide reasonable results for biomass estimates.

The catches of all skate species groups are substantially lower than in the years preceding 2014 (particularly 2009-2013). This decrease likely is due to prohibitions on retention of big skates in the CGOA (beginning in 2013), which discouraged “topping-off” behavior that resulted in high levels of catch, particularly for big skates in the CGOA.

Skates are managed in Tier 5 in the Gulf of Alaska. Applying $M$=0.1 and 0.75$M$ to the estimated biomass from the random effects models for each stock component, gives stock specific OFLs and ABCs. Catch as currently estimated does not exceed any gulf-wide OFLs, and therefore, is not subject to overfishing. It is not possible to determine the status of stocks in Tier 5 with respect to overfished status.

## D. Pacific Cod

### *1. Research*

Genetic variation among Pacific cod is being used to investigate wide-scale seasonal and ontogenetic movement patterns. Analyses of 6442 single nucleotide polymorphisms (SNPs) from the cod genome showed a strong isolation-by-distance (IBD) pattern along a geographic gradient. The large number of genetic markers, along with the strong IBD relationship, provided significant power to assign individuals to putative genetic ‘stocks’ obtained from samples collected at or near spawning time, when population site fidelity is assumed to be highest. Correct assignment of individuals to putative source populations ranged from 88-100%, suggesting the potential use of this approach to estimate wide-scale migration patterns. By genetic assignment of individuals spanning multiple year classes collected during the summer, when cod are known to go on feeding migrations, to putative source populations, we anticipate resolving seasonal and ontogenetic migration patterns in cod that have not been obtained with conventional physical tagging efforts.

### *2. Stock Assessment*

**Bering Sea**- For the 2015 stock assessment, all survey and commercial data series on CPUE, catch at age, and catch at length were updated. There were no changes in the assessment model and the 2016 specifications were based on the same model used in 2011-2014. Last year the Plan Team expressed serious reservations about this model’s poor retrospective performance and continued reliance on a fixed value of survey catchability that lacks credibility.

The Plan Team requested a different model for this year, and the author presented a version that has been in development for a few years, but he judged it not yet ready for use. It produces OFL/ABC estimates much lower than the present model. The EBS assessment will receive a CIE review in February 2016, and the Plan Team looks forward to seeing an improved model next year.

Survey biomass in 2015 was about the same as in 2014: just above a million tons, which is at the upper end of the range of values observed since 1977. As estimated in the current model, the spawning biomass of 409,000 t is well above $B_{40\%}$ (330,000 t) and increasing briskly, driven by a number of strong year-classes beginning in 2006 and also in 2008, 2011 and 2013. This increasing trend can be counted on despite any weaknesses in the present assessment model because the relative year-class strengths are well determined even if the scale is not. That is, even if the recommended ABC is somewhat high, spawning biomass will be higher next year than it is this year.

This stock is assigned to Tier 3a. The maximum 2016 ABC in this tier as calculated using the present model fit is 332,000 t, but the author recommended that ABC be held at the 2014 level of 255,000 t, as it was last year, to compensate for the poor retrospective behavior of the present model and the continuing concerns about the fixed survey catchability. The same value was recommended for the preliminary 2017 ABC. The corresponding OFLs (from the model) are 390,000 t and 412,000 t.

EBS Pacific cod is not being subjected to overfishing, is not overfished, and is not approaching an
overfished condition.

**Aleutian Islands**- This stock has been assessed separately from Eastern Bering Sea cod since 2013, and managed separately since 2014. Both age-structured (Tier 3) and survey-based (Tier 5) assessments have been considered, but to date it has not been possible to obtain a usable fit from any of the age-structured models that have been attempted. This year's assessment is the same Tier 5 method used since the 2013 assessment: a simple random effects model of the trawl survey biomass trajectory. The Aleutians cod assessment will receive a CIE review in February 2016.

After declining by more than half between 1991 and 2002, survey biomass has since stayed in the range of 50-100 kilotons. The last Aleutians survey was in 2014. The author recommended using the Tier 5 assessment again for 2016 where ABC=17,600 t and OFL=23,400 t. These are the same as last year because there was no Aleutian Islands trawl survey in 2015.
This stock is not being subjected to overfishing.

**Gulf of Alaska**
The fishery catch data series was updated for 2014 and 2015 (projected for 2015 expected total year catch). Fishery size composition data were updated for 2014, and preliminary fishery size composition were included for 2015. Estimates of biomass, numbers, and length compositions from the 2015 bottom trawl survey were also included. The 2015 trawl survey biomass estimate was 50% lower than the 2013 estimate.

The assessment evaluated three models. Model 1 is identical to the final model configuration from 2014. Model 2 and 3 differed from Model 1 by using only the 27 cm plus trawl survey abundance, length, and age compositions, 4 blocks of survey selectivity instead of 3, capping sample sizes for fishery length composition data at 400, and lowering likelihood weights for fishery length compositions.

Model 3 differed from Model 2 by including an additional block for fishery selectivity-at-length for 2013 through 2015 for all gear-season combinations except for pot gear in season three (data were limited in that category). This selectivity change was made to account for possible changes in the characteristics of the fishery length data since the fishery observer program was restructured in 2013. The authors recommended Model 3.

***Spawning biomass and stock trends***

According to Model 3, $B_{40\%}$ for this stock is estimated to be 130,000 t, and projected spawning biomass in 2016 is 165,600 t. The estimated recruitment was well above average for the 2005-2008 year classes and mostly below average for the 2009-2014 year classes. Spawning biomass is expected to decline in the near term.

***Tier determination/ Plan Team discussion and resulting ABC and OFL recommendations***

Models 2 and 3 with the likelihood weight on fishery length compositions reduced from 1 to 0.25 were preferred over Model 1 because Models 2 and 3 fit the trawl survey abundance index better than Model 1 or other Model 2 and 3 configurations with higher weights on fishery length data. Model 3 fit the survey index and most fishery length compositions better than Model 2. The Plan Team accepted the author's recommendation to use Model 3 (with 0.25 weight on fishery length data) as the preferred model.

Since 2016 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 0.495 and 0.407, respectively. The maximum permissible ABC estimate (98,600 t) is a 4% decrease from the 2015 ABC of 102,850 t.

***Status determination***

The stock is not being subjected to overfishing and is neither overfished nor approaching an overfished condition.

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

## E. Walleye Pollock

### *1. Research*

**Energy Density and Recruitment of Walleye Pollock - ABL**

In 2015 calorimetric analysis of pollock samples collected in 2014 and 2015, including those collected north 60 degrees. Previous analysis had indicated that energy densities tracked climate conditions in the southeastern Bering Sea so that warm conditions

(2003-2005) were associated with low energy densities and cool conditions (2006-2012) were associated with high energy densities. These variations in energetic status have been shown to correlate with pollock recruitment in the Bering Sea. In 2014 the eastern Bering Sea south of 60° N shifted back to warm conditions following a prolonged cool period. Accordingly, we observed a decrease in energy density between 2012 and 2014 (no survey was conducted in 2013). In 2015 the eastern Bering Sea continued to be very warm, although retreating sea ice left a large pool of cold water north of 60°, creating conditions much like those observed in the southern Bering Sea between 2006-2012. We observed a strong latitudinal pattern of energy densities in walleye pollock, suggesting conditions in the northern Bering Sea were more conducive to pollock production than those to the south.

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**Pre- and Post-Winter Temperature Change Index and the Recruitment of Bering Sea Pollock - ABL**

*Description of indicators:* The temperature change (TC) index is a composite index for the pre- and post-winter thermal conditions experienced by walleye pollock (*Gadus chalcogramma*) from age-0 to age-1 in the eastern Bering Sea (Martinson et al., 2012). The TC index (year t) is calculated as the difference in the average monthly sea surface temperature in June (t) and August (t-1) (Figure 1) in an area of the southern region of the eastern Bering Sea (56.2°N to 58.1°N latitude by 166.9oW to 161.2oW longitude). Time series of average monthly sea surface temperatures were obtained from the NOAA Earth System Research Laboratory Physical Sciences Division website. Sea surface temperatures were based on NCEP/NCAR gridded reanalysis data (Kalnay et al., 1996, data obtained from http://www.esrl.noaa.gov/psd/cgi-bin/data/timeseries/timeseries1.pl). Less negative values represent a cool late summer during the age-0 phase followed by a warm spring during the age-1 phase for pollock.

*Status and trends:* The 2015 TC index value is -5.96, lower than the 2013 TC index value of -3.84. Both the late summer and following spring sea temperatures were warmer than average. The TC index was positively correlated with subsequent recruitment of pollock to age-1 through age-6 for based on abundance estimates from Table 1.25 in Ianelli et al. 2014 (Table 1). Over the longer period (1964-2014), the TC index was more statistically significant for the age-1, age-2, and age-3 pollock, than for the older pollock (Table 1). For years 2002-2014, this relationship was less statistically significant.

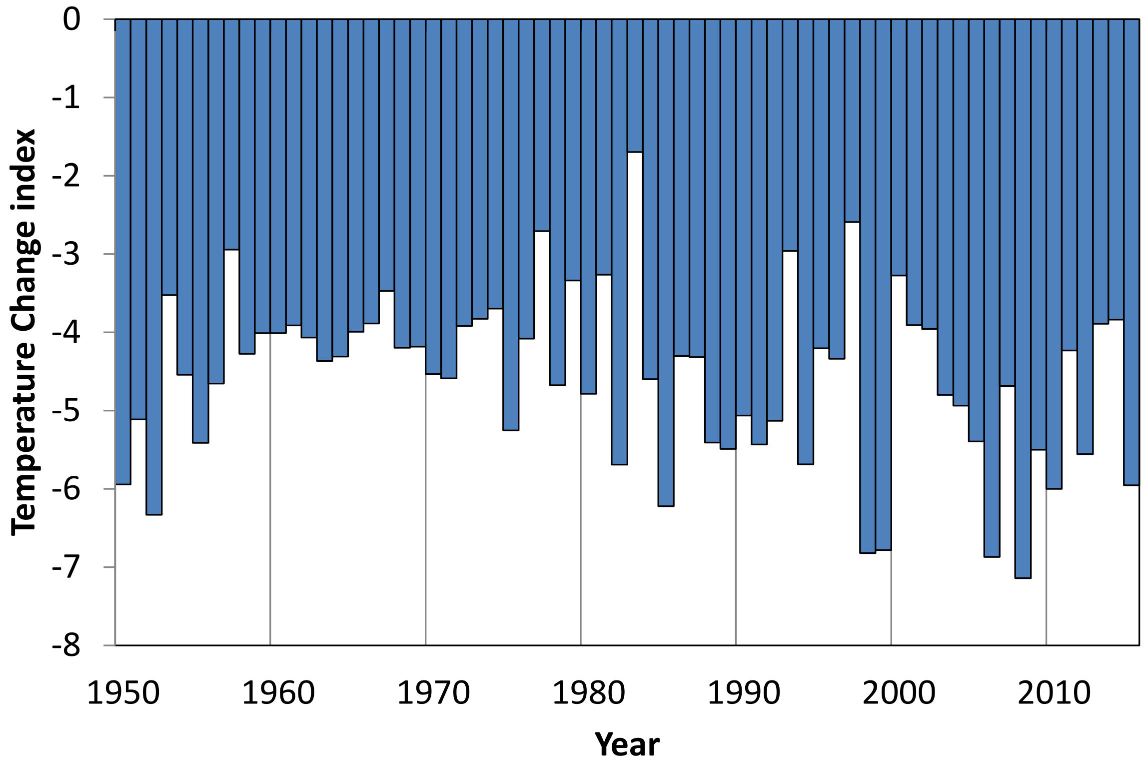


Figure 1: The Temperature Change index values from 1950 to 2015.

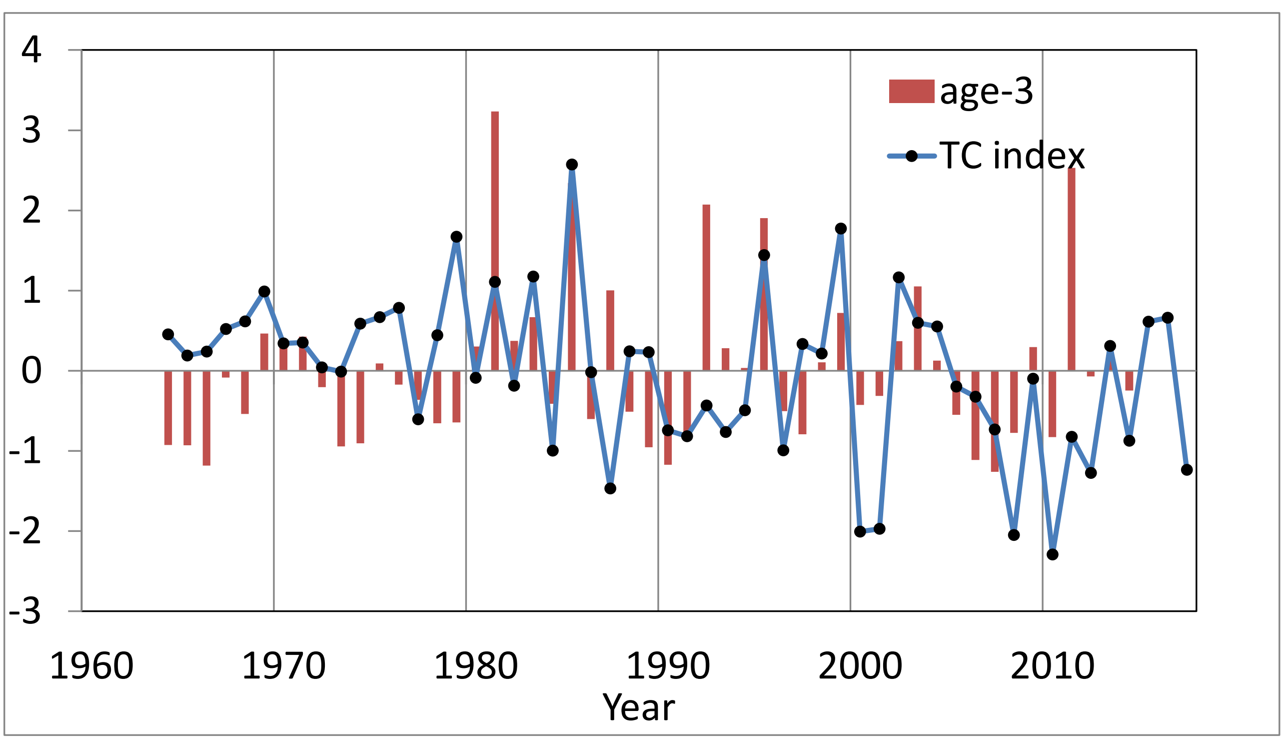

Figure 2: Normalized time series values of the temperature change index (t-2) and the estimated abundance of age-3 walleye pollock in the eastern Bering Sea (t) from Table 1.25 in Ianelli et al. 2014.

Table 1: Pearson's correlation coefficient relating the temperature change index to subsequent estimated year class strength of pollock (Age-x+1). Bold values are statistically significant ($p < 0.05$).

| | Correlation | | | | |
|---|---|---|---|---|---|
| | Age 1 (t) | Age 2 (t+1) | Age 3 (t+2) | Age 4 (t+3) | Age 5 (t+4) |
| 1964-2014 | **0.38** | **0.38** | **0.36** | **0.31** | 0.28 |
| 2002-2014 | 0.29 | 0.29 | 0.21 | 0.21 | 0.17 |

*Factors causing observed trends:* The age-0 pollock are more energy-rich and have higher over wintering survival to age-1 in a year with a cooler late summer (Coyle et al., 2011; Heintz et al., 2013). Warmer spring temperatures lead to an earlier ice retreat, a later oceanic and pelagic phytoplankton bloom, and more food in the pelagic waters at an optimal time for use by pelagic species (Hunt et al., 2002, 2011; Coyle et al., 2011). Colder later summers during the age-0 phase followed by warmer spring temperatures during the age-1 phase are assumed favorable for the survival of pollock from age-0 to age-1.

*Implications:* In 2013, the TC index value of -3.89 was above the long-term average of -4.60, therefore we expect slightly above average numbers of pollock to survive to age-3 in
2015 (Figure 2). In the future, the TC values of -5.96 in 2015 indicate an expected below average abundances of age-3 pollock in 2017.

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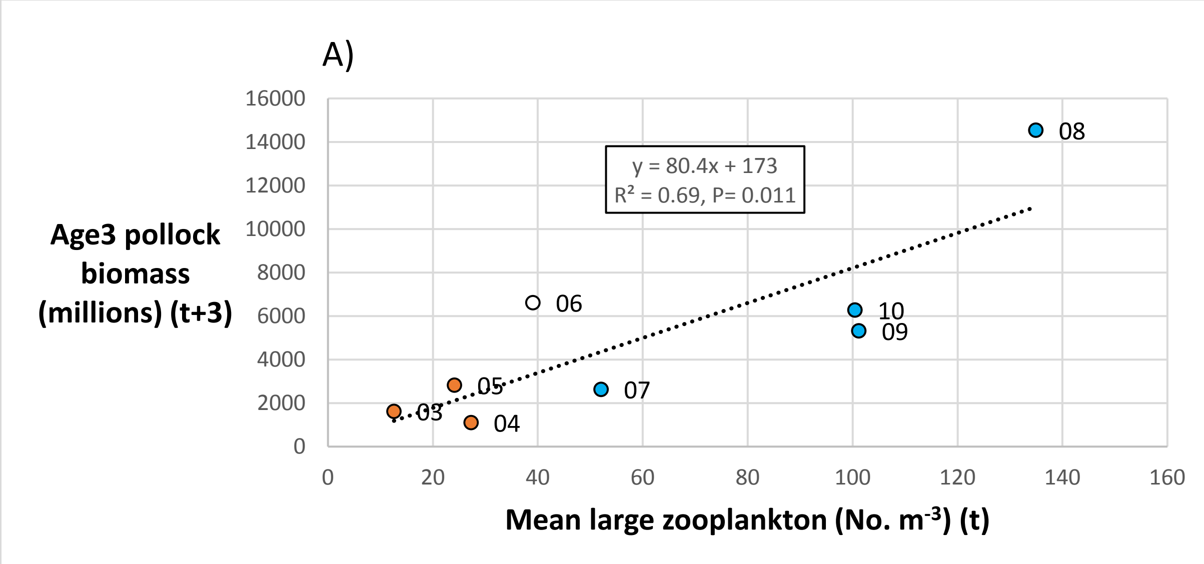
**Large zooplankton abundance as an indicator of pollock recruitment to age-3 in the southeastern Bering Sea – ABL**

*Description of indicator:* Interannual variations in large zooplankton abundance (sum of all large zooplankton taxa, excluding euphausiids) were compared to age 3 walleye pollock abundance (millions of fish) per biomass (thousands of tons) of spawner for year classes 2003-2010 on the southeastern Bering Sea shelf. Zooplankton samples were collected with oblique bongo tows over the water column (60 cm, 505 µm mesh nets) on BASIS fishery oceanography surveys during mid-August to late September, for three warm years (2003-2005) followed by one average (2006) and four cold years (2007-2010) (Eisner et al., 2014). Pollock abundance and biomass was available from the stock assessment report for the 2006-2013 year classes (Ianelli et al., 2014).

*Status and trends:* For the 2003-2010 year classes of pollock, a positive significant (P= 0.011) linear relationship was found between mean abundances of large zooplankton at year t (when pollock were age-0), and age3 pollock abundance at year t+3 (Fig. A). A strong relationship (P = 0.004) was also observed for large zooplankton and age 3 pollock abundance (t+3)/ spawner biomass (t) (Fig. B). These results suggest that increases in the availability of large zooplankton prey during the first year at sea were favorable for age-0 pollock survival and recruitment into the fishery at age 3.

*Factors influencing observed trends*: Increases in sea ice extent and duration were associated with increases in large zooplankton abundances on the shelf (Eisner et al., 2014), increases in large copepods and euphausiids in pollock diets (Coyle et al., 2011) and increases in age-0 pollock lipid content (Heintz et al., 2013). The increases in sea ice and associated ice algae and phytoplankton blooms may provide an early food source for large crustacean zooplankton reproduction and growth (Baer and Napp 2003; Hunt et al., 2011). These large zooplankton taxa contain high lipid concentrations (especially in cold, high ice years) which in turn increases the lipid content in their predators such as age-0 pollock and other fish that forage on these taxa. Increases in energy density (lipids) in age-0 pollock allow them to survive their first winter (a time of high mortality) and eventually recruit into the fishery. Accordingly, a strong relationship has been shown for energy density in age0 fish and age3 pollock abundance (Heintz et al., 2013).

*Implications:* If the relationship between large zooplankton and age 3 pollock remains robust as more years are added to the analysis, this index could be used to predict the survival of pollock three years in advance of recruiting to age 3, the year pollock enter the fishery, from zooplankton data collected 3 years prior. This relationship also provides further support for the revised oscillating control hypothesis that suggests as the climate warms, reductions in the extent and duration of sea ice could be detrimental large crustacean zooplankton and subsequently to the pollock fishery in the southeastern Bering Sea (Hunt et al., 2011).

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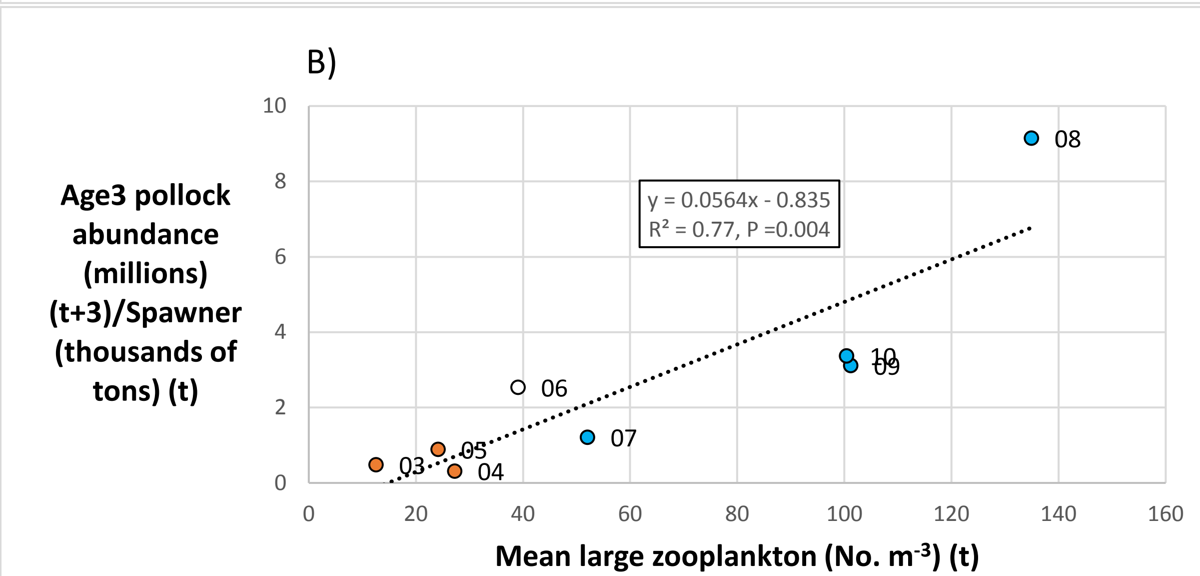


Figure 1. Linear relationships between A) mean large zooplankton abundance (t) and A) age 3 pollock abundace (t+3) and between B) mean large zooplankton abundance (t) and age3 pollock abundance (t+3)/Spawner biomass (t). Orange symbols are warm (low ice) years, blue are cold (high ice) years and white is an average year. Year classes (when pollock were age 0) and zooplankton were collected are shown next to symbols.

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**Salmon, Sea Temperature, and the Recruitment of Bering Sea Pollock – ABL**

*Description of indicator:* Chum salmon growth and sea temperature were used to predict the recruitment of pollock to age-1 in 2014 and 2015 (Yasumiishi et al. 2015). 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 temperatureBering Sea and used the model parameters and biophysical indices from 2013 and 2014 to predict age-1 pollock abundances in 2014 and 2015. Estimates of age-1 pollock abundance were from Ianelli et al. (2014).

*Status and trends:* Pollock recruitment was highly variable within the 10-year time series, 2001-2010 (Figure 1). 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 ($R^2$ = 0.73; p – value = 0.008).

Model residuals (Figure 2) had an alternating year pattern. A slight alternating year pattern was observed in the time series, with higher recruitment to age-1 in odd-numbered years. The higher than expected (positive residuals) recruitment to age-1 in odd-years (age-0 in even-numbered years) may be associated with fewere adult pink salmon (a predator and competitor) in even-years as age-0s or as a predator buffer in odd-years during the early spering age-1 stage of pollock.

*Factors influencing observed trends:* The model parameters (2001-2010) and biophysical indices (2013and 2014) were used to predict the recruitment of Bering Sea pollock in 2014. The 2013 biophysical indices (chum salmon growth = 0.969 kg, spring sea temperature = 3.95°C) produced a forecast of 14 million (3,837 standard error, c.v. = 0.22) age-1 pollock in 2014. The 2014 biophysical indices (chum salmon growth = 0.80 kg, spring sea temperature = 4.00°C) produced a forecast of 5 million age-1 pollock in 2015.
The 2014 biophysical indices indicated below ocean productivity (chum salmon growth) and warm spring sea temperatures (less favorable). These factors are expected to result in below average age-1 pollock recruitment in 2015.

*Implications:* The model predicts a below average recruitment of pollock to age-1 in 2015.

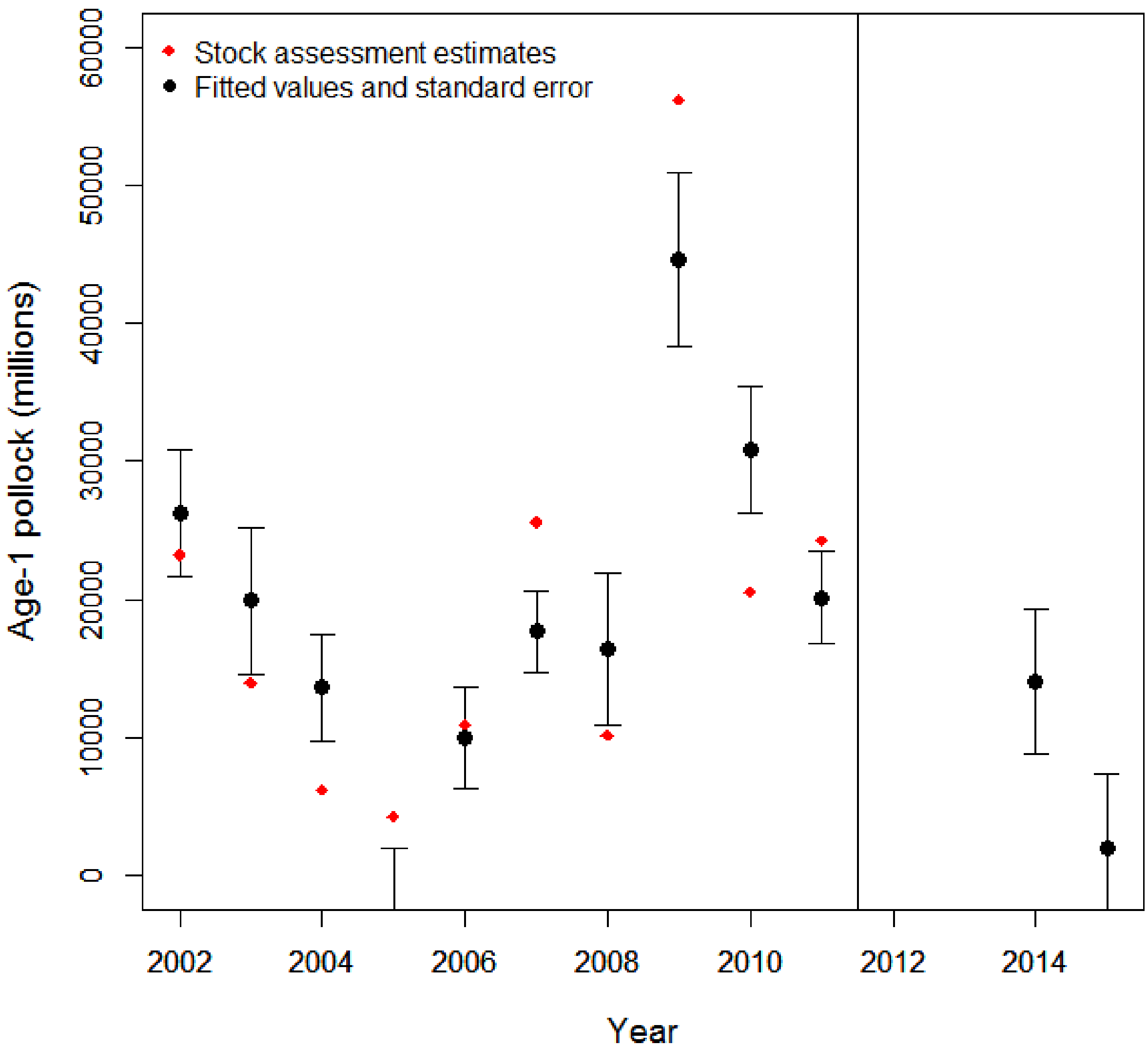


Figure 1. Age-1 pollock modeled as a function of the intra-annual growth in body weight of chum salmon during the age-0 stage (*t*-1) and spring sea temperature during the age-1 stage (*t*).

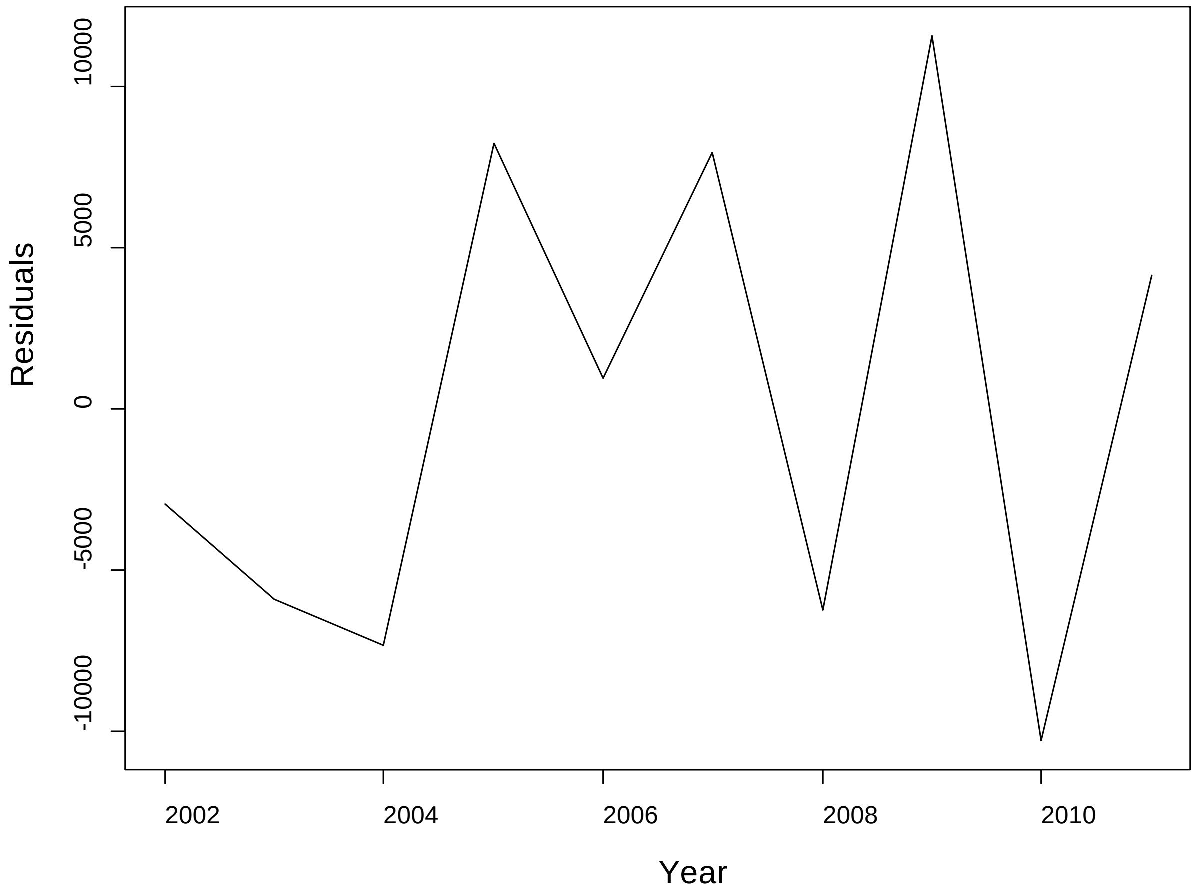


Figure 2. Residuals of the regression model relating age-1 pollock abundance (t) to spring sea surface temperature (t) and chum salmon growth (t-1).

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## *2. Stock Assessment*

### GULF OF ALASKA - REFM

**The 2015 pollock assessme**nt features the following new data: 1) 2014 total catch and catch-at-age from the fishery, 2) 2015 biomass and age composition from the Shelikof Strait acoustic survey, 3) 2015 biomass and length composition from NMFS bottom trawl survey, 4) 2015 biomass and 2014 age composition from the ADFG crab/groundfish trawl survey, and 5) 2013 and 2015 biomass estimates, 2013 age composition, and 2015 length composition from the summer acoustic survey.

The age-structured assessment model used for GOA W/C/WYAK pollock assessment implemented two model changes relative to the model used for the 2014 assessment. These changes were necessary to include the summer acoustic survey in the assessment, and to estimate a power coefficient for the age-1 winter acoustic survey index catchability. The 2015 assessment compared the following models to the 2014 model with the new data, each added to sequential models in a cumulative manner: 1) adding the summer acoustic survey data, 2) adding a power term for age-1 winter acoustic catchability, and 3) revising the Shelikof Strait acoustic survey estimates for net selectivity. Last year's base model used iterative re-weighting for composition data based on the harmonic mean of effective sample size. An initial "tuning" step was conducted after incorporating new data. However, to facilitate model comparison, subsequent models were not tuned until a potential base model was identified, and then a final tuning step was done for that model. To add the summer acoustic data as a new survey time series, the authors used simple approach for modeling selectivity due to the limited amount of data; this approach will need to be revisited as additional data become available. Adding a power term for age-1 significantly improved the model fit and is the authors' recommended model. Adding a power term for age-2 resulted in a value close to zero and failed to improve the model fit so was excluded. Improvement to the model fit by revising the Shelikof Strait acoustic survey estimates for net selectivity was equivocal. Before using the net-selectivity corrected estimates, the Team noted that the method should be fully documented and reviewed. The Plan Team accepted the authors' recommended final model configuration that incorporated the summer acoustic survey data and a power term for age-1 winter acoustic catchability.

Model fits to fishery age composition data appeared to be reasonable in most years. The largest residuals tended to be at ages 1-2 in 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 model to fit the rapid increase in the Shelikof Strait acoustic survey and the NMFS bottom trawl survey in 2013 since an age-structured pollock population cannot increase as rapidly as is indicated by these surveys. The model is unable to fit the extreme low value for the ADFG survey in 2015, though otherwise the fit to this survey is quite good. The fit to the age-1 and age-2 Shelikof acoustic indices appeared adequate though variable.

The model estimate of spawning biomass in 2016 is 321,626 t, which is 42.9% of unfished spawning biomass (based on average post-1977 recruitment) and above the *B40%* estimate of 300,000 t. The 2015 Shelikof Strait acoustic survey estimate of age-3+ pollock is 1.64 billion, which is the largest age-3+ estimate in the time series. There was a large and unexplained decline in pollock biomass in the 2015 ADFG survey (58% decline), which is a concern, especially since this time series has shown relatively little variability compared to the others. The 2012 year class still appears to be very strong based on recent information. The estimated abundance of mature fish is projected to peak in 2017, and then decline as the strong 2012 year class passes through the population. Over the years 2009-2013 stock size has shown a strong upward trend from 25% to 50% of unfished stock size, but declined to 33% of unfished stock size in 2015. The spawning stock is projected to increase again in 2016 as the strong 2012 year class starts maturing.

The author’s recommendation to reduce *FABC* from the maximum permissible using the “constant buffer” approach (first accepted in the 2001 GOA pollock assessment) was employed. Because the model projection of female spawning biomass in 2016 is above *B40%*, the W/C/WYAK Gulf of Alaska pollock stock is in Tier 3a. The projected 2016 age-3+ biomass estimate is 1,937,900 t (for the W/C/WYAK areas). Markov Chain Monte Carlo analysis indicated the probability of the stock dropping below *B20%* will be negligible in all years.

The 2016 ABC for pollock in the Gulf of Alaska west of 140° W longitude (W/C/WYAK) is 254,310 t which is an increase of 33% from the 2015 ABC. In 2017, the ABC based on an adjusted *F40%* harvest rate is 250,544 t. The OFL is 322,858 t in 2016 and 289,937 t in 2017. The 2016 Prince William Sound (PWS) GHL is 6,358 t (2.5% of the 2016 ABC of 254,310 t); the 2017 PWS GHL is 6,264 t (2.5% of the 2017 ABC of 250,544 t).

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

**EASTERN BERING SEA - REFM**

The following new data were incorporated into the 2015 stock assessment:

1)A “corrected index” (formerly known as the Kotwicki index) for the summer bottom trawl survey
(BTS) biomass and abundance at age time series (1982-2015) was included for the first time, after
having been tested for several years; 2) 2014 and 2015 acoustic vessels-of-opportunity (AVO) data; 3) Age compositions from the 2014 NMFS summer acoustic-trawl survey (ATS) were updated; 4) Catch at age and average weight at age from the 2014 fishery; and 5) Updated total catch, including a preliminary estimate for 2015. The only methodological change was the use of a new random effects model for projecting future weight at age.

Spawning biomass in 2008 was at the lowest level since 1980, but has increased by 114% 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 recruitment from the very strong 2008 year class and the above average 2012 year class, along with reductions in average fishing mortality (ages 3-8) from 2009-2010 and 2013-2015. Spawning biomass is projected to be 78% above $B_{MSY}$ in 2016.

The SSC has determined that EBS pollock qualifies for management under Tier 1 because there are
reliable estimates of $B_{MSY}$ and the probability density function for $F_{MSY}$. The updated estimate
of $B_{MSY}$ from the present assessment is 1.984 million t, up 2% from last year’s estimate of 1.948 million t. Projected spawning biomass for 2016 is 3.540 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 0.401, down 22% from last year’s value of 0.512. The harvest ratio of 0.401 is multiplied by the geometric mean of the projected fishable biomass for 2016 (7.610 million t) to obtain the maximum permissible ABC for 2016, which is 3.050 million t, up 5% and almost identical to the maximum permissible ABCs for 2015 and 2016 projected in last year’s assessment, respectively. However, as with other recent EBS pollock assessments, the authors recommend setting ABCs well below the maximum permissible levels. The rationale for this recommendation, that results in an ABC well below the maximum permissible level, is: 1) The fleet was able to operate with reasonably good catch rates and 2) the fleet was able to maintain salmon bycatch at relatively low levels.

From 2010-2013, harvest recommendations were based on the most recent 5-year average fishing mortality rate. Last year, the Team and SSC felt that stock conditions had improved sufficiently that an increase in the ABC harvest rate was appropriate. Specifically, they recommended basing the 2015 and 2016 ABCs on the harvest rate associated with Tier 3, the stock’s Tier 1 classification notwithstanding. This method gives a 2016 and 2017 ABC of 2.090 million t and 2.019 million t, respectively. The OFL harvest ratio under Tier 1a is 0.514, 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 2016 determines the OFL for 2016, which is 3.910 million t. The current projection for OFL in 2017 given a projected 2016 catch of 1.350 million t is 3.540 million t.

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

**Aleutian Islands:**
This year's assessment estimates that spawning biomass reached a minimum level of about $B_{29\%}$ in 1999 and has since slowly increased to a projected value of $B_{36\%}$ for 2016. The increase in spawning
biomass since 1999 has resulted more from a dramatic decrease in harvest than from good recruitment, as there have been no above-average year classes spawned since 1989. Spawning biomass for 2016 is projected to be 74,377 t.
The model estimates $B_{40\%}$ at a value of 82,785 t, placing the AI pollock stock in sub-tier "b" of Tier 3. The model estimates the values of $F_{35\%}$ as 0.40 and $F_{40\%}$ as 0.32. Under Tier 3b, with the adjusted value of $F_{40\%}$=0.27, the maximum permissible ABC is 32,227 t for 2016. Following the Tier 3b formula with the adjusted value of $F_{35\%}$=0.34, OFL for 2016 is 39,075 t. If the 2015 catch is 1,500 t and 1,188 for 2016 (i.e., equal to the five year average for 2010-2014), the 2017 maximum permissible ABC would be 36,664 t and the 2017 OFL would be 44,455 t. The Team recommended setting 2017 the ABC and OFL at these levels.

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

Bogoslof Pollock

Estimated catches for 2014 and 2015 were updated and 2014 survey age data were completed and
included. The only change in assessment methodology from 2014 was to accept the estimate of natural mortality from the age-structured assessment that was introduced in 2014. The new estimate is 0.3, up from the estimate of 0.2 used previously.

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 estimate of current biomass from the random effects model is 106,000 t.

The SSC has determined that this stock qualifies for management under Tier 5. The maximum
permissible ABC value for 2016 would be 23,850 t (assuming $M$ = 0.3 and $F_{ABC}$ = 0.75 x $M$ = 0.225): ABC = $B_{2014}$ x $M$ x 0.75 = 106,000 x 0.3 x 0.75 = 23,850 t. The projected

ABC for 2017 is the same. Following the Tier 5 formula with $M$=0.301, OFL for 2016 is 31,906 t. The OFL for 2017 is the same.

The walleye pollock stock in the Bogoslof district is not being subjected to overfishing. It is not possible to determine whether this stock is overfished or whether it is approaching an overfished condition because it is managed under Tier 5.

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## F. Pacific Whiting (hake)

## G. Rockfish

### *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 sampled blackspotted and rougheye rockfish with longline gear at depths from 123-279 m. Barotrauma was assessed immediately after capture and then fish were recompressed in tanks on-board the fishing vessel. After re-pressurization in the tanks, the great majority of fish no longer had external signs of barotrauma.

Survival was highest when fish were given four days to acclimate from 70 psi to atmospheric pressure in the tanks (77.8% in 2013), opposed to two days (50% in 2011 and 60% in 2012). There were delayed mortalities of fish caught in 2011 and 2012, but none in 2013. Increased experience with the tanks improved our ability to control water flow, keep pressure consistent, and reduce handling time. This experience as well as an increase in the decompression time in 2013 (4 days to acclimate to surface pressure instead of 2) helped to increase survival. The time required for decompression will likely be species specific. Both the presence of barotrauma and the depth of capture were not associated with survival. However, as fish length increased mortality increased significantly (fish length ranged from 275 to 685 mm).

The healing of eyes was tracked for 40 fish in the laboratory. The majority of fish put into recompression tanks had both exophthalmia and corneal emphysema at-sea (34 out of 40; 85%). Of these 34 fish, 76% had clear eyes after holding in the lab. It sometimes took several months to over a year for eyes to become clear. All fish that had clear eyes at sea or only exophthalmia had clear eyes directly after recompression (6 out of 40; 15%). Eye health did not always improve with holding. Ruptured swim bladders were observed in 41% (14 of 34) of fish dissected after long-term holding (6-18 months). All but one of the fish with ruptures (13 of 14) had healed and their swim bladders were inflated.

Fish not recompression in tanks were tagged and released at ~75 m using a weighted cage. Video of fish being released demonstrated that all fish were negatively buoyant and 67% swam away. A rockfish that was tagged with an external spaghetti tag in July, 2012 was recaptured in March, 2013 in the Pacific halibut (*Hippoglossus stenolepis*) longline fishery 58 km from the capture/release location. To swim to the recapture location, the fish had to cross over areas that reach depths of 590 m. Blackspotted and rougheye rockfish are closely associated with the bottom, so it may have descended to deeper depths than the capture/release depths in order to reach the recapture location.

Figure: Photos of a blackspotted or rougheye rockfish immediately after capture (top) and the same fish after being recompressed at-sea and then held long term in captivity (bottom).

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### First Behavioral Observations of a *Sebastes* Using Pop-up Satellite Archival Tags (PSATs) Post Barotrauma – ABL

Pop-up satellite archival tags (PSATs) were deployed on 8 blackspotted rockfish (*Sebastes melanostictus*) (37-54 cm fork length) caught at depths from 148-198 m after incurring barotrauma. The 6 fish released immediately after capture in a weighted cage descended quickly to what was assumed to the bottom depth. Tags ascended to the surface before the preprogrammed pop-up date after only 11-14 days. Two fish were held in captivity for 8 months or 4 years after capture and then released at the surface. One tag came to the surface after only 12 days and a tag deployed on a 37 cm fish was retained for 190 days. Both fish made dives initially and then quickly moved to more shallow depths, indicating that rockfish may require time to acclimate to increased pressure. For the tag that was retained for 190 days, we identified six phases of vertical movement behavior. During the longest phase (123 days) the fish made rapid, 16-39 m dives (sometimes in less than 15 minutes), which were significantly deeper during the day and during high tide. During some of the shorter phases the fish was more sedentary or was deeper at night. Our results show that a Sebastes as small as 37 cm can be tagged with PSATs, if recompression and recovery are allowed to occur in captivity.

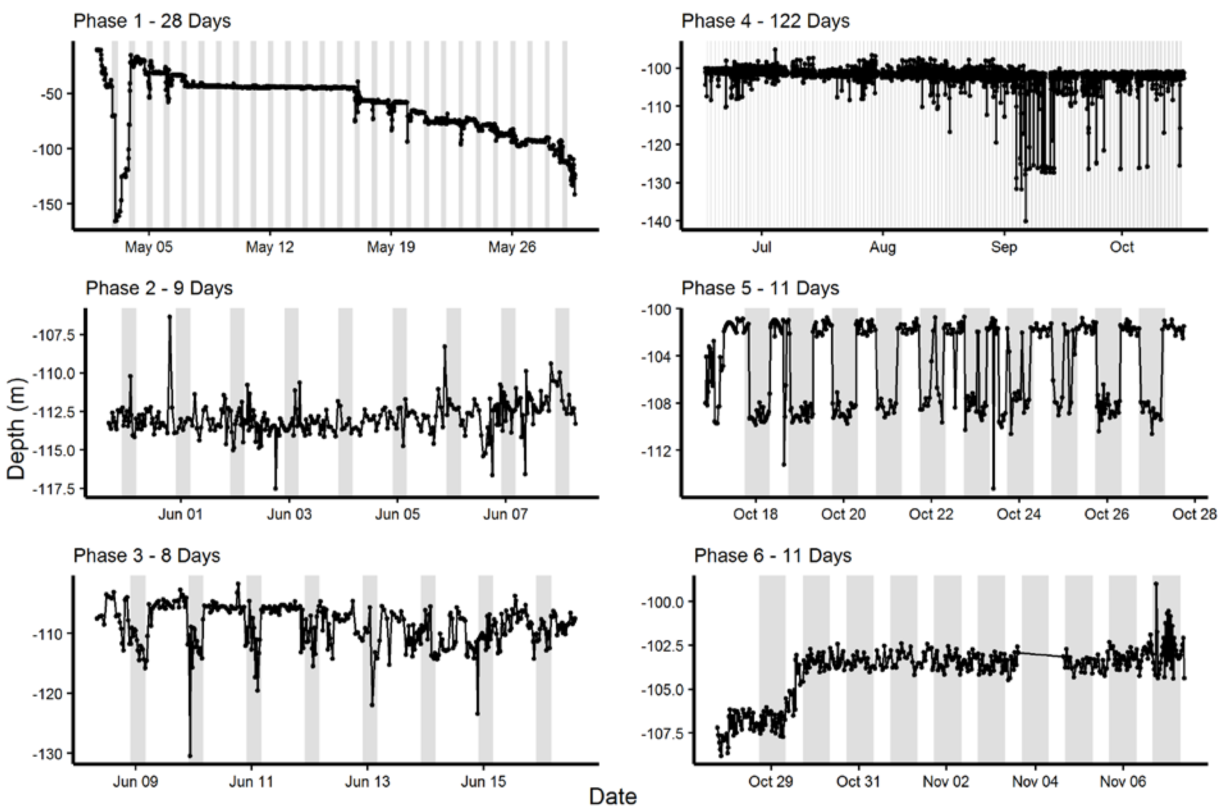


Figure: Depth readings from a PSAT deployed on a blackspotted rockfish during 6 behavioral phases over 190 days. White bars are daytime hours and dark bars encompass the time after sunset and before sunrise.

## 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*. This species occupies deep water on the continental shelf and slope and is taken in directed fisheries as well as in non-directed fisheries as bycatch. Despite the value of this fishery, 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 movement patterns, distribution, stock structure, and life history parameters of Pacific ocean perch.

In August of 2015, we trawled in the Gulf of Alaska near Kodiak Island with a livebox (aquarium codend) attached to a midwater trawl. POP caught in the trawl passed into the livebox and were shunted into a calm, water-filled compartment. This compartment protected the fish from being crushed while the net was pulled through the water and while the livebox was retrieved to the deck of the vessel. Once on deck, rockfish were removed from the livebox, quickly measured and tagged. Most tagged fish were loaded into a weighted mesh cage, lowered to approximately 90 m, and released at depth. In total, 28 tows were made on Albatross Bank and 2,527 POP were tagged and released. Cameras were installed on the release cage to observe POP behavior at-depth post-capture. External signs of barotrauma were significantly reduced as the fish descended and a small percentage of POP swam away from the cage but most were lethargic. A subsample of tagged fish were recompressed on board the vessel in portable recompression chambers. After the initial pressurization, pressure was slowly reduced over 24-48 hours. Survival of recompressed POP was low (4.2%) but fish were subjected to significant thermal stress in the recompression chambers that may have adversely effected survival. Temperatures at capture depths averaged 5.7º C while temperatures in the recompression chambers were at least as high as 16.4º C.

This work was completed in an area that receives substantial commercial fishing effort. By tagging in these areas, the probability of recovering tagged fish was maximized. 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, recoveries will allow for growth calculations which are important for stock assessments.

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### 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 examined 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. These habitats were sampled at two locations in the Gulf of Alaska during the months of August, May, and December. Differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success were examined within the different habitat types. 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

### Rockfish Reproductive Studies - RACE GAP Kodiak

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 the 2017 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.

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**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.

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***Assessment***

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 2015, a full assessment document with updated assessment and projection model results were presented.

We use a statistical age-structured model as the primary assessment tool for Gulf of Alaska dusky rockfish which qualifies as a Tier 3 stock. This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels.

A substantive change was made in the assessment in 2015 which was to use a geostatistical estimator for determining survey biomass in favor of the traditional design-based estimator. The survey biomass time series for dusky rockfish is characterized by high variability because the survey does a poor job at sampling untrawlable habitat where dusky rockfish are encountered. The geostatistical estimator described by Thorson et al. (2015) is a preferred method to the design-based methodology for estimating biomass as it uses the available survey catch data more efficiently than conventional estimators and reduces the inter-annual variability in the biomass estimates by over 63% compared to the design-based estimates. The Plan Team and Science and Statistical Committee (SSC) endorsed this methodology, which provided alternative survey biomass estimates based on the geostatistical estimator.

For the 2016 GOA fishery, a maximum allowable ABC for dusky rockfish was set at 54,686 t. This ABC is 8% less than last year’s ABC of 5,109 t. The decrease in ABC is supported by a decline in the trawl survey biomass estimate in 2015 from 2013. The stock is not overfished, nor is it approaching overfishing status.

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**Pacific Ocean Perch (POP) - BERING SEA AND ALEUTIAN ISLANDS - REFM**
This chapter was presented in executive summary format, as a scheduled "off-year" assessment as full assessments are scheduled to coincide with years when an Aleutian Islands trawl survey is conducted. Therefore, only the projection model was run, with updated catches. New data in the 2015 assessment included updated 2014 catch and estimated 2015 and 2016 catches. No changes were made to the assessment model.

The survey biomass estimates in the Aleutian Islands were high in 2014. New projections were very
similar to last year's projections because observed catches were very similar to the estimated catches used last year. Spawning biomass is projected to be 222,369 t in 2016 and to decline to 211,339 t in 2017. These projections indicate that the stock is at an abundant level.

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 0.109, respectively. Spawning biomass for 2016 (222,369 t) is projected to exceed B40%, thereby placing POP in sub-tier "a" of Tier 3. The 2016 and 2017 catches associated with the F40% level of 0.089 are 33,320 t and 31,724 t, respectively, and are the authors' recommended ABCs. The 2016 and 2017 OFLs are 40,529 t and 38,589 t.

ABCs are set regionally based on the proportions in combined survey biomass as follows (values are for 2016): EBS = 8,353 t, Eastern Aleutians (Area 541) = 7,916 t, Central Aleutians (Area 542) = 7,355 t, and Western Aleutians (Area 543) = 9,696 t. The recommended OFL for 2016 and 2017 is not regionally apportioned. Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**POP - GULF OF ALASKA - ABL**
Pacific ocean perch (POP), *Sebastes alutus*, is the dominant fish in the slope rockfish assemblage and has been extensively fished along its North American range since 1940. Since 2005, Gulf of Alaska rockfish have been moved to a biennial stock assessment schedule to coincide with the biennial AFSC trawl survey that occurs in this region. In odd years (such as 2015's assessment for the 2016 fishery) there is new trawl survey data available from the GOA bottom trawl survey and a full assessment is completed. In the 2015 full assessment the notable changes to the assessment model included estimating growth information using length-stratified methods (following from the manner in which age observations are collected in the GOA bottom trawl survey), and constructing a new ageing error matrix that extends the modeled ages past the ages fit in the age composition data to more precisely fit the plus age group and age classes adjacent to the plus age group with the model.

Spawning biomass is above the $B_{40\%}$ reference point and projected to be 157,080 t in 2016 and to increase to 158,124 t in 2017. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 114,131 t, 0.102, and 0.119 respectively. Spawning biomass for 2016 is projected to exceed $B_{40\%}$, thereby placing POP in sub-tier “a” of Tier 3. The 2016 and 2017 catches associated with the $F_{40\%}$ level of 0.102 are 24,437 t and 24,189 t, respectively, and were the authors’ and Plan Team’s recommended ABCs. The 2016 and 2017 OFLs are 28,431 t and 28,141 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 2016: Western GOA = 2,737 t, Central GOA = 17,033 t, and Eastern GOA = 4,667 t. The Eastern GOA is further subdivided West (called the West Yakutat subarea) and East (called the East Yakutat/Southeast subarea, where trawling is prohibited) of 140° W longitude using a weighting method of the upper 95% confidence of the ratio in biomass between these two areas. For W. Yakutat the ABC in 2016 is 2,847 t and for E. Yakutat/Southeast the ABC in 2016 is 1,820 t. The recommended OFL for 2016 is apportioned between the Western/Central/W. Yakutat area (26,313 t) and the E. Yakutat/Southeast area (2,118 t). Pacific ocean perch is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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**Northern Rockfish - BERING SEA AND ALEUTIAN ISLANDS - REFM**
This chapter was presented in executive summary format, as a scheduled “off-year” assessment.
Therefore, only the projection model was run, with updated catches. New data in the 2015 assessment included updated 2014 catch and estimated 2015 and 2016 catches. No changes were made to the assessment model.

The 1980s cooperative surveys in the Aleutian Islands had low biomass estimates relative to the
remainder of the time series, and removal of these data in last year’s assessment increased the estimated population size. Spawning biomass has been increasing slowly and almost continuously since 1977 until recent years, when it appears to be leveling off. Female spawning biomass is projected to be 91,648 t and 88,326 t in 2016 and 2017, respectively. Recent recruitment has generally been below average. The catch of northern rockfish more than tripled from 2014 to 2015 because of changes in management measures and increased retention, although 2015 catch is still well below the ABC.

The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$ (57,768 t), $F_{40\%}$ (0.070), and $F_{35\%}$ (0.087). Because the projected female spawning biomass of 91,648 t is greater than $B_{40\%}$, sub-tier "a" is applicable, with maximum permissible $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{35\%}$. Under Tier 3a, the maximum permissible ABC for 2016 is 11,960 t, which is the authors' and Team's recommendation for the 2016 ABC. Under Tier 3a, the 2016 OFL is 14,689 t for the Bering Sea/Aleutian Islands combined. The Plan Team continues to recommend setting a combined BSAI OFL and ABC, resulting in a 2017 ABC of 11,468 t and a 2016 OFL of 14,085 t.

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

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**Northern Rockfish - 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. In odd years (such as 2015's assessment for the 2016 fishery) there is new trawl survey data available from the GOA bottom trawl survey and a full assessment is completed. In the 2015 full assessment the notable changes to the assessment model included estimating growth information using length-stratified methods (following from the manner in which age observations are collected in the GOA bottom trawl survey), constructing a new ageing error matrix that extends the modeled ages past the ages fit in the age composition data to more precisely fit the plus age group and age classes adjacent to the plus age group with the model, and extending the plus age group of the data to 45+ (from 33+) to ensure the proportion of fish in the plus age group was not too large.

Spawning biomass is above the $B_{40\%}$ reference point and projected to be 31,313 t in 2016 and to decrease to 29,033 t in 2017. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying northern rockfish for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 27,983 t, 0.062, and 0.074 respectively. Spawning biomass for 2016 is projected to exceed $B_{40\%}$, thereby placing northern rockfish in sub-tier "a" of Tier 3. The 2016 and 2017 catches associated with the $F_{40\%}$ level of 0.062 are 4,008 t and 3,772 t, respectively, and were the authors' and Plan Team's recommended ABCs. The 2016 and 2017 OFLs are 4,783 t and 4,501 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 2016: Western GOA = 457 t, Central GOA = 3,547 t, and Eastern GOA = 4 t (note that the small ABC in the Eastern GOA is included with ‘other rockfish’ for management purposes). The recommended OFL for 2016 and 2017 is not regionally apportioned. Northern rockfish is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

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**Shortraker Rockfish - BERING SEA AND ALEUTIAN ISLANDS - REFM**
2015 is an off year for the shortraker rockfish (Tier 5) assessment; therefore the management specifications are unchanged. The remainder of this section is last year’s description of last year’s assessment.

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. 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 Team recommends basing the biomass estimate on the random effects model. The Team recommended setting $F_{ABC}$ at the maximum permissible level under Tier 5, which is 75 percent of $M$. The accepted value of $M$ for this stock is 0.03 for shortraker rockfish, resulting in a $maxF_{ABC}$ value of 0.0225. 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.

**Shortraker Rockfish - GULF OF ALASKA – ABL**

Rockfish in the Gulf of Alaska (GOA) are assessed on a biennial assessment schedule to coincide with new data from the AFSC biennial trawl surveys in the GOA. For 2016, the biomass estimate was updated with 2015 survey data. Estimated shortraker rockfish biomass is 57,175 t, which is a decrease of 3% from the previous estimate in the 2015 assessment. Catch data were updated as well.

Shortraker rockfish has always been classified into "tier 5" in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, the methodology used to estimate the exploitable biomass that is used to calculate the ABC and OFL values for the 2016 fishery has changed this year to the use of a random effects model applied to the trawl survey data from 1984-2015. Estimated shortraker biomass is 57,175 mt, which is a decrease of 3% from the 2015 estimate. Shortraker biomass in the GOA has generally shown a progressive increase since 1990. The NPFMC's "tier 5" ABC definitions state that $F_{ABC} \leq 0.75M$, where $M$ is the natural mortality rate. Using an $M$ of 0.03 and applying this definition to the exploitable biomass of shortraker rockfish results in a recommended ABC of 1,286 t for the 2016 fishery. Gulfwide catch of shortraker rockfish was 685 t in 2014 and estimated at 538 t in 2015. 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.

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**Blackspotted/rougheye Rockfish Complex - BERING SEA AND ALEUTIAN ISLANDS - REFM**

This chapter was presented in executive summary format for the 2015 assessment, as a scheduled "off-year" assessment. New data included updated catch for 2014 and estimated catches for 2015 and 2016. The projection model for the Tier 3 component of the assessment was re-run using the results from last year's full assessment. The complex is assessed by combining results from the age-structured population model applied to the fishery and survey data from the AI management area with a Tier 5 approach of smoothing recent survey biomass estimates in the EBS management area using a random effects model.

Total biomass for the AI component of the stock in 2015 is projected to be 42,605 t. The available survey biomass estimates for EBS blackspotted/rougheye rockfish include the southern Bering Sea (SBS) portion of the AI survey and the EBS slope survey estimates. There are no new survey data from these two subareas; thus, the EBS biomass estimate is identical to last year at 1,339 t.

For the Aleutian Islands, this stock qualifies for management under Tier 3 due to the availability of
reliable estimates for $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$. Because the projected female spawning biomass for 2016 of 9,076 t is less than $B_{40\%}$, (11,403 t) the stock qualifies as Tier 3b and the adjusted $F_{ABC}$= $F_{40\%}$ values for 2016 and 2017 are 0.037 and 0.042, respectively. The maximum permissible ABC for the Aleutian Islands is 528 t, which is the authors' and Plan Team's recommendation for the AI portion of the 2016 ABC. The apportionment of 2016 ABC to subareas is 382 t for the Western and Central Aleutian Islands and 179 t for the Eastern Aleutian Islands and Eastern Bering Sea. The Team recommends an overall 2016 ABC of 561 t and a 2016 OFL of 693 t. Given on-going concerns about fishing pressure relative to biomass in the Western Aleutians, the SSC requested that the apportionment by sub-area be calculated and presented. The maximum subarea species
catch (MSSC) levels within the WAI/CAI, based on the random effects model, are as follow: MSSC (2016) 58 and 324 and MSSC (2017) 73 and 405 for the western and central Aleutian Islands, respectively.

**Blackspotted/rougheye Rockfish Complex - 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. In this odd year, there was a new bottom trawl survey as well as the annual longline survey and a full assessment was completed. New and updated data added to this model include updated catch estimates for 2014, new catch estimates for 2015-2017, new fishery ages for 2010, new fishery lengths for 2013, a new trawl survey estimate for 2015, new trawl survey ages for 2013, new longline survey relative population numbers (RPNs) for 2015, and new longline survey lengths for 2015.

In 2015, we incorporated several changes to the assessment methodology which resulted in seven models being presented. Model 0 was the last full assessment base model from 2014. The remaining models were hierarchal in that each subsequent model includes the changes from the previous model. Models 1 and 2 incorporated changes to the treatment of samples based on the appropriate sampling design and adjustment to the ageing error matrix. In past assessments the trawl survey age samples have been treated as if they were randomly collected which incurs bias in the growth parameters since age samples are collected using a length-stratified sampling design. We now account for this design in the growth estimation by weighting the age samples by the total number of fish measured at a given length. The ageing error transition matrix was updated to appropriately model the ages at or near the plus age group which heretofore were consistently overestimated. The new matrix extends the modeled ages compared to ages fit in the data until >99.9% are in the plus age group of the data. The final two models also include sub-models to explore sensitivity to the trawl survey selectivity functional form and the interaction with the age composition plus group. The plus age group extension and new functional forms for the trawl survey selectivity were explored. Selection of the final plus age group and trawl survey selectivity curve balanced (1) reducing the plus age group proportion to no more than 10-15% of the total samples, (2) ensuring the plus age group was less than the maximum proportion in the remainder of the age composition data, (3) minimizing age bins with zero samples, (4) examining model fits and residuals, and (5) sensitivity to selectivity changes while adding age bins.

The 2015 trawl survey estimate increased 25% from the low 2013 estimate and was 24% below average. The 2015 longline survey abundance estimate (RPN) decreased about 6% from the 2014 estimate and was 10% above average. Since 2005, the total allowable catches (TACs) for RE/BS rockfish have not been fully taken, and are generally between 20-60% of potential quota. This is particularly true for the Western GOA since 2011, where catches have been between 20-35% of potential quota.

For the 2016 fishery, we recommended the maximum allowable ABC of 1,328 t from the author preferred model. This was an 18% increase from last year's ABC of 1,122 t. Recent recruitments are steady and near the median of the recruitment time series. This was evident in the ages for the trawl survey with more young fish over time. Female spawning biomass is well above $B_{40\%}$, and projected to be stable. 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 - 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 have previously been 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. However, in the 2015 assessment, some of the species which are rarely encountered in trawl gear were classified as “tier 6”. Also beginning in the 2015 assessment, the Tier 4/5 species exploitable biomass was estimated using the random effects model. This results in a current exploitable biomass of 104,826 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 tier 5 specites to the exploitable biomass for Other Rockfish results in a recommended ABC in the GOA of 4,079 t, which was combined with the tier 6 ABC of 127 t for a total complex ABC of 5,769 t for 2016 and 2017. The large increase in exploitable biomass was due to increases in biomass estiamtes of redstrip, sharpchin, and silvergray rockfish. The biomass estimate of harlequin rockfish was the lowest of the time series (2,326 t).

Gulfwide catch of Other Rockfish was 988 t and 1,111 t in 2014 and 2015, 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 = 3 t, but annual catch averages ~ 16 t. Catch of harlequin and yelloweye rockfish average ~ 450 t and 156 t, respectively, exceeding the ABCs of 320 t and 120 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

## H. Thornyheads

### *Research*

### *Stock Assessment*

### GULF OF ALAKSA - ABL

Gulf of Alaska thornyheads (*Sebastolobus* species) are assessed as a stock complex under Tier 5 criteria in the North Pacific Fishery Management Council's (NPFMC) definitions for ABC and overfishing level. Following the recommendation of the NPFMC for all Tier 5 stocks, the methodology used to estimate the exploitable biomass that is used to calculate the ABC and OFL values for the 2016 fishery has changed this year to the use of a random effects model applied to the trawl survey data from 1984-2015. Estimated thornyhead biomass is 87,155 mt, which is an increase of 6% from the 2015 estimate. Thornyhead biomass in the GOA has generally shown an increasing pattern since 2011. This follows a steady decline since 2003. 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 thornyhead rockfish results in a recommended ABC of 1,961 t for the 2016 fishery. Gulfwide catch of thornyhead rockfish was 1,131 t in 2014 and estimated at 931 t in 2015. Thornyhead rockfish in the GOA are 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 more information please contact Katy Echave at (907) 789-6006 or katy.echave@noaa.gov.

## I. Sablefish

### *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 2015. Total sablefish tag recoveries for the year were around 755. Twenty five percent of the recovered tags in 2015 were at liberty for over 10 years. About 40 percent of the total 2015 recoveries were recovered within 100 nautical miles (nm; great circle distance) from their release location, 37 percent within 100 – 500 nm, 17 percent within 500 – 1,000 nm, and 6 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 2015 recovered sablefish tag was 1,730 nm. Two adult sablefish and seven juvenile sablefish tagged with archival tags were recovered in 2015. Data from these electronic archival tags, which will provide information on the depth and temperature experienced by the fish, are still being analyzed.

Tags from shortspine thornyheads, Greenland turbot, Pacific sleeper sharks, lingcod, spiny dogfish, and rougheye rockfish are also maintained in the Sablefish Tag Database. Eighteen thornyhead and one archival thornyhead were recovered in 2015.

Releases in 2015 on the groundfish longline survey totaled 2,503 adult sablefish, 871 shortspine thornyheads, and 26 greenland turbot.  Pop-up satellite tags (PSAT) were implanted on 35 sablefish.  An additional 702 juvenile sablefish (642 spaghetti and 60 archival) and 40 adult sablefish (28 with internal electronic archival tags and 20 with pop-off satellite tags) were tagged during additional cruises in 2015. 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 2015. A total of 570 juvenile sablefish were caught and tagged and released in St John Baptist Bay near Sitka, AK over 4 days (May 26th – May29th) with 90 rod hrs. Seventy six of these tags were electronic archival tags, collecting data on depth and temperature. Total catch-per-unit-effort (CPUE) equaled 4.01 sablefish per rod hour fished. This was up significantly from 2014 (2.29), but lower than the millennial size catch in 2011 (7.63). However, the recent 5-year trend is positive. The St. John Baptist Bay juvenile sablefish tagging cruise will likely be conducted again in 2016 from July 13-16.

In addition to the annual juvenile sablefish tagging in St John Baptist Bay, three tagging trips in southcentral Alaska occurred following several reports of sablefish catch by sport fishermen. These rare reports indicate that 2014 has the potential to be a larger than average year class. Three days (7/24 - 7/26/15) were spent fishing within Kachemak Bay. A broad spatial distribution including various habitat types and depths were fished, but sablefish were only found on soft bottom near Homer. Two days (7/28 – 7/29/15) were spent fishing three locations both inside and outside of Resurrection Bay out of Seward, AK. Outside of Resurrection Bay, sablefish were caught in unlikely habitat approximately 10 m below the surface intermixed with adult coho salmon. Inside Resurrection Bay, sablefish were found on soft bottom in glacial silt waters. Two days (8/24 – 8/25/15) were spent fishing off Kodiak Island in Kalsin Bay and near the Port Lions’ dock. Total CPUE (8.9 sablefish per rod hour fished) during the two days sampling off Kodiak was one of the highest seen in the time series of juvenile sablefish tagging.

Juvenile sablefish ranged in size from approximately 31 - 41 cm fork length. Average fork length was 37 cm. A total of 60 archival tags were implanted and 519 spaghetti tags were deployed. The electronic archival tags will record temperature, depth, and total magnetic field intensity every 2 minutes, providing data on the fish’s ontogenetic migration into deeper, colder slope waters. These archival tags are the first to be released on juvenile sablefish in waters outside the eastern GOA, and should be available for recovery within approximately 4 years as they recruit to the commercial fishery.

These were the first successful tagging trips in areas outside of the eastern Gulf of Alaska (EGOA) and will provide information regarding movement of juvenile fish in the central Gulf of Alaska.
For more information, contact Dana Hanselman at dana.hanselman@noaa.gov.

Age at maturity, Skipped Spawning, and Fecundity, 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. For a study of age at maturity, female 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). Age at maturity estimates were 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 and ranged in age from 4-15 (sablefish max age is 94 years old). 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.

In December 2015 female sablefish were sampled in the same areas as in 2011, gullies and the slope nearby Kodiak Island. There were 490 female sablefish sampled ranging in length from 440-1,010. Pictures of ovaries were taken at-sea and histology and aging will be completed in 2016. Liver weights were also taken for a comparison of energy storage in skipped spawning, spawning, and immature fish. Fecundity measurements were performed for fish ranging in length from ~500-1,000 mm. Results from this study will be compared to those from the 2011 study (described above).

ABL conducts a bottom longline survey in Alaska every summer. Sablefish maturity data is collected at-sea each year, without histology. Because these samples are not taken at the ideal time of year, which is just prior to spawning, the data has not been used for stock assessment. Because skipped spawning fish that were identified in the winter did not produce vitellogenic oocytes, skipped spawning fish 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. The goals of this project include determining what dates of the survey are late enough in the reproductive cycle to correctly classify maturity, see if skipped spawning fish are sampled during the summer, and to determine if energy storage in the liver or relative gonad size are related to whether a fish will spawn in the coming winter. In 2015 594 female sablefish were collected in the Gulf of Alaska during June-August. Ovaries were assigned a maturity status at-sea, photos were taken, and livers and ovaries were saved for analyses. Maturity staging from histology slides, aging, and fecundity measurements will be completed in 2016. In addition to investigating ovarian development during the summer months, these data will be a good comparison to the samples collected in December 2015 in the Gulf of Alaska.

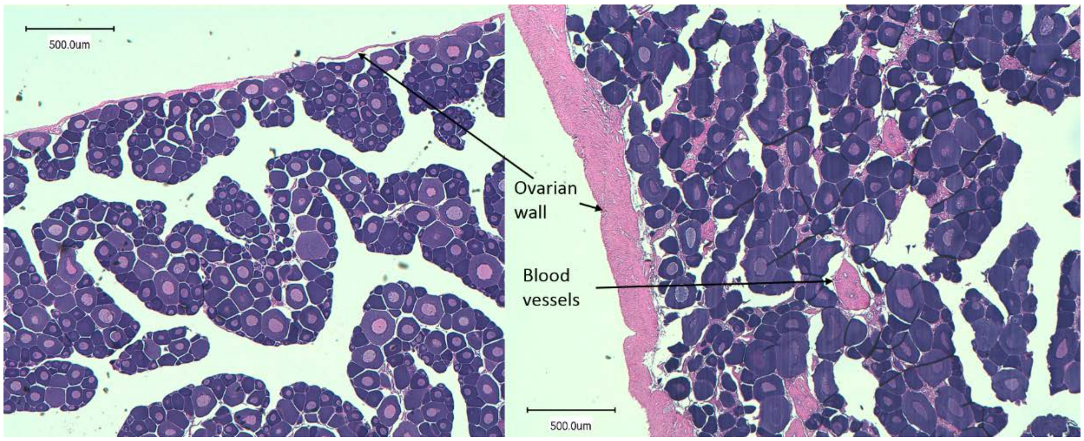



Figure: Images of histology slides made from an ovarian section from an immature female sablefish (left) and a skipped spawning female (right) collected in the Gulf of Alaska in December 2011.

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

**Juvenile Sablefish Ecology – ABL and UAF**

Although the range of depths inhabited by Sablefish throughout their life history have been documented, very little is known about fine-scale patterns in habitat use. Adults are demersal, inhabiting deep continental slope and outer shelf waters in the Gulf of Alaska and Bering Sea, where they are commercially caught by longlines and pot gear. They spawn offshore near the continental shelf and eggs have been found at depths >200m. Larval and pre-settlement juvenile Sablefish are caught in surface trawls in shelf waters and are associated with the neuston layer. We analyzed fine-scale vertical movement patterns of post-settlement juvenile Sablefish during their nearshore residence period using an acoustic telemetry dataset collected by NOAA in 2003. Specifically, we aimed to 1) quantify the vertical distribution of juvenile Sablefish in St. John Baptist Bay (SJBB), Southeast Alaska; and 2) describe vertical movement patterns in relation to daylight and tidal cycles within SJBB. We hypothesized that juvenile Sablefish would be detected at a range of depths, reflecting their use of both benthic and pelagic prey resources in SJBB. Furthermore, we hypothesized that Sablefish would be more active during crepuscular periods to exploit prey while avoiding

predation and that they would display higher rates of vertical movement in the water column during flood events, due to the potential influx of pelagic prey.
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 effects 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 tidal stages. Higher probability of excursions at dawn may be due to factors such as predator avoidance or increased prey densities in the water column during crepuscular periods. This is the first study describing vertical migration of juvenile Sablefish in the wild and reveals that environmental conditions have the potential to influence the fine-scale movements of juvenile Sablefish within nearshore habitats.

For more information, contact Karson Coutré at (907) 789-6020 or karson.coutre@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 2013-2015, data analysis will resume in 2016 or 2017. For more information, contact Mike Sigler mike.sigler@noaa.gov or Pete Hulson pete.hulson@noaa.gov.

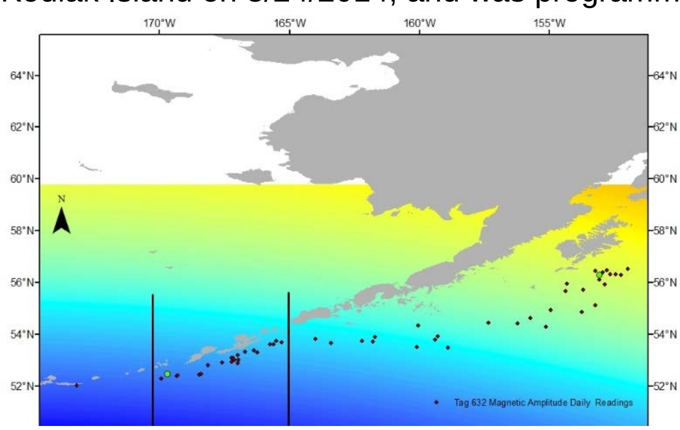
**Sablefish Satellite Tagging - ABL**

The fourth year of extensive tagging of sablefish with pop-up satellite tags (PSATs) was conducted on the AFSC annual longline (LL) survey in 2015. Pop-off satellite tags were deployed on 35 sablefish throughout the Gulf of Alaska (GOA) and the Bering Sea (BS) to study daily and large-scale movements. These tags were programmed to release from the fish 1 January 2016 and 1 February 2016, 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 2015 released tags join the 43 tags that were released in the GOA and AI on the LL Survey in 2014, 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 four years of data acquired from summer survey released tags and still in the early stages of analysis of the data that has been received, it is still too early to determine if there is any directed movement by sablefish for spawning purposes. Admittedly, tags should be programmed to remain on the fish for an entire year in order to determine if sablefish are exhibiting any homing behavior for spawning purposes. Ideally, the fish would be tagged just before the spawning season in the winter and programmed to release the following winter during the spawning season. However, having the release location of the tag and the pop up location (location of the fish when the tag released) has provided great insight into (relatively) short term and winter behavior of sablefish.

The following is an example of the data received from one tag, and how it may be utilized.

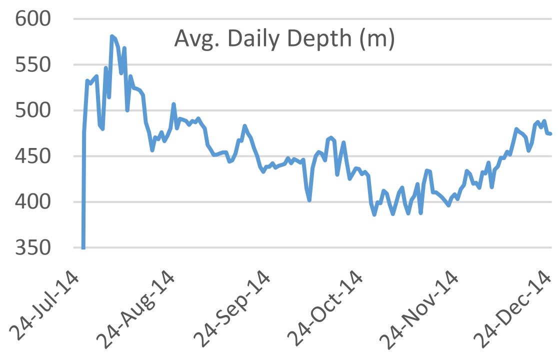
***Tag 632***

The following is a figure showing the estimated daily locations of tagged fish #632, overlayed on a heat map of the earth's magnetic field. Green dots are the release and pop off locations. The bars indicate the area where the fish was located during suspected time of pre spawning/spawning. This fish was tagged just southeast of Kodiak Island on 8/24/2014, and was programmed to release from the fish on 1/1/2015.



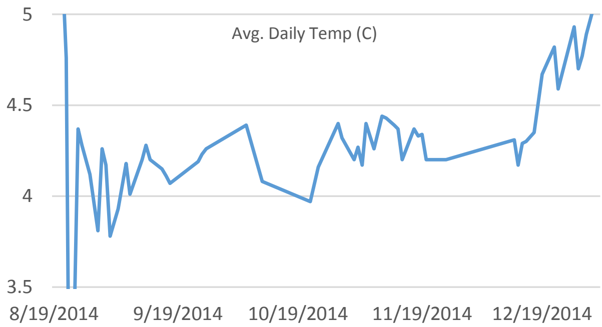

*Estimated daily location (black dots) of tagged fish #632. These geolocations were estimated from collected geomagnetic field data. Green dots are the tag release and tag pop off locations. The bars indicate the bounded area where the fish was located during suspected time of pre spawning/spawning.*

The fish exhibits constant daily movement from its release location off the coast of Kodiak toward its end location in the Aleutians (note there are days with missing data). Movement remains consistent until around mid-November through the end of December. At this time (presumably the time in which the fish is preparing to spawn), daily movement following the shelf break towards the Aleutians ceases. The fish remains within a bounded location displaying sporadic movement. The following figure of the average daily depth (m) of the fish shows a change in the depth distribution during the suspected "pre spawning" time as well.




*Daily average depth (m) readings collected by tag #632.*

The fish displays movement towards shallower depths during the assumed pre spawning period, with a return to deeper depths following this time period. The shallow movements may represent pre spawning to spawning behavior. The following figure displays the average daily temperatures from tag #632.




*Daily average temperature (C) readings collected by tag #632. The fish, on average, stayed in temperatures between 4 and 4.5 degrees C. These are typical bottom temperatures in this area.*

*Photo of sablefish with attached pop-off satellite tag (PSAT) prior to deployment on the summer longline survey. This tag was programmed to remain on the fish for close to one year, releasing in the winter during the presumed spawning season.*

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

**Life History Model for Sablefish - ABL**

In 2015 RECA completed a life history model for energy allocation of sablefish. This is a composite model developed from samples obtained from various efforts. The model charts the lipid content of sable fish from the earliest post-metamorphic stages to adult. The model for sable fish is very similar to the model developed for arrowtooth flounder and is unlike most other species. There is virtually no change in energy density with length until the fish begin maturing. Most other species reveal a positive relationship between length and energy density among age-0s. Demersal species often show a drop in energy density following settlement. Sablefish and arrowtooth flounder do not display either of these patterns. It is worth noting that both these species have similar life histories during the larval stage.

For more information contact Ron Heintz at Ron.Heintz@noaa.gov

**Southeast Coastal Monitoring Survey Indices and the Recruitment of Alaska Sablefish to Age-2 – ABL**

*Description of indicator*: Biophysical indices from surveys and fisheries were used to predict the recruitment of sablefish to age-2 from 2011 to 2016 (Yasumiishi et al., 2015). The southeast coastal monitoring project has an annual survey of oceanography and fish in inside and outside waters of northern southeast Alaska (Orsi et al. 2012). 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. These oceanographic metrics may index sablefish recruitment, because sablefish use these waters as rearing habitat early in life (late age-0 to age2). Estimates of age-2 sablefish abundance are from (Hanselman et al., 2013). We modeled age-2 sablefish recruitment estimates from 2001 to 2010 as a function of sea temperature, chlorophyll a, and pink salmon productivity during the age-0 stage for sablefish.

*Status and trends:* Estimated recruitment to sablefish to age-2 was described as a function of late August sea temperature, late August chlorophyll a, and a juvenile pink salmon productivity index (based on adult salmon returns to southeast Alaska during the age-1 stage) during the age-0 stage for sablefish (Figure 93). A multiple regression model indicated that chlorophyll a during the age-0 phase was most strongly correlated with sablefish recruitment ($R2 = 0.88$; p-value = 0.00006) with a three-fold increases in chlorophyll a in 2000 and recruitment (age-2) in 2002. Sea temperature and pink salmon productivity explained an additional 10% of the variation in sablefish recruitment ($R2 = 0.98$; p-value < 0.00001).

*Factors influencing observed trends:* Warmer sea temperatures were associated with high recruitment events in sablefish (Sigler and Zenger Jr., 1989). 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.

*Implications:* The model parameters (2001-2010) and biophyscial indices (2009-2014) were used to predict the recruitment of Gulf of Alaska sablefish (2011-2016). Above average recruitment of sablefish to age-2 is expected in 2016.

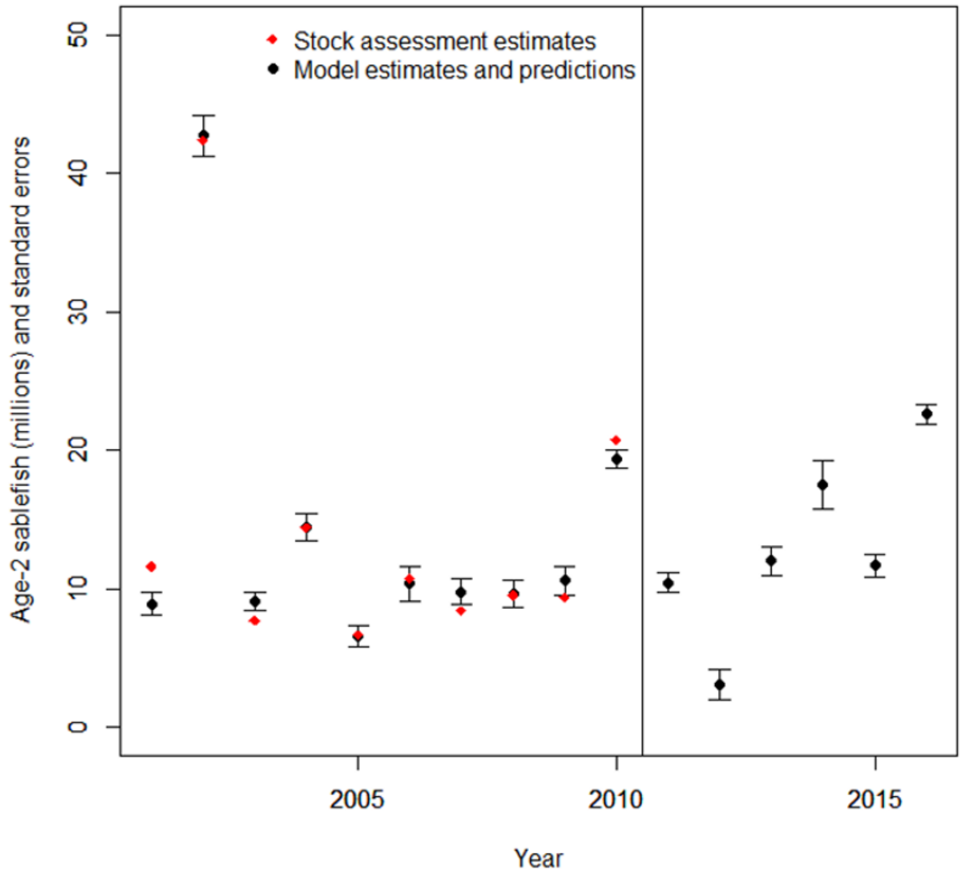



Figure 93: Age-2 sablefish modeled as a function of chlorophyll a during the age-0 stage (t-2), sea temperature during the age-0 stage (t-2), and juvenile pink salmon productivity during the age-0 stage and overwintering survival to age-1 (based on adult pink salmon in year t-1).

For more information contact Ellen Yasumiishi at [ellen.yasumiishi@noaa.gov](mailto:ellen.yasumiishi@noaa.gov)

***Stock Assessment***

**BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA - ABL**

A full sablefish stock assessment was produced for the 2016 fishery. We added relative abundance and length data from the 2015 AFSC longline survey, relative abundance and length data from the 2014 longline and trawl fisheries, biomass and length compositions from the 2015 Gulf of Alaska bottom trawl survey, age data from the 2014 longline survey and 2014 fixed gear fishery, updated 2014 catch, and estimated catches for 2015-2017.

The longline survey abundance index decreased 21% from 2014 to 2015 following a 15% increase from 2013 to 2014 and is at the lowest point of the time series. The fishery abundance index increased 6% from 2013 to 2014 (the 2015 data are not available yet). The Gulf of Alaska trawl survey index was at its lowest point in 2013 but increased 12% in 2015. Spawning biomass is projected to decrease from 2016 to 2019, and then stabilize. Sablefish are currently slightly below the spawning biomass limit reference point and well below the target, which automatically lowers the potential harvest rate We recommended a 2016 ABC of 11,795 t. The maximum permissible ABC for 2016 is 14% lower than the 2015 ABC of 13,657 t. The 2014 assessment projected a 10% decrease in ABC for 2016 from 2015. This slightly larger decrease is supported by a new low in the domestic longline survey index time series that offset the small increases in the fishery abundance index seen in 2014 and the Gulf of Alaska trawl survey index in 2015. The fishery abundance index has been trending down since 2007. The 2014 IPHC GOA sablefish index was not used in the model, but was similar and trending low in 2013 and 2014. The 2008 year class showed potential to be large in previous assessments based on patterns in the age and length compositions. However the estimate in this year’s assessment is only just above average because the recent large overall decrease in the longline survey and trawl indices have lowered the overall scale of the population. 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 2017 to 10,782 t and 10,869 t in 2018.

Projected 2016 spawning biomass is 34% of unfished spawning biomass. Spawning biomass had increased from a low of 33% of unfished biomass in 2002 to 42% in 2008 and has now declined back to 34% of unfished biomass projected for 2016. The 1997 year class has been an important contributor to the population; however, it has been reduced and is predicted to comprise less than 6% of the 2016 spawning biomass. The last two above-average year classes, 2000 and 2008, each comprise 15% of the projected 2016 spawning biomass. The 2008 year class will be about 75% mature in 2016.

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

## J. Lingcod

## K. Atka Mackerel

The following new data were included for the 2015 assessment: The 2014 fishery and survey age composition data were added. Total 2014 year-end catch was updated, and the projected total catch for 2015 was set equal to the 2015 TAC. In addition, the estimated average selectivity for 2011-2015 was used for projections.

Atka mackerel spawning biomass reached an all-time high in 2005, but thereafter decreased by 55% through 2015, and is projected to increase through 2028 under Scenario 3 (average 2011-15 *F,* a reasonable scenario to choose since recent TACs have been lower than ABCs). Addition of new data in 2015 increased the estimated abundances of the 2006, 2007, and 2011 year classes, all of which are above the long-term mean. The projected female spawning biomass for 2016 is 166,407 t, which is above $B_{40\%}$ (135,654 t). The stock is projected to remain above $B_{40\%}$ through 2018 at the recommended harvest levels.

The projected female spawning biomass under the recommended harvest strategy is estimated to be above $B_{40\%}$, thereby placing BSAI Atka mackerel in Tier 3a**.** The projected 2016 yield (ABC) at $F_{40\%}$= 0.30 is 90,340 t, down 15% from the 2015 ABC and 8% from last year's projected ABC for 2016. The projected 2016 overfishing level at $F_{35\%}$ = 0.35 is 104,749 t, down 16% from the 2015 OFL and 10% from last year's projected OFL for 2016. The decreases in ABC and OFL are due primarily to drops in the $F_{40\%}$ and $F_{OFL}$ reference fishing mortality rates (last year's $F_{40\%}$= 0.40 and $F_{35\%}$ = 0.49) which resulted from increased selectivity of younger fish (primarily age 3 in the 2014 fishery).

The random effects model was used in this assessment to apportion the ABC among areas, replacing the weighted average of the four most recent surveys used previously. The recommended ABC apportionments by subarea for 2016 are 30,832 t for Area 541 and the southern Bering Sea region, 27,216 t for Area 542, and 32,292 t for Area 543.

Atka mackerel is not being subjected to overfishing, is not overfished, and is not approaching an
overfished condition. Atka mackerel are the most common prey item of the endangered western Steller sea lion throughout the year in the Aleutian Islands. Analysis of historic fishery CPUE revealed that the fishery may create temporary localized depletions of Atka mackerel, and fishery harvest rates in localized areas may have been high enough to affect prey availability for Steller sea lions. The objectives of having areas closed to Atka mackerel fishing around Steller sea lion haulouts and rookeries, and time-area ABC/TAC allocations, are to maintain sufficient prey for the recovery of Steller sea lions in the Aleutian Islands while also providing opportunities to harvest Atka mackerel. Steller sea lion surveys indicate that counts of adults, juveniles, and pups continue to decline in the Aleutian Islands, particularly in the western Aleutians (area 543) where counts of pups and non-pups declined 9%/year and 7%/year, respectively,

## L. Flatfish

### *Research*

**Bering Sea Infauna Communities and Flatfish Habitats - RACE GAP**
Research continues in characterizing and assessing the productivity of flatfish habitat in the eastern Bering Sea (EBS) under the Essential Fish Habitat provision of the fishery management plan. Recent studies focus on the habitat of juvenile yellowfin sole (*Limanda aspera*; YFS) and northern rock sole (*Lepidopsetta polyxystra*; NRS). In 2011 and 2012, field sampling was conducted in conjunction with the EBS bottom-trawl survey along the southern boundary of the EBS, where juvenile flatfish have historically been relatively abundant. Juvenile flatfish of ≤20 cm and adults of ≥30 cm total length were collected from bottom trawl catch samples at stations located 10 to 120 km from the Alaska Peninsula coast, and in bottom depths of 28 to 85 m. Stomach contents and stable isotopes of carbon and nitrogen from muscle tissue were analyzed to describe diet composition. The spatial correlations between body condition, diet, and the prey field were examined to assess habitat quality. The quantity and quality of prey did not significantly affect the distribution of juvenile NRS and YFS. Spatial mismatch in diet and prey compositions suggested that prey availability was not limiting across the area. The body condition of juvenile NRS was higher in the east – the Bristol Bay area, where they cohabited with juvenile YFS, than in the west – the Unimak Island area, where juvenile YFS were largely absent, suggesting that habitat quality may be higher in Bristol Bay (Yeung and Yang, In review). Investigations are extending to other areas of high concentrations of juvenile flatfish, such as the northern EBS area around Nunivak Island- a hypothesized juvenile NRS “hotspot”, which was sampled in 2014. Continual monitoring of possible juvenile hotspots is being planned to test the hypothesis of alternate habitat use during periods of “warm” and “cold” oceanographic environment in the EBS.

Yeung, C. and M.-S. Yang. Habitat quality of the coastal southeastern Bering Sea for juvenile yellowfin sole (*Limanda aspera*) and northern rock sole (*Lepidopsetta polyxystra*) from diet and prey relationships. In review.

Contact: Cynthia Yeung

**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 Peter Munro for more information (wayne.palsson@noaa.gov).

**Bering Sea drifter deployment study to discern northern rock sole larval advection -REFM**

In an effort to better understand the physics of the eastern Bering Sea shelf current as it relates to flatfish advection to favorable near-shore areas, sets of multiple, satellite-tracked, oceanic drifters were released in 2010, 2012 and 2013. The release sites and dates were chosen to coincide with known spawning locations for northern rock sole (*Lepidopsetta polyxystra*) and known time of larval emergence. The drifters were drogued 5-each at 20 and 40 meters in 2010 and 2012, and 4 at 40 meters and 2 at 20 meters in 2013. The locations of drifters were used to calculate divergence over a 90-day period that corresponds to the larval pelagic duration of Bering Sea shelf northern rock sole. Results indicate that there are alternating periods of positive and negative divergence with an overall trend toward drifter separation after 90 days, roughly the end of the rock sole planktonic larval period. Examination of the drifter behavior at the hourly scale indicates that semi-daily tidal forcing is the primary mechanism of drifter

divergence and convergence. Field observations of early-stage northern rock sole larval distributions over the same period indicate that predominant oceanographic advection is northerly over the continental shelf among preflexion stages, though juveniles are predominantly found in nursery areas located ~400 km eastward and inshore. Evidence from drifter deployments suggests that behavioral movements during the postflexion and early juvenile larval phases that optimize eastward periodicity of tidal cycles is a viable mechanism to enhance eastward movement of northern rock sole larvae to favorable nursery grounds. A regional ocean modeling system (ROMS) was implemented to track the different rates of dispersion in simulations both with and without tidal forcing, and was used to estimate effective horizontal eddy diffusion in the case of both isobaric (fixed-depth) and Lagrangian (neutrally buoyant) particles. The addition of tidal forcing had a pronounced effect on horizontal eddy diffusion, increasing its value by a factor of five in the case of fixed-depth floats, as compared with a factor of two in the case of neutrally buoyant floats. Further, the incorporation of diurnal vertical behavior in phase with favorable (on shelf) tides transported the “larvae” ~ 400 km within 40 days of their release date. Empirical drifter data coupled with model evidence suggest that semi-diurnal tidal forcing is the primary mechanism of eastward advection over the Bering Sea shelf, and larval observational data suggest that northern rock sole larvae can maximize their eastward transport to nursery grounds by synchronizing their vertical movements to tidal periodicity during the postflexion stage. Paper available at DOI: 10.1016/j.seares.2016.03.003.
Tom Wilderbuer (REFM), Janet Duffy-Anderson (FOCI), Phyllis Stabeno (PMEL) and Al Hermann (JISAO)

***Assessment***

**Yellowfin sole Stock Assessment - BERING SEA - REFM**
The 2015 EBS bottom trawl survey resulted in a biomass estimate of 1.93 million t, compared to the 2014 survey biomass of 2.51 million t (a decrease 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 (60% 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 the 2006 is also an above average contributor to the reservoir of female spawners. The 2015 catch of 124,000 t represents the largest flatfish fishery in the world and the five-year average exploitation rate has been 6% for this stock (consistently less than the ABC).

New data for this year’s assessment include:
2014 fishery and survey age compositions
2015 trawl survey biomass point estimate and standard error
estimates of the discarded and retained portions of the 2014 catch
estimate of total catch through the end of 2015.

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. New for 2015 was the smoothing of weights at ages from 11 to 20 in the assessment model and an updated maturity schedule.

The projected female spawning biomass estimate for 2016 of 702,200 t is a 9% increase from last
year's 2016 estimate (648,600 t). Although there was an increase in projected spawning biomass for 2016, the overall trend continues to be a general decline that has prevailed since 1994. The total stock biomass was relatively stable through the early 2000s, but had been steadily approaching $B_{40\%}$ since 2007 (currently 11% above $B_{40\%}$).

The SSC has determined that reliable estimates of $B_{MSY}$ and the probability density function for $F_{MSY}$ exist for this stock. The estimate of $B_{MSY}$ from the present assessment is 435,000 t, and projected spawning biomass for 2016 is 702,200 t, meaning that yellowfin sole qualify for management under Tier 1a. 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 0.098. The current value of the OFL harvest ratio (the arithmetic mean of the $F_{MSY}$ ratio) is 0.105. The product of the maximum permissible ABC harvest ratio and the geometric mean of the 2016 biomass estimate produced the 2016 ABC of 211,700 t recommended by the author and Plan Team, and the corresponding product using the OFL harvest ratio produces the 2016 OFL of 228,100 t. For 2017, the corresponding quantities are 203,500 t and 219,200 t, respectively.

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

**Northern Rock Sole - BERING SEA - REFM**

The northern rock sole stock is currently at a high level due to strong recruitment from the 2001, 2002,2003 and 2005 year classes which are now contributing to the mature population biomass. The 2015 bottom trawl survey resulted in a biomass estimate of 1.41 million t, a 24% decrease from the 2014 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 (25%) 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) 2014 fishery age composition. 2) 2014 survey age composition. 3) 2015 trawl survey biomass point estimate and standard error. 4) updated fishery discards through 2014. 5) fishery catch and discards projected through the end of 2015.

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 58,000 t at the beginning of the model time series in 1975 to a peak of 794,000 t in 2001. Spawning biomass then declined to 521,000 t in 2008, but has increased continuously since then, reaching 665,000 t in 2015. The 2000-2006 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 2016 spawning biomass of 635,000 t. This was slightly less than the 2015 value projected in last year's assessment.

The 2015 assessment contains summaries for two assessment models. The Plan Team recommended retaining Model 1, which is the model that has been used for the last several years.
The SSC has determined that northern rock sole qualifies for management under Tier 1. Spawning
biomass for 2016 is projected to be well above the $B_{MSY}$ estimate of 265,000, placing northern rock sole in sub-tier "a" of Tier 1. The Tier 1 2016 ABC harvest recommendation is 161,100 t ($F_{ABC}$ = 0.148) and the 2016 OFL is 165,900 t ($F_{OFL}$ = 0.153). The 2017 ABC and OFL values are 145,000 t and 149,400 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.

Northern Rock Sole - 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. A full assessment for shallow water flatfish was conducted in 2015 which included updated 2014 catch and the partial 2015 catch as well as projections using the updated results from the northern and southern rock sole assessment. 2015 catches of northern and southern rock sole were substantially lower than catches in 2014, and comprised about 80% of the shallow water complex .

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. The 2015 trawl survey biomass estimates were used for tuning the rock sole models and random effects model were used for apportionments and the tier 5 components of this complex. Specific changes to the rock sole assessment models included adding catch-at-length for 2015 and adding GOA bottom trawl survey biomass and length composition data from 2015. The model was the same as in 2014 (stock synthesis version 3.24S).

The rock sole assessment model estimates are used for trend and spawning biomass estimates whereas the remaining species in this complex are based solely on the NMFS bottom trawl surveys. The complex total current biomass estimate is 303,299 t an increase from the 2015 value of 287,534 t due primarily to an increase in the model estimate of southern rock sole and 2015 survey estimates that were higher for yellowfin sole and butter sole (estimated from the random effects model). The random effects model estimates for current biomass of Starry flounder, English sole, Sand sole, Alaska plaice were lower than estimated for 2015 in the 2014. The model estimate of current biomass for northern rock sole was lower than last year as well.

Northern and southern rock sole are in Tier 3a while the other species in the complex are in Tier 5. The GOA Plan Team agrees with authors' recommended ABC for the shallow water flatfish complex which was equivalent to maximum permissible ABC. 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 44,364 t and OFL of 54,520 t for 2016.

Information is insufficient to determine stock status relative to overfished criteria for the complex as a whole. 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.

**Flathead Sole - 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 2015 shelf trawl biomass estimate decreased 25% from 2014 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.

This assessment was changed to a bi-annual cycle beginning with the 2013 assessment; this is an offcycle year and only a projection model was run. Changes to the input data in this analysis include: Updated 2014 fishery catch and estimated 2015 and 2016 fishery catch. The age 3+ biomass is projected to increase through 2017, although spawning biomass is projected to decline.
The 2015 survey biomass estimate was 25% below the 2014 estimate (22% below 2013 estimate).

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby
qualifying flathead sole for management under Tier 3. The current values of these reference points are $B_{40\%}$=127,682 t, $F_{40\%}$=0.28, and $F_{35\%}$=0.35. Because projected spawning biomass for 2016 (240,427 t) is above $B_{40\%}$, flathead sole is in sub-tier "a" of Tier 3. The authors recommend setting ABCs for 2016 and 2017 at the maximum permissible values under Tier 3a, which are 66,250 t and 64,580 t, respectively. The 2016 and 2017 OFLs under Tier 3a are 79,562 t and 77,544 t, respectively. Flathead sole is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Flathead Sole - GULF OF ALASKA - REFM**
Flathead sole are assessed on a biennial schedule to coincide with the timing of survey data. This year a full assessment was conducted and updated the most recent model presented in 2013 and includes the 2015 NMFS bottom trawl survey data. Minor changes included iteratively re-weighting length and age composition data using a new methodology and effective sample sizes were changed to equal the number of hauls samples were taken from. Harvest apportionments were computed using the random effects model and included the 2015 NMFS bottom trawl survey biomass distributions.

The 2016 spawning biomass estimate (82,375 t) is above $B_{40\%}$ (36,866 t) and projected to be stable through 2017. Total biomass (3+) for 2016 is 265,088 t and is projected to increase in 2017.
Flathead sole are determined to be in Tier 3a. For 2016 the authors recommended to use the maximum permissible ABC of 35,020 t which is down from the 2015 ABC (41,349 t). The $F_{OFL}$ is set at $F_{35\%}$ (0.40) which corresponds to an OFL of 42,840 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.
*Area apportionment*
Area apportionments of flathead sole ABC's for 2016 and 2017 are based on the random effects model applied to GOA bottom trawl survey biomass in each area.
For further information, contact Ingrid Spies (206) 526-4786, Teresa A'Mar (206) 526-4068 or Cary McGillard (206) 526-4693

**Alaska Plaice - REFM**
The Alaska plaice resource continues to be estimated at a high and stable level with very light exploitation. The 2015 Bering Sea shelf survey biomass estimate for Alaska plaice was 355,640 t, a 21% decrease from the 2014 biomass point estimate and the lowest point-estimate for the survey time-series since it began in 1982. The combined results of the 2010 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. The stock is expected to remain at an abundant 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 1975-2015.

This assessment was changed to a biennial cycle beginning with the 2013 assessment; thus 2015 is an off-cycle year and only a projection model was run. Changes to the input data in this analysis include: Updated 2014 fishery catch and estimated 2015 and 2016 fishery catch

Last year's assessment indicated that above average recruitment strength in 1998 and exceptionally strong recruitment in 2001 and 2002 have contributed to recent highs level of female spawning biomass. The spawning stock biomass is projected to decline as these year classes exit the population. Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore qualifying it for management under Tier 3. The current estimates are $B_{40\%}$ = 138,100 t, $F_{40\%}$ = 0.143, and $F_{35\%}$ = 0.175. Given that the projected 2016 spawning biomass of 204,600 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2016 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the $F_{40\%}$ level gives a 2016 ABC of 41,000 t and a 2017 ABC of 39,100 t. The recommended Tier 3a OFLs are 49,000 t and 46,800 t for 2016 and 2017.

Alaska plaice is not being subjected to overfishing, is not overfished, and is not approaching an overfished condition.

**Greenland Halibut (Turbot)**

The 2015 Greenland turbot assessment was updated as follows:
1) Updated 2014 and projected 2015 catch data; 2) 2015 EBS shelf survey biomass; 3) 2015 ABL longline survey RPN; 4) 2015 EBS shelf survey and ABL longline length composition estimates; 5) 2013 and 2014 EBS shelf survey age composition and size at age data; 6) Updated fishery catch-at-length data for 2015.

Analyses of new data (namely size and age composition data for 2013 – 2015) made available in September 2015 revealed a data conflict with the NMFS EBS Shelf and Slope trawl surveys necessitating unexpected model configuration changes to resolve what are clear structural misspecifications. The assessment included three new models, in addition to last year's accepted model (Model 14.0): Model 14.1. Used refined sample size estimates for the slope survey composition data and re-weighted other data. The shelf survey size composition data and size at age data were used but the age composition data were not. Model 15.1. Same configuration as Model 14.1 except the selectivity for the fixed gear fishery was changed from logistic to the "double normal" to account for a perceived change in fishing behavior in 2008; also the 2006 and 2007 trawl fishery size composition data were excluded due to very small sample sizes. Model 15.3. Same configuration and data as Model 15.1 except the fisheries and shelf and slope survey selectivities were allowed to vary using a penalized random walk process.

The authors and Team recommend use of Model 15.1 for harvest specification purposes.

The projected 2016 female spawning biomass is 31,028 t, which is a 0.6% increase from last year's 2015 estimate of 30,853 t. Female spawning biomass is projected to increase to 41,015 t in 2017. While spawning biomass continues to be near historic lows (currently at $B_{18\%}$), 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 $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock. Greenland
turbot therefore qualifies for management under Tier 3. Updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 50,577 t, 0.139, and 0.169, respectively. The stock remains in Tier 3b. The maximum permissible value of $F_{ABC}$ under this tier translates into a maximum permissible ABC of 3,462 t for 2016 and 6,132 t for 2017, and an OFL of 4,194 t for 2016 and 7,416 t for 2016. These are the authors' and Plan Team's ABC and OFL recommendations.

As in previous assessments, apportionment recommendations are based on unweighted averages of EBS slope and AI survey biomass estimates from the four most recent years in which both areas were surveyed. The authors' and Team's recommended 2016 and 2017 ABCs in the EBS are 2,673 t and 4,734 t, respectively. The authors' and Team's recommended 2015 and 2016 ABCs in the AI are 789 t and 1,398 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.

**Arrowtooth Flounder - BERING SEA AND ALEUTIAN ISLANDS- REFM**
Because the 2015 assessment is an "off-year" for the BSAI ATF, new survey information is not incorporated into the assessment model for this update. Instead, a projection model is run with updated catch information. This projection model run incorporates the most recent catch information and provides estimates of 2016 and 2017 ABC and OFL without re-estimating the stock assessment model parameters and biological reference points. The projection model is based on last year's assessment model results.

The following new data were included in the projection model: Final 2014 catch and estimates of 2015 - 2017 catch.  Projection model results estimate age 1+ total biomass for 2016 at 910,012 t, a slight decrease from the value of 911,652 t projected for 2016 in last year's assessment. The projected female spawning biomass for 2016 is 535,350 t which is an increase from last year's 2016 estimate of 528,020 t, and at the highest level estimated since 1975..

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock. Arrowtooth flounder therefore qualifies for management under Tier 3. The point estimates of $B_{40\%}$ and $F_{40\%}$ from last year's assessment were 222,019 t and 0.153, and are carried over for this year. The projected 2016 spawning biomass is far above $B_{40\%}$, so ABC and OFL recommendations for 2016 were calculated under sub-tier “a” of Tier 3. The authors and Team recommend setting $F_{ABC}$ at the $F_{40\%}$ level, which is the maximum permissible level under Tier 3a, resulting in 2016 and 2017 ABCs of 80,701 t and 72,216 t, respectively, and 2016 and 2017 OFLs of 94,035 t and 84,156 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.

***Ecosystem Considerations***
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 are 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.

**Arrowtooth Flounder - GULF OF ALASKA - REFM**
For the 2015 assessment, several improvements were made to the input data and the model structure. Fishery length composition data was updated for all years from 1977-2015, which included adding the length compositions for 1982 and 1983. The age-length transition matrix and weight at age vector were re-estimated based on data from 1977-2015, and the maturity-at-age ogive was updated based on the most recent GOA arrowtooth maturity study. Model changes included development of a generalized ADMB model used for both the BSAI and GOA arrowtooth flounder assessments, which resulted in the modeled ages for the GOA arrowtooth flounder changing from 3-15+ to 1-21+, with selectivity estimated non-parametrically for ages 1-19.

Arrowtooth flounder biomass estimates from the current model are very similar to those estimated in the last full assessment in 2013. The generalized model estimates biomass for two additional ages, ages 1 and 2. The model estimates of total (age 1+) biomass increased from a low of 390,626 t in 1970 to a high of 2,109,820 t in 2009 and slight decrease to 2,103,860 t in 2016. Female spawning biomass in 2016 was estimated at 1,175,240 t, which is above $B_{40\%}$, and represents a 1% decrease from the 2015 estimate in last year’s assessment.

Arrowtooth flounder is estimated to be in Tier 3a. The 2016 ABC ($F_{40\%}$=0.171) is 186,188 t, which is a small decrease from the 2015 ABC of 192,921 t. The 2016 OFL ($F_{35\%}$=0.204) is 219,430 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.

The recommended area apportionment by the random effects model was used to provide apportionments for the 2016 and 2017 ABCs. Percentages and area apportionments of arrowtooth flounder for 2016 and 2017 are based on the fraction of the 2015 survey biomass occurring in each area from the random effects model.

**Other Flatfish - 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 2015 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 EBS survey estimate for 2015 was 102,300 t, well below that of last year.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) borrowed from the Gulf of Alaska are used, along with a value of 0.15 for all other species in the complex. Projected harvesting at the 0.75 $M$ level (average $F_{ABC}$ = 0.117) gives a 2015 ABC of 13,061 t for the "other flatfish" complex. The corresponding 2015 OFL (average $F_{OFL}$ = 0.155) is 17,414 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.

**Deep-water flatfish - REFM GULF OF ALASKA**

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. Dover sole are assessed as a Tier 3a species. The 2015 model was updated to include the most recent data and implemented several model changes relative to the model used for the 2013 assessment. Length and age composition data were iteratively re-weighted using a new methodology, effective sample sizes were changed to equal the number of hauls samples were taken from, and fishery selectivity was estimated using an asymptotic selectivity curve rather than dome-shaped.

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 calculating complex-level OFLs and ABCs. Dover sole apportionment was computed using the random effects model and included the 2015 NMFS bottom trawl survey biomass distributions. Greenland turbot and deepsea sole apportionments were computed using historical survey biomass distributions of both species.

The model estimate of 2016 spawning stock biomass for Dover sole is 49,179 t, which is well above $B_{40\%}$ (22,692 t). Spawning stock biomass and total biomass are expected to remain stable through 2017. Stock trends for Greenland turbot and deepsea sole are unknown.

Starting in 2013, the Dover sole stock has been assessed using an age-structured model and is determined to be in Tier 3a. Both Greenland turbot and deepsea sole are determined to be in Tier 6. The 2016 and 2017 Dover sole ABCs are 9,043 t and 9,097 t, respectively. The Tier 3a calculations for Dover sole result in 2016 and 2017 OFLs of 10,858 t and 10,924 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 2016 and 2017. The GOA Plan Team agrees with the authors' recommendation to use the combined ABC and OFL for the deepwater flatfish complex for 2016 and 2017. This equates to a 2016 maximum permissible ABC of 9,226 t and OFL of 11,102 t for the deepwater flatfish complex.

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.

The recommended apportionment for the deepwater flatfish complex is based on the random effects model applied to survey biomass (percentage by area for all survey years) of Dover sole and the historical survey. This approach results in apportionments based on the relative abundance (biomass) of each species in the stock complex in each management area.

## M. Pacific halibut

### Research

**Halibut Excluders-RACE MACE Conservation Engineering**
In 2015 halibut bycatch quota in the Bering Sea/Aleutian Islands (BSAI) groundfish fisheries was significantly reduced by 21% across four different fishing sectors. CE scientists collaborated with fishing gear manufacturer's and fisherman to test different halibut excluder designs. The basic design concept is a squared mesh tunnel inside the net, target species pass through the tunnel and into the codend, species (halibut, skates, etc) that can't fit through the square mesh tunnel stay inside of the tunnel and escape out the escape hole. The design tested in pollock trawl fleet showed too high a loss of target catch and the manufacturer is working to redesign it. There are several different configuration of the base concept being tested in the bottom trawl fleet with very promising results to so far. We hope to do more rigorous testing in 2017.

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## N. Other Groundfish Species

**Selectivity ratio: a useful tool for comparing size selectivity of multiple fishing gear _ RACE GAP**
Selectivity studies have found applications in the wide range of topics within fishery science, such as fishery management, stock assessments, and ecological process studies. However, obtaining selectivity functions can often be a difficult and costly endeavor. Because of this difficulty, many studies are limited to the catch comparison of 2 fishing gears. These studies usually result in the length-dependent selectivity ratio function defined as the quotient of the selectivity of one gear versus selectivity of another gear. Literature review indicates that although selectivity ratio has been a subject of many studies, there is generally a lack of standard methods for its estimation and general lack of standard naming conventions. In this study we propose a new general approach to estimate selectivity ratio and present examples of its practical application in three case studies: a comparison of fine-and large mesh bottom trawls used in Arctic surveys in the recent several decades, a study testing an assumption of full selectivity of the Bering Sea Fisheries Research Foundation Nephrops bottom trawl for snow crab in the Bering Sea, and a comparison of 2 survey midwater trawls for pollock in the Bering Sea. We show that selectivity ratio statistics can be used as generalization of selectivity studies, where one gear is fully selective, as well as in catch comparison studies where selectivity of both gears is unknown. We provide advice on methods for comparing alternative modelling approaches for the selectivity ratio. We advocate for standardization of the naming conventions and methods used in catch comparison studies.

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The effect of variable sampling efficiency on reliability of observation error as a measure of uncertainty in abundance indices from scientific surveys- RACE GAP and REFM

One of the main goal of fisheries surveys (hereafter referred to as surveys) is to obtain indices of abundance of fish populations. These indices can be directly used in fishery stock assessments to infer about the stock status and provide advice for fisheries management. Survey abundance estimates are often used in the assessment models with multiple data inputs such as integrated analyses. However, integrated analyses require independent inputs to be assigned appropriate weights as the outcomes and their uncertainty may be strongly influenced by the choice of weights.

The most commdon approach to weighting the abundance estimates from surveys is to use survey sampling variance (observation error) as a measure of uncertainty. However the variance estimates derived from samples alone may not represent total variance of the index of abundance. Sampling variance is usually estimated accordingly to the survey design assuming equal and constant efficiency across all samples. However, sampling efficiency studies indicate that sampling efficiency vary between samples and can be a source of additional variation in the observed abundance trends. In such cases, both observation error and variability in sampling efficiency must be accounted for to fully evaluate the uncertainty of an abundance estimate.

The main goals of this study were to examine the effect of variable sampling efficiency on the estimates of survey sampling variance and on the total variance of the abundance index. To achieve this, we simulated realistic fish distributions based on walleye pollock distributions in the eastern Bering sea (EBS) over the last 10 years and multiple fishery surveys with varying sampling efficiency and varying variance in sampling efficiency. Our results indicate that variable sampling efficiency can result in bias and loss of precision in both abundance estimates and survey variance estimates. The degree of these effects depends on the mean value of sampling efficiency as well as the variance in sampling efficiency.

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**Systematics Program - RACE GAP**

Several projects on the systematics of fishes of the North Pacific have been completed or were underway during 2015. Orr and Wildes are continuing their work on sandlances by including Atlantic species in a global analysis and conducting more detailed population-level studies in the eastern Pacific. A guide to cods and cod-like fishes (Gadiformes) was published (Hoff, Orr, and Stevenson, 2015). A taxonomic revision of snailfishes in the *Careproctus rastrinus* species complex, including the description of a new species from the Beaufort Sea, was published (Orr et al., 2015). 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); a partial revision of the lumpsucker genus *Eumicrotremus* (Stevenson); and a study of the developmental osteology of the bathymasterid *Ronquilus jordani* (Stevenson, with Hilton and Matarese). A description of two new species of snailfishes from the Aleutian Islands has been accepted (Orr, in press). Work on the morphology of the pectoral girdle of snailfishes (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, a publication now in press (Gardner, Orr, Stevenson, Somerton, and Spies, in press), a project also unexpectedly leading to the recognition of at least one new snailfish in Alaska. Also with AFSC geneticists, we will examine population-level genetic diversity in the Alaska Skate, *Bathyraja parmifera*, especially as related to its nursery areas, to be 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, now published (Pietsch and Orr, 2015), and a paper documenting the first occurrence of two rare manefish species from Japanese waters (Okamoto and Stevenson, 2015). Stevenson recently completed a section on manefishes for the upcoming FAO guide to the living marine resources of the Eastern Central Atlantic, to be published later in 2016 (Stevenson et al., in Press).

Orr and Stevenson have also conducted work with invertebrates. With the support of NPRB and JISAO, an annotated checklist of the marine macroinvertebrates of Alaska, comprising over 3500 species, is now in press (Drumm et al., in press). A report on a pilot study to collect coral bycatch data from the Alaska commercial fishing fleet was also completed (Stone et al., 2015). Collections are now being made to evaluate the population- and species-level genetic variation among populations of the soft coral *Gersemia* (Orr and Stevenson, with NWFSC).

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**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.” 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%. In 2015 and early 2016 the over/under design was tested in the Bering Sea pollock fleet with only about 10% escapement of salmon and about 1% pollock escapement. It is unclear at this time why the salmon escape rates are so different between the two different fleets. 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.

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**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 in 2017.

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

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 3 years now and have proven to be very easy to use, durable and flexible. Six new systems have been 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.

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## V. Ecosystem Studies

**Energetic Condition Juvenile Groundfish in the Gulf of Alaska - ABL**

In 2015 the synthesis we began synthesizing data describing the energetic condition of juvenile Pacific cod, pollock, arrowtooth flounder and Pacific Ocean Perch collected during the GOAIERP and Gulf Surveys. The analyses largely corroborated the conclusions drawn by the GOAIERP that environmental indices predicting future recruitment need to be species specific. A spatially explicit growth potential model that directly compared the growth of cod and pollock sampled from pelagic trawls indicated that pollock employ a “sweepstakes” strategy to early life history and future recruitment is likely dependent on spatial matches between juveniles and optimal growing conditions. “Hot spots” for pollock growth are ephemeral and their spatial distribution is highly variable. Features defining these hotspots are, in order of importance, prey quality and temperature. In contrast, Pacific cod are more tuned to average conditions. Consequently, growing conditions for cod are more consistently located around the Gulf and they are less sensitive to variations in prey quality or temperature.

A second analysis examined the energy allocation strategy of Pacific Ocean Perch juveniles with their length during their pelagic residence. A distinct trade-off between growth and energy storage was detected at about 25 mm, the size at which predation by Chinook and coho salmon begins decreasing. Examination of catch records for Pacific Ocean Perch on the GOAIERP and Gulf surveys indicates that in cool years, fish are vulnerable to predation for a longer time and have less time to store energy.

A third analysis indicates that juvenile fish sampled from the epipelagic in the GOA are storing energy for different reasons. Data mining of the RECA energy database provided plots of energy density versus length for the entire life history for many of the speciies encountered in AFSC surveys. The plots revealed distinct life history patterns suggesting appropriate periods for monitoring juveniles to predict recruitment. For example, Pacific Ocean Perch and Pacific cod both demonstrated significant losses in energy associated with settling out of the water column. For both species the low energy densities observed after settling out were maintained until fish began maturing several years later. This suggests constraints on survival for post-settlement care different than those of earlier life stages. The similarity of energy allocation strategy with older aged juveniles indicates survival of post-settlement age-0’s is constrained by the same factors as those constraining older juveniles. This story is very different from that of walleye pollock, which appear to store energy as age-0 to forestall starvation in winter when prey supplies are diminished.

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**ACES RECA** completed its last field season sampling the nearshore areas around Pt Barrow. The nearshore area around Pt. Barrow, Alaska offers a variety of habitats making it an ideal location for understanding the ecological dependencies of juvenile fish in the arctic. Pt. Barrow demarks the boundary between the Chukchi and Beaufort Seas. On the Chukchi side the shallow continental shelf is deeply incised by Barrow canyon. In contrast, the shelf on the Beaufort side of Pt. Barrow is broad and shallow extending eastward. The Beaufort coast is lined with a series of barrier islands that bound brackish inland lagoons. In summer, predominantly easterly winds drive the warm brackish water out of the lagoons and along the Beaufort coast towards Pt. Barrow, although energetic wind-driven flow reversals are common. The energetic and continually adjusting flows around Pt. Barrow support productive waters. Our project is focusing on monitoring the current structure in the nearshore including influx and efflux from Elson Lagoon. In addition we are sampling the zooplankton community and nearshore fish community in the marine and lagoon waters with a combination of beach seines and nearshore trawling. Laboratory analysis of retained samples include diets, isotopic analysis, energy densites and elemental analysis of otoliths of fish and invertebrate species typically encountered. These include Arctic cod, saffron cod, capelin, sand lance, and various sculpins.

**ACES – ABL**

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**Alaska Coral and Sponge Initiative – RACE & ABL**

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.

Fieldwork for the AKCSI project was completed in FY15 with a remotely operated vehicle cruise in Southeast Alaska to examine Primnoa thickets at two study sites. Data analysis and image analysis is underway. It is anticipated that the final report for this project will be completed by September 2016 and delivered at the International Coral Symposium in Boston, MA.

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**Defining EFH for Alaska Groundfish Species using Species Distribution Modeling-RACE**

**Principal Investigators:** Chris Rooper, Ned Laman, Dan Cooper (RACE Division, AFSC)

In Alaska, most EFH descriptions for groundfish are limited to qualitative statements on the distribution of adult life stages. These are useful, but could be relatively easily refined both in terms of spatial extent and life history stage using species distribution models and available data. Distribution models have been widely used in conservation biology and terrestrial systems to define the potential habitat for organisms of interest (e.g. Delong and Collie 2004, Lozier et al. 2009, Elith et al. 2011, Sagarese et al. 2014). Recently species distribution models have been developed for coral and sponge species in the eastern Bering Sea and Aleutian Islands (Rooper et al. 2014, Sigler et al. in review). The models themselves can take a number of forms, from relatively simple frameworks such as generalized linear or additive models to complex modeling frameworks such as boosted regression trees, maximum entropy models, two-stage models or other formulations. The models can be used to predict potential habitat, probability of presence or even abundance, but they all have some features in common.

- the underlying data consists of some type of independent variables (predictors) and a dependent response variable (presence, presence/absence or abundance)
- raster maps of independent variables are used to predict a response map
- confidence bounds on the predictions and partitioning of the data can produce test statistics useful for evaluating the model

We used species distribution modeling framework to refine the descriptions (to level 2) of Essential Fish Habitat for Alaskan groundfish species. This was completed for each of the Alaska regions and for all groundfish species for four seasons separately. The independent variables were variables (such as depth, slope, bottom water temperature, current speeds, etc.) widely available from remote sensing or long-term monitoring programs at the AFSC. The dependent variables were survey catches (primarily bottom trawl, but we will include pelagic surveys and ichthyoplankton surveys where available) of the Alaska FMP species. Where no scientific survey data were available (in the winter spring and fall seasons), observer catches were also used for distribution modeling. Where possible, the species were divided by life history stage into egg/larval, juvenile and adult groups.

Three types of models were used, depending on the catch data characteristics. The ichthyoplankton data and the observer data were treated as presence-only and Maximum Entropy modeling was used. For bottom trawl data, generalized additive models, hurdle models or maximum entropy models were used depending on the number of zero catches in the data set.

Over 400 different models were completed (for example see the models for yellowfin sole in the eastern Bering Sea shown in Figure 1). The results were generally consistent and the models generally fit the data well. Validation data sets and diagnostic plots were produced and examined for each of the models.

The most important variables explaining the distribution of fish species tended to be depth for juvenile and adult life history stages that were on or near the seafloor and surface currents for the early life history stages found in the water column (Figure 2). The model-based EFH maps produced were different for most species than the maps produced in 2010 (Figure 3).

The new maps and descriptions were reviewed by stock authors in late 2015 and were delivered to the North Pacific Fishery Management Council in early 2015.

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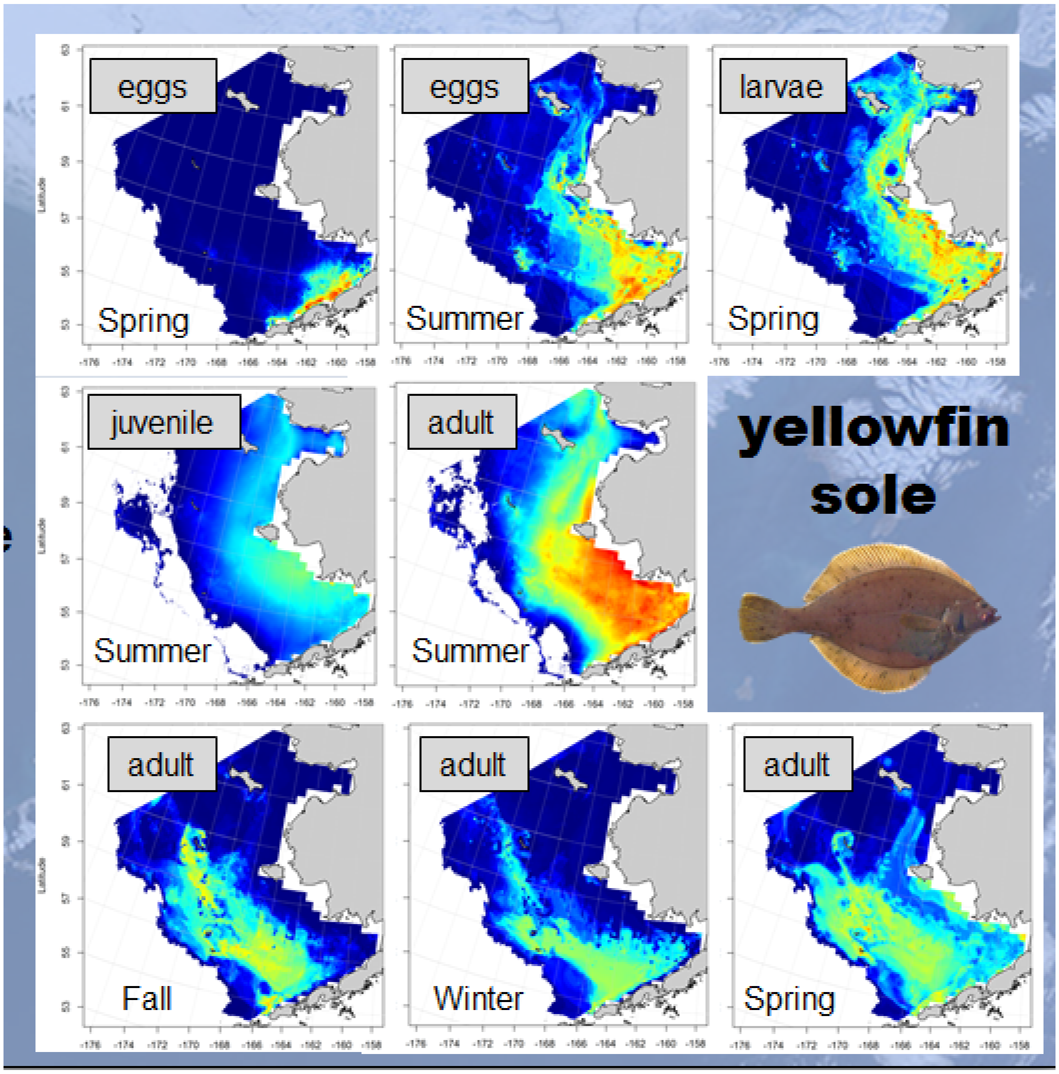



Figure 1. Yellowfin sole distribution models for all life history stages and seasons where data was available. Yellow-red colors indicate higher CPUE or probability of suitable habitat.

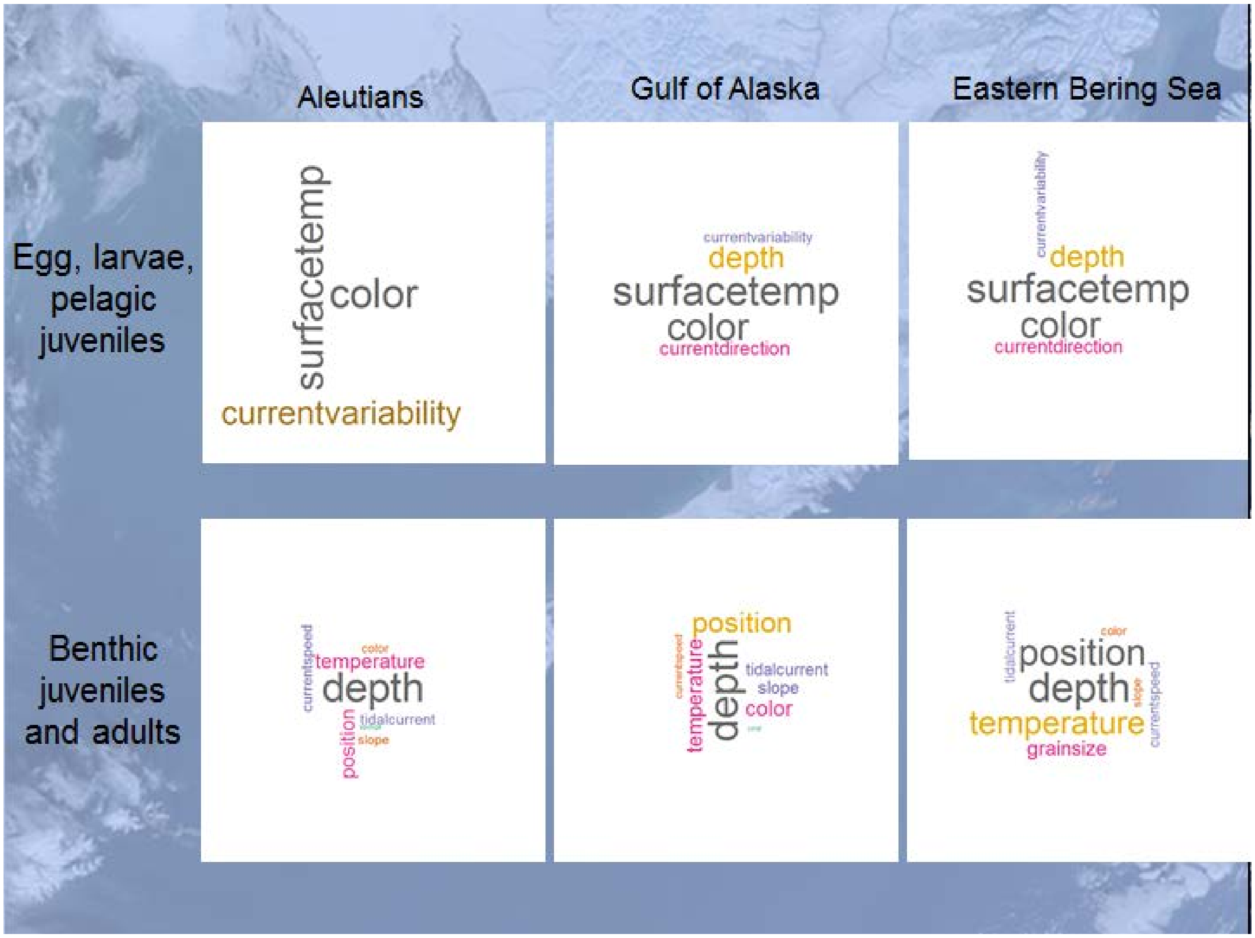



Figure 2. Word clouds for important habitat variables (explaining the most variance) summarized for each region and across life history stages.

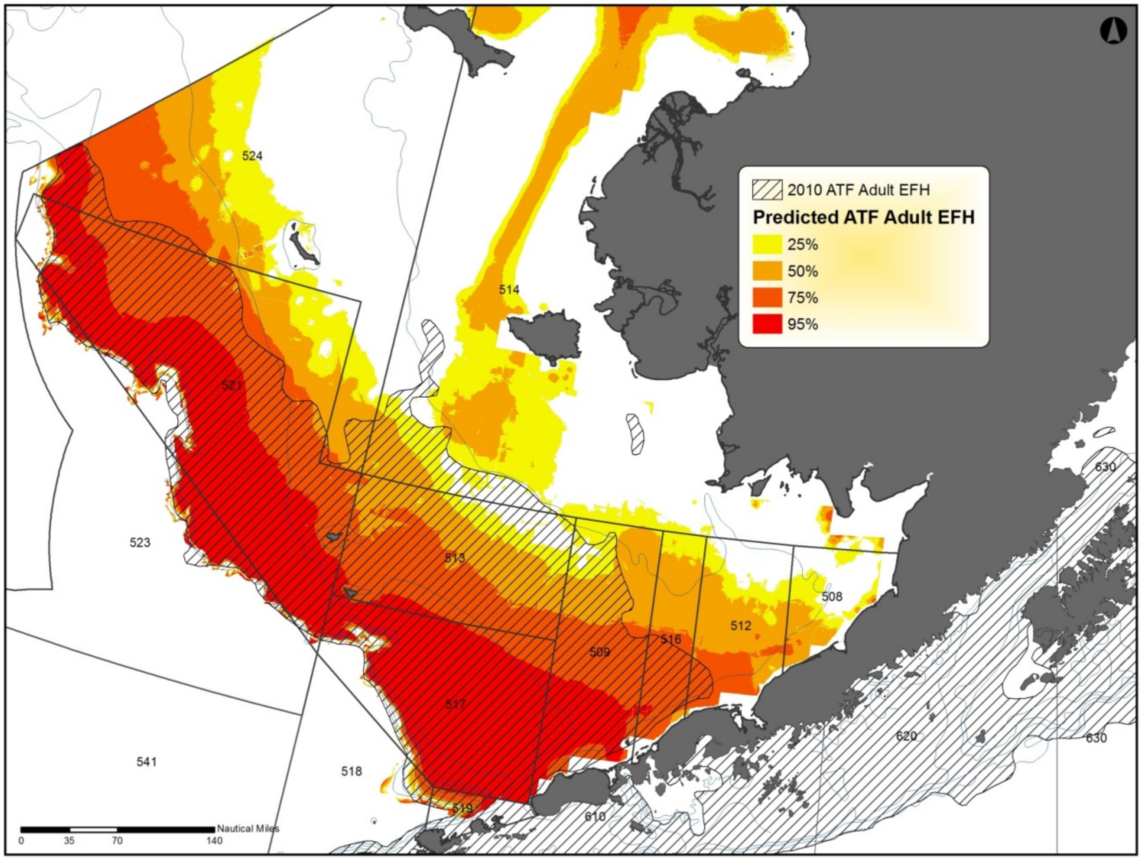
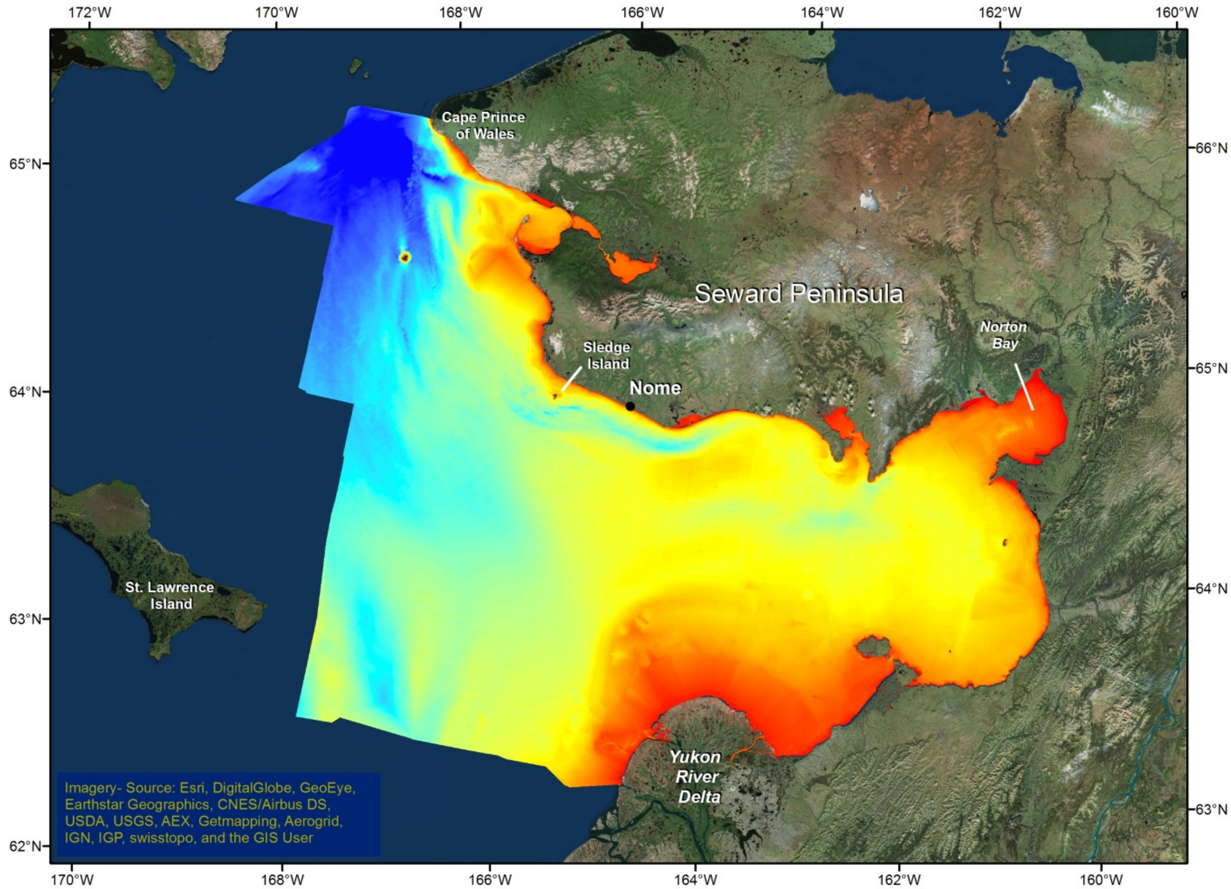



Figure 3. Essential fish habitat for adult arrowtooth flounder in the eastern Bering Sea as predicted by models (yellow-red scale) and the 2010 polygons (cross-hatched areas).

Smooth sheet bathymetry of the Norton Sound - RACE GAP
As a continuation of work in Alaskan waters (http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/default.htm ), scientists with the AFSC's Groundfish Assessment Program (GAP) have published smooth sheet bathymetry for Norton Sound, Alaska. This work is part of a project using smooth sheets to provide better seafloor information for fisheries research.

The Norton Sound project includes smooth sheet bathymetry editing, the digitizing of sediments, inshore features, and shoreline, as well as incorporating higher resolution multibeam bathymetry data, where available, to supersede some areas of older, lower resolution smooth sheet bathymetry ( http://www.afsc.noaa.gov/RACE/groundfish/Bathymetry/Norton_Sound.htm ).




Over 230,000 National Ocean Service (NOS) bathymetric soundings from 39 smooth sheet surveys in Norton Sound were corrected, digitized, and assembled, as well as over 6000 soundings from a GAP research cruise, and three NOS multibeam surveys. The bathymetry compilation ranged geographically from the eastern point of St. Lawrence Island, southeast to the Yukon River delta and north along the Seward Peninsula and around the point of Cape Prince of Wales.

Our Norton Sound coverage is very shallow, with a maximum depth of 63 meters in the outer waters along the Bering Sea, while the sound itself, bounded by the westernmost point on the Yukon River delta along the south and Nome on the North, has an average depth of just 13 meters. 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. These data are not to be used for navigational purposes.

Funding from the NMFS Alaska Regional Office's Essential Fish Habitat (AKR EFH: http://www.afsc.noaa.gov/HEPR/docs/Sigler_et_al_2012_Alaska_Essential_Fish_Habitat_Research_Plan.pdf ) made this work possible. This Norton Sound bathymetry and sediment work was done in response to a NMFS AKRO (Alaska Regional Office) request to provide information for a new predictive modeling effort examining Norton

Sound red king crab and potential effects of offshore marine mining activities on their habitat. The Alaska Regional Office will also investigate use of the bathymetry and sediment information to oversee sustainable fisheries, conduct Essential Fish Habitat (EFH) reviews, and manage protected species. This Norton Sound bathymetry compilation is part of a GAP (Groundfish Assessment Program) effort to create more detailed bathymetry and sediment maps in order to provide a better understanding of how studied animals interact with their environment

Users of these data should cite the source as: Prescott, M. M., and M. Zimmermann. 2015. Smooth sheet bathymetry of Norton Sound. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-298, 23 p.

Contact Mark.Zimmermann@noaa.gov

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

Contact:  Janet Duffy-Anderson

Icthyoplankton Assemblages and Distribution in the Chukchi Sea 2012-2013 - RPP
There is significant interest in the effects of climate change on the Pacific Arctic ecosystem, and in determining influences on resident biota.  In summer 2012 and 2013, large-scale fisheries oceanographic surveys that included ichthyoplankton tows were conducted in the northern Bering and eastern Chukchi Seas as part of the Arctic Ecosystem Integrated Survey (Arctic Eis).  Collections of pelagic fish eggs found high concentrations of  *Limanda* spp. (probably yellowfin sole *L. aspera*) along the north shore of Seward Peninsula and also near Point Hope and Cape Lisburne in both 2012 and 2013 with greater abundances collected in 2012 (Fig 1).  *Hippoglossoides robustus* (Bering flounder) eggs were caught to the west and offshore from Point Barrow in 2012. Similar but less pronounced trends in egg distribution were observed in 2013.  These localized concentrations of eggs of both species suggest the presence of aggregations of spawning adults in those immediate areas.

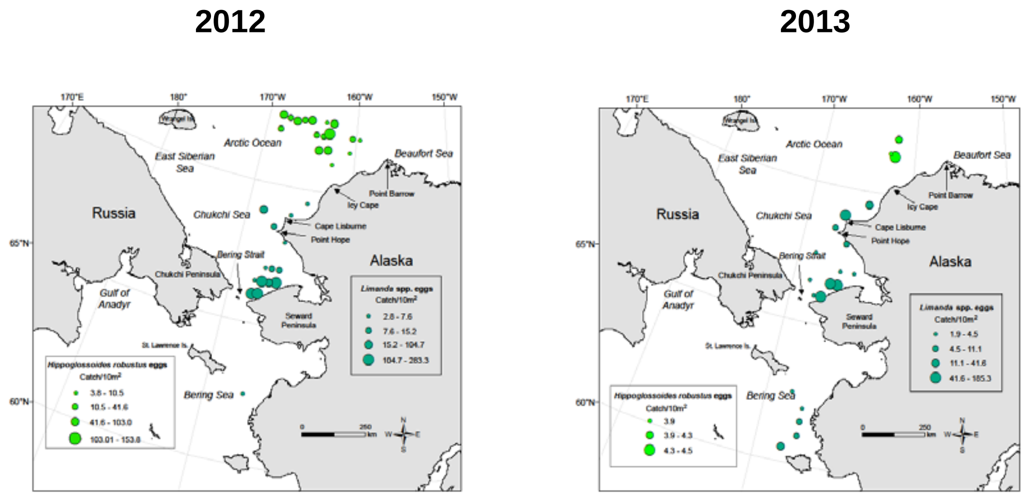



Figure 1. Abundance and distribution of *Limanda* spp. and *Hippoglossoides robustus* eggs in 2012 and 2013

Contact: M. Busby, J. Duffy-Anderson, K. Mier (NOAA/AFSC/EcoFOCI Program) and H. Tabisola (UW/JISAO)

### Redesigning a survey to capture the early life stages of groundfishes in the Bering Sea - RPP

The Eco-FOCI program conducts biennial spring surveys in the Bering Sea to study the early life stages of groundfishes, in particular Walleye Pollock, in order to better understand the ecosystem processes underlying fisheries recruitment and productivity. Studies have shown that the spatial distribution of Walleye Pollock larvae differs in cold and warm years, and that the existing survey design was failing to capture the full extent of their distribution. In 2015-16 we reassessed our survey design to ensure it covers the major known spawning areas of Walleye Pollock on the SE Bering Sea shelf, captures the variable spatial extent of larvae, and can be used to create an index of larval abundance for ongoing studies of early life stage survival. We considered three possible alterations to the survey grid in order to reduce sampling intensity and increase spatial coverage: 1) dropping every other station in the cross shelf direction, 2) dropping every other station in the along-shelf direction, and 3) dropping every other station from each line to create an evenly spaced, staggered grid. An analysis of the spatial autocorrelation in pollock larvae counts from 2012 and 2014 provided no consistent support for reducing sampling intensity in one direction versus the other. We used geostatistical delta generalized linear mixed models to construct an abundance index from the survey data in 2012 and 2014, and compared the mean estimates and their precision with those resulting from analyzing subsets of the data corresponding to the three candidate grids. The skip-across-shelf design had the highest precision, whereas the stagger design was most accurate. We decided on a stagger design, with stations spaced approximately 22 nm apart (the existing design had 15 nm spacing). The new design has two types of stations: core sampling stations that are always sampled, and adaptive sampling stations on the edges of the core that can be added dynamically during a survey if the edge of the distribution of larvae has not yet been reached (Figure 1). A stopping rule, based on counts of larvae at sea, will be used to determine whether sampling should continue along a line beyond the core stations. We anticipate that this survey design will result in a minor loss of precision, while greatly improving our ability to census the full spatial extent of pollock larvae, ultimately improving our understanding of early life history dynamics and pollock recruitment variability.

Contact: L. Rogers, K. Mier, S. Porter (NOAA/AFSC/EcoFOCI Program)

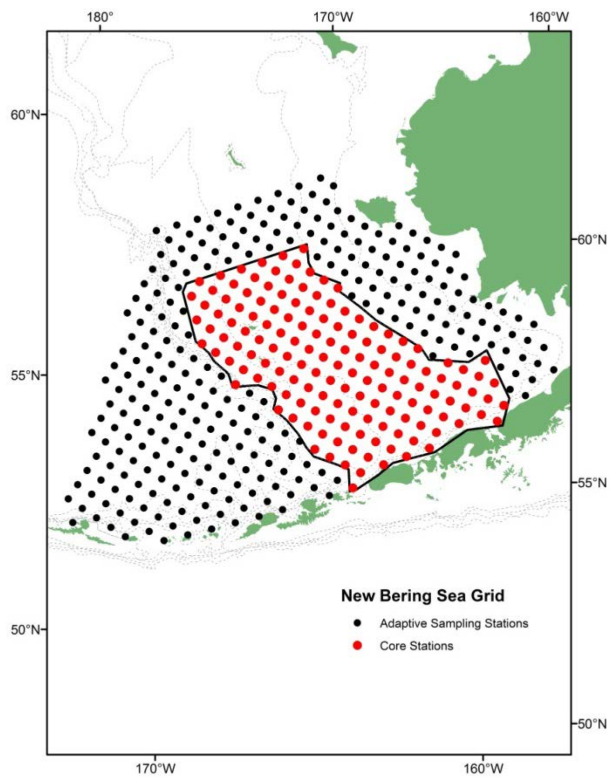



Figure 1: The new sampling grid for the Eco-FOCI spring survey in the SE Bering Sea consists of core stations (red) that are sampled every survey, and adaptive stations (black) that are sampled if the edge of the distribution of Walleye Pollock larvae has not been reached, as indicated by at-sea counts.

New midwater trawl for the Recruitment Processes Alliance - RPP
EMA and Eco-FOCI completed an integrated ecosystem survey from 6 September to 6 October 2016. We evaluated a new midwater trawl which will be adopted for future surveys. The trawl gear was a NETS 156 small mesh midwater trawl designed and built by NETS Systems to attempt to create a durable trawl with high catch efficiency of age-0 pollock in late summer and early fall.
Oblique tows to 10 meters off bottom or 200 meters maximum depth were conducted on the BASIS survey grid. Age-0 pollock abundances were highest over the middle shelf.

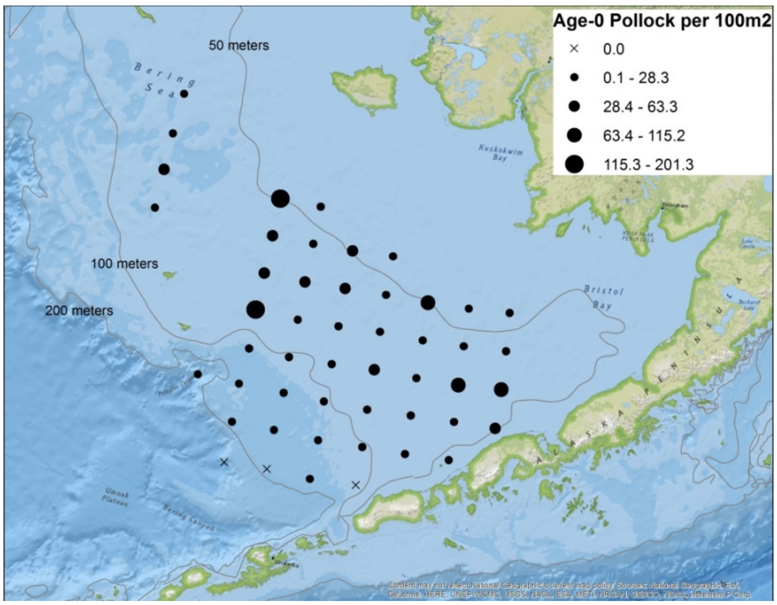



Figure 1. Age-0 Pollock per 100m$^2$ surface area from oblique midwater tows.

The trawl was equipped with an FS-70 third wire to measure vertical and horizontal opening to quantify the mouth opening and the volume of the water filtered by the trawl.

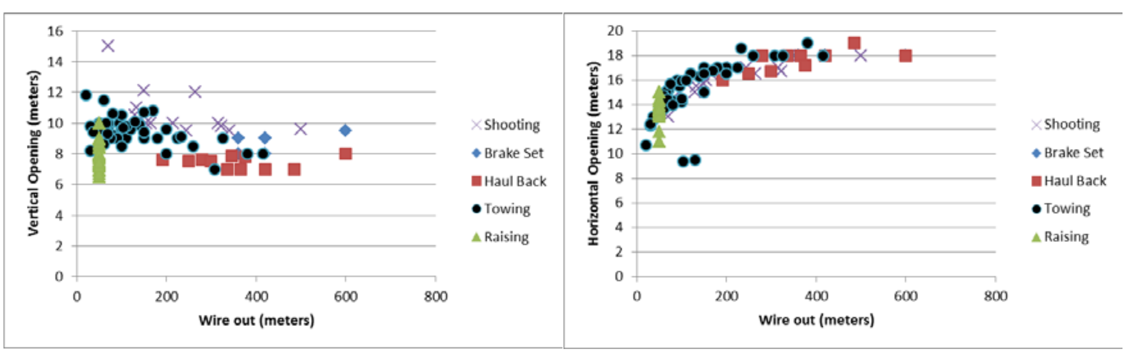



Figure 2. Vertical opening (left panel) and horizontal opening (right panel) at trawl warp wire out for the NETS 156 midwater trawl.

A camera was mounted at various places in the net to observe how the net fished and to look for fish escapement. A bulge was observed in the trawl body forward of the connection to the codend, and some age-0 pollock were observed escaping the net at this bulge. The trawl is currently being modified to reduce the constriction causing the bulge to improve water flow through the net and net catch efficiency. Future work with pocket nets will evaluate the catch efficiency of the trawl.
The trawl fished well at depths near the bottom up to a headrope depth of about 10 meters, but would not fish at depths more shallow than 10 meters. Additional floats are being added to include in an attempt to fish oblique tows all the way to the surface in 2016.

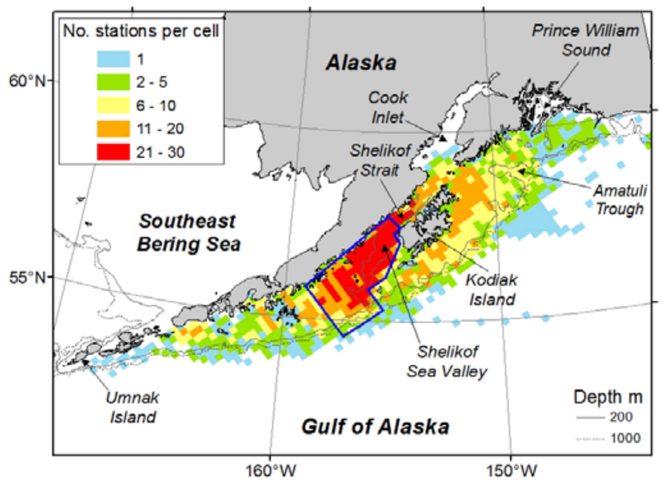
Contact: D. Cooper, A. Spear (NOAA/AFSC/EcoFOCI Program), A. Andrews (NOAA/AFSC/EMA Program)

**Gulf of Alaska Ichthyoplankton Abundance Indices 1981–2013 - RPP**
The Alaska Fisheries Science Center's (AFSC) EcoDAAT Database includes data from collections in the Gulf of Alaska (GOA) from 1972 to the present with annual sampling 1981–2011 and biennial sampling thereafter. Since 1985 these collections have been part of AFSC's recruitment processes research under the Ecosystems and Fisheries Oceanography Coordinated Investigations Program (EcoFOCI). The primary sampling gear used for these collections is a 60-cm bongo sampler fitted with 333 or 505-µm mesh nets; oblique tows are carried out mostly from 100 m depth to the surface or from 10 m off bottom in shallower water (Ichthyoplankton Information System (http://access.afsc.noaa.gov/ichthyo/). Historical distribution of sampling effort extends from the coastal area to the east of Prince William Sound southwestwards along the Alaska Peninsula to Umnak Island, covering coastal, shelf and adjacent deep water, but sampling has been most intense in the vicinity of Shelikof Strait and Sea Valley during mid-May through early June (Fig. 1A). From this area and time, a subset of four decades of data has been developed into a time-series of ichthyoplankton species abundance and it is now updated through 2013.

The 2013 time series data suggest that environmental conditions in the Gulf of Alaska favored high abundances of certain species of fish larvae in May 2013 (7 out of 12 show positive anomalies, the remaining 5 are neutral to slightly negative). Abundance of walleye pollock larvae displayed a moderately positive anomaly for 2010, a slightly negative response in 2011 and then a very high positive anomaly in 2013. The abundance of larvae in 2013 was the second largest of the time series after 1981. For rockfish larvae, a moderate positive anomaly in 2010 was followed by a very high positive anomaly in 2011 and an even higher one in 2013. Pacific cod also showed a high positive anomaly in 2013. For flatfishes in 2013, moderately positive anomalies occurred in starry flounder, northern and southern rock sole and Pacific halibut while moderately negative anomalies occurred in flathead sole and arrowtooth flounder.

Increases in observed abundances across some species in 2013 may be due to: 1) circulation features that favored retention of larvae over the shelf; it was noted that satellite-tracked drifter trajectories indicated the presence of eddies in the region in spring, 2) improved growth and survival mediated by moderate temperature (see Dougherty, this document, for survey temperatures in 2013 and 2015), and 3) robust feeding conditions (NPRB/GOAIERP zooplankton data analyses in progress, Hopcroft personal communication). More information on factors influencing larval abundance and distribution will be made available through the GOAIERP Synthesis program (2015–2018).

**A**

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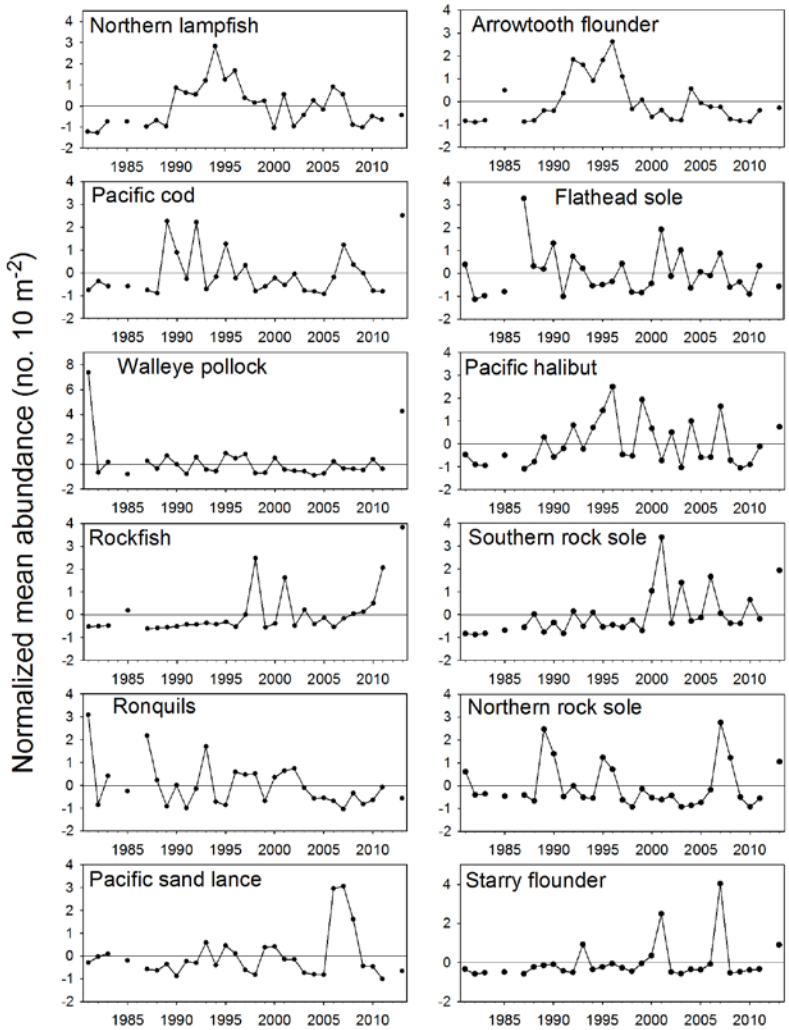
**B**

Figure 1. (A) Distribution of historical ichthyoplankton sampling in the Gulf of Alaska. (B) Interannual variation in late spring larval fish abundance for the most abundant species. For each year and taxon, the larval abundance index is expressed as the mean abundance (no. 10 $m^{-2}$) normalized by the time-series mean and standard deviation.




Contact: A. Matarese and K. Mier (NOAA/AFSC/EcoFOCI Program)

## Temperature and Gulf of Alaska Larval Walleye Pollock Survival - RPP

The 2015 Eco-FOCI Gulf of Alaska larval survey was conducted from May 14 to June 5 aboard the NOAA research vessel Oscar Dyson. A total of 276 stations were sampled using the 20/60 cm bongo array with 0.153/0.505 mm mesh to collect larvae and zooplankton. A rapid assessment of the zooplankton community was conducted at sea from each mesh size throughout the survey (see results presented by N. Ferm in the 2015 Ecosystem Considerations). Plankton tows for larval fish, especially walleye pollock, were conducted to 10 meters off bottom or 100 meters maximum. A Sea-Bird FastCat was mounted above the bongo array to acquire gear depth, temperature, and salinity profiles. Temperature at 40 meters (depth of larval residence) was selected at each station to represent the temperature field.  Abundance and temperature maps were constructed to illustrate the distribution of larval pollock throughout the survey area.  Larval walleye pollock rough counts for 2015 were consistently lower throughout the grid compared to the counts in 2013 (note drastic reduction in RCountL scale range for 2015).  The temperature field at 40 meters in 2015 was 3-5°C warmer than in 2013.  The rapid assessment of the 2015 zooplankton community showed an abundance of small copepods, the preferred prey of larval pollock, suggesting that the larvae were not food limited during this life stage.

The 2013 year-class was reported to have resulted in slightly below average numbers of age-1 recruits in the 2014 Stock Assessment and Fish Evaluation document (Table 1.18).  Preliminary results from the MACE survey, conducted in March of 2016 to assess adult pollock abundance in the Gulf of Alaska, reported very few 1 year-old pollock (2015 year-class).

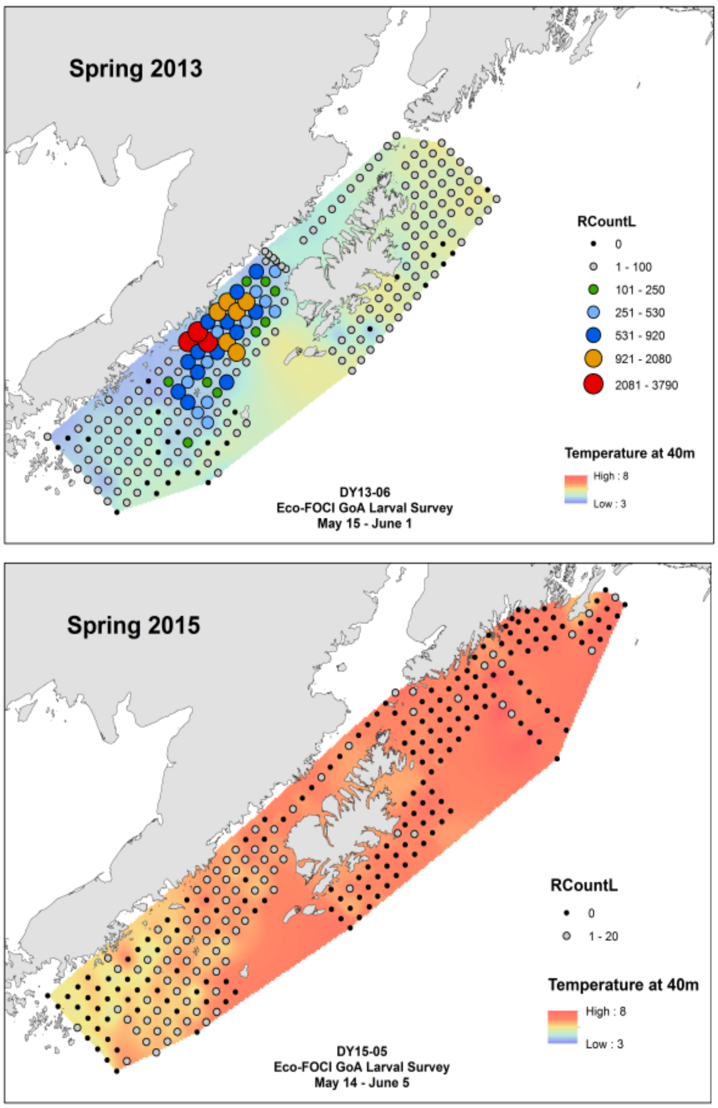



Figure 1.  Temperatures at depth (color ramp) and larval abundance estimates (at-sea rough counts, circles) for walleye pollock in the Shelikof Sea valley in 2013 and 2015.

Contact: A.B. Dougherty (NOAA/AFSC/EcoFOCI Program)

**The Eco-FOCI late-summer Gulf of Alaska small-mesh trawl survey, August-September 2015 - RPP**

The EcoFOCI late-summer time series of small neritic fishes in the western Gulf of Alaska now extends from 2000 – 2015. Most recently, we observed relatively few age-0 walleye pollock, which reflected low abundance of larvae in May. This extends the recent spate, since 2012, of low-abundance year classes. Juvenile rockfishes were comparatively abundant; presumably, these were mostly Pacific ocean perch, which were once quite abundant in the Gulf and as adults may compete with pollock for krill. Water temperatures were higher than in previous years; however, the geographic patterns of temperature and salinity were similar to past observations and consistent with known circulation patterns. Possible temperature-mediated ecosystem responses are being investigated.

Contact: M. Wilson, S. Porter (NOAA/AFSC/EcoFOCI Program) and W. Strasburger (NOAA/AFSC/EMA Program)

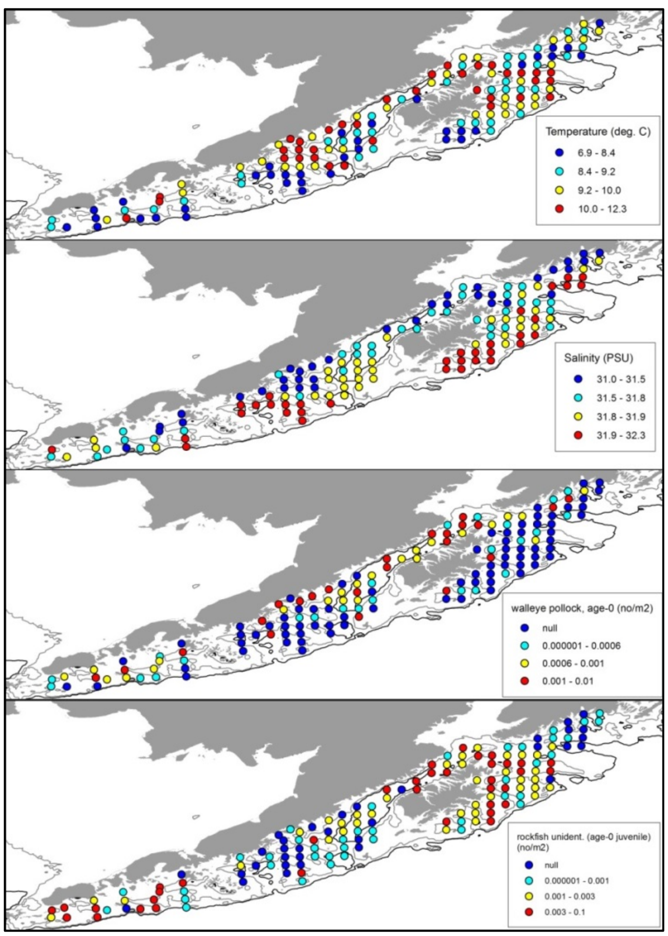



Figure 1. Water temperature and salinity, at 40-m depth, and abundance of age-0 juvenile walleye pollock and rockfishes as estimated in the western Gulf of Alaska during August-September 2015.

## Using cell-cycle analysis to measure growth of Walleye Pollock *Gadus chalcogrammus* larvae - RPP

Preliminary results of a new method using cell-cycle analysis of muscle cell nuclei with flow cytometry for measuring the growth rate of Walleye Pollock *Gadus chalcogrammus* larvae collected as eggs from the Gulf of Alaska are presented here. This method is based on the premise that cell proliferation is related to growth. An advantage of using flow cytometry is that it is faster than counting otolith daily increments, particularly when increments are difficult to discern due to slow growth. Walleye Pollock larvae were reared in the laboratory using different prey ration diets. A generalized additive model (GAM) to estimate growth rate (mm/d) was formulated beginning from when those larvae initiated feeding. The best fit model had standard length (SL), proportion of cells in the S phase of the cell cycle, and proportion of cells in the G2 and mitosis phases for covariates, and $R^2 = 0.84$. The model calculated growth rates more accurately for larvae > 7.5 mm SL (5% mean error), than for smaller larvae where accuracy was much more variable and in some cases error was > 100% (Table 1). A future model will include multiple temperatures that larvae can experience in the field. Accurate growth measurements of Walleye Pollock larvae will lead to better understanding of the relationship between environmental variability and larval survival in Alaskan waters.

Table 1. Growth model accuracy tested with an independent group of larvae.

| Standard length (mm) | Actual growth rate (mm/d) | Model growth rate (mm/d) | SE | % error |
|---|---|---|---|---|
| 5.61 | 0.00 | 0.02 | 0.01 | > 100 |
| 5.85 | 0.01 | 0.03 | 0.01 | > 100 |
| 6.05 | 0.08 | 0.06 | 0.01 | 34 |
| 6.08 | 0.04 | 0.06 | 0.01 | 70 |
| 6.55 | 0.11 | 0.10 | 0.01 | 9 |
| 6.56 | 0.05 | 0.09 | 0.01 | 71 |
| 7.44 | 0.06 | 0.11 | 0.01 | 81 |
| 7.76 | 0.14 | 0.14 | 0.01 | 0 |
| 9.35 | 0.14 | 0.14 | 0.01 | 0 |
| 9.45 | 0.14 | 0.14 | 0.01 | 0 |
| 9.93 | 0.16 | 0.18 | 0.01 | 12 |

Contact: S. Porter (NOAA/AFSC/EcoFOCI Program)

How many species are represented in a sample of several hundred *Bathymaster* spp. specimens collected in ichthyoplankton surveys? - -RPP

As part of a long-term multi-disciplinary project to identify larvae of three species of ronquils from the genus *Bathymaster* (family Bathymasteridae) routinely collected in the northeastern Pacific Ocean and Bering Sea, we developed a rapid restriction fragment length polymorphism (RFLP) protocol. Larvae from the genus *Bathymaster* have one of the highest average abundances in spring and summer ichthyoplankton surveys from the Bering Sea and Gulf of Alaska. Because these larvae are presently unidentifiable to species using morphological characters, a subsample ($n$ = 260) of specimens were identified using a PCR-amplified portion of the mitochondrial DNA cytochrome *c* oxidase I (COI) gene region scored to species type based on an RFLP protocol with restriction enzyme *Cac*8I. Of these samples 259 of 260 were correctly identified and the results revealed that 137 of 260 were Searcher, *B*athymaster *signatus*, 101 were Alaskan Ronquil, *B*. *caeruleofasciatus*, and 22 Smallmouth Ronquil, *B*. *leurolepis* (Figure 1). Information on larval distribution is a critical component to understanding the dynamics of ecosystems where larvae occur. Multivariate statistical analysis showed that seasonal timing and water bottom depth may be correlated to species occurrence for two of the species, *B*. *signatus* and *B*. *caeruleofasciatus*. A chi-square statistical test performed for independence of these two species and bottom depth revealed that spring samples are significantly related to species occurrence for the samples tested, $\chi^2$(d.f. = 1, $N$ = 133) = 37.7, $p$ <0.001, with *B*. *caeruleofasciatus* more likely to occur at sampling stations with a bottom depth exceeding 180 m and *B*. *signatus* at shallower depths of ≤100 m.

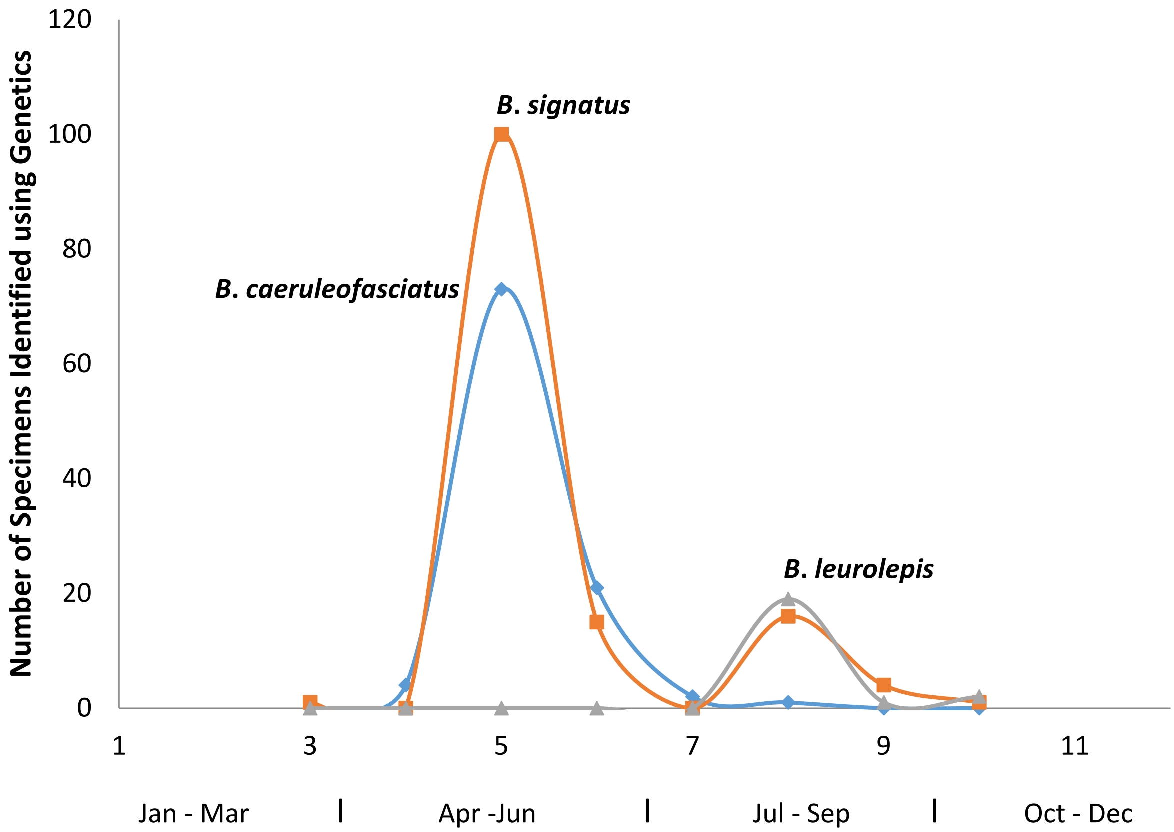



Figure 1. Collection date plotted against the number of bathymasterid (ronquils) specimens identified using genetic analyses (*N* = 260).

Contact: M.M. Paquin, M.F. Canino, A.C. Matarese (NOAA/AFSC/EcoFOCI Program)

**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. All objectives for this project have been completed and the final report has been submitted to the North Pacific Research Board (NPRB). Additionally, a draft manuscript by Pirtle et al. (In Reivew) was submitted for review in a special issue of Deep-Sea Research II describing the work on the early juvenile stage habitat suitability models for the five species.

The Final Report to the NPRB (100+pgs) included the following information for the five focal species: 1) extensive literature review of habitat preferences with life stage tables, 2) methods and maps of the high resolution suite of benthic habitat variables, 3) methods and database of the field observations for the early juvenile stages, 4) methods and maps for the literature based habitat suitability, 5) methods, model selection, model results, and final maps for the model-based habitat suitability 6) regional based habitat suitability estimates, and 7) extensive discussion of project. The follow up Essential Fish Habitat (EFH) project (Pirtle, Shotwell, Rooper) was also completed this year. The baseline habitat suitability framework from the GOA Project was extended to include new biophysical habitat metrics (e.g. production, temperature, corals) and applied to a variety of groundfish species from the early juvenile life stage through adults (including the five focal species). The results from this project were included in the 2016 EFH update which was submitted to stock assessment scientists for review. These EFH results are also planned for inclusion in the new species-specific ecosystem considerations sections of the stock assessment fishery evaluation (SAFE) process and may assist fishery managers in future decisions regarding survey planning and habitat assessment. During the next phase of the GOA Project Synthesis, the baseline habitat suitability models will be combined with individual based models (IBMs) in a novel approach to delineating survival trajectories for understanding recruitment of groundfish. The case study for this approach will be Alaska sablefish. We will also be developing a habitat metrics geodatabase for future research.

For more information, please contact Kalei Shotwell at (907) 789-6056 or kalei.shotwell@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 examined 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. These habitats were sampled at two locations in the Gulf of Alaska during the months of August, May, and December. Differences in density, community structure, prey availability, diet diversity, condition, growth, and reproductive success were examined within the different habitat types. All field work for this project has been completed and sample processing and data analysis will be completed within the next year.

## 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 2015 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. The acoustic data are also being studied to improve trawl-survey catchability models for stock assessment purposes. A global investigation 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 - HRG

The HRG is building numerical models to explain the distribution and abundance of groundfish and benthic invertebrates in the 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 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 1$^{st}$ 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[1] demonstrated that surficial sediments affect

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

the distribution and abundance of groundfish, however direct sampling with grabs or cores is impractical over large areas and spatial interpolations of limited data are imprecise and potentially biased. Subsequent pilot studies[2,3] showed that acoustic systems were suitable for broad-scale seafloor surveys and that processed acoustic data can be used to improve the numerical habitat models.

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 2015, for multiple purposes. Bathymetric data were cleaned and submitted for nautical charting (registry D00169, D00170). 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.[4] Thirty-four years of trawl survey data (catch per unit effort, kg ha$^{-1}$) have been assembled and statistical analyses with the backscatter statistics are being conducted 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 in August 2016 (Fig. 2), and will be the basis for improved EFH models for multiple species.

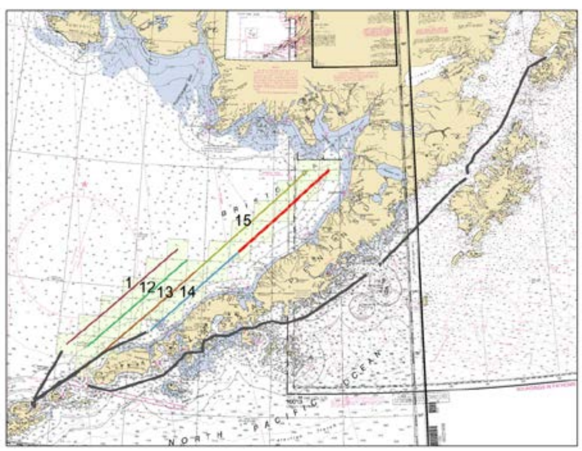



**Figure 2. Completed FISHPAC 2012 survey tracklines. Shaded boxes represent 20 by 20 nautical mile squares centered on RACE bottom trawl survey stations for the Bering Sea shelf. Each line was surveyed with five different sonar systems, with the exception that only multibeam echosounder data were collected over the northeast section of line 14 and during the transits to and from the numbered**

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

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

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

**tracklines. For additional information, see [http://www.afsc.noaa.gov/RACE/surveys/cruise_archives/cruises2012/results_Fairweather_FISHPAC-2012.pdf](http://www.afsc.noaa.gov/RACE/surveys/cruise_archives/cruises2012/results_Fairweather_FISHPAC-2012.pdf).**

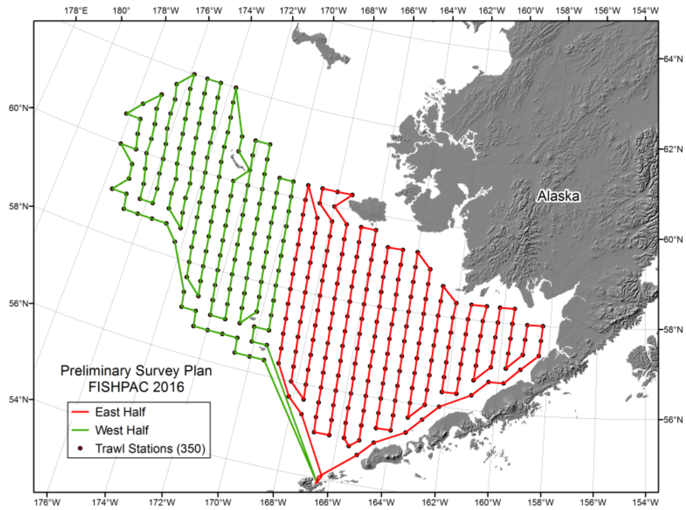


**Figure 3. The Bering Sea shelf will be systematically mapped to improve groundfish habitat models and fishery stock assessments. Quantitative sonars will be used characterize the seafloor for the eastern half of the NMFS trawl-survey stations during a multi-mission cruise. In addition to quantitative 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 - HRG

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 2015, 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* (renamed *IMPULSE*, 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) [5] 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 and trawlability 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 being considered for use in next generation models.

**Seabed Characterization to Improve Stock Assessment Models - HRG**

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.

[5] 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

Catchability experiments have been conducted on the bottom trawl used for the annual EBS survey[6], 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[7]. 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.[8] In some cases, estimates were based on sediments collected over 60 miles away. The option to collect physical sediment samples at all 270 trawl-sampling stations included in the snow crab distribution is prohibitively expensive considering the additional ship time required and the sample processing costs.

This project is examining whether indices of bottom type, derived from standardized and calibrated ES-60 acoustic data collected at each snow crab sampling station, are more informative in the snow crab bottom trawl catchability model than measured values of sediment type that were broadly extrapolated. This determination will be based solely on the amount of spatial variation in the snow crab efficiency model that is explained by the two kinds of sediment information. While the currently used data are based on a directly measurable attribute of the sediment (mean grain diameter), the acoustically derived index is related to this attribute but also to a variety of previously unmeasured variables affecting the time-dependent shape of the bottom echo. Although there is not a simple mathematical relationship between the two types of information, we believe an acoustic index is sufficiently related, will be more reliable, can be collected more efficiently, and will result in a better fitting catchability model for EBS snow crab. Preliminary analyses with generalized additive models indicate that bottom characteristics described by the principal components of the acoustic data after processing with *IMPULSE* software[9] (*i.e.*, Q-values) increased the deviance explained by 6% for males and 35% for females, relative to the previous catchability model using mean grain size values that were interpolated (kriged) to the locations of the trawl stations[7]. In cooperation with industry, this research topic is being expanded in 2016 to investigate the catchability of Bristol Bay red king crab using three different sonars, including the LRSSS (Fig. 2).

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

[7] Somerton, D. A., K. Weinberg, and S. Goodman. 2013. Catchability of snow crab (*Chionoectetes opilio*) by the eastern Bering Sea bottom trawl survey estimated using a catch comparison experiment. Can. J. Fish. Aquat. Sci. 70: 1699–1708.

[8] 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

[9] Formerly IMPACT software by Quester Tangent Corporation; see Maritime Way Scientific: http://www.maritimeway.ca/seabed-classification/impulse15/net

## Effects of Bottom Trawling: Global Study of Bottom-trawling and Dredging Effects - HRG

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.[10] 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 led 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, Narrangansett), 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), Adriaan Rijnsdorp (Wageningen University and Research Center, IJmuiden, Netherlands), and Petri Suuronen (United Nations FAO, Rome, Italy). Two post-doctoral research associates (Drs. Ricardo Amaroso 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 (Fig. 3) 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 practices.' The scope of the Phase 5 effort was broadened in 2015 to include a closer look at trawl-fishery

[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.

[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.

management in south and southeast Asia, where approximately 80,000 trawlers operate under a variety of management practices and contrasting policy drivers. This focus entailed collaborative interactions with trawl-fishery scientists and management experts from India, Indonesia, Malaysia, the Philippines, and Vietnam, and included an extended site visit to Vietnam to conduct structured interviews about industry practices and management decision processes. Additional details about the project, products, and the study group are available at http://trawlingpractices.wordpress.com/.

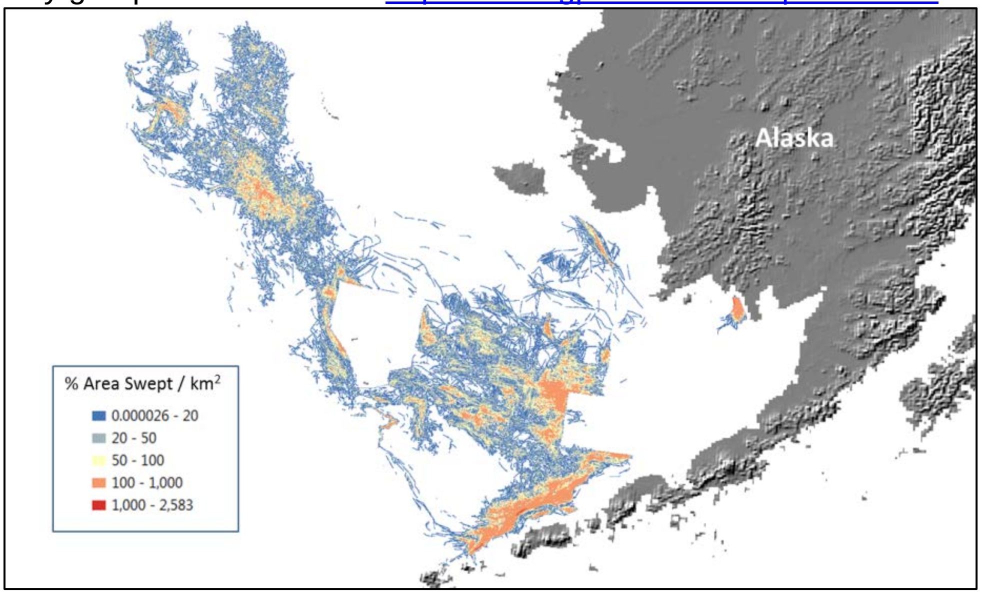


**Figure 4. Distribution of trawling effort in the eastern Bering Sea, based on VMS data. Percentages indicate the total area swept in each 1 $km^2$ grid cell during 2008. Values greater than 100% indicate the total area swept in a cell exceeded 1 $km^2$. (Summary produced by S. Intelmann using the Catch In Area database developed by S. Lewis, NOAA.)**

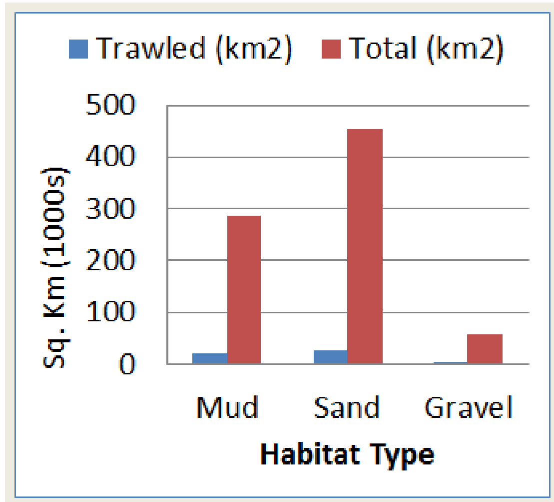


**Figure 5. The distribution of trawling effort in different habitat types of the eastern Bering Sea in 2008. A total of 6.7%, 5.5%, and 4.0% of available mud, sand, and gravel habitats at depths <1,000 m was trawled with bottom-contact gear.**

**Effects of Bottom Trawling**: **Characterization of Korean Trawling Effort - HRG**
Another international collaboration is determining the types and quantities of bottom habitats in Korea that are being affected by trawling, thereby informing sustainable management of multiple demersal stocks. Working with Dr. Junghwa Choi at the National Fisheries Research and Development Institute in Busan, South Korea, effort data for Korean trawl fisheries in the Yellow Sea and the East Sea regions are being combined with standardized benthic-habitat information to describe the trawling footprint by habitat type for three different classes of bottom-contact gear: (1) otter trawls, (2) single trawls, and (3) pair trawls (Fig. 5). This work is being conducted under the guidance of the Fisheries Panel that is part of the Joint Project Agreement between NOAA and the Korean Ministry of Oceans and Fisheries for scientific and technical cooperation in integrated coastal and ocean resources management.

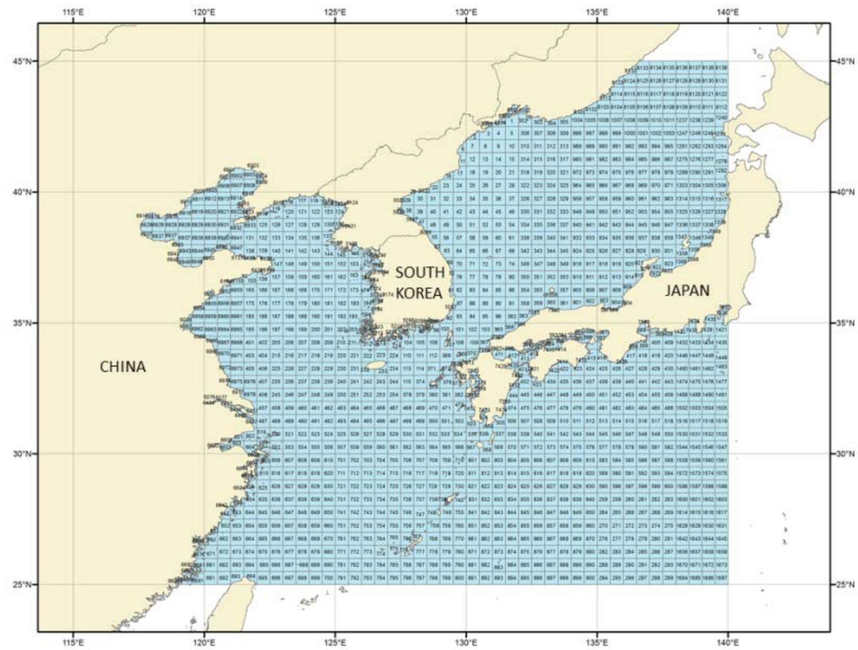


**Figure 6. System of 0.5 degree sea blocks used to report catch and effort data for Korean trawl fisheries.**

Benthic Invertebrate Ecology: Consistent Taxonomic Classification of Invertebrates Caught in AFSC Bottom Trawl Surveys - HRG
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 objectively 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.

**Miscellaneous Projects: Bibliography on the Applicability of Sonars for Habitat Mapping - HRG**
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 United States 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 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[12] 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[13], as many as 80 different parameters have been used to describe the physical and material properties of the seafloor, of which 6 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. As a result, various combinations of grain size, surface roughness, and slope, for example, may be indistinguishable with acoustics (the so-called “inverse problem”). 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. Notwithstanding the challenges of interpretation, many useful applications of sonars for habitat mapping have been reported in the scientific literature.

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

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[12] 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.

[13] 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.

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 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, 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.

**Miscellaneous Projects Benthic Mapping Specialist Billet - HRG**

NOAA Corps hydrographer LTJG Theresa Smith was billeted 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 will be replaced in winter 2016 by the 5th officer in this post, ENS Kathryn

**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 – REFM/REEM**

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 2015, AFSC personnel analyzed the stomach contents of more than 40 species sampled from the eastern Bering Sea and Gulf of Alaska. The contents of 12,589 stomach samples were analyzed including 3,557 stomach samples analyzed at sea during the Gulf of Alaska groundfish survey. This resulted in the addition of 32,044 records to AFSC's Groundfish Food Habits Database. In addition to stomach samples from groundfish, bill-load and regurgitation samples from 1,285 seabirds were analyzed for the Alaska Department of Fish and Game. REEM also analyzed 48 zooplankton samples and nine benthic-grab samples for special investigations comparing food habits with prey types available in the environment.

In 2015, REEM published a useful Stomach Examiner's Tool that can now be found at: http://access.afsc.noaa.gov/REEM/set/.

Collection of additional stomach samples was accomplished through resource surveys, research surveys, and special studies comparing stomach contents with prey-sampling. Over 7,500 stomach samples were collected from large and abundant predators during the eastern Bering Sea bottom trawl survey of the continental shelf. Over 1,700 stomach samples were collected from the Gulf of Alaska to supplement the 3,557 stomach contents that were analyzed at sea in that region. No stomach samples were collected from Alaskan fishing grounds by Fishery Observers in 2015, but seven buckets of samples collected in previous years were returned to the AFSC. In cooperation with a special tag-recovery study conducted by the Fisheries Interaction Team (FIT) Program in the Aleutian Islands, stomach samples were collected from 1,080 Atka mackerel and 1,336 samples were collected from other species.

**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.php.

### Ecosystem Considerations 2015: the Status of Alaska's Marine Ecosystems completed and posted online-REFM/REEM

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 is now available online at the Ecosystem Considerations website at: http://access.afsc.noaa.gov/reem/ecoweb/index.php.

The report includes additional new and updated sections, including the 2015 Eastern Bering Sea and Aleutian Islands Report Cards and ecosystem assessments. This year, the report presented a new Gulf of Alaska Report Card and ecosystem assessment. Over 40 experts participated via an online poll in the selection of ecosystem indicators that were included in the report card. The indicator list will be refined over the coming year with participation from the scientists involved with the NPRB-funded Gulf of Alaska Integrated Ecosystem Research Project. Overall, there were seven new and 51 updated indicator contributions from scientists.

During 2015, most of the physical indicators showed the continuation of the warm conditions present in 2014, but biological indicators suggest overall lower productivity in 2015 compared to 2014. In 2014, ocean temperatures were warmer than usual over a large area of the Northeast Pacific – this was "The Blob" that received much media attention – a condition that persisted through 2015. In 2014, many of the monitored ecosystem indicators indicated increased overall productivity. For example, groundfish sampled in the bottom trawl survey were heavier per length that average, and seabirds in the Pribilof Islands produced higher than average numbers of chicks. These indicators indicated average or lower productivity in 2015, with groundfish of average to low weight per length and poor reproductive success of seabirds.

## VI - AFSC GROUNDFISH-RELATED PUBLICATIONS AND DOCUMENTS

Published January 2015 through December 2015 (AFSC authors in bold text)

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2015. NOAA Fisheries Climate Science Strategy, J. S. Link, R. Griffis, and S. Busch, (editors). U.S. Dep. Commer., NOAA Tech. Memo., NMFS-F/SPO-155, 70 p. Online. (.pdf, 4.24 MB).

BREITBURG, D. L., J. SALISBURY, J. M. BERNHARD, W-J. CAI, S. DUPONT, S. C. DONEY, K. J. KROEKER, L. A. LEVIN, **W. C. LONG**, L. M. MILKE, S. H. MILLER, B. PHELAN, U. PASSOW, B. A. SEIBEL, A. E. TODGHAM, and A. M. TARRANT.
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**FISSEL**, **B.**, **R. FELTHOVEN**, **S. KASPERSKI**, and C. O'DONNELL.
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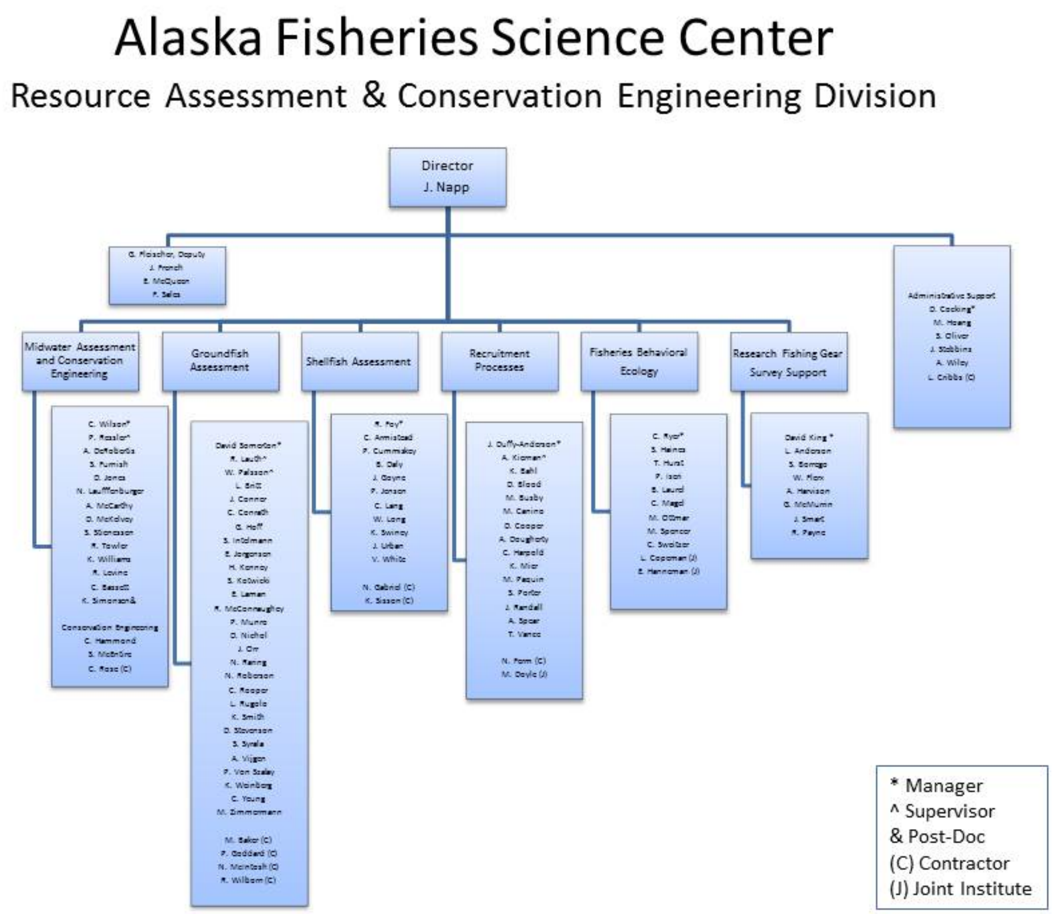
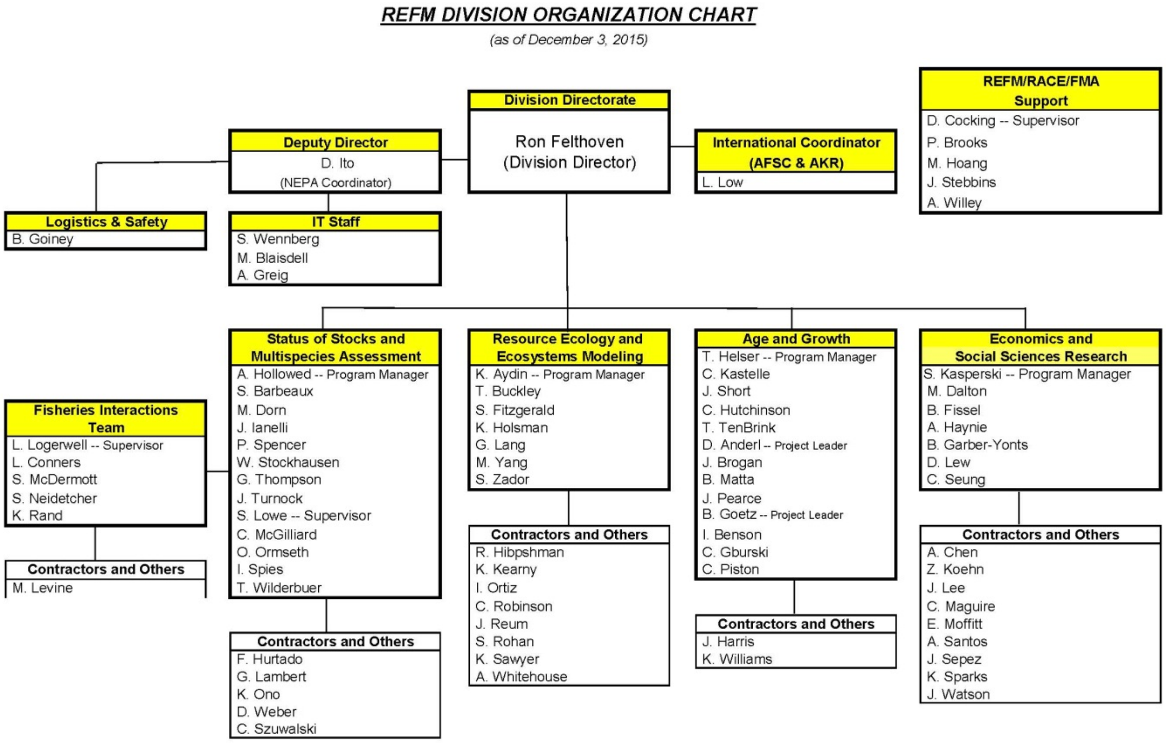
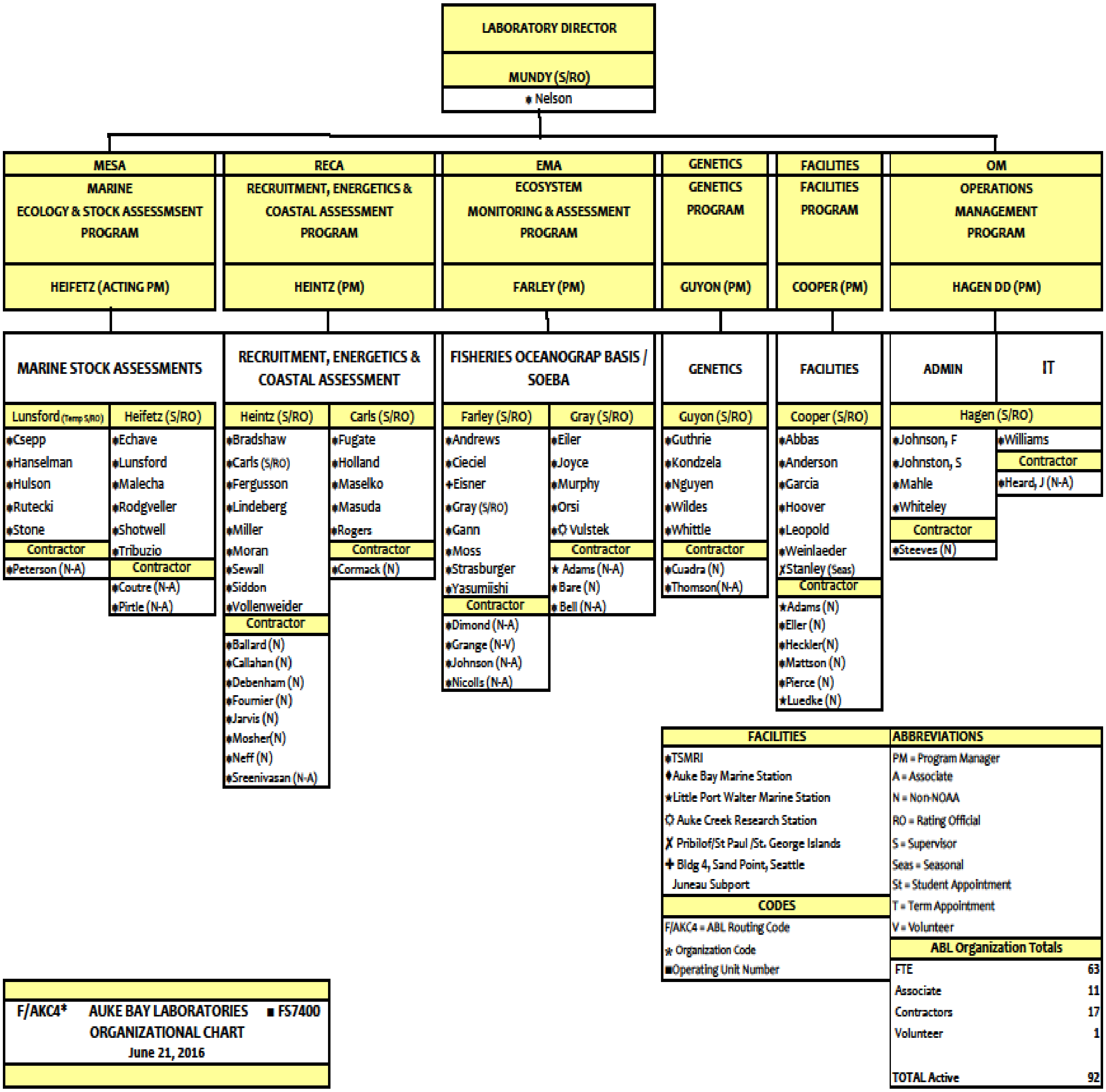
## APPENDIX I. RACE ORGANIZATION CHART



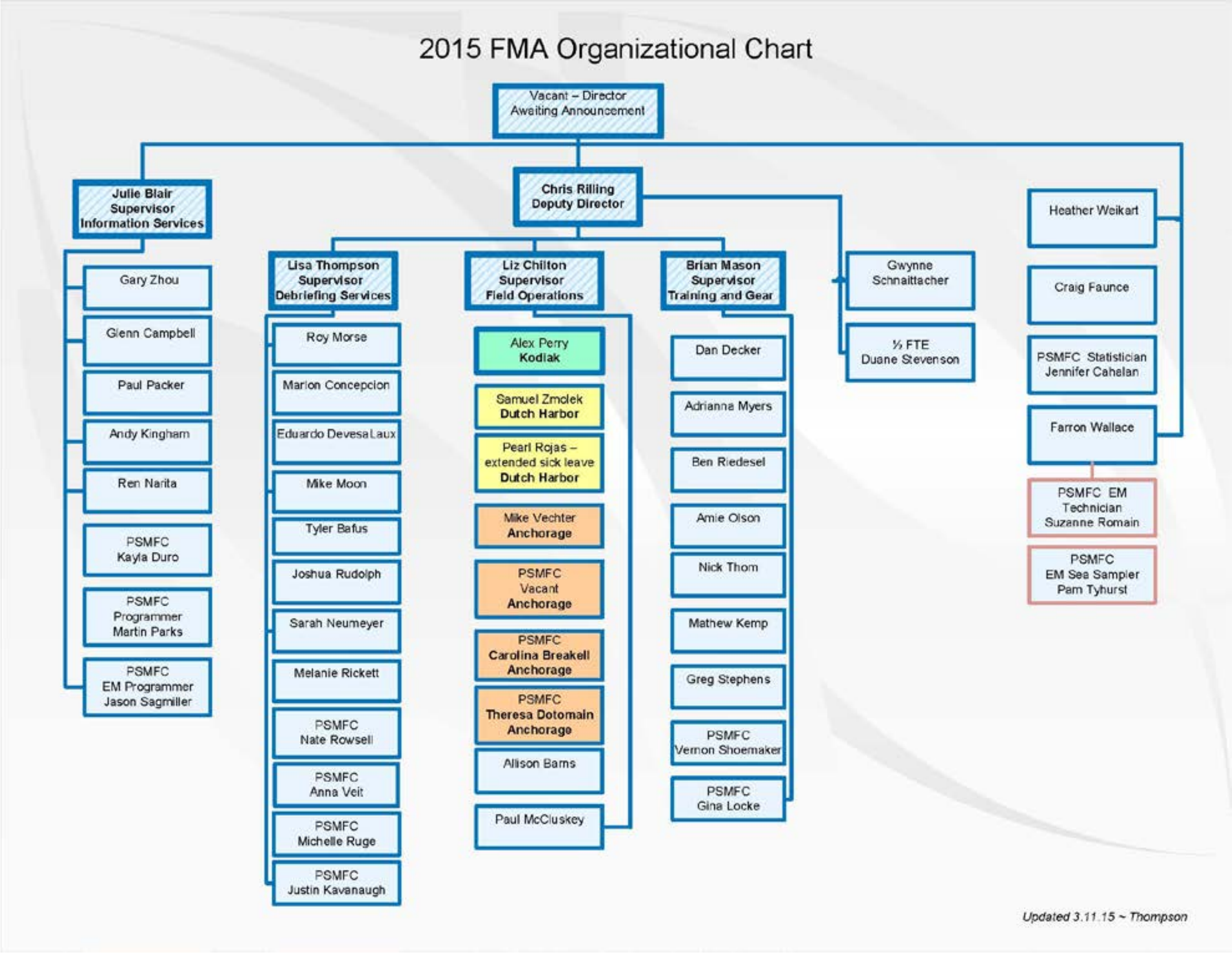
# APPENDIX II. REFM ORGANIZATION CHART



# APPENDIX III – AUKE BAY LABORATORY ORGANIZATIONAL CHART



## APPENDIX IV – FMA ORGANIZATIONAL CHART



**CANADA**

# British Columbia Groundfish Fisheries and Their Investigations in 2015

**April 2016**

Prepared for the 57th Annual Meeting of the
Technical Sub-Committee of the Canada-United States Groundfish Committee
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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 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. Kim Houston |
| Salmon & Freshwater Ecosystems | Mr. Mark Saunders |
| Marine Ecosystems & Aquaculture | Dr. Nathan Taylor (Acting) |

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

| | |
|---|---|
| Groundfish | Mr. Greg Workman |
| Invertebrates | Mr. Dennis Rutherford |
| Pelagic Fish Research & Conservation Biology | Mr. Sean MacConnachie (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 2016 Groundfish Integrated Fisheries Management Plan can be viewed at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.html#Groundfish.

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 2015-16 between Fisheries and Oceans Canada and several partner organizations to support groundfish science activities through the allocation of fish to finance the activities. These JPAs will be updated for 2016-17.

## Surveys

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 2015, please see Appendix 1. Other research surveys conducted in 2015 include longline and trap surveys. These surveys are described under their respective species programs below.

## Reserves

## Review of Agency Groundfish Research, Assessment and Management

### Hagfish

#### Research

An experimental fishery has been conducted since 2013. The experimental program consist of three elements: 1) a systematic depth stratified survey in each of the 3 area pairs (PFMAs 23/123, 25/125, and 8-9/108-109); 2) experimental fishing to fixed effort caps in each of the area pairs; and 3) monitoring the previously selected index site within PFMA 23 (Kirby Point).

The sequence of activities intended during the initial development of the science program was to undertake a survey in each of the area pairs and conduct an initial sampling at the Kirby Point site prior to commencing the depletion experiment; once these two activities were completed experimental fishing could then start with subsequent surveys occurring every 6 months. The reason for doing the surveys and sampling first is to establish a baseline snap-shot of the species distribution, relative abundance and biological condition prior to removals. It was anticipated that once experimental fishing began, changes (reductions) in survey and fishery CPUE would be detectable after some period of fishing. The levels of effort authorized for the experimental fishery should be sufficient to impose a detectable signal in the CPUE data that should make it possible to generate a depletion estimate of abundance, at least for the locations where fishing is taking place.

#### Assessment

A summary of the experimental fishery will be undertaken for completion in 2017.

Management

Dogfish and other sharks

1. Research

Ongoing data collection in support of the Dogfish and Shark research program continued in 2015 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

Skates

1. Research

Ongoing data collection in support of the Dogfish and Shark research program continued in 2015 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

Pacific cod

1. Research

Ongoing data collection in support of the Pacific cod research program continued in 2015 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys. Collection of DNA was initiated in the spawning areas of Hecate Strait (PSMFC Area 5D) and will continue in 2016.

Walleye pollock

1. Research

There is no directed work being conducted on Walleye Pollock but ongoing data collection continued in 2015 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

Pacific whiting (hake)

1. Research

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 2015, to continue the biennial time series. The estimated biomass from the 2015 survey was 2.156 million metric tonnes with a CV of 0.092. The survey catch was dominated by five year-olds, which represent the very large 2010 year class. This cohort was distributed in both the U.S. and Canadian waters.

### Assessment

As in previous years, and as required by The Agreement, The 2016 harvest advice was prepared jointly by Canadian and U.S. scientists working together, collectively called the Joint Technical Committee (JTC) as stated in the treaty. The assessment model used was Stock Synthesis 3 (SS3). The 2016 model had the same model structure used in 2015, with time series updates (catch and age compositions) and a new acoustic biomass index.

### Management

Management of Pacific Hake has been under a treaty (The Agreement) between Canada and the United States since 2011. The stock is managed by the Joint Management Committee (JMC) which is made up of fisheries managers and industry representatives from both the U.S. and Canada. These managers receive advice from the JTC and the Scientific Review Group (SRG), which is a committee responsible for the scientific review of the assessment.

The total Canadian TAC for 2015 was 114,928 t including a carryover of 14,793 t. The shoreside/freezer trawler sector was allocated 84,928 t of this and caught 36,507 t (31.8% of total TAC). The Joint Venture (JV) fishery received a quota of 30,000 t in 2015, but did not choose to participate in the fishery. For the second year in a row, the four freezer trawlers caught more than the shoreside vessels. The majority of the Canadian Pacific Hake catch for the 2015 season was taken from the west coast of Vancouver Island in the third quarter (July-Sept).

The final decision on catch advice for the 2016 fishing season was made at the meeting of the International Pacific Hake JMC in Vancouver, B.C. on March 15-18, 2016. A coastwide TAC of 497,000 t for 2016 was agreed upon. As laid out in the treaty, Canada will receive 26.12% of this, or 129,816 t. Managers will choose how to allocate this between the domestic and joint venture fisheries as the season progresses.

The final assessment document and other treaty-related documents are posted at: http://www.nwr.noaa.gov/fisheries/management/whiting/pacific_whiting_treaty.html

## Grenadiers

1. Research

There is no directed work being conducted on Grenadiers but ongoing data collection continued in 2015 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

## Rockfish

### 1. Research

#### Surveys on the inside (PMFC Area 4B)

A Fisheries and Oceans Canada (DFO) 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 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 (Lochead and Yamanaka 2004; 2006; 2007). 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, in August 2015, were allocated for the longline survey in the Southern region. The Northern region is due to be surveyed over 24 days in August 2016.

#### 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). Funding for this survey has evolved from industry sources to DFO National budgets throughout the survey series, with the exception of 2013 where no funding mechanism was available to fund the surveys. Since 2014, the survey program has been conducted under a "Use-of-Fish" DFO policy in conjunction with a Collaborative Agreement which outlines this project and includes responsibilities for the IPHC, the Pacific Halibut Management Association (PHMA) and DFO.

In collaboration with industry (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 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. 198 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, annually, with the exception of 2013. Similar to the IPHC survey, a survey program was conducted for the southern portion of BC in 2014 under a "Use-of-Fish" policy and Collaborative Agreement with the PHMA. These Collaborative Agreements are scheduled for renewal in 2016.

#### 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.

### Slope Rockfish Program

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.

All PBS packages on CRAN are kept current as needed to comply with the CRAN Repository Policy – PBSmapping 2.69.76 published Jan 14, 2015; PBSmodelling 2.67.266 published Jan 23, 2015; PBSddesolve 1.11.29 published May 16, 2014; PBSadmb 0.68.104 published Apr 9, 2014. The full suite of PBS R packages was migrated successfully from Google Code to GitHub. Rowan maintains these packages on his local machine which are then pushed to the GitHub repositories (see PBS Software). Additionally, Rowan collaborates on a package called *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 continued in collaboration with Jackie King (PBS) and postdoctoral fellow Jean-Baptiste Lecomte on a project called "Implementing Ecosystem-based Fisheries Management in the Groundfish Stock Assessment Process" funded by DFO's 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.

#### Assessment

##### a) Yelloweye Rockfish

A stock assessment for the Outside population of Yelloweye Rockfish in 2014 was reviewed by the Canadian Science Advisory Secretariat in September 2015. The Science Advisory Report from this process is available at: http://www.dfo-mpo.gc.ca/csas-sccs/publications/sar-as/2015/2015_060-eng.pdf

A non-equilibrium, age-aggregated Bayesian surplus production (BSP) model was used to assess the Outside population of Yelloweye Rockfish in BC, employing catch data derived from historic commercial, recreational and Aboriginal catch records reconstructed back to 1918, life history data to estimate the intrinsic rate of increase (r), and abundance trends derived from research surveys and commercial hook and line catch records. Sensitivity analyses considered six different sources of uncertainty: assumptions about the historic catch, priors for the intrinsic rate of increase and carrying capacity, process error standard deviation, various abundance indices, form of the surplus production function, and the form of the stock assessment model.

The biomass in 2014 (B2014) is estimated at 3,821 t (90% credibility interval of 2,428 – 7,138 t), which is 18% (90% credibility interval 10 – 33 %) of the estimated initial biomass (B1918) of 21,955 t (90% credibility interval 13,747 – 37,694 t) in 1918. Fisheries reference points consistent with DFO's Precautionary Reference Points are presented for this assessment. There is a 63% probability that stock biomass in 2014 is below the Limit Reference Point (LRP) of 0.4BMSY and a 99% probability that it is below the Upper Stock Reference (USR) of 0.8BMSY.

Advice to management is presented in the form of decision tables, using 5, 10, and 15 year projections, for constant catch policies between 0 and 300 t/year. Replacement yield or surplus production in 2014 is estimated at 162 t (90% credibility interval 80 – 258 t). The current catch of 287 t in 2014 is estimated at 178% (90% credibility interval 114 – 360%) of replacement yield.

The assessment suggests that the stock has continued to decline, despite more than a decade of rockfish conservation measures. Increases in Yelloweye Rockfish density have not yet been seen in Rockfish Conservation Areas, but given the low productivity of this species, benefits are not expected to be detected until at least 10 years after their closure.

Management

a) Inshore Rockfish

Management, in consultation with the commercial industry, will step down the current Outside Yelloweye Rockfish Total Allowable Catch (TAC) over the next three years to bring harvests from 290 t to 100 t by the 2018/19 fishing year. An industry proposal for a more spatially explicit quota apportionment was adopted by management, which shifts the current apportionment slightly to better match higher TACs with areas of higher survey CPUE. Similarly, recreational bag limits have been reduced from 3 to 2 Yelloweye Rockfish in the north and from 2 to 1 in the south.

Yelloweye Rockfish was listed as Special Concern under the SARA in 2011 and DFO is currently developing a SARA management plan. Yelloweye Rockfish is up for reassessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2018.

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 2015. Quillback Rockfish is up for reassessment by the COSEWIC by November 2019.

## Thornyheads

### 1. Research

Responsibility for assessing thornyheads lies with the Slope Rockfish group. In 2015, the Sclerochronology Lab made progress developing a thin-sectioning technique for thornyheads, which helps to resolve the fine micro-structure of older specimens. Some of the findings from the thin-sectioning technique include: (i) the sulcal groove appears to be the most promising reading plane, (ii) there is difficulty in determining the first year, (iii) there are many fine checks, and (iv) there is an uneven growth pattern in the mature stages of life (>20y).

### Assessment

Historically, Shortspine Thornyhead (*Sebastolobus alascanus*) was caught in amounts less than 100 t by the commercial trawl fishery up to the late 1980s, followed by increasing catches into the 1990s, when catches reached 958 t. Although there is some directed fishing on this species, it is most often caught along with other groundfish species in the commercial trawl fishery. Species separation with its congener *S. altivelis* (Longspine Thornyhead) did not occur in catch records until 1996 with the introduction of 100% observer coverage.

The coastwide stock was assessed using a delay-difference model fit to five fishery-independent surveys, a catch per unit of effort (CPUE) time series derived from commercial catch and effort data, and an annual time series of mean weights derived from unsorted commercial catch samples.

Uncertainty due to growth, natural mortality, and the age of knife-edged selectivity was evaluated by selecting 12 model scenarios for inclusion in the final averaged model. These included growth (options DFO vs. NMFS), natural mortality with three options ($M$ = 0.03, 0.06, 0.08) for both growth functions, and size at knife-edge selectivity – one option for DFO growth ($k$ = 29 cm) and three options for NMFS growth ($k$ = 29, 24, 21 cm).

A model-averaged decision table was presented using the provisional reference points from the Fisheries and Oceans Canada Fishery Decision-making Framework incorporating the Precautionary Approach policy: a limit reference point (LRP) of $0.4B_{\text{MSY}}$, an upper stock reference (USR) of $0.8B_{\text{MSY}}$, and a reference harvest rate of $u_{\text{MSY}}$.

The estimated stock biomass trajectory remained above the estimates of the stock status reference points throughout the history of the fishery. Estimated current stock status (beginning year biomass in 2016) has a 0.97 probability of being above the USR and a 1.0 probability of being above the LRP (Figure 7). The probability that $u_{2015}$ exceeded $u_{\text{MSY}}$ is 0.72.

The stock is expected to decline if annual harvests of 600 t/year (the 2010-2014 average catch) are removed in each of the next three years. The probability that the decline will stay above the USR at the end of the next three years is 0.76. The probability that the stock will remain above the LRP after three years is 0.88.

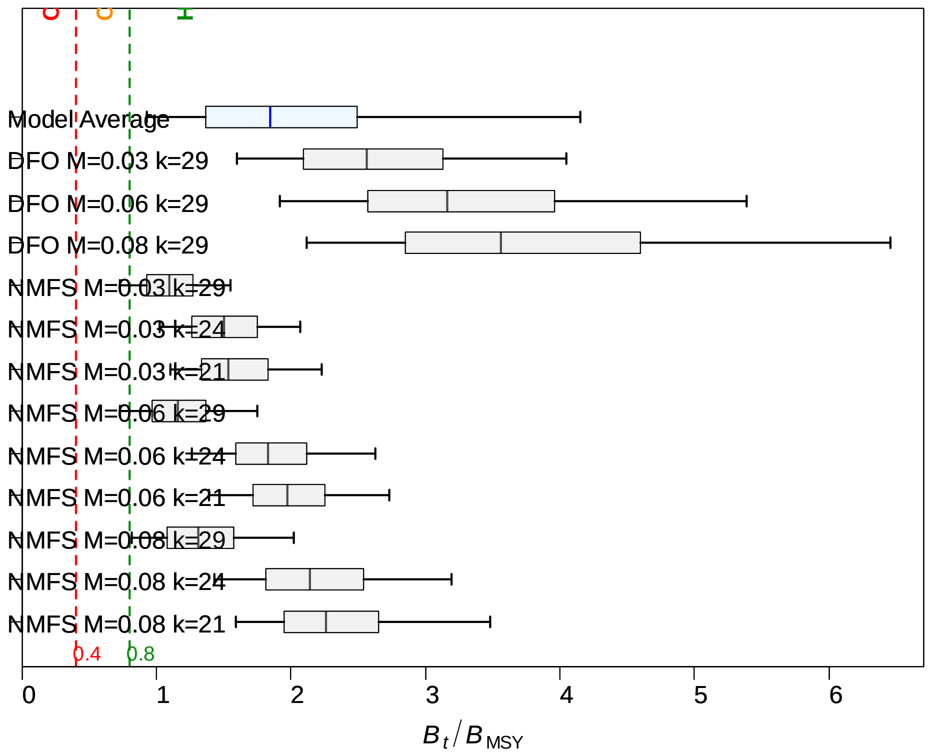


**Figure 7. Current status of the coastwide BC Shortspine Thornyhead stock relative to the DFO Precautionary Approach provisional reference points of 0.4BMSY and 0.8BMSY. The value of Bt /BMSY uses t=2016. Boxplots show the 5, 25, 50, 75 and 95 percentiles from the MCMC results. The model average (top boxplot in blue) summarizes the 12 scenarios represented in the grey boxplots below the model average. DFO = Canadian Fisheries and Oceans; NMFS = US National Marine Fisheries Service; M = natural mortality (y-1); k = length (cm) at knife-edge selectivity.**

## Sablefish

### 1. Research

The Sablefish management system in British Columbia is an adaptive ecosystem-based approach in which three pillars of science – hypotheses, empirical data, and simulation - play a central role in defining management objectives and in assessing management performance relative to those objectives via Management Strategy Evaluation (MSE) processes. Objectives relate to outcomes for three categories of ecosystem resources: target species (TS), non-target species (NTS), and Sensitive Benthic Areas (SBAs). The MSE process is used to provide management advice each year that supplements the stock assessment process by providing a way to explicitly evaluate harvest strategies given a set of stock and fishery objectives and uncertainties/hypotheses about Sablefish fishery and resource dynamics. Fisheries and Oceans Canada (DFO) and Wild Canadian Sablefish Ltd. have collaborated for many years on fisheries management and scientific research with the aim of further supporting effective assessment and co-management of the Sablefish stock and the fishery in Canadian Pacific waters. Fishery independent research surveys include the following activities:

a) A Stratified Random Survey using Longline Trap Gear (2003-2015)

This activity captures Sablefish for tagging and release following a depth and area stratified random survey design. Tag-recoveries are used for deriving estimates of gear selectivity and studying Sablefish movement. The catch rate data are used to derive an index of stock abundance. The survey also provides biological samples for determination of life history characteristics for Sablefish and non-target species (e.g., Blackspotted and Rougheye Rockfish.

An Inlets Survey using Longline Trap Gear (1995-2015)

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

Sablefish research surveys are planned for the fall of 2016 contingent on the availability of resources.

A new introduction to both surveys (a, b) in 2013-2015 was the deployment 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). This novel equipment will be deployed for the 2016 survey, and has been deployed on commercial trap gear fishing trips to SGaan Kinghlas-Bowie Seamount over the 2013-2015 period.

Assessment

As part of the ongoing development of the Sablefish MSE process, the Sablefish operating model was revised in 2015/16 to account for potential structural model mis-specification and lack-of-fit to key observations recognized in previous models. Specific modifications include: (i) changing from an age-/growth-group operating model to a two-sex/age-structured model to account for differences in growth, mortality, and maturation of male and female Sablefish, (ii) adjusting model age-proportions via an ageing error matrix, (iii) testing time-varying selectivity models, and (iv) revising the multivariate-logistic age composition likelihood to reduce model sensitivity to small age proportions. Structural revisions to the operating model improved fits to age-composition and at-sea release data that were not well-fit by the previous operating model. Accounting for ageing errors improved the time-series estimates of age-1 Sablefish recruitment by reducing the unrealistic auto-correlation present in the previous model results. The resulting estimates clearly indicate strong year classes of Sablefish that are similar in timing and magnitude to estimates for the Gulf of Alaska. Two unanticipated results were that (i) time-varying selectivity parameters were not estimable (or necessarily helpful) despite informative prior information from tagging and (ii) improved recruitment estimates helped to explain the scale and temporal pattern of at-sea release in the trawl fishery. The latter finding represents a major improvement in the ability to assess regulations (e.g., size limits) and incentives aimed at reducing at-sea releases in all fisheries. Estimates of Sablefish stock status, productivity, and trends over the past several years are consistent with previous harvest strategy simulations.

#### Management

In 2013, fishing industry stakeholders proposed a TAC floor of 1,992 t, because lower quotas may increase economic risks. The management procedure first applied in 2010 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 2010 procedure. Applying the revised procedure to updated landings and biomass index data resulted in a harvest recommendation of 1,992 t for the 2016/17 fishing season. The Sablefish operating model revised in 2015/16 will be used for feedback simulations to evaluate the expected performance of the existing management procedure against alternatives in 2016/17.

### Lingcod

1. Research

Ongoing data collection in support of the lingcod research program continued in 2015 through the Groundfish Synoptic Surveys, port sampling, at-sea observer sampling, and recreational creel surveys.

### Atka mackerel

The distribution of Atka mackerel does not extend into the Canadian zone.

### Flatfish

1. Research

Ongoing data collection in support of the flatfish research program continued in 2015 through the Groundfish Synoptic Surveys, port sampling, and at-sea observer sampling.

#### Assessment

In 2015, the first assessment of Arrowtooth Flounder since 2001 was done in B.C. The assessment model used was the Integrated Statistical Catch-at-Age model (iSCAM). A formal, statistical catch-at-age model has never previously been done in B.C. The model was female-only, since the catch data was found to be composed of 80-90% females. The model was fit to four indices of abundance and catch data. Reference points estimated were the annual harvest rate producing MSY ($U_{MSY}$), and parameters relating to the initial biomass ($B_0$).

The probability of reducing the biomass to less than the level in 2015 was found to be less than 13% for all catch projections ranging from 0 to 30,000 t. The probability of reducing the biomass to less than the level in 1996 was found to be less than 11% for all catch projections ranging from 0 to 50,000 t.

The final assessment document is currently being completed for submission to CSAS.

Management

Arrowtooth Flounder are managed on a status-quo basis. An annual allocation of 15,000 t has been applied by managers since 2006. Before that time, there were no limits on catches or discards.

From 2005 – 2013, four freezer trawlers were added to the fishery. Their ability to process Arrowtooth Flounder while at sea mitigated some of the issues with proteolysis of the flesh and made the product more marketable. These new vessels have increased the fishing pressure on this stock, although they have stayed well below the 15,000 t TAC. The highest catch was in 2014 with 13,571 t and the last 5-year's average catch was 8,487 t.

Pacific halibut & IPHC activities

Pacific halibut caught incidentally by Canadian groundfish trawlers are measured and assessed for condition prior to being released. Summaries of this length data is supplied annually to IPHC. In addition, summaries of live and dead releases (based on condition) are provided.

Other groundfish species

Ecosystem Studies

A. 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.

Work was initiated on this project in 2015. A workplan has been developed and one of the first steps was a literature search and annotated bibliography on work that has been carried out on tiered approaches in other international jurisdictions. A workshop will be held in May 2016 to present this work and to make decisions on an approach for BC groundfish fisheries.

Publications

A. Primary

Breed, G.A, Severns, P.M, Edwards, A.M. 2015. Apparent power-law distributions in animal movements can arise from intraspecific interactions. *Journal of the Royal Society Interface,* 12 (103): 20140927.

Forrest, R.E., Savina, M., Fulton, E.A., Pitcher, T.J. 2015. Do marine ecosystem models give consistent policy evaluations? A comparison of Atlantis and Ecosim. Fisheries Research 167: 293-312.

Haigh, R., Ianson, D., Holt, C.A., Neate, H.E., Edwards, A.M. 2015. Effects of ocean acidification on temperate coastal marine ecosystems and fisheries in the northeast Pacific. *PLOS ONE* 10(2): e0117533. doi:10.1371/journal.pone.0117533

Other publications

Appendix 1

## SUMMARY OF FISHERIES AND OCEANS CANADA PACIFIC REGION GROUNDFISH BOTTOM TRAWL SURVEYS IN 2015



### A. Multi-Species Small-mesh 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. Starting in 2014, only one groundfish staff participated in the survey. At that time, the sampling program was reduced so that a single person could accomplish all the work. In addition, the sampling program was also rationalized to only include species where the survey is expected to provide a useful index of abundance.

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 Queen Charlotte Sound area was also not visited in 2015 due to staffing limitations.

The 2015 survey was conducted onboard the W.E. Ricker and ran from April 30 to May 16. A total of 122 tows were completed (Figure 8). The total catch weight of all species was 48,185 kg. The mean catch per tow was 395 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 Pacific Herring (*Clupea pallasii*), Arrowtooth Flounder (*Reinhardtius stomias*), Flathead Sole (*Hippoglossoides elassodon*), and Spotted Ratfish (*Hydrolagus colliei*). 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 9,454 individual fish from 18 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 directly collect the biological data from this species.

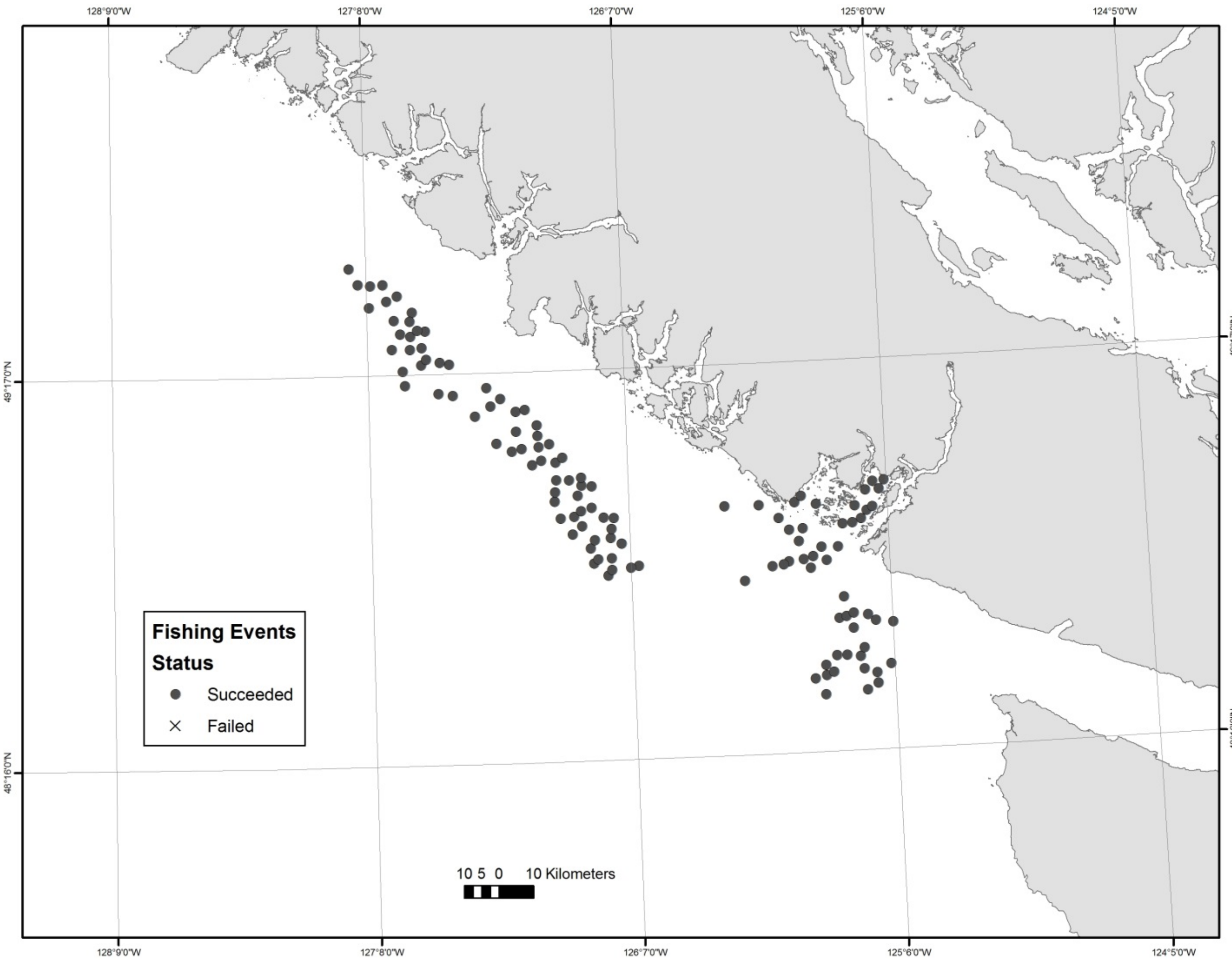


Figure 8. Barkley Sound and West Coast Vancouver Island set locations of the 2015 Multi-species Small Mesh Bottom Trawl Survey

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 2015 Multi-species Small Mesh Bottom Trawl Survey.

| Species | Scientific Name | Num. Tows | Catch (kg) | Biomass (t) | Rel. Error |
|---|---|---|---|---|---|
| Eulachon | *Thaleichthys pacificus* | 66 | 5777 | 1262 | 0.38 |
| Pacific Herring | *Clupea pallasii* | 70 | 3086 | 266 | 0.28 |
| Arrowtooth Flounder | *Reinhardtius stomias* | 71 | 2755 | 614 | 0.39 |
| Flathead Sole | *Hippoglossoides elassodon* | 69 | 1347 | 279 | 0.38 |
| Pacific Cod | *Gadus macrocephalus* | 58 | 1105 | 238 | 0.51 |
| Rex Sole | *Glyptocephalus zachirus* | 70 | 945 | 154 | 0.25 |
| Yellowtail Rockfish | *Sebastes flavidus* | 28 | 841 | 107 | 0.81 |
| Walleye Pollock | *Theragra chalcogramma* | 61 | 775 | 170 | 0.59 |
| Pacific Sanddab | *Citharichthys sordidus* | 40 | 627 | 105 | 0.45 |
| Slender Sole | *Lyopsetta exilis* | 71 | 623 | 84 | 0.29 |
| Dover Sole | *Microstomus pacificus* | 67 | 549 | 64 | 0.31 |
| Sablefish | *Anoplopoma fimbria* | 50 | 328 | 29 | 0.51 |
| Spotted Ratfish | *Hydrolagus colliei* | 61 | 289 | 47 | 0.28 |

| | | | | | |
|---|---|---|---|---|---|
| Lingcod | *Ophiodon elongatus* | 44 | 264 | 54 | 0.28 |
| Pacific Halibut | *Hippoglossus stenolepis* | 31 | 214 | 38 | 0.4 |
| Pacific Hake | *Merluccius productus* | 32 | 208 | 23 | 0.51 |
| English Sole | *Parophrys vetulus* | 53 | 142 | 31 | 0.32 |
| Blackbelly Eelpout | *Lycodes pacificus* | 59 | 139 | 22 | 0.58 |
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 17 | 104 | 11 | 0.73 |
| Petrale Sole | *Eopsetta jordani* | 27 | 78 | 14 | 0.58 |
| Longnose Skate | *Raja rhina* | 31 | 70 | 5 | 0.58 |
| Darkblotched Rockfish | *Sebastes crameri* | 42 | 31 | 2 | 0.32 |
| Chinook Salmon | *Oncorhynchus tshawytscha* | 14 | 25 | 3 | 0.61 |
| American Shad | *Alosa sapidissima* | 18 | 23 | 1 | 0.55 |
| Whitebait Smelt | *Allosmerus elongatus* | 22 | 18 | 2 | 0.52 |

Table 2. Number of fish sampled for biological data during the 2015 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** |
|---|---|---|---|
| Big Skate | *Raja binoculata* | 6 | 0 |
| Sandpaper Skate | *Bathyraja interrupta* | 9 | 0 |
| Longnose Skate | *Raja rhina* | 107 | 0 |
| American Shad | *Alosa sapidissima* | 188 | 0 |
| Pacific Herring | *Clupea pallasii* | 750 | 0 |
| Eulachon | *Thaleichthys pacificus* | 4799 | 0 |
| Pacific Cod | *Gadus macrocephalus* | 322 | 0 |
| Walleye Pollock | *Theragra chalcogramma* | 541 | 0 |
| Rougheye Rockfish | *Sebastes aleutianus* | 61 | 61 |
| Sablefish | *Anoplopoma fimbria* | 255 | 0 |
| Lingcod | *Ophiodon elongatus* | 58 | 12 |
| Arrowtooth Flounder | *Reinhardtius stomias* | 671 | 0 |
| Petrale Sole | *Eopsetta jordani* | 12 | 0 |
| Rex Sole | *Glyptocephalus zachirus* | 1028 | 0 |
| Flathead Sole | *Hippoglossoides elassodon* | 28 | 0 |
| Pacific Halibut | *Hippoglossus stenolepis* | 68 | 0 |
| Dover Sole | *Microstomus pacificus* | 275 | 0 |
| English Sole | *Parophrys vetulus* | 276 | 0 |

## 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 core 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. The synoptic bottom trawl surveys are conducted on both chartered commercial vessels and government research vessels. The Hecate Strait survey, the West Coast Vancouver Island survey, and the Strait of Georgia survey are all 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 2015 the Hecate Strait and Queen Charlotte Sound surveys were conducted.

In addition to the four core surveys, a Strait of Georgia survey was initiated in 2012 with the intention of repeating the survey every 3 years. The first scheduled repeat of the survey was in 2015 but it was not possible to conduct the survey during March. Nonetheless, research vessel time was available during May and it appeared that the time period would remain available in future years. Unfortunately, due to changing priorities, the May time period will not be available in future years. Research vessel time has been secured for March 2017 and the new plan is to move forward conducting the Strait of Georgia survey biennially, in odd numbered years.

The four core synoptic surveys (Hecate Strait, Queen Charlotte Sound, West Coast Vancouver Island, and West Coast Haida Gwaii) are all fished using an Atlantic Western bottom trawl. In contrast, the SOG survey is fished using a much smaller Yankee 36 bottom trawl. The decision to use the smaller trawl makes direct comparisons between the areas difficult but allowed us to conduct the survey in the available days. The use of the smaller trawl allows more blocks to be fished each day as the net is faster to deploy and retrieve and catches tend to be smaller.

1. Strait of Georgia Multi-species Synoptic Bottom Trawl Survey

The Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between May 17 and 24. We assessed a total of 121 blocks (Table 3, Figure 9). Of the 45 total tows conducted, 42 were successful and 3 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 7 different DFO staff participated in the survey.

The total catch weight of all species was 17,972 kg. The mean catch per tow was 408 kg, averaging 27 different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (*Squalus suckleyi*), Spotted Ratfish (*Hydrolagus colliei*), Pacific Hake (*Merluccius productus*), and Slender Sole (*Lyopsetta exilis*). 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 6,976 individual fish of 31 different species (

Table 5). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 3. 2015 Strait of Georgia 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, other vessels in the area, or insufficient time at the end of the survey) by stratum.

| Depth Stratum (m) | Rejected Prior | Rejected Inspected | Failed | Success | Not Fished | Total |
|---|---|---|---|---|---|---|
| 10 - 75 | 18 | 13 | 1 | 4 | 8 | 44 |
| 75 - 150 | 6 | 6 | 2 | 16 | 1 | 31 |
| 150 - 250 | 5 | 4 | 0 | 11 | 8 | 28 |
| 250 - 500 | 5 | 3 | 0 | 11 | 4 | 23 |
| **Total** | **34** | **26** | **3** | **42** | **21** | **126** |

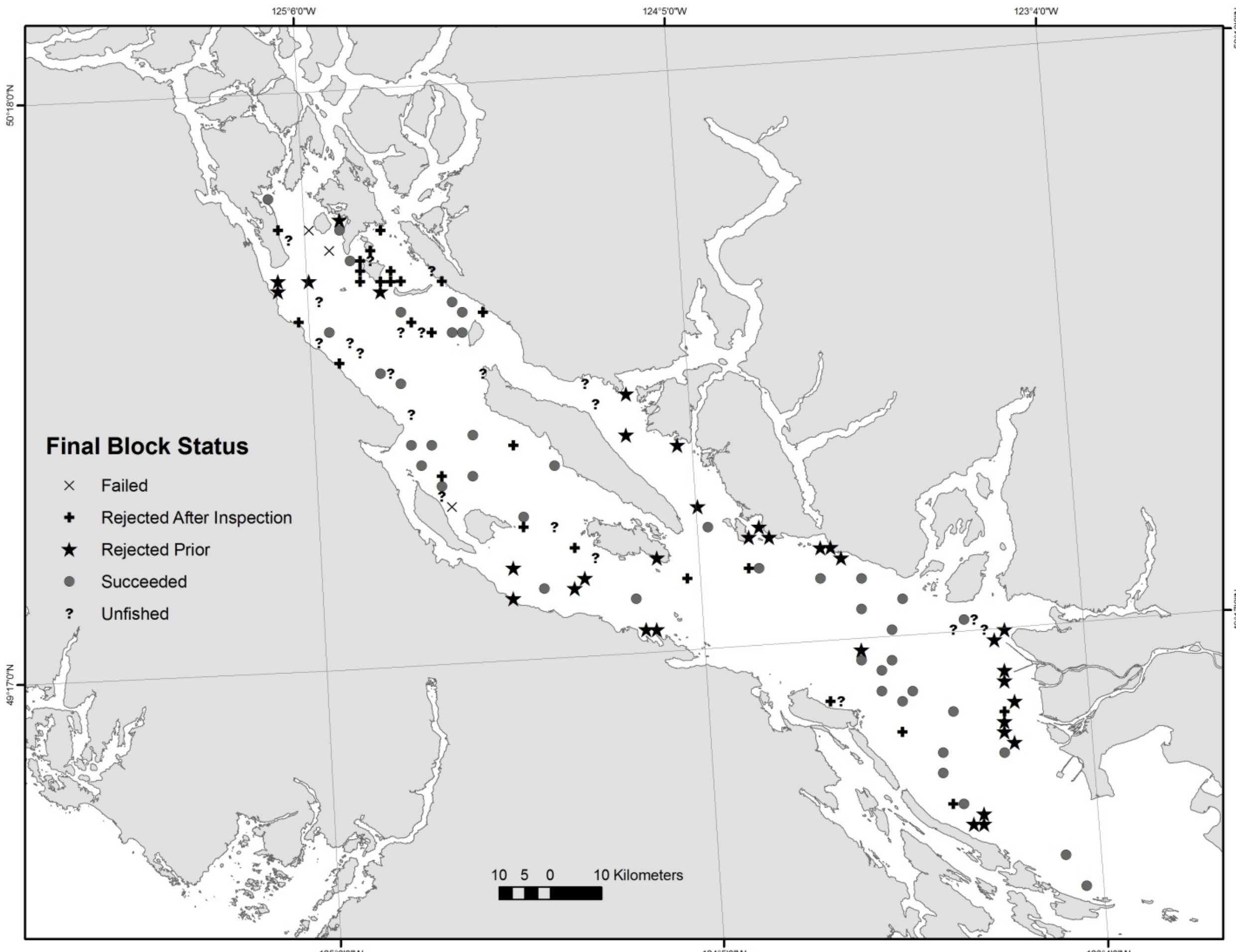


Figure 9. Final status of the allocated blocks for the 2015 Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey.

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 2015 Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey.

| **Species** | **Scientific Name** | **Num. Tows** | **Catch (kg)** | **Biomass (t)** | **Rel. Error** |
|---|---|---|---|---|---|
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 42 | 4175 | 3583 | 0.24 |
| Spotted Ratfish | *Hydrolagus colliei* | 42 | 3958 | 4354 | 0.17 |
| Pacific Hake | *Merluccius productus* | 38 | 3635 | 2902 | 0.33 |
| Slender Sole | *Lyopsetta exilis* | 41 | 1308 | 1079 | 0.31 |
| English Sole | *Parophrys vetulus* | 35 | 1116 | 1201 | 0.43 |
| Walleye Pollock | *Theragra chalcogramma* | 21 | 736 | 694 | 0.46 |
| Pacific Cod | *Gadus macrocephalus* | 20 | 499 | 456 | 0.36 |
| Flathead Sole | *Hippoglossoides elassodon* | 14 | 282 | 340 | 0.53 |
| Plainfin Midshipman | *Porichthys notatus* | 15 | 215 | 156 | 0.42 |
| Greenstriped Rockfish | *Sebastes elongatus* | 18 | 165 | 147 | 0.4 |
| Dover Sole | *Microstomus pacificus* | 32 | 140 | 136 | 0.17 |
| Longnose Skate | *Raja rhina* | 34 | 121 | 105 | 0.18 |
| Starry Flounder | *Platichthys stellatus* | 4 | 115 | 200 | 0.81 |
| Arrowtooth Flounder | *Reinhardtius stomias* | 27 | 111 | 80 | 0.35 |
| Blackbelly Eelpout | *Lycodes pacificus* | 16 | 98 | 127 | 0.47 |
| Big Skate | *Raja binoculata* | 7 | 93 | 106 | 0.42 |
| Quillback Rockfish | *Sebastes maliger* | 9 | 82 | 60 | 0.44 |
| Splitnose Rockfish | *Sebastes diploproa* | 15 | 81 | 54 | 0.39 |
| Pacific Herring | *Clupea pallasii* | 15 | 58 | 71 | 0.54 |
| Rex Sole | *Glyptocephalus zachirus* | 19 | 48 | 35 | 0.3 |
| Lingcod | *Ophiodon elongatus* | 14 | 44 | 38 | 0.3 |
| Yelloweye Rockfish | *Sebastes ruberrimus* | 9 | 25 | 23 | 0.5 |
| Brown Cat Shark | *Apristurus brunneus* | 18 | 23 | 22 | 0.19 |
| Southern Rock Sole | *Lepidopsetta bilineata* | 11 | 23 | 29 | 0.3 |
| Black Eelpout | *Lycodes diapterus* | 19 | 16 | 15 | 0.22 |

Table 5. Number of fish sampled for biological data during the 2015 Strait of Georgia 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** |
|---|---|---|---|
| Bluntnose Sixgill Shark | *Hexanchus griseus* | 1 | 0 |
| Brown Cat Shark | *Apristurus brunneus* | 96 | 0 |
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 706 | 26 |
| Big Skate | *Raja binoculata* | 18 | 0 |
| Longnose Skate | *Raja rhina* | 127 | 0 |
| Spotted Ratfish | *Hydrolagus colliei* | 1043 | 0 |
| American Shad | *Alosa sapidissima* | 9 | 0 |
| Pacific Herring | *Clupea pallasii* | 157 | 0 |
| Pacific Sardine | *Sardinops sagax* | 1 | 0 |
| Pacific Cod | *Gadus macrocephalus* | 164 | 150 |
| Pacific Hake | *Merluccius productus* | 1086 | 253 |
| Walleye Pollock | *Theragra chalcogramma* | 370 | 28 |
| Shiner Perch | *Cymatogaster aggregata* | 1 | 0 |
| Pile Perch | *Rhacochilus vacca* | 1 | 0 |
| Copper Rockfish | *Sebastes caurinus* | 1 | 1 |
| Splitnose Rockfish | *Sebastes diploproa* | 207 | 0 |
| Greenstriped Rockfish | *Sebastes elongatus* | 343 | 0 |
| Quillback Rockfish | *Sebastes maliger* | 90 | 88 |
| Yelloweye Rockfish | *Sebastes ruberrimus* | 27 | 27 |
| Shortspine Thornyhead | *Sebastolobus alascanus* | 65 | 0 |
| Sablefish | *Anoplopoma fimbria* | 22 | 0 |
| Lingcod | *Ophiodon elongatus* | 32 | 20 |
| Arrowtooth Flounder | *Reinhardtius stomias* | 118 | 0 |
| Petrale Sole | *Eopsetta jordani* | 11 | 9 |
| Rex Sole | *Glyptocephalus zachirus* | 149 | 0 |
| Flathead Sole | *Hippoglossoides elassodon* | 208 | 0 |
| Southern Rock Sole | *Lepidopsetta bilineata* | 27 | 0 |
| Slender Sole | *Lyopsetta exilis* | 981 | 0 |
| Dover Sole | *Microstomus pacificus* | 333 | 30 |
| English Sole | *Parophrys vetulus* | 550 | 249 |
| Starry Flounder | *Platichthys stellatus* | 32 | 27 |

## Hecate Strait Multi-species Synoptic Bottom Trawl Survey

The Hecate Strait Multi-Species Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between May 26 and June 22. We assessed a total of 184 blocks (Table 6, Figure 10). Of the 152 total tows conducted, 148 were successful and 4 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 62,496 kg. The mean catch per tow was 411 kg, averaging 24 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (R*einhardtius stomias*), Spotted Ratfish (*Hydrolagus colliei*), Dover Sole (*Microstomus pacificus*), and Rex Sole (*Glyptocephalus zachirus*). 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 24,421 individual fish of 48 different species (

Table 8). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 6. 2015 Hecate Strait 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 in the area) by stratum.

| Depth Stratum (m) | Rejected Prior | Rejected Inspected | Failed | Success | Not Fished | Total |
|---|---|---|---|---|---|---|
| 10-70 | 0 | 21 | 2 | 47 | 6 | 76 |
| 70-130 | 1 | 1 | 1 | 46 | 0 | 49 |
| 130-220 | 0 | 3 | 0 | 40 | 0 | 43 |
| 220-500 | 0 | 1 | 0 | 15 | 0 | 16 |
| **Total** | **1** | **26** | **3** | **148** | **6** | **184** |

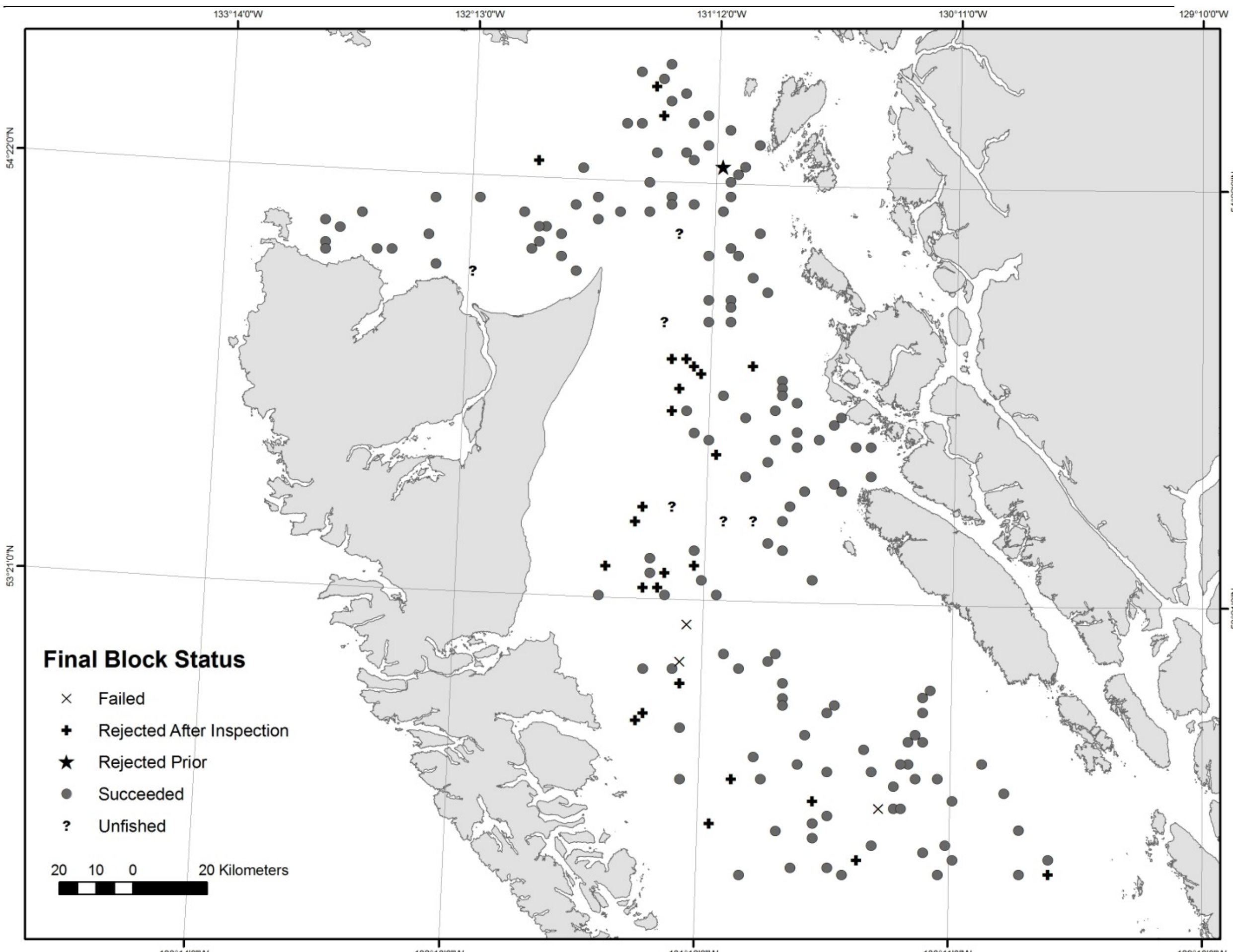


Figure 10. Final status of the allocated blocks for the 2015 Hecate Strait Multi-Species Synoptic Bottom Trawl Survey.

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 2015 Hecate Strait Multi-Species Synoptic Bottom Trawl Survey.

| **Species** | **Scientific Name** | **Num. Tows** | **Catch (kg)** | **Biomass (t)** | **Rel. Error** |
|---|---|---|---|---|---|
| Arrowtooth Flounder | *Reinhardtius stomias* | 123 | 13322 | 8563 | 0.18 |
| Spotted Ratfish | *Hydrolagus colliei* | 135 | 10927 | 9056 | 0.19 |
| Dover Sole | *Microstomus pacificus* | 117 | 5707 | 3258 | 0.17 |
| Rex Sole | *Glyptocephalus zachirus* | 120 | 4011 | 2504 | 0.12 |
| English Sole | *Parophrys vetulus* | 94 | 3973 | 3748 | 0.15 |
| Pacific Halibut | *Hippoglossus stenolepis* | 111 | 3636 | 3434 | 0.17 |
| Walleye Pollock | *Theragra chalcogramma* | 89 | 2924 | 1987 | 0.28 |
| Southern Rock Sole | *Lepidopsetta bilineata* | 70 | 2436 | 3294 | 0.28 |
| Sablefish | *Anoplopoma fimbria* | 93 | 1961 | 1539 | 0.37 |
| Flathead Sole | *Hippoglossoides elassodon* | 74 | 1802 | 1287 | 0.25 |
| Pacific Cod | *Gadus macrocephalus* | 107 | 1343 | 953 | 0.21 |
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 77 | 1299 | 975 | 0.35 |
| Sand Sole | *Psettichthys melanostictus* | 33 | 651 | 840 | 0.27 |
| Eulachon | *Thaleichthys pacificus* | 59 | 649 | 471 | 0.35 |
| Yellowtail Rockfish | *Sebastes flavidus* | 28 | 522 | 422 | 0.5 |
| Redbanded Rockfish | *Sebastes babcocki* | 38 | 467 | 281 | 0.19 |
| Big Skate | *Raja binoculata* | 35 | 465 | 367 | 0.21 |
| Pacific Ocean Perch | *Sebastes alutus* | 53 | 461 | 249 | 0.28 |
| Silvergray Rockfish | *Sebastes brevispinis* | 48 | 439 | 265 | 0.23 |
| Petrale Sole | *Eopsetta jordani* | 69 | 369 | 281 | 0.16 |
| Pacific Herring | *Clupea pallasii* | 69 | 358 | 456 | 0.29 |
| Shortspine Thornyhead | *Sebastolobus alascanus* | 43 | 358 | 276 | 0.3 |
| Quillback Rockfish | *Sebastes maliger* | 32 | 314 | 280 | 0.32 |
| Longnose Skate | *Raja rhina* | 29 | 267 | 157 | 0.27 |
| Pacific Sanddab | *Citharichthys sordidus* | 21 | 260 | 298 | 0.45 |

Table 8. Number of fish sampled for biological data during the 2015 Hecate Strait 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 |
|---|---|---|---|
| Tope Shark | *Galeorhinus galeus* | 9 | 0 |
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 292 | 79 |
| Aleutian Skate | *Bathyraja aleutica* | 4 | 0 |
| Big Skate | *Raja binoculata* | 69 | 0 |
| Sandpaper Skate | *Bathyraja interrupta* | 21 | 0 |
| Longnose Skate | *Raja rhina* | 59 | 0 |
| Spotted Ratfish | *Hydrolagus colliei* | 3040 | 0 |
| Pacific Herring | *Clupea pallasii* | 50 | 0 |
| Eulachon | *Thaleichthys pacificus* | 1272 | 0 |
| Pacific Cod | *Gadus macrocephalus* | 903 | 834 |
| Pacific Tomcod | *Microgadus proximus* | 404 | 0 |
| Walleye Pollock | *Theragra chalcogramma* | 1061 | 240 |
| Rougheye Rockfish | *Sebastes aleutianus* | 63 | 63 |
| Pacific Ocean Perch | *Sebastes alutus* | 364 | 269 |
| Redbanded Rockfish | *Sebastes babcocki* | 208 | 208 |
| Shortraker Rockfish | *Sebastes borealis* | 2 | 2 |
| Silvergray Rockfish | *Sebastes brevispinis* | 223 | 56 |
| Copper Rockfish | *Sebastes caurinus* | 123 | 109 |
| Puget Sound Rockfish | *Sebastes emphaeus* | 28 | 28 |
| Widow Rockfish | *Sebastes entomelas* | 34 | 28 |
| Yellowtail Rockfish | *Sebastes flavidus* | 184 | 82 |
| Quillback Rockfish | *Sebastes maliger* | 321 | 261 |
| Bocaccio | *Sebastes paucispinis* | 3 | 3 |
| Canary Rockfish | *Sebastes pinniger* | 62 | 54 |
| Redstripe Rockfish | *Sebastes proriger* | 84 | 24 |
| Yellowmouth Rockfish | *Sebastes reedi* | 5 | 0 |
| Yelloweye Rockfish | *Sebastes ruberrimus* | 4 | 4 |
| Pygmy Rockfish | *Sebastes wilsoni* | 7 | 0 |
| Sharpchin Rockfish | *Sebastes zacentrus* | 43 | 0 |
| Shortspine Thornyhead | *Sebastolobus alascanus* | 509 | 85 |
| Sablefish | *Anoplopoma fimbria* | 695 | 186 |
| Kelp Greenling | *Hexagrammos decagrammus* | 60 | 0 |
| Lingcod | *Ophiodon elongatus* | 36 | 14 |
| Pacific Sanddab | *Citharichthys sordidus* | 236 | 0 |
| Arrowtooth Flounder | *Reinhardtius stomias* | 3019 | 853 |
| Petrale Sole | *Eopsetta jordani* | 364 | 255 |
| Rex Sole | *Glyptocephalus zachirus* | 2715 | 321 |
| Flathead Sole | *Hippoglossoides elassodon* | 1283 | 233 |
| Pacific Halibut | *Hippoglossus stenolepis* | 686 | 0 |
| Butter Sole | *Isopsetta isolepis* | 366 | 188 |
| Southern Rock Sole | *Lepidopsetta bilineata* | 1550 | 874 |
| Yellowfin Sole | *Limanda aspera* | 25 | 0 |
| Slender Sole | *Lyopsetta exilis* | 101 | 0 |
| Dover Sole | *Microstomus pacificus* | 1868 | 1068 |
| English Sole | *Parophrys vetulus* | 2215 | 1156 |
| Starry Flounder | *Platichthys stellatus* | 37 | 0 |
| Curlfin Sole | *Pleuronichthys decurrens* | 93 | 49 |
| Sand Sole | *Psettichthys melanostictus* | 603 | 0 |

## Queen Charlotte Sound Multi-species Synoptic Bottom Trawl Survey

The Queen Charlotte Sound Multi-Species Synoptic Bottom Trawl Survey was conducted on the F/V Frosti between July 6 and August 8. We assessed a total of 293 blocks (Table 9, Figure 11). Of the 251 total tows conducted, 239 were successful and 12 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 six different DFO staff and four contract science staff from Archipelago Marine Research participated in the survey.

The total catch weight of all species was 90,986 kg. The mean catch per tow was 368 kg, averaging 23 different species of fish and invertebrates in each. The most abundant fish species encountered were Arrowtooth Flounder (*Reinhardtius stomias*), Pacific Ocean Perch (*Sebastes alutus*), Silvergray Rockfish (*Sebastes brevispinis*), and Rex Sole (G*lyptocephalus zachirus*), 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 10. Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 28,686 individual fish of 46 different species (Table 11). Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 9. 2015 Queen Charlotte Sound 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 in the area) by stratum.

| **Depth Stratum (m)** | **Rejected Prior** | **Rejected Inspected** | **Failed** | **Success** | **Not Fished** | **Total** |
|---|---|---|---|---|---|---|
| North 50 to 125 m | 0 | 8 | 1 | 12 | 0 | 21 |
| North 125 to 200 m | 2 | 7 | 2 | 50 | 0 | 61 |
| North 200 to 330 m | 0 | 3 | 0 | 44 | 0 | 47 |
| North 330 to 500 m | 0 | 0 | 0 | 7 | 1 | 8 |
| South 50 to 125 m | 2 | 1 | 2 | 30 | 5 | 40 |
| South 125 to 200 m | 3 | 5 | 0 | 65 | 0 | 73 |
| South 200 to 330 m | 0 | 6 | 2 | 26 | 0 | 34 |
| South 330 to 500 m | 0 | 4 | 1 | 4 | 0 | 9 |
| **Total** | **7** | **34** | **8** | **238** | **6** | **293** |

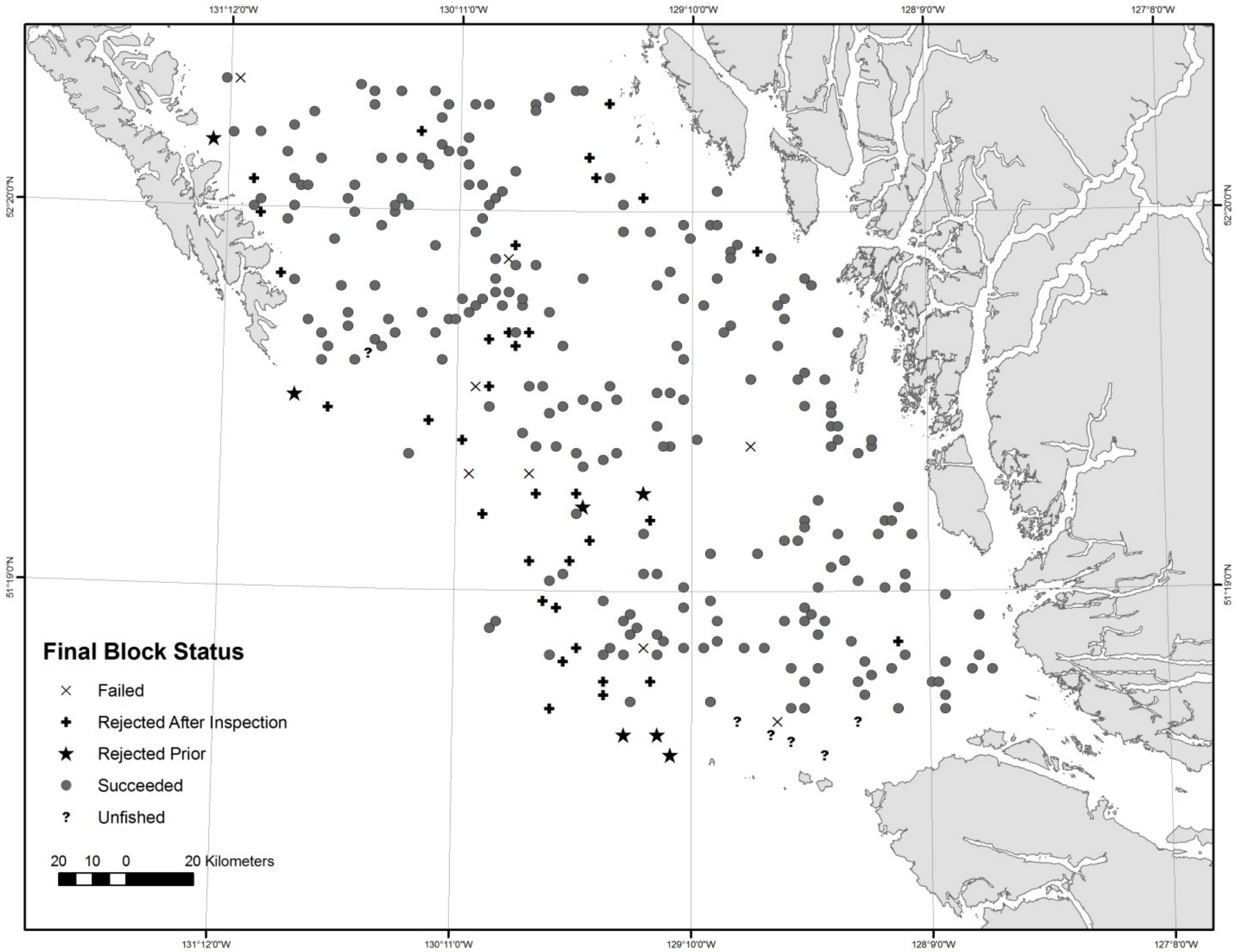

Figure 11. Final status of the allocated blocks for the 2015 Queen Charlotte Sound Multi-Species Synoptic Bottom Trawl Survey.

Table 10. 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 2015 Queen Charlotte Sound Multi-Species Synoptic Bottom Trawl Survey.

| **Species** | **Scientific Name** | **Num. Tows** | **Catch (kg)** | **Biomass (t)** | **Rel. Error** |
|---|---|---|---|---|---|
| Arrowtooth Flounder | *Reinhardtius stomias* | 225 | 19602 | 14099 | 0.15 |
| Pacific Ocean Perch | *Sebastes alutus* | 159 | 19504 | 14715 | 0.23 |
| Silvergray Rockfish | *Sebastes brevispinis* | 139 | 8072 | 5169 | 0.33 |
| Walleye Pollock | *Theragra chalcogramma* | 145 | 2727 | 2107 | 0.31 |
| Rex Sole | *Glyptocephalus zachirus* | 201 | 2725 | 2151 | 0.12 |
| Dover Sole | *Microstomus pacificus* | 168 | 2704 | 2190 | 0.17 |
| Yellowtail Rockfish | *Sebastes flavidus* | 51 | 2421 | 1561 | 0.34 |
| Redstripe Rockfish | *Sebastes proriger* | 58 | 2296 | 1555 | 0.31 |
| Sablefish | *Anoplopoma fimbria* | 134 | 2249 | 1952 | 0.11 |
| Canary Rockfish | *Sebastes pinniger* | 43 | 2098 | 1447 | 0.44 |
| Flathead Sole | *Hippoglossoides elassodon* | 94 | 1847 | 1526 | 0.33 |
| Rougheye Rockfish | *Sebastes aleutianus* | 58 | 1842 | 1848 | 0.4 |
| Pacific Cod | *Gadus macrocephalus* | 125 | 1617 | 1144 | 0.28 |
| Shortspine Thornyhead | *Sebastolobus alascanus* | 94 | 1556 | 1287 | 0.12 |
| Yellowmouth Rockfish | *Sebastes reedi* | 45 | 1405 | 1013 | 0.41 |
| Pacific Hake | *Merluccius productus* | 62 | 1308 | 1159 | 0.18 |
| Spotted Ratfish | *Hydrolagus colliei* | 202 | 1279 | 1336 | 0.23 |
| Pacific Halibut | *Hippoglossus stenolepis* | 90 | 1117 | 1080 | 0.31 |
| Redbanded Rockfish | *Sebastes babcocki* | 103 | 1075 | 778 | 0.25 |
| English Sole | *Parophrys vetulus* | 79 | 785 | 755 | 0.23 |
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 106 | 577 | 447 | 0.18 |
| Sharpchin Rockfish | *Sebastes zacentrus* | 70 | 562 | 392 | 0.4 |
| Longnose Skate | *Raja rhina* | 62 | 561 | 441 | 0.13 |
| Splitnose Rockfish | *Sebastes diploproa* | 46 | 493 | 333 | 0.45 |
| Greenstriped Rockfish | *Sebastes elongatus* | 66 | 415 | 276 | 0.27 |

Table 11. Number of fish sampled for biological data during the 2015 Queen Charlotte Sound 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** |
|---|---|---:|---:|
| North Pacific Spiny Dogfish | *Squalus suckleyi* | 75 | 0 |
| Aleutian Skate | *Bathyraja aleutica* | 2 | 0 |
| Big Skate | *Raja binoculata* | 12 | 0 |
| Sandpaper Skate | *Bathyraja interrupta* | 19 | 0 |
| Longnose Skate | *Raja rhina* | 126 | 0 |
| Spotted Ratfish | *Hydrolagus colliei* | 885 | 0 |
| Eulachon | *Thaleichthys pacificus* | 1043 | 0 |
| Pacific Cod | *Gadus macrocephalus* | 965 | 778 |
| Pacific Hake | *Merluccius productus* | 462 | 76 |
| Pacific Tomcod | *Microgadus proximus* | 18 | 0 |
| Walleye Pollock | *Theragra chalcogramma* | 1439 | 216 |
| Rougheye Rockfish | *Sebastes aleutianus* | 332 | 332 |
| Pacific Ocean Perch | *Sebastes alutus* | 2249 | 1344 |
| Redbanded Rockfish | *Sebastes babcocki* | 495 | 332 |
| Shortraker Rockfish | *Sebastes borealis* | 39 | 39 |
| Silvergray Rockfish | *Sebastes brevispinis* | 1362 | 770 |
| Darkblotched Rockfish | *Sebastes crameri* | 31 | 0 |
| Splitnose Rockfish | *Sebastes diploproa* | 212 | 0 |
| Greenstriped Rockfish | *Sebastes elongatus* | 513 | 24 |
| Widow Rockfish | *Sebastes entomelas* | 67 | 32 |
| Yellowtail Rockfish | *Sebastes flavidus* | 396 | 232 |
| Rosethorn Rockfish | *Sebastes helvomaculatus* | 155 | 0 |
| Shortbelly Rockfish | *Sebastes jordani* | 8 | 0 |
| Quillback Rockfish | *Sebastes maliger* | 88 | 57 |
| Bocaccio | *Sebastes paucispinis* | 6 | 6 |
| Canary Rockfish | *Sebastes pinniger* | 318 | 258 |
| Redstripe Rockfish | *Sebastes proriger* | 491 | 320 |
| Yellowmouth Rockfish | *Sebastes reedi* | 282 | 194 |
| Yelloweye Rockfish | *Sebastes ruberrimus* | 60 | 60 |
| Harlequin Rockfish | *Sebastes variegatus* | 5 | 0 |
| Pygmy Rockfish | *Sebastes wilsoni* | 103 | 0 |
| Sharpchin Rockfish | *Sebastes zacentrus* | 655 | 137 |
| Shortspine Thornyhead | *Sebastolobus alascanus* | 1686 | 283 |
| Longspine Thornyhead | *Sebastolobus altivelis* | 45 | 29 |
| Sablefish | *Anoplopoma fimbria* | 1228 | 349 |
| Lingcod | *Ophiodon elongatus* | 89 | 31 |
| Pacific Sanddab | *Citharichthys sordidus* | 258 | 0 |
| Arrowtooth Flounder | *Reinhardtius stomias* | 3805 | 1291 |
| Petrale Sole | *Eopsetta jordani* | 279 | 161 |
| Rex Sole | *Glyptocephalus zachirus* | 3230 | 292 |
| Flathead Sole | *Hippoglossoides elassodon* | 1654 | 134 |
| Pacific Halibut | *Hippoglossus stenolepis* | 214 | 0 |
| Southern Rock Sole | *Lepidopsetta bilineata* | 377 | 177 |
| Slender Sole | *Lyopsetta exilis* | 321 | 0 |
| Dover Sole | *Microstomus pacificus* | 1660 | 626 |
| English Sole | *Parophrys vetulus* | 927 | 451 |

## TSC Agency Reports - IPHC

**Contents**



I. Agency Overview

Management of the Pacific halibut resource and fishery has been the responsibility of the International Pacific Halibut Commission (IPHC) since its creation in 1923. Assessing, forecasting, and managing the resource and fishery requires accurate assessments, continuous monitoring, and research responsive to the needs of managers and stakeholders. The fishery for Pacific halibut (*Hippoglossus stenolepis*) is one of the most valuable and geographically largest in the northeast Pacific Ocean. Industry participants from Canada and the United States have prosecuted the fishery and have depended upon the resource since before the turn of the 20th Century. Annual removals have been as high as 100 million pounds, and the long-term average of removals is 64 million pounds.

Staffing Updates: In addition to some standard turnover seen in both the port and sea sampling seasonal positions, the following transitions have occurred in 2015 and 2016, or are planned for 2016.

| Name | Position | Start Date | End Date |
|---|---|---|---|
| Claude Dykstra | Survey Manager | | June 2015 |
| Claude Dykstra | Research Biologist | June 2015 | |
| Anna Henry | Survey Manager | June 2015 | |
| Jim Traub | Database and IT Program Manager* | | Sept. 2015 |
| Dr. Steve Martell | Quantitative Scientist | | December 2015 |
| Dr. Allan Hicks | Quantitative Scientist | April 2016 | |
| Heather Gilroy | Fisheries Statistics Program Manager* | | April 30, 2016 |
| Dr. Josep Planas | Research Program Manager | January 2016 | |
| Dr. Bruce Leaman | Executive Director | | August 31, 2016 |
| Dr. David Wilson | Executive Director | August 1, 2016 | |

*The Commission is in the process of hiring for this position.

## II. Surveys

In 2015, fourteen commercial longline vessels, seven Canadian and seven U.S., were chartered by the International Pacific Halibut Commission for survey operations. During a combined 73 trips and 736 charter days, these vessels fished 30 charter regions, covering habitat from southern Oregon to the island of Attu in the Aleutian Islands, and north along and including the Bering Sea continental shelf. All 1,368 survey stations planned for the 2015 survey season were either scouted or completed. Of these stations, 1,360 (99.4%) were considered successful for stock assessment analysis. Approximately 751,340 pounds of halibut, 70,635 pounds of Pacific cod, and 42,532 pounds of rockfish were landed from the standardized survey stations. Compared to the 2014 survey, weight per unit effort (WPUE) increased in Regulatory Areas 2A, 2C, 3B, 4B, 4C, and 4D. WPUE decreased in areas 2B, 3A, and 4A.
The 2015 survey design encompassed both nearshore and offshore waters of Oregon, Washington, British Columbia, southeast Alaska, the central and western Gulf of Alaska, Aleutian Islands, and the Bering Sea continental shelf. These areas were divided into 30 regions, each requiring between 12 and 43 charter days to complete (Table 1). Stations were located at the intersections of a 10 nmi by 10 nmi square grid within the depth range occupied by Pacific halibut during summer months (20-275 fm in most areas). As a continued part of a multi-year coastwide effort to expand our survey depth profile and update our calibration with other surveys, the IPHC conducted a standardized grid survey in the eastern Bering Sea (EBS) for 2015. Figure 1 depicts the survey station positions, charter region divisions, and regulatory areas surveyed.

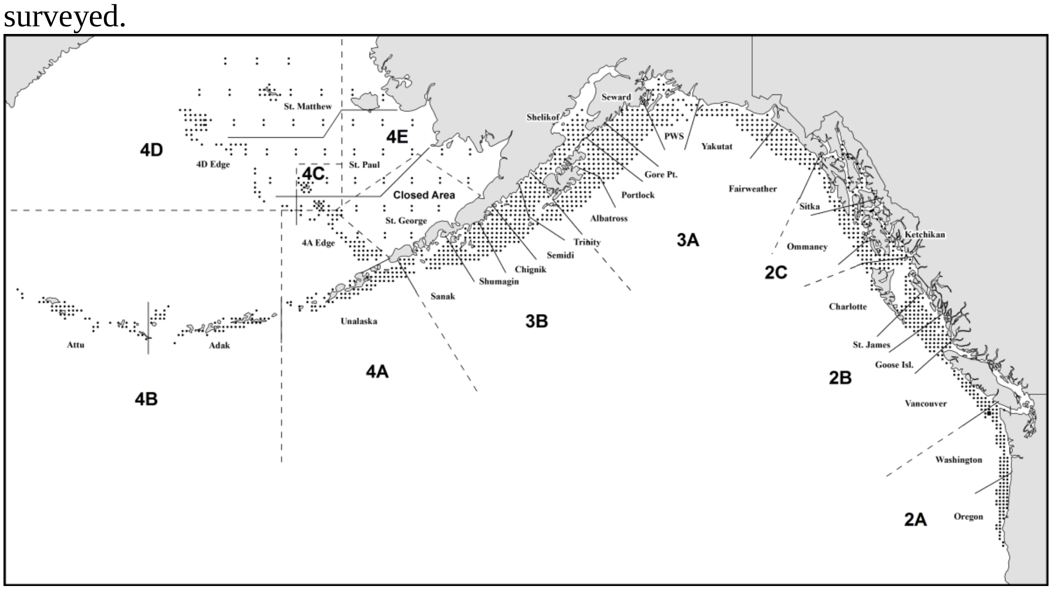


Figure 1. 2015 SSA survey stations with regulatory area (two-character codes) and charter region (formal names) divisions.

III. Reserves

Review of Agency Groundfish Research, Assessment, and Management

A. Pacific halibut and IPHC activities

1. Research

This section provides a brief recap of projects conducted in 2015. Full reports on most projects can be found in the 2015 Report of Assessment and Research Activities (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.

**Ongoing Projects for 2016**
**Commercial Sex Marking Pilot**

Supports: Objective 1 – stock identification and assessment, Objective 2 – harvest policy and management
Priority: High
Start: 2015
Anticipated Ending: 2017
Personnel: T. Loher, I. Stewart, J. Marx

This project is part of a combined program with Project 621.16 to pair marks from commercially caught fish with a positive validation of sex via genetic means, at a much lower cost than direct estimation of the sex ratio of landings via genetic testing.

This project has three primary objectives: a) test a single method of sex marking aboard increasingly larger samples of commercial fishing trips in order to determine its feasibility from a logistical 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 621.16.

The 2016 field season will represent a scaling up of sampling relative to 2015. The 2015 design represented a single-port (~eight offloads) effort, wherein vessels marked their fish in advance of offloads that they knew would be sampled. In 2016, we aim to sample 20-30 offloads, representing vessels associated with one of the fleet's fishing vessel owners associations, wherein all vessels from the association mark all of the fish retained during all trips, without prior knowledge of whether those trips will be sampled port-side.

For each sampled offload, the port sampler will record the length and marked sex of each fish (including unmarked individuals) within the sample 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 within the same area during the same year.

- Storage of genetic samples pending the development of Single Nucleotide Polymorhpisms (SNP) assays, which will allow the accuracy of fishermen's marks to be tested directly.

Sample collection protocols are expected to change from prior years, at least in part, due to the requirements for shipping the tissue samples. 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.

**Genetic Sexing via Single Nucleotide Polymorhpisms (SNPs)**
Supports: Objective 1 – stock identification and assessment, Objective 2 – harvest policy and management
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. At present, the sex composition of the catch is estimated from IPHC survey data.

The sequencing of Restriction site Associated DNA (RAD tags) has revolutionized genetics by allowing the discovery and genotype-calling of thousands of SNPs 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. 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 dozen 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.

**Evaluation of Pacific halibut macroscopic maturity stage assignments**
Supports: Objective 2 – harvest policy and management, Objective 3 – biology, physiology, and migration
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). The assumption is that 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 F1 stage is only seen with immature fish, but we are seeing anomalies during the survey that suggest a fish may go back to this stage after achieving other maturity stages, and is therefore not truly immature. This study uses gonad samples collected in 2004. In 2016, 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; and
- Developing the sampling plan required to characterize seasonal maturation, including determination of the value of current summer assessment of halibut maturity stages.

**Assessment of mercury and contaminants in Pacific halibut**

Supports: Objective 4 – ecosystem interactions and environmental influences
Priority: Medium
Start Date: 2002
Anticipated ending: Continuing
Personnel: C. Dykstra, B. Gerlach (Alaska Department of Environmental Conservation)

The IPHC staff continues its collaboration with the Alaska Department of Environmental Conservation (ADEC) in 2016, collecting halibut tissue samples for analysis of heavy metal and organic pollutant loading. This work has been ongoing since 2002, when results from a collection of halibut samples that year led the Alaska Division of Public Health in 2003 to conclude that the concentrations of heavy metals in Alaskan Pacific halibut were not a public health concern. In 2004 the first results regarding organic pollutants (PCBs, pesticides) were released, demonstrating that halibut had the lowest concentrations of the five species (including salmon and sablefish) examined.

IPHC and ADEC are continuing to qualify the data with physical parameters (age, size, and weight) and additional analyses will be done on the samples. Our involvement in the project has allowed us to provide input on study design and sampling protocols in the field, which will make the resultant information much more robust.

**Archival tags: tag attachment protocols**

Supports: Objective 3 – biology, physiology, and migration
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. Rewards of $100 are given for all tags recovered.

**_Ichthyophonus_ prevalence in halibut**

Supports: Objective 4 – ecosystem interactions and environmental influences
Priority: Low
Start Date: 2012
Anticipated ending: Ongoing
Personnel: C. Dykstra, P. Hershberger (U.S. Geological Survey)

*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 2011-2013, 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 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.

**Estimate of length/weight relationship and head/ice/slime adjustment**

Supports: Objective 2 – harvest policy and management, Objective 3 – biology, physiology, and migration
Priority: High
Start: 2013
Anticipated Ending: Continuing
Personnel: R. Webster

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 2016 from ports staffed with IPHC samplers throughout the fishing season. The goal is to determine whether seasonal or area-specific length-weight 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 includes adjustments for the weight of the head, and 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.

**Length-weight relationship at sea**

Supports: Objective 2 – harvest policy and management, Objective 3 – biology, physiology, and migration
Priority: High
Start: 2015
Anticipated Ending: Ongoing
Personnel: E. Soderlund

This project integrates with the above 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 the IPHC's standardized stock assessment 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 the on-going project detailed above, 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 time of the offload. 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 the Estimate of length/weight relationship and head/ice/slime adjustment project.

**Wire tagging of juveniles on NMFS survey**

Supports: Objective 1 – stock identification and assessment
Priority: High
Start: 2015
Anticipated Ending: Ongoing
Personnel: L. Sadorus, J. Forsberg

IPHC routinely participates in the NMFS groundfish trawl surveys in the Bering Sea (annual), Gulf of Alaska (biennial), and Aleutian Islands (biennial). Fish caught range in size from about 20 to 100 cm fork length. In response to bycatch-related requests at the 2015 IPHC Annual Meeting to learn more about juvenile halibut distribution and movement, IPHC staff launched a pilot project during the 2015 survey season to test the practicability of wire tagging halibut of all sizes aboard the trawl surveys. In 2015, samplers aboard both the Bering Sea and Gulf surveys wire tagged and released 50% of the viable halibut caught at each station. They also evaluated various aspects of the sampling plan as it was set forth and reported on ways that could make the tagging most effective without creating undue disruption to the survey deck work. Overall, the plan was very successful, with 487 and 1,497 halibut tagged in the Bering Sea and Gulf, respectively.

Given that the pilot was successful and NMFS personnel were receptive to the idea of tagging, the tagging effort on these platforms is scheduled to continue for the next several years.

## New projects for 2016

**Condition factor of halibut**
Supports: Objective 3 – biology, physiology, and migration, Objective 4 – ecosystem interactions and environmental influences
Priority: High
Start: 2016
Anticipated Ending: Ongoing
Personnel: C. Dykstra, J. Planas

Tracking condition factors for the halibut population can provide information on the productivity of the stock in different areas, and can be coupled to reproductive information and/or energetics modeling as we develop our knowledge on these topics further under the guidance of Dr. Josep Planas, who joined the IPHC staff in January. This information is a component of understanding growth variation in halibut and is also valuable to the development of harvest policy.

**Project 2016-02: Early life history studies**
Supports: Objective 3 – biology, physiology, and migration
Priority: Medium
Start: 2016
Anticipated Ending: 2016
Personnel: L. Sadorus, I. Stewart, J. Duffy-Anderson (NMFS)

This project is a collaborative effort with NMFS to examine existing NMFS ichthyoplankton data on halibut distribution, survival, diet habits, size/weight, and these factors in relation to environmental variables for halibut in life stages prior to metamorphosis. Current efforts to develop more spatially explicit models for stock assessment and harvest policy analysis and to evaluate the potential factors influencing year-class strength would benefit from an improved understanding of early life history.

This year's focus will be on analysis of components of connectivity between the Gulf of Alaska and the Bering Sea, using existing larval survey and oceanographic data, and is expected to require little or no additional cost to staff time. This effort may ultimately result in proposals for various experiments or other research in future years to fill identified data gaps.

**RNA sequencing of gonads**
Supports: Objective 3 – biology, physiology, and migration, Objective 4 – ecosystem interactions and environmental influences
Priority: High
Start: 2016
Anticipated Ending: 2017
Personnel: J. Planas

This project aims to provide important direct markers of reproductive activity in halibut gonads. Sex-specific genetic markers are important to the determination of spawning biomass.

A small sample (4-6) of fish, balanced by sex, will be sampled at each maturity stage. Genetic sequencing will be conducted under contract with a commercial lab or UW.

Additional details and future direction for this and related follow-up projects will be developed.

**RNA sequencing of skeletal/liver tissue**

Supports: Objective 3 – biology, physiology, and migration, Objective 4 – ecosystem interactions and environmental influences
Priority: High
Start: 2016
Anticipated Ending: 2017
Personnel: J. Planas

This project will perform initial screening of skeletal muscle and liver tissue for transcriptome markers associated with growth characteristics. The project directly addresses the issue of determining causes of growth variation in halibut.

A small sample (4-6) of fish, balanced by sex, will be sampled at each maturity stage. Genetic sequencing will be conducted under contract with a commercial lab or UW.

This project is a pilot to determine future activities in experimental examination of the sources of halibut growth variation.

**4D Edge PAT tags**

Supports: Objective 2 – harvest policy and management, Objective 3 – biology, physiology, and migration
Priority: Medium
Start: 2016
Anticipated Ending: 2017
Personnel: T. Loher

This project will help increase our understanding of the relationship of adult distribution and spawning contributions in the Bering Sea.

The IPHC has a history of conducting PAT tagging in the Bering Sea and Aleutian Islands (BSAI) in order to investigate both seasonal and inter-annual dispersal. These studies have been aimed at gaining greater understanding of the timing of movements within this stock component, identifying winter spawning locations and investigating mixing among regulatory areas in a fishery-independent manner. The results of these experiments have complemented previous large-scale Passive Integrated Transponder (PIT) tagging experiments.

Notable gaps in spatial coverage of PAT tag deployments still exist, however, relative to areas fished by BSAI fleet components. The IPHC currently plans to extend its standardized stock assessment survey into two of these areas during the 2016 and 2017 surveys, presenting a unique opportunity to fill these gaps in understanding. This project will tag halibut at the far-northern 4D Edge expansion stations in 2016; this is to be followed by tagging on Bowers Ridge during the 2017 survey expansion.

The work will be complementary to previous BSAI PAT tagging, using identical tagging and tag program protocols. A total of 32 halibut will be tagged at 4D Edge expansion stations, using PAT tags programmed to detach and report location and download archived environmental data.

**Other**

**Undergraduate internship**

This internship is designed to provide research experience and outreach to one undergraduate student per year who would not ordinarily have the skills and qualifications to work at the IPHC. Students are chosen through a highly competitive selection process from schools in both the U.S. and Canada. The intern is assigned a specific research project, and with staff guidance they then design, execute, report, and present their results at the end of the work term. Additionally, interns are assigned support tasks as time allows, that vary from year to year and generally include several different departments within the IPHC. In 2015, the intern was Nicholas Wong from Simon Fraser University. Nicholas worked with marine mammal depredation data collected during the IPHC setline surveys over several years. The data were collected in previous years and did not require a field component, but the intern was still able to spend one trip on the survey and shadow a port sampler for a week. A report on the 2015 intern project is included in the IPHC Report on Assessment and Research Activities 2015 (Wong 2016).

**Remote Data Entry**

In 2015, 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 for the port sampling program and EaSEA (Entry At SEA) for the survey program.

The eLogs application was finalized for testing in the field and tablets were deployed with port samplers in select ports in 2014 for testing. Port samplers are using Panasonic Toughpads on which the eLog application was installed. Testing was ongoing throughout the season with fixes to the programming. At the start of the 2015 commercial halibut season all ports receiving Alaskan catch used the eLogs application on their assigned tablet to enter either all or as many of the logs they collected as possible. In 2016, Port samplers are 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 EaSEA application was also developed to replace the paper data forms that are currently used on the survey. In 2015 the EaSEA application was pilot tested in the field on two survey trips. Development and testing continued throughout the fall, and a larger scale pilot project will occur in 2016 using the EaSEA application as the main form of data collection on three vessels in the stock assessment survey. The goal is to use the EaSEA program on all vessels in the 2017 survey.

## Future research directions

The IPHC staff has identified the following major themes for future research:

1. Reproduction and recruitment.
    a. Better understanding of halibut reproductive biology, growth, swimming performance, and behavior from a physiological perspective.
    b. Application of environmental data to recruitment scenarios and year class strength.
    c. Recruitment drivers – processes that affect recruitment and their relative contributions.
2. Size composition and mortality of released/discarded fish. Currently, little is known about the size/age of discards for some directed fisheries or the appropriate discard mortality rate to be

applied. In addition, the increasing use of size restrictions in sport fishery management to more fully achieve harvest goals increases discards, but data collection programs are lacking and implications to the IPHC harvest policy are unclear. Lastly, changes in harvest policy, such as changes in the minimum commercial size limit, require data collection programs so that the impact of the changes in management procedures can be assessed. New tag technology using accelerometers offers great potential for this effort.

3. Full catch accounting. Information on removals from all sources is needed for the best assessment of stock status. Identification of gaps in reporting programs and impediments to progress in achieving full accounting are necessary to reach these goals.

4. Migration studies.
    a. An improved understanding of U26 migration, i.e., rates and timing by area and size of fish, as well as inter- and intra-annual variability. The current wire tag study is part of this effort.
    b. Improvements to archival tag technology for application to smaller halibut. Currently, pop-up satellite tags are limited to fish larger than 75 cm (~8 pounds), and archival tags to fish larger than 50 cm (~2.2 pounds). Being able to place similar or newer technology tags on smaller halibut would enable collection of movement data for a size range over which data are currently lacking.

## 2. Assessment

The IPHC conducted a stock assesment in 2015 to report the recent trends and status of the Pacific halibut (*Hippoglossus stenolepis*) resource in the northeastern Pacific Ocean (see Stewart et al. 2016). Commercial fishery landings in 2015 were 24.7 Mlb, up from 23.7 Mlb in 2014. The 2015 setline survey coastwide legal (O32) and total (O32+U32) WPUE were 5% higher than values observed in 2014. Age distributions in 2015 from both the survey and fishery remained similar to those observed in 2011-2014, indicating a relatively stable stock, and no clear evidence of recent strong coastwide recruitments. At the coastwide level, individual size-at-age remains low relative to the rest of the time series, although there has been little change over the last several years.

The 2015 scientific review process produced a number of important recommendations that have been incorporated into this assessment. However, the basic approach used in 2014 remains unchanged: results from four assessment models are combined together into an 'ensemble.' As has been the case since 2012, results from this stock assessment are based on approximate probability distributions derived from the ensemble, thereby incorporating both the uncertainty within each model, as well as the uncertainty among models.

The two long time-series models provide a different perception of current vs. historical stock sizes. The Areas-As-Fleets (AAF) long model suggests the stock is currently increasing gradually and is at 39% of the equilibrium unfished stock size; however the model estimates that current spawning biomass is at only 140% of the minimum values estimated for the 1970s. The coastwide long model also suggests that the stock is currently increasing and at 54% of the equilibrium unfished stock size; however, the current spawning biomass is estimated to be at 236% of the minimum values estimated for the 1970s. The two short models are unable to provide insight into historical dynamics, and also provide differing perspectives of current stock size. These model differences highlight the considerable uncertainty in both the current stock size and trend. The results of the 2015 stock assessment indicate that the Pacific halibut stock declined continuously from the late 1990s to around 2010. That trend is estimated to have been a result of decreasing size-at-age, as well as recent recruitment strengths that are smaller than those observed during the 1980s and 1990s. Since that time period, the estimated female spawning biomass is estimated to have stabilized near 200 Mlb, with a slightly increasing trend. The median 2016 estimate of exploitable biomass, consistent with the IPHC's current harvest policy, is 185 Mlb.

Three-year projections were conducted for a range of alternative management actions; and probabilities of various risk metrics are reported in a decision-making table framework. The Blue Line of the decision table (representing the application of the current harvest policy) results in a coastwide total mortality of 38.7 Mlb. The stock is projected to increase gradually, given Blue Line levels of future harvest, and decrease with a greater than 50/100 chance for total mortality exceeding around 43 Mlb.

## 3. Management

The International Pacific Halibut Commission (IPHC) completed its 92nd Annual Meeting in Juneau, Alaska, on January 29, 2016, with Dr. James Balsiger presiding as Chair. More than 280 halibut industry stakeholders attended the meeting, with over 80 more participating via the web. All of the Commission's public and administrative sessions during the meeting were open to the public and broadcast on the web.

The Commission recommended, to the governments of Canada and the United States, catch limits for 2016 totaling 29.89 million pounds. The Commission also addressed other regulatory issues and took actions regarding assessment survey expansion and bycatch management. Documents and presentations from the Annual Meeting can be found on the Annual Meeting page of the IPHC website: http://www.iphc.int/meetings-and-events/annual-meeting.html.

### Catch Limits

The Commission received harvest advice for 2016 from the scientific staff, Canadian and United States harvesters and processors, and recommended to the two governments the following catch limits for 2016:

| IPHC Regulatory Area | Catch Limit (pounds) |
|---|---|
| **Area 2A** (California, Oregon, and Washington) | **1,140,000** |
| Non-treaty directed commercial (south of Pt. Chehalis) | 193,364 |
| Non-treaty incidental catch in salmon troll fishery | 34,123 |
| Non-treaty incidental catch in sablefish fishery (north of Pt. Chehalis) | 49,686 |
| Treaty Indian commercial | 365,100 |
| Treaty Indian ceremonial and subsistence (year-round) | 33,900 |
| Sport – Washington | 214,110 |
| Sport – Oregon | 220,077 |
| Sport – California | 29,640 |
| **Area 2B** (British Columbia) (includes sport catch allocation) | **7,300,000** |

| | |
|---|---|
| **Area 2C** (southeastern Alaska) (combined commercial/guided sport[1]) | **4,950,000** |
| Commercial fishery (3,924,000 catch and 120,000 incidental mortality) | 4,044,000 |
| Guided sport fishery | 906,000 |
| **Area 3A** (central Gulf of Alaska) (combined commercial/guided sport[1]) | **9,600,000** |
| Commercial fishery (7,336,000 catch and 450,000 incidental mortality) | 7,786,000 |
| Guided sport fishery | 1,814,000 |
| **Area 3B** (western Gulf of Alaska) | **2,710,000** |
| **Area 4A** (eastern Aleutians) | **1,390,000** |
| **Area 4B** (central/western Aleutians) | **1,140,000** |
| **Areas 4CDE** | **1,660,000** |
| Area 4C (Pribilof Islands) | 733,600 |
| Area 4D (northwestern Bering Sea) | 733,600 |
| Area 4E (Bering Sea flats) | 192,800 |
| **Total** | **29,890,000** |

Fishing Season Dates

The Commission approved a season of March 19 to November 7, 2016, for the U.S. and Canadian quota fisheries. Seasons will commence at noon local time on March 19 and terminate at noon local time on November 7, 2016 for the following fisheries and areas: the Canadian Individual Vessel Quota (IVQ) fishery in Area 2B, and the United States IFQ and CDQ fisheries in Areas 2C, 3A, 3B, 4A, 4B, 4C, 4D, and 4E. All Area 2A commercial fishing, including the treaty Indian commercial fishery, will take place between March 19 and November 7, 2016. The Saturday opening date was chosen to facilitate marketing.

In Area 2A, eight 10-hour fishing periods for the non-treaty directed commercial fishery south of Point Chehalis, Washington, are recommended: June 22, July 6, July 20, August 3, August 17, August 31, September 14, and September 28, 2016. All fishing periods will begin at 8 a.m. and end at 6 p.m. local time, and will be further restricted by fishing period limits announced at a later date.

Area 2A fishing dates for incidental commercial halibut fisheries concurrent with the limited-entry sablefish fishery north of Point Chehalis and the salmon troll fishing seasons will be established under U.S. domestic regulations by the National Marine Fisheries Service (NMFS). The remainder of the Area 2A CSP, including sport fishing seasons and depth restrictions, will be determined under regulations promulgated by NMFS. Further information regarding the depth restrictions in the commercial directed halibut fishery, and details for the sport fisheries, is available at the NMFS hotline (1-800-662-9825). The Area 2A IPHC licensing procedures did not change.

*Regulatory Changes*

Charter Halibut Sector Management Measures for Areas 2C and 3A
The Commission received a request from the NPFMC to adopt charter halibut sector management measures in accordance with the NMFS CSP for Areas 2C and 3A. The NPFMC proposal is designed to keep removals by the charter fishery within the limits of the CSP. After consideration of the advice of the Council, Commission staff, Canadian and United States harvesters and processors, and other fisheries agencies, the Commission approved the following measures:

In Area 2C, 1) a one-fish daily bag limit, and 2) a "reverse slot" size limit restriction (≤ 43 inches or ≥ inches).

In Area 3A, 1) a two-fish daily bag limit, 2) a maximum size limit for the second fish of 28 inches, 3) a four-fish annual limit, 3) a vessel limit of one trip per calendar day, 4) a limit of one trip per charter permit per calendar day, and 5) a one-day-per-week closure of halibut charter fishing on Wednesdays throughout the year. In addition, immediately upon landing a halibut a harvest record is required, for which the angler must record the date and regulatory area in ink on the back of the State of Alaska sport fishing license.

The requirement to retain the filleted carcass on board the vessel until the fillets are offloaded will be removed from IPHC regulations. This requirement now appears in the NMFS regulations.

Longline Pot Gear

The NPFMC and NMFS are developing regulations that allow the use of longline pot gear, as defined by the NPFMC, in the IFQ sablefish fishery in the Gulf of Alaska (GOA). The NPFMC recommended that the Commission allow the retention of legal-sized halibut, if unfished halibut IFQ is available, in longline pot gear during the commercial halibut fishery season in the GOA.

The Commission approved longline pot gear, as defined by the NPFMC, as legal gear for the commercial halibut fishery in Alaska when NMFS regulations permit the use of this gear in the IFQ sablefish fishery. The expectation is that NMFS will implement regulations to allow the use of pot gear in the GOA IFQ sablefish fishery in late 2016 or at the beginning of the 2017 fishery.

The Commission intends to review the use of pot gear as legal gear for halibut in this fishery after three years.

Halibut with External IPHC Tags
The Commission approved the exemption of halibut with external IPHC tags from sport daily bag or possession limits, size limits, and season restrictions, and from personal use and subsistence daily bag or catch limits. Such tagged halibut are already exempt from commercial fisheries, and this change was made to ensure IPHC receives information from all tagged halibut that are caught.

Use of the NMFS eLog in Alaska
The Commission approved the explicit addition of the electronic version of the NMFS Groundfish/IFQ Daily Fishing Longline and Pot Gear logbook to the list of acceptable logbooks for use in the Alaskan commercial halibut fishery.

Area 2A Fish Tickets
The Commission approved changing the wording of regulations to make it clear that the Tribal Identification Number and not the Vessel Identification Number should be recorded on the fish ticket in the Area 2A Treaty Indian fisheries.

Other Actions

Discard Mortality Rate
In response to a motion approved by the Conference Board, the Commission directed the staff to re-examine the appropriateness of the 16% discard mortality rate (DMR) currently assigned to halibut released in the U.S. and Canadian directed halibut fisheries. The Commissioners noted that this would be part of a larger evaluation of DMRs that the IPHC and NMFS staffs are currently engaged in.

Nunivak Survey
In response to a Conference Board motion that the IPHC consider the feasibility of including in the annual IPHC setline survey additional sites around Nunivak Island, the Commission directed the staff to look at all available sources of information on abundance and distribution around Nunivak. The Commission invited fishers in that area to participate in the IPHC logbook program as a ready source of such information, and asked the staff to continue its outreach to the communities there.

Harvest Policy Analysis
The Conference Board recommended that the Commission prioritize and assign sufficient resources for the staff and the Management Strategy Advisory Board (MSAB), in conjunction with the Scientific Review Board, to review and update the harvest policy and harvest control rules. The Commission confirmed that such a review is a priority for the staff and the MSAB, and noted that it has provided additional resources for the project in this year’s budget.

Halibut Bycatch
The Commission affirmed its commitment to bycatch reduction. The Commission directed the staff to continue its work to quantify bycatch and its impact on the halibut stock, and to promote the reduction of bycatch. The Commission also noted that bycatch management is a primary focus of the IPHC’s developing relationship with the NPFMC.

Expanded Survey
The Commission approved the next in a series of expansions to the Commission’s standardized stock assessment survey. In 2016, the Commission’s survey in the Area 4D Edge will be expanded. The purpose of the expansion series is to reduce potential biases in the surveys among regulatory areas and to encompass depths to which the commercial fishery has recently

expanded.  The Commission will continue to review survey expansion at the next Annual Meeting.

V.  Ecosystem Studies

**Oceanographic monitoring of the north Pacific and Bering Sea continental shelf with water column profilers**

Supports:  Objective 4 – ecosystem interactions and environmental influences
Priority:  Medium
Start date:  2009
Anticipated ending:  Continuing
Personnel:  L. Sadorus, J. Walker

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.

In particular, understanding the dynamics of the structure of the mixed layer depth – a major Global Ocean Ecosystem Dynamics (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 National Oceanographic and Atmospheric Administration (NOAA) grant 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.

VI.  Publications

International Pacific Halibut Commission. 2016. Report of Assessment and Research Activities 2015. http://www.iphc.int/publications/rara/2015/RARA2015_01TOC.pdf

Citations:

Stewart, I.J., Monnahan, C.C., Martell, S. 2016. Assessment of the Pacific halibut stock at the end of 2015. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2015: 188-209.

Wong, N. 2016. Marine mammal depredation on IPHC standardized setline surveys: a look at killer whales and sperm whales as major depredators in Alaska waters. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2015: 418-441.

**Northwest Fisheries Science Center**

**National Marine Fisheries Service**

NOAA Fisheries

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

**April 2016**

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## I. 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 2015, FRAMD 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.

## II. Surveys

### A. U.S. West Coast Groundfish Bottom Trawl Survey

The NWFSC conducted its eighteenth annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2015 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 *Excalibur* surveying the coast during the initial survey period from May to July. The *Noah's Ark* 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 2015, 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: Additional data were collected during the trawl survey for collaborative research projects with several NMFS/academic colleagues: 1) Assessing sublethal effects of hypoxia on greenstriped rockfish – NWFSC, Conservation Biology Division, Environmental and Fisheries Sciences Division; 2) Collection of voucher specimens for multiple fish species – Northwest Fisheries Science Center; 3) Accumulation and maternal transfer of organic contaminants in the sandpaper skate collected from the eastern Pacific Ocean – University of Calgary; 4) An Investigation into a potential cryptic species of the pygmy rockfish, *Sebastes wilsoni* – Marine Science Institute, University of California; 5) Mitochondrial DNA barcodes to identify macrourid larvae – Alaska Fisheries Science Center; 6) Does Puget Sound represent a distinct population segment for yelloweye and canary rockfish? – NWFSC, Conservation Biology Division; 7) Request for Pacific Lamprey samples from Groundfish and Hake/Sardine surveys – NWFSC, Conservation Division, Newport; 8) Lingcod study – whole specimens for stomachs, tissue, fecundity, DNA sampling – NWFSC, Conservation Biology Division; 9) Record all sightings of basking sharks – Moss Landing Marine Laboratories; 10) Collection of all thornback rays, *Platyrhinoidis triseriata* – Moss Landing Marine Laboratories; 11) Collection of 25 big skate (*Raja binoculata*) egg cases– Moss Landing Marine Laboratories 12) Genus *Bathyraja* – Moss Landing Marine Laboratories; Collections of eastern North Pacific softnose skates, Genus *Bathyraja* – Moss Landing Marine Laboratories; 13) Collection of 25 Pacific spotted spiny dogfish, *Squalus suckleyi* between San Francisco, CA and Morro Bay, CA – Moss Landing Marine Laboratories; 14) Collection of any Pacific black dogfish, *Centroscyllium nigrum* – Moss Landing Marine Laboratories; 15) 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; 16) Collection of all unusual or unidentifiable sharks including small sleeper sharks, *Somniosus pacificus* and velvet dog shark (*Zameus squamulosus*) – Moss Landing Marine Laboratories; 17) Collection of any chimaera that is not *Hydrolagus colliei*, including: *Harriotta raleighana*, *Hydrolagus* spp. and *Hydrolagus trolli* – Moss Landing Marine Laboratories; 18) Collection of voucher specimens for multiple fish species – Oregon State University; 19) 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; 20) Shadow vessel study to compare rockfish in rocky habitat to nearby groundfish survey catch via video lander - Moss Landing Marine Laboratories and the Nature Conservancy.

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 near-bottom dissolved oxygen concentration; 6) Composition and abundance of benthic marine debris collected during the 2015 West Coast Groundfish Trawl Survey; and 8) Collection of ovaries from blackspotted/rougheye rockfish, darkblotched rockfish, lingcod, petrale sole, sablefish, yelloweye rockfish, Pacific hake, aurora rockfish, shortspine thornyheads, and canary rockfish to assess maturity.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

**B. Southern California shelf rockfish hook-and-line survey**

In early Fall 2015, FRAM personnel conducted the 12th 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 14 days of at-sea research, with 14 biologists participating during the course of the survey. The three vessels sampled a total of 197 sites ranging from Point Arguello in the north to the US-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. 2015 marked the second consecutive year of sampling within the Cowcod Conservation Areas (CCAs). Approximately 76 sites across several areas of the CCAs were sampled as part of an ongoing 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 during subsequent surveys.

Approximately 6,822 sexed lengths and weights, 5,480 fin clips, and 5,371 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 779 ovaries were collected from 17 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. 2015 joint U.S.-Canada integrated acoustic and trawl survey of Pacific hake and coastal pelagic species (SaKe 2015)**

The joint U.S.–Canada integrated acoustic and trawl (IAT) survey was conducted in U.S. and Canadian waters by two U.S. teams (NWFSC/FRAM and SWFSC/FRD) on the NOAA ship *Bell M. Shimada* from 15 June 2015 to 10 September 2015, and by a Canadian team (DFO/Pacific region) on the CCGS *W.E. Ricker* from 22 August 2015 to 12 September 2015. The data collected during the survey were processed to provide an estimate of the abundance and spatial distribution of the coastal Pacific hake stock shared by both countries. The survey covered the slope and shelf of the U.S. and Canada West Coast with acoustic transects from roughly 32.7°N (off San Diego) to 55.1°N (Southeast Alaska and Dixon Entrance). Transects in the Southern California Bight were spaced 20 nmi apart and were oriented northeast-southwest. Transects from Point Conception and north (except for four in Dixon Entrance that were oriented north-south) were oriented east-west and were variably spaced 20, 15, or 10 nm apart. Twelve diagonal cross transects (oriented southwest-northeast) were also run. Acoustic data were collected on the *Shimada* with a Simrad EK60 echosounder operating at frequencies of 18, 38, 70, 120, and 200 kHz, and on the *Ricker* with a Simrad EK60 echosounder operating at frequencies of 18, 38, and 120 kHz. The survey resulted in 116 transects with 6,269 nautical miles of acoustical transect that were used for the hake biomass estimate. Aggregations of adult (age 2+) Pacific hake were detected on 63 transects from just south of Morro Bay (35.3°N), north along the U.S. coast, and along the west side of Vancouver Island and Haida Gwaii. Highest concentrations of Pacific hake were observed along the coasts of Oregon and Washington, as well as the west side of Vancouver Island. Hake sign was relatively light off the California coast. North of Vancouver Island and into Southeast Alaska, hake were absent, except for small amounts off Haida Gwaii. Midwater trawls equipped with a camera system were conducted to verify species composition of observed backscatter layers and to obtain biological information (e.g., size and sex distribution, age composition, sexual maturity). A total of 96 successful trawls (76 by the *Shimada* and 20 by the *Ricker*) resulted in a combined total hake catch of 17,645 kg (13,460 kg from the *Shimada* and 4,185 kg from the *Ricker*). The estimated total biomass of adult Pacific hake in 2015 was 2.156 million metric tons, which was the largest estimate observed since the NWFSC began conducting IAT surveys for Pacific hake in 2003. The 2015 estimate represented a slight increase over the previous biomass estimate from 2013 (1.929 mmt), and approximately 78% of the 2015 estimate was from U.S. waters. Age-5 hake (2010 year class) were dominant in 2015, accounting for approximately 57% of the total survey-wide observed adult biomass.

For more information, please contact Larry Hufnagle at lawrence.c.hufnagle@noaa.gov.

## III. Reserves

### A. How does the definition of 'home range' affect predictions of the efficacy of marine reserves?

Investigators: N. Tolimieri, K.S. Andrews and P.S. Levin.

Understanding how animals use space is fundamental to the employment of spatial management tools like marine protected areas (MPAs). A commonly used metric of space use is home range—defined as the area in which an individual spends 95% of its time and often calculated as 95% of the utilization distribution (UD), which is a probabilistic map describing space use. Since home range represents only 95% of an animal's time, it is important to understand whether the other 5% matters to the design of MPAs. We developed an MPA-population model for lingcod *Ophiodon elongatus* that examined the population recovery under six characterizations of space use ranging from one mean home range to nine real lingcod UDs. Mean home range and similar estimates (based on the area in which a fish spent 95% of its time) predicted higher biomass and numbers relative to the more complete analysis of space use like the UD (which represented 99.99% of a fish's time) and underestimated the size of reserves necessary to achieve the same level of recovery of biomass. Our results suggest failing to account for the full extent of a fish's time overestimates the effectiveness of marine reserves.

For more information, please contact Dr. Nick Tolimieri at NOAA's Northwest Fisheries Science Center, Nick.Tolimieri@noaa.gov.

## IV. Review of Agency Groundfish Research, Assessments, and Management

### A. Hagfish: No research or assessments in 2015

### B. Dogfish and other sharks

#### 1. Research

##### a) If the tag fits.....finding the glass slipper of tags for spiny dogfish (*Squalus suckleyi*).

Investigators: C. Tribuzio and K.S. Andrews

There are a multitude of technologies available for tagging and tracking fish species, however, not all tags are appropriate for all species or situations. The spiny dogfish (*Squalus suckleyi*) is a small species of shark, common in coastal waters of the eastern North Pacific Ocean. Fishery dependent tags, those requiring recapture of the fish to recover data, are less appropriate for this species because of the likely biased response rate. The purpose of this study was to examine fishery independent tag technology for spiny dogfish. There are two main types of fishery independent tags: satellite transmitting (relatively high resolution archived data) and acoustic transmitting (low resolution data, only when tags are in range of receiver). The satellite tags have historically been too large to apply to small species, but miniaturization of the technology has dramatically reduced tag size. These tags are limited to a short battery life and greater potential for failure. Acoustic tags have a longer battery life and less of a potential for failure, but data are limited to the spatial extent of the receivers. In this study we double tagged six spiny dogfish in Puget Sound, WA with both satellite and acoustic tags. Results suggest that either tag type would work well for the species, but both have benefits and drawbacks. In general, the satellite tags perform better for large scale movements, and provide high resolution depth and temperature (i.e., habitat) data, while the acoustic tags provide better fine scale movement information with lower resolution depth data.

For more information please contact Kelly Andrews at NOAA's Northwest Fisheries Science Center, Kelly.Andrews@noaa.gov.

**b) Sibling rivalry: do sixgill sharks (*Hexanchus gris*eus) co-occur in kin-structured pairs within nursery habitat of an inland estuary?**

Investigators: K.S. Andrews and 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. 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 NOAA's Northwest Fisheries Science Center, Kelly.Andrews@noaa.gov.

**c) Incorporating movement in the modelling of shark and ray population dynamics: approaches and management implications**

Investigators: M. Braccini, A. Aires-da-Silva, and I. Taylor

The explicit incorporation of movement in the modelling of population dynamics can allow improved management of highly mobile species. Large-scale movements are increasingly being reported for sharks and rays. Hence, the authors summarize the current understanding of long-scale movement patterns of sharks and rays and then present the different methods used in fisheries science for modelling population movement with an emphasis on sharks and rays. The use of movement data for informing population modelling and deriving management advice remains rare for sharks and rays. In the few cases where population movement was modelled explicitly, movement information has been solely derived from conventional tagging. Though shark and ray movement has been increasingly studied through a range of approaches these different sources of information have not been used in population models. Integrating these multiple sources of movement information could advance our understanding of shark and ray dynamics. This, in turn, would allow the use of more adequate models for assessing stocks and advising management and conservation effort.

For more information, please contact Ian Taylor at ian.taylor@noaa.gov

## C. Skates

### 1. Research

#### a) Improved life history parameters of longnose skate (*Raja rhina*): Estimation of spatial and temporal variability in growth and maturity with implications for stock assessment.

Investigators: T.E. Helser, T.E. Essington, V. Gertseva, M.E. Matta, and C. Gburski

Skates are commonly taken as bycatch in Pacific groundfish fisheries, yet relatively little is known regarding their life history parameters, and consequently most species are managed as data-poor stocks. The well-documented deleterious effects of fishing on North Atlantic skates emphasize the need for detailed biological information and effective management for this vulnerable group. In particular, accurate age data would enable the development of age-structured stock assessment models, resulting in a better understanding of population dynamics and the setting of sustainable catch limits. An NPRB-funded project was recently completed in which the age determination method for longnose skate (*Raja rhina*) was successfully validated by bomb-derived radiocarbon analysis. However, potential regional and temporal differences in length at age remain unknown. Furthermore, the project indicated possible inconsistencies in ageing protocols among management agencies along the Pacific coast of North America, casting uncertainty on life history parameters of this species, including unquantified effects on regional stock assessments. Improved estimates of age, growth, maturity, and natural mortality are vital to improve the stock assessment of this species. Therefore, three objectives of this collaborative study are to: 1) standardize the age determination protocol based on the validated ageing method across the three federal agencies responsible for skate management on the U.S. West Coast (NWFSC), British Columbia, Canada (DFO), and the Gulf of Alaska (AFSC), 2) age a backlog of approximately 2,000 longnose skate vertebrae collected since 2008, as well as reexamine 900 historically aged specimens based on standardized protocols, and 3) estimate important life history parameters including maximum age, growth rate, age at maturity, and natural mortality, and examine spatial and temporal variability in those vital rates for sensitivity analysis in the stock assessment. Together these parameters will allow for improved stock assessments of longnose skate across a significant portion of its range.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

#### b) Developing spatial surplus production models including individual movement to monitor harvest rates for exploited fishes

Investigators: J.T. Thorson, J. Jannot, and K. Somers

Protected and managed species, including harvested fishes, exhibit spatial and temporal variation in their distribution and density. Spatio-temporal variation can arise from differences in habitat quality, human impacts (including harvest), density-dependent changes in per capita productivity, as well as individual movement rates. Human impacts (e.g., direct harvest) also vary spatially and over time, and monitoring the overlap between impacts and population distribution is necessary to ensure that human impacts are sustainable and to prioritize research and management for populations that are heavily impacted. However, estimating spatio-temporal variation in human impacts and population dynamics while accounting for individual movement has remained computationally challenging for decades.

In this study, we develop a spatial population growth ("surplus production" in the fisheries literature) model that is inspired by finite element analysis, which estimates spatio-temporal population dynamics given density-dependent population regulation, individual movement, and spatially explicit harvest. We demonstrate the method using data for big skate (*Raja binoculata*) in the California Current from 2003-2013, and demonstrate that results can be processed to estimate an upper limit on sustainable harvest (an "overfishing limit"). We also conduct a simulation experiment to explore the small-sample properties of parameter estimates. The simulation experiment confirms that real-world sample sizes are sufficient to estimate the sustainable harvest level within 20% of its actual value. However, sample sizes are likely insufficient to reliably estimate movement rates.

The spatial population growth model estimates an overfishing limit of 740-890 metric tonnes for big skate from 2010-2013, compared with annual harvest less than 100 tonnes. This suggests that recent harvest of big skate is likely sustainable, and sensitivity analysis confirms that this conclusion is robust to different potential rates for individual movement.

Synthesis and applications: We recommend that spatio-temporal population models be used across systems and taxa to monitor the spatial overlap between species distribution and human impacts. For big skate, we recommend management rules triggering additional data collection and assessment effort if harvest rates for big skate substantially increase. We also recommend future research regarding spatial management regulations for regulating emerging fisheries.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

## C. Pacific cod: No research or assessments in 2015

## D. Walleye Pollock: No research or assessments in 2015

## E. Pacific whiting (hake)

### 1. Research

#### a) 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 and 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.

## 2. Assessment

### a) Pacific Hake (*Merluccius productus*) stock assessment for 2015

Authors: I. Taylor, C. Grandin, A. Hicks, N. Taylor, S. Cox

This stock assessment 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 for 2015. Coast-wide fishery landings of Pacific hake averaged 225 thousand mt from 1966 to 2014, 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 2005–2014 have been above the long term average, at 283 thousand mt. Landings between 2001 and 2008 were predominantly comprised of fish from the very large 1999-year class, with the cumulative removal from that cohort exceeding 1.2 million mt. In 2014, U.S. fisheries caught mostly 6- and 4-year old fish from the 2008 and 2010 year classes, while the

Canadian fisheries encountered older fish from the 2005, 2006, and 2008 year classes. 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%.

Data were updated for the 2015 assessment with the addition of new ages into the 2013 fishery age composition and the addition of a new age distribution from the 2014 fishery. 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 four times in the fishery, although with 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 0.497 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 2015 female spawning biomass is estimated to be 73.6% of the unfished equilibrium level ($B_0$) with a 95% posterior credibility interval ranging from 34% to 150%. The median estimated 2015 female spawning biomass is 1.66 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 2014. Uncertainty in estimated recruitments is substantial, especially for 2010, as indicated by broad posterior intervals. The fishing intensity on the Pacific Hake stock is estimated to have been below the $F_{40\%}$ target except for 2008 and 2010 when the median estimated fishing intensity was slightly above target. Fishing intensity has been substantially below the $F_{40\%}$ target since 2012. 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 1.

A management strategy evaluation (MSE) continues to evolve for Pacific hake to investigate data inputs, stock assessment assumptions, and management actions. In 2015, a closed-loop simulation looking at the addition of an age-1 index in the stock assessment showed that on average it resulted in slightly less risk to the stock and a smaller annual variability in recommended total allowable catch. Other MSE activities in 2015 involved soliciting input from stakeholders and managers to better define fishery and management objectives.

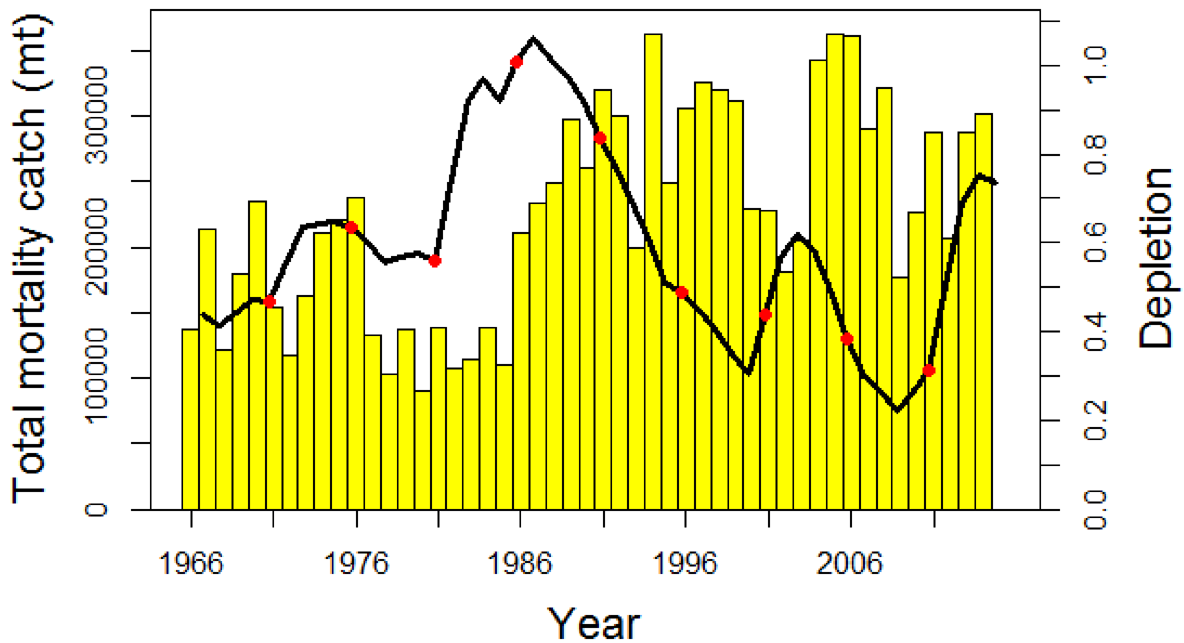


Figure 1. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Pacific hake, 1966-2015.

For more information, please contact Ian Taylor at Ian.Taylor@noaa.gov

**F. Grenadiers: No research or assessments in 2015**

**G. Rockfish**

**1. Research**

**a) Feeding Ecology of Select Groundfish Species Captured in the Northwest Fisheries Science Center's West Coast Bottom Trawl Survey, Using Gut Contents and Stable Isotopes**

Investigators: J. Buchanan, K.L. Bosley, A.C. Chappell, D. Draper and K.M. Bosley

The authors examined the diets of multiple groundfish species as an ongoing component of the NOAA Fisheries West Coast Bottom Trawl Survey. Stomachs and tissue samples were collected at sea and preserved for gut content and stable isotope analyses. 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%). Stable-isotope values averaged by year indicate that bocaccio and yelloweye rockfish feed approximately one trophic level above Pacific ocean perch and above darkblotched, greenstriped, sharpchin, stripetail and widow rockfishes. All other species in this study feed at mixed trophic levels. Multivariate analyses of diet data show significant differences in diet among species but strong overlap among benthic and bentho-pelagic species. Stable-isotope data also show significant differences among species and years. These results demonstrate the groundfishes in this study are significant consumers in both benthic and pelagic habitats, feeding across multiple trophic levels.

For more information, please contact John Buchanan at John.Buchanan@noaa.gov

**b) Understanding relationships between biological population data and environmental variation for rockfish off the West Coast of the United States.**

Investigators: V. Gertseva and S.E. Matson

Environment has complex effects on spatial and temporal dynamics of marine fish species. Several assessments for one groundfish sentinel species (darkblotched rockfish) reported noticeable year-to-year variability in size composition of the surveyed portion of the stock, with the most stark change observed during the 2014 warm anomaly. This variability had a pronounced effect of stock assessment results. Understanding how biological data such as length structure vary in relation to changing oceanographic conditions is critical for accurately interpreting results of the research surveys and assessing the status of our fisheries resources. We analyzed NMFS bottom trawl survey data on distribution and abundance of different darkblotched size classes in relation to environmental factors, such as temperature, salinity and dissolved oxygen, and found that there are indications of size-specific habitat preferences in darkblotched rockfish. To answer the question whether change in darkblotched rockfish size composition is triggered by oceanographic conditions, we present our findings, propose several mechanisms to explain variability in darkblotched rockfish size composition, and discuss the observed pattern in the context of the ecosystem dynamics.

For more information, please contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

**c) 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, A. Elz, O. Rodriguez, M. Head, R.M. Barnhart, P. McDonald, J.A. Benante and A.A. Keller

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

**d) 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, and J.R. Wallace

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

**e) Determining the distribution and abundance of shelf rockfish: A cooperative study in the Southern California Bight**

Investigators: C. Jones, J.H. Harms, J.A. Benante, A. Chappell, A.C. Hicks, J.R. Wallace, and A.A. Keller

We conduct an annual fishery-independent hook and line survey to monitor groundfish within the Southern California Bight (SCB). The survey was developed in 2003 and is a collaborative effort among Pacific States Marine Fisheries Commission (PSMFC), Northwest Fisheries Science Center (NWFSC), and southern California's sportfishing industry. The survey targets rocky, high-relief habitats that are generally not well-sampled using other survey techniques, such as bottom trawls and acoustic backscatter. The primary objective of this survey is to provide an annual index of relative abundance and a time series of biological data for several key species of shelf rockfish (genus *Sebastes*) in the SCB, including bocaccio (*S. paucispinis*), the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*), and greenspotted rockfish (*S. chlorostictus*). The survey's sampling frame currently consists of 198 fixed sites including 77 sites within the Cowcod Conservation Areas (CCAs), which were added during the 2014 and 2015 surveys. We report here information on: (1) materials and methods used during the survey; (2) year class strength and trends for multiple species; (3) habitat characterization using a towable camera sled; (4) genetic and maturity analysis; and (5) potential impacts of the CCAs on important groundfish species in the region.

For more information, please contact John Harms at John.Harms@noaa.gov

**f) 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 were listed as “threatened” and bocaccio *S. paucispinis* populations were listed as “endangered” in Puget Sound, WA and the Strait of Georgia 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 and 2015, we worked with local recreational charter boat captains to collect fin clips from 49 yelloweye, 51 canary and 3 bocaccio inside the Puget Sound/Georgia Basin DPS. These samples were compared with samples gathered from the outer coasts of U.S. and Canada and the Strait of Georgia. Population structure was examined using three methods: principal components analysis, calculation of $F_{ST}$ among geographic groups, and a population genetics based model clustering analysis (STRUCTURE). Each analytical method indicated significant genetic differentiation between the inland and coastal samples for yelloweye rockfish, confirming the existence of a separate Puget Sound/Georgia Basin DPS. In addition, yelloweye rockfish from Hood Canal were genetically differentiated from other Puget Sound/Georgia Basin fish, indicating a previously unknown degree of population differentiation within the DPS. The same analytical methods indicated a lack of genetic differentiation between coastal and Puget Sound/Georgia Basin samples for canary rockfish, suggesting there is no separate Puget Sound/Georgia Basin DPS. There were insufficient samples (n=3) to determine whether bocaccio in the Puget Sound/Georgia Basin DPS were genetically similar or dissimilar to coastal populations. These findings have direct implications for the listing status of canary rockfish and the boundaries of the DPS for yelloweye rockfish.

For more information please contact Kelly Andrews at NOAA's Northwest Fisheries Science Center, Kelly.Andrews@noaa.gov

**g) Assessing sublethal effects of hypoxia on West Coast groundfish: do growth rates of greenstriped rockfish *Sebastes elongatus* vary with levels of dissolved oxygen?**

Investigators: C.J. Harvey, K.S. Andrews, B.R. Beckman, V. Simon, P.H. Frey and D. Draper

In this project, we examine variation in the levels of insulin-like growth factor (IGF) in the blood plasma of greenstriped rockfish (*Sebastes elongatus*) in the northern portion of the U.S. West Coast as sampled by the FRAM groundfish trawl survey (legs 1, 2 and 3 to Cape Mendocino). The authors collected IGF samples on the first and second passes of the 2015 survey. IGF is an indicator of feeding and somatic growth in fishes. Our objective was to determine if IGF levels of greenstriped rockfish, a model groundfish species, are correlated with physical parameters of the environment, with an emphasis on temperature and dissolved oxygen (DO). We collected samples from the smallest size-frequency bins of greenstriped rockfish on the first pass, i.e., likely before hypoxia has developed, and on the second pass, i.e., likely after hypoxia has become established. We collected these samples over a broad spatial range of the northern portion of the survey domain, so that there are individuals both inside and outside but adjacent to the region most affected by hypoxic conditions. In addition to collecting blood, scientists collected and will analyze stomach contents for comparison with IGF levels. Samples are being processed in the spring of 2016 and we plan to collect samples again during the FRAM groundfish trawl survey in 2016 and 2017.

For more information please contact Dr. Chris Harvey at NOAA's Northwest Fisheries Science Center, Chris.Harvey@noaa.gov.

**h) A new approach to reproductive analysis for fisheries management, a case study on *Sebastes pinniger***

Investigators: M.A. Head, P.H. Frey, J.M. Cope, and A.A. Keller

Since the initiation of the NWFSC's reproductive maturity program (FRAM Division) in 2009, we have identified several key factors to understanding reproductive biology of west coast groundfishes. These include: (1) spatial and temporal patterns, (2) oceanographic conditions related to skip spawning and abortive maturation, and (3) estimating biological (sexual) versus functional (potential spawner) maturity. In the past many stock assessments have relied on outdated or incomplete life-history information from opportunistic or geographically/temporally limited data sources. Our goal is to provide updated, coast wide maturity information on an annual basis to reduce uncertainty in parameters used to estimate spawning biomass and recruitment. Ecosystem variables, such as habitat, predator-prey interactions, food availability, upwelling, and oceanographic patterns may also have an outsized influence on the reproductive behavior of groundfish stocks in a given year. We are investigating how these variables affect skip-spawning and abortive maturation patterns and how spatial/temporal relationships are associated with maturity schedules.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

**i) Challenges associated with assessing maturity, skipped spawning, and abortive maturation rates in groundfish: a case study of *Sebastes pinniger***

Investigators: M.A. Head, P.H. Frey, and A.A. Keller

Incorporating accurate estimates of life history parameters into population models can increase the reliability of biomass estimates used to manage groundfish stocks. In addition, understanding the reproductive biology and life history strategies of these fish provides support for sustainable management. However, seasonal data collection can create challenges for gaining a full understanding of the reproductive biology of some species. Many groundfish species on the U.S. West Coast spawn between November and March, when opportunities to collect biological data on research surveys or from fisheries landings are limited. We examined the reproductive biology and maturity schedule of canary rockfish, *Sebastes pinniger*, using ovary specimens collected on the West Coast groundfish bottom trawl survey (WCGBT) from 2009 – 2014 (n = 431) and from Oregon Department of Fish and Wildlife (ODFW) port biologists in 2014 and 2015 (n = 250). This allowed for comparisons of length and age at maturity estimates based on the histological examination of ovaries collected within and outside the canary rockfish spawning season. Temporal and spatial patterns in oocyte development, and rates of abortive maturation and skip-spawning, were investigated to determine their impact on canary rockfish reproductive patterns.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

**j) Using Genetic Analysis to Reduce Uncertainty in the Assessment of Morphologically-similar West Coast Rockfish**

Investigators: A.A. Keller, J. Cope, A. Elz, J. Harms, J. Orr, L. Park, P.H. Frey, and V. Tuttle

Cryptic and incipient speciation within rockfishes (genus *Sebastes*) abounds on the U.S. West Coast. Investigation into morphological, life history, and genetic differences between similar species continues to reveal important distinctions among known species as well as within currently recognized species. Ambiguity in the taxonomy and biology of such species may result in historical data being pooled inappropriately, potentially obscuring important life history differences and adding uncertainty to stock assessments. We identify differences in the depth, spatial distribution, and growth for the rougheye *(S. aleutianus*)/blackspotted (*S. melanostictus*) complex while also offering preliminary results into newly discovered genetic variability within darkblotched rockfish (*S. crameri*).

The West Coast Groundfish Bottom Trawl Survey, At-Sea Hake Observer Program, and Oregon Department of Fish and Wildlife provided over 900 tissue samples for the rougheye/blackspotted genetic analysis. The process employed a diagnostic Taqman assay of the ND3 mitochondrial region developed for this species pair. Morphometrics and meristics confirm these species are challenging to distinguish via visual diagnostics, but are definitively identifiable using genetic techniques. Results indicate over 15% of the catch previously considered as nominal rougheye rockfish may be blackspotted. These results have implications for long-term data sets including commercial landings and historical survey data.

Color variability in darkblotched rockfish has elicited a similar investigation into stock structure. Preliminary analysis suggests consistent genetic variation among samples at multiple loci. However, voucher specimens examined to date have thus far not revealed a connection between observed genetic differences and various morphometric and meristic characteristics. Further investigations are underway.

For more information, please contact Aimee Keller at [Aimee.Keller@noaa.gov](mailto:Aimee.Keller@noaa.gov)

**k) Maturity and growth of darkblotched rockfish, *Sebastes crameri,* along the U.S. west coast**
Investigators: P.H. Frey, M.A. Head, and 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 based on specimens collected from 1986 to 1987. 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.

## 2. Assessment

### a) Status of the Darkblotched Rockfish Resource off the Continental U.S. Pacific Coast in 2015

Authors: V.V. Gertseva, S.E. Matson, and E. Councill

Darkblotched rockfish (*Sebastes crameri*) in the Northeast Pacific Ocean occur from the southeastern Bering Sea and Aleutian Islands to near Santa Catalina Island in southern California. This species is most abundant from off British Columbia to Central California. Commercially important concentrations are found from the Canadian border through Northern California. This assessment focuses on the portion of the population that occurs in coastal waters of the western United States, off Washington, Oregon and California, the area bounded by the U.S.-Canada border on the north and U.S.-Mexico border on the south. The population within this area is treated as a single coastwide stock, due to the lack of biological and genetic data supporting the presence of multiple stocks.

Darkblotched rockfish has always been caught primarily with commercial trawl gear, as part of a complex of slope rockfish, which includes Pacific ocean perch (*Sebastes alutus*), splitnose rockfish (*Sebastes diploproa*), yellowmouth rockfish (*Sebastes reedi*), and sharpchin rockfish (*Sebastes zacentrus*). Catches taken with non-trawl gear over the years comprised less than 2% of the total coastwide domestic catch. This species has not been taken recreationally.

Catch of darkblotched rockfish first became significant in the mid-1940s when balloon trawl nets (efficient in taking rockfish) were introduced, and due to increased demand during World War II. The largest removals of the species occurred in the 1960s, when foreign trawl fleets from the former Soviet Union, Japan, Poland, Bulgaria and East Germany came to the Northeast Pacific Ocean to target large aggregations of Pacific ocean perch, a species that co-occurs with darkblotched rockfish. In 1966 the removals of darkblotched rockfish reached 4,220 metric tons. By the late-1960s, the foreign fleet had more or less abandoned the fishery. Shoreside landings of darkblotched rockfish rose again between the late-1970s and the late-1980s, peaking in 1987 with landings of 2,415 metric tons. In 2000, the species was declared overfished, and landings substantially decreased due to management regulations. During the last decade the average landings of darkblotched rockfish made by the shoreside fishery was around 120 metric tons. Since the mid-1970s, a small amount of darkblotched rockfish has been also taken as bycatch in the at-sea Pacific hake fishery, with a maximum annual removal of 49 metric tons that occurred in 1995. In 2000, the species was declared overfished, and landings substantially decreased due to management regulations. This species is currently in under rebuilding. During the last decade the average landings of darkblotched rockfish made by the domestic trawl fishery was around 120 metric tons.

The first stock assessment of darkblotched rockfish was done in 1993 and stock assessments have been conducted frequently since then. This current assessment, conducted in 2015, shows that the stock of darkblotched rockfish off the continental U.S. Pacific Coast is currently at 39% of its unexploited level. This is above the overfished threshold of 25% of unexploited stock ($SB_{25\%}$), but slightly below the management target of 40% of unfished spawning output ($SB_{40\%}$). The spawning output of darkblotched rockfish started to decline in the 1940s, during World War II, but exhibited a sharp decline in in the 1960s during the time of the intense foreign fishery targeting Pacific ocean perch. Between 1965 and 1976, spawning output dropped from 94% to 65% of its unfished level. Spawning output continued to decline throughout the 1980s and 1990s and in 2000 reached its lowest estimated level of 16% of its unfished state. Since 2000, the spawning output has been slowly increasing, which corresponds to decreased removals due to management regulations.

The time series of total mortality catch (landings plus discards) and estimated depletion for darkblotched rockfish are presented in Figure 2.

The assessment model captures some uncertainty in estimated size and status of the stock through asymptotic confidence intervals estimated within the model. To further explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in key model assumptions, a variety of sensitivity runs were performed. A major source of uncertainty in the assessment is related to natural mortality, which was found to have a relatively large influence on the perception of current stock size. Female natural mortality in the assessment is fixed at the value estimated outside the model, based on other life history characteristics of the species, while male natural mortality is estimated within the model. Uncertainty from natural mortality is reported via alternate states of nature in the decision table, bracketing the base model results.

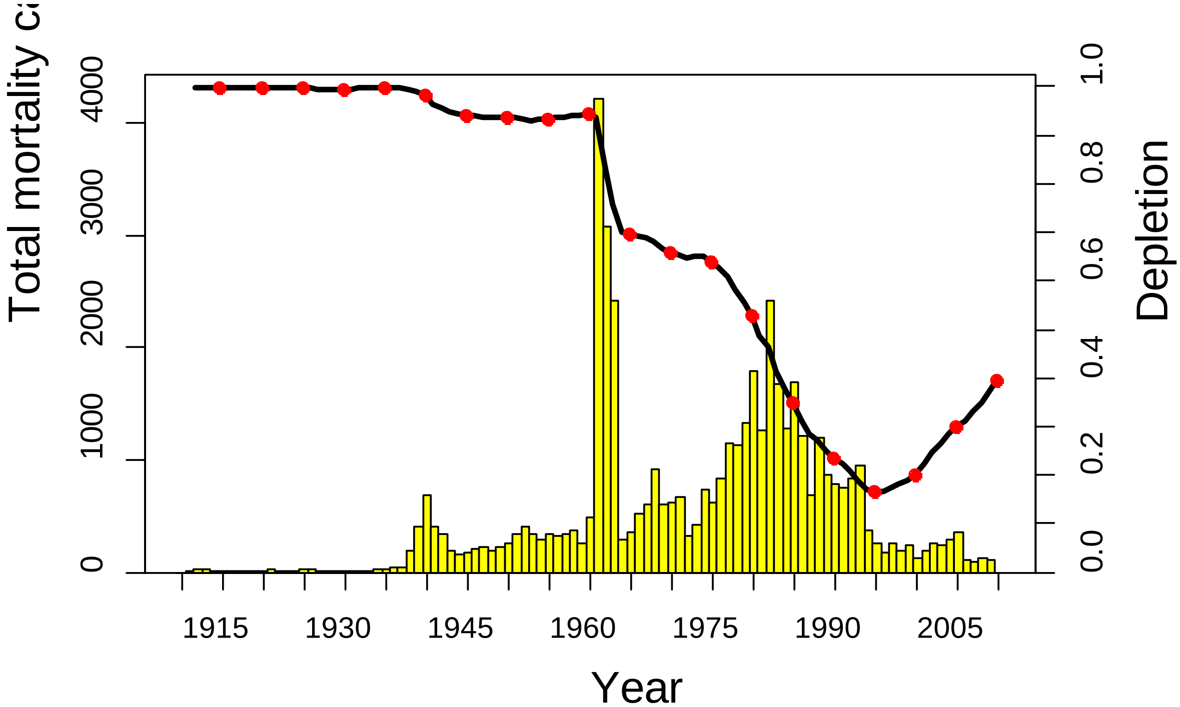


Figure 2. The time series of total mortality catch (bars) and estimated depletion (line) for darkblotched rockfish.

For more information on the darkblotched rockfish assessment, contact Dr. Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

**b) Assessments of Black Rockfish (*Sebastes melanops*) Stocks in California, Oregon and Washington Coastal Waters.**

Authors: J.M. Cope, D. Sampson, A. Stephens, M. Key, P.P. Mirick, M. Stachura, Tien-Shui Tsou, P. Weyland, A. Berger, T. Buell, E. Councill, E.J. Dick, K.H. Fenske, M. Monk, and B.T. Rodomsky

Three state-based stock assessments were performed for the black rockfish. Each assessment used catches, indices (including recreational-based indices) and length and age compositions. Each state demonstrated distinct exploitation histories as well as recruitment time series, and ultimately different stock statuses.
Washington Assessment

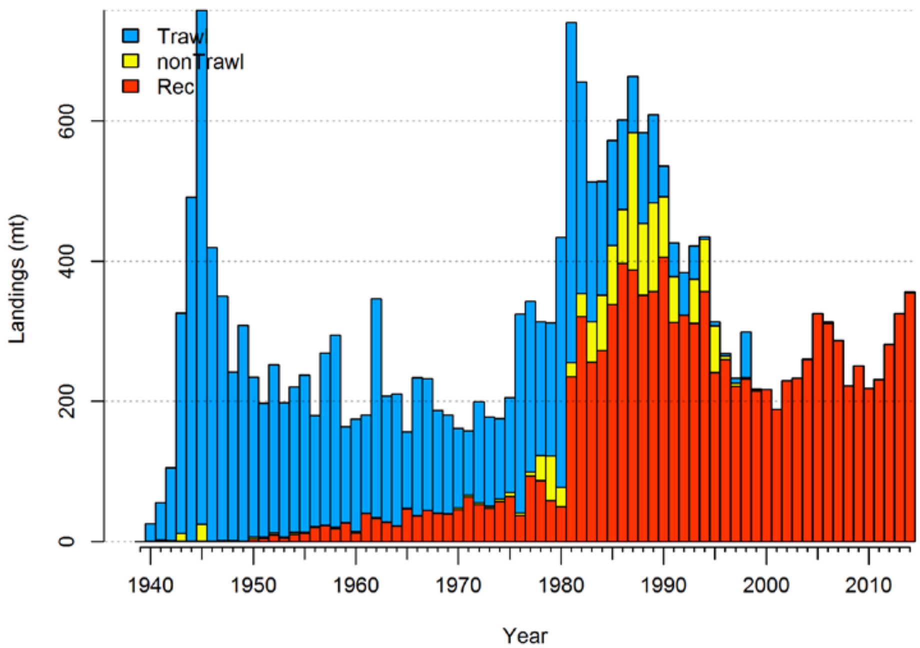


Figure 3. Washington Assessment: Landings (mt)

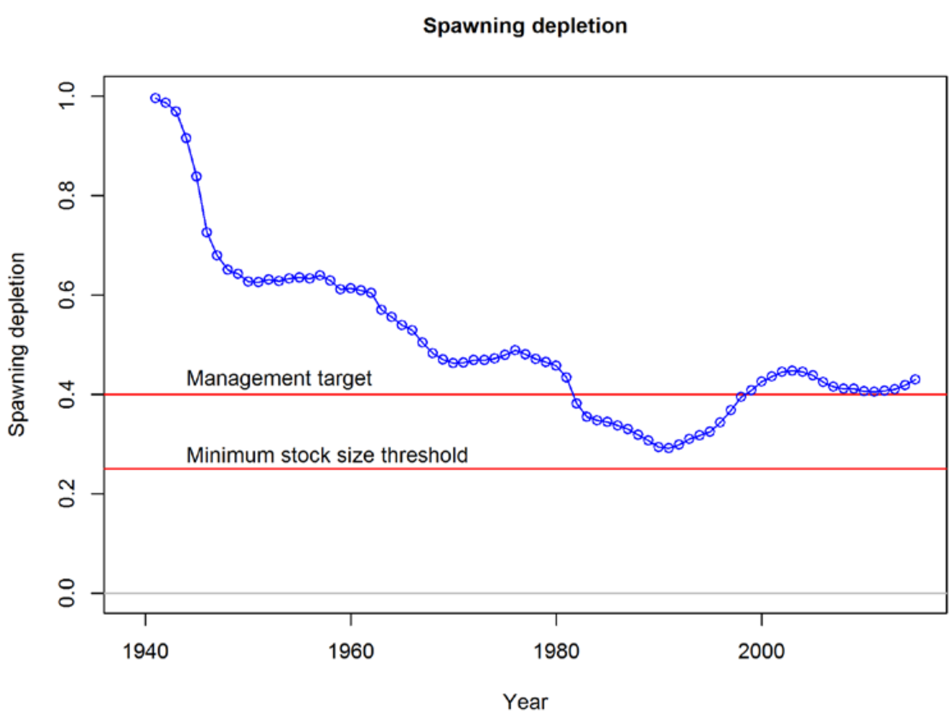


Figure 4. Washington Assessment: Spawing depletion

Oregon Assessment

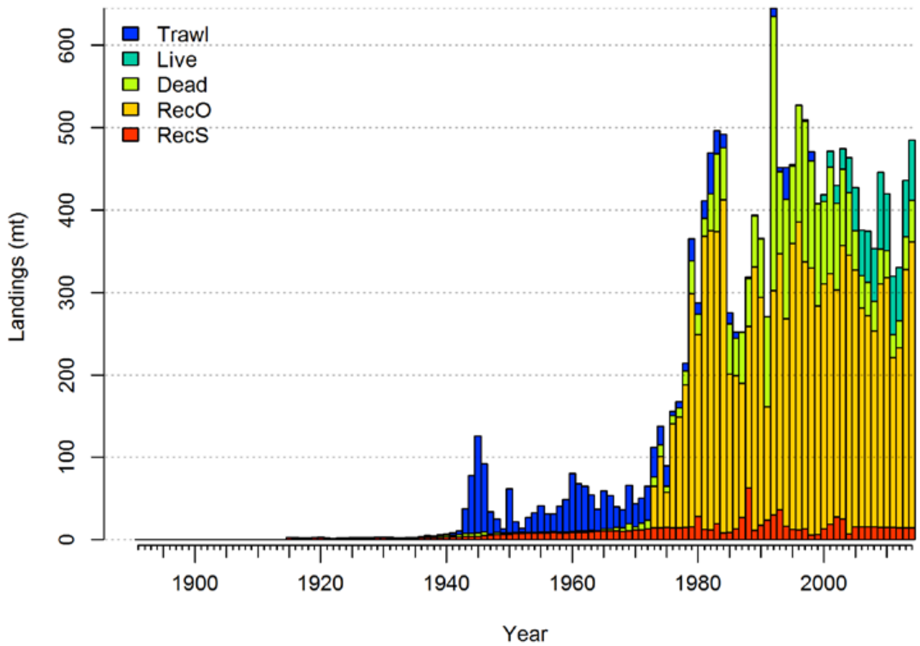


Figure 5. Oregon Assessment: Landings (mt)

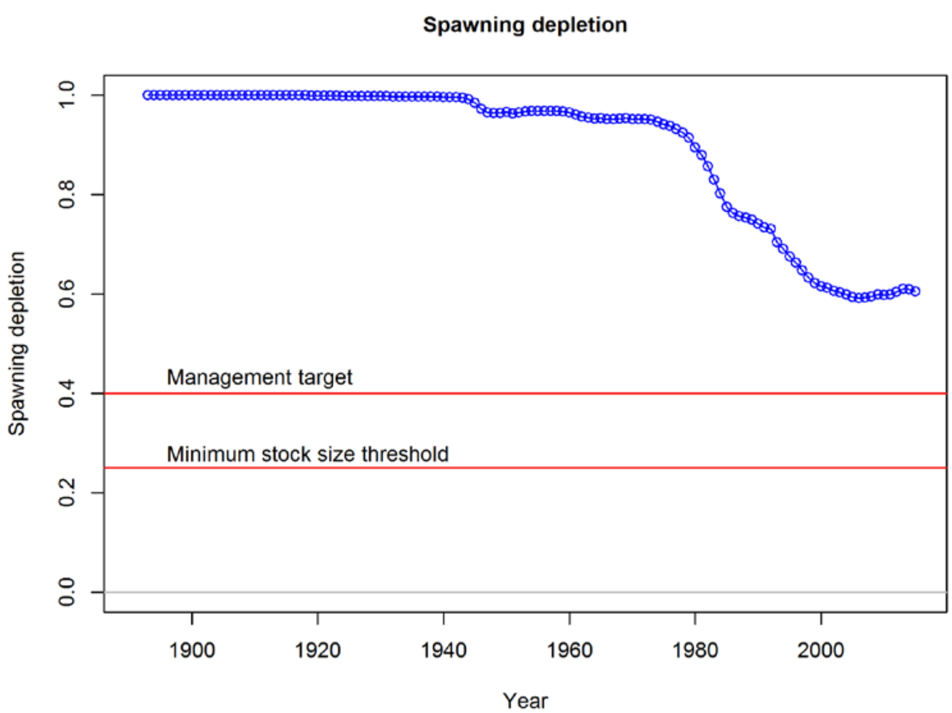


Figure 6. Oregon Assessment: Spawning depletion

California Assessment

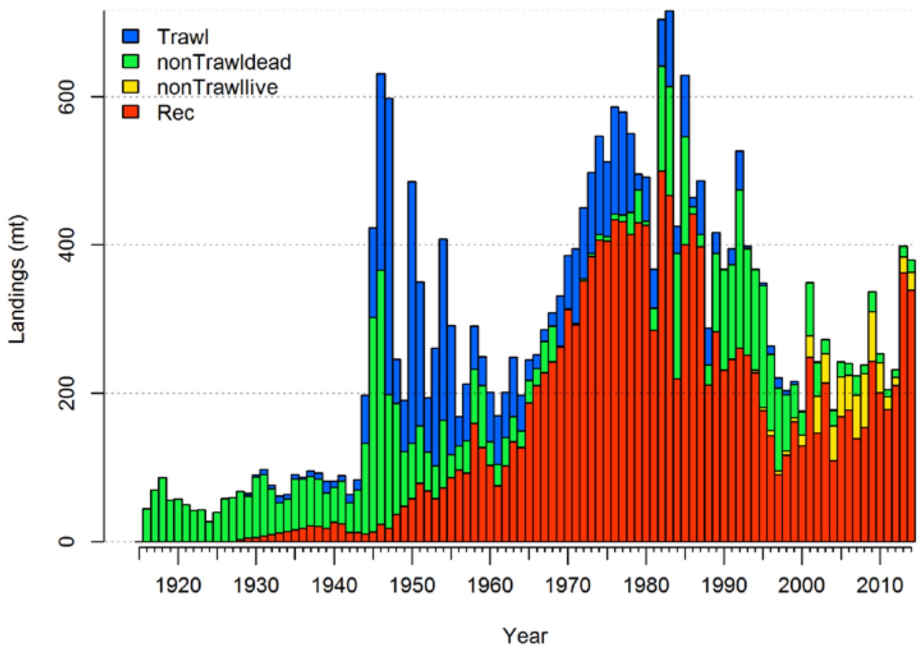


Figure 7. California Assessment: Landings (mt)

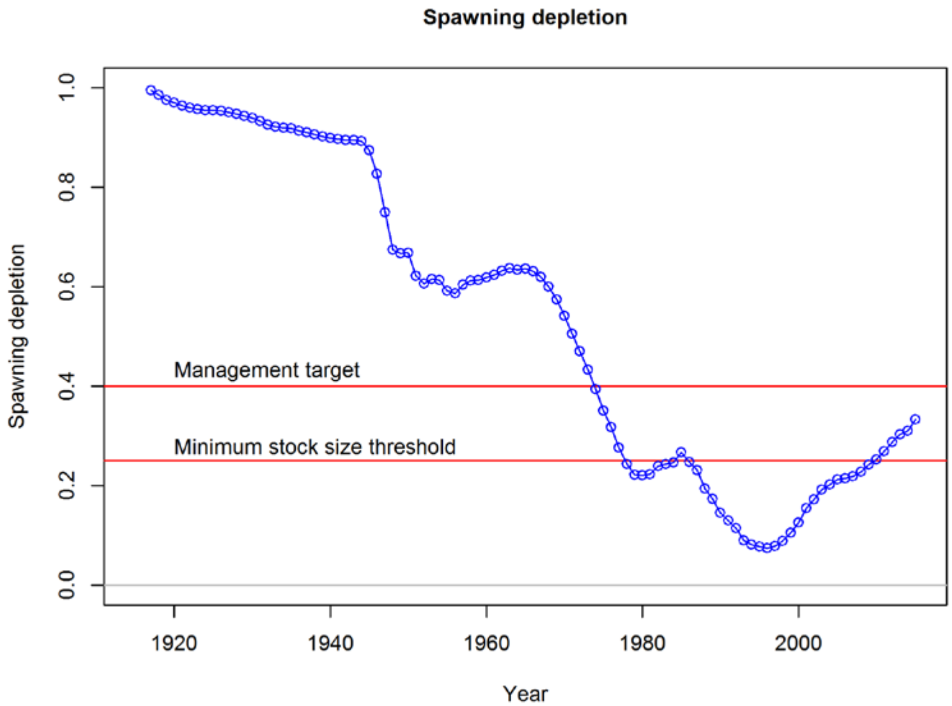


Figure 8. California Assessment: Spawning depletion

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

**c) The status of Widow Rockfish (*Sebastes entomelas*) in 2015**

Authors: A.C. Hicks and C.R. Wetzel

This is an assessment of widow rockfish (*Sebastes entomelas*) that reside in the waters off California, Oregon, and Washington from the U.S. – Canadian border in the north to the U.S. – Mexico border in the south. Widow rockfish inhabit water depths of 25 – 370 m from northern Baja California, Mexico to Southeastern Alaska. Although catches north of the U.S. – Canada border and south of the U.S. – Mexico border were not included in this assessment, it is not certain if those populations contribute to the biomass of widow rockfish off of the U.S. West Coast possibly through adult migration and/or larval dispersion.

Total landings of widow rockfish peaked in the early 1980s, increasing from approximately 1,000 metric tons (mt) in 1978 to a peak in landings exceeding 25,000 mt in 1981. After this sudden increase in catch, widow rockfish were given their own market category and often specifically identified in the landings. Uncertainty in species composition is greater in past years, thus landings of widow rockfish are not well known further back in history.

The large landings in the early 1980s were curtailed with trip limits beginning in 1982, which resulted in a decline in landings throughout the 1980s and 1990s following sequential reductions in the trip limits. From 2000 to 2003, landings of widow rockfish dropped from over 4,000 mt to about 40 mt and have been slowly increasing since, with a more rapid relative increase in 2013 and 2014 to above 700t. Widow rockfish are a desirable market species and it is believed that discarding was low historically. However, management restrictions (e.g., trip limits) resulted in a substantial amount of discarding beginning in 1982. Trawl rationalization was introduced in 2011, and since then very little discarding of widow rockfish has occurred.

This assessment was a new full assessment for widow rockfish which was last assessed in 2011. In this assessment, all aspects of the model including catches, data, and modelling assumptions were re-evaluated as much as possible. The assessment was conducted using the length- and age-structured modeling software Stock Synthesis (version 3.24U, pers. comm. Richard Methot, NMFS). The coastwide population was modeled assuming separate growth and mortality parameters for each sex (a two-sex model) from 1916 to 2015, and forecasted beyond 2015.

The data used in the assessment model consisted of survey abundance indices, length compositions, discard data, and age compositions. Model-based biomass indices and length compositions were determined from two different surveys. Length and age data were available for five fisheries (based on gear type).

Although there are many types of data available for widow rockfish since the late 1970s, which were used in this assessment, there is little information about steepness and natural mortality, and recent recruitment. Estimates of steepness are uncertain partly because of variable recruitment. Uncertainty in natural mortality is common in many fish stock assessments even when length and age data are available. Finally, there is little information about the strength of recent recruitment because the young fish are seen with a lower probability in the fisheries and surveys. These uncertainties were characterized as best as possible in the predictions and projections from this assessment.

The predicted spawning biomass from the base model generally showed a slight decline over the time series until 1966 when the foreign fleet began. A short, but sharp decline occurred, followed by a steep increase due to strong recruitment in 1970 and 1971. The spawning biomass declined rapidly with the developing domestic midwater fishery in the late 1970s and early 1980s. The stock continued to decline until 2000 when a combination of strong recruitment and low catches resulted in a quick increase. The 2015 spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass (75.1%), with a low of 37.3% in 1998.

Exploitation rates on widow rockfish were mostly above target throughout the 1980's and 1990's. Recent exploitation rates were predicted to be significantly below target levels. Recent catch and levels of depletion are presented in Figure 9.

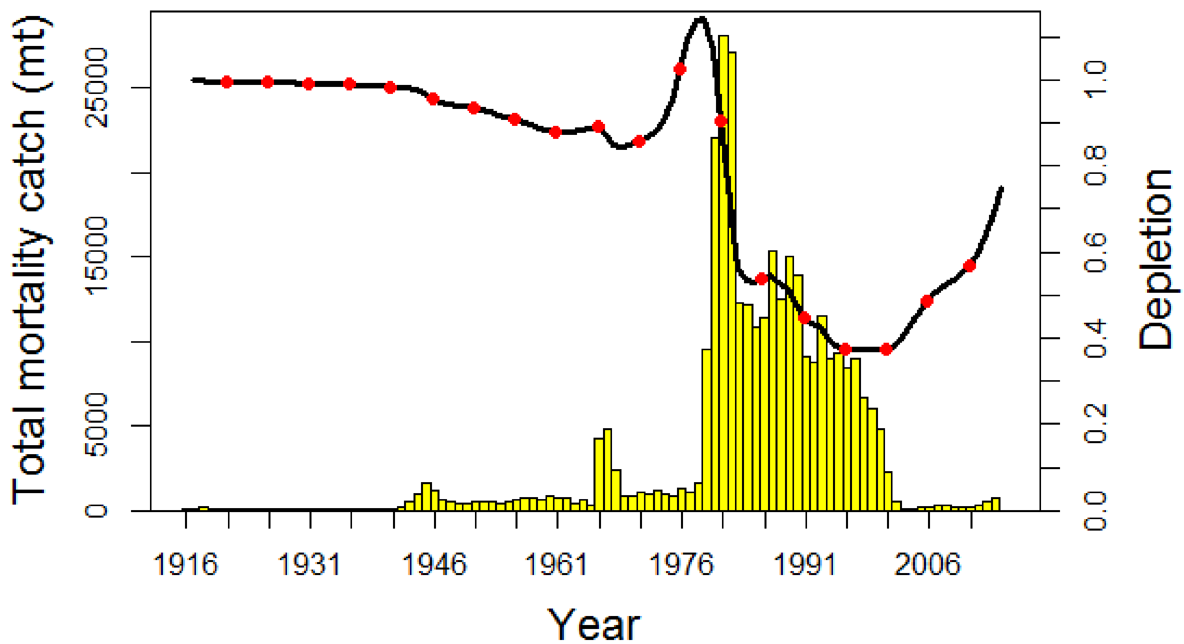


Figure 9. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for widow rockfish, 1916-2015.

**d) Catch Report for Rebuilding Species Not Being Assessed in the 2015-16 Biennium**

Investigator: J.R. Wallace

This catch report summarizes recent estimates of fishing mortality for three rebuilding species: yelloweye rockfish (*Sebastes ruberrimus*), Pacific ocean perch (*Sebastes alutus*), and cowcod (*Sebastes levis*), in waters off the coast of the United States from Southern California to the U.S.-Canada border (or the species spatial extent if not coast wide). These estimates are compared with annual catch limits (ACLs) adopted to promote rebuilding through 2014.

http://www.pcouncil.org/wp-content/uploads/2015/05/D8_Att9_CatchReports_JUN2015BB.pdf

**e) Catch only Projection for Yelloweye Rockfish**

Investigators: J.R. Wallace and J.Budrick

For yelloweye rockfish, a catch only projection was developed after updating the latest assessment with current total mortality information through 2014.

http://www.pcouncil.org/wp-content/uploads/2015/10/I4_Att3_SpexProjections_Arrowtooth_Yelloweye_Blue_CASF_Nov2015BB.pdf

For more information, please contact John Wallace at John.Wallace@noaa.gov

**f) Catch only Projection for Blue Rockfish**

Investigators: J.R. Wallace and J. Budrick

For blue rockfish, a catch only projection was developed after updating the latest assessment with current total mortality information through 2014.

http://www.pcouncil.org/wp-content/uploads/2015/10/I4_Att3_SpexProjections_Arrowtooth_Yelloweye_Blue_CASF_Nov2015BB.pdf

For more information, please contact John Wallace at John.Wallace@noaa.gov

**H. Thornyheads: No research or assessments in 2015**

**I. Sablefish**

**1. Research**

**a) 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, and 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 GCM ensemble forecasts of sablefish productivity under a suite of future climate variability and change scenarios. 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

**2. Assessment**

**a) Status of the U.S. sablefish resource in 2015**

Authors: K.F. Johnson, M.B. Rudd, M. Pons, C.A. Akselrud, Q. Lee, F. Hurtado-Ferro, M.A. Haltuch, and O.S. Hamel

During the first half of the 20th century it is estimated that sablefish were exploited at relatively modest levels. With modest harvest rates continuing until the 1960s and above average, though highly uncertain, estimates of recruitment between 1960 and 1975, the spawning stock biomass rebounded to nearly unexploited levels in the late 1970s. Subsequently, between 1976 and 2001 estimates of biomass show a continuous decline, with large harvests during the late 1970s and lower than average recruitment throughout the 1980s and early-1990s as hypothesized drivers of the decline. Despite harvest rates that were below overfishing rates from1988 to 2008 along with higher than average recruitments in 1995, 1999, and 2000, the spawning biomass increased only slightly during the early-2000s. Since 2005 the stock has continued to decline, in large part due to extremely poor recruitments from 2002 to 2007. Although the relative trend in spawning biomass is quite robust to uncertainty in the leading model parameters, the productivity of the stock is highly uncertain due to confounding of natural mortality, absolute stock size, and productivity. The estimated spawning biomass in 2015 is 52,001 mt, however, the 95% interval ranges broadly from 25,698 to 78,303 mt. The relative spawning biomass is currently estimated at 35% of unexploited levels (95% interval: 22-48%). Forecasts from the 2011 assessment projected the spawning biomass to decrease by 6.4% from 2011 to 2015 given specified harvests, whereas the current assessment update estimated the decline was 9.8%. Furthermore, the current assessment update estimated unexploited spawning biomass 17% lower than what was estimated in 2011 and estimates depletion in 2015 higher than what was previously forecasted for 2015. The higher rate of decline appears to be because the current assessment update estimates the sum of the 2010 and 2011 recruitment events at 57% of what was estimated in the 2011 assessment.

Sablefish recruitment is estimated to be quite variable with large amounts of uncertainty in individual recruitment events. Within this variability, the average recruitment is estimated to have declined steadily between the 1970s and 2007. Recruitments during the 1970s were, on average, roughly six times that of the smaller cohorts between 2002 and 2005. It appears that large 1995, 1999, and 2000 year classes briefly slowed the rate of stock decline in the early 2000s and above-average cohorts from 2008, 2010, and 2013 are currently moving through the population. More specifically, the 2013 cohort appears to be the third largest recruitment event in the history of the fishery. However, of the three recent large recruitments, only the 2008 cohort has begun to mature and thus their contribution to the trend in spawning biomass remains minimal.

Unfished female spawning biomass was estimated to be 150,622 mt (95% interval: 114,728-186,516 mt). Therefore, the management target stock size (SB40%) is 60,249 mt and the overfished threshold (SB25%) is 37,656 mt. Total and age-4+ biomass at unexploited equilibrium were estimated to be 440,648 and 413,038 mt respectively. Steepness is not estimated in this assessment, thus uncertainty in reference point yields is grossly underestimated. Maximum sustainable yield (MSY), conditioned on current fishery selectivity and allocations, was estimated to occur at a spawning stock biomass of 44,090 (29% of unfished female spawning biomass), and produce a dead catch (excluding surviving discards) of 7,837 mt. However, dead catch at MSY varies almost linearly with steepness. MSY is estimated to be achieved at an SPR of 41%. This is very close to the yield, 7,476 mt, generated by the SPR (50%) that stabilizes the stock at the SB40% target. The fishing mortality target/overfishing level (SPR45%) results in an intermediate equilibrium yield of 7,759 mt at a spawning biomass of 51,212 mt (34% of the unfished equilibrium).

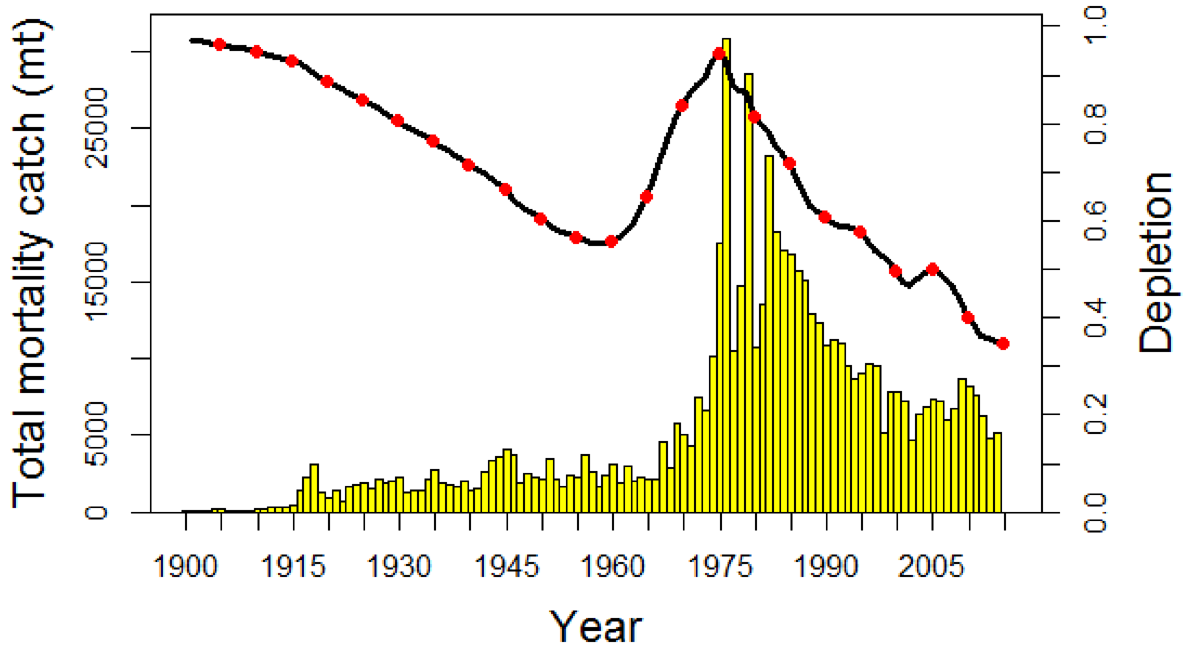


Figure 10. Time series of spawning stock biomass depletion and catch.

The complete stock assessment can be viewed online at: http://www.pcouncil.org/groundfish/gfstocks.html

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

**J. Lingcod: No research or assessments in 2015**

**K. Atka mackerel: No research or assessments in 2015**

## L. Flatfish

### 1. Research

### 2. Assessment

#### a) Stock Assessment Update: Status of the U.S. petrale sole resource in 2014

Authors: C.C. Stawitz, F. Hurtado-Ferro, P.K. Kuriyama, J.T. Trochta, K.F. Johnson, M.A. Haltuch, and O.S. Hamel

Petrale sole were lightly exploited during the early 1900s, but by the 1950s the fishery was well developed and showing clear signs of depletion and declines in catches and biomass. The rate of decline in spawning biomass accelerated through the 1930s–1970s reaching minimums generally around or below 10% of the unexploited levels during the 1980s through the early 2000s. The petrale sole spawning stock biomass is estimated to have increased slightly from the late 1990s, peaking in 2005, in response to above average recruitment. However, poor recruitments during the period of stock increase resulted in stock declines between 2005 and 2010, resulting in harvests that, in hind site, were great than those suggested by the current harvest policy. Since 2010 the total biomass of the stock has increased as large recruitments during 2007 and 2008 appear to be moving into the population. The estimated relative depletion level in 2015 is 30.70% of unfished biomass (~95% asymptotic interval: 22.2% - 39.2%, ~ 75% interval based on the range of states of nature: 27.3%-34.5%), corresponding to 10,290 mt (~95% asymptotic interval: 8,453 – 12,126 mt, states of nature interval: 9,969 – 10,572 mt) of female spawning biomass in the base model (Table c). The base model indicates that the spawning biomass was generally below 25% of the unfished level between the 1960s and 2013 and was rebuilt above this target in 2014.

Annual recruitment was treated as stochastic, and estimated as annual deviations from log-mean recruitment where mean recruitment is the fitted Beverton-Holt stock recruitment curve. The time-series of estimated recruitments shows a relationship with the decline in spawning biomass, punctuated by larger recruitments. The three strongest recruitments during the last 10 years are estimated to be from 2006, 2007, and 2008, with the 2007 and 2008 year classes being the third-largest and largest recruitments estimated during the assessed period. The four weakest recruitments are estimated to be from 2005, 2010, and 2011.

The abundance of petrale sole was estimated to have dropped below the $SB_{25\%}$ management target during the 1960s and stayed under that level through the beginning of 2013. The stock declined below the $SB_{12.5\%}$ overfished threshold from the early 1980s until the early 2000s. In 1984 the stock dropped below 10% of the unfished spawning biomass and did not rise above the 10% level until 2001. From 2000 to 2005 the stock increased, reaching a peak of 14.2% of unfished biomass in 2005, then declining through 2010, and again increasing from 2011-2014. Fishing mortality rates in excess of the current F-target for flatfish of $SPR_{30\%}$ are estimated to have begun during the 1950s and continued until 2010. Current F (catch/biomass of age-3 and older fish) is estimated to be 0.15 during 2015.

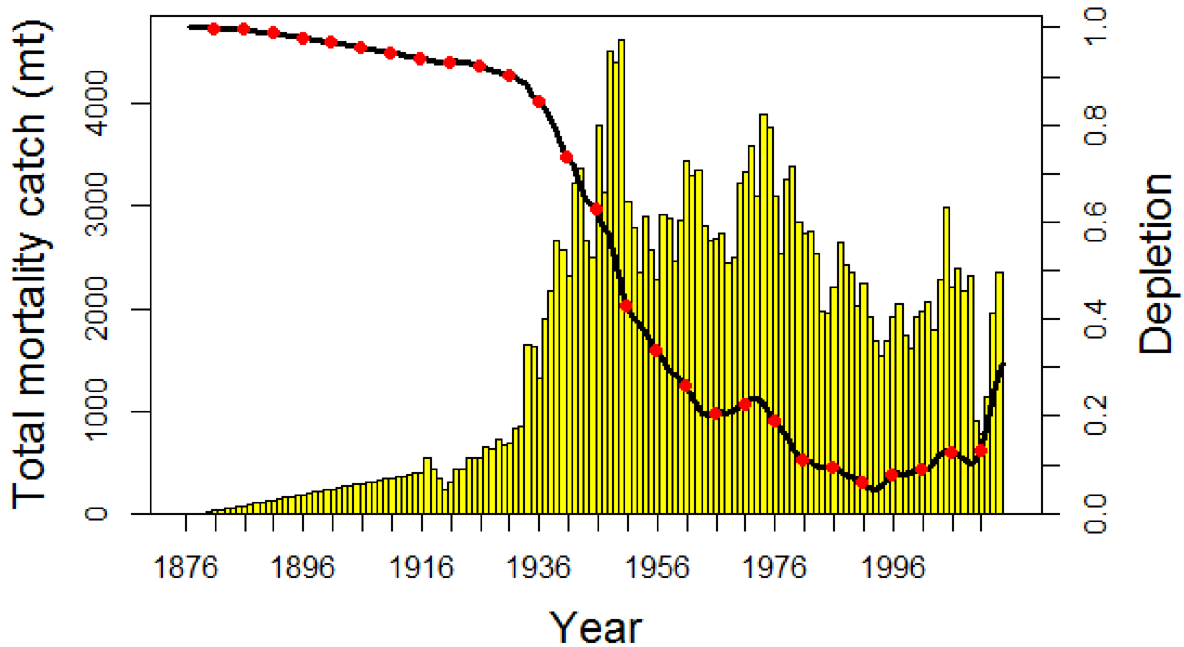


Figure 11. Petrale sole time series of spawning stock biomass depletion and catch.

The complete stock assessment can be viewed online at:
http://www.pcouncil.org/groundfish/gfstocks.html

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

**b) The 2015 stock assessment of arrowtooth flounder (*Atheresthes stomias*) in California, Oregon, and Washington waters.**

Author: J.M. Cope

A data-moderate approach, using only catch and index data, was used exploring several model specifications. No one model was used for setting catch targets, so not reported here, but several were used to consider stock status and how one could approach data-moderate assessments in the future.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

**c) Catch only Projection for Arrowtooth Flounder**

Investigators: J.R. Wallace and J.Budrick

For arrowtooth flounder a catch only projection was developed after updating the latest assessment with current total mortality information through 2014.

http://www.pcouncil.org/wp-content/uploads/2015/10/I4_Att3_SpexProjections_Arrowtooth_Yelloweye_Blue_CASF_Nov2015BB.pdf

For more information, please contact John Wallace at John.Wallace@noaa.gov

**M. Pacific halibut & IPHC activities: No research or assessments in 2015**

**N. Other groundfish species**

**1. Research**

**a) Size at maturity for grooved Tanner crab (*Chionoecetes tanneri*) along the U.S. west coast (Washington to California)**

Investigators: A.A. Keller, J.C. Buchanan, E. Steiner, D. Draper, A. Chappell, P.H. Frey, and M.A. Head

We conducted a multiyear study to examine interannual variability in mean size (carapace width, mm), maturity size (mm), and depth (m) for grooved Tanner crab (*Chionoecetes tanneri* Rathbun, 1893) along the U.S. west coast. An additional goal was to provide updated, estimates of carapace width (mm) at 50% maturity (W50) for male and female grooved Tanner crab and assess changes over time. Randomly selected samples came from trawl surveys undertaken annually by the Northwest Fisheries Science Center at depths of 55 to 1280 m. We used allometric relationships between carapace width and either abdominal width (females) or chela length (males) to determine functional maturity by sex. We evaluated maturity by fitting logistic regression models to proportion mature. W50 varied significantly between males (125.2 mm) and females (89.1 mm) but interannual differences were slight. Annual mean carapace widths (CW) were greater for mature males (139.9 – 143.4 mm) relative to females (98.8 – 100.4 mm). Average sizes of immature grooved Tanner crab 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 crab but considerable overlap between immature grooved Tanner crab. The best model expressing complexity in growth incorporated width, sex, and maturity stage. Depth ranged from 195 – 1254 m with the average depth of mature grooved Tanner crab (females, 737 m; males, 767 m) significantly shallower than immature (females, 949 m; males, 918 m) grooved Tanner crab.

For more information, contact Aimee Keller at Aimee.Keller@noaa.gov

**2. Assessment**

**a. Kelp Greenling stock assessment (OR waters)**

Author: A. Berger

This is the second stock assessment of the population status of kelp greenling (*Hexagrammos decagrammus*) along the Oregon coast. Kelp greenling is endemic to nearshore rocky reef, kelp forest, and eelgrass habitats of the Northeast Pacific Ocean, ranging from southern California to the Aleutian Islands in Alaska, to depths usually less than 50 meters. Despite the overall range, this assessment applies to waters off the Oregon coast due to a lack of sufficient population information or catch in California and Washington.

The assessment is structured as a single, sex-disaggregated, unit population, spanning Oregon marine waters. It operates on an annual time step covering the period 1915 to 2015, assumes negligible catch prior to that time, and thus assumes a stable equilibrium population prior to 1915. Kelp Greenling spawning biomass was estimated to be 316 mt in 2015 (~95% asymptotic intervals: 116-516 mt), which when compared to unfished spawning biomass equates to a depletion level of 80% (~95% asymptotic intervals: 0.59-1.00) in 2015. Stock size is estimated to be at the lowest level throughout the historic time series in 1998, but has since increased as a result of strong recruitment in 2000 and 2009. Throughout the time series, the stock is estimated to be above the management target of B40%. Due to uncertainty associated with natural mortality and the resulting influence it had on overall population scale, a sigma value (representing uncertainty in current stock status) was calculated by taking the log of the ratio of the base model spawning biomass in 2015 to the assumed low values for natural mortality model spawning biomass in 2015 and dividing by 1.15 (the z-score equivalent to a probability of 0.125). This calculation resulted in a sigma of 0.441 for use in harvest management.

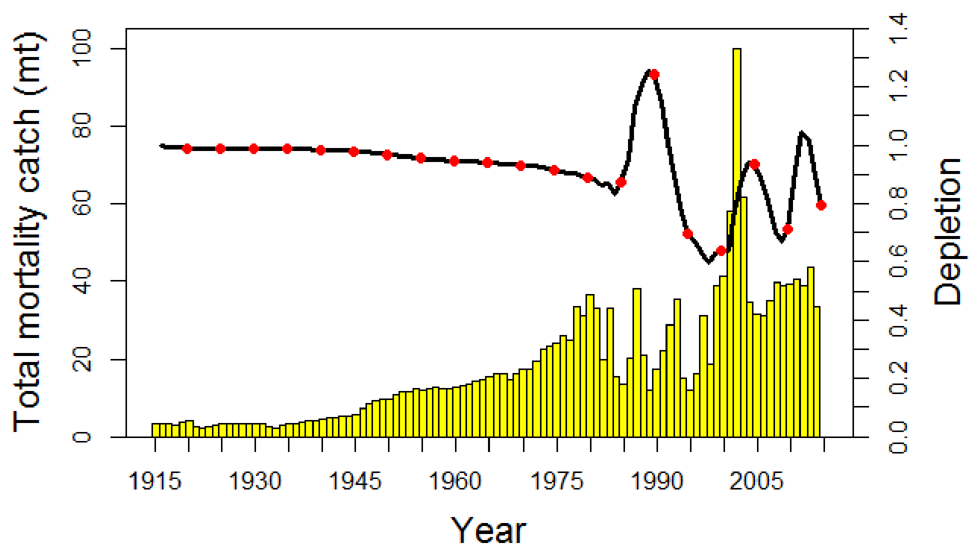


Figure 12. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Kelp Greenling, 1915-2014)

The complete assessment document: "Status of Kelp Greenling (*Hexagrammos decagrammus*) along the Oregon Coast in 2015" is available at:
http://www.pcouncil.org/groundfish/stock-assessments/by-species/

For more information, please contact Aaron Berger at aaron.berger@noaa.gov

**b) Catch only Projection for California Scorpionfish**

Investigators: J.R. Wallace and J. Budrick

For California scorpionfish a catch only projection was developed after updating the latest assessment with current total mortality information through 2014.

http://www.pcouncil.org/wp-content/uploads/2015/10/I4_Att3_SpexProjections_Arrowtooth_Yelloweye_Blue_CASF_Nov2015BB.pdf
For more information, please contact John Wallace at John.Wallace@noaa.gov

## VII. Ecosystem Studies

### A. Assessment Science

#### 1. Modeling

#### a) Stock assessment model development

Investigator: R.D. Methot and C.R. Wetzel

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). It is now at version 3.24y as of August 2015.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

#### b) Random effect estimation of time-varying factor in Stock Synthesis

Investigators: J.T. Thorson, A.C. Hicks, and 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 Richard Methot at Richard.Methot@noaa.gov

**c) Simulation testing the robustness of stock assessment models to error: some results from the ICES strategic initiative on stock assessment methods**

Investigators: J.J. Deroba, D.S. Butterworth, R.D. Methot, J.A.A. De Oliveira, C. Fernandez, A. Nielsen, S.X. Cadrin, M. Dickey-Collas, C.M. Legault, J. Ianelli, J.L. Valero, C.L. Needle, J.M. O'Malley, Y-J. Chang, G.G. Thompson, C. Canales, D.P. Swain, D.C.M. Miller, N.T. Hintzen, M. Bertignac, L. Ibaibarriaga, A. Silva, A. Murta, L.T. Kell, C.L. de Moor, A.M. Parma, C.M. Dichmont, V.R. Restrepo, Y. Ye, E. Jardim, P.D. Spencer, D.H. Hanselman, J. Blaylock, M. Mood, and P.-J. F. Hulson

The World Conference on Stock Assessment Methods (July 2013) included a workshop on testing assessment methods through simulations. The exercise was made up of two steps applied to datasets from 14 representative fish stocks from around the world. Step 1 involved applying stock assessments to datasets with varying degrees of effort dedicated to optimizing fit. Step 2 was applied to a subset of the stocks and involved characteristics of given model fits being used to generate pseudo-data with error. These pseudo-data were then provided to assessment modelers and fits to the pseudo-data provided consistency checks within (self-tests) and among (cross-tests) assessment models. Although trends in biomass were often similar across models, the scaling of absolute biomass was not consistent across models. Similar types of models tended to perform similarly (e.g. age based or production models). Self-testing and cross-testing of models are a useful diagnostic approach, and suggested that estimates in the most recent years of time-series were the least robust. Results from the simulation exercise provide a basis for guidance on future large-scale simulation experiments and demonstrate the need for strategic investments in the evaluation and development of stock assessment methods.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

**d) Performance of a fish stock assessment model that incorporates a coefficient for catch calibration**

Investigator: R.D. Methot, P.D. Lynch

The level of fishery catch in fish stock assessment models is nearly always treated as known with no bias and high precision. Recent findings with recreational fisheries in the U.S. challenge this assertion. Fishery assessment models need to evolve to address the uncertainty associated with catch time series. A prototype version of the Stock Synthesis (SS) assessment model (Methot and Wetzel, 2013) now incorporates a coefficient for catch calibration that operates on catch time series in essentially the same way that a catchability coefficient (q) operates on indices of stock abundance. The catch coefficient is implemented to be a fleet-specific estimable parameter that can be informed by a prior and can accommodate various time-varying protocols available in SS. The performance of SS with respect to this coefficient is investigated using simulated assessment data. Our evaluations focus on investigating the bias and imprecision of model results as the catchability coefficient is allowed to be estimated with varying biases and variances of its informative priors.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

**e) The limits of single species assessment models**

Investigator: R.D. Methot

The essence of simple population models is that they can obtain information from contrasts. This can be as simple as a time series of catch and relative abundance showing a coupled pattern with changing levels of catch pushing abundance down or allowing it to grow, or a steeper slope to the size composition in areas or eras with higher catch levels. Integrated analysis models have evolved to a high level of statistical capability to simultaneously extract information from both types of data while taking into account various confounding factors. All models are simplifications of nature based upon simple concepts of population regulation. Models can make inferences about species abundance and sustainable levels of fishing because of these simplifications, especially when data are limited. Single species models generally are structured to take into account random perturbations caused by the larger system in which the species occurs. The limitation of single species models is that they cannot make good predictions when the whole system is shifting on longer time scales, whether through fishery-induced or natural changes in abundance of biologically interacting species, or through long-term shifts in climate. Addressing these factors requires information about those external processes and their effect on fish.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

**f) 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.

**g) Addressing cohort-strength correlated ageing error in fishery stock assessment**

Investigators: O.S. Hamel, C. Legault, R. Methot and G. Thompson

Fishing intensity metrics describe the expected impact of fishing on a fish stock when setting management limits, such as OFLs, ABCs and ACLs. Three commonly used metrics are Spawning Potential Ratio (SPR), instantaneous fishing rate (F), and Exploitation Rate (H) but none is a perfect measure of either the short or long-term impact of fishing on the stock. H ignores the effect of age, size and gender selectivity on the impact the removals have on future spawning output and thus recruitment, but it is the only available measure for biomass dynamics models. SPR measures the expected long-term relative spawning output per recruit, assuming constant selectivity and fishing intensity, as well as no changes or variation in life history parameters, but is not informative about short-term removals. F is ambiguous because its impact depends upon the range of ages that are nearly fully selected hence experience that level of F. These differences impede consistent reporting of fishing intensity. In addition, SPR, F, and H can fail to measure the cumulative effects of multiple years of fishing under certain conditions such as substantial or systematic variation in selectivity, including fisheries targeting strong year classes.

Alternative metrics have been developed over the years which incorporate the cumulative effects of past fishing or measure future impacts of a particular year's fishing. We propose to develop simulation models and test previously developed as well as new metrics of fishing intensity and impact. In particular we will test how well management goals are met when using these alternative metrics. Performance metrics will include total catch, variability in catch, proportion of time above target, and proportion of simulations for which an overfished status is reached. The best metrics will also allow for better comparisons of fishing intensity among species.

The outcome of this work will be guidelines about which single or suite of impact metrics are appropriate under different circumstance of stock, fisheries, and assessment. This will improve the consistency and effectiveness of management in meeting goals, such as those regarding protecting stock status, optimizing yield, and minimizing variance in catch limits.

Presentations on this subject were given at the National Stock Assessment Workshop in Portland, OR in August 2015 and at the Western Groundfish Conference in Newport, OR in February 2016. Funding is being sought for further work on this topic.

For more information, please contact Owen Hamel at Owen.Hamel@noaa.gov.

**h) The magnitude of time-variation in demographic rates for marine fishes, and their impact on fisheries management targets.**

Investigators: J.T. Thorson, C. Monnahan, J.M. Cope

Fisheries scientists are increasingly concerned about changes in vital rates caused by environmental change and fishing impacts. Demographic parameters representing individual growth, maturity, mortality, and recruitment have previously been documented to change over decadal time scales. However, there has been relatively little comparison regarding which vital rates cause relatively greater or lesser impacts on commonly used fisheries management targets. We therefore use a life table (based on age-structured assessment models) to explore the sensitivity of fishing mortality, spawning biomass, and catch targets to changes in parameters representing growth, mortality, recruitment, and maturation rates for three representative life histories representing long-, medium-, and short-lived species. The elasticity analysis indicates that demographic changes can result in substantial variation in fisheries management targets, but that changes in mortality rates are particularly important for spawning biomass and catch targets while maturity and recruitment compensation are also important for fishing mortality targets. We conclude by discussing the importance of improved data repositories to address covariation among maturity, growth, and mortality parameters.

For more information, please contact Jason Cope at Jason.Cope@noaa.gov

**i) Decision Support System for Assessing and Managing Data and Capacity-Limited Fisheries**

Investigators: N.A. Dowling, J.R. Wilson, M.B. Rudd, E.A. Babcock, M. Caillaux, J.M. Cope, D. Dougherty, R. Fujita, T. Gedamke, M. Gleason, N.L. Gutiérrez, A. Hordyk, G.W. Maina, P. Mous, D. Ovando, A.M. Parma, J. Prince, C. Revenga, J. Rude, C. Szuwalski, S. Valencia, and S. Victor

A majority of fisheries across the globe are data- and/or capacity-limited, in that they lack data and resources to generate statistical estimates of stock status, often leading to ineffective or non-existent management. Improving management actions and outcomes could be accomplished by using analytical methods and management measures that are effective even when data and capacity are limited, positively impacting the livelihoods of millions of people and generating significant conservation benefits. Cost-effective methods for analyzing and managing data-limited fisheries exist, but they are challenging to navigate due to the myriad options, different data requirements, unique outputs and a lack of understanding of the relative costs and advantages of each approach. There is also an increasing body of general guidance for the process of developing management strategies, i.e., the pre-agreed system of monitoring, assessment, and decision rules used to achieve management objectives for data-limited fisheries. However, this body of guidance has yet to be organized in a way that allows fishery management practitioners to apply it easily. Thus, there remains a disconnect between the development of assessment approaches and decision rule options, and their on-the-ground implementation in a management context. To fill this gap, we have developed FishPath: a decision support system that allows users to characterize their fishery with respect to i) available data; ii) biological/life history attributes of relevant species; iii) fishery operational characteristics; iv) socio-economic characteristics; and, v) governance context. FishPath allows users to identify a subset of management strategy options appropriate for the fishery based on this characterization. We are currently applying the DSS to a range of data-limited fisheries globally to evaluate its efficacy. FishPath is the first ever comprehensive and standardized approach to guiding the selection of monitoring, assessment and decision rule options for data-limited fisheries. If widely applied, FishPath will help ensure that more data-limited, capacity-limited fisheries, particularly those in developing countries, become assessed and managed, leading to improved conservation and fishery outcomes.

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**j) Toward a synoptic approach to reconstructing West Coast groundfish historical removals.**

Investigators: J.M. Cope, T. Tsou, P. Weyland, G. Lippert, T. Buell, P. Mirick, V. Gertseva, J. Field, P. Pearson, R. Leos, and J. Budrick

Quantifying the removal time series of a stock is an essential input to a variety of stock assessment methods and catch-based management. But estimating removals is extremely challenging. Sampling protocols, fishery diversity, catch versus landing location, dead discards, and species identification are just some of the complications that vary across time and space. Given that most groundfish stocks are distributed coastwide and a complete time series of removals is needed, this project aims to coordinate approaches across the states of Washington, Oregon and California to confront removal reconstruction challenges and establish common practices. Both California and Oregon have attempted historical removal reconstructions, while Washington is just beginning the process. We use the Washington effort to focus on six groundfish species that vary in the difficulty of estimating removal histories: black (*Sebastes melanops*), canary (*S. pinniger*) and rougheye (*S. aleutianus*) rockfishes, petrale sole (*Eopsetta jordani*), sablefish (*Anoplopoma fimbria*), and lingcod (*Ophiodon elongatus*). The Washington reconstruction is compared to the approaches taken for the same species in Oregon and California with the goal of matching reconstruction protocols across states to the extent possible. Lastly, uncertainty levels across periods, species and states are established. This is a new feature of all three removal reconstructions which will improve treatment of uncertainty in future stock assessments.

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**k) MARSS models for estimating population status for data-poor species: three ESA listed rockfishes in Puget Sound**

Investigators: N. Tolimieri, E.E. Holmes and G.D. Williams

Time-series analysis is a fundamental tool for evaluating the status of species thought to be potentially at risk of extinction. We show how multivariate autoregressive state-space models (MARSS) can combine gappy data from disparate gear types and multiple survey areas to estimate the regional population trajectory over time, the population growth rate, and the uncertainty in these estimates. MARSS can also test hypotheses about the spatial structure of subpopulations. We illustrate our approach with an analysis of population status for three, rockfishes listed in Puget Sound WA under the Endangered Species Act: bocaccio (endangered), yelloweye (threatened) and canary rockfishes (threatened). Data were available from three sources: 1) Washington Department of Fish and Wildlife (WDFW) recreational fishery survey, 2) REEF scuba surveys, and a WDFW trawl survey. The surveys use different gear and sample different depths likely providing information on different rockfish assemblages. Changes in bag limits reduced catch by recreational fishers through time, and all three data sets have data gaps. Because there were few observations of the listed species, we estimate the population trajectory and growth for ‘total rockfish’. We then make inferences about the listed species by evaluating evidence that they have increased or decreased as a proportion of the assemblage. Our analysis indicates that total rockfish declined ~3.1 – 3.8% per year from 1977-2014 with similar rates of decline north and sound of Admiralty Inlet. The listed species all declined as a proportion of the local assemblage suggesting stronger rates of negative population growth for the listed species than for total rockfish. Although rates of decline were similar in north and south of Admiralty Inlet, there was evidence of temporal independence in these two regions as evidenced by higher and more variable catch north of Admiralty Inlet and data support for unique trajectories (year to year abundances).

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**l) Exploring an Individual Based Modeling Approach in Fisheries.**

Investigator: Andi Stephens

Much fishery modeling is focused on the average characteristics of a population and simulates the rates of survival or mortality, or changes in population size in terms of the population as a whole. The underlying support for these models comes from the mathematics associated with linear algebra and differential equations. Stock Synthesis is a well-known example of this type of top-down approach.

In contrast, an individual based model (IBM) is a bottom-up approach that allows emergent properties of a system to arise from individual contributions. A model of this type features a simulation framework in which individual organisms are tracked in time; these individuals may be subject to environmental forcing and to anthropogenic pressure (e.g., fishing). The responses of interest may range from survival to the evolution of genetic traits, while the timeframe of interest may range from days to decades.

This work presents an individual based model that evaluates intergenerational genetic drift in individual growth parameters in response to a variety of fishery management practices.

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**m) Revisiting a Regression Technique for Recreational Data Analysis: a Simulation Study.**

Investigator: Andi Stephens

This work addresses the interpretation of the logistic regression technique of Stephens and MacCall (2004), used to analyze recreational data from a multispecies fishery. This technique was used with varying degrees of success in the NWFSC/SWFSC 2015 assessments of near-shore species.

The method assumes that the species composition of the catch implies targeting of a species that uses a particular type of habitat. If this is true, catch records can be used to segregate the effort to catch a groundfish species from effort to catch other groundfish, or effort to catch tuna or salmon. Partitioning the data in this way results in improved calculation of catch per unit effort (CPUE).

For this study, I simulated data to resemble fishery records of catch in a multispecies fishery, and applied the method to those datasets to evaluate its ability to correctly infer whether habitat for the target species was fished on a particular "trip". Analysis of the regression results provides insight into the limitations of the method: it performs poorly when data are limited, when the target species or the covariate predictor species change habitats, or when the suite of covariatepredictor species are predominantly negative or predominantly positive predictors of the target species. However, the regression is relatively robust to changes in population size among the predictor species.

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**n) Applying a length-frequency based analysis to inform regional-scale fisheries management**

Investigator: Andi Stephens

Changes in population fecundity are typically used to inform fishery management. Spawning potential ratio (SPR) is often used to reflect fecundity, however this is an age-based method not available for use with data-limited stocks. An analogous method that can be used in data-limited situations is fractional lifetime egg production (FLEP).

FLEP quantifies the between-year change in fecundity from the change in the length-frequencies of the catch in those years. This estimation method has been shown to be relatively unbiased and less-sensitive than SPR to estimates of M. This work involves an FLEP analysis of fisheries in Oregon, performed at the state-wide and regional levels, investigating the potential of the method to inform regional management.

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**o) Hierarchical analysis of phylogenetic variation in intraspecific competition across fish species**

Investigators: A. Foss-Grant, E. Zipkin, J. Thorson, O. Jensen, O., and W. Fagan

The nature and intensity of intraspecific competition can vary greatly among taxa, yet similarities in these interactions can lead to similar population dynamics among related organisms. Variation along the spectrum of intraspecific competition, with contest and scramble competition as endpoints, leads to vastly different responses to population density. Here we investigated the diversity of intraspecific competition among fish species, predicting that functional forms of density-dependent reproduction would be conserved in related taxa. Using a hierarchical model that links stock-recruitment parameters among populations, species, and orders, we found that the strength of overcompensation, and therefore the type of intraspecific competition, is tightly clustered within taxonomic groupings, as species within an order share similar degrees of compensation. Specifically, species within the orders Salmoniformes and Pleuronectiformes exhibited density-dependence indicative of scramble competition (overcompensation) while the orders Clupeiformes, Gadiformes, Perciformes, and Scorpaeniformes exhibited dynamics consistent with contest competition (compensation). Maximum potential recruitment also varied among orders, but with less clustering across species. We also tested whether stock-recruitment parameters correlated with maximum body length among species, but found no strong relationship. Our results suggest that much of the variation in the form of density-dependent reproduction among fish species may be predicted taxonomically due to evolved life history traits and reproductive behaviors.

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**p) A generic approach to bias correction in population models using random effects, with spatial and age-structured examples**

Investigators: J. Thorson and K. Kristensen

Statistical models play an important role in fisheries science when reconciling ecological theory with available data for wild populations or experimental studies. Ecological models increasingly include both fixed and random effects, and are often estimated using maximum likelihood techniques. Quantities of biological or management interest (“derived quantities”) are then often calculated as nonlinear functions of fixed and random effect estimates. However, the conventional “plug-in” estimator for a derived quantity in a maximum likelihood mixed-effects model will be biased whenever the estimator is calculated as a nonlinear function of random effects. We therefore describe and evaluate a new “epsilon” estimator as a generic bias-correction estimator for derived quantities. We use simulated data to compare the epsilon-method with an existing bias-correction algorithm for estimating recruitment in four configurations of an age-structured population dynamics model. This simulation experiment shows that the epsilon-method and the existing bias-correction method perform equally well in data-rich contexts, but the epsilon-method is slightly less biased in data-poor contexts. We then apply the epsilon-method to a spatial regression model when estimating an index of population abundance, and compare results with an alternative bias-correction algorithm that involves Markov-chain Monte Carlo sampling. This example shows that the epsilon-method leads to a biologically significant difference in estimates of average abundance relative to the conventional plug-in estimator, and also gives essentially identical estimates to a sample-based bias-correction estimator. The epsilon-method has been implemented by us as a generic option in the open-source Template Model Builder software, and could be adapted within other mixed-effects modeling tools such as Automatic Differentiation Model Builder for random effects. It therefore has potential to improve estimation performance for mixed-effects models throughout fisheries science.

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**q) Space-time investigation of the effects of fishing on fish populations**

Investigators: K. Ono, A.O. Shelton, E.J. Ward, J.T. Thorson, B.E. Feist, and R. Hilborn

Species distribution models (SDMs) are important statistical tools for obtaining ecological insight into species-habitat relationships, and providing advice for natural resource management. Many SDMs have been developed over the past decades, with a focus on space- and more recently, time-dependence. However, most of these studies have been on terrestrial species and applications to marine species have been limited. In this study, we used three large spatio-temporal data sources (habitat maps, survey-based fish density estimates, and fishery catch data) and a novel space-time model to study how the distribution of fishing may affect the seasonal dynamics of a commercially important fish species (Pacific Dover sole, *Microstomus pacificus*) off the US West coast. Dover sole showed a large scale change in seasonal and annual distribution of biomass and its distribution shifted from mid-depth zones to inshore or deeper waters during late summer/early fall. In many cases, the scale of fishery removal was small compared to these broader changes in biomass, suggesting that seasonal dynamics were primarily driven by movement and not by fishing. The increasing availability of appropriate data and space-time modeling software should facilitate extending this work to many other species – particularly those in marine ecosystems – and help tease apart the role of growth, natural mortality, recruitment, movement, and fishing on spatial patterns of species distribution in marine systems.

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**r) Using spatiotemporal species distribution models to identify temporally evolving hotspots of species co-occurrence**

Investigators: E. Ward, O. Shelton, J. Thorson, K. Ono, K., and Y. Lee

Identifying spatiotemporal hotspots is important for understanding basic ecological processes, but is particularly important for species at risk. A number of terrestrial and aquatic species are indirectly affected by anthropogenic impacts, simply because they tend to be associated with species that are targeted for removals. Using newly developed statistical models that allow for the inclusion of time-varying spatial effects, we examine how the co-occurrence of a targeted and nontargeted species can be modeled as a function of environmental covariates (temperature, depth) and interannual variability. The nontarget species in our case study (eulachon) is listed under the

U.S. Endangered Species Act, and is encountered by fisheries off the U.S. West Coast that target pink shrimp. Results from our spatiotemporal model indicated that eulachon bycatch risk decreases with depth and has a convex relationship with sea surface temperature. Additionally, we found that over the 2007–2012 period, there was support for an increase in eulachon density from both a fishery data set (+40%) and a fishery-independent data set (+55%). Eulachon bycatch has increased in recent years, but the agreement between these two data sets implies that increases in bycatch are not due to an increase in incidental targeting of eulachon by fishing vessels, but because of an increasing population size of eulachon. Based on our results, the application of spatiotemporal models to species that are of conservation concern appears promising in identifying the spatial distribution of environmental and anthropogenic risks to the population.

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**s) Relative magnitude of cohort, age, and year-effects on growth of marine fishes**

Investigators: J.T. Thorson and C. Minte-Vera

Variation in individual growth rates contributes to changes over time in compensatory population growth and surplus production for marine fishes. However, there is little evidence regarding the prevalence and magnitude of time-varying growth for exploited marine fishes in general, whether it is best approximated using changes in length-at-age or weight-at-length parameters, or how it can be represented parsimoniously. We therefore use a database of average weight in each year and age for 91 marine fish stocks from 25 species, and fit models with random variation in length and weight parameters by year, age, or cohort (birth-year). Results show that year effects are more parsimonious than age or cohort effects and that variation in length and weight parameters provide roughly similar fit to average weight-at-age data, although length parameters show a greater magnitude of variability than weight parameters. Finally, the saturated model can explain nearly 2/3 of total variability, while a single time-varying factor can explain nearly 1/2 of variability in weight-at-age data. We conclude that time-varying growth can often be estimated parsimoniously using a single time-varying factor, either internally or prior to including ‘empirical’ weight at age in population dynamics models.

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**t) Spatial delay-difference models for estimating spatiotemporal variation in juvenile production and population abundance**

Investigators: J. Thorson, J. Ianelli, S. Munch, K. Ono, and P. Spencer

Many important ecological questions require accounting for spatial variation in demographic rates (e.g., survival) and population variables (e.g., abundance per unit area). However, ecologists have few spatial modelling approaches that (i) fit directly to spatially referenced data, (ii) represent population dynamics explicitly and mechanistically, and (iii) estimate parameters using rigorous statistical methods. We therefore demonstrate a new and computationally efficient approach to spatial modelling that uses random fields in place of the random variables typically used in spatially aggregated models. We adapt this approach to delay-difference dynamics to estimate the impact of fishing and natural mortality, recruitment, and individual growth on spatial population dynamics for a fish population. In particular, we develop this approach to estimate spatial variation in average production of juvenile fishes (termed recruitment), as well as annual variation in the spatial distribution of recruitment. We first use a simulation experiment to demonstrate that the spatial delay-difference model can, in some cases, explain over 50% of spatial variance in recruitment. We also apply the spatial delay-difference model to data for rex sole (*Glyptocephalus zachirus*) in the Gulf of Alaska and show that average recruitment (across all years) is greatest near Kodiak Island but that some years show greatest recruitment in Southeast Alaska or the western Gulf of Alaska. Using model developments and software advances presented here, we argue that future research can develop models to approximate adult movement, incorporate spatial covariates to explain annual variation in recruitment, and evaluate management procedures that use spatially explicit estimates of population abundance.

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**u) Evaluating a prior on relative stock status using simplified age-structured models**

Investigators: J. Cope, J. Thorson, C. Wetzel, and 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.

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**v) Catch curve stock-reduction analysis: an alternative solution to the catch equation**

Investigators: J. Thorson and J. Cope

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.

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**w) Spatial factor analysis: a new tool estimating multispecies spatial distributions and correlated distributions among species**

Investigators: J. Thorson, H. Skaug, A.O. Shelton, K. Kristensen, and M. Scheuerell

Predicting and explaining the distribution and density of species is one of the oldest concerns in ecology. Species distributions can be estimated using geostatistical methods, which estimate a latent spatial variable explaining observed variation in densities, but geostatistical methods may be imprecise for species with low densities or few observations. Additionally, simple geostatistical methods fail to account for correlations in distribution among species and generally estimate such cross-correlations as a post hoc exercise.

We therefore present spatial factor analysis (SFA), a spatial model for estimating a low-rank approximation to multivariate data, and use it to jointly estimate the distribution of multiple species simultaneously. We also derive an analytic estimate of cross-correlations among species from SFA parameters.

As a first example, we show that distributions for 10 bird species in the breeding bird survey in 2012 can be parsimoniously represented using only five spatial factors. As a second case study, we show that forward prediction of catches for 20 rockfishes (Sebastes spp.) off the U.S. West Coast is more accurate using SFA than analysing each species individually. Finally, we show that single-species models give a different picture of cross-correlations than joint estimation using SFA.

Spatial factor analysis complements a growing list of tools for jointly modelling the distribution of multiple species and provides a parsimonious summary of cross-correlation without requiring explicit declaration of habitat variables. We conclude by proposing future research that would model species cross-correlations using dissimilarity of species' traits, and the development of spatial dynamic factor analysis for a low-rank approximation to spatial time-series data.

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**x) Mixed effects: a unifying framework for modelling in aquatic ecology**

Investigators: J.T. Thorson and C. Minto

Fisheries biology encompasses a tremendous diversity of research questions, methods, and models. Many sub-fields use observational or experimental data to make inference about biological characteristics that are not directly observed (called "latent states"), such as heritability of phenotypic traits, habitat suitability, and population densities to name a few. Latent states will generally cause model residuals to be correlated, violating the assumption of statistical independence made in many statistical modelling approaches. In this exposition, we argue that mixed-effect modelling (i) is an important and generic solution to non-independence caused by latent states; (ii) provides a unifying framework for disparate statistical methods such as time-series, spatial, and individual-based models; and (iii) is increasingly practical to implement and customize for problem-specific models. We proceed by summarizing the distinctions between fixed and random effects, reviewing a generic approach for parameter estimation, and distinguishing general categories of non-linear mixed-effect models. We then provide four worked examples, including state-space, spatial, individual-level variability, and quantitative genetics applications (with working code for each), while providing comparison with conventional fixed-effect implementations. We conclude by summarizing directions for future research in this important framework for modelling and statistical analysis in fisheries biology.

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**y) Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes**

Investigators: J. Thorson, O. Shelton, E. Ward, and H. Skaug

Indices of abundance are the bedrock for stock assessments or empirical management procedures used to manage fishery catches for fish populations worldwide, and are generally obtained by processing catch-rate data. Recent research suggests that geostatistical models can explain a substantial portion of variability in catch rates via the location of samples (i.e. whether located in high- or low-density habitats), and thus use available catch-rate data more efficiently than conventional "design-based" or stratified estimators. However, the generality of this conclusion is currently unknown because geostatistical models are computationally challenging to simulation-test and have not previously been evaluated using multiple species. We develop a new maximum likelihood estimator for geostatistical index standardization, which uses recent improvements in estimation for Gaussian random fields. We apply the model to data for 28 groundfish species off the U.S. West Coast and compare results to a previous "stratified" index standardization model, which accounts for spatial variation using post-stratification of available data. This demonstrates that the stratified model generates a relative index with 60% larger estimation intervals than the geostatistical model. We also apply both models to simulated data and demonstrate (i) that the geostatistical model has well-calibrated confidence intervals (they include the true value at approximately the nominal rate), (ii) that neither model on average under- or overestimates changes in abundance, and (iii) that the geostatistical model has on average 20% lower estimation errors than a stratified model. We therefore conclude that the geostatistical model uses survey data more efficiently than the stratified model, and therefore provides a more cost-efficient treatment for historical and ongoing fish sampling data.

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**z) The potential impact of time-variation in vital rates on fisheries management targets for marine fishes**

Investigators: J. Thorson, C. Monnahan, and J. Cope

Fisheries scientists are increasingly concerned about changes in vital rates caused by environmental change and fishing impacts. Demographic parameters representing individual growth, maturity, mortality, and recruitment have previously been documented to change over decadal time scales. However, there has been relatively little comparison regarding which vital rates cause relatively greater or lesser impacts on commonly used fisheries management targets. We therefore use a life table (based on age-structured assessment models) to explore the sensitivity of fishing mortality, spawning biomass, and catch targets to changes in parameters representing growth, mortality, recruitment, and maturation rates for three representative life histories representing long-, medium-, and short-lived species. The elasticity analysis indicates that demographic changes can result in substantial variation in fisheries management targets, but that changes in mortality rates are particularly important for spawning biomass and catch targets while maturity and recruitment compensation are also important for fishing mortality targets. We conclude by discussing the importance of improved data repositories to address covariation among maturity, growth, and mortality parameters.

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**aa) The importance of spatial models for estimating the strength of density dependence**

Investigators: J. Thorson, H. Skaug, K. Kristensen, E. Ward, O. Shelton, J. Harms, and J. 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, USA 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 reexamine classic questions regarding the existence and magnitude of density dependence in wild populations.

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**bb) Spatio-temporal variation in fish condition is not consistently explained by density, temperature, or season for Northeast Pacific groundfishes**

Investigator: J. Thorson

Condition (the relationship between individual weight and length) has been researched in fisheries science for over 100 yr and is claimed to be an integrated measure of physiological status for fishes. Spatial or temporal variation in condition can contribute to otherwise unexplained variation in the relationship between spawning biomass and recruitment. Individual condition is also included in age-structured population models, which use weight at age to convert population estimates between numbers and biomass. However, no study has analyzed spatial and temporal variation in condition for multiple marine species. Here I apply recent improvements in spatial modeling to analyze coastwide variation in condition for 28 groundfishes in the California Current. I show that, on average, 22% of individual-level variation in condition can be explained via persistent (constant over time) and annually varying spatial differences in condition, and condition for many species varies 10 to 20% spatially and among years. While population density, bottom temperature, and calendar date are parsimonious descriptors of condition in several species, the sign of these coefficients varies, and their magnitude is small relative to the magnitude of residual spatial and temporal variation. Additionally, annually varying spatial differences have nearly twice the magnitude of persistent spatial differences in condition. I therefore conclude that dynamic habitat conditions contribute a substantial portion of variation in individual condition for these groundfishes. Spatial and temporal variation in condition will be important for population models that convert between numbers, fishery catch, and population biomass, and may also clarify unexplained variability in productivity for marine fishes.

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**cc) Giants' shoulders 15 years later: Lessons, challenges, and guidelines in fisheries meta-analysis**

Investigators: J.T. Thorson, K. Kleisner, J. Samhouri, E. Ward, A. Shelton, A., and J. Cope

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.

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**dd) Probability of stochastic depletion: an easily interpreted diagnostic for stock assessment modelling and fisheries management**

Investigators: J. Thorson, O. Jenson, and R. Hilborn

Marine fish populations have high variation in cohort strength, and the production of juveniles (recruitment) may have persistent positive or negative residuals (autocorrelation) after accounting for spawning biomass. Autocorrelated recruitment will occur whenever average recruitment levels change between oceanographic regimes or due to predator release, but may also indicate persistent environmental and biological effects on shorter time-scales. Here, we use estimates of recruitment variability and autocorrelation to simulate the stationary distribution of spawning biomass for 100 real-world stocks when unfished, fished at FMSY, or fished following a harvest control rule where fishing mortality decreases as a function of spawning biomass. Results show that unfished stocks have spawning biomass (SB) below its deterministic equilibrium value (SB0) 58% of the time, and below 0.5SB0 5% of the time on average across all stocks. Similarly, stocks fished at the level producing deterministic maximum sustainable yield (FMSY) are below its deterministic prediction of spawning biomass (SBMSY) 60% of the time and below 0.5SBMSY 8% of the time. These probabilities are greater for stocks with high recruitment variability, positive autocorrelation, and high natural mortality—traits that are particularly associated with clupeids and scombrids. An elevated probability of stochastic depletion, i.e. biomass below the deterministic equilibrium expectation, implies that management actions required when biomass drops below a threshold may be triggered more frequently than expected. Therefore, we conclude by suggesting that fisheries scientists routinely calculate these probabilities during stock assessments as a decision support tool for fisheries managers.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

**ee) The determination of data-poor catch limits in the United States: Is there a better way?**

Investigators: J. Thorson and J. Berkson

Methods for determining appropriate management actions for data-poor stocks, including annual catch limits (ACLs), have seen an explosion of research interest in the past decade. We perform an inventory of methods for determining ACLs for stocks in the United States, and find that ACLs are assigned to 371 stocks and/or stock complexes with 193 (52%) determined using methods involving catch data only. The proportion of ACLs involving these methods varies widely among fisheries management regions, with all the 67 ACLs in the Caribbean determined using recent catch when compared with 1 of 33 ACLs in the New England region (US Northeast). Given this prevalence of data-poor ACLs, we recommend additional research regarding the potential effectiveness of simple management procedures for data-poor stocks that are currently managed using ACLs. In particular, simple management procedures may allow a broader range of data types and management instruments that better suit the particulars of individual regions and stocks.

For more information, please contact Jim Thorson at James.Thorson@noaa.gov

**2. Survey and Observer Science**

**a) Resolving the issues of hook saturation, hook competition, and fixed-site design in the Southern California hook-and-line survey**

Investigators: P. Kuriyama, A.C. Hicks, J.H. Harms, and T.A. Branch

The Southern California hook-and-line survey has been conducted by the Northwest Fisheries Science Center since 2004 to monitor the untrawlable habitat of the Southern California Bight. Data from the survey have been used in stock assessments and supporting research for a number of shelf rockfish species, such as bocaccio (*Sebastes pauicispinis*) and vermillion rockfish (*S. miniatus*). However, an index of abundance estimated from hook-and-line data may be biased due to the fixed-site design of the survey, hook saturation, and hook competition. Here, I will present empirical results from the hook-and-line data and results of a simulation study exploring the biases associated with aspects of the survey. Bocaccio are the most sampled species in the survey, and sites with low catch rates of bocaccio have high catch rates of vermilion rockfish. Preliminary results from the simulations indicate that hook saturation causes estimates of abundance to be negatively biased at large population sizes, hook competition leads to positively biased indices of abundance, and weighting catch rates by site leads to the least biased index of abundance. These results identify methods of incorporating hook-and-line data from untrawlable habitat into stock assessments and identify ways of correcting biases common to all hook-and-line surveys.

For more information, please contact John Harms at John.Harms@noaa.gov

**b) The Northwest Fisheries Science Center's (NWFSC) wireless back deck and data logging system**

Investigators: V. Simon, T. Hay, A.A. Keller

The NWFSC's West Coast Groundfish Bottom Trawl Survey (WCGBTS) annually samples approximately 750 stations at depths from 55 to 1280 meters off the continental United States using four chartered commercial fishing vessels. To improve data capture efficiency, the FRAM division uses a sophisticated wireless network (802.11 protocols) to input data into several in-house applications. We demonstrated the use of all WCGBTS wireless back-deck data gathering instruments in concert with our new back deck data logging software at the 2016 TSC electronic data capture methods workshop held in Newport OR as part of the 2016 Western Groundfish Conference. We demonstrated the incorporation of the NWFSC's communication box that provides power, networking, and printing resources in the extremely harsh conditions of an open and small backdeck work environment. Electronic sampling components include scales, fish measuring boards, barcode wand, barcode gun, calipers, and label printers. We demonstrated a new Python language data-based logging program including refined and practical real-time validations which limit data input errors, expedite resolution of data errors and facilitate data dissemination.

For more information, please contact Victor Simon at Victor.Simon@noaa.gov

**c) 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

**d) Refinement and upgrades of the EchoPro software package with inclusion of a geo-statistical technique (kriging) to process and re-process Integrated Acoustic and Trawl Survey (IATS) data for hake biomass estimate from 1998 to 2015**

The EchoPro software package developed in FY11 has been updated to increase flexibility and reduce program complexity. The historical Integrated Acoustic and Trawl survey data of Pacific hake from 1998 to 2015 have been processed and re-processed. It reads the Nautical Area Scattering Coefficient exported from EchoView (Myriax) and can provide length-, age-, and sex-structured biomass estimates promptly. Data processing is totally independent of any Oracle database and the processing cycle is much shorter.

With the updated software, the historical and 2015 survey data have been processed using consistent formats of the input files and processing procedures. The results are shown in Figure 13. Geostatistics-based (kriging) biomass analysis is the accepted technique for biomass estimate by the Pacific hake Science Review Group (SRG). The Kriging has been considered suitable for estimating fish abundance and precision by an ICES Study Group. In addition, a sensitivity analysis of the biomass estimate in terms of the extrapolation (Figure 14), stratification scheme, variogram and kriging variables, and the kriging parameters was performed, which indicated that the biomass estimate was robust.

For more information, contact Larry Hufnagle at Lawrence.C.Hufnagle@noaa.gov.

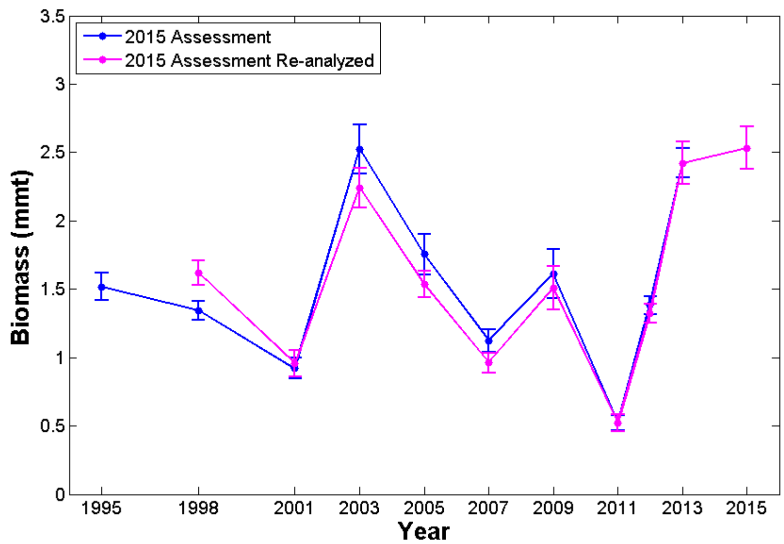


Figure 13. Re-processed estimated biomass of Pacific hake from 1998 to 2015. The 2015 Assessment curve is the old biomass estimate.

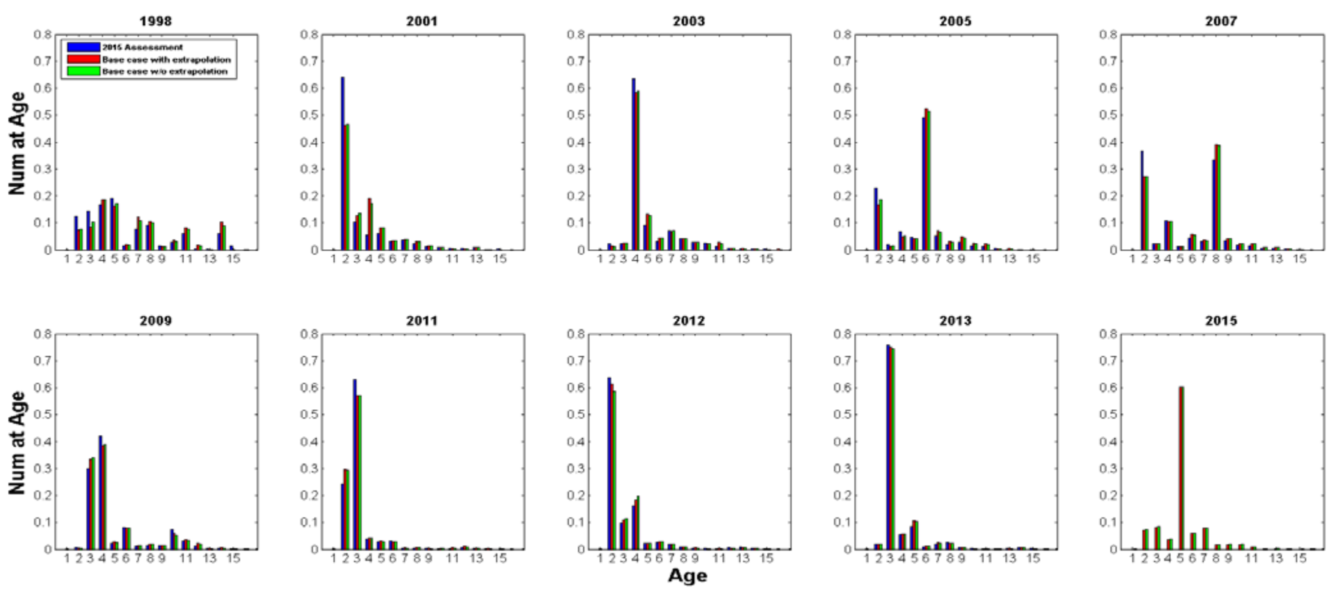


Figure 14. Comparison of age composition of the re-processed estimated biomass of Pacific hake from 1998 to 2015 with different processing method.

**e) Development of an age-1 hake index and analysis of historical data**

An age-1 index for Pacific hake is under development, with a preliminary analysis of 2003 to 2015 data concluded February 2016. The results are shown in Figs. 15 and 16. This analysis included an overall index of abundance as well as a spatial component of age-1 echosign. This index of abundance was joined to the 1995–2001 historic AFSC data set of age-1 abundance. Results indicate that the age-1 index was consistent with major recruitment events; however, more years of data and a full spatial analysis are needed. Currently, work is proceeding on converting historical 1995–2001 echogram data, with hopes to get a full spatial component similar to that in spatial years. Also, as the adult hake biomass estimate is currently calculated using kriging methods, but the age-1 index currently is calculated using simple linear interpolation, a goal is for the age-1 index to incorporate kriging as well eventually.

For more information, contact Larry Hufnagle at Lawrence.C.Hufnagle@noaa.gov.

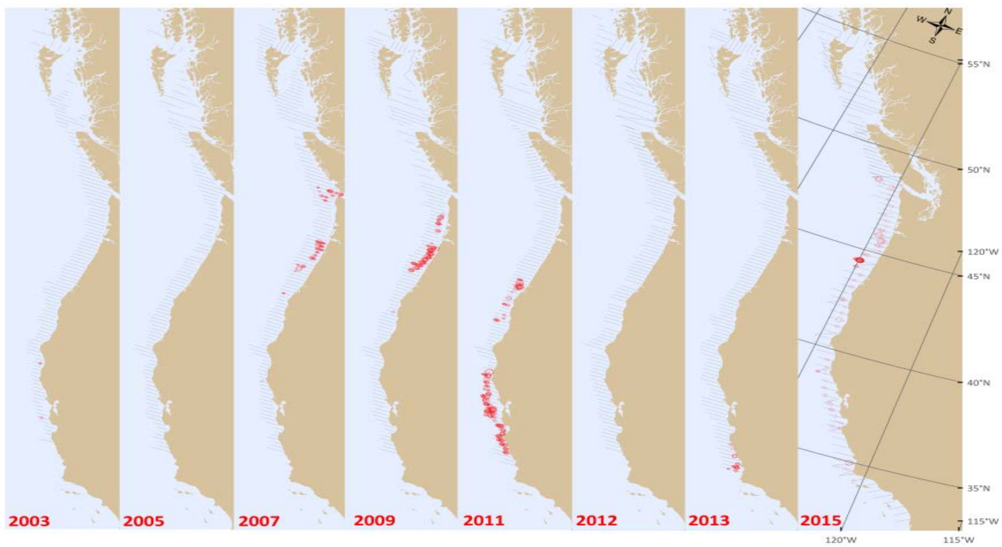


**Figure 15.** Acoustic backscatter of the Age-1 hake spatial distribution from 2003 to 2015.

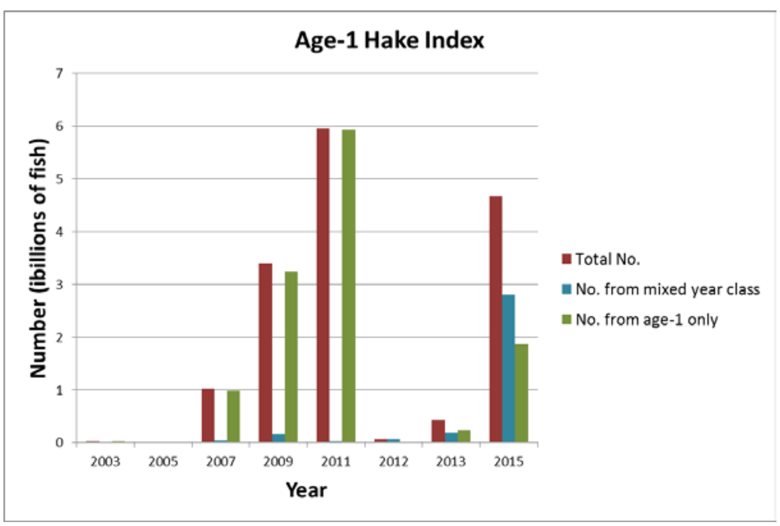


**Figure 16.** Age-1index of Pacific hake from 2003 to 2015.

**f) Laboratory measurements of the acoustic absorption coefficient in seawater**

The absorption coefficient of seawater is an important component to the sonar equation underlying fisheries and zooplankton acoustic investigations. The equations currently considered most accurate and widely used for calculating the coefficient are the three decades-old work of Francois and Garrison (1982a, 1982b). However, there is evidence to suggest that these equations are inadequate for the higher frequencies increasingly used today in both fisheries and ecosystem investigations (Fig. 17). To address this, a systematic investigation of sound absorption (up to 500 kHz) will be undertaken by varying temperature, salinity, pressure, and pH within a resonance chamber equipped with interchangeable end caps mounting a 30-500 kHz broadband transducer. By analyzing the decay rate using statistical and computational tools developed in the decades since Francois and Garrison's work, we can develop a new systematic curve for absorption at these higher frequencies.

Francois, R.E., Garrison, G.R. 1982a. Sound absorption based on ocean measurements. Part I: Pure water and magnesium sulphate contributions. J. Acoust. Soc. Am. 72(3): 896- 907.

Francois, R.E., and Garrison, G.R. 1982b. Sound absorption based on ocean measurements. Part II: Boric acid contribution and equation for total absorption. J. Acoust. Soc. Am. 72(3): 1879-1890.

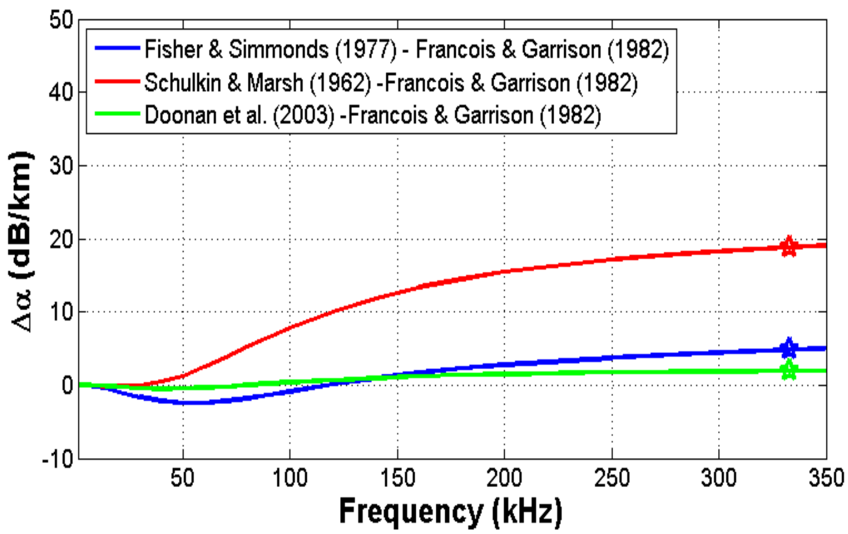


**Figure 17.** Comparison between various absorption models. Each model's 333 kHz absorption coefficient is indicated by the appropriately colored star (Ona et al., 2012).

During CY 2015, we have constructed the most part of the pressure housing to conduct the absorption coefficient measurements (Fig. 18). The experiments will be conducted with the various parameters given in Table 1.

**Table 1.** Proposed ranges in insonification frequency, temperature, salinity, pressure ranges, and pH, in evaluating experimental effect on seawater's absorption coefficient.

| Frequency (kHz) | Temperature ($^oC$) | Salinity (PSU) | Pressure (psi) | pH |
|---|---|---|---|---|
| 30 – 500 | 2 – 25 | 0 – 40 | 0 –1125 (~760m) | 7.5 – 8.4 |

Numerical simulations of the acoustic absorption in seawater will be performed using a finite element software package COMSOL Multiphysics®. COMSOL Multiphysics® is a finite-element based software package that enables programmers to model and analyze any physics-based system. It can import a variety of 3D CAD data formats including SolidWorks®, generate a 3D mesh automatically, and refine the mesh size and density easily. COMSOL Multiphysics® represents a far more sophisticated analytic approach than was available to Francois and Garrison in the 1970-80's.

The modular nature of the program provides customizable modeling capabilities. The acoustics module enables modeling for thermo-acoustics, vital for accurate simulation of acoustics in geometries with small dimensions such as the pressure vessel we propose to use (Fig. 18). Additionally, the physics interfaces for thermo-acoustics, will allow us to solve coupled equations dealing with thermo-effects of acoustic radiation and scattering.

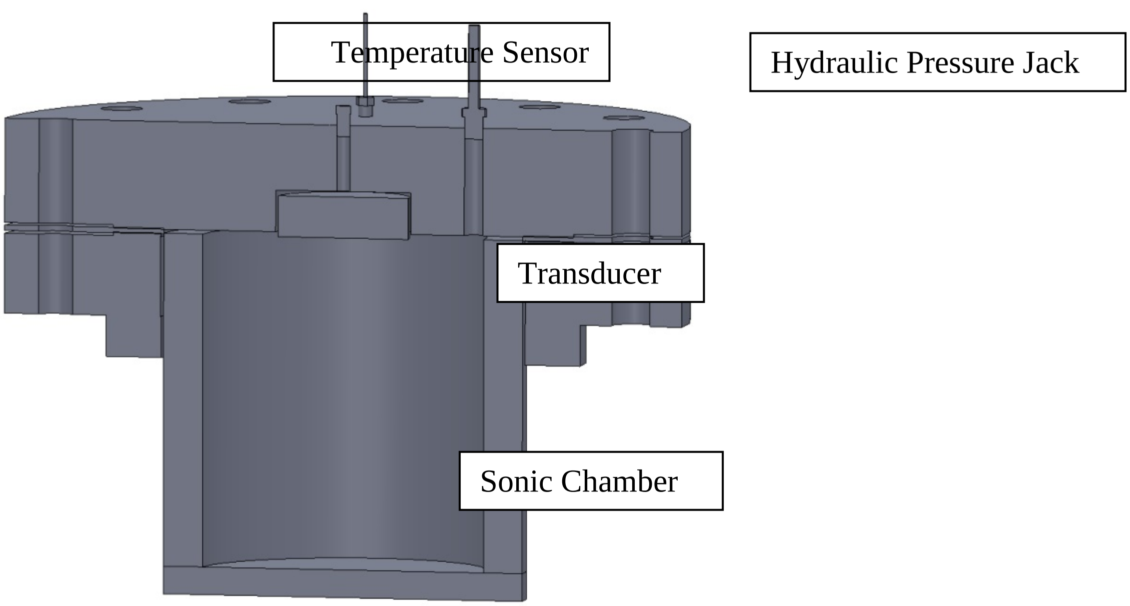


**Figure 18.** Schematic diagram of the cylindrical pressure vessel.

For more information, please contact Larry Hufnagle at Lawrence.C.Hufnagle@noaa.gov

**g) 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 experiments in the Gulf of Mexico during August 2014 and July 2016. 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 60m 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. Ongoing analyses are being conducted for the stereo and DIDSON imaging systems, as well as the mobile platforms. For the 2016 field season, the UHSI field program will transition to untrawlable habitats off the U.S. West Coast.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov

**h) West Coast Observer Program**

The FRAM West Coast Groundfish Observer Program (WCGOP) continued collecting fishery-dependent data during 2015 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 2.** Number of observers that were deployed by the WCGOP in 2015

| 2015 | |
|---|---|
| **Number of catch share observers** | **66** |
| **Number of non-catch share observers** | **33** |
| **Number of A-SHOP Observers** | **36** |

**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 3 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 3.** Summary of observer coverage and sea days in the catch share fisheries

| DESCRIPTION | SS IFQ Trawl | SS IFQ Fixed Gear | SS Hake | MSCV | A-SHOP |
|---|---|---|---|---|---|
| Number of vessels | 59 | 14 | 5 | 5 | 12 |
| Number of trips* | 938 | 74 | 129 | 7 | 74 |
| Number of Sea days* | 3,471 | | 340 | 139 | 1506 |
| Number of Observers | 66 | | | | 36 |

*Includes trips and/or sea days where no fishing activity occurred.

**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

**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 2,490 sea days in the non-catch share fisheries in 2015 aboard vessels ranging in size from skiffs to larger fixed gear vessels at depths from < 20 ft. to > 300 ft.

**Table 4.** Non-Catch Share sea day summary by fisheries/sectors:

| Non-catch share coverage by fishery | |
|---|---|
| **FISHERY DESCRIPTION** | SEA DAYS* |
| OR Blue/Black Rockfish Nearshore | 126 |
| OR Blue/Black Rockfish | 71 |
| OR Pink Shrimp | 597 |
| WC Open Access Fixed Gear | 103 |
| WA Pink Shrimp | 446 |
| Limited Entry Sablefish | 464 |
| CA Emley-Platt EFP | 3 |

| | |
|---|---|
| Electronic Monitoring EFP | 93 |
| Limited Entry Zero Tier | 123 |
| CA Halibut | 120 |
| CA Nearshore | 280 |
| CA Pink Shrimp | 64 |

*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.

**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

## 3. Age and Life History

### a) 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 2015, CAP aged more than 26,056 otoliths. Ages were produced to support the 2015 assessments on 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. The lab also provided 346 vermilion rockfish ages from the Hook and Line Survey. Throughout 2015, 6.703 hake otoliths were aged for use in the 2016 joint hake assessment with Canada. CAP also completed over 650 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. The lab also acquired a Micromill for coring otoliths with the intent to conduct age validation studies. Considerable time was spent learning the new operating system and developing SOP's for sample preparation and lab hygiene. Resources were also allocated to acquiring the skills and equipment for lingcod fin ray preparation which includes pinning, drying, gluing, sectioning and mounting.

For more information, please contact Jim Hastie at Jim.Hastie@noaa.gov

**b) 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, Ono, Valero 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 et al. 2011). 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. Ongoing radiocarbon age validation work is focusing on black and canary rockfish with the aim of producing more reliable ageing error matrices that will improve stock assessment's ability to model age imprecision and bias, reducing assessment uncertainty. 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.

For more information, contact Melissa Haltuch at Melissa.Haltuch@noaa.gov

**c) Techniques for improving estimates of maturity ogives in groundfish using double-reads and measurement error models**

Investigators: M.A. Head, G.L. Stokes, 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 early yolk development. Application to three U.S. 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 differences in rates of skipped spawning among species which should be further investigated. We recommend that future maturity studies record reader certainty, use models that incorporate covariates into the analysis, and conduct an initial double reader analysis. If readers exhibit little variation, then double reads may not be necessary. In addition, slide quality should also be recorded, so that future studies do not confuse this with reader imprecision. This improved protocol will assist in estimating life history, as well as environmental, and anthropogenic effects on maturity.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

**d) FRAM's reproductive maturity program and its application for fisheries management**

Investigator: M.A. Head

Since the initiation of the NWFSC's reproductive maturity program (FRAM Division) in 2009, we collected over 10,000 ovaries from 32 groundfish species. We identified several key factors essential for understanding reproductive biology of west coast groundfishes: (1) spatial and temporal patterns, (2) oceanographic conditions related to skip spawning and abortive maturation, and (3) estimating biological (sexual) versus functional (potential spawner) maturity. FRAM is currently obtaining reproductive samples for multiple groundfish species via multiple sampling platforms, (west coast groundfish trawl survey, Southern California hook and line survey, hake acoustics survey), observers (at sea hake observers), and collaboration with Washington and Oregon state departments (WDFW and ODFW). Samples are histologically assessed for maturity using a binocular microscope and imaging software. In the past many stock assessments relied on outdated or incomplete life-history information from opportunistic or geographically/temporally limited data sources. Our goal is to provide updated, coast wide maturity information on an annual basis to reduce uncertainty in parameters used to estimate spawning biomass and recruitment. Ecosystem variables, such as habitat, predator-prey interactions, food availability, upwelling, and oceanographic patterns may also have an outsized influence on the reproductive behavior of groundfish stocks in a given year. We are investigating how these variables affect skip-spawning and abortive maturation patterns and how spatial/temporal relationships are associated with maturity schedules.

For more information, please contact Melissa Head at Melissa.Head@noaa.gov

**e) A state-space approach for measuring growth variation and application to North Pacific groundfish CJFAS. In Review.**

Christine 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

## B. Ecosystem Research

### 1. Habitat

#### a) Fine-scale benthic habitat classification as part of the NWFSC Southern California Shelf Rockfish Hook and Line Survey

Investigators: A. Chappell, C.E. Whitmire, J.H. Harms, J.A. Benante and A.A. Keller

The NWFSC's Southern California Shelf Rockfish Hook and Line Survey samples hard bottom habitats within the Southern California Bight via rod and reel gear to provide management information for multiple demersal rockfishes (*Sebastes* spp.). The survey, initiated in 2004, traditionally samples 121 fixed stations annually from Pt. Arguello ($34.6^0$ N) to the Mexican border ($32.1^0$ N) at depths of 37 – 229 m. To complement the fishing component of the survey, a towed camera-sled equipped with a low-light analog camera and mini-DV recording system is deployed opportunistically to collect video data on fish presence and benthic habitat. Through the 2015 survey, we have analyzed nearly 10,000 benthic habitat observations collected during 90 dives at 78 unique sites.

Benthic habitat observations were categorized both by major strata (primary, ≥50% of habitat in the field of view (FOV); secondary, ≥20% of the next most abundant habitat in the FOV; and, all other habitats in the FOV), and by eight previously-defined substrata categories: mud, sand, pebble, cobble, boulder, continuous flat rock, diagonal ridge and vertical rock-pinnacle top.

When compared with existing National Oceanic and Atmospheric Administration's Essential Fish Habitat (EFH) maps in the areas of our camera-sled tows, we found significantly different habitat classification values, especially for hard habitats. This suggests hard-bottom habitat features, especially smaller reefs, rock outcrops and boulder patches are not fully resolved within available habitat maps. Incorporating habitat designation from EFH substrate maps into the development of abundance indices or other metrics for groundfish stock assessments may misrepresent the total available hard-bottomed habitats available to many species that use them, resulting in biased estimates. Additionally, users of EFH substrate data on small-scale projects should be aware of the associated limitations.

For more information, please contact Aaron Chappell at Aaron.Chappell@noaa.gov

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

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

Some cold-water corals and sponges occur in such dense aggregations that they provide structurally complex habitats which support a diverse assemblage of associated invertebrates and fish. In many cases, marine fishes have been linked to the presence of epibenthic invertebrates, although the specific nature of this relationship is often unknown. The Northwest Fisheries Science Center's West Coast Groundfish Bottom Trawl Survey has collected approximately 250 coral specimens per year since 2006, and has identified, on average, 200 sites (of 750) per year where sponges are present. For this study we investigated the relationship between these two groups of epibenthic invertebrates and their associations with demersal fish using trawl survey data from 2003-2013, 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.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

**c) 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, AND 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, 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 community metrics of 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% or 10% of its range. There was minimal spatial overlap among 10% 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 one percent of the coast was identified as within a hotspot for three or more metrics. Since different indices represent various aspects of diversity, our results caution against the uninformed use of these indices 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 Dr. Nick Tolimieri at Nick.Tolimieri@noaa.gov.

**d) Genotyping-by-sequencing reveals lack of structure in the deep-sea octocoral *Swiftia simplex* (Nutting 1909) on the United States West coast**

Investigators: M. V. Everett, L. K. Park, E.A. Berntson, A. E. Elz, C. E. Whitmire, A. A. Keller, M.E. Clarke

Deep-sea corals provide important habitat in the deep ocean and have been recognized as regional hotspots for biodiversity. Despite their ecological importance, little is known about the connectivity and life history of deep-sea octocoral populations. An understanding of the population structure of deep-sea corals is critical to ascertaining the effects of habitat loss and genetic connections between distant populations. Next generation sequencing, including restriction site-associated DNA sequencing, has allowed the discovery and application of thousands of novel SNP markers in non-model species, including marine invertebrates. In this study we utilized high-throughput RAD-tag sequencing to develop the first molecular resource for the deep-sea octocoral *Swiftia simplex* (Nutting 1909). Using this technique, we discovered thousands of putative genome-wide SNPs from twenty-three *S. simplex* individuals collected from along the U.S. West Coast. After quality control, we successfully assayed up to 1,145 SNPs across all individuals, and analyzed the resulting multi-locus genotypes to assess putative population structure across the region. Across all areas, no geographic genetic structure was detected for this species, suggesting a high degree of connectivity and potential panmixia along the U.S. West Coast.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

**e) Distribution of demersal fishes in relation to near-bottom oxygen levels within the California Current ecosystem**

A.A. Keller, L. Ciannelli, W.W. Wakefield, V.H. Simon, J.A. Barth, and S.D. Pierce

The Northwest Fisheries Science Center conducts an annual groundfish bottom trawl survey in cooperation with the fishing industry within the California Current Large Marine Ecosystem along the U.S. West Coast upper continental slope and shelf. The survey occurs from May to October and targets commercial groundfish resources inhabiting depths of 55-1280 m from U.S.-Canada to U.S.-Mexico. In response to hypoxia observed on the continental shelf of the Pacific Northwest, environmental sensing packages (e.g., depth, temperature, salinity, dissolved oxygen, chlorophyll fluorescence, turbidity, and light) were added to trawls in 2008. Near-bottom dissolved oxygen (DO) concentration was monitored along tow tracks in conjunction with fishery sampling from 2008 to the present. Temporal and spatial variations in near-bottom DO and catch are explored to evaluate the severity and extent of hypoxia in recent years. DO ranged from 0.02 to 5.5 mL $L^{-1}$ with 64% of the 3394 stations experiencing hypoxic conditions. Catch and species richness exhibited significant and positive relationships with near-bottom oxygen concentration. Based on general additive models (GAMs) sensitivity to changes in near-bottom oxygen varied among 33 demersal fish species.

For more information, please contact Aimee Keller at Aimee.Keller@noaa.gov

**2. Ecosystems**

**a) Potential effects of ocean acidification on the California Current food web and fisheries: ecosystem model projections**

Investigators: K.N. Marshall, I.C. Kaplan, E.E. Hodgson, A. Hermann, S. Busch, P. McElhany, T.E. Essington, C.J. Harvey, E.A. Fulton

Humans rely heavily on ocean ecosystems and the services they provide. Global climate change manifests in the ocean through a number of pathways, one of which is ocean acidification. In this project and associated manuscripts, we describe the effects of ocean acidification on an upwelling system that is particularly prone to low pH conditions, the California Current. We used an end-to-end ecosystem model (Atlantis), forced by downscaled global climate models and informed by a meta-analysis of the pH sensitivities of local taxa, to investigate the direct and indirect effects of future pH on biomass and fisheries revenues. Our model projects wide-ranging magnitudes of effects across guilds and functional groups, although with more “losers” than “winners”. The most dramatic effects of future pH may be expected on demersal fish, sharks, and epibenthic invertebrates. State-managed fisheries such as those that harvest Dungeness crab were particularly vulnerable in our projections, with revenues declining by almost 30%. The model’s pelagic species, marine mammals, and seabirds were much less influenced by future pH. Our results provide a set of projections that generally support and build upon previous findings and set the stage for hypotheses to guide future modeling and experimental analysis on the effects of OA on marine ecosystems and fisheries.

For more information please contact Drs. Kristin Marshall or Isaac Kaplan at Kristin.Marshall@noaa.gov, Isaac.Kaplan@noaa.gov

**b) Integrated Ecosystem Assessment of the California Current**

Investigators: C.J. Harvey, N. Garfield, E.L. Hazen and 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.

We are entering the Phase IV iteration of the California Current IEA, which builds on earlier reports by focusing on integrative products, particularly: in-depth quantitative analysis of ecosystem indicators; assessing the risk posed by natural and anthropogenic stressors to key ecosystem resources and human wellbeing; and evaluating potential management strategies to determine which strategies are most effective in moving the ecosystem toward management goals and objectives, and to identify potential management tradeoffs. Many of these efforts involve analyses related to groundfish and will be fleshed out further between now and 2017.

For more information, please contact Dr. Chris Harvey at Chris.Harvey@noaa.gov

**c) 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, and 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, ~55-1280 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 (including groundfish) 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 pelagic fishes (including pelagic stages of groundfish) 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.

**d) The legacy of a crowded ocean: indicators, status, and trends of anthropogenic pressures in the California Current ecosystem**

Investigators: Andrews, K. S., 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

**e) Incorporating Climate Driven Growth Variability into Stock Assessment Models: a Simulation-based Decision Table Approach**

Investigators: Q. Lee, 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

**f) 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 NOAA's Northwest Fisheries Science Center, Kelly.Andrews@noaa.gov.

**g) Learning to review end-to-end marine ecosystem models for management applications**

Investigators: I.C. Kaplan and 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 Dr. Isaac Kaplan Isaac.Kaplan@noaa.gov.

## C. Bycatch Reduction Research

*Recent Conservation Engineering Work in US 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.

**1. Evaluation of a Sorting Grid Bycatch Reduction Device for the Selective Flatfish Bottom Trawl in the U.S. West Coast Fishery**

The U.S. West Coast limited entry groundfish trawl fishery is managed under an individual fishing quota program. For many fishermen targeting flatfishes in this fishery, catches of rockfishes (*Sebastes* spp.), sablefish (*Anoplopoma fimbria*), and Pacific halibut (*Hippoglossus stenolepis*) can be a concern because quota is limited relative to flatfish quotas. Thus, approaches to minimize bycatch of limiting species are important to the economic viability of the fishery. In this study, we examined the size-selection characteristics of a flexible sorting grid bycatch reduction device (designed to retain flatfishes while reducing catches of rockfishes, sablefish, and Pacific halibut) using a recapture net. The mean codend retention of target flatfishes (five species evaluated) ranged from 68.1% to 92.3%. Combined, the mean flatfish retention was 85.6%. Codend catches of shelf rockfishes, slope rockfishes, sablefish, and Pacific halibut were reduced by 80.3%, 64.0%, 97.0%, and 90.3% by weight, respectively. Significant differences in selectivity parameters between flatfishes, rockfishes, sablefish, and Pacific halibut were observed. Over fishing grounds where fishermen need a more selective trawl to harvest flatfishes, the experimental gear tested could provide fishermen a technique to reduce catches of non-target species.
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

**2. Artificial light: Its influence on Chinook salmon escapement out a bycatch reduction device in a Pacific whiting midwater trawl**

The Pacific whiting (*Merluccius productus*) midwater trawl fishery represents the largest groundfish fishery by volume along the U.S. west coast. While landed catches consist of mostly Pacific whiting, bycatch of Chinook salmon (*Oncorhynchus tshawytscha*) is an issue affecting the fishery. Although the catch ratio of Chinook salmon caught in the fishery is typically <0.03 fish per metric ton of Pacific whiting, bycatch is a concern because of the high volume of the fishery and the incidental capture of Endangered Species Act listed salmon. In this study, we examined the use of artificial light as a technique to reduce Chinook salmon bycatch. Specifically, we tested if Chinook salmon can be attracted towards and out of specific escape windows/openings of a bycatch reduction device (BRD) using artificial light. Data on fish behavior and escapement was collected using underwater video camera systems. During sea trials, video observations were made on 437 Chinook salmon with escapement occurring in 298 individual (68.2% of fish). At trawl depths, 266 Chinook salmon escaped with 230 individuals (86.5% of fish) exiting out a window that was illuminated. This result was highly significant (P<0.00001). These data show that light can influence where Chinook salmon exit a BRD, but also suggest that light could be used to enhance their escapement overall.

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. Tests of artificial light for bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl: Strong but opposite effects at the footrope and near the bycatch reduction device**

This Study investigated how the addition of artificial light in the vicinity of the rigid-grate bycatch reductiondevice (BRD) and along the fishing line of an ocean shrimp (Pandalus jordani) trawl altered fish bycatch andocean shrimp catch. In separate trials using double-rigged shrimp nets, with one net incorporating artifi-cial lights and the other serving as a control, we 1) attached one to four Lindgren-Pitman Electralume®LEDlights (colors green or blue) in locations around the rigid-grate BRD, and 2) attached 10 green lights alongthe trawl fishing line. Both experiments were conducted with rigid-grate BRDs with 19.1 mm bar spacinginstalled in each net. Contrary to expectations, in 12 paired hauls the addition of artificial light aroundthe rigid-grate increased the bycatch of eulachon (Thaleichthys pacificus), a threatened anadromous smeltspecies, by 104% (all by weight, $P = 0.0005$) and slender sole (Lyopsetta exilis) by 77% ($P = 0.0082$), withno effect on ocean shrimp catch or bycatch of other fishes ($P > 0.05$). In 42 paired hauls, the addition of10 LED lights along the fishing line dramatically reduced the bycatch of a wide variety of fishes with noeffect on ocean shrimp catch ($P > 0.05$). Bycatch of eulachon was reduced by 91% ($P = 0.0001$). Bycatch ofslender sole and other small flatfishes were each reduced by 69% ($P < 0.0005$). Bycatch of darkblotchedrockfish (Sebastes crameri), a commercially important but depressed rockfish species, was reduced by 82%($P = 0.0001$) while the bycatch of other juvenile rockfish (Sebastes spp.) was reduced by 56% ($P = 0.0001$).How the addition of artificial light is causing these changes in fish behavior and bycatch reduction is notknown. However, in both experiments the addition of artificial light appears to have greatly increasedthe passage of fishes through restricted spaces (between BRD bars and the open space between trawlfishing line and groundline) that they typically would not pass through as readily under normal seafloorambient light conditions.

For more information, contact Bob Hannah at bob.w.hannah@state.or.us or 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

**4. Reducing the Bycatch of Overfished and Rebuilding Rockfish Species in the U.S. Pacific Hake Fishery**

This study examined a flexible sorting grid excluder designed to reduce rockfish (*Sebastes* spp.) bycatch in the U.S. Pacific hake (*Merluccius productus*) fishery. Tests occurred off Oregon during 2013 aboard a commercial trawler. A recapture net was used to quantify the retention of Pacific hake and rockfish bycatch. During this study, widow rockfish (*S. entomelas*) was the primary rockfish species caught. Their bycatch was reduced 26.2% by weight. The retention of Pacific hake was 92.7% by weight. Widow rockfish caught in the recapture net were statistically larger than widow rockfish retained in the trawl. Mean lengths of Pacific hake caught between the trawl and recapture net did not differ significantly. Estimated single haul catches of Pacific hake ranged from 40 to 100 mt. Catches producing over 90 mt of Pacific hake in haul durations less than 2.5 hours were made. However, under heavier fish volumes (over 90 mt of Pacific hake caught in less than 45 minutes of towing) the excluder tended to clog. While further refinement of the excluder is needed for the gear to function under heavy volumes of fish, this project has developed a bycatch reduction device that can assist Pacific hake fishermen in reducing rockfish bycatch when fishing conditions are moderate to high.

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

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# NMFS Southwest Fisheries Science Center

**Draft Agency Report to the Technical Subcommittee**

**of the Canada-U.S. Groundfish Committee**

**April 2016**

Edited by Xi He and John Field

With contributions from Aaron Mamula
Susan Sogard, William Watson, Nick Wegner 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 SWFSC divisions 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. Identifying multiple brooding in rockfishes

Contact: Susan Sogard (susan.sogard@noaa.gov)
Investigators: David Stafford (UCSC), Lyndsey LeFebvre (UCSC), Neosha Kashef (UCSC), Sabrina Beyer (UCSC), John Field (FED, SWFSC) & Susan Sogard (FED, SWFSC)

Viviparous rockfishes (*Sebastes* spp.) most commonly produce one brood annually, however, multiple brooding within a reproductive season has been documented in a handful of rockfish species. Prevalence of multiple brooding appears to co-vary with geographic location and female size, with increased occurrence in southern California and in larger females. Our lab has observed evidence of multiple brooding in central California in chilipepper (*S. goodie,* Figure 1), rosy rockfish (*S. rosaceus*), speckled rockfish (*S. ovalis*), squarespot rockfish (*S. hopkinsi*), cowcod (*S. levis*) and boccacio (*S. paucispinis*) but the drivers of this process are unclear. Efforts are currently focused on Chilipepper rockfish off of central and southern California as a "model" population from which to better understand this phenomena, due to their healthy stock status, the observation that younger, smaller fish may also undergo atreasia (abortive maturation) which has consequences to maturity estimation, and a rich and growing dataset as a consequence of ongoing research efforts. Identification of multiple brooding, and determination of the proportion of occurrence, is essential for accurate projections of spawning output.

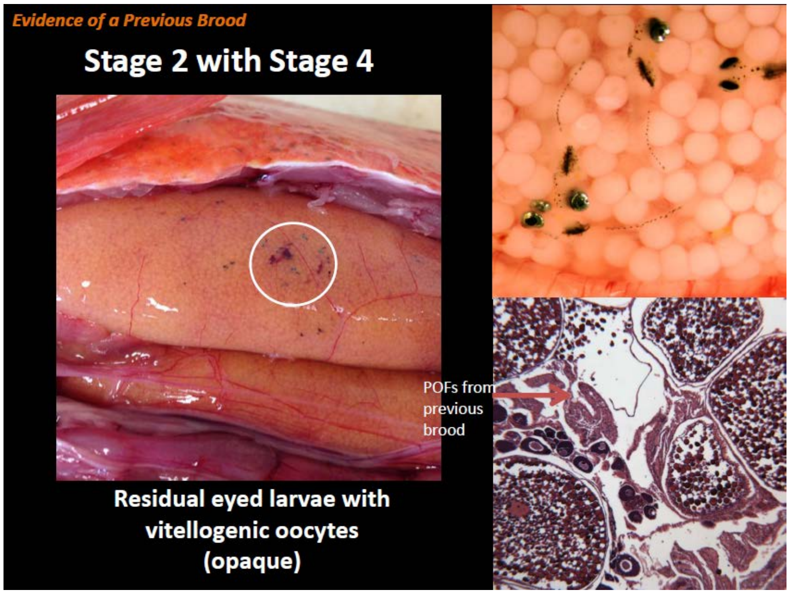



Figure 1. Evidence of multiple broods in a chilipepper rockfish. Residual larvae remaining in the ovary are evident with all three methods of macroscopic examination (left photo), microscopic inspection (top right photo) and histology (bottom right photo). POF = post-ovulatory follicle.

**B2. Effects of Hypoxia & Ocean Acidification on Critical Swimming Speed & Aerobic Scope in Rockfishes (*Sebastes* spp.)**
Contact: Susan Sogard (susan.sogard@noaa.gov)
Investigators: Neosha Kashef (UCSC), David Stafford (UCSC), Scott Hamilton (MLML), Evan Mattieson (MLML) & Susan Sogard (FED, SWFSC)

Future climate change predicts a 'double whammy' of reduced oxygen (hypoxia) occurring in conjunction with reduced pH (ocean acidification) in nearshore habitats of the California Current. We are using controlled laboratory experiments to test the sublethal effects of low dissolved oxygen and low pH on behavior and physiology of juvenile rockfishes. Initial experiments tested each stressor separately at 4 levels; future experiments will test varying combinations of the two stressors. Critical swimming speed was reduced for both species tested (blue and copper rockfish) at the lower levels of both stressors. Aerobic scope additionally declined with reduced dissolved oxygen levels for copper rockfish, but only at the most extreme treatment (Figure 2). Analyses are underway for other physiological responses as well as changes in gene expression associated with each treatment.

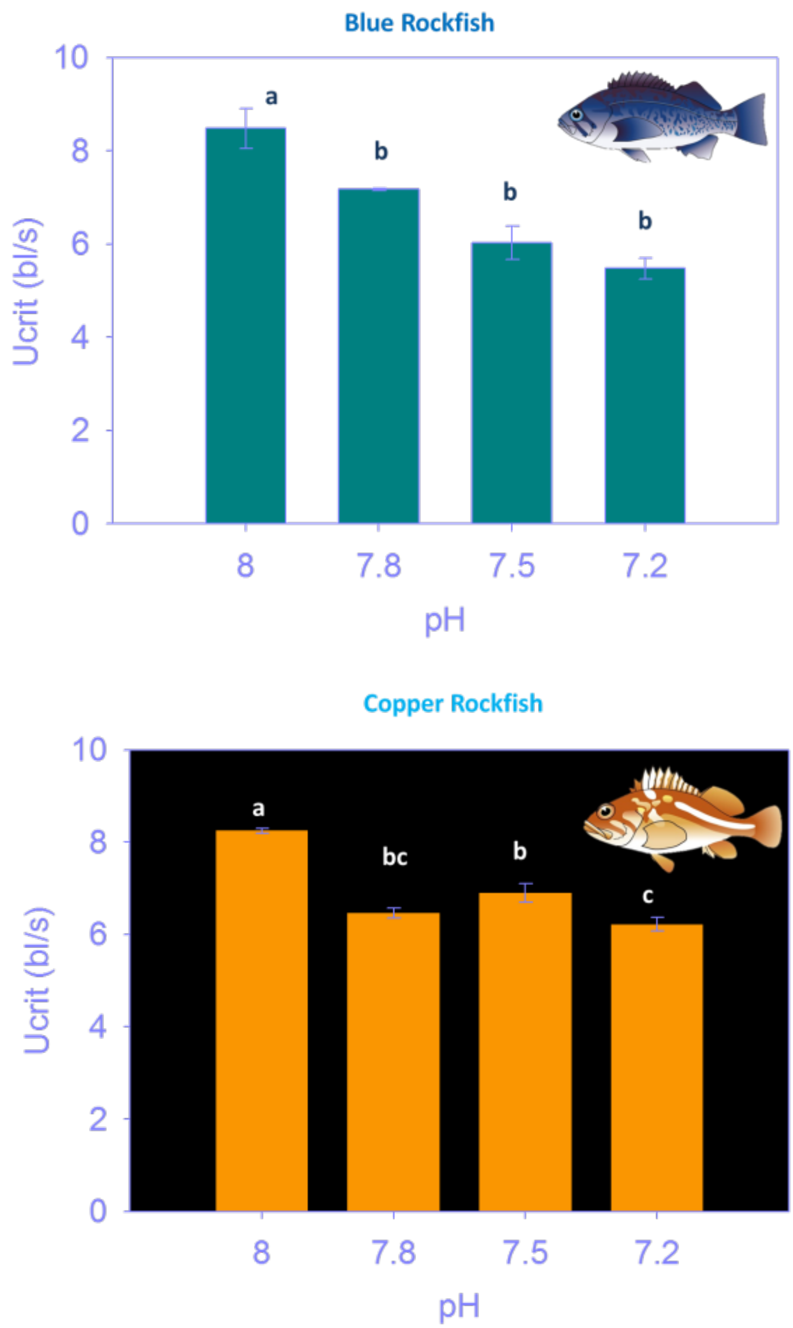



Figure 2. Critical swimming speed (Ucrit) as a function of pH in juvenile blue and copper rockfish. Bars with different letters were significantly different.

**B3. Ecosystem indicators for the Central California Coast, May-June 2015**

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 pelagic juvenile (young-of-the-year, YOY) rockfish (*Sebastes spp*.) and other groundfish off of Central California (approximately 36 to 38°N) since 1983, and has enumerated most other pelagic micronekton encountered in this survey since 1990 (Ralston et al. 2015). The survey, conducted in late spring (May-June), expanded the spatial coverage to include waters from the U.S./Mexico border north to Cape Mendocino in 2004. The primary objectives are to estimate the abundance of YOY rockfish and other groundfish for stock assessments and fisheries oceanography studies, but the survey also quantifies trends in the abundance and composition of other components of the micronekton forage assemblage (including other juvenile fishes, krill, coastal pelagic species, and mesopelagic species), as well as the collection of oceanographic information (CTD casts, continuous data on surface conditions and productivity, and acoustic data) and seabird and marine mammal abundance data. The data for the 2015 survey are preliminary, and corrections have been made in catch data for previous years which have resulted in very slight changes to overall abundance trends.

Figure 3: High pelagic young-of-the-year (YOY) rockfish catches off of Central California in the Spring of 2015

The 2015 data generally show a continuation of the very high catches of juvenile rockfish and Pacific sanddab in the core, southern and northern California areas; in fact in both the core and southern areas mean catches were the highest observed in the entirety of the time series (Figure 3, and see photo). Catches of octopus, lingcod (*Ophiodon elongates*), Pacific hake (*Merluccius productus*) and several other groundfish were also high, although north of Cape Mendocino, catches of YOY rockfish and her groundfish were at very low levels in both 2014 and 2015 (R. Brodeur, unpublished data). In addition to the high catches of YOY rockfish and other groundfish, catches tended to be very high for a suite of both less commonly encountered and less consistently reported (over the course of the time series) species, including record high numbers of pelagic red crabs (*Pleuroncodes planipes*), California spiny lobster (*Panulirus interruptus*) phyllosoma (pelagic larvae), and the largely subtropical krill *Nyctiphanes simplex*. Additionally, these included the first time catches (in this survey) of the greater argonaut (*Argonauta arga*), the slender snipefish (*Macroramphosus gracilis*), and the subtropical krill *Euphausia eximia*. These catches were likely a consequence of the 2014-2015 "blob" (warm water event) in the NE Pacific and the ongoing development of El Niño conditions throughout the region, however the 2015 survey results were unusual in that during past warm events (such as 1983, 1998 and 2005-06), YOY rockfish and other groundfish catches were at record low, rather than record high levels (Figure 4).

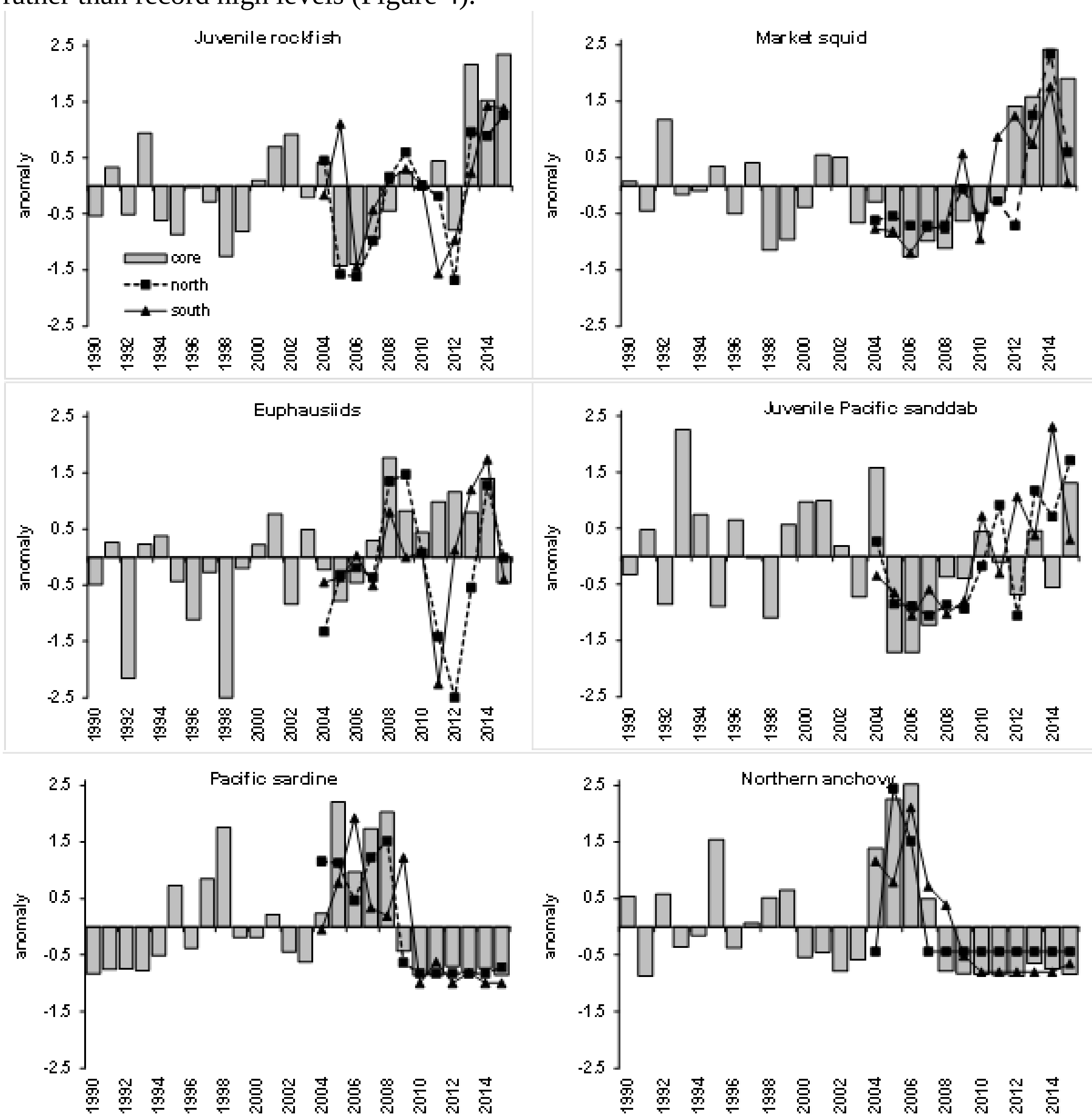


Figure 4: Long-term standardized anomalies of several of the most frequently encountered pelagic forage species from rockfish recruitment survey in the core (Central California) region (1990-2014) and the southern and northern California survey areas (2004-2014, excluding 2012 for the northern area).

**B4. Research on larval rockfish at the SWFSC**

Contact: William Watson (william.watson@noaa.gov)

Over the past year (2015-2016) the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division in La Jolla completed molecular identification of larval rockfishes collected from winter core CalCOFI stations between 1998 and 2013. The overall aim of this research is to develop a species-specific larval rockfish time-series and then use this 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 involved sorting rockfishes (which can mostly only be identified to the genus level 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. In total, we identified 39 species from the CalCOFI samples. Preliminary results indicate that the rockfish assemblage is dominated by diminutive species not targeted by fishing pressure. However, abundances of both targeted and untargeted species increased significantly over the 15-year period (Figure 5) and targeted species were relatively more prominent in recent years. We are currently in the process of completing analysis of this data and preparing manuscripts detailing the results. We are also evaluating the utility of this data for stock assessment.

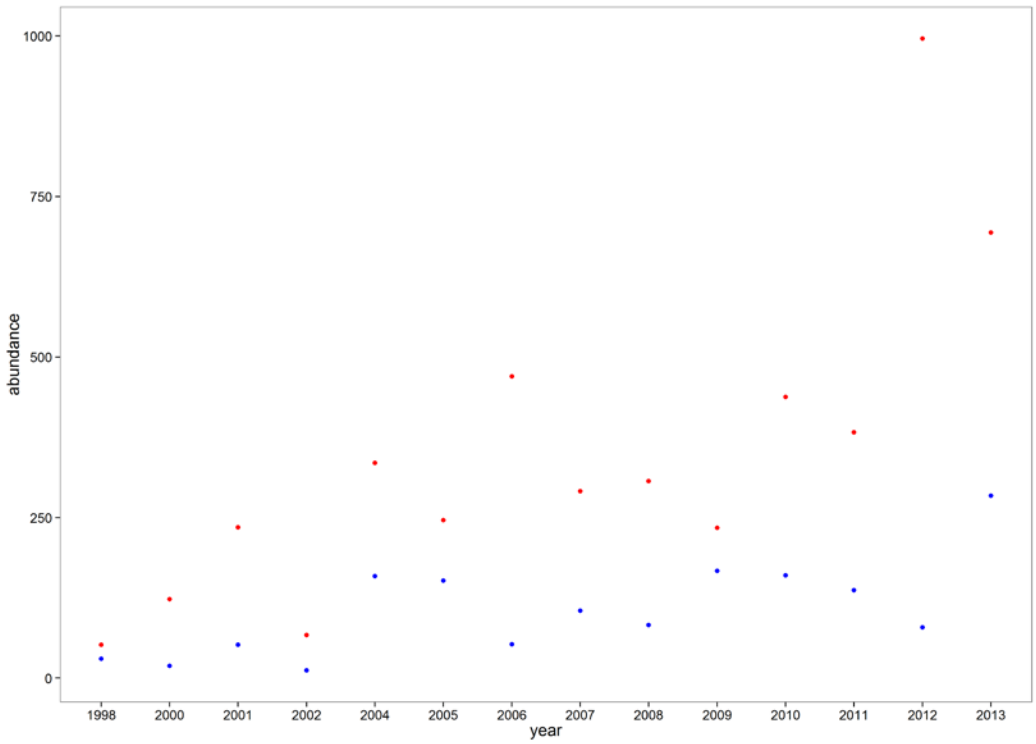


Figure 5. Total abundance of targeted (blue) and untargeted (red) rockfish larvae from winter CalCOFI samples.

In addition, we genetically identified larval rockfishes from a 2005 cruise that conducted fine-scale ichthyoplankton sampling from 95 stations witihn the southern California Bight (SCB). Here, we identified 36 rockfish species. Results indicated that targeted species were mostly found in the western portion of the SCB while untargeted species were more widespread (Figure 6). The abundance of targeted species was negatively correlated with temperature, primary productivity and depth and positively correlated with the amount of hard substrate on the benthos. By contrast, abundances of untargeted larvae were correlated positively only with hard substrate. These findings have been published (Thompson et al. 2016).

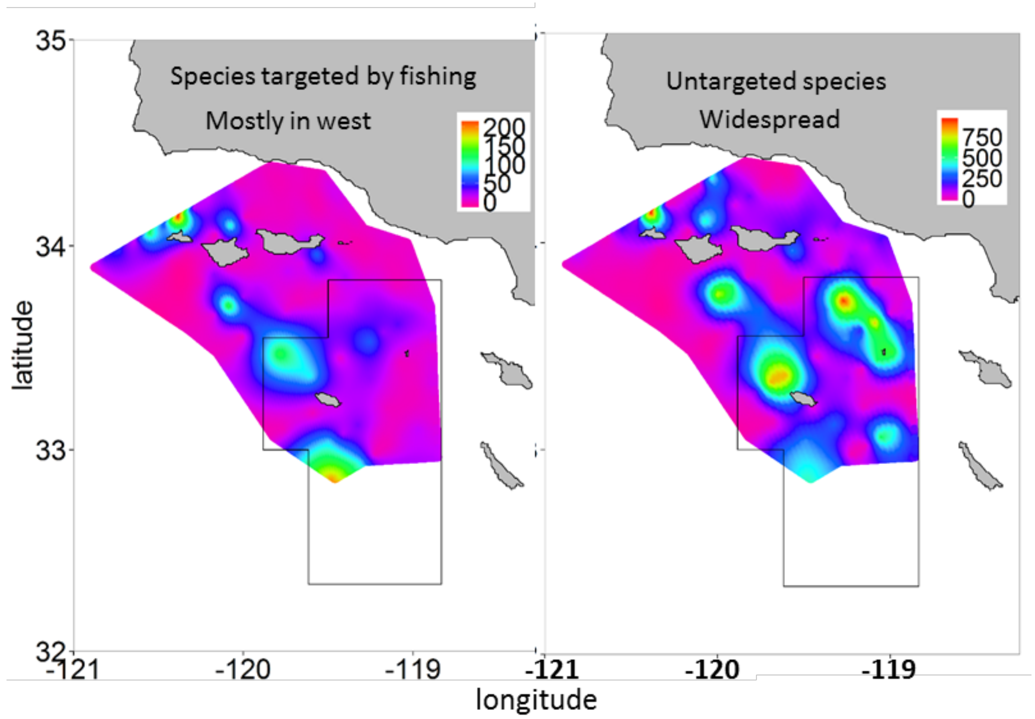



Figure 6. Abundances of larval rockfishes in winter 2005. Left panel depicts species targeted by fishing and the right panel untargeted species.

Finally, we have continued updating larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from mid-1964 through 2012, and by the end of this year expect to complete samples collected during the first half of 1964 in addition to completing samples collected in 2013. This will provide a 49 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

Contact: E.J. Dick (edward.dick@noaa.gov)

A full stock assessment for China rockfish (*Sebastes nebulosus*) was conducted in 2015 (Dick et al., 2015) and was reviewed by an external panel in July 2015. The assessment was then adapted by the Pacific Fisheries Management Council for fishery management. This assessment reports the status of the China rockfish resource in U.S. waters off the coast of the California, Oregon, and Washington using data through 2014. China rockfish are modelled with three independent stock assessments to account for spatial variation in exploitation history as well as regional differences in growth and size composition of the catch. The northern area model is defined as Washington State Marine Catch Areas. The central area model spans from the Oregon-Washington border to 40°10′ N. latitude. The southern area model spans 40°10′ N. latitude to the

U.S.-Mexico border. However, very little catch of China rockfish occurs south of Point Conception, California (34º27′ N. latitude).

Estimated spawning output in the northern area (Washington State) declined between the 1960s and 1990s but has been largely stable during the past two decades. The estimated relative depletion level (spawning output relative to unfished spawning output) of the northern stock in 2015 is 73.4%. The central area model for China rockfish estimates that spawning output is just above the biomass target in 2015. The rate of spawning output decline is estimated to be steepest during the 1980s to 1990s and continued to decline from the early 2000s at a slower rate to an estimated minimum of 39.6% in 2014. The estimated relative depletion level of the central stock in 2015 is 61.5%. The assessment for the southern management area suggests that China rockfish were lightly, but steadily exploited since the early 1900s, with more rapid declines in spawning output beginning with development of the recreational Fishery in the 1950s. The estimated relative depletion level of the southern stock in 2015 is 29.6% (~95% asymptotic interval: ± 25.0% - 34.3%). Although spawning output in the southern area is more depleted than the central and northern areas, it is the only area with an increasing trend over the past 15 years.

### C2. Shelf Rockfish

#### C2.a. Rockfish barotrauma and survival research at SWFSC Lo Jolla Lab

Contact: Nick Wegner (nick.wegner@noaa.gov)

The Genetics, Physiology, and Aquaculture program at the SWFSC 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. In 2015 we recovered 21 out of 22 acoustic receivers deployed at our main study site on the 43 fathom bank, and to date we now have data back from 54 bocaccio (*S. paucispinis*), 47 cowcod (*S. levis*), 13 sunset rockfish (*S. crocotulus*), 12 bank rockfish (*S. rufus*), and three starry rockfish (*S. constellatus*) that had been outfitted with accelerometer and depth sensing transmitters. The large number of receivers in our array have allowed us to incorporate 3D tracking of individual fish in addition to the basic behavior and survival data. These tracking data will thus provide a rare insight into natural movements (horizontal and vertical) at fine temporal (~ 4min data points) and spatial scales, allowing us to better understand habitat and foraging behavior that will ultimately inform capture probabilities in visual and acoustic based surveys.

In addition to fish tracking, multiple oxygen as well as temperature and depth loggers were deployed between 80 and 200m at the 43 fathom bank 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. Twelve of our tagged bocaccio were also outfitted in 2014/2015 with dissolved oxygen sensor tags to monitor fine-scale oxygen preferences. Additional bocaccio have been brought into captivity for measurement of both $O_{2critical}$ and $O_{2lethal}$ levels to determine their sensitivity to hypoxia. These data show that bocaccio need approximately 58% oxygen saturation to meet full metabolic demands and that below 28% saturation aerobic respiration sets in. 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.

While our research has shown relatively high survival rates of adult cowcod and other species released with descending devices at the 43-fathom bank, recent increases in the incidental catch of juvenile cowcod in Southern California within legal fishing limits have highlighted the need for additional estimates of post-release survival of juvenile animals captured at shallower depths. In addition, information is limited regarding the extent to which descending devices are actually used in the recreational fleet and the effectiveness of each type of descending device. In cooperation with both the recreational Commercial Passenger Fishing Vessel (CPFV) fleet and commercial (live-fish) vessels, we have recently begun a project to use acoustic telemetry to measure movements and survival of juvenile cowcod along the San Diego coastal shelf. As part of this project, we will also estimate angler preferences for and effectiveness of different descending devices onboard CPFVs. This project will yield three products: quantitative information essential to rebuilding cowcod populations, significantly improved collaborative relationships between numerous stakeholders, and greatly increased public awareness of rockfish management efforts.

**C2.b. Stock assessments**

Contact: John Field (john.field@noaa.gov)

Two stock assessments were conducted in 2015. One is a full stock assessment for Bocaccio (*Sebastes paucispinis*. It is the first time the stock is fully assessed since 2009, and also the first time that the otolith ageing data were used in the recent assessments (He et al., 2015). The second one is an update stock assessment for Chilipepper rockfish (*Sebastes goodei*) in the California Current (Filed et al., 2015). Both assessments were adapted by the Pacific Fisheries Management Council for fishery management.

This Bocaccio assessment reports the status of the species off of the West Coast of the United States, from the U.S.-Mexico border to Cape Blanco, Oregon (representing the Conception, Monterey and Eureka INPFC areas). Although the range extends considerably further north, there is some evidence that there are two demographic clusters of Bocaccio, centered around southern/central California and the West Coast of British Columbia, with a relative rarity of Bocaccio (particularly smaller fish) in the region between Cape Mendocino and the mouth of the Columbia River. In addition to catch, survey and length composition data, ageing data (from over 8,000 otoliths) from the recent ageing project in the Fisheries Ecology Division were used in the assessment. The assessment estimates increasing trends of total biomass and spawning outputs in recent years, and a current (2015) depletion level for the stock is estimated to be 36.8% of unfished level.

The Chilipepper assessment is an update for the stock between the U.S./Mexico border and the Columbia River, and is the first update since 2007. The update maintins the same fundamental model structure as the 2007 assessment. New estimates of historical catch data from catch reconstructions were included in the model. Commercial and recreational age and length composition data from 2007-2014, as well as a revised NWFSC bottom trawl survey index, and a revised pelagic juvenile survey abundance index (as an indicator of year class strength) were included in the update. Age composition data not available in 2007, primarily from bottom trawl surveys, were included. Some refinements to life history data (relative fecundity, maturity relationship) were also made. Most data revisions or additions had some influence on model estimates of stock status, but very few resulted in substantive changes to the model estimate of relative stock status. The stock depletion is estimated to be 63.9% of unfished level, well above the target level.

## D. OTHER RELATED STUDIES

### D1. SWFSC FED Habitat Ecology Team 2015-16 Research on California Demersal Communities

Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)

The SWFSC/FED Habitat Ecology Team (HET) conducts research focused on deep-water California demersal communities. Our goal is to provide sound scientific information to ensure the sustainability of marine fisheries and the effective management of marine ecosystems, with objectives to: (1) improve stock assessments, especially of overfished rockfish species in untrawlable habitats; (2) characterize fish and habitat associations to improve EFH identification and conservation; (3) contribute to MPA design & monitoring; and (4) understand the significance of deep-sea coral as groundfish habitat. The HET uses a variety of underwater vehicles to survey demersal fishes, macro-invertebrates (including members of deep-water coral communities), and associated seafloor habitats off central and southern California. These surveys have resulted in habitat-specific assemblage analyses on multiple spatial scales; fishery-independent stock assessments; baseline monitoring of MPAs; documentation of marine debris on the seafloor; and predictive models of the distribution and abundance of groundfishes and deepsea corals. The following are a few examples of recent projects conducted by the HET and collaborators.

### D2. Characterizing deep-sea coral and sponge communities in areas of high bycatch in bottom trawls off Northern California

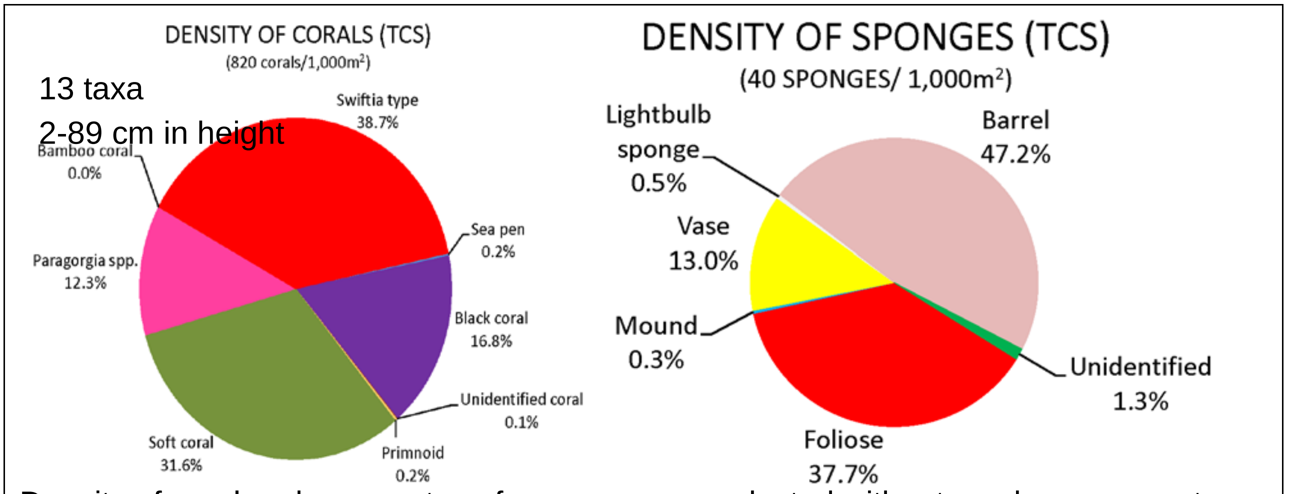
Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)

The FED Habitat Ecology Team and NWFSC collaborators recently used an autonomous underwater vehicle (AUV) and towed camera system (TCS) to visually survey deep-sea corals, sponges, and seafloor habitats for the first time in areas of longtime trawl fishing off northern California. During an 11-day cruise aboard the R/V Point Sur, researchers completed 6 dives with the AUV and 9 deployments of the TCS, and spent over 42 hours underwater at depths of 586-1169 meters from the Oregon-California border to the Mendocino Ridge.

Over 60,000 images of corals, sponges, fishes and other marine life were recorded with digital, paired still cameras during daytime operations. Nearly 48,000 corals from at least 23 taxa were observed, including black corals, bamboo corals, and gorgonians, some of which may be hundreds if not thousands of years old. Sponges occurred on most of the dives, with a total of 5,200 individuals represented by 13 taxa. There were only a few instances of fishes (mostly

Sebastolobus spp.) in close association with corals and sponges.

Fishermen have long known that corals occur in this area off northern California, having retrieved parts of corals in their fishing nets along with the harvested fishes. Areas of relatively high numbers of corals also have been recorded in NMFS West Coast groundfish bottom trawl surveys. From the exploration of these sites with cameras, we have begun to determine the extent of these coral colonies for the first time. The highlight of the cruise was discovering forests of relatively small corals on rocky ridges adjacent to the trawl grounds. These areas of rough terrain likely have received less fishing pressure in recent years, with the elimination of large roller gear on the trawl nets. Further analyses of data from this cruise and additional surveys in nearby areas will improve our understanding of the influence of fishing on coral communities and will inform decisions to protect and conserve these sensitive habitats.

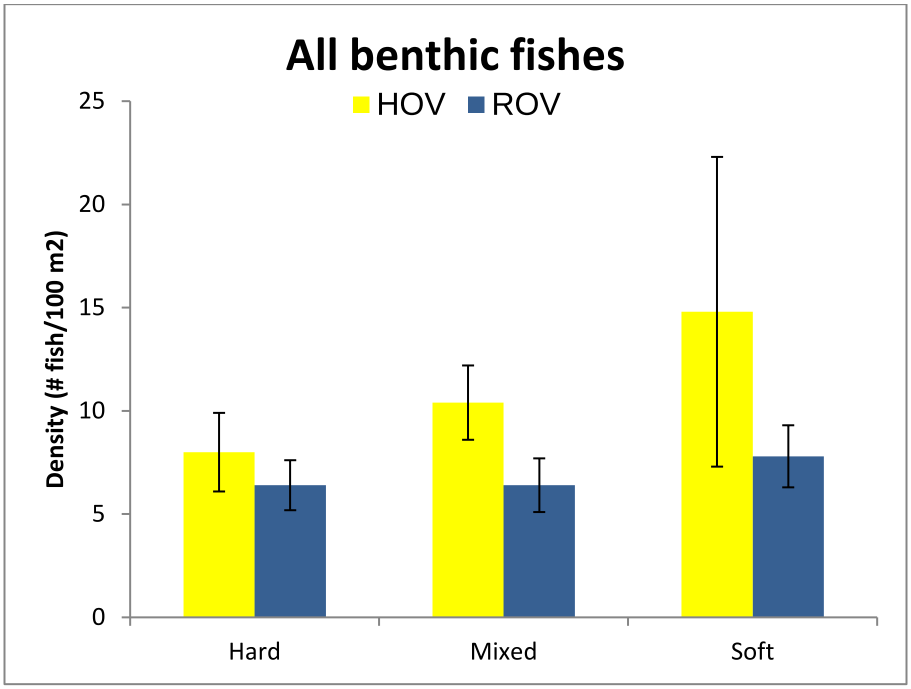



Density of coral and sponge taxa from surveys conducted with a towed camera system (TCS) at depths 600-770 m off northern California.

**D3. Evaluating densities and related behaviors of Pacific groundfishes using two visual-survey vehicles**

Contact: Tom Laidig (tom.laidig@noaa.gov)

Visual surveys of sea floor communities in deep water are becoming more common, and the results are being used to provide fishery-independent abundance estimates and to improve stock assessments for some groundfish species. When selecting a survey vehicle for visual assessments, associated assumptions, biases, and limitations must be considered. To examine some of these issues, the HET estimated fish densities using two survey vehicles (a manned submersible and a remotely operated vehicle [ROV]), and considered vehicle capabilities and fish reactions as related to these estimates. Visual surveys were conducted in three benthic habitat types in deep water off the coast of central California. Over 4,000 fishes were counted from the manned submersible and >6,000 from the ROV. Fish densities were estimated from 28 paired strip transects.




Higher densities of benthic fishes were observed from submersible surveys than from ROV surveys in hard, mixed, and soft habitats. Interestingly, a higher percentage of benthic fishes reacted to the ROV compared to the submersible, which may in turn reflect the lower densities in ROV surveys. Differences in fish detection and identification also were observed between vehicles, for example densities of unidentified rockfishes, unidentified Sebastomus, and unidentified fishes were significantly lower in submersible surveys compared to ROV surveys.

**D4. FY16-17 NMFS Untrawlable Habitat Strategic Initiative: Southern California Bight Test Bed**

Contact: Mary Yoklavich (mary.yoklavich@noaa.gov)

NMFS Untrawlable Habitat Strategic Initiative (UHSI) Team has initiated field research in the Southern California Bight to further our understanding of the effects of mobile survey vehicles on the behavior of rockfish species living in deep rocky habitats. Surveillance platforms with paired visual and acoustic (DIDSON) cameras will be used to observe rockfish movement and behavior in response to various survey tools (e.g., AUV, manned submersible, and other systems) in order to estimate efficiency of these tools to count and measure demersal rockfish species. In FY16 we are developing and testing the necessary tools and deployment methods, and monitoring fish reactions to underwater lighting of various types and intensities. We also are characterizing the spectral sensitivity and reflectance of rockfishes in order to minimize impacts of light on fishes while maximizing detection and identification of the fishes. A full-scale field study will be conducted in FY17. The research in Southern California complements an ongoing experiment conducted in the Gulf of Mexico (GOM) to monitor the effects of mobile optical and acoustic survey gear in shallow water using ambient light. The GOM study yielded important information on fish reaction to survey vehicles and provides valuable insights on survey and equipment designs. The UHSI experiments in Southern California will be conducted by a team of researchers from Southwest Fisheries Science Center, Northwest Fisheries Science Center, and Alaska Fisheries Science Center, along with academic partners.

**D5. Diet composition and foraging ecology of U.S. West Coast groundfishes, with applications for fisheries management**

Contact: Joseph Bizzarro (joseph.bizzarro@noaa.gov)

Determining the prey composition and foraging habitats of U.S. West Coast groundfishes is a mandated but neglected component of the Magnuson-Stevens Fishery Conservation and Management Act. To address this lack of consideration, HET researchers and NWFSC collaborators accumulated and analyzed diet composition data for 18 species of interest to the Pacific Fishery Management Council's review of West Coast groundfish essential fish habitat (EFH). A Major Prey Index was developed to evaluate relative importance among 47 prey taxa. Using this metric, euphausiids, polychaetes, amphipods, brachyuran crabs, and unidentified teleosts were the most important major prey items. When 14 generalized prey categories were used, fishes represented the dominant taxon (mean weight/volume = 32.3%), followed by shrimps (11.5%), crabs (10.0%), and euphausiids (9.5%). From a PERMANOVA analysis, species-specific differences were the primary source of variability in diet composition among tested variables (life stage, habitat, taxonomic group). West Coast groundfishes mainly were characterized as mesopredators having estimated trophic levels ranging from 3.4 to 4.2. Foraging habitats differed significantly within functional (benthic, demersal, pelagic) and taxonomic (elasmobranch, roundfish, rockfish, flatfish) groups. Using hierarchical agglomerative cluster analysis we identified a benthic guild (juvenile, juvenile–adult Dover Sole; juvenile–adult English Sole) that forages on polychaetes and hard-shelled molluscs and a midwater guild (juvenile Pacific Hake; juvenile–adult Darkblotched Rockfish) that forages on euphausiids. Our findings fill important data gaps in the trophic ecology and habitat-based management of commercially important species and can be used to inform future reviews of West Coast groundfish EFH.

**D6. SWFSC FED Economics Team Activities**

Contact: Aaron Mamula (aaron.mamula@noaa.gov)

Landing receipts are an important source of economic data on West Coast commercial harvest. Currently, considerable effort is required to join these data with other important sources of economically relevant information such as permit ownership, vessel characteristics, and dealer/processor information. SWFSC/FED economists have been working with PacFIN staff to create database views that will expedite the retrieval of economic and behavioral data from PacFIN. Through a collaboration with Rob Ames at PacFIN, we have created an economic data view which combines landings receipts data with information on i) all federal and state commercial fishing permits attached to each vessel identifier and ii) key characteristics (length, weight, horsepower) of each vessel. This view also contains a field assigning each landing to an economically relevant sector designation. SWFSC/FED economists and PacFIN staff are continuing to work on enhancements to the PacFIN database. Ongoing projects include: i) adding a data table to PacFIN which will contain important location and employment information obtained from a survey of fish buyers, dealers and processors, and ii) the addition of tables containing key demographic and economic information for coastal counties. The tables will facilitate the economic analysis of impacts to fishing communities of important environmental, biological, or management changes in commercial fisheries.

The FED Economics Team continues to analyze data from the 2014 survey of California groundfish anglers. That survey was detailed in the 2015 TSC report. The team also continues to work with VMS data under a project initiated in 2014. VMS data is currently being utilized to gain insight into important socio-economic linkages between major West Coast fisheries.

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**STATE OF ALASKA**
**GROUNDFISH FISHERIES**

**ASSOCIATED INVESTIGATIONS IN 2015**

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, Miranda Westphal, 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

April 2016

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 2015

AGENDA ITEM VII. REVIEW OF AGENCY GROUNDFISH RESEARCH, STOCK ASSESSMENT, AND MANAGEMENT

## I. 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 140° 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 144° 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 staff is located in Sitka, Juneau, and Petersburg. Sitka staff is comprised of a fishery biologist, one full-time fishery technician, and a seasonal technician. Staff in Juneau includes the project leader and two full time fishery biologists, and Petersburg staff contains a fishery biologist and a seasonal fishery technician. In addition, the project provides support for port samplers in Ketchikan to allow sampling of groundfish landings at this port. The project also receives biometric assistance from ADF&G 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. Three resource assessment surveys and a marking survey were conducted in 2015. The ADF&G vessel the R/V *Medeia* is home ported in Juneau and is used to conduct the biennial sablefish marking survey, which was conducted in 2015.

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's Scallop Plan Team 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; and
7) 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; 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 National Marine Fishery Service (NOAA Fisheries, both the Alaska Regional office and the Alaska Fishery Science Center), 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), NOAA Fisheries, 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.

Groundfish fishery milestones for this ongoing ADF&G AKFIN program are primarily the annual production of catch records and biological samples. In calendar year 2015, ADF&G AKFIN personnel processed 17,538 groundfish fish tickets, collected 26,612 groundfish biological samples and measured 19,502 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 20152015

| ADF&G Region | |
|---|---|
| 1 - Southeast | 3,330 |
| 2 - Central | 2,416 |
| 4 – Westward (Kodiak, AK Pen.) | 10,708 |
| 4 – Westward (BSAI) | 1,084 |
| Total | 17,538 |

Groundfish Biological Data Collection - Calendar Year 2015

| ADF&G Region | AWL Samples Collected | Age Estimates Produced by Regional Personnel | Age Estimates Produced by the Age Determination Unit |
|---|---|---|---|
| 1 - Southeast | 4,091 | none | 10,465 |
| 2 - Central | 14,325 | 1,230 | 2,274 |
| 4 - Westward | 8,196 | 5,533 | N/A |
| Total | 26,612 | 6,763 | 12,739 |

**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, then summarized and made available to Pacific Fisheries Information Network (PacFIN).

Beginning in 2001, the agencies tasked with commercial fisheries management in Alaska (ADF&G, NOAA Fisheries, 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 teamhave implemented an electronic logbook application, ***eLogbook***, currently used by groundfish catcher processors and longline catcher vessels. The ***eLogbook*** will be expanded to be used for all federal groundfish and crab catcher vessels, in the near future. 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. Salmon fisheries are more diverse and seasonal than groundfish and crab fisheries. The ADF&G will always support conventional, paper-based reporting for smaller salmon buyers and processors. November 2015, the ADF&G adopted a regulation to require larger seafood processors to use the tLandings application for all tendered salmon. All tendered groundfish must be reported using the tLandings application, as well. We expect 70 percent of all salmon landings to be submitted electronically in 2016. Statewide shellfish and herring fisheries will be addressed in 2017.

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 2015, the IERS recorded more than 155,002 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/

In August 2015, the IERS system was in place for ten years. Given the tenure of this innovative reporting system, it was appropriate for the interagency managers to coordinate an evaluation and review of the IERS system with an emphasis on the costs and benefits to agency and industry stakeholders. The report from this analysis is available at: https://elandings.atlassian.net/wiki/display/tr/Review+of+IERS+with+an+Emphasis+on+Costs+and+Benefits+to+Stakeholders

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 NOAA Fisheries 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.

Detailed data are distributed to the State of Alaska Commercial Fisheries Entry Commission (CFEC) annually. As outlined in State of Alaska statue, 16.05.815, detailed groundfish data are available to the NOAA Fisheries-Alaska regional office from the eLandings repository 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, NOAA Alaska Science Center staff 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 Mark, Tag, and Age (MTA) Laboratory's Age Determination Unit (ADU) is the statewide groundfish and invertebrate age reading program based out of Juneau, AK. The ADU is responsible for providing age data support to regional commercial fisheries programs to monitor population health, assess stock size and growth, and research species life history. The ADU also is responsible for monitoring and improving the quality of age data through precision testing of production data and continual training of age readers. During 2015, the ADU received 7,442 otolith sets from central and southeast Alaska commercial and survey sampling (representing 7 groundfish species). The ADU distributed 12,742 ages to region managers, including data from samples received in previous years but processed in 2015. Age data quality is assessed through precision monitoring using additional, independent estimates. A random 30% of specimens and reads with outlying fish and otolith size-at-age are selected for precision testing (data are compared to estimated ranges from growth models; otolith measurements are described below). Discrepancies between precision tests and original ages are resolved through development of independent age estimates by the disputing readers. During 2015, quality control procedures resulted in an additional 8,592 age estimates. Personnel learn to interpret seasonal banding patterns through training with experienced age readers and independent reading of preprocessed age structures. Trained personnel also continue to calibrate on preprocessed structures to insure consistency of age estimates. Training and calibration procedures resulted in an additional 2,614 age estimates. Given production, quality control, and training procedures, the ADU recorded 10,803 groundfish ages.

Correlations have been found between fish length, otolith morphometrics, and age. The ADU collects otolith measurements and uses them to identify and resolve age estimation, specimen sequence, data entry, and species identification errors. During processing, otolith length, height, and weight are recorded from a minimum of one age structure per fish (18,151 otoliths in 2015, representing 14 groundfish species). To identify possible age estimation errors, the ADU compares fish length, otolith weight, and age to estimated fish and otolith size-at-age ranges for lingcod, yelloweye rockfish, rougheye rockfish, shortraker rockfish, and sablefish. Estimated sizes-at-age were developed from von Bertalanffy and exponential growth models, and reasonable error ranges per size were entered into a database table. To increase quality control efforts, the ADU recently developed estimated size-at-age ranges for central Alaska shortspine thornyhead fish length and otolith weight.

To ensure consistency of age criteria across programs, the ADU exchanged specimens and data, attended workshops, and presented research through the Committee of Age Reading Experts (CARE; Working Group of the TSC) in 2015. The ADU participated in a lingcod otolith age comparison and submitted a section on lingcod otolith pattern interpretation for addition to the CARE manual. The ADU also submitted updates to the sablefish pattern interpretation section of the manual and carried out additional analysis of otolith sizes of one-year-old sablefish for the CARE sablefish working group. ADU personnel also attended the 2015 CARE meeting and crustacean age workshop in Seattle, WA. During the meeting, personnel calibrated with other agencies on sablefish, lingcod, shortraker, and yelloweye rockfish pattern criteria. Personnel also presented on the ADU's use of fish and otolith measurements in quality control procedures, preliminary evaluation of multispecies bomb radiocarbon activity data for potential age validation, and measurements of otolith weight fluctuation due to drying and storage.

The ADU is funded by State of Alaska, AKFIN, and special project support. In fiscal year 2015 and 2016, approximately 60% was provided by the State of Alaska, 30% by AKFIN, and 8% from a research grant. During 2015, the ADU employed five people (approximately 50 man months) to age, process samples, enter data, maintain sample archives, measure samples, and complete other support tasks for both groundfish and invertebrates.

2. Description of the State of Alaska sport groundfish fishery program (Sport Fish Division)

ADF&G manages all sport 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 sport 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 sport 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 provides scientifically-based advice for assessment and management of halibut and groundfish.

Regional programs with varying objectives address estimation of sport 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.

a. Southeast Region Sport Fish

The Southeast Region extends from the EEZ boundary in Dixon Entrance north and westward to Cape Suckling, at approximately 144$^{o}$ W. longitude. 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 NOAA Fisheries.

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 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. 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 time 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 sport groundfish regulations, and dissemination of information to the public.

## IV. Review of Agency Groundfish Research, Assessment and Management

### **1.** Hagfish

1. Research

There was no research on hagfish during 2015

2. Assessment

There are no stock assessments for flatfish.

3. Management

A commissioner's permit is required before a directed fishery may be prosecuted for hagfish. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes. In 2015, one commissioner's permit was submitted for directed fishing of hagfish in **Southeast Region**; however, no fishing occurred for the permit.

4. Fisheries

There was no directed fishery for hagfish in 2015. Currently in the **Westward**, **Central**, and **Southeast Regions** hagfish are allowed up to 20% as bycatch in aggregate with other groundfish during directed fisheries for groundfish.

### **2.** Dogfish and other 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 Fisheries 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. A 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 2017. 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 J. 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. Two salmon sharks were reported harvested by interviewed anglers in 2015, and both fish were measured. Nineteen spiny dogfish were reported harvested by interviewed anglers in over 14,900 angler-days of effort. Nine length measurements were obtained from spiny dogfish in 2015. 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. Assessment

There is no stock assessment work being conducted on sharks in Central Region (Contact Dr. Kenneth J. 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 set net fishery in Yakutat. This action was an effort to minimize waste of dogfish in these 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. 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 Commissioner's permit. Directed fishing for dogfish is also allowed in Southeast Alaska under the terms of a Commissioner's permit but no permits have been issued in recent years.

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.

Sport 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. Sport demand for sharks continued to be low in 2015.

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 2015 in the **Central** or **Southeast Region**. In Cook Inlet, there was no harvest of spiny dogfish in 2015 and in PWS 0.3 mt was harvested.

Sport shark harvest in 2014 was estimated at 748 sharks of all species in Southeast Alaska and 1,353 sharks in Southcentral Alaska. The precision of these estimates was low; the Southeast estimate had a CV of 57% and the Southcentral estimate had a CV of 44%. 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 sport salmon shark harvest. The 2014 reported charter harvest from logbooks was 15 salmon sharks in Southeast Alaska and seven salmon sharks in Southcentral Alaska.

**3.** Skates

1. Research

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. From 2010 through 2013, all skate species of all sizes were tagged on ADF&G surveys. In addition to ADF&G's interest in skates, tagging was also in support of a UAF doctoral students work (Contact Dr. Kenneth J. Goldman).

2. Assessment

There are no stock assessments for skates.

3. Management

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 to be necessary for conservation and management purposes.

4. Fisheries

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 the authority of a Commissioner's permit 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 the Cook Inlet Area, big and longnose skate harvest as bycatch was 74.4 mt in 2015, a large increase from 24.4 mt in 2014. In PWS, skate harvest was 121.8 mt in 2015, more than twice the amount harvested in 2014, 54.6 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. Retention of big skate incidental catch was closed by emergency order in both Cook Inlet and PWS on February 11, 2015 in response to the federal CGOA closure due to the TAC being achieved.

## **4.** 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.

### 1. Research

In the **Central Region**, skipper interviews and biological sampling of commercial Pacific cod deliveries from Prince William Sound (PWS) and Cook Inlet (CI) area during 2015 occurred in Seward, , and Homer. Sample data collected included date and location of harvest, species, length, weight, sex, and gonad condition. Otoliths were collected from approximately 20% sampled fish. Data is provided to National Marine Fisheries Service (NMFS) for use in stock assessment (Contact Elisa Russ).

The **Westward Region** discontinued the cod-tagging program in 2011 that was initiated in 1997 in the Central, Western, and Eastern Gulf of Alaska. Of the 18,529 tagged cod released, a total of 1,272 were recaptured, a tag recovery rate of 6.86%. Tagged cod continue to be captured from earlier years, with 3 recovered in 2015. Fish spent from 1 to 2,503 days (6.86 years) at liberty. While 72% of Pacific cod were recovered within 0.6 – 30 km of their tagging location, much longer recapture distances have occurred. A total of 12 fish were recaptured more than 300 km from their tagging location, the maximum distance recorded was 614 km. The relatively small number of long distance recaptures show movement of cod 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.

### 2. Assessment

No stock assessment programs were active for Pacific cod during 2014.

### 3. 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 depletion. 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. Further changes were implemented in 2014 making allocation simpler, 85% of the GHL can be harvested by longline gear and 15% is allocated to mechanical jigging machine and hand troll and groundfish pot gear 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 sport fisheries in Alaska, and the season is open year-round. Sport 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.

4. Fisheries

Most of the Pacific cod harvested in **Southeast Alaska** are taken by longline gear in the NSEI Subdistrict during the winter months. For Central Region Pacific cod fisheries, 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. Total harvest in the CI parallel fishery doubled from 2014 to 2015 and in 2015 was at the highest level since 1999. In the most recent 5 parallel seasons in CI, longline took the largest percentage in 2015 at 81% of the harvest. Harvest in the CI state-waters was the highest since 2012. The total harvest during the PWS parallel fishery from 2002 to 2008 was at low levels, picked up in the next 6 years and jumped dramatically from 2011 to 2012 and then again in 2013; the largest increase occurred from 2014 to 2015 when the harvest increased more than fourfold. The PWS state-waters season had the lowest Pacific cod harvest since 2008, the year prior to longline becoming a legal gear type in the fishery, however, this was mainly due to an extended parallel season. 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 2015, 9% 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 424 mt of Pacific cod were harvested in Southeast state-managed (internal waters) fisheries during 2015 with 396 mt harvested from the directed fishery.

The 2015 GHLs for the state-waters Pacific cod seasons in the Cook Inlet and Prince William Sound Areas of the **Central** Region were 2,299 mt and 707 mt, respectively. The 2015 harvest from the Cook Inlet Area state-waters Pacific cod fishery totaled 1,509 mt and the Prince William Sound Area harvest totaled 104 mt. In Cook Inlet in 2015, state-waters GHLs were not achieved by pot and jig gear, and fishing with these two gear types was open all year in parallel or state-waters seasons. In PWS, the parallel longline season stayed open until it closed by regulation on June 10 and had a short state-waters season. Longline only harvested 88 mt and jig gear harvest was confidential due to only 2 vessels participating in the state-waters season. For the parallel season, longline gear harvested 100% of the total, 1,382 mt. In 2015, 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 2015 Pacific cod GHLs were 7,665 mt in the Kodiak Area, 5,366 mt in the Chignik Area and 11,611 mt in the South Alaska Peninsula Area. Total state-waters Pacific cod catch in the Kodiak, Chignik and South Alaska Peninsula was 5,497 mt, 4,649 mt and 10,826 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 2015 total state-waters Pacific cod catch in the Aleutian Islands District is confidential due to limited participation. 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 2015, the total state-waters catch for the Dutch Harbor Subdistrict was 8,000 mt.

Estimates of the 2015 sport harvest of Pacific cod are not yet available from the statewide harvest survey, but the 2014 estimates were 20,323 fish in **Southeast** and 40,381 fish in **Southcentral Alaska**. The estimated annual harvests for the prior five-year period (2009-2013) averaged about 11,000 fish in **Southeast** Alaska and 29,000 fish in **Southcentral** Alaska.

### **5.** Walleye Pollock

#### a. Research

In the **Central Region** skipper interviews and biological sampling of PWS commercial trawl pollock deliveries during 2015 occurred in Seward and Kodiak. Additionally, onboard observers were placed on vessels participating in the Cook Inlet Area pollock seine fishery occurring by Commissioner’s Permit from Homer. 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 1,230 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).

There are no bag, possession, or size limits for pollock in the sport fisheries in Alaska. Harvest of pollock is not explicitly estimated by the SWHS and no pollock harvest information is collected in charter logbooks or creel surveys in Southcentral or Southeast Alaska.

b. Assessment

No stock assessment work was conducted by the department on pollock in 2014 (Contact Dr. Kenneth J. 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. 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 2014, inhouse rockfish bycatch limits for this fishery were put into regulation in the Rockfish Management Plan, allowing only 0. 5% bycatch of rockfish during this pollock fishery. 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 Area (CI),** directed fishing for pollock is managed under a “Miscellaneous Groundfish” Commissioner’s permit. Initiated in December 2014, a Commissioner’s permit fishery for pollock using seine gear has been prosecuted. In 2015, season dates ran January 1 to March 31 and from October 1 to December 31 with an allowable annual harvest level set at 220,000 lb. In **Central Region**, pollock is also retained as bycatch to other directed groundfish fisheries, primarily Pacific cod (Contact Jan Rumble).

d. Fisheries

The 2015 PWS Pollock Pelagic Trawl fishery opened January 20, and continued through February 5th at noon, 16 days. The fleet rotated through with 6 vessels or less fishing in PWS at any one time. There were 35 landings made by 17 vessels. The total harvest for the fishery was 4,454 mt harvesting 99% of the guideline harvest level of 4,511 mt. Rockfish bycatch during the fishery totaled 11 mt well below the 31 mt of rockfish that was caught in 2014. In the Cook Inlet Area (CI) in 2015, aseine pollock fishery under the terms of a commissioner's permit was opened January 1 through March 31 and from October 1 to December 31. For this fishery, 99.8 mt of pollock was available and 13.3 mt was harvested in 2015. There were 2 permits issued for the fishery and both vessels participated; both vessels agreed to release confidential data. In addition, pollock was harvested in **Central Region** as bycatch to other groundfish fisheries; in 2015, 1.7 mt was harvested in PWS and 5.8 mt in CI (Contact Jan Rumble).

In Southeast, three commissioner's permits were submitted to fish for pollock, two with harvest by purse seine and one with harvest by jig. However, no fishing occurred in 2015 (Contact Mike Vaughn).

**6.** Pacific Whiting (hake)

1. Research

There was no research conducted on Pacific whiting (hake) in 2015.

2. Assessment

There are no stock assessments for Pacific whiting (hake).

3. Management

A commissioner's permit is required in **Central Region** and **Southeast Region** before a directed fishery may be prosecuted for Pacific Whiting (hake). This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for Pacific whiting (hake) in 2015. There was no directed fishery for Pacific whiting (hake) in 2015. Currently in **Central Region** and **Southeast Region** Pacific whiting (hake) are considered other groundfish and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

7. Grenadiers

1. Research

There was no research conducted on grenadiers in 2015.

2. Assessment

There are no stock assessments for grenadiers.

3. Management

A commissioner's permit is required in **Central Region** and **Southeast Region** before a directed fishery may be prosecuted for grenadiers. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for grenadiers in 2015. Currently in the **Central Region** and **Southeast Region** grenadiers are considered other groundfish and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

8. 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 commercial 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 are 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. Length, weight and age structures were collected from 1,378 yelloweye rockfish caught in the directed and halibut commercial longline fisheries. No biological samples of yelloweye rockfish were collected from the internal waters commercial 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 3,097 $km^2$ of seafloor within SEO. More importantly, over 1,706 $km^2$ of rocky habitat has been mapped. In 2015, a mapping survey was conducted jointly with the U.S. Geological Survey in the NSEO management area and surveyed approximately 849 $km^2$ area with 442 $km^2$ rocky habitat.

In addition, an age-structured assessment model for yelloweye rockfish has been submitted to the Gulf of Alaska Groundfish Plan Team and is under review (Contact Kristen Green).

Skipper interviews and port sampling of commercial rockfish deliveries in **Central Region** during 2015 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 with sampling goals for CI black rockfish met in both 2014 and 2015. Additional rockfish samples were collected from bycatch fisheries in CI and PWS with the sampling goal achieved or nearly achieved for quillback and yelloweye rockfish in both areas, and shortraker and rougheye rockfish in PWS. 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 ADF&G Age Determination Unit in Juneau. Additional sampling occurred during CI and PWS research trawl surveys (Contact Elisa Russ).

Due to budget shortfalls, no seafloor mapping surveys were conducted in Central Region in 2015. An evaluation of existing ROV survey and seafloor bathymetry data was done to determine the location and scale of the next ROV survey to be conducted in 2016. Commercial and sport DSR harvest density and current management concerns were studied to help guide this process. It was determined that the PWS Management Area should be the location of the 2016 survey. Sport fish DSR harvest in the PWS Management Area have increased steadily in recent years as has the commercial harvest since the inception of the directed Pacific cod longline fishery in 2009. The PWS Inside District has the most multibeam sonar data available from which more accurate seafloor habitat delineations can be made. Mapping the extent of available rocky habitat is necessary for conducting ROV surveys and estimation of population size. Some of the highest harvest rates occur in the outside district. Much of this district has not been mapped with multibeam and the only bathymetry data available from which to delineate habitat is from lower resolution single beam sonar surveys. The final habitat delineations will be made using a combination of analytical methods and heads-up digitizing using multibeam and single beam sonar data, seafloor sediment samples, visual observations, and survey catch data. Work on delineating rocky seafloor features for the inside and outside districts of PWSMA was begun in 2015 and will continue into the winter and fall of 2016 (Contact Mike Byerly or Dr. Kenneth J. Goldman).

The **Westward Region** continued port sampling of several commercial rockfish species and Pacific cod in 2015. 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 2015 season. Pacific cod otolith aging is ongoing.

The **Westward Region** also continued to conduct hydroacoustic surveys of black and dark rockfish in the Northeast, Afognak, and Westside districts of the Kodiak Management Area in 2015 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 2016 (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. A total sample size of 10,671 rockfish was obtained from the sport harvests at Ketchikan, Craig, Klawock, Wrangell, Petersburg, Juneau, Sitka, Gustavus, Elfin Cove, and Yakutat in 2015 (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 2015 total sample size from the sport harvests at Seward, Valdez, Whittier, Kodiak, and Homer was 4,661 rockfish (Contact Barbi Failor).

The Division of Sport Fish continued research in Prince William Sound on survival of rockfish following recompression. In 2015, dusky, tiger, canary, 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. Ninety 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 Jay Baumer).

b. 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 fathom 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). In the past, the yelloweye biomass estimate was expanded to the entire DSR assemblage by multiplying the proportion of other DSR species in the commercial catch (2–4.0%). However, in 2015, the non-yelloweye DSR biomass estimate was calculated from the catch data from 2010–2014 recreational, commercial, and subsistence fisheries; the non-yelloweye ABC was added to the yelloweye ABC to obtain a total for the entire 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 1,755 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, 2013 in SSEO, and 2015 in EYKT. Yelloweye rockfish density was 752 yelloweye per $km^2$ (CV=14%) for CSEO in 2012, 986 yelloweye per $km^2$ (CV=22%) in SSEO in 2013, and 1,755 yelloweye per $km^2$ (CV=25%) for EYKT in 2015. 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. There were no ROV surveys conducted in 2015. Due to the need to address more urgent management concerns, it was determined that population estimates on the management area or district scales are needed more quickly than what is being obtained using the current assessment approach. As discussed in the preceding research section of this report, a survey of the PWSMA was identified as the best location for the next ROV DSR assessment survey. This survey will be conducted in summer 2016. (Contact Mike Byerly or Dr. Kenneth J. 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, Afognak, and Westside 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 5$^{th}$ 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 2015 ABC for DSR was 293 mt, which resulted in a total TAC of 217 with a 182 mt to commercial fisheries and 35 mt to sport fisheries, and the 2016 ABC is set at 224 mt, resulting in a TAC of 188 mt for commercial and 36 mt for sport fisheries. The TACs are set after deducting the subsistence catch, 8 mt for 2015 and 7 mt for 2016. 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 has been applied to the current year's quota to estimate bycatch of DSR. This change in methodology was made for greater accuracy and was implemented once several years of landings were available under the DSR full retention regulation. This regulation has been in place 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 addition, logbooks are required to be filled out during the CI directed fishery and returned to the department. 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. In addition, a .05 % rockfish bycatch limit was established for the PWS pollock pelagic trawl fishery . Proceeds from rockfish landed in excess of allowable bycatch and harvest levels 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 2015, 51 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 2015, vessels made directed black rockfish landings in the Aleutian Islands Area but harvest information is confidential due to limited participation. 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 2015. 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 sport 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 2015 season, the entire **Southeast Alaska** region’s sport bag and possession limit for pelagic rockfish was five fish per day, 10 in possession. The non-pelagic rockfish regulations were set as follows:

Southeast Alaska Outside Waters: 1) 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.

Southeast Alaska Inside Waters: 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).

Sportfish 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 2015. Effort in the directed black rockfish fishery in Southeast Outside District (SEO) was low with 3.6 mt and only three vessels participating; consequently, directed harvest is confidential. Black rockfish harvest in all groundfish, halibut, and salmon troll fisheries in SEO was 7.8 mt. In addition, one application for a commissioner’s permit was made for directed fishing of black rockfish in inside waters. Because there are no GHLs set for black rockfish in internal waters by regulation, a commisioner’s permit is required. The harvest of black rockfish from this directed fishery in inside waters is confidential due to limited participation. The directed fishery for DSR in SEO only opened in the East Yakutat (EYKT) area. 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 those areas was not large enough to support an orderly fishery. Directed fishing for DSR was also opened in internal waters. The 2015 harvest of DSR by directed fisheries in EYKT was 33.2 mt and in internal waters (SSEI and NSEI) was 13.6 mt. In addition, DSR was taken as bycatch with 68.7 mt harvested in SEO and 17.8 mt in internal waters. Eighty-nine percent in SEO was harvested from the IFQ halibut or sablefish fisheries, and 89% in internal waters was harvested from the IFQ halibut fishery. Slope, PSR, and thornyhead rockfish were also taken as bycatch in internal waters with 70.8 mt harvested in 2014.

In the **Central Region**, in the Cook Inlet Area in 2015, the total rockfish harvest, including the directed jig PSR rockfish fishery and bycatch, more than doubled from 2014, with a harvest of 63.9 mt. PSR harvest comprised 59% of the total harvest with DSR at 38%, and slope rockfish (including thornyhead) at 3%. Most of the harvest came from the directed PSR fishery. In PWS, rockfish are only harvested as bycatch, there is no directed fishery. For PWS, the rockfish harvest exceeded the GHL by a small amount in 2015, the total was 69 mt. A majority of this rockfish bycatch was caught by longline gear (85%) with the remaining rockfish harvested by trawl gear (15%).
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. Sport rockfish harvest is typically estimated in numbers of fish. Estimates of the 2015 harvest are not yet available from the SWHS, but the 2014 estimates for all species combined were 193,098 fish in Southeast and 141,808 fish in Southcentral Alaska. The average estimated annual harvest for the prior five-year period (2009–2013) was 115,361 rockfish in Southeast Alaska and 110,687 fish in Southcentral Alaska.

## **9.** Thornyheads

### 1. Research

There was no research conducted on thornyheads in 2015.

### 2. Assessment

There are no stock assessments for thornyheads.

### 3. Management

A commissioner's permit is required before a directed fishery may be prosecuted for thornyheads. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

### 4. Fisheries

There was no directed fishery for thornyheads in 2015. In **Central Region** thornyheads are retained as bycatch up to 10% in aggregate with other groundfish during a halibut or directed groundfish fishery, with exceptions occurring for the bycatch allowance for the directed sablefish fishery (20%), Pacific cod (5%), and directed pollock trawl fishery (0.5%). For directed drift or set gillnet fisheries for salmon or herring up to 10% of thornyheads and other rockfish in aggregate may be retained. Any bycatch overages that occur are forfeited to ADF&G.

In **Southeast Region** thornyheads are retained as bycatch of up to 15% in aggregate with other rockfish for a directed DSR fishery, 5% in aggregate with other rockfish for halibut fishing and a directed lingcod fishery, 15% for a directed black rockfish, sablefish, and Pacific cod, 0% for a directed pot fishery for sablefish and Pacific cod, and 5% for a directed fishery in outside waters of **Southeast Region**. Any bycatch overages that occur are forfeited to ADF&G.

**10.** Sablefish

a. Research

In 2015, 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; however, in 2015 three commercial fishermen participated in the surveys and were allowed to sell their Personal Quota Share (PQS); thus, reducing the impact on the quota by approximately 30% for fish harvested and sold by the state. The department plans to allow permit holders to harvest their PQS aboard future NSEI longline surveys.

The survey CPUE for NSEI decreased in 2015 from 1.47 lb/hook in 2014 to 1.36 lb/hook in 2015. In the SSEI stock assessment, analyses revealed a decline in the overall longline survey CPUE index (round lb/hook) from 0.61 in 2014 (0.53 in 2015. There is a high proportion of immature fish in the SSEI longline and pot fisheries (>45% from 2011–2015) and in the SSEI survey (>55% from 2011–2015). In 2013, the SSEI 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 SSEI commercial fishery (40 to 60% of the annual commercial harvest), yet this area had been underrepresented in the department survey. The new survey design has been used since 2013.

A mark-recapture survey has been conducted using longlined pots since 2000 with this survey performed using the state vessel the R/V *Medeia* since 2012. In May and June 2015, 6,862 fish were marked and released in NSEI over the course of the tagging survey. Over the 18 day survey, 33 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 tagging survey is scheduled for 2016; due to budget restrictions, this survey is scheduled to occur biannually in the future rather than on an annual schedule.

In 2015, groundfish staff met with port samplers in Ketchikan and 26 ovary samples were collected from the SSEI pot and longline fisheries in order to determine if samplers were correctly classifying fish using macroscopic methods. During these fisheries it is difficult to accurately classify fish as immature or mature for inexperienced samplers, because there is little yolk development in mature fish with the spawning season months away. We hope to use the information and pictures collected from this study to develop guidelines for samplers to better distinguish mature and immature fish using macroscopic classification (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, 2013, and 2015 using pot longline gear. There were 1,203, 318, and 26 fish tagged in 2011, 2013, and 2015, respectively. CPUE was very low in 2013 with an average of 0.11 fish per pot. To date, 302 fish have been recaptured from the 2011 survey and 41 were captured from the 2013 survey. Of all tagged releases, 65% have been recaptured within PWS and 25% outside in the GOA with the remainder of unknown location. There is no PWS sablefish tagging survey planned for 2016.

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. With such small catches in the recent survey and the reduction in funding to continue this work, a request will be made for biometric support for analysis of all Central Region sablefish data (Contact Mike Byerly or Dr. Kenneth J. 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. In 2015, due to extremely low effort and poor fishery performance for the PWS fishery, sampling goals for sablefish were not achieved. The Cook Inlet Area fishery also showed decreased effort and fishery performance, however, sampling goals were still met. 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. 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 2015 recommended ABC of 447 mt for the NSEI fishery was calculated by applying the 2014 fishery mortality at age (based on a harvest rate of 7.1% using the $F_{50\%}$ biological reference point (BRP)) to the 2015 forecast of total biomass at age and summing across all ages. The 2015 ABC was a 4% increase from the 2014 ABC (432 mt), which was also based on the $F_{50\%}$ BRP (the harvest rate was 6.9% for 2014). 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 2015.

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 Area 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 2015 fishery GHL was 25.02 mt. In 2004, the BOF adopted sablefish fishery-specific registration, a logbook requirement, and a 48-hour trip limit of 1.36 mt in the Cook Inlet Area. For PWS, a limited-entry program that included gear restrictions and established vessel size classes was adopted in 1996.

Between 1996 and 2014, the PWS fishery GHL was set at 110 mt, which is the midpoint of the harvest range set by a habitat-based estimate. PWS fishery management developed 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 2015 PWS sablefish fishery had a guideline harvest level of 55.3 mt. This is a reduction of approximately 50% from the 2014 GHL, and is in response to declining trends in fishery catch per unit effort (CPUE) and harvest; harvest in 2014 was 43.9 mt. In addition, tagging studies conducted by the National Marine Fisheries Service (NMFS) and ADF&G indicate that sablefish populations throughout the Gulf of Alaska (GOA) including the PWS area are likely mixed. Therefore, the GHL was adjusted by applying the relative change each year in the NMFS GOA sablefish acceptable biological catch (ABC), which is derived from NMFS stock assessment surveys.

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 2015 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. Creel surveys in Southeast Alaska in 2015 sampled 114 sablefish, reflecting the small harvest relative to other species. The sablefish sport fishery in Southcentral Alaska was unregulated, with no bag, possession, or size limits. Port samplers in Southcentral Alaska measured one sablefish from the sport harvest, again reflecting the relatively small harvests.

d. Fisheries

In the **Southeast Region** the 2015 NSEI sablefish fishery opened August 15 and closed November 15. The 78 permit holders landed a total of 354 mt of sablefish. The fishery is managed by equal quota share; each permit holder was allowed 4.6 mt. In the NSEI fishery, the overall CPUE (adjusted for hook spacing expressed in round lb/hook) declined from 0.85 lb/hook in 2014 to 0.71 in 2015. The 2015 SSEI sablefish fishery opened June 1 and closed November 15. Twenty-two permit holders landed a total of 233 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. However, one of the longline permits did not fish in 2015. SSEI longline fishery CPUE has remained fairly stable in the last four years (0.30–0.33 lb/hook from 2012–2015) (Contact Kristen Green).

In the **Central Region,** the 2015 open access sablefish fishery in the Cook Inlet Area opened at noon July 15 and was open through the remainder of the calendar year. Four vessels participated and harvested 14.4 mt, the fourth year that the GHL was not achieved, and the lowest annual harvest since 1990. During the 2015 PWS sablefish fishery, harvest totaled 8 mt, was the lowest harvest on record, less than 10% of the historical average and a decrease of 36 mt from 2014 (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 2015 Aleutian Island fishery opened on March 14 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 2015 Aleutian Islands sablefish fishery was 69 mt. The season remained open until the November 7 closure date (Contact Miranda Westphal).

The most recent sablefish sport harvest estimates from the SWHS are for 2014. The estimated harvest was 8,622 fish in Southeast Alaska and 3,788 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 6,983 sablefish in Southeast Alaska and 267 sablefish in Southcentral Alaska in 2014 (Contact Bob Chadwick, Dan Bosch).

K. Lingcod

a. Research

Since 1996, 9,189 lingcod have been tagged and 499 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 2015 in Sitka, Yakutat, and Ketchikan with 1,067 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 318 lingcod samples collected in 2015 and 87% 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 2015. All lingcod were harvested incidental to other federal and state managed groundfish fisheries. The 2015 harvest totaled 28 mt in the Kodiak Area and 1 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 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 2015 included Juneau, Sitka, Craig/Klawock, Wrangell, Petersburg, Gustavus, Elfin Cove, Yakutat, and Ketchikan. Length and sex data were collected from 1,368 lingcod in 2015, primarily from the ports of Sitka, Ketchikan, Craig, Klwock, 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. The program sampled 530 lingcod from the sport harvest at Seward, Valdez, Whittier, Kodiak, and Homer in 2015. These ports accounted for the majority of sport lingcod harvest in Southcentral Alaska (Contact Barbi Failor).

b. 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 sport 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 generally 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 four 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, increased from 2010 to 2014, and declined again in 2015. Higher CPUE in recent years may be 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. There were no ROV surveys conducted in 2015. Due to the need to address more urgent management concerns, it was determined that population estimates on the management area or district scales are needed more quickly than what is being obtained using the current assessment approach. A similar analysis for lingcod to the one which was done for DSR discussed in the preceding rockfish research section of this report was conducted in 2015. As with DSR, the PWS Management Area was identified as the best location for the next ROV lingcod assessment survey. This survey will be conducted in summer 2016. (Contact Mike Byerly or Dr. Kenneth J. 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 (GHLs) 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. Cook Inlet also allows 20% bycatch levels for lingcod, however, no bycatch may be retained after the GHL is achieved.

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 2015 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, with 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 sport 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 2015 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 104 mt of lingcod in 2015. An additional 59 mt was landed as bycatch in halibut and other groundfish fisheries and 11 mt in the salmon troll fishery.

**Central Region** commercial lingcod harvests have primarily occurred in the North Gulf District of the Cook Inlet Area and PWS. Lingcod harvests in 2015 totaled 3.1mt in Cook Inlet and 9.2 mt in PWS. Approximately 41% of the lingcod harvest in Cook Inlet resulted from directed jig effort. In PWS, approximately 99% 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 2015. 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.

**Sport lingcod harvest** estimates from the statewide mail survey for 2014 (the most recent year available) were 13,528 lingcod in Southeast Alaska and 18,789 lingcod in Southcentral Alaska. The average estimated annual harvest for the prior five-year period (2009–2013) was 10,887 fish in Southeast Alaska and 22,019 fish in Southcentral Alaska.

L. Atka Mackerel

1. Research

There was no research on Atka mackerel during 2015.

2. Assessment

There are no stock assessments for Atka mackerel.

3. Management

A commissioner's permit is required in **Central Region** and **Southeast Region** before a directed fishery may be prosecuted for Atka mackerel. This permit may restrict depth, dates, area, and gear, establish minimum size limits, and require logbooks and/or observers, or any other condition determined to be necessary for conservation and management purposes.

4. Fisheries

There was no directed fishery for Atka mackerel in 2015. Currently in the **Central Region** and **Southeast Region** Atka mackerel are considered other groundfish and are allowed up to 20% as bycatch in aggregate during directed fisheries for groundfish.

M. Flatfish

a. Research

There was no research on flatfish during 2015.

b. 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 an ADF&G Commissioner’s permit. The permit may stipulate fishing depth, seasons, areas, allowable sizes of harvested fish, gear, logbooks, and “other conditions” deemed necessary for conservation or management purposes. No permits have been issued to harvest flatfish.

There are no bag, possession, or size limits for flatfish (excluding Pacific halibut) in the sport 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 sport fisheries in Southcentral or Southeast Alaska. Flatfish are occasionally taken incidentally to other species and in small shore fisheries, but the sport harvest is believed to be negligible.

d. Fisheries

Very little effort has occurred in the **Southeast** fishery in recent years. Since the 1998–1999 season only once vessel 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 NOAA Fisheries regulations and the flatfish fishery is managed under a parallel management structure. No permits to harvest flatfish were issued in **Central Region** during 2015.

N. Pacific Halibut and IPHC Activities

The sport halibut fishery is a focus of a statewide monitoring and management effort by the Division of Sport Fish. Data on the sport fishery and harvest are collected through port sampling in Southeast and Southcentral Alaska. Estimates of harvest and related information is 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 provides an analysis each year that is used by the Council to recommend regulatory changes for the charter fishery to keep its harvest within allocations specified in the Catch Sharing Plan for Guided Sport and Commercial Fisheries in Alaska. The Council’s recommendations are also considered by the IPHC and incorporated as annual management measures for the charter fishery. Estimates of sport harvest and associated analyses are posted on the North Pacific Fishery Management Council’s web page at http://www.npfmc.org (Contact Scott Meyer).

O. Other groundfish 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 species that do not already have regulations in place. 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.

Other Related Studies

Staff in the **Central Region** currently house 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 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 NOAA Fisheries in regulating fisheries in 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 2015 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 |
| 2015 | 24 | 35 | 2 | 10 | 96 | 5 | 112 |

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 herring fishery and some salmon assessments.

4. Statistical Area Charts

Digital groundfish and shellfish statistical area charts are available and can be viewed or downloaded at:
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps
(Contact Lee Hulbert)

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 |
| 2015 | 24 | 59 | Closed | 156 | 71 | 6 | 0 | closed |

Since 1998, marine sport 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

Sport Fisheries home page: http://www.adfg.alaska.gov/index.cfm?adfg=fishingSport.main

News Releases: http://www.adfg.alaska.gov/index.cfm?adfg=newsreleases.main

Rockfish Conservation page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportFishingInfo.rockfishconservation

Age Determination Unit Home Page:
http://mtalab.adfg.alaska.gov/ADU/http://mtalab.adfg.alaska.gov/ADU/

Region I, Southeast Region, Groundfish Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareasoutheast.groundfish

Gene Conservation Laboratory Home Page:
http://www.adfg.alaska.gov/index.cfm?adfg=fishinggeneconservationlab.main

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

Demersal shelf rockfish stock assessment document:
http://www.afsc.noaa.gov/REFM/Docs/2015/GOAdsr.pdf

Groundfish charts:
http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.groundfishmaps

VI. Publications

Byerly, M., B. Chadwick, H. Fitch, B. Failor, K. Goldman, K. Green, L. Hulbert, M. Jaenicke, K. McNeil, S. Meyer, J. Rumble, E. Russ, G. Smith, M. Stichert, and C. Worton. 2014. State of Alaska Groundfish Fisheries Associated Investigations in 2013, Prepared for the Fifty-fourth Annual Meeting of the Technical Sub-committee of the Canada-United States Groundfish Committee, April 2014.

Chadwick, B., B. Frenette, and T. Tydingco. 2015. Overview of the sport fisheries for groundfish in Southeast Alaska through 2014: a report to the Board of Fisheries. Alaska Department of Fish and Game, Special Publication No. 15-01, Anchorage.

Conrath, C.L., C.A. Tribuzio and K.J. Goldman. 2014. Notes on the reproductive biology of female salmon shark *Lamna ditropis*, in the eastern North Pacific Ocean. Trans. Am. Fish. Soc. 143:363-368.

Green, K., Van Kirk, K., Stahl, J., Meyer, S. and Jaenicke, 2015.M. 2015. Chapter 14: Assessment of the demersal shelf rockfish stock complex in the southeast outside district of the Gulf of Alaska. Pages 1219–1302 in Stock Assessment and Fishery Evaluation Report for 2016. North Pacific Fishery Management Council, Anchorage, AK2015. .

Meyer, S. C. and R. Powers. 2015. Analysis of management options for the Area 2C and 3A charter halibut fisheries for 2016. Unpublished report prepared for the North Pacific Fishery Management Council, December 2015. Available online at npfmc.legistar.com/gateway.aspx?M=F&ID=395e0f70-9f6d-41cd-bc16-2bd800648d2d.pdf (accessed 3/29/16).

Powers, B. and D.

Sigurdsson. 2016. Participation, effort, and harvest in the sport fish business/guide licensing and logbook programs, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-02, Anchorage.

Stahl, J. P., K. Green, A. Baldwin, and K. Carroll. 2015. Southern Southeast Inside commercial sablefish fishery and survey activities, 2014. Alaska Department of Fish and Game, Fishery Management Report No. 15-22, Anchorage.

Wessel, M., J. Rumble, K.J. Goldman, E. Russ, M. Byerly, and C. Russ. 2014. Prince William Sound Registration Area E Groundfish Fisheries Management Report, 2009-2013. Alaska Department of Fish and Game, Fishery Management Report No. 14-42, Anchorage. November 2014.

# APPENDICES

## Appendix I. Alaska Department of Fish and Game Full-time Groundfish Staff During 2016

### COMMERCIAL FISHERIES DIVISION

**HEADQUARTERS**, P.O. Box 25526, Juneau, Alaska 99802-5526

| | | |
|---|---|---|
| Chief, Computer Services<br>Kathleen Jones<br>(907) 465-4753 | Age Determination Unit Supervisor<br>Kevin McNeel<br>Box 115526<br>Juneau, AK 99811<br>(907) 465-3054 | Elandings Program Coordinator II<br>Gail Smith<br>(907) 465-6157 |
| Alaska Fisheries Information Network (AKFIN) Program Coordinator<br>Lee Hulbert<br>(907) 465-6109 | April Rebert<br>Box 115526<br>Juneau, AK 99811<br>(907) 465-1174 | |

**SOUTHEASTERN REGION**

| | | |
|---|---|---|
| Groundfish Project Leader<br>Andrew Olson<br>Box 240020<br>Douglas, AK 99824-0020<br>(907) 465-4259 | Fishery Biologist II<br>Jennifer Stahl<br>Box 240020<br>Douglas, AK 99824-0020<br>(907) 465-4071 | Fishery Biologist II<br>Mike Vaughn<br>304 Lake St. Rm. 103<br>Sitka, AK 99835<br>(907) 747-6688 |
| Project Biometrician<br>Kray Van Kirk<br>Box 240020<br>Douglas, AK 99824-0020<br>(907) 465-4216 | Fishery Biologist I<br>Aaron Baldwin<br>Box 240020<br>Douglas, AK 99824-0020<br>(907) 465-3896 | Fishery Technician IV<br>Kamala Carroll<br>304 Lake St. Rm. 103<br>Sitka, AK 99835<br>(907) 747-6688 |
| Fishery Biologist I<br>Asia Beder<br>P.O. Box 667<br>Petersburg, AK 99833-0667<br>(907) 772-5223 | Fishery Technician IV<br>Jennifer Dupree<br>P.O. Box 667<br>Petersburg, AK 99833-0667<br>(907) 772-5231 | Fishery Technician III<br>Naomi Bargmann<br>304 Lake St. Rm. 103<br>Sitka, AK 99835<br>(907) 747-6831 |

**CENTRAL REGION**

| | | |
|---|---|---|
| CI/PWS Groundfish & Shellfish Research Project Leader<br>Dr. Kenneth J. Goldman<br>3298 Douglas Place<br>Homer, AK 99603-7942<br>(907) 235-8191 | CI/PWS Area Management Biologist<br>Jan Rumble<br>3298 Douglas Place<br>Homer, AK 99603-7942<br>(907) 235-8191 | Groundfish Sampling and Ageing Coordinator<br>Elisa Russ<br>3298 Douglas Place,<br>Homer AK 99603-7942<br>(907) 235-8191 |
| Fish Ticket Processing and Data Analyst<br>Chris Russ<br>3298 Douglas Place,<br>Homer, AK 99603-7942<br>(907) 235-8191 | Fishery Biologist<br>Mike Byerly<br>3298 Douglas Place<br>Homer, AK 99603-7942<br>(907) 235-8191 | PWS Management Biologist<br>Maria Wessell<br>PO Box 669<br>Cordova, AK  99574-0669<br>(907) 424-3212 |

| | | |
|---|---|---|
| GIS Analyst<br>Josh Mumm<br>3298 Douglas Place<br>Homer, AK 99603-7942<br>(907) 235-8191 | Fishery Biologist<br>Martin Schuster<br>3298 Douglas Place<br>Homer, AK 99603<br>(907) 235-8191 | |

**WESTWARD REGION**

| | | |
|---|---|---|
| Shellfish/Groundfish Biologist<br>Wayne Donaldson<br>351 Research Ct<br>Kodiak, AK 99615-6399<br>(907) 486-1840 | Area Management Biologist<br>Mark Stichert<br>351 Research Ct., Kodiak, AK<br>99615-6399<br>(907) 486-1840 | Groundfish Research Biologist<br>Carrie Worton<br>351 Research Ct Kodiak, AK<br>99615-6399<br>(907) 486-1849 |
| Groundfish Sampling Coordinator<br>Kally Spalinger<br>351 Research Ct Kodiak, AK 99615<br>(907) 486-1840 | Assistant Area Management Biologist<br>Nathaniel Nichols<br>351 Research Ct<br>Kodiak, AK 99615<br>(907) 486-1840 | Area Management Biologist<br>Miranda Westphal<br>P.O. Box 920587<br>Dutch Harbor, AK 99692<br>(907) 581-1239 |
| Assistant Groundfish Research Biologist<br>Philip Tschersich<br>351 Research Ct<br>Kodiak, AK 99615-6399<br>(907) 486-1871 | Assistant Area Management Biologist<br>Justin Leon<br>P.O. Box 920587<br>Dutch Harbor, AK 99692<br>(907) 581-1239 | |

## SPORT FISH DIVISION

**STATEWIDE**, P.O. Box 25526, Juneau, Alaska 99802-5526

| | | |
|---|---|---|
| Deputy Director<br>Tom Brookover<br>333 Raspberry Road<br>Anchorage, AK 99518-1599<br>(907) 465-6187 | Statewide Bottomfish Coordinator<br>Scott Meyer<br>3298 Douglas Place<br>Homer, AK 99603-8027<br>(907) 235-1742 | Logbook Program Coordinator<br>Bob Powers<br>333 Raspberry Road<br>Anchorage, AK 99518-1565<br>(907) 267-2299 |

**SOUTHEAST REGION**

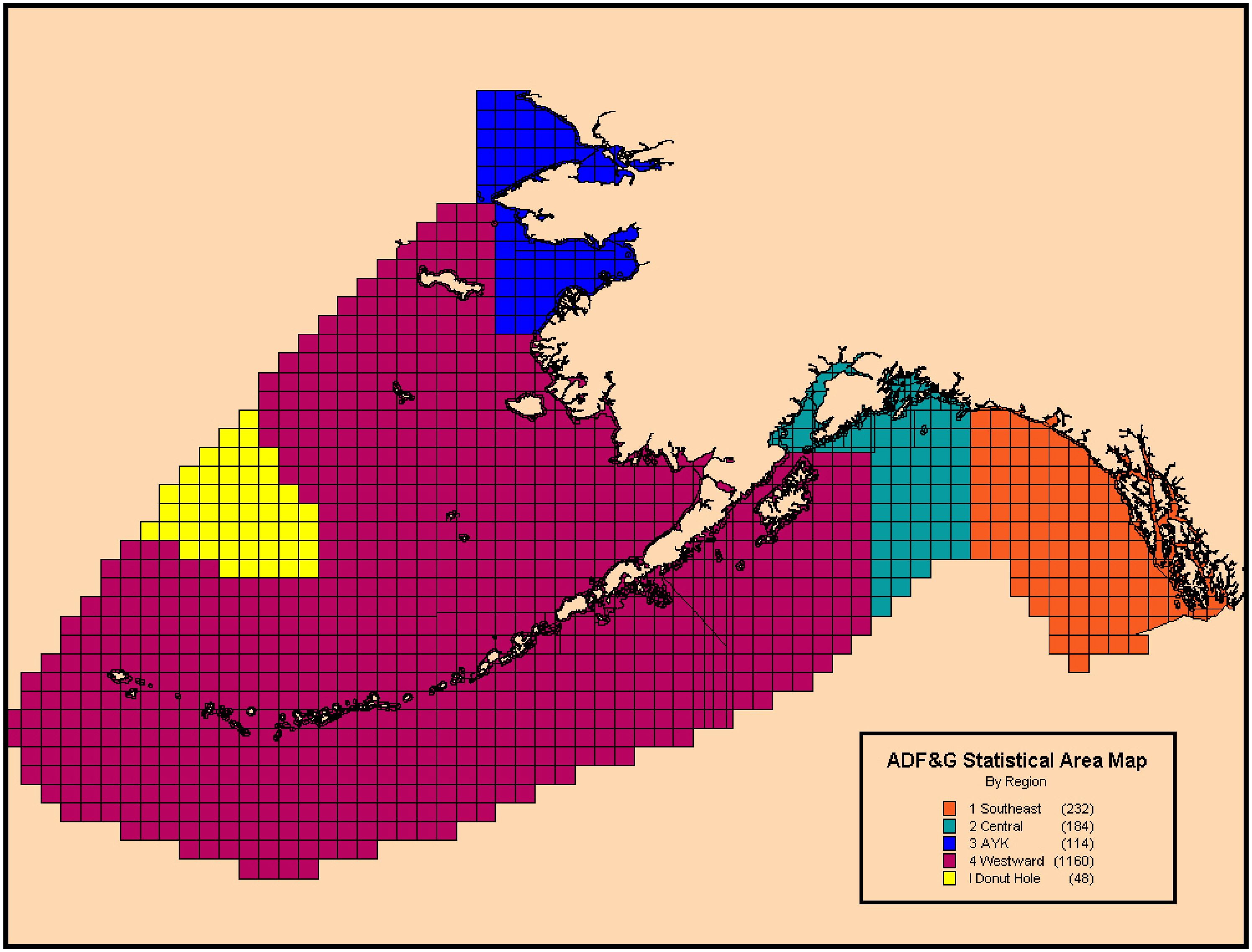
| | | |
|---|---|---|
| Project Leader, Marine Harvest Studies<br>Michael Jaenicke<br>PO Box 110024<br>Juneau, AK 99811-0024<br>(907) 465-4301 | Regional Management Biologist<br>Robert Chadwick<br>304 Lake St., Room 103<br>Sitka, AK 99835-7563<br>(907) 747-5551 | Regional Research Biologist<br>Jeff Nichols<br>P.O. Box 110024<br>Juneau, AK 99811-0024<br>(907) 465-4398 |
| Yakutat Area Management Biologist<br>Brian Marston<br>P.O. Box 49<br>Yakutat, AK 99689-0049<br>(907) 784-3222 | Haines/Skagway Area Mgmt. Biol.<br>Richard Chapell<br>P.O. Box 330<br>Haines, AK 99827-0330<br>(907) 766-3638 | Juneau Area Management Biologist<br>Daniel Teske<br>PO Box 110024<br>Juneau, AK 99811-0024<br>(907) 465-8152 |
| Sitka Area Management Biologist<br>Troy Tydingco<br>304 Lake St., Room 103<br>Sitka, AK 99835-7563<br>(907) 747-5355 | Petersburg/Wrangell Area Mgmt. Biologist<br>Patrick Fowler<br>P.O. Box 667<br>Petersburg, AK 99833-0667<br>(907) 772-5231 | Prince of Wales Area Management Biologist<br>Craig Schwanke<br>P.O. Box 682<br>Craig, AK 99921<br>(907) 826-2498 |
| Ketchikan Area Mgmt. Biologist<br>Kelly Piazza<br>2030 Sea Level Drive, Suite 205 | Biometrician<br>Sarah Power<br>Division of Sport Fish-RTS | |

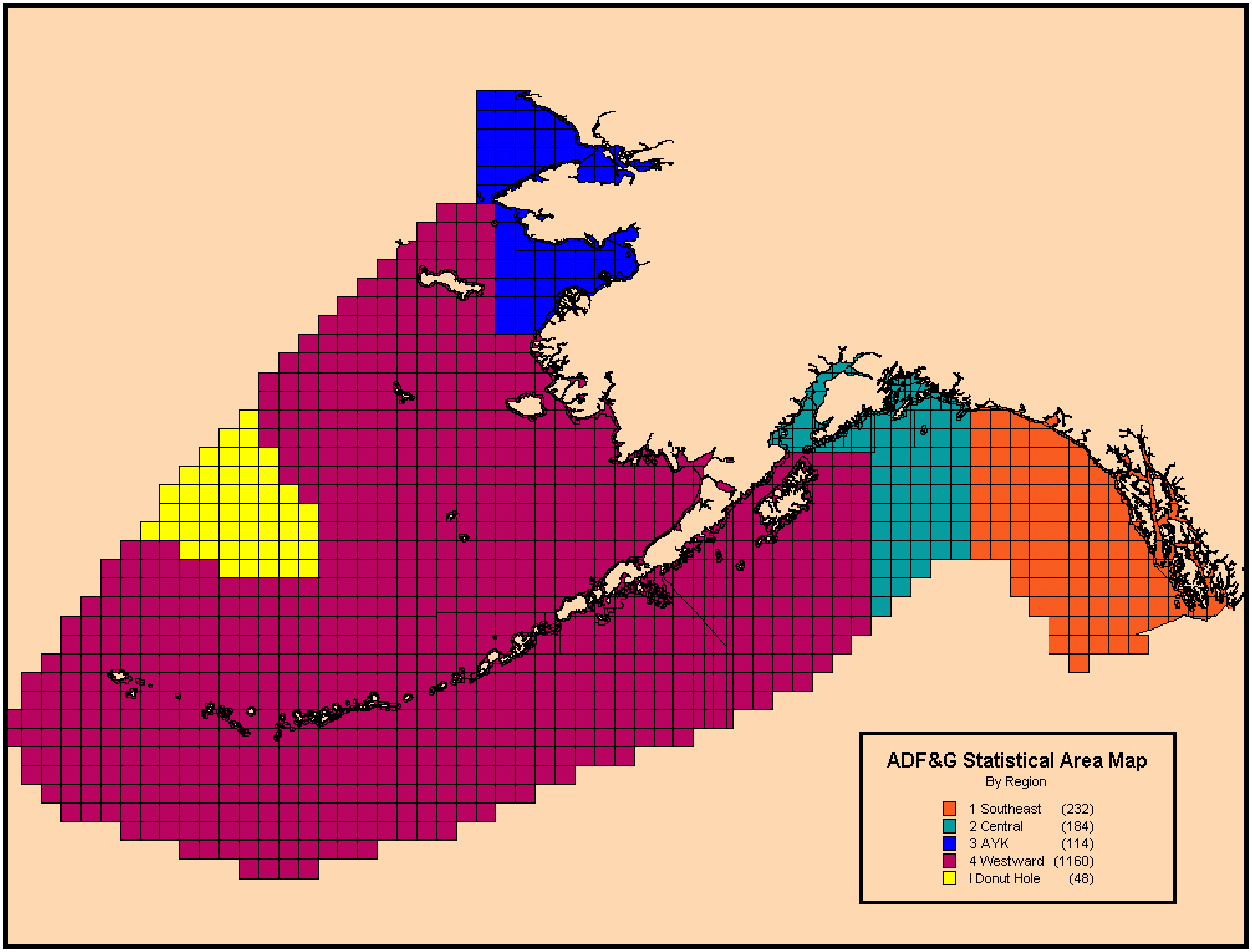
| | | |
|---|---|---|
| Ketchikan, AK 99901<br>(907) 225-2859 | PO Box 110024<br>Juneau, AK 99811-0024<br>(907) 465-1192 | |

**SOUTHCENTRAL REGION**

| | | |
|---|---|---|
| Halibut/Groundfish Project Leader<br>Barbi Failor<br>3298 Douglas Place<br>Homer, AK 99603<br>(907) 235-8191 | Regional Management Biologists<br>Dan Bosch, Matthew Miller<br>333 Raspberry Road<br>Anchorage, AK 99518-1565<br>(907) 267-2218 | Regional Research Biologist<br>Tim McKinley<br>333 Raspberry Road<br>Anchorage, AK 99518-1565<br>(907) 267-2218 |
| Lower Cook Inlet Mgmt. Biol.<br>Vacant<br>3298 Douglas Place<br>Homer, Alaska 99603-8027<br>(907) 235-8191 | PWS and North Gulf Mgmt. Biol.<br>Mike Thalhauser<br>333 Raspberry Road<br>Anchorage, AK 99518-1599<br>(907) 267-2153 | Kodiak, Alaska Pen., and Aleutian Islands Management Biologist<br>Donn Tracy<br>211 Mission Road<br>Kodiak, AK 99615-6399<br>(907) 486-1880 |
| | Biometrician<br>Adam Reimer<br>Division of Sport Fish-RTS<br>43961 Kalifornsky Beach Road, Suite B<br>Soldotna, AK 99669-8276<br>(907) 262-9368 | |

Appendix II. Map Depicting State of Alaska Commercial Fishery Management Regions.




ADF&G Statistical Area Map
By Region
1 Southeast (232)
2 Central (184)
3 AYK (114)
4 Westward (1160)
I Donut Hole (48)

Appendix III. Tissue samples of *Sebastes* species and pollock collected for genetic analyses and stored at Alaska Department Fish and Game, Gene Conservation Laboratory, Anchorage. Species, sampling location, year collected, sample size, and tissue type are given.

| Species | Location | Year | Sample size | Tissues |
|---|---|---|---|---|
| **Yelloweye rockfish, *Sebastes ruberrimus*** | | | | |
| | Gravina, Danger, Herring | 1991 | 27 | muscle, liver, eye |
| | Knight Is./Naked Islands area | 1998 | 100 | fin |
| | 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 |
| | Kachemak Bay | 1999 | 58 | fin |
| | Kodiak Island | 1999 | 115 | fin |
| | Resurrection Bay | 1999 | 100 | fin |
| | Fairweather Grounds | 1999 | 100 | fin |
| | SE Stat Areas 355601, 365701 (CSEO) | 1999 | 100 | fin |
| | Whittier | 2000 | 97 | fin |
| | Whittier | 2000 | 50 | fin |
| **Black rockfish, *S. melanops*** | | | | |
| | Kodiak Island | 1996 | 2 | muscle, liver, heart, eye |
| | Ugak Bay, Kodiak Island | 1997 | 100 | muscle, liver, heart, eye |
| | Resurrection Bay - South tip Hive Island | 1997 | 82 | muscle, liver, heart, eye, fin |
| | Carpa Island | 1998 | 40 | fin |
| | Eastside Kodiak Is.: Ugak and Chiniak Bays | 1998 | 100 | fin |
| | Southwest side Kodiak Island | 1998 | 86 | fin |
| | Westside Kodiak Island | 1998 | 114 | fin |
| | North of Fox Island | 1998 | 24 | fin |
| | Washington - Pacific Northwest | 1998 | 20 | fin |
| | Sitka | 1998 | 50 | fin |
| | Castle Rock near Sand Point | 1999 | 60 | fin |
| | Akutan | 1999 | 100 | fin |
| | Oregon - Pacific Northwest | 1999 | 50 | muscle, liver, heart |
| | SE Stat Areas 355631, 365701 (CSEO) | 1999 | 83 | fin |
| | Sitka Sound Tagging study | 1999 | 200 | fin |
| | Dutch Harbor | 2000 | 6 | fin |
| | Chignik | 2000 | 100 | fin |
| | Valdez | 2000 | 13 | fin |
| | Whittier | 2000 | 16 | fin |
| | Valdez | 2001 | 50 | fin |

| | | | |
|---|---|---|---|
| Whittier | 2001 | 93 | fin |
| Yakutat Bay | 2003 | 130 | fin |
| **Dusky rockfish, *S. ciliatus*** | | | |
| Kodiak Island | 1997 | 50 | muscle, liver, heart, eye |
| Resurrection Bay | 1998 | 3 | fin |
| Eastside Kodiak Is.: Ugak, Chiniak, Ocean Bays | 1998 | 100 | muscle, liver, heart, eye |
| Sitka Black RF Tagging study | 1999 | 15 | muscle, liver, heart, eye |
| Sitka | 2000 | 23 | liver, fin |
| Sitka | 2000 | 23 | fin |
| Harris Bay - Outer Kenai Peninsula | 2002 | 37 | muscle |
| North Gulf Coast - Outer Kenai Peninsula | 2003 | 45 | fin |
| **Walleye pollock, *Gadus chalcogrammus*** | | | |
| Exact location unknown; see comments | 1997 | 402 | fin |
| Bogoslof Island | 1997 | 120 | muscle, liver, heart |
| Middleton Island | 1997 | 100 | fin |
| NE Montague/E Stockdale | 1997 | 100 | fin |
| Orca Bay, PWS | 1997 | 100 | fin |
| Port Bainbridge | 1997 | 100 | fin |
| Shelikof Strait | 1997 | 104 | muscle, liver, heart, eye, fin |
| Bogoslof Island | 1998 | 100 | muscle |
| Eastern Bering Sea | 1998 | 40 | muscle, liver, heart |
| Middleton Island | 1998 | 100 | muscle, liver, heart |
| Port Bainbridge | 1998 | 100 | muscle, liver, heart |
| Resurrection Bay | 1998 | 120 | fin |
| Shelikof Strait | 1998 | 100 | muscle, liver, heart |
| PWS Montague | 1999 | 300 | heart |
| Eastern PWS | 1999 | 94 | heart |
| Kronotsky Bay, E. Coast Kamtchatka | 1999 | 96 | muscle, liver, heart, eye, fin |
| Avacha Bay | 1999 | 100 | unknown |
| Bogoslof Island | 2000 | 100 | muscle, liver, heart |
| Middleton Island | 2000 | 100 | muscle, liver, heart |
| Prince William Sound | 2000 | 100 | muscle, liver, heart |
| Shelikof Strait | 2000 | 100 | muscle, liver, heart |

# California Department of Fish and Wildlife
# Agency Report
# to the
# Technical Subcommittee
# of the
# Canada-United States Groundfish Committee

April 2016

Prepared by

Joanna Grebel
Traci Larinto
Caroline Mcknight
Melanie Parker
Michael Prall
Travis Tanaka
Amanda VanDiggelen

Table of Contents

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 (PFMC). 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, PFMC, and other agencies or entities involved with the management, protection, and utilization of finfish, shellfish, invertebrates, and plants in California's ocean waters. There are only six permanent Marine Region staff that are tasked with managing groundfish and providing policy recommendations to the CDFW, CFGC, and PFMC.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

IX. Surveys

In December 2013, the CDFW Marine Region's Statewide Marine Protected Area (MPA) Management Project initiated a contract with Marine Applied Research and Exploration to perform visual surveys statewide using remotely operated vehicle (ROV). The contract draws upon a $1.9 million grant awarded to the CDFW by the Coastal Impact Assistance Program (CIAP). The CIAP grant funds deep water surveys of MPA's and fishery resources statewide through 2016 (Figure 1). This project has allowed the CDFW to continue its deep water MPA surveys, which have been ongoing since 1999. It also has provided the opportunity to fill in gaps of coverage in surveys funded through the baseline MPA monitoring programs in the south, central, north central, and north regions. In addition to MPA focused monitoring these surveys have been designed to collect valuable information on abundance, density, size frequency and habitat associations of groundfish species in rocky habitats inside and outside of marine reserves and conservation areas.

<u>Survey Milestones to Date</u>

In 2014, two deployments were completed across the southern MPA region covering 52 sites and completing 142 km (88.2 mi) of transects. An additional deployment in 2014 in the northern MPA region completed 28 sites and 75 km (46 mi) of transects. In 2015, one deployment at 24 sites collected 76 km (47.2 mi) of transects within the north central MPA region. Along with hundreds of hours of video recorded during these transects approximately 33,000 high resolution digital still images were collected across all the surveys thus far.  In 2016, two deployments are planned for 40 sites and 140 km (87 mi) of transects within the central MPA region. These final surveys of the CDFW grant will complete the statewide coverage of the project.

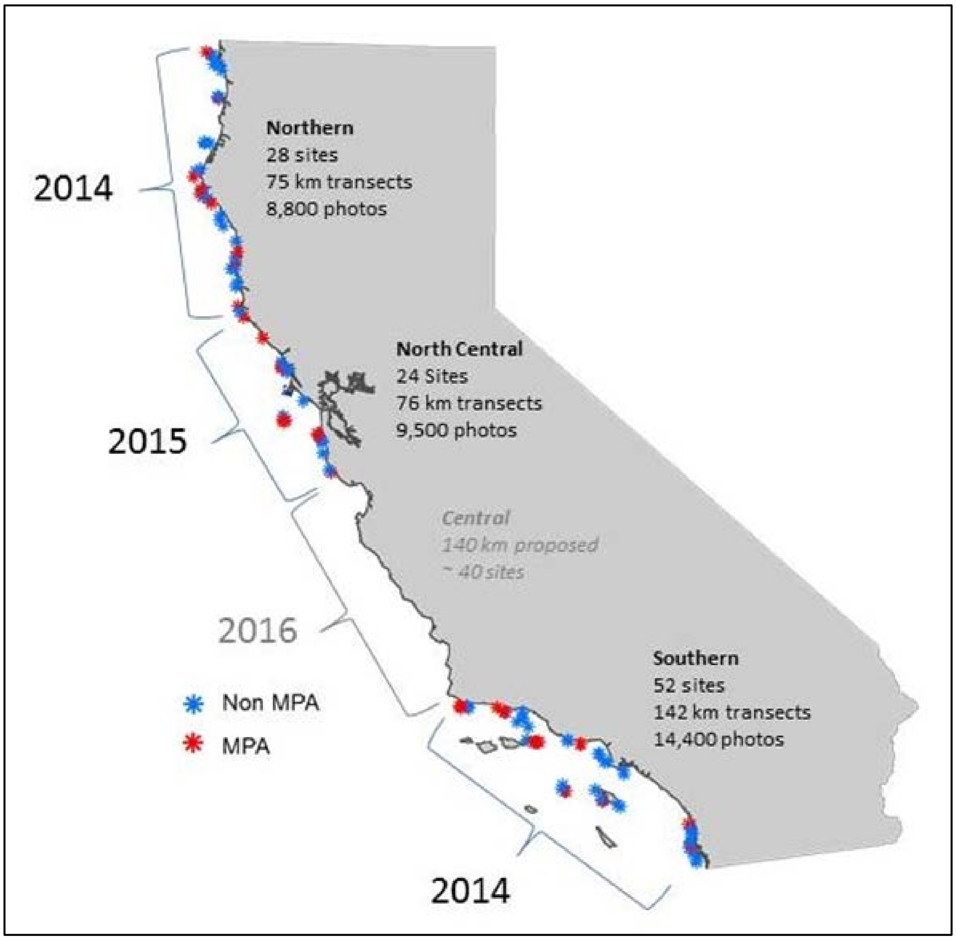



Figure 12.  CDFW ROV Survey locations completed in 2014 and 2015.

<u>Preliminary Statewide Findings</u>

Analysis of data collected from quantitative video transects for the statewide dataset will describe baseline ecological conditions inside and outside of MPAs while examining abundance, density and size frequency of managed fish and invertebrate species.  Preliminary observations appear to show high juvenile and adult lingcod (*Ophiodon elongatus*) abundance throughout entire state.  Also, differential patterns of abundance were observed in northern vs. southern sites for some species. For example, in the north and north central regions, only larger adult vermillion rockfish (*Sebastes miniatus*) were observed in comparably moderate abundance vs. higher abundance and smaller size classes in the southern region.  In the north central region previous surveys in 2011 showed very low abundance of brown rockfish (*S. auriculatis*) compared to the current surveys where they were one of the most prevalent species observed throughout all sites.

<u>Next Steps</u>

After completion of surveys in 2016, the resulting dataset from all surveys will be compiled into a searchable georeferenced database which will allow analysis for statewide and regional MPA monitoring and fishery specific needs.  Detailed processing of the video based transects records observations of all fish and macro invertebrates as well as habitat characterization. Size frequency of select species will also be determined from stereographic video. This extensive effort will provide much needed fishery independent data for multiple management uses and establishes an unprecedented set of index sites across the entire California coast.

Contributed by Michael Prall (Michael.Prall@wildlife.ca.gov)

X. Reserves

Overview

California is home to the largest scientifically designed network of MPAs in the contiguous United States, consisting of 124 MPAs, protecting approximately 16 percent of state waters along the mainland coast and offshore islands (https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Network). Pursuant to the 1999 Marine Life Protection Act (MLPA), California's existing system of MPAs was redesigned to increase its coherence and effectiveness at protecting the state's marine life and habitats, ecosystems, natural heritage, and function as a network. From 2005 to 2012, new and revised MPAs were implemented incrementally on a regional basis through four science-based and stakeholder driven MPA planning processes. The CDFW manages California’s MPAs as a statewide network using a partnership-based approach, primarily through four focal areas: monitoring and research, enforcement and compliance, outreach and education, and policy and permitting.

California has developed a two-phase approach to MPA monitoring: 1) baseline monitoring and 2) long-term monitoring. Baseline monitoring data was collected through four collaborative regional MPA Baseline Programs funded by the State to establish a benchmark of ecological and socioeconomic conditions when each regional MPA network took effect, and informs a management review of the first five years of MPA implementation in each region. After the baseline monitoring period, long-term monitoring based on regional and statewide objectives, will follow and continue into the future. Long-term monitoring will seek to understand conditions and trends of marine populations, habitats, and ecosystems across regions towards a statewide network scale. Adaptive management, as defined by the MLPA, is an ongoing process which seeks to improve management by learning from program actions such as monitoring, evaluation, and other management actions that affect California’s MPA network. Adaptive management coupled with a commitment to a partnership-based approach will continue to set the foundation for managing California’s MPA network.

Adaptive Management Activities in 2015

The CDFW updated the 2008 Master Plan for MPAs (Master Plan). The updated Master Plan shifts the focus away from MPA design and planning towards managing California’s MPA network to meet the goals of the MLPA. The CFGC is anticipated to adopt the updated plan early 2016. To improve MPA regulation compliance, the CFGC adopted a rulemaking package proposed by CDFW to provide consistency and clarity to MPA regulations. Amended regulations were implemented March 1, 2016 and include: refined boundaries, simplified MPA names, language amendments to improve clarity and consistency, addressing aquaculture concerns in

Drakes Estero State Marine Conservation Area and Morro Bay State Marine Recreational Management Area, changing Año Nuevo's designation to a state marine reserve, and updating troll gear references.

Baseline MPA Monitoring Programs

Regional MPA baseline monitoring programs were administered through a partnership among CDFW, Ocean Science Trust (OST), Ocean Protection Council (OPC), and California Sea Grant (CASG). 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. 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. To date, the central coast and north central coast regions baseline programs are the only completed programs. In 2013, a central coast "State of the Region" baseline MPA monitoring report was released, and in 2015 a similar north central coast "State of the Region" baseline MPA monitoring report was also released. These reports and other related material inform CDFW's five-year MPA management recommendations for the CFGC, and provide an update on regional MPA progress. Figure 2 shows the status of the regional baseline programs.

| **MLPA Coastal Region** | *Fund projects* | *Collect data* | *Analyze data* | *Report results* | *5-year review* |
|---|---|---|---|---|---|
| Central Coast | 2007 | 2007 | 2008 | 2010 | 2013 |
| North Central | 2010 | 2011 | 2013 | 2014 | 2016 |
| South Coast | 2011 | 2012 | 2014 | 2016 | *2017* |
| North Coast | 2014 | 2015 | *2016* | *2017* | *2018* |

= completed = underway = ~ year complete

Figure 13. Status of the regional baseline monitoring programs.

Geographic Information System (GIS) and MarineBIOS

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. As a venue to discover, visualize, and access data relevant for adaptive management, CDFW's GIS unit has developed an interactive web map called MarineBIOS. This platform is continually evolving as new source data is uploaded and interface improvements are added to increase system functionality. Most recently, data from the 2015 aerial survey of coastal kelp canopies (along the mainland coast and the Channel Islands) was incorporated into the web map. For more information please visit the Marine Region GIS website.

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## XI. Review of Agency Groundfish Research, Assessment and Management

### P. Hagfish

There are two species of hagfish that reside off California, Pacific hagfish (*Eptatretus stoutii*) and black hagfish (*Eptatretus deani*). Of the two, the Pacific hagfish (hagfish) is the preferred species for California's export-only fishery. Using traps, fishermen land hagfish in live condition. The hagfish are usually stored dockside until packaged for live export to South Korea where they are sold live for human food. Considered scavengers, hagfish are found over deep, muddy habitat.

#### 1. Research

The Department conducted two research studies relative to trap gear and hagfish take. The first was a 2013 research cruise in Monterey Bay which showed the influence of hole diameter on average size of trap-retained hagfish. These holes are for water circulation and to allow for the escape of small fish, the entrance funnel is larger. Prior to this research, many fishermen used 12.7 millimeter (1/2 inch) diameter holes for circulation and for escape of smaller fish. Increasing the hole diameter to 14.2 millimeters (9/16 inch) inches resulted in a 10 percent reduction of immature hagfish, thus improving average size and reducing impacts to the population. As a result, the Department recommended to the CFGC to increase in minimum hole size to 12.2 millimeters (9/16 inch).

The second research study was an evaluation of two experimental gear permits for the use of barrel traps in the Bodega Bay area conducted in 2014-15. When applying for the experimental gear permits, the fishermen noted that these were already in use in other jurisdictions and suggested that barrel traps were a way to decrease potential for negative gear interactions with other commercial benthic fisheries (e.g. Dungeness crab) and to improve catch quality by reducing dead loss or damage to captured fish through crowding. These barrel traps are approximately 40 gallons (150 liters), eight times the size of traditional bucket traps [5 gallon (19 liter)] that were allowed in the fishery at the time. A condition of the experimental gear permits required that the Department be allowed to observe fishing activity.

An earlier Department study of the smaller, bucket traps resulted in a two percent dead loss; although, one trap that was filled to capacity had a much higher loss rate. For the current study on the use of larger, barrel traps, there were no observed trips where barrel traps were filled to capacity and no dead loss was observed. However, the greater trap volume and large number of holes allows for better water circulation, which may improve survivorship. Both fishermen reported no incidents of negative gear interaction with other fisheries or marine mammals and Department staff did not observe any interactions. Only one trap was lost throughout the entire evaluation period by experimental gear permittees. The limited logbook data (logs are not required) show that during the barrel trap evaluation period (September 2013-April 2015), the bucket trap fishery lost 141 buckets. The reasons cited for trap loss included cut ground line, lost trap string, or traps cut off by another vessel. The Department recommended to the CFGC to allow the use of barrel traps.

2. Assessment

Little is known about the status or biomass of Pacific hagfish stocks. Since 2007, the Department's Northern and Central California Finfish Research and Management Project monitors and documents changes in the average size and spawning status of landed hagfish by sampling hagfish. Sampling activity began in Moss Landing, but ended a year later due to market changes. Currently staff collects samples from the ports of Morro Bay and Eureka. Due to the physical impossibility of accurately measuring hagfish in a live condition, staff employs a count-per-pound method to monitor changes in average size of retained hagfish. Randomly selected hagfish from sampled landings are retained for spawning status and length data. Landings have been relatively stable from 2010 to 2015, fluctuating between 360 and 745 metric tons (0.8 and 1.6 million pounds) annually. The value of the landings has ranged from $565,000 to $1.3 million per year during that same time period.

3. Management

The commercial hagfish fishery is open access; only a commercial fishing license and a general trap permit are required. Hagfish may be taken in 19 liter (5 gallon) bucket traps, Korean traps, or, since January 1, 2016, barrel traps [approximately 150 liters (40 gallons) each]. The maximum number of traps allowed is 200 bucket traps, 500 Korean traps, or 25 barrel traps; fishermen must choose one trap type and may not combine hagfish trap types or have other, non-hagfish traps onboard when fishing with hagfish traps. When fishing barrel traps, traps may be attached to no more than three groundlines. There is no limit on the number of groundlines when using buckets or Korean traps. All traps must have a Department-approved destruct device and all holes, except for the entrance, in any hagfish trap shall have a minimum diameter of 14.2 millimeters (9/16 inch). When in possession of hagfish, no other finfish species may be possessed on board. Currently logbooks are not required for this fishery. There are no annual quotas or minimum size limits.

Contributed by Travis Tanaka (Travis.Tanaka@wildlife.ca.gov)

Q. Groundfish, all species combined

1. Research

Scientific Collecting Permits are issued by CDFW to take, collect, capture, mark, or salvage, for scientific, educational, and non-commercial propagation purposes. Permits are generally issued for three years, except that student permits are for one year. Each year the Marine Region reviews about 40 permits involving the take of groundfish. While a complete report of groundfish-related research activities isn't available for this report, the permits fall into four broad categories: 1) public display in aquariums and interpretive centers; 2) environmental monitoring; 3) life history studies that include age and growth, hormone assays and genetics for population structure; and, 4) studies related to changing environmental conditions such as ocean acidification and hypoxia.

In 2015, two studies were ongoing by Marine Region staff, and are described below.

a. Yelloweye Rockfish

The yelloweye rockfish (*Sebastes ruberrimus*) population off the West Coast was designated as an overfished stock in the early 2000s. Commercial and recreational regulations were implemented to minimize gear interactions in combination with a prohibition on retention (or limited retention in designated fishing sectors) and area closures. As a result, there has been limited opportunity to collect current biological information for studying age and growth parameters that are crucial components of stock assessment modeling. In 2010, CDFW implemented a data collection policy within the recreational sampling program (California Recreational Fishery Survey Program) to collect yelloweye that are that mistakenly landed by recreational anglers.

Between 2010 and 2015, the CDFW's Groundfish Ecosystem Management and Science Project staff has processed approximately 81 yelloweye from the recreational fishing sector. Length, weight, sexual maturity, and otoliths were collected from each specimen. A sub-set of specimens (approximately 25) were processed to collect tissue for genetic testing. The sample set ranges between 134-706 mm in total length, and are approximately 41 percent female, 38 percent male and 16 percent unknown sex. The geographic samples extend from Monterey to Crescent City with the majority coming from North of Point Arena (Fort Bragg, Shelter Cove, Eureka and Crescent City).

In anticipation of the next full stock assessment, CDFW expects to send the data from all processed samples to the appropriate agency for ageing and incorporation into the assessment's data streams.

Contributed by Caroline Mcknight (Caroline.Mcknight@wildlife.ca.gov)

b. Yellowtail Rockfish

Starting in 2013, the PFMC granted an Exempted Fishing Permit (EFP) 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. Data from trips taken between 2013 and 2015 indicate that the fishing method focuses catch on yellowtail and widow rockfish (*S. entomelas*) (88 percent of total catch). Catch of overfished species was minimal [bocaccio (*S. paucispinis*), canary (*S. pinniger*) and yelloweye rockfish were 8.9, 0.7 and 0.2 percent of total catch, respectively]. The remainder (2.4 percent) was a combination of shelf rockfish and other species. This EFP was renewed for 2015-2016.

Contributed by Joanna Grebel (Joanna.Grebel@wildlife.ca.gov)

2. Assessment
The CDFW did not conduct any stock assessments in 2015 for groundfish species.

3. Management

Groundfish management is a complex issue and is conducted by the PFMC with input by CDFW as well as the states of Oregon and Washington, and guided by the federal Pacific coast Groundfish Fishery Management Plan. With the exception of some nearshore species, discussed below, harvest guidelines, fishery sector allocations, commercial trip limits and recreational management measures (e.g., bag limits, season limits) are established by the PFMC and implemented by National Marine Fisheries Service (NMFS). Additionally, the PFMC establishes rockfish conservation areas (RCA) which are spatial closures to protect overfished species.

The state's Nearshore Fishery Management Plan manages 16 species that are also listed in the federal Groundfish Fishery Management Plan [black (*Sebastes melanops*), black-and-yellow (*S. chrysomelas*), blue (*S. mystinus*), brown, 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 greenling (*Hexagrammos decagrammus*); California scorpionfish (*Scorpeana guttata*)], along with three other species [California sheephead (*Semicossyphus pulcher*), rock greenling (*H. lagocephalus*), and monkeyface prickleback (*Cebidichthys violaceus*)].

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

PFMC. Weekly tallies of landing receipts are used for inseason monitoring. At present, inseason monitoring focuses on black rockfish and sablefish (*Anoplopoma fimbria*).

For the recreational fisheries, inseason monitoring relies on data collected by CDFW's California Recreational Fisheries Survey (CRFS) staff using a combination of CRFS weekly reports that are replaced by CRFS monthly estimates, as they become available. Inseason monitoring for the recreational fisheries focuses on black rockfish and California scorpionfish as well as some overfished species, such as cowcod (*Sebastes levis*) and yelloweye rockfish. Inseason monitoring of recreational yelloweye rockfish catch is posted on CDFW's website so that the angling public can see how the season is progressing.

4. 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), or species groups (e.g., group shelf rockfish). Samplers need to determine the species composition so that landings of market categories can be split into individual species for management purposes. Biological data is collected for use in stock assessments and for data analyses to inform management decisions.

5. Recreational Fishery Monitoring

The CRFS program 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, 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.

Contributed by Traci Larinto (Traci.Larinto@wildlife.ca.gov)

R. Pacific halibut & IPHC activities

1. Research and Assessment

Research and assessment activities for Pacific halibut (*Hippoglossus stenolepis*) off the coast of California are conducted by the International Pacific Halibut Commission (IPHC).

2. Management

The CDFW collaboratively manages the Pacific halibut resource off the coast of California with the IPHC, NMFS, PFMC, other west coast states, and the CFGC. Pacific halibut management activities occur on an annual timeline, with most changes to management occurring through the PFMC's Catch Sharing Plan and federal regulations published by NMFS. Changes to the Catch Sharing Plan for the following year are approved in November by the PFMC.

Changes in management for the 2015 recreational Pacific halibut fishery off of California included a number of open and closed periods, and a new weekly inseason catch tracking and monitoring process to keep catches within the California quota. The fishery was scheduled to be open the first through the fifteenth of each month from May through August, and September 1 through October 31, or until the quota was met, whichever was earlier.

To track Pacific halibut catch, CDFW generated a Preliminary Projected Catch amount by using sample information directly from CRFS weekly field reports to approximate catch during the lag time until monthly CRFS catch estimates are available six weeks later. The Preliminary Projected Catch would be replaced by the monthly CRFS catch estimate, once available. The CDFW provided this information online so that the angling public could see how the season was progressing (https://www.wildlife.ca.gov/Conservation/Marine/Pacific-Halibut/2015). Using this inseason tracking methodology, the quota was projected to have been met on August 12, 2015, and the fishery closed early on August 13, 2015. Final season catch estimates were 24,906 net pounds, 99 percent of the 25,220 net pound quota.

Contributed by Melanie Parker (Melanie.Parker@wildlife.ca.gov)

XII. Publications

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**OREGON'S GROUNDFISH FISHERIES AND INVESTIGATIONS IN 2015**

**OREGON DEPARTMENT OF FISH AND WILDLIFE**

2016 AGENCY REPORT
PREPARED FOR THE 26-27 APRIL 2016 MEETING OF THE TECHNICAL SUB-COMMITTEE OF THE CANADA-UNITED STATES GROUNDFISH COMMITTEE


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I) Agency Overview

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|---|---|
| MRP Program Manager: | Dr. Caren Braby |
| Resource Management and Assessment: | Dave Fox |
| Fishery Management: | Maggie Sommer |
| Technical and Data Services: | Dan Erickson |

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.

II) Surveys

a) Sport Fisheries Monitoring

Sampling of the ocean boat sport fishery by MRP's Ocean Recreational Boat Survey (ORBS) continued in 2015. 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. Lingcod (*Ophiodon elongatus)*, several rockfish species (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus)* and kelp greenling (*Hexagrammos decagrammus)* are the most commonly landed species.

The ORBS program continued collecting information on species composition, length and weight of landed groundfish species at Oregon coastal ports during 2015. 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. Beginning in 2003, the recreational harvest of several groundfish species is monitored inseason for catch limit tracking purposes.

Other ODFW management activities in 2015 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 2016, 2017-2018, and beyond.

Contact: Lynn Mattes (lynn.mattes@state.or.us), Patrick Mirick (patrick.p.mirick@state.or.us )

b) Commercial Fisheries Monitoring

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, 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 2015 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.

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c) Pilot study – Using Electronic Monitoring in Commercial Fishery sampling

Sampling tools for collecting biological data from commercial groundfish landings have not changed in many years. Currently, lengths are determined on manual plastic length boards. Data are recorded on paper datasheets, and transcribed and entered into spreadsheets once back in the office. Funding was secured in 2015 to acquire and test new electronic-based system that includes an electronic length board and scale connected to tablets for commercial landings in 2016. Field and office based tests will collect data on effort, errors and accuracy of the new system to compare with the existing paper-based system. Study design will be finalized in early 2016, and testing will occur during the second half of 2016.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

d) Pilot study – Reinitiating the Shore and Estuary Boat Survey (SEBS)

In July 2005, sampling of the shore and estuary fishery was discontinued due to a lack of funding. Marine finfish catches outside the ocean boat modes have not been sampled since. In late 2015, ODFW received funds from two outside sources to resume a survey of limited scope for estimating shore and estuary marine finfish catches in 2016. This pilot study includes two main components – an angler intercept survey and a fishing effort survey that compares effort estimates from both phone and mail surveys. Effort surveys will also include estimates of ocean boat effort, to compare with existing Oregon Recreational Boat Survey effort estimates. Angler intercept surveys will begin in May 2016, and effort surveys will begin July.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

III) Marine Reserves

a) Management

The ODFW Marine Reserves Program is responsible for overseeing the management and scientific monitoring of Oregon's five marine reserve sites. ODFW has launched a new Oregon Marine Reserves website: OregonMarineReserves.com. Also, a new Oregon Marine Reserves *Ecological Monitoring Plan* was released in 2015, which includes information on survey study designs, the four core monitoring tools used by the Marine Reserve Program, and site specific monitoring plans and timelines for ecological surveys. Finally, harvest restrictions began at Oregon's fifth and final marine reserve site, at Cape Falcon, on January 1, 2016.

b) Monitoring

*Hook and Line Surveys:* The ODFW Marine Reserves Program continued hook and line surveys in 2015 at three of the marine reserves: Cape Falcon, Cascade Head, and Redfish Rocks and their associated comparison areas. Data collection was broken into two periods: Spring (April-May) and Fall (September-October). Surveys were conducted on 36 at-sea fishing days with the assistance of 93 volunteer anglers. Although each site is unique in species composition, the 2015 survey caught a total of 4,325 fish representing 22 species and seven families.

*Lander Surveys:* In 2015, the ODFW Marine Reserves Program completed lander surveys at Redfish Rocks and Otter Rock marine reserves and their associated comparison areas as well as Seal Rock. A total of 400 drops were conducted with 69% meeting requirements for view, habitat, and visibility. Surveys were conducted February – June and September – October of 2015. The drops conducted at these three sites contained observations of 12 different species from four families.

*ROV Surveys:* ROV surveys were conducted by the ODFW Marine Habitat Project at Cape Perpetua and Cascade Head marine reserves, and the Cavalier comparison area in 2015. The surveys were conducted in April and September of 2015. A total of five transects were completed at Cape Perpetua marine reserve and nine transects were completed at the Cascade Head marine reserve and Cavalier comparison area.

c) Research

*Development and Testing of a Video Mini-Lander for Studying Demersal Fishes on Nearshore Rocky Reefs:* In 2015, the ODFW Marine Reserves Program completed a pilot study designed to test a new video lander configuration that is both light-weight and cheap to build -- to more readily survey shallow, rocky, nearshore reefs. Pilot studies using this new configuration were conducted to optimize use of this tool in Oregon’s nearshore waters.

First, our studies of fish behavior did not uncover species fleeing the tool (avoidance behavior) or continually curious (attractive behavior). Rather most fish seemed unaffected by this new apparatus entering their home---a good thing for collecting unbiased data on species abundances. Second, while bait has been useful in increasing the numbers and diversity of fishes observed in other lander systems around the globe, in Oregon’s nearshore waters baiting the lander did not increase the species diversity or abundance of fish captured on the video nor improve our ability to identify the fish to species. Lastly, this pilot study found that 8 minutes is an appropriate deployment duration to get a representative sample of fish populations at a nearshore study site. Ultimately, these results help our team and other scientists better understand strengths and limitations of video survey tools.

The ODFW Marine Reserve Program has submitted the results of this pilot study for publication to the *Journal of Experimental Marine Biology and Ecology*.

*Development and Testing of a Fishery-independent Longline Method for Studying Demersal Fishes on Nearshore Rocky Reefs:* While in the early stages of establishing robust, long-term monitoring protocols for evaluating fish communities in Oregon’s system of marine reserves, the ODFW Marine Reserve Program is experimenting with alternative fishery-independent methods tailored to each specific reserve site. In 2015, a longline pilot study was conducted concurrently with our ongoing hook-and-line survey in an attempt to increase the catch of species of interest (e.g. rockfishes such as quillback, copper, China, vermilion, and yelloweye), that are valued in the local fishery surrounding Redfish Rocks Marine Reserve. Our objectives were threefold. First, we sought to document detectability, or the probability of observing a species, among the sampling approaches. Second, we wanted to compare the observed species richness, catch rate (i.e. CPUE), and size distributions for fish species among the sampling approaches. Finally, we sought to compare the cost-benefit of each approach including survey costs, workforce needed, and prevalence of body injury and mortality on fishes by sampling method.

A total of 19 species were observed across all sampling methods. Average species richness varied between eight and ten species, with longline obtaining higher daily species richness compared to hook-and-line. Average daily catch rates of black rockfish, the primary species observed, were significantly different depending on the sampling method that was employed. Hook-and-line sampling had the highest catch rate of black rockfish. Longline sampling methods caught significantly larger sized canary rockfish ($p < 0.001$) and lingcod ($p < 0.001$) compared to the hook-and-line method. Longlining resulted in low incidence of predation (4%) and mortality (0.7%) in the fishes retrieved. Mortality was restricted to two species: canary and deacon rockfish (a single individual each). Similarly, observed barotrauma symptoms were low and only observed in canary rockfishes, though nearly all fish species retrieved did exhibit lethargy/exhausting likely due from time spent on the line. Results of this gear comparison study revealed that detectability of nearshore rocky reef fish species was highest for longline survey and opportunistic jigging surveys compared to hook-and-line sampling. Longline gear was found to select for larger lingcod and canary rockfish, both in mean size and maximum size of landed fish. Longline surveys were more cost effective than hook-and-line surveys and reduced our dependency on using volunteer anglers which can be difficult to obtain in rural communities adjacent to Oregon's marine reserve sites. However, it is important to consider that this sampling tool is not suitable in all areas given the requirements of knowledgeable longline captains who are willing to operate these types of surveys.

More information, including copies of monitoring plans and reports, is available on the Oregon Marine Reserves website at OregonMarineReserves.com.

Contact: Cristen Don (cristen.n.don@state.or.us)

IV) Review of Agency Groundfish Research, Assessment and Management

a) Hagfish

i) Research

No research on hagfish was conducted by ODFW in 2015.

ii) Assessment

No hagfish assessments were completed by ODFW in 2015.

iii) Management

The commercial hagfish fishery operates year-round. Two types of trap gear are typically used by the hagfish fleet, a 55 gallon drum and five gallon bucket. Each of these contains escape holes to increase the size selectivity of the commercial fishery. Commercial hagfish landings in 2015 were 1,824,624 pounds, which is 91% of the 2010 – 2014 average (2,004,150 pounds). No major management actions were taken in 2015 by ODFW.

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b) Dogfish and other sharks
   i) Research

No research on dogfish or other sharks was conducted by ODFW in 2015.

   ii) Assessment

No dogfish or shark assessments were completed by ODFW in 2015.

   iii) Management

There were no major management actions taken for dogfish or other sharks by ODFW in 2015.

c) Skates
   i) Research

No research on skates was conducted by ODFW in 2015.

   ii) Assessment

No skate assessments were completed by ODFW in 2015.

   iii) Management

There were no major management actions taken for skates by ODFW in 2015.

d) Pacific cod
   i) Research

No research on Pacific cod was conducted by ODFW in 2015.

   ii) Assessment

No Pacific cod assessments were completed by ODFW in 2015.

   iii) Management

There were no major management actions taken for Pacific cod by ODFW in 2015.

e) Walleye pollock
   i) Research

No research on pollock was conducted by ODFW in 2015.

   ii) Assessment

No pollock assessments were completed by ODFW in 2015.

   iii) Management

There were no major management actions taken for pollock by ODFW in 2015.

f) Pacific whiting (hake)
 i) Research

No research on whiting was conducted by ODFW in 2015.

ii) Assessment

No whiting assessments were completed by ODFW in 2015.

iii) Management

There were no major management actions taken for whiting by ODFW in 2015.

g) Grenadiers
 i) Research

No research on grenadiers was conducted by ODFW in 2015.

ii) Assessment

No grenadier assessments were completed by ODFW in 2015.

iii) Management

There were no major management actions taken for grenadiers by ODFW in 2015.

h) Rockfish
 i) Research

There were several ongoing research projects for rockfish. These are detailed below.

*Movement of yelloweye rockfish using acoustic telemetry*: We continued work writing up prior years field work on yelloweye rockfish movements.

Contact: Polly Rankin (polly.s.rankin@state.or.us) or Bob Hannah (bob.w.hannah@state.or.us)

*Discard mortality of hook-and-line caught yelloweye rockfish with barotrauma*: We continued work writing up our 2014 study evaluating the longer-term survival, health and behavioral competency of yelloweye rockfish experiencing capture-related barotrauma.

Contact: Polly Rankin (polly.s.rankin@state.or.us) or Bob Hannah (bob.w.hannah@state.or.us)

*Investigation of site fidelity and movement of deacon rockfish (Sebastes diaconus)*: We will be investigating the site fidelity and movement tendencies of deacon rockfish at a site near Seal Rocks, Oregon.

Contact: Polly Rankin (polly.s.rankin@state.or.us) or Bob Hannah (bob.w.hannah@state.or.us)

ii) Assessment

Two federal nearshore rockfish assessments were completed in 2015 for China and Black rockfish. ODFW staff were co-authors on both rockfish assessments (available in early 2016) and ODFW staff also participated in STAR panels reviewing these assessments in the summer and fall of 2015. Assessments indicated harvest of China rockfish could increase while harvest of Black rockfish needs to decrease slightly.

iii) Management

*Commercial fishery*: Rockfish are mainly taken in the nearshore commercial 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, 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. Fishing occurs mainly with hook-and-line jig and bottom longline gear types. 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.

There were several notable events in 2015 commercial nearshore fishery management. Allowable impacts to federal minor nearshore rockfish were reduced. To manage to these reductions state trip limits for other nearshore rockfish were reduced and a separate trip limit for Blue Rockfish, alone, was established. Stock assessments occurred for three commercial nearshore species including Black rockfish, China rockfish, and kelp greenling. Landings from 2014 commercial nearshore fishing, logbook compliance, economic data, and biological data were published in the 2014 Commercial Nearshore Fishery Summary (Rodomsky et al. 2015). Overall, the majority of active fishery permit holders are located on the southern Oregon coast, resulting in most of the catch landed in Port Orford, Gold Beach and Brookings. Black rockfish continued to comprise the majority of landings. In-season management in 2015 included increases to two-month trip limits for Black rockfish, Blue rockfish, Other Nearshore Rockfish, and Greenling.

Contact: Brett Rodomsky (Brett.T.Rodomsky@state.or.us), Troy Buell (Troy.V.Buell@state.or.us)

*Recreational fishery*: Black rockfish (*Sebastes melanops*) remains the dominant species caught in the recreational ocean boat fishery. As in recent years, the retention of 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. New in 2015 for the first time since 2004, retention of canary rockfish (*S. pinniger;* one fish sub-bag limit) was allowed, due to increasing trends in the stock abundance.

Contact: Lynn Mattes (lynn.mattes@state.or.us ), Patrick Mirick (patrick.p.mirick@state.or.us )

*Outreach:* 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 12,000 descending devices to date, to all charter vessel owners and to the majority of sport boat owners who had previously targeted groundfish or halibut. ODFW staff have also participated in a number of angler education workshops, meetings, and shows to educate anglers and distribute devices. In addition, several thousand stickers bearing an emblem of the brand (**Error! Reference source not found.**) have been distributed with the goal of making rockfish conservation an innate aspect of fishing culture. This outreach and education 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, ODFW's Restoration and Enhancement (R & E) program, and the National Marine Fisheries Service (NMFS) Saltwater Recreational Policy.

Contact: Lynn Mattes (lynn.mattes@state.or.us ), Patrick Mirick (patrick.p.mirick@state.or.us )

i) Thornyheads

i) Research

No research on thornyheads was conducted by ODFW in 2015.

ii) Assessment

No thornyhead assessments were completed by ODFW in 2015.

iii) Management

There were no major management actions taken for thornyheads by ODFW in 2015.

j) Sablefish

i) Research

No research on sablefish was conducted by ODFW in 2015.

ii) Assessment

No sablefish assessments were completed by ODFW in 2015.

iii) Management

There were no major management actions taken for sablefish by ODFW in 2015.

k) Lingcod

i) Research

No research on lingcod was conducted by ODFW in 2015.

ii) Assessment

No lingcod assessments were completed by ODFW in 2015.

iii) Management

Lingcod are landed both commercially and recreationally. Commercial lingcod landings are monitored weekly as part of the nearshore commercial groundfish fishery. In 2015, nearshore landings were dominated by hook and line catches (91%) and totaled 207,066 pounds. The Dahl limited entry/open access sector landings were 147,861 pounds in 2015. Recreational lingcod landings are monitored by ORBS and subject to a daily bag limit and a minimum size limit (22 inches).

l) Atka mackerel

i) Research

No research on atka mackerel was conducted by ODFW in 2015.

ii) Assessment

No atka mackerel assessments were completed by ODFW in 2015.

iii) Management

There were no major management actions taken for atka mackerel by ODFW in 2015.

m) Pacific halibut & IPHC activities

i) Research

ODFW did not conduct any halibut research projects in 2015.

ii) Assessment

ODFW did not complete any halibut assessments completed in 2015.

iii) Management

Oregon's recreational fishery for Pacific halibut continues to be a popular, high profile fishery requiring International Pacific Halibut Commission (IPHC), federal, and state technical and management considerations. In 2015, the IPHC recommended an annual catch limit for Area 2A (Oregon, Washington, and California) of 0.97 million pounds. The recreational fishery for Pacific halibut is managed under three subareas with a combination of all-depth and nearshore quotas. In 2015, the Columbia River subarea quota was 10,254 pounds, the Central coast subarea quota was 175,633 pounds, and the Southern coast subarea quota, after inseason adjustments, was 3,081 pounds. Landings in the sport Pacific halibut fisheries are monitored weekly for tracking landings versus catch limits. The majority of halibut continue to be landed in the central coast subarea, with the greatest landings in Newport followed by Garibaldi or Pacific City. Total 2015 recreational landings in the Central coast subarea was 174,957 pounds (99% of quota). Landings in the Southern subarea were 2,583 pounds (84% of quota) and in the Columbia River subarea, landings were 9,339 pounds (91%).

n) Other groundfish species
   i) Kelp greenling

Kelp greenling are a component of both the nearshore commercial fishery and the recreational fishery. Commercial landings from the nearshore commercial fishery totaled 28,467 pounds in 2015. Recreational catches totaled 11,464 pounds (5.2 metric tons). ODFW staff acted a co-author on the federal kelp greenling stock assessment, which was completed in 2015 (Berger et al, 2015). An ODFW informational report on kelp greenling growth and maturity was completed in 2015 and is available on the ODFW website.

   ii) Cabezon

Commercial cabezon landings from the commercial nearshore fishery in 2015 were 36,064 pounds. Recreational landings were 35,715 pounds (16.2 metric tons). Pre-season in 2014, and continuing in 2015, the cabezon season was modified to July 1 through December 31. This allowed the cabezon season to proceed with a lower chance of inseason actions being necessary.

V) Ecosystem Studies
   a) Development of a Fishery Independent Survey

The Marine Resources Program annual retreat in 2015 identified the development of a fishery independent survey for nearshore groundfish species as a high priority for the MRP. Four working groups were established to accomplish this and other identified high priorities. One specific task assigned to the Stock Assessment and Management working group was to host a workshop with federal assessors to invite their input on preliminary designs and tools appropriate for a fishery independent survey. The workshop is planned for early 2016.

Multiple projects at MRP have been working on the development of both visual and acoustic tools for the purposes of estimating population size and fish habitat associations of various types of groundfish for many years. Further information on these tools can be found in sections V.b – V.e below and in the Marine Reserves section above (Section III).

Contact: Alison Whitman (alison.d.whitman@state.or.us)

   b) Video lander development and surveys

*Development and testing of video lander lighting conditions*: 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 is currently "in press" at the Marine and Coastal Fisheries journal.

Contact: Bob Hannah, (bob.w.hannah@state.or.us), or Matthew Blume (matthew.blume@state.or.us)

*Surveys of subtidal rocky areas with the video lander*: Surveys of shallow (<55 m) subtidal rocky areas were continued in the spring of 2015 in the waters near Newport, OR. This effort focused on exploring the use of the video lander designed by ODFW (Hannah and Blume 2012) as a tool for fishery independent surveys of nearshore rocky reef associated fishes and invertebrates and their habitat associations. In addition to collecting information to classify the primary and secondary substrates in view, water column properties were collected at the drop site using a casting conductivity temperature depth instrument (Seabird 19plus) equipped with an oxygen sensor. In 2015 we sampled 102 stations, adding to the 105 stations sampled in 2014. The lander sampled the bottom for approximately 14 minutes. Initial examination of the video collected in 2014 by both this project and similar video lander tools utilized by the ODFW marine reserves group suggests that the number of fish species seen in the videos collected on Oregon's nearshore rocky reefs tends to level off after approximately 8 to 10 minutes and the maximum number for any given species seen at any one time also occurs within that time frame. We plan to analyze how the fish community in Oregon's nearshore varies with environmental gradients.

Contact: Greg Krutzikowsky, (greg.krutzikowsky@state.or.us)

c) Hook and Line Surveys

We conducted two brief field studies evaluating standardized methods for nearshore hook-and-line surveys including an evaluation of semi-circle barbless hooks and a comparison of approaches to fishing site selection. Internal summary reports available upon request.

Contact: Bob Hannah (bob.w.hannah@state.or.us)

d) Drop Camera development

Work has been initiated, and will be continued, on developing a suspended GoPro-based stereo-video drop camera for estimating species and size composition of suspended rockfish schools for use in conjunction with acoustic estimates of rockfish abundance. If successful, we hope to use this device in conjunction with acoustic estimates of rockfish abundance on nearshore rocky reefs.

Contact: Bob Hannah, (bob.w.hannah@state.or.us) or Matthew Blume (matthew.blume@state.or.us)

e) Acoustic survey development

Surveys for Pacific herring in Yaquina Bay with an acoustic system began in 2014 to estimate spawning population size in early spring. A DT-X acoustic system was purchased from BioSonics Inc. to continue these surveys in 2015 and to expand use of this system to groundfish fishery independent surveys. Additional training in general hydroacoustic theory and analysis for ODFW MRP staff was completed in October 2015. Accompanying tool development was initiated by the Research Project (see V.d "Drop Camera development", above) and infrastructure for acoustic deployment on larger vessels was manufactured in late 2015. Initial testing of simultaneous deployment of the acoustic and drop camera will occur in early 2016.

Contact: Alison Whitman (alison.d.whitman@state.or.us)

f) Aging Activities

During 2015, 4,356 age estimates were produced for recreation, commercial, and research purposes within the Marine Resource Program. For recreation and commercial programs, 2092 black rockfish ages were produced, with an additional 413 test ages generated. Kelp greenling were also aged for the recreation fishery with 326 ages generated, and 66 tested. To fulfill research needs, an additional 404 black rockfish (76 tested), 456 red banded rockfish (76 tested), 254 brown rockfish (52 tested), and 117 kelp greenling (24 tested) were also aged.

Contact: Lisa Kautzi (Lisa.A.Kautzi@state.or.us)

g) 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 completed work on female deacon and blue rockfish (previously called blue-sided and blue-blotched rockfish, respectively), as well as kelp greenling, in 2014. We also completed a summary of female maturity data for redbanded rockfish from Oregon waters. Agency Informational Reports describing our findings can be accessed at: http://www.dfw.state.or.us/MRP/publications/#Research. A report summarizing ODFW maturity studies from 2000-2015 will be worked on.

Contact: Bob Hannah (bob.w.hannah@state.or.us; summary report, rockfish); Brett Rodomsky (Brett.T.Rodomsky@state.or.us; kelp greenling)

h) ROV Habitat studies

The Marine Habitat project conducted video transect surveys of seafloor habitats and biota at five locations in 2015 using a remotely operated vehicle (ROV). The Department's first ROV surveys at Cape Arago Reef quantified habitat and groundfish abundance in 19 transects targeting rocky reef between 20 m and 100 m depth in October 2015. Other surveys, focused on methodological development for assessing potential biogenic habitats in nearshore waters, were conducted at Cape Perpetua Marine Reserve, Cascade Head Marine Reserve, Cavalier Comparison Area, and further offshore at Stonewall Banks, with a total of 19 transects conducted over three days in April 2015. In addition, in September 2015 the ROV was used to investigate the potential for large sand dollar beds to provide low-relief habitat for flatfish and other organisms in shallow water (15 - 20 m) near Otter Rock Marine Reserve, and also to repeat transects at Cape Perpetua Marine Reserve for a continuation of the ongoing time series of reef observations at that site.

Contact: Scott Marion (Scott.R.Marion@state.or.us)

VI) Publications

Berger, A., L. Arnold, and B.T. Rodomsky. 2015. Status of Kelp Greenling (*Hexagrammos decagrammus*) along the Oregon coast in 2015. www.pcouncil.org.

Easton, R.R., S.S. Heppell and R.W. Hannah. 2015. Quantification of habitat and community relationships among nearshore temperate fishes through analysis of drop camera video. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Science 7:87-102.

Hannah, R. W. and M. T. O. Blume (in press). Variation in the effective range of a stereo-video lander in relation to near-seafloor water clarity, ambient light and fish length. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Science.

Hannah, R. W. and L. A. Kautzi. 2015. Age, growth and female length and age at maturity of redbanded rockfish (*Sebastes babcocki*) from Oregon waters. Oregon Dept. Fish Wildl., Information Rept. Ser., Fish. No. 2015-03. 22 p.

Hannah, R. W., M. J. M. Lomelli and S. A. Jones. 2015. Tests of artificial light for bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl: strong but opposite effects at the footrope and near the bycatch reduction device. Fisheries Research 170:60-67.

Hannah, R.W., Wagman, D.W. and L.A. Kautzi. 2015. Cryptic speciation in the blue rockfish (*Sebastes mystinus*): age, growth and female maturity of the blue-sided rockfish, a newly identified species, from Oregon waters. Oregon Dept. Fish Wildl., Information Rept. Ser., Fish. No. 2015-01. 24 p.

Rodomksy, B.T. and T. Calavan. 2015. The Oregon Nearshore Commercial Fishery Summary: 2014. http://www.dfw.state.or.us/MRP/publications/#Finfish.

Rodomsky, B.T., L.A. Kautzi, R.W. Hannah and C.D. Good. 2015. Kelp Greenling (*Hexagrammos decagrammus*) growth, spawning seasonality, and female length at maturity based on histological evaluation of ovaries from Oregon waters. Oregon Dept. Fish Wildl., Information Rept. Ser., Fish. No. 2015-02. 21 p.

# Washington Contribution to the 2016 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2015-April 2016

**April 26th-27th, 2016**


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**Washington Department of Fish and Wildlife**


**April 2016**

**Contents**

**Agency Overview**

The WDFW Marine Fish Science (MFS) Unit is broadly separated into two groups that deal with distinct geographic regions, though there is some overlap of senior staff. Staff of the Puget Sound Marine Fish Science (PSMFS) Unit during the reporting period included Dayv Lowry, Robert Pacunski, Larry LeClair, Todd Sandell, Jen Blaine, Adam Lindquist, Lisa Hillier, Andrea Hennings, Mike Burger, Jim Beam, Casey Wilkinson, Chris Fanshier, Will Dezan, Amanda Philips, Phil Campbell, and Erin Wright. In addition, Courtney Adkins and Peter Sergeeff work as PSMFS employees during the annual spring bottom trawl survey. The PSMFS Unit is also overseen by Theresa Tsou and supported by Phil Weyland (programming and data systems) and Kari Fenske (statistics and stock assessment).

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) and management has become increasingly sensitive to the ESA-listing of canary and yelloweye rockfish, and bocaccio, in Puget Sound since 2010 (National marine Fisheries Service 2010).

**Primary Contacts – 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).*
Forage Fish Stock Assessment and Research (*Contact: Dayv Lowry 360-95-2558, dayv.lowry@dfw.wa.gov;Todd Sandell 425- 379-2310, todd.sandell@dfw.wa.gov).*
Puget Sound Ecosystem Monitoring Program (PSEMP) *(Contact: Jim West 360-902-2842, james.west@dfw.wa.gov).*

Staff of the Coastal Marine Fish Science (CMFS) Unit during the reporting period included Lorna Wargo, Brad Speidel, John Pahutski, Bob Le Goff, Brian Walker, Donna Downs, Jamie Fuller, and Vicky Okimura. Seasonal and project staff include Michael Sinclair, Robert Davis, Jennifer Simpson, Grace Thornton, 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 CMFS Unit is also overseen by Theresa Tsou and supported by Phil Weyland and Kari Fenske.

The MFS Unit 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. Additional regional fishery management support is provided by Michele Culver, Corey Niles, Heather Reed, and Carol Henry.

**Primary Contacts – Coastal Washington:**
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), Regional Fisheries Management).*
Forage Fish Management, Monitoring, Research, and Assessment (*Contact: Lorna Wargo 360-249-1221 lorna.wargo@dfw.wa.gov; Dayv Lowry 360-902-2558, dayv.lowry@dfw.wa.gov)*

**Surveys**
**Puget Sound Bottom Trawl –** Since 1987, WDFW has conducted bottom trawl surveys in Puget Sound—defined as all marine waters of the State of Washington east of a line running due north from the mouth of the Sekiu River in the Strait of Juan de Fuca—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 initiation. 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.

The specific objectives of the annual "Index" trawl survey are to estimate the relative abundance, species composition, and biological characteristics of bottomfish species at pre-selected, permanent index stations. Key species of interest include Pacific Cod, Walleye Pollock, Pacific Whiting (Hake), English Sole, North Pacific Spiny Dogfish, and skates, but all species of fishes and invertebrates are identified and recorded. For the "Index" survey, the study area is subdivided into eight regions (eastern Strait of Juan de Fuca, western Strait of Juan de Fuca, San Juan Islands, Gulf of Bellingham, Whidbey Island sub-basin, central Puget Sound, Hood Canal, and South Puget Sound) and four depth strata ("S"= 5-20 fa, "T"= 21-40 fa, "U"= 41-60 fa, "V"= >60 fa), and 51 index (fixed) stations throughout the study area are sampled each spring (late April-early June) (Figure 1).

These index stations were originally selected from trawl stations sampled during previous trawl survey efforts at randomized locations throughout Puget Sound. Station selection was based on known trawlability and other logistical concerns and was informed by previously obtained biological data. Stations are named using a four-letter system with the first two letters designating the region, the third letter indicating the sub-region, or position within the region (north, south, mid), and the final letter designating the depth stratum. The index stations have remained relatively consistent since 2008, with a few exceptions: starting in 2009, 5 stations were added to make the current 51-station design; in 2012 and 2013, stations in the shallowest stratum (S) were not surveyed because of concerns from NOAA about impacts to juvenile salmonids; and in 2014 and 2015, stations JEWU and CSNV, respectively, were moved slightly to accommodate concerns raised by fiber-optic cable companies.

The trawling procedure of the survey has remained largely consistent. The 57-foot F/V CHASINA is the chartered sampling vessel, and it is equipped with an agency-owned 400-mesh Eastern bottom trawl fitted with a 1.25 inch codend liner. The net is towed at each station for a distance of

~0.40 nautical miles at a speed of 1-3 knots, and the tows last approximately 11 minutes. The resulting catch is identified to the lowest taxonomic level possible, weighed, counted, and most of the catch is returned to the sea. The density of fish at each station is determined by dividing the catch numbers or weight by the area sampled by the net. Some of the catch is taken for biological samples that are sampled on deck or preserved for laboratory analysis.

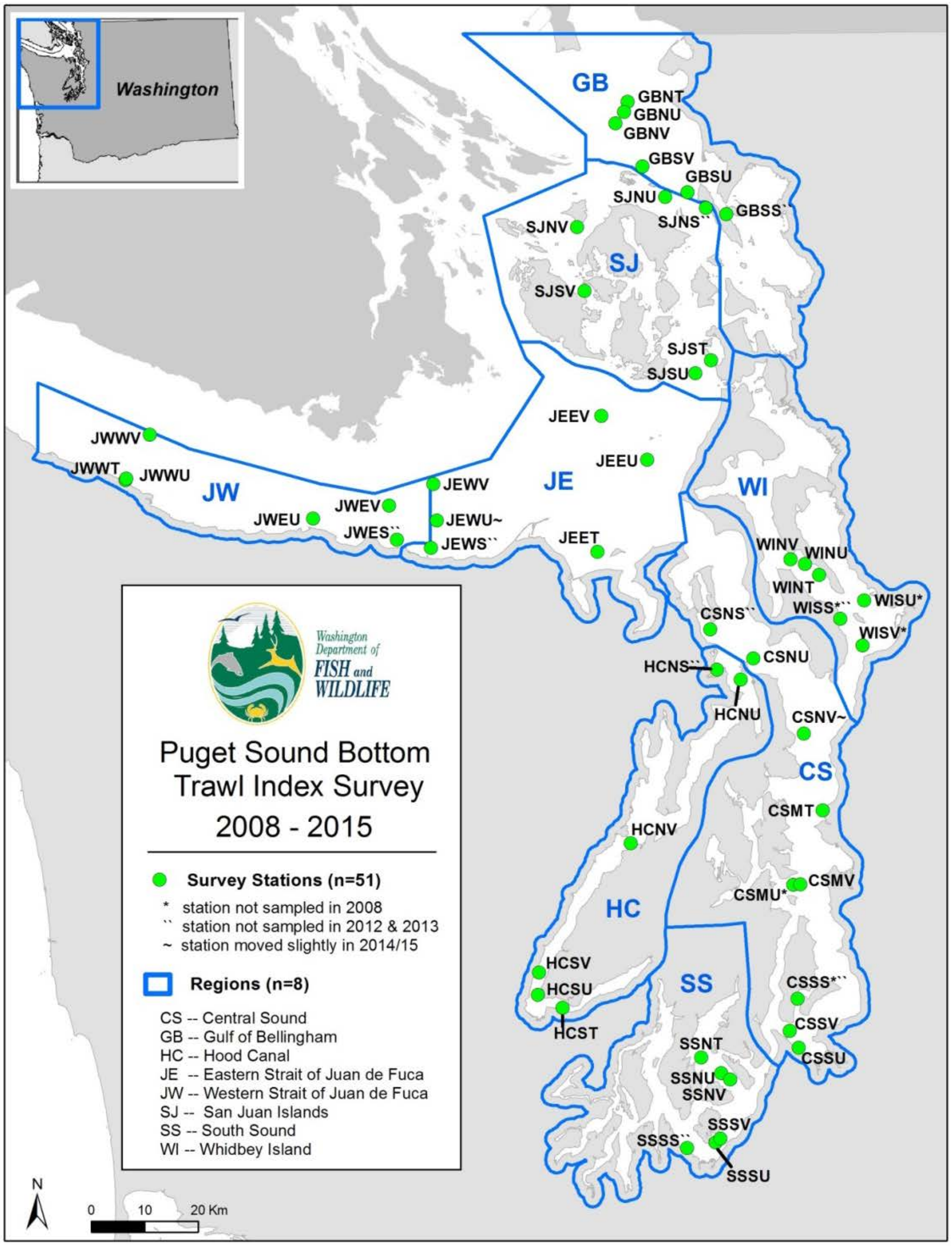



**Figure 1.** Trawl site locations for the Index survey design sampled in 2015

From 2008 to 2013, two 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 these paired tows at most stations, and in the interest of minimizing bottomfish mortality associated with the trawl survey, we altered our protocol in 2014. After the first tow is completed, the processed catch is compared to the average catch at that station since

2008. If the species comprising the majority (>75% by weight) of the tow falls within the previous years' average, no second tow is conducted at that station. If it is determined that the species composition was substantially different than expected, only then is a second tow conducted. This greatly improved the efficiency of the survey, as only 6 stations in 2014 and 4 stations in 2015 required a second tow. This newly gained efficiency has allowed us to institute two new sampling programs: vertical plankton tows, and gastric lavage/stomach collection on large predatory species (Pacific Cod, Spiny Dogfish, Lingcod, Walleye Pollock, Pacific Whiting/Hake). We also included the addition of bottom-contact sensors to the footrope to improve our understanding of net performance and increase the accuracy of density estimates from the trawl, and a mini-CTD on the headrope to collect water quality data at each trawl station and provide more accurate depth readings.

In 2015, WDFW conducted the 8$^{th}$ Index trawl survey of Puget Sound from April 27 through June 1, splitting boat time with PSEMP's biennial trawl survey. During our 14 survey days, we occupied all 51 stations and conducted 55 bottom trawls. An estimated 20,300 individual fish among 77 species weighing 7.7 mt were collected (2014: 25,700 fish; 78 species; 7.8 mt). Similar to 2014, Spotted Ratfish constituted 57% of the total fish catch by weight and 25% of the total number of individual fish, followed by English Sole at 17% and 23%, respectively. The remaining fish species contributed 5% or less to the fish catch weight and 7% or less to the total number of individual fish. For invertebrates, an estimated 9,500 individuals from 67 different species/taxa weighing 1.8 mt were caught in 2015, compared to 10,800 individuals from 76 species/taxa weighing 1.7 mt caught in 2014. By weight, the most dominant species were Dungeness Crab and Metridium anemones, comprising a respective 46% and 20% of the total invertebrate catch weight. By number of individuals, Alaskan Pink Shrimp and Dungeness Crab comprised 25% and 15%, respectively, of the invertebrate catch. The remaining species contributed 9% or less to the total invertebrate catch by weight or by number.

Pacific Eulachon was the only confirmed ESA-listed species encountered during the 2015 survey; 24 individuals were caught (up from 6 in 2014), and genetic samples were collected for each in accordance with the Section 10 permit for the trawl survey. One juvenile rockfish that was tentatively identified as a Canary was also caught; a genetic sample was collected and will be used to confirm identification.

Catches of three key Gadiformes species decreased in the 2015 survey compared to the 2014 survey: Pacific Cod, Walleye Pollock, and Pacific Whiting (Hake). In 2015, we caught 43 individual Pacific Cod weighing a total of 75 kg, compared to 2014's 88 individuals totaling 86 kg. Similar to previous years, Pacific Cod were primarily found in the western Strait of Juan de Fuca; in fact 65% of the total number of cod was caught at just one station north of Port Angeles. Walleye Pollock catch in 2015 consisted of an estimated 810 individuals weighing a total of 114 kg, compared to 1460 individuals totaling 277 kg in 2014. The steepest decline occurred in the western Strait of Juan de Fuca, in which our pollock catch dropped 97% by both weight and number. Lastly, Pacific Whiting (Hake) catch decreased from an estimated 1557 individuals weighing a total of 72 kg in 2014 to 450 individuals totaling 25 kg in 2015, with the largest declines occurring in the Whidbey Island region (90% drop in individuals, 84% in weight).

In contrast with the gadids noted above, North Pacific Spiny Dogfish were encountered at the highest rates since 2008. In the 2015 survey, we caught 246 individuals weighing a total of 387 kg, compared to the 2014 survey in which we caught just 34 individuals totaling 35 kg. Dogfish were most prevalent in the Gulf of Bellingham region (40% of the total individuals; 46% of the total weight), followed by the western and eastern Straits of Juan de Fuca and the San Juan Islands. Few dogfish were encountered in the rest of Puget Sound.

The 2016 Index bottom trawl survey is scheduled to occur from May 2 - May 26.

**Threatened and Endangered species surveys at Naval Installations –** The U.S. Navy controls multiple restricted areas throughout Puget Sound that have been exempted from rockfish critical habitat designation by the NMFS. The Navy maintaining an Integrated Natural Resource Management Plan (INRMP) is a prerequisite, however, to fulfill the requirements that authorize these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at NBK-Bremerton and NUWC-Keyport in 2013, the WDFW's PSMFS Unit entered into a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and critical habitat at the following installations: NASWI-Crescent Harbor, NAVMAG-Indian Island, NBK-Bangor, NBK-Bremerton, NUWC-Keyport, NAVSTA-Everett. These surveys, which expanded on the 2013 surveys, were conducted during 2014-15 and included ROV, scuba, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. As of February 2016, a final report for each installation was submitted, which concluded that: no ESA-listed rockfish were observed; no deep-water critical habitat (>30m) for adult rockfish was present; and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish do exist within the surveyed areas. These nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect methods in 2016-17. The deep-water surveys concluded in 2015.

The WDFW's PSMFS Unit has also entered into a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed forage fish and salmonids at the following installations: NASWI-Crescent Harbor, NASWI-Lake Hancock, NAVMAG-Indian Island, NBK-Bangor, Manchester Fuel Depot, NAVSTA-Everett. Monthly sampling at each installation began in May 2015 and will continue through the summer of 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. A summary of the results from 2015 sampling was included with the rockfish final reports. The only ESA-listed fish captured in beach seine conducted in 2015 were Puget Sound Chinook Salmon, Puget Sound Steelhead, Hood Canal Summer Chum Salmon, and Bull Trout. Regarding timing and abundance, juvenile salmonids and forage fish species generally followed trends previously documented in similar reports, which supports the work windows outlined in the WAC. In 2016-17 samples taken from these ESA-listed fish will be processed to determine stock of origin, using both genetic markers and coded wire tags.

**Annual Pacific Herring Assessment in Puget Sound –** Annual herring spawning biomass was estimated in Washington in 2015 using spawn deposition surveys. WDFW staff based in the Mill Creek, La Conner, Olympia, and Port Townsend offices conduct these assessment surveys of all 21 known herring stocks in Puget Sound and Hood Canal waters annually from January to June.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2015 is 13,246 tons (Table 1). The cumulative total is an increase from the 2014 total of 9,796 tons and higher than the mean cumulative total for the previous ten year (2006-2015) period of 11,658 tons. The increase in driven in part by increases in the Quilcene Harbor stock (Hood Canal), estimated at 4,097 tons in 2015, the highest spawning biomass for this stock since 2011. The other stock in this region, South Hood Canal, also increased from 112 tons in 2014 to 282 tons in 2015.

**Table 1**. Pacific Herring spawning biomass estimates (short tons) in Puget Sound by stock and year

| STOCK | YEAR | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| **Squaxin Pass** | 755 | 557 | 1,025 | 824 | 510 | 565 | 589 | 554 | 394 | 324 |
| **Purdy** | | | 496 | 125 | 500 | 711 | 135 | 260 | 83 | 32 |
| **Wollochet Bay** | 27 | 35 | 45 | 360 | 11 | 21 | 31 | 10 | 39 | 0 |
| **Quartermaster Harbor** | 987 | 441 | 491 | 843 | 143 | 96 | 108 | 157 | 44 | 55 |
| **Elliot Bay** | | | | | | | 290 | 214 | 29 | 135 |
| **Port Orchard-Port Madison** | 2,112 | 1,589 | 1,186 | 1,768 | 350 | 123 | 217 | 184 | 90 | 92 |
| **Port Gamble** | 774 | 826 | 208 | 1,064 | 433 | 1,464 | 404 | 273 | 170 | 345 |
| **Kilisut Harbor** | 54 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| **Port Susan** | 321 | 643 | 345 | 252 | 152 | 138 | 61 | 29 | 68 | 70 |
| **Holmes Harbor** | 1,297 | 572 | 686 | 1,045 | 673 | 3,003 | 678 | 585 | 459 | 456 |
| **Totals for South and Central Puget Sound** | **6,327** | **4,687** | **4,482** | **6,281** | **2,772** | **6,121** | **2,513** | **2,266** | **1,381** | **1,509** |
| **Skagit Bay** | 2,826 | 1,236 | 1,342 | 1,036 | 402 | 469 | 443 | 454 | 294 | 285 |
| **Fidalgo Bay** | 323 | 159 | 156 | 15 | 103 | 119 | 89 | 100 | 221 | 80 |
| **Samish/Portage Bay** | 412 | 348 | 409 | 320 | 649 | 387 | 430 | 693 | 778 | 559 |
| **Int. San Juan Islands** | 285 | 33 | 60 | 0 | 24 | 0 | 5 | 0 | 5 | 38 |
| **NW San Juan Islands** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| **Semiahmoo Bay** | 1,277 | 1,124 | 662 | 990 | 909 | 1,605 | 879 | 569 | 2,828 | 5,852 |
| **Cherry Point** | 2,216 | 2,169 | 1,352 | 1,341 | 774 | 1,301 | 1,120 | 908 | 1,003 | 524 |
| **Totals for North Puget Sound/SJI** | **7,339** | **5,069** | **3,981** | **3,702** | **2,861** | **3,881** | **2,966** | **2,724** | **5,129** | **7,338** |
| **South Hood Canal** | 244 | 70 | 223 | 156 | 214 | 156 | 264 | 199 | 112 | 282 |
| **Quilcene Bay** | 2,530 | 2,372 | 2,531 | 3,064 | 2,012 | 4,443 | 2,626 | 2,072 | 3,097 | 4,097 |
| **Totals for Hood Canal** | **2,774** | **2,442** | **2,754** | **3,220** | **2,226** | **4,599** | **2,890** | **2,271** | **3,209** | **4,379** |
| **Discovery Bay** | 1,325 | 42 | 248 | 205 | 26 | 0 | 105 | 0 | 5 | 12 |
| **Dungeness/Sequim Bay** | 0 | 34 | 69 | 46 | 75 | 104 | 43 | 71 | 72 | 8 |
| **Totals for Straight of Juan de Fuca** | **1,325** | **76** | **317** | **251** | **101** | **104** | **148** | **71** | **77** | **20** |
| **Annual Totals** | **17,765** | **12,274** | **11,534** | **13,454** | **7,960** | **14,705** | **8,517** | **7,332** | **9,796** | **13,246** |

The combined spawning biomass of South/Central Puget Sound herring stocks in 2015 of 1,509 tons is a slight increase from 2014, when the cumulative spawning biomass for this region was 1,381 tons. A number of stocks in the region that were previously at relatively large abundances are now at low levels, particularly the Port Orchard-Port Madison, Port Susan, Holmes Harbor and Quartermaster Harbor stocks.

The cumulative biomass of North Puget Sound stocks again increased dramatically in 2015 (7,338 tons) in comparison with 2014 (5,129 tons), which was also an increase from 2013 (2,724 tons). This was primarily the result of a robust year for the Semiahmoo Bay stock, which increased from 2,828 tons in 2014 to 5,582 in 2015. However, the spawning biomass of the Cherry Point stock decreased by roughly half in 2015 (524 tons) from the 2014 cumulative total (1,003 tons). This stock, which is genetically distinct from other herring stocks in Puget Sound and British Columbia, continues to be at critically low levels of abundance. Estimated herring spawning activity for the Strait of Juan de Fuca region also declined dramatically in 2015 (20 tons) in comparison with 2014 (77 tons), and remains at a very low level of abundance.

**Rockfish surveys on the Washington outer coast –** The focus of the fall 2015 cruise season was to experiment with longline gear in nearshore waters (inside 30 fathoms [55 m]) to target benthic rockfishes. The WDFW has been considering longline gear as a potential option for future nearshore rockfish surveys and currently conducts offshore longline surveys for Yelloweye Rockfish. Previously, the existing rod-and-reel survey for Black Rockfish had been modified to accommodate the need for information on additional rockfish species that inhabit nearshore waters. Issues with fishing tackle selection and general concerns about gear standardization with rod-and-reel surveys prompted the effort to begin experimentation with longline gear in nearshore waters. One spring cruise in 2015 was dedicated to longline experimentation, and it was immediately apparent that the longline gear would be a viable option for targeting the additional focal rockfish species. In September of 2015 a five-day pilot survey that utilized fixed longline gear to target nearshore groundfish species was completed. The specific objectives of this survey were to:

1. Deploy conventional fixed (tub gear) longline gear in nearshore waters, using a modified version of the standard IPHC survey gear. Key gear differences were hook size, gangion size and material, and bait used.
2. Target Blue/Deacon Rockfish, China Rockfish, Copper Rockfish, Quillback Rockfish, Tiger Rockfish, Vermilion Rockfish, Yelloweye Rockfish, Cabezon, and Kelp Greenling
3. Investigate suitable locations to deploy the gear in order to catch a wide variety of demersal rockfish, especially China Rockfish.
4. Collect biological information such as length, sex, weight, and otoliths from all retained fish. Retain all rockfish, cabezon, and kelp greenling.
5. Deploy a CTD at all fishing locations.
6. Tag and release any encountered Yelloweye Rockfish
7. Choose locations where rod-and-reel gear could sample in conjunction with the longline for gear comparison.

September was chosen for this pilot survey due to vessel availability, logistical reasons (followed by offshore yelloweye survey), weather, and staff availably. The first good weather opportunity after mid-September was chosen to begin work.

The longline gear developed for this survey was modified from the standardized gear that the IPHC uses for their annual halibut surveys. IPHC gear consists of a weighted mainline with 16/0 circle hooks affixed by a #72 gangion line 24-28 inches in length. Gangions are tied to the mainline and hooks are attached to loops tied at the end of the gangions. Hooks are baited with #2 semi-bright chum salmon. The mainline is broken into units of length called “skates” which are 1800’sections with gangions spaced at 18’ intervals to accommodate 100 hooks per skate. Each skate can be attached to another so that mainline length can vary from 1800’ to any desired length. The ends of each set (multiple skates combined) receive a length of anchor line followed by a 40-60 lb fishermen type anchor and then a buoy line varying in length (based on depth) attached to a surface buoy array. A 10 lb lead is attached at the junction of each skate. WDFW began modification experiments with this gear in 2013 on yelloweye surveys to target smaller sized fish.

The modified gear included identical mainline lengths and hook spacing, but smaller 12/0 and 14/0 circle hooks baited with squid were used with smaller #60 hard lay gangions 24-28 inches in length. Squid was used as bait because the smaller hooks do not hold pieces of salmon very well and squid is a typical bait choice for longline fishermen that target rockfish. 14/0 hooks were chosen over the 12/0 hooks because there seemed to be more fish dropping off of the line with the 12/0 hooks. This experimental gear was changed again just before fall 2015 to experiment with a different type of gangion for this nearshore pilot study. The #60 hard lay gangions would kink easily and break. A different type of gangion material (nylon) that is more pliable (soft lay) was used instead to address this issue. The use of weights (end anchors and mainline lengths) were kept the same except the mainline weights (10 lb lead) were placed mid-skate since sets were only going to be one skate in length. In summary, gear used for this survey was standard IPHC mainline material and length units with soft lay #60 nylon gangions, 14/0 Mustad circle hooks, and American squid.

Three hours was estimated as sufficient soak time to provide good catch rates, limit lingcod predation on hooked fish, and allow for logistical needs of travel and bottom familiarization while deploying gear each day. Soak time is defined as the elapsed time between deployment of the first anchor and the beginning of retrieval of the buoy line for any given set.

Five general fishing areas (Figure 2) were identified as survey areas to investigate and deploy gear over the five day survey. These areas were identified as potential target species habitat by looking at species compositions from previous rod and reel survey locations. Objectives for the 2014 and 2015 rod and reel surveys included searching for undocumented rockfish habitat and targeting a broader list of focal species. This information showed particular areas where demersal rockfish encounters could be expected. Within each of the daily areas, skipper and WDFW staff discretion were applied in identifying exact set locations at a rate of four to five sets of one skate each per day.

Data collected at each station in the 2015 survey included set start and stop GPS locations, set depth ranges, set and haul times, 100 percent hook by hook tally of catch identified as close to species level as possible, and status of unoccupied hooks such as empty or baited. Biological information was collected from retained and released fish; released fish were measured and retained fish were measured, weighed, sexed, and dissected for otoliths. A CTD was deployed at each set location immediately before set retrieval to collect temperature, depth, salinity, dissolved oxygen and chlorophyll measurements. All data was immediately logged electronically as gear was set and hauled. Biological information from retained fish was collected during the mid-cruise weather day and after the cruise in port. The cruise data was housed in a master MS Access database for all WDFW coastal longline surveys.

The five planned fishing areas were sampled over five charter days (Table 2) with 23 individual locations (sets) fished at 4-5 sets per day. Individual sets (Table 3) ranged in depth from 7-24 fathoms (13-44 meters). The cruise started out of Westport, WA to begin sampling at Pt.

Grenville, moving north each day to the next fishing area. The cruise was completed in Makah Bay with one bad weather day spent in La Push mid-way through the trip. Before gear deployment each day, time was spent getting familiarized with reef structures at specific locations identified from rod-reel survey data to determine suitability for longline fishing operations. Specific locations and set orientations were chosen based on rugosity, previous rod-reel catch rates and compositions, safety, and reef size and shape. The gear was set to maximize hard substrate coverage yet minimize potential snagging on steep pinnacle structures.

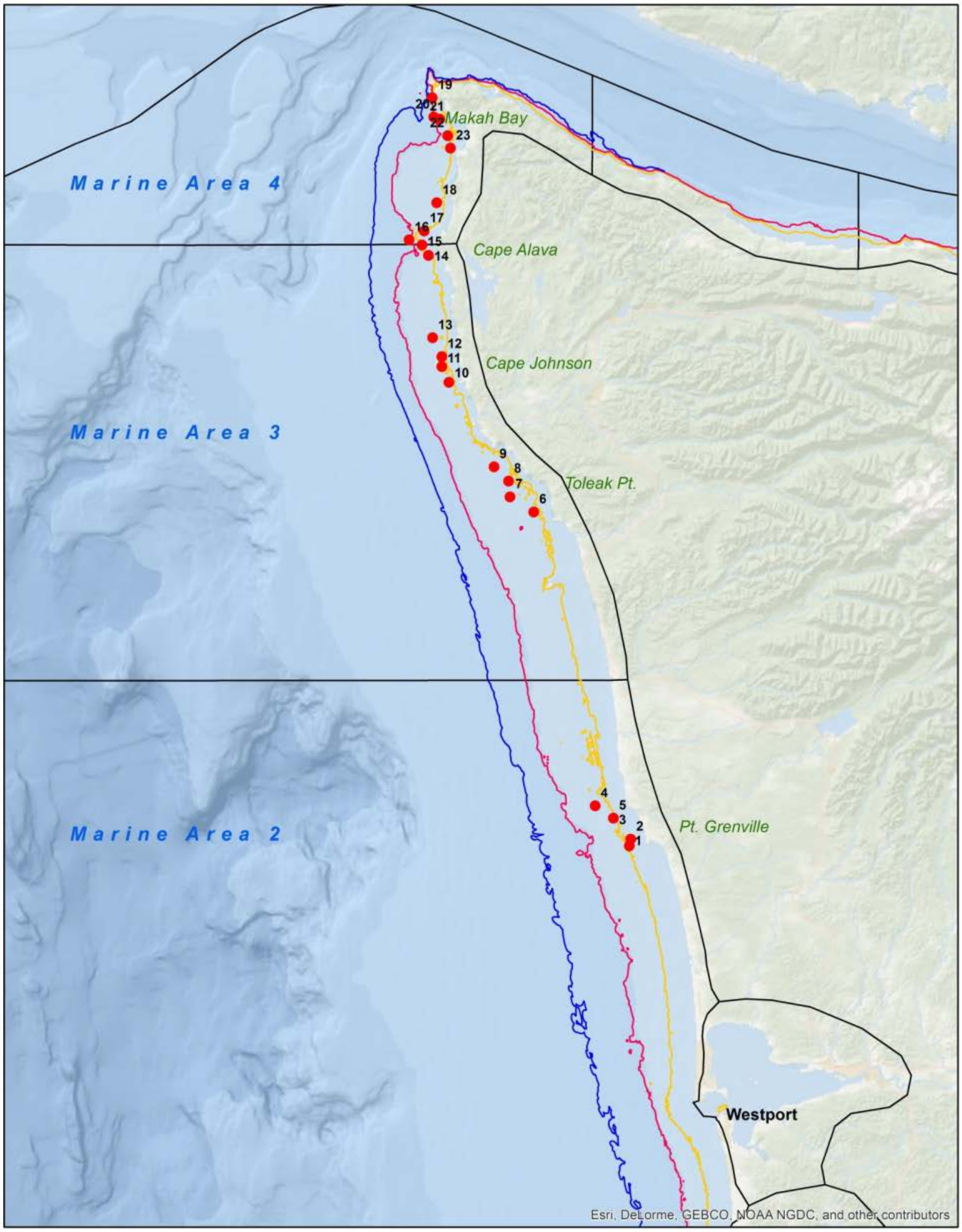



**Figure 2**. Longline set locations for all fished areas.

**Table 2**. Summary of deployed effort and catch by date and area.

| Date | Survey Area | Marine Area * | Locations Fished | Hooks Deployed | Fish Caught | Fish Species Caught |
|---|---|---|---|---|---|---|
| 9/22/2015 | Pt. Grenville | 2 | 4 | 497 | 19 | 6 |
| 9/23/2015 | Toleak Pt. | 3 | 4 | 396 | 30 | 8 |
| 9/25/2015 | Cape Johnson | 3 | 4 | 400 | 57 | 8 |
| 9/26/2015 | Cape Alava | 3/4 | 5 | 498 | 80 | 11 |
| 9/27/2015 | Makah Bay | 4 | 5 | 503 | 61 | 12 |

* WDFW recreational punchcard area

**Table 3**. Summary of set details and total catch.

| Set | Date | Survey Area | Skates Set | Hooks | Soak Time (min) | Fish Caught | Fish Species Caught | Start Depth (ftm) | Start Depth (m) | End Depth (ftm) | End Depth (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9/22/2015 | Pt. Grenville | 1 | 98 | 185 | 0 | 0 | 9 | 16 | 10 | 18 |
| 2 | 9/22/2015 | Pt. Grenville | 1 | 99 | 194 | 0 | 0 | 8 | 15 | 7 | 13 |
| 3 | 9/22/2015 | Pt. Grenville | 1 | 100 | 210 | 2 | 2 | 10 | 18 | 11 | 20 |
| 4 | 9/22/2015 | Pt. Grenville | 1 | 100 | 228 | 12 | 5 | 15 | 27 | 15 | 27 |
| 5 | 9/22/2015 | Pt. Grenville | 1 | 100 | 79 | 4 | 3 | 10 | 18 | 10 | 18 |
| 6 | 9/23/2015 | Toleak Pt. | 1 | 100 | 182 | 1 | 1 | 10 | 18 | 12 | 22 |
| 7 | 9/23/2015 | Toleak Pt. | 1 | 97 | 197 | 11 | 4 | 14 | 26 | 14 | 26 |
| 8 | 9/23/2015 | Toleak Pt. | 1 | 99 | 209 | 10 | 4 | 15 | 27 | 15 | 27 |
| 9 | 9/23/2015 | Toleak Pt. | 1 | 100 | 220 | 6 | 4 | 17 | 31 | 16 | 29 |
| 10 | 9/25/2015 | Cape Johnson | 1 | 100 | 179 | 28 | 6 | 14 | 26 | 16 | 29 |
| 11 | 9/25/2015 | Cape Johnson | 1 | 99 | 200 | 9 | 3 | 15 | 27 | 15 | 27 |
| 12 | 9/25/2015 | Cape Johnson | 1 | 100 | 213 | 8 | 4 | 14 | 26 | 13 | 24 |
| 13 | 9/25/2015 | Cape Johnson | 1 | 101 | 229 | 12 | 5 | 18 | 33 | 18 | 33 |
| 14 | 9/26/2015 | Cape Alava | 1 | 99 | 198 | 21 | 4 | 9 | 16 | 9 | 16 |
| 15 | 9/26/2015 | Cape Alava | 1 | 101 | 232 | 9 | 3 | 8 | 15 | 9 | 16 |
| 16 | 9/26/2015 | Cape Alava | 1 | 100 | 246 | 29 | 9 | 22 | 40 | 17 | 31 |
| 17 | 9/26/2015 | Cape Alava | 1 | 97 | 257 | 9 | 3 | 11 | 20 | 8 | 15 |
| 18 | 9/26/2015 | Cape Alava | 1 | 101 | 274 | 12 | 5 | 16 | 29 | 14 | 26 |
| 19 | 9/27/2015 | Makah Bay | 1 | 102 | 180 | 17 | 6 | 16 | 29 | 21 | 38 |
| 20 | 9/27/2015 | Makah Bay | 1 | 99 | 203 | 19 | 7 | 16 | 29 | 24 | 44 |
| 21 | 9/27/2015 | Makah Bay | 1 | 100 | 233 | 12 | 3 | 13 | 24 | 17 | 31 |
| 22 | 9/27/2015 | Makah Bay | 1 | 101 | 251 | 5 | 3 | 12 | 22 | 11 | 20 |
| 23 | 9/27/2015 | Makah Bay | 1 | 101 | 267 | 9 | 3 | 10 | 18 | 10 | 18 |

In total, 254 hooks were occupied at the rail upon retrieval for an overall hook occupancy rate of 11.1%. Hook occupancy rates varied from zero catch to 30% for individual sets. Catch rates were very low at Pt. Grenville with an overall catch rate of 4.4%; sand flea predation was suspected due to the quantity of empty hooks (no remaining bait attached) recorded at the rail. Seventeen different fish species were caught over the 5 sampling days, including 10 different rockfish species. Catch rates increased (Table 4) and number of species encountered increased (Figures 3-5) as the sampling progressed northward. Highest catch rates and species diversity were seen at Cape Alava and Makah Bay. Cabezon and China Rockfish were the most frequently caught species, comprising almost half of the total catch. Fifty-eight percent of the total catch was rockfish. Kelp Greenling were the only target species not encountered during sampling.

**Table 4**. CPUE and average CPUE (bold numbers) by area for rockfish, cabezon, and lingcod. CPUE reported as ratio of total catch by set to number of hook soak hours.

| Area - Set | Black Rockfish | Blue Rockfish | Cabezon | Canary Rockfish | China Rockfish | Copper Rockfish | Lingcod | Quillback Rockfish | Tiger Rockfish | Vermilion Rockfish | Yelloweye Rockfish | Yellowtail Rockfish |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pt. Grenville** | **0.0104** | | **0.0029** | **0.0026** | | | **0.0086** | | | | | |
| 3 | | | 0.0029 | | | | 0.0029 | | | | | |
| 4 | 0.0132 | | | 0.0026 | | | 0.0079 | | | | | |
| 5 | 0.0076 | | | | | | 0.0152 | | | | | |
| **Toleak Pt.** | **0.0076** | | **0.0083** | **0.0029** | **0.0126** | | | | | | **0.0027** | |
| 6 | | | 0.0033 | | | | | | | | | |
| 7 | 0.0031 | | 0.0157 | | 0.0126 | | | | | | | |
| 8 | 0.0116 | | 0.0116 | 0.0029 | | | | | | | | |
| 9 | 0.0082 | | 0.0027 | | | | | | | | 0.0027 | |
| **Cape Johnson** | **0.0111** | **0.0156** | **0.0163** | **0.0026** | **0.0064** | **0.0040** | **0.0034** | | | | | |
| 10 | 0.0302 | 0.0235 | 0.0201 | | 0.0101 | 0.0067 | 0.0034 | | | | | |
| 11 | 0.0061 | | 0.0182 | | | | | | | | | |
| 12 | 0.0028 | | 0.0141 | | 0.0028 | 0.0028 | | | | | | |
| 13 | 0.0052 | 0.0078 | 0.0130 | 0.0026 | | 0.0026 | | | | | | |
| **Cape Alava** | **0.0122** | **0.0049** | **0.0115** | **0.0024** | **0.0239** | **0.0043** | **0.0041** | **0.0083** | **0.0024** | **0.0024** | **0.0022** | |
| 14 | | | 0.0153 | | 0.0367 | 0.0061 | 0.0061 | | | | | |
| 15 | | | 0.0051 | | 0.0154 | | 0.0026 | | | | | |
| 16 | 0.0122 | 0.0049 | 0.0098 | 0.0024 | 0.0195 | | 0.0049 | 0.0122 | 0.0024 | 0.0024 | | |
| 17 | | | 0.0144 | | | 0.0024 | 0.0048 | | | | | |
| 18 | | | 0.0130 | | | 0.0043 | 0.0022 | 0.0043 | | | 0.0022 | |
| **Makah Bay** | **0.0025** | **0.0177** | **0.0057** | **0.0209** | **0.0128** | **0.0023** | **0.0033** | **0.0060** | | **0.0068** | **0.0030** | **0.0033** |
| 19 | | 0.0294 | 0.0033 | | 0.0131 | | 0.0033 | | | 0.0033 | | 0.0033 |
| 20 | | 0.0060 | | 0.0209 | 0.0060 | | | 0.0060 | | 0.0119 | 0.0030 | |
| 21 | 0.0026 | | | | 0.0232 | | | | | 0.0052 | | |
| 22 | 0.0024 | | 0.0071 | | | 0.0024 | | | | | | |
| 23 | | | 0.0067 | | 0.0089 | 0.0022 | | | | | | |
| **Average** | **0.0088** | **0.0143** | **0.0104** | **0.0063** | **0.0148** | **0.0037** | **0.0053** | **0.0075** | **0.0024** | **0.0057** | **0.0026** | **0.0033** |

Biological information was collected from all encountered catch excluding invertebrates (Figure 6). All rockfish and Cabezon were retained with the exception of two Cabezon and one Blue Rockfish that were lost at the rail. Otoliths, lengths, sex, and weights were collected from all retained fish where complete specimens were retained. All fish during the cruise were scanned for previously implanted tags, but no previously tagged fish were encountered. Three Yelloweye Rockfish were tagged with external Floy tags and internal pit tags before release. Tissue samples were collected from the three encountered yelloweye and 50 encountered china rockfish for DNA analysis.

Gear deployment for all sets was successful with no gear loss or significant bottom hang up. Soak times varied from 3 to 4.6 hours with each successive set for the day soaking longer than the previous set. Set 5 for the trip was an exception to this; set 5 was a repeat of set 3 but modified with mainline floats meant to investigate potential sand flea predation on baits. Although the soak time was only 80 minutes on set 5, more than twice as many baits were retained and catch rates were higher. Bait retention increased as the survey progressed northward with the most bait retention recorded in Makah Bay. No lingcod predation was noticed on any of the catch.

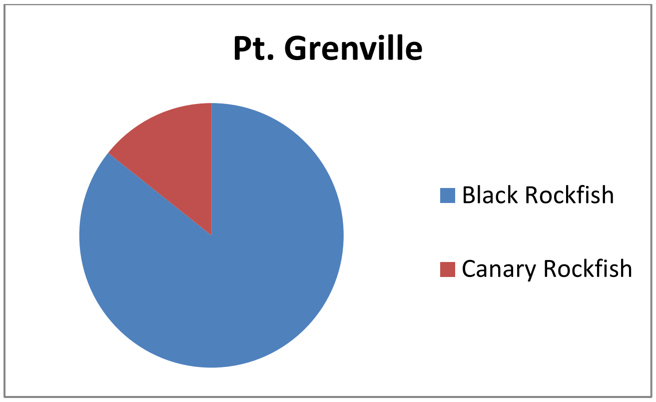
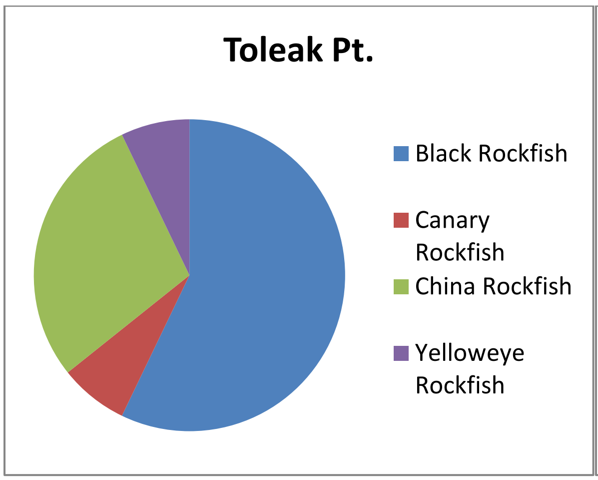



**Figure 3**. Rockfish catch composition for Pt. Grenville.



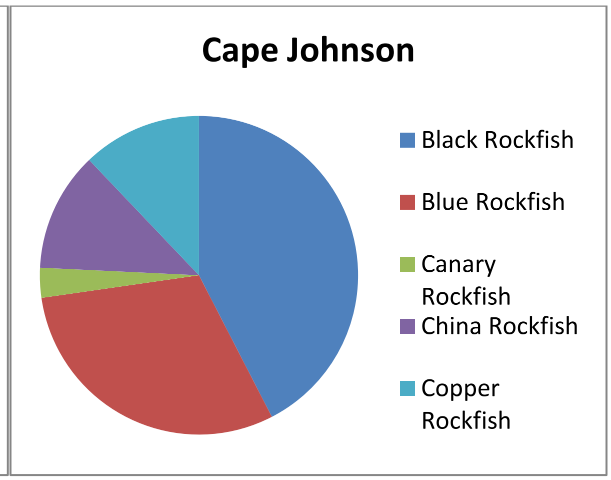
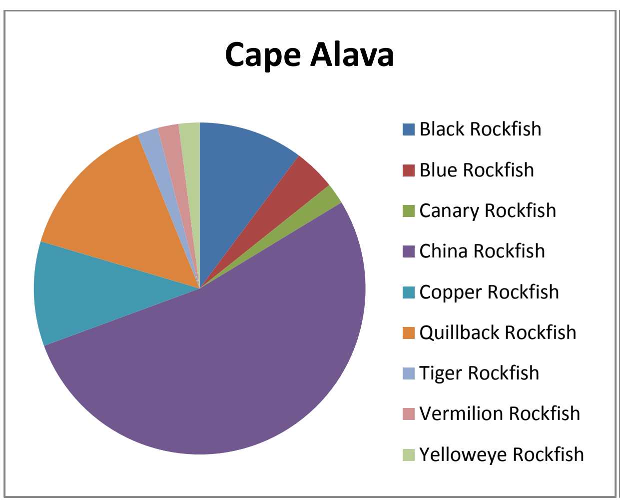




**Figure 4**. Rockfish catch composition for fishing areas near La Push.



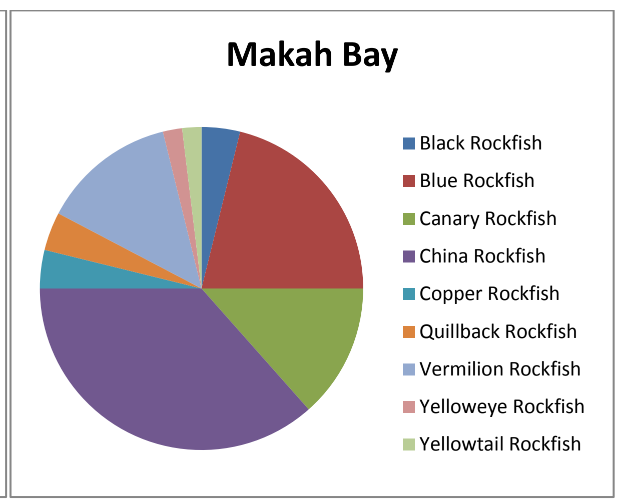




**Figure 5.** Rockfish catch composition for north coast fishing areas.

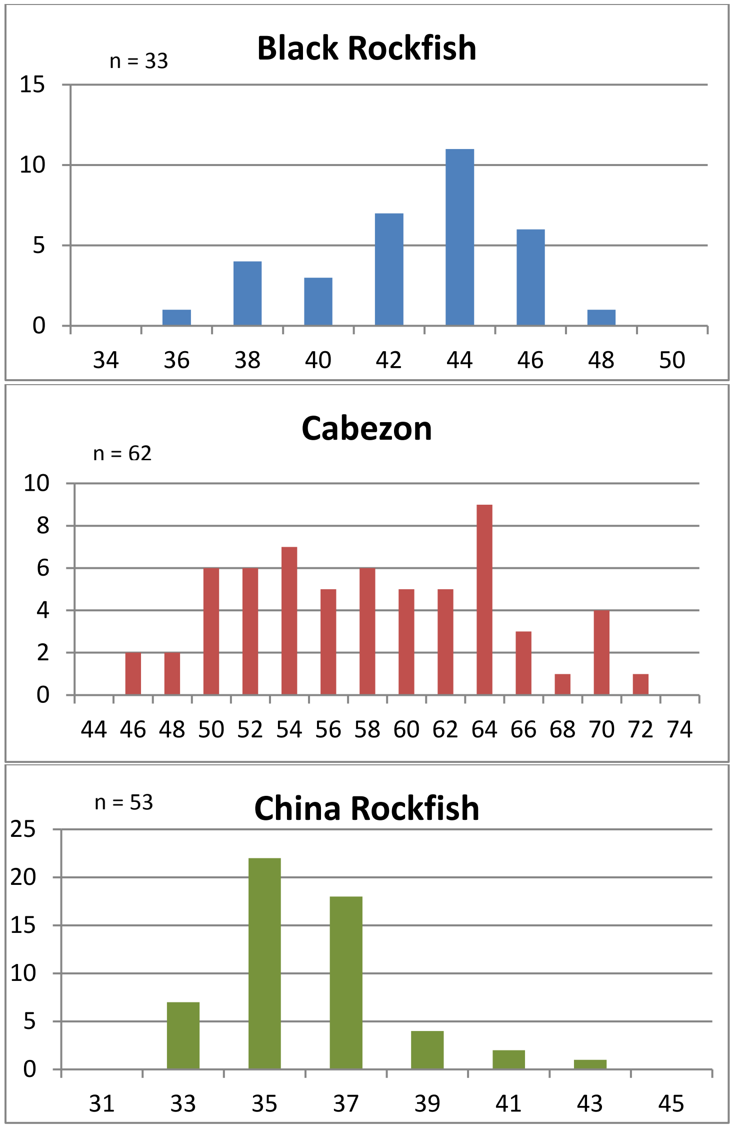



**Figure 6**. Length frequencies for the most encountered fish species.

**Toward a synoptic approach to reconstructing west coast groundfish historical removals –** Quantifying the removal time series of a stock is an essential input to a variety of stock assessment methods and catch-based management. But estimating removals is really hard. Sampling protocols, fishery diversity, catch versus landing location, dead discards, and species identification are just some of the complications that vary across time and space. Given that most groundfish stocks are distributed coast-wide and a complete time series of removals is needed, this project aims to coordinate approaches across the states of Washington, Oregon and California to confront removal reconstruction challenges and establish common practices. Both California and Oregon have attempted historical removal reconstructions, while Washington is just beginning the process. We use the Washington effort to focus on six groundfish species that vary in the difficulty of estimating removal histories: Black, Canary, and Rougheye rockfishes, Petrale Sole, Sablefish, and Lingcod. The Washington reconstruction is compared to the approaches taken for the same species in Oregon and California with the goal of matching reconstruction protocols across states to the extent possible. Lastly, uncertainty levels across periods, species and states are established. This is a new feature of all three removal reconstructions which will improve treatment of uncertainty in future stock assessments.

**Reserves**

**Marine reserve monitoring and evaluation –** Due to changes in program priorities and staffing limitations brought on by intensive ROV survey work, very little directed monitoring of marine protected areas and reserves has occurred in Puget Sound since 2011 and no monitoring activities were conducted in 2015. A systematic evaluation of data from SCUBA-based surveys collected between 2000 and 2010 is nearing completion and six sites for which sufficient data are available are being used to evaluate reserve efficacy.

Preliminary results indicate that site-specific variation in average fish size, biomass, and density are all significant factors influencing long-term trends in these variables. Despite this, significant trends toward more, larger fish are apparent for Lingcod, Copper Rockfish, and Quillback Rockfish at some locations. Notable recruitment pulses are also clearly apparent at multiple sites, specifically for rockfishes during 2006. For most species and locations it appears that a 15-yar evaluation period simply doesn't represent a long enough time frame to observe significant changes in abundance, biomass, and density, given the level of noise observed in these parameters. Planning has begun to replicate these studies at longer intervals (e.g., 20 years, 30 years).

Over the next six months Larry LeClair, Lisa Hillier, and Dayv Lowry will be drafting a report on these six sites that includes, as an appendix, data from other sites surveyed during the evaluation period for which data collection was more sparse.

**Review of Agency Groundfish Research, Assessment, and Management**

Hagfish

**The Washington Hagfish commercial fishery –** Opened in 2005 under developmental regulations, the Washington hagfish fishery is small in scale, exporting hagfish for both frozen and live-fish food markets in Korea. Management of the Washington hagfish fishery is challenged by a lack of life history information, partial controls, and high participant turnover. Active fishery monitoring and sampling began in 2009. Due to limited agency resources, only fishery dependent data programs have been developed to inform management, including logbooks, fish receiving tickets and biological sampling of catch. Current efforts intend to focus on refining and improving these programs, including improving systematic sampling, developing species composition protocols, shifting to use the maturity scale developed by Martini (2013). Interest in conducting a study similar to research conducted in California (Tanaka, 2014) to evaluate escapement relative to barrel dewatering-hole size exists but will depend on funding availability.

The Washington hagfish fishery operates by rule only in offshore waters deeper than 50 fathoms. It is also regulated under open access provisions. Figure 7 presents annual landings by state since 2000. However, landings don't necessarily represent where fishing actually occurred. Washington licensed fishers can fish federal waters off Oregon and land that catch into Washington. Vessels that freeze at sea are particularly able to advantage themselves this way. Live hagfish vessels typically fish grounds closer to their home port. The fishery catches predominantly Pacific Hagfish (*Eptatretus stoutii*). Occasionally, Black Hagfish (*Eptatretus deani*) are landed incidentally. Landings data cannot distinguish between species as only one code exists for hagfish. Hagfish are caught in long-lined barrels (Figure 8); rules limit each fisher to 100. The barrels are constructed from olive oil or pickle barrels modified with an entrance tunnel and dewatering holes. Average soak time is 21 hours.

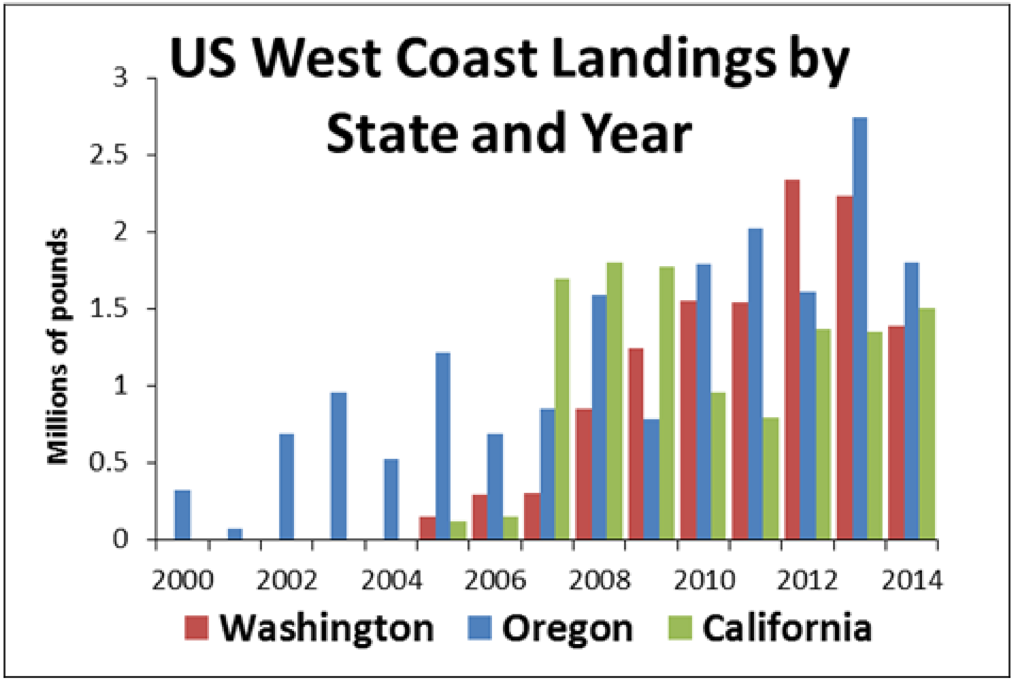



**Figure 7.** Hagfish Landings in pounds by Washington, Oregon, and California; 2000-2014.

Fishing location and catch per unit effort have been evaluated from logbook data (Figure 9). Fishing occurs on soft, muddy habitat. Pacific hagfish are predominant from 50 to 80 fathoms. Deeper sets, up to 300 fathoms, have been made to target Black Hagfish. Pacific and Black Hagfish ranges appear to overlap between 80 and 100 fathoms.

Figure 4 presents catch per unit effort (CPUE) for years with more than 100 sets by catch area. Median CPUE is about 4.5 pounds. Instances of high CPUE are evident; in these situations skippers reported "plugged" barrels.

**Figure 14.** Hagfish barrels used in the commercial fishery.

Length, weight, and maturity data have been collected from Pacific and Black Hagfish; however, only Pacific Hagfish data are reported here. Male and female hagfish present similar size distributions, ranging from 30 to 65 cm (Figure 10). The in-sample largest specimen was 78 cm male, the smallest a 25 cm female. By depth, male and female distribution is similar at the depths the fishery operates; none of the samples were from sets shallower than 59 fathoms (Figure 11). An evaluation of maturity suggests year-round spawning (Figure 12). Fecundity is low; the number of mature eggs rarely exceeds 10 to 12. Very few females with fully developed eggs and even fewer spent females have been sampled.

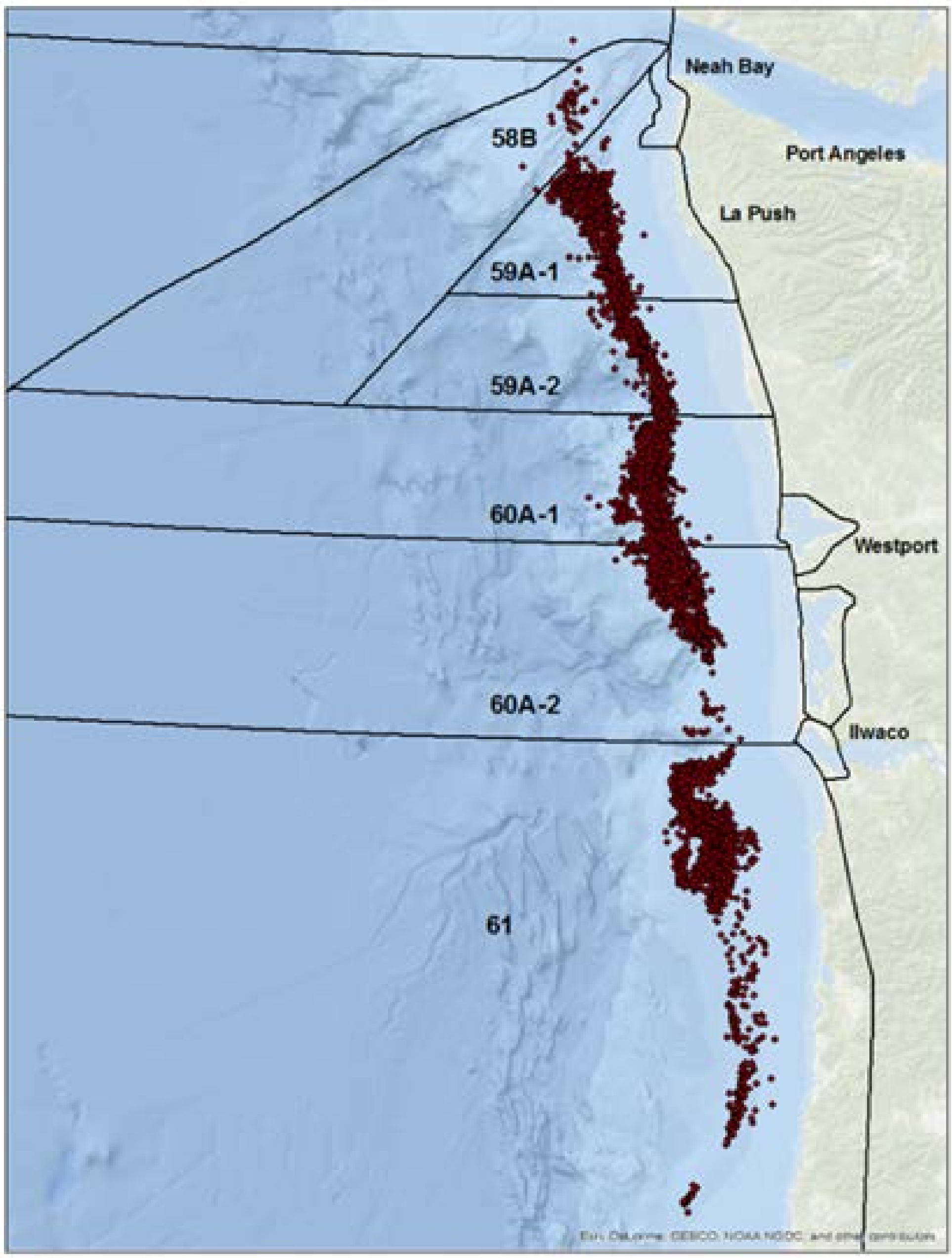


**Figure 9.** Hagfish fishing off WA and OR, from Washington logbooks, 2005-2014.

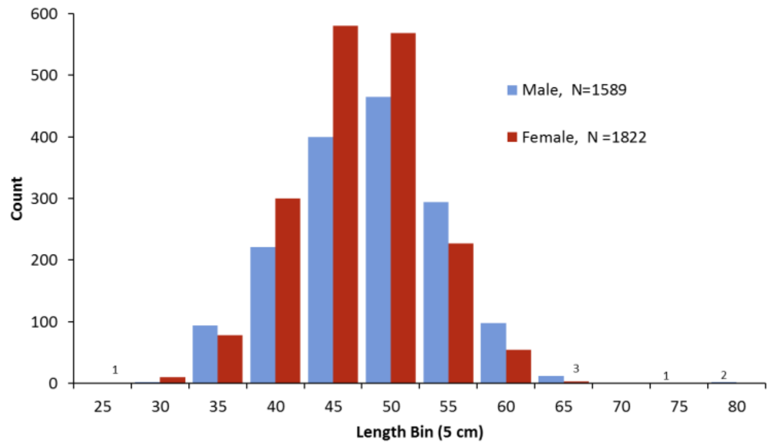



**Figure 10.** Length (cm), male and female Pacific Hagfish only.

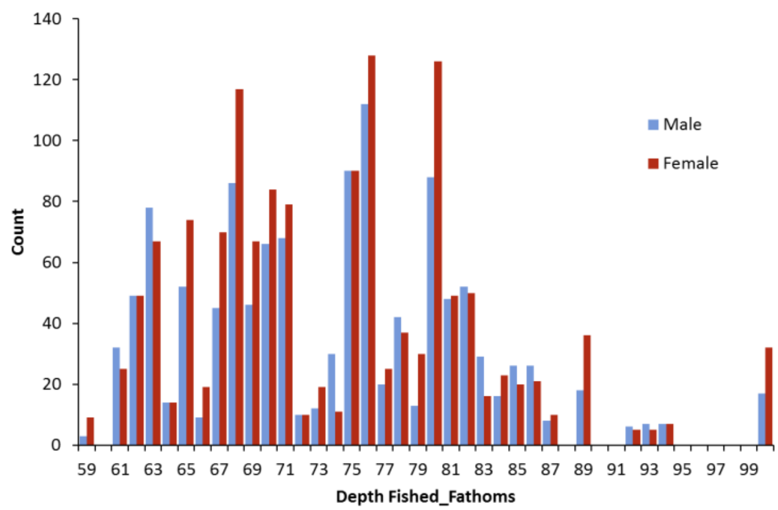



**Figure 11**. Distribution, by depth (fa), of male and female Pacific Hagfish.

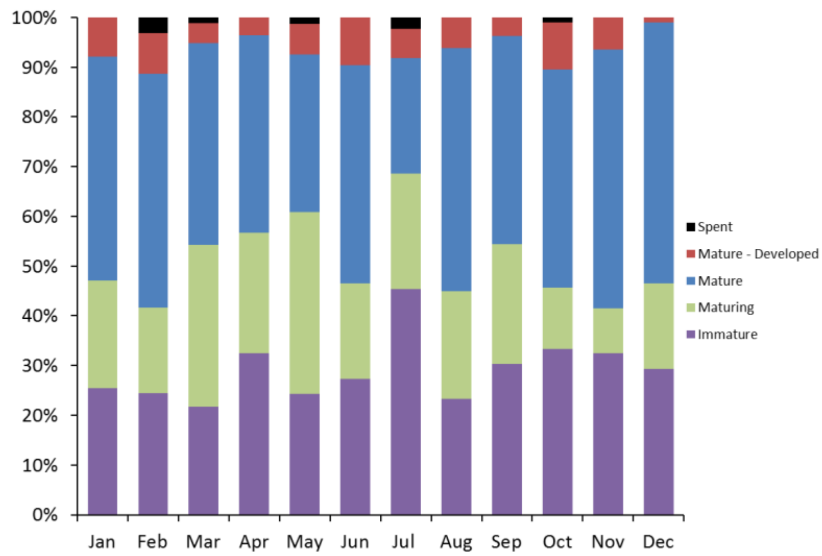



**Figure 12.** Female Pacific Hagfish maturity, proportion by month.

North Pacific Spiny Dogfish and other sharks

**Lummi Nation dogfish fishery in northern Puget Sound –** Directed commercial fishing for North Pacific Spiny Dogfish *Squalus suckleyi* was formally closed in Puget Sound in 2010 to protect ESA-listed rockfishes (Canary Rockfish, Yelloweye Rockfish, and Bocaccio) and their habitats. This included both State-sponsored and Tribal commercial fisheries. Prior to this closure, annual Sound-wide State harvest was below 500k lbs since 1997, though harvests as large as ~8.6M lbs once occurred (1979). By contrast, dogfish harvest in Puget Sound by Native American tribes peaked in 1996 at 159k lbs.

In 2014 the Lummi Nation initiated a directed drift- and set-gillnet fishery for dogfish in their Usual and Accustom Fishing Ground in northern Puget Sound. The harvest quota for this fishery was set at 250k lbs, 159k of which was taken in 2014 and 219k of which was taken in 2015. Harvest occurs predominantly from May-August, involves little to no reported bycatch, and tails off as fishers transition to targeting salmon in the fall.

In August of 2015 Lummi Nation biological staff collected biological data and fin clips from a representative sub-sample of sharks caught in two locations as part of the tribal fishery. Every one of these 100 sharks was female, and their average size was 87 cm. Many contained full-term embryos. Lummi biologist Breena Apgar-Kurtz confirmed that this was a representative sub-sample and that the "vast majority" of the harvest consisted of relatively large female sharks. The WDFW is currently working with the Lummi Nation to address conservation concerns associated with the size and sex composition of the catch.

**Shark book --** Together with Dr. Shawn Larson of The Seattle Aquarium, Dayv Lowry will be co-editing a book entitled *Northeast Pacific Shark Biology, Research, and Conservation.* Planning for this undertaking began in November of 2015 and final author commitments were obtained in March of 2016. Topics covered will include regionally specific policy, current taxonomy and population trends, fisheries impacts/interactions, food web ecology, advances in aging techniques, genetic population identification, the role of captive husbandry programs in conservation, the economy of ecotourism, and future challenges to long-term conservation. Publication is expected in the summer of 2017 through Elsevier Scientific.

Skates
No specific, directed research or management to report.

Pacific Cod
**Assigning individual Pacific Cod to population of origin along an isolation-by-distance gradient –** Many marine species are characterized by an isolation-by-distance pattern (IBD), where more geographically distant samples are also more genetically differentiated. IBD patterns are problematic for management because population boundaries, and thus spatial management units, cannot be cleanly delineated. Assignment tests could potentially be used to identify population of origin, facilitating management by estimating seasonal migration patterns and distances, as well as detecting productive areas. However, most IBD patterns are shallow and assignment tests have little power. The team of Kristen Gruenthal and Lorenz Hauser at the University of Washington, Mike Canino at NOAA's Alaska Fisheries Science Center, and Dayv Lowry successfully applied restriction site associated DNA (RAD) sequencing toward stock identification in the Pacific Cod (*Gadus macrocephalus*), which exhibits nearly perfect IBD along the northeastern Pacific coast. Using 6,756 SNPs, they were able to reassign 95-100% of fish to their population of origin, with high confidence, while still reproducing the strong IBD pattern found in earlier studies. Moreover, they were able to identify over 200 SNPs that may be under selection across the sampled range. These results lay the groundwork for future genetic stock identification and genetics-based management of Pacific cod. A manuscript details these results in current in preparation and expected to be complete by late summer 2016.

Walleye Pollock
No specific, directed research or management to report.

Pacific Whiting (Hake)
No specific, directed research or management to report.

Grenadiers
No specific, directed research or management to report.

Rockfishes
**Participation in the Federal Rockfish Technical Recovery Team –** Since 2012 Dayv Lowry and Bob Pacunski have served on 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 since April of 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 underwent 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 of the document was postponed in early 2016 due to the initiation of the five-year status review for these species by the Biological Review Team. A final plan will be finalized late in 2016, depending on the completion date for the five-year review and the outcome of a pending delisting decision (see below).

**Genetic study on ESA-listed rockfish –** In April of 2014 WDFW partnered with NOAA to conduct a two-year fishing study aimed at collecting genetic samples of ESA-listed rockfish (Dayv Lowry and Bob 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 obtained samples from over 60 Yelloweye Rockfish, over 70 Canary Rockfish, and 3 Bocaccio in the Puget Sound DPS, with collections occurring throughout the Sound (Figure 13). 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, and one additional fish sighted by each method in 2016).

Results from the genetic analysis strongly demonstrate that Canary Rockfish within the Puget Sound/Georgia Basin DPS are not genetically distinct from Canary Rockfish outside the DPS, and it a recommendation has been passed to the Biological Review Team conducting the five-year status review to delist this species. Yelloweye Rockfish, however, are genetically distinct within and outside the DPS boundary, and fish in Hood Canal also form a largely independent cluster. Additional samples collected from Canadian waters north of the current DPS boundary line have prompted a recommendation to extend this boundary to include more of Johnstone Strait and interior waters to the northern end of Vancouver Island. Listing status recommendations for Bocaccio were not made due to low sample size.

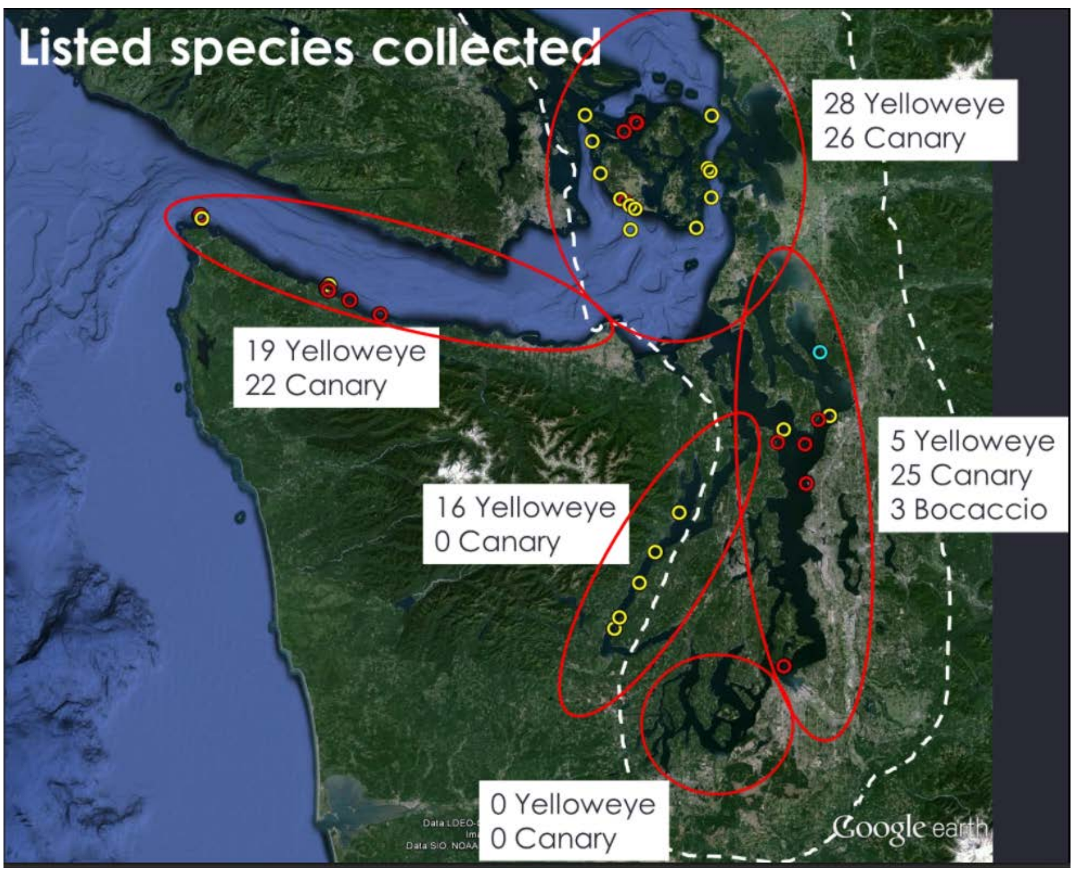



**Figure 13**. Total sample numbers for ESA-listed rockfish by region as of December 2015 for the Sound-wide genetic study.

**Developing an index of abundance for Yelloweye Rockfish (*Sebastes ruberrimus*) off the Washington coast –** Yelloweye Rockfish (*Sebastes ruberrimus*) was declared overfished by the PFMC in 2002 and since has been a "choke species" limiting groundfish fishing opportunities along the U.S. west coast. One of the many challenges in monitoring and managing this stock is the lack of adequate fisheries-independent surveys. The conventional bottom trawl survey does not consistently sample Yelloweye Rockfish habitat; and the only survey used in the past assessments was the International Pacific Halibut Commission's fixed-station setline survey. For Yelloweye Rockfish caught by the IPHC survey off the Washington coast, more than 90% were from one single station off Cape Alava and the minimum size was 40 cm (older than 10 years old). The abundance trend derived from the IPHC survey is uninformative for the population in Washington waters, thus the need for another survey.

Since 2006, the Washington Department of Fish and Wildlife has been conducting pilot projects to identify the best location, season, and hook-size for constructing a representative Yelloweye Rockfish abundance index trend. Working together with Jason Cope from NOAA's FRAM Division, the CMFS Unit has conducted pilot projects, compared abundance trends, and is working toward future research recommendations. Surveys will continue in 2016.

**Yelloweye Rockfish life history project –** A collaborative, ongoing project involving the NWFSC, SWFSC, ODFW, and WDFW is collecting and analyzing data for a Yelloweye Rockfish life history project. Port samplers and survey teams are collecting Yelloweye Rockfish ovaries for fecundity and maturity estimates from WDFW port-sampled fish, the West Coast groundfish bottom trawl survey, southern California hook and line survey, and ODFW port sampled-fish. The goal is to complete a coast-wide analysis of Yelloweye Rockfish size and age at maturity, as well as look at temporal trends in maturity since the data span from 2002-2015. In addition, we hope to investigate spatial and temporal relationships in length, weight, age, and growth relationships with the available Yelloweye Rockfish data. We also have access to Yelloweye Rockfish genetic samples collected during 2004-2014 and, if we can secure funding, could look for potential shifts in genetic structure over the sampled period, as well as determine whether different stock structures are present.

Current collaborators and contributors who've helped with this project include: Melissa Head (NWFSC, project lead), Neosha Kashef & David Stafford (SWFSC), Kari Fenske & Robert Le Goff (WDFW), and Sheryl Flores (ODFW)

**Lumping vs. splitting: Comparing two Black Rockfish assessment modelling options –** Stock assessment models are constructed to estimate fish population abundance, but there is often uncertainty in the understanding of stock structure components such as the spatial extent of the population, movement rates, and sub-stock mixing. In addition, fish tend to ignore political boundaries between states, countries and other political divisions, leading to stock assessment models based on best estimates of stock structure within the confines of data availability, management boundaries, and management convenience. To examine the effects of 'model lumping' vs. 'model splitting' on estimates of biomass and management reference points, we compared results from two models of black rockfish off the west coast US: 1) A single area model using data from California, Oregon, and Washington and assumes spatially constant M and growth. This ignores potential spatial heterogeneity in growth and mortality; and 2) The three state-specific separate models, as conducted for the 2015 PFMC assessment cycle, with spawning output and total biomass for individual states summed for comparison to the single area model output. We found that the sum of predicted total biomass for the state-specific models was on average 28% greater than the predicted total biomass for the coast-wide model, though the population trends were otherwise similar. The single area coast-wide model estimated that the spawning depletion level has been at or very near to the management target of 40% depletion, whereas the individual state models varied, with Oregon above the target, Washington near the target, and California below the management target. As expected, a non-spatial coast-wide model cannot give area-specific details about management performance so for a species managed at regional levels and with potentially different fishing history and regulations, it is practical to assess the stock based on management boundaries.

Thornyheads
No specific, directed research or management to report.

Sablefish
**An evaluation of the standard conversion factor for dressed sablefish: is it accurate? –** Sablefish (*Anoplopoma fimbria*) is a high dollar-value species caught in the Eastern North Pacific Coast groundfish fishery, and is often landed dressed. The scale weight of dressed sablefish is reported on fish receiving tickets and later converted to derive the equivalent whole weight. Fishery managers use the standard conversion factor of 1.6, but the accuracy of this value has been questioned due to varying cut types and seasonal spawning trends. Because inaccurate accounting can have a significant impact on annual commercial harvest limits, we collected fishery samples in 2015 to evaluate conversion factor accuracy for two commonly used cut styles, as well as the effect of seasonally related spawning condition on recovery rate. Sampling was stratified by quarter to produce the mean recovery rate at the 95% confidence interval.

Our data confirm the conversion factor is different between the rolled-cut (Figure 14) and slight angle-cut (Figure 15) types investigated, 1.54 and 1.57 respectively (Figure 16). Furthermore, data show seasonal differences, with Quarters 1 and 2 being characterized by a lower conversion factor than that of Quarters 3 and 4 for both J-cut types (Figure 17).

In conclusion the slight angle-cut is comparable to the standard conversion factor of 1.6. In contrast, the rolled-cut differs from the standard conversion factor slightly. Our data suggest two conversion factors are necessary for J-cut types and season. The idea of having two conversion factors is problematic. Further discussion between fishery managers is necessary to evaluate the impact resulting from a change to the conversion factor if one is implemented, or when and where to use the most appropriate factor if both are to be used.

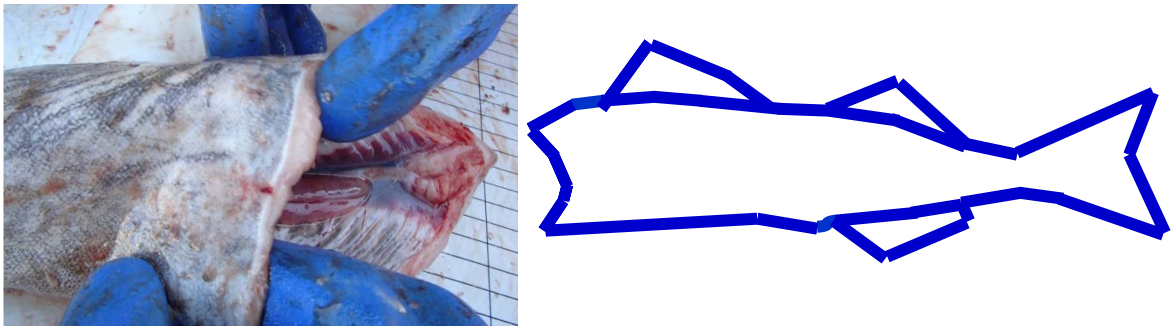


**Figure 14.** Rolled-cut: Fish laid on its side, cut started behind the pectoral fin and knife blade rolled toward the direction of the head and ended at the bony base; fish was flipped over and same cut made on its other side.

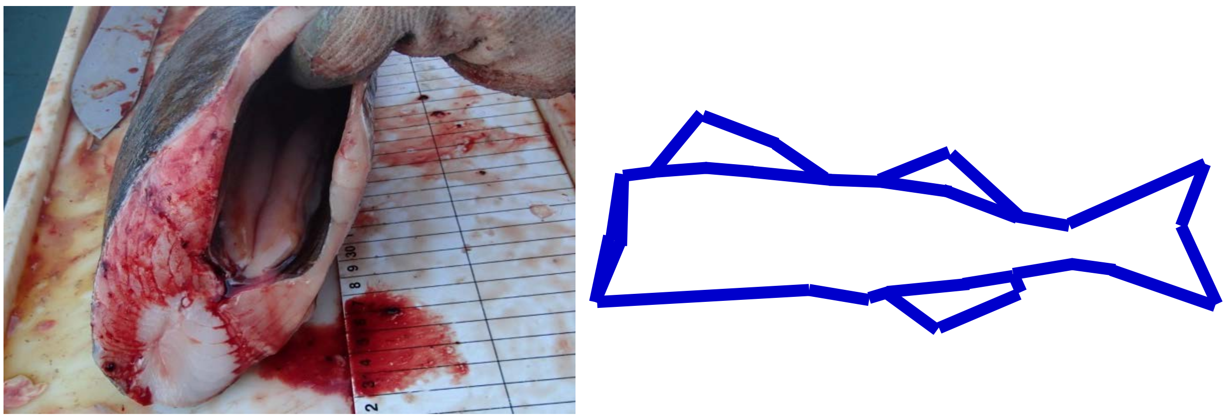
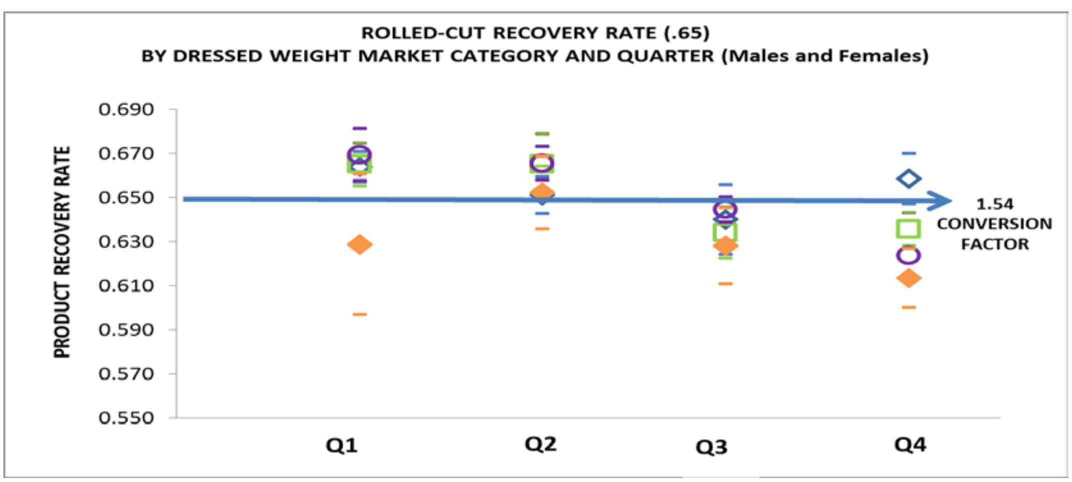


**Figure 15**. Slight angle-cut: The cut was made anterior of the origin of the first dorsal fin, fish belly side up, slight angle cut made to remove the head, gills, pelvic and pectoral fins.



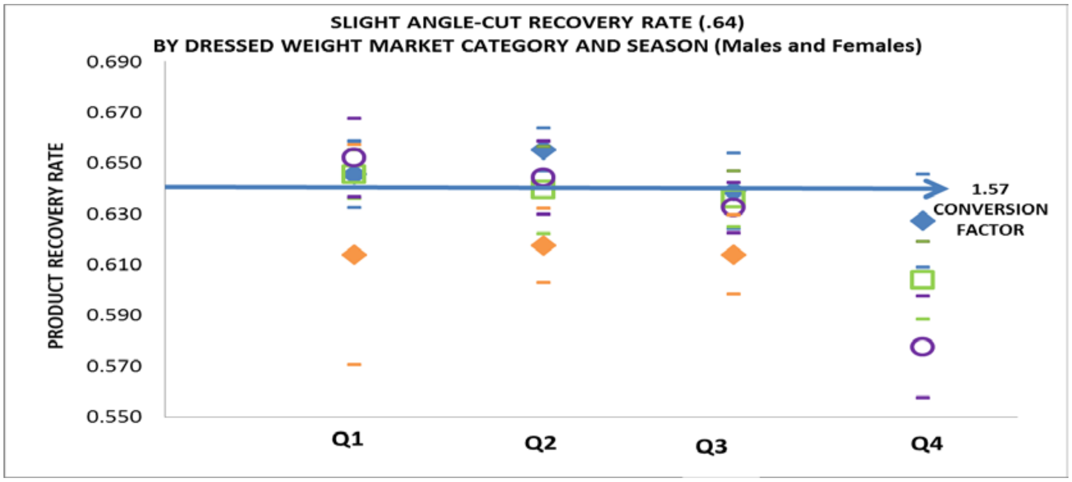



**Figure 16**. Recovery rate of the two J-cut styles, stratified by quarter, graph depicts the mean recovery rate at the 95 percent confidence interval (conversion factor for the rolled-cut and slight angle-cut types investigated, 1.54 and 1.57 respectively).

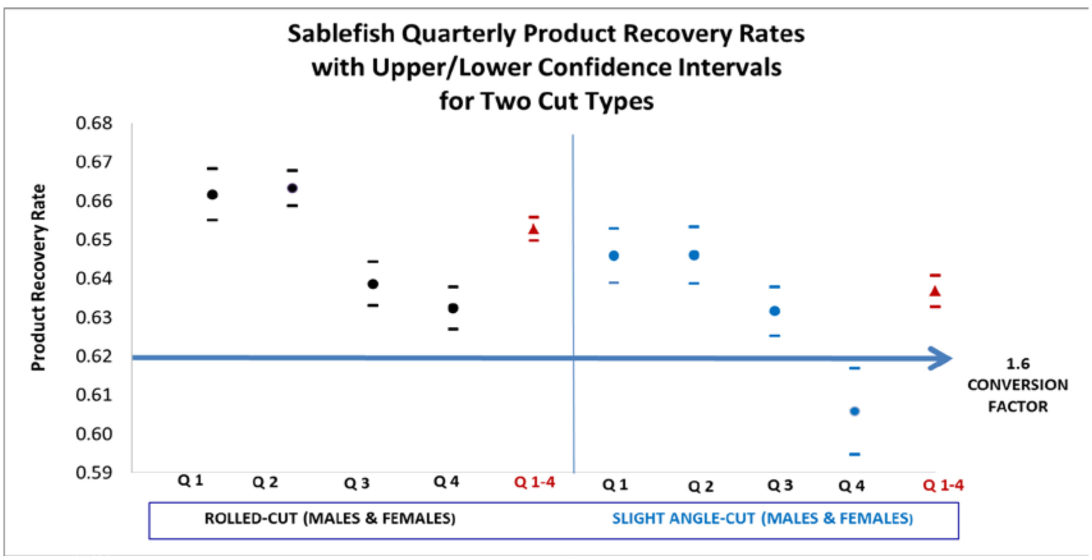



**Figure 17.** Seasonal differences for the product recovery rate of both J-cut types, rolled-cut and slight angle-cut, by quarter.

Lingcod

**Comparison of ages determined from vertebrae, dorsal fin rays, and otoliths in Lingcod** – An accurate and economical methodology for determining fish age is important to the successful management of any species. For Lingcod (*Ophiodon elongatus*), dorsal fin rays have been the primary structure used to determine age. However, this method is labor intensive and concerns have been raised regarding the precision of age determinations. The objective of a recent WDFW study was to evaluate the utility of otoliths and vertebrae as alternate ageing structures to dorsal fin rays while evaluating, cost, precision, bias, and uncertainty of determinations among structures. To address this objective we opportunistically sampled 124 lingcod from the recreational and commercial fishery off the coast of Washington, stratified by length (Large > 90 cm; Medium = 60-89 cm; Small < 59 cm TL). A set of 121 paired otoliths and fin rays, and 47 paired otoliths, fin rays, and vertebrae, were prepared using standard methodology, aged by two readers independently, and given a readability code. We evaluated each structure using average percent agreement (APE), age-bias plots, readability anomalies, and preparation and ageing time for each structure. Otoliths (surface aged) took just 3 minutes per sample to prepare and age but, had below average readability (readability anomaly = -0.8), the least precision between readers (APE = 14%), and the most bias between readers. Otoliths and vertebrae tended to produce younger age estimates relative to fin rays, and in particular for fish older than age-7. Vertebrae (surface aged) ages had intermediate precision between readers (APE = 8%), above average readability (readability anomaly = 0.13), and little bias between readers. Ages from fin rays and vertebrae had the highest concordance (APE = 8%), and vertebrae ages were on average 1 year younger than fin ray ages. Ages from dorsal fin rays were the most precise between readers (APE = 5%), had above average readability (readability anomaly = 0.17), and no bias between readers. We observed a negative relationship between the cumulative time it takes to prepare and age each sample and precision between readers. For example, ageing structures that were more intensive to prepare and age (fin rays and vertebrae > 30 minutes/sample), had the most repeatable age determinations. Our results suggest that despite some concordance between structures for younger fish, fin rays currently produce the most precise estimates across age classes, and are the only validated structure for ageing lingcod. Future work should focus on different preparation techniques for otoliths and vertebrae (e.g., sectioning, staining) and developing specific ageing criteria for those structures.

Atka mackerel
No specific, directed research or management to report.

Flatfish
**Opening of localized flatfish fishery in long-term closure area –** Hood Canal is a 110-km long fjord on the western side of Puget Sound that receives its water through a narrow (~2-km wide) connection with Admiralty Inlet. While much of the Canal is deep (approaching 175 m), a 65-m deep sill near the mouth of the canal, combined with seasonal stratification of the water column, significant freshwater input, and episodic upwelling in response to seasonal changes in wind patterns, leads to late fall and early winter fish kills in the southern portion of the Canal. As a consequence, the WDFW closed the entirety of Hood Canal to all bottom fishing in 2004. Though these fish kills typically only affect the southern third, or less, of the Canal, the northern portion was also closed under the assumption that individuals in this area would exploit vacant space in the southern portion of the Canal and redistribute themselves post-kill.

Quilcene and Dabob Bays are northwestern offshoots from the main arm of Hood Canal. These bays are well removed from areas known to host fish kills and significant pressure has been put on the WDFW in recent years to allow a localized bottomfish fishery here. Through the Fish and Wildlife Commission rulemaking process, a petition was received in 2014 requesting a flatfish only fishery in these two bays. After considering all known observations of ESA-listed rockfish in the vicinity, opportunistically reviewing localized ROV footage and bottom trawl sampling data, conducting a two-day test fishery in the area, and conducting two public meetings, PSMFS Unit staff recommended that a fishery be opened in the portion of the bays north of the mouth of Turner Creek, and only in waters shallower than 120 ft deep. This latter provision mirrored an existing requirement effective in all other Marine Areas of Puget Sound in order to reduce barotrauma on bycaught rockfish (which are illegal to retain throughout most of Puget Sound). All species of flatfish, other than Pacific Halibut, are now legal to retain in this area. Anecdotal information collected from local fishers indicates that this was a well-received policy change and that they appreciate seeing this fishing opportunity made available to them. Formal catch monitoring from this area is not currently planned, but periodic test fisheries will occur on a semi-annual basis for the next few years.

Pacific halibut & IPHC activities
No specific, directed research or management to report.

Other groundfish species
No specific, directed research or management to report. Various species of groundfish are counted, and density and abundance estimates are derived for them, during ROV, scuba, and trawl surveys described above.

**Ecosystem Studies**
**Puget Sound Ecosystem Monitoring Program update –** 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. The WDFW's "Toxics in Biota" group is staffed by Jim West, Jennifer Lanksbury, Laurie Niewolny, Stefanie Orlaineta, Andrea Carey, Mariko Langness, 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 pallasii*) embryos. (Contact: Jim West, james.west@dfw.wa.gov; 360-902-2842)

**Groundfish, Forage Fish, and Salmonid Surveys at U.S. Navy Facilities –** The U.S. 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 NUWC-Keyport in 2013, the WDFW entered a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and critical habitat at the following installations: NASWI-Crescent Harbor, NAVMAG-Indian Island, NBK-Bangor, NBK-Bremerton, NUWC-Keyport, NAVSTA-Everett. These surveys, which expanded on the 2013 surveys, were conducted during 2014-15 and included ROV, scuba, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. As of February 2016, a final report for each installation was submitted which concluded: no ESA-listed rockfish were observed, no deep-water critical habitat (>30m) for adult rockfish was present, and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish do occur. These nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect methods in 2016-17. The deep-water surveys have concluded and will not continue in 2016.

The WDFW has also entered a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed forage fish and salmonids at the following installations: NASWI-Crescent Harbor, NASWI-Lake Hancock, NAVMAG-Indian Island, NBK-Bangor, Manchester Fuel Depot, NAVSTA-Everett. Monthly sampling at each installation began in May 2015 and will continue through the summer of 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. A summary of the results from 2015 sampling was included with the rockfish final reports. The only ESA-listed fish captured in the beach seine in 2015 were Puget Sound Chinook Salmon, Puget Sound Steelhead, Hood Canal Summer Chum Salmon, and Bull Trout. Regarding timing and abundance, juvenile salmonids and forage fish species generally followed trends previously documented in similar reports, which supports the work windows outlined in the Washington Administrative Code.

**Puget Sound mid-water trawl study –** Funding from the Washington State Legislature was appropriated through Substitute Senate Bill No. 5166 in May of 2015 to support an evaluation of forage fish abundance and distribution throughout Puget Sound using an acoustic/trawl survey design. The resulting survey design calls hydroacoustic data, mid-water trawl samples, and plankton samples to be collected for three weeks every other month from February of 2016 to February of 2017 at 18 reaches throughout the Sound (Figure 18). The initial field sampling phase of the Puget Sound Mid-water Acoustic/Trawl Survey was conducted February 2$^{nd}$-23$^{rd}$. To date, acoustic analysis has been limited to comparing historic methods, when data were collected using older equipment, to current methodologies employing state of the art hydroacoustic equipment (Biosonics DT-X; 38 kHz and 120 kHz transducers). Additional analyses will include species-specific estimation of abundance, density, and biomass by site and across sites.

A total of 32 mid-water trawls were completed in February, including three trawls that captured no fish. The empty trawls occurred during the first week of the survey when there was no real-time information on net performance or depth during the tows. Prior to the second week of the survey, a Marport Trawl sensor was placed on the head rope of the trawl. This system provides the trawl vessel with real-time information on net depth and performance and greatly improves efficiency of the tows.

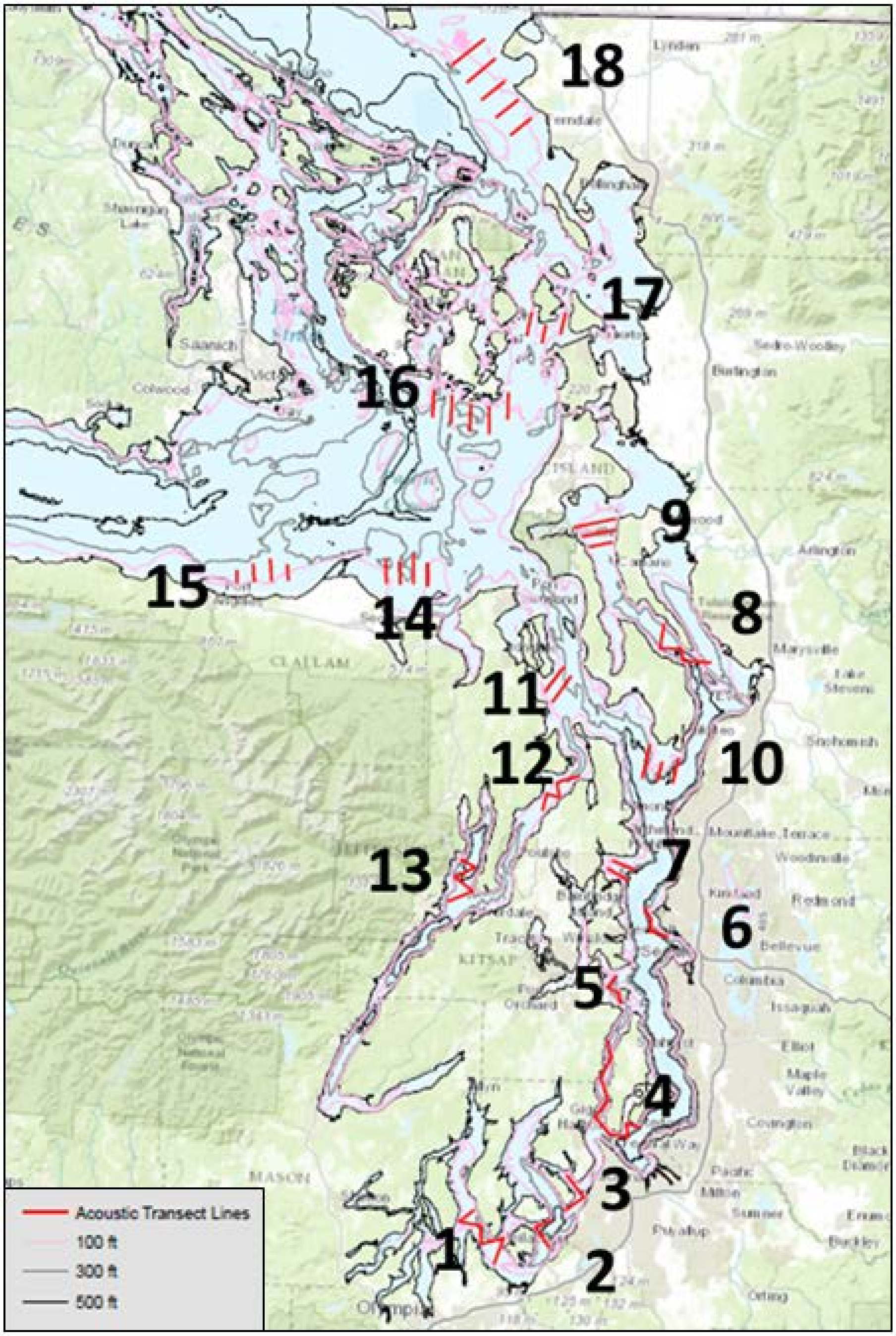



**Figure 158.** Map of station locations for the Puget Sound Mid-Water Acoustic Trawl Survey.

A total of 52 different species of fish and invertebrates were captured in the trawls (Figure 19). Pacific Herring were the numerically most abundant species in the trawl catch and were the dominate species in the North (Whidbey) Basin and Hood Canal. Pacific Whiting (Hake) catch dominated the Central Puget Sound, and northern anchovy and shiner perch dominated in South Sound. A total of 11 Chinook Salmon were captured (200-374 mm FL) and all were released alive. No other ESA listed species were encountered.

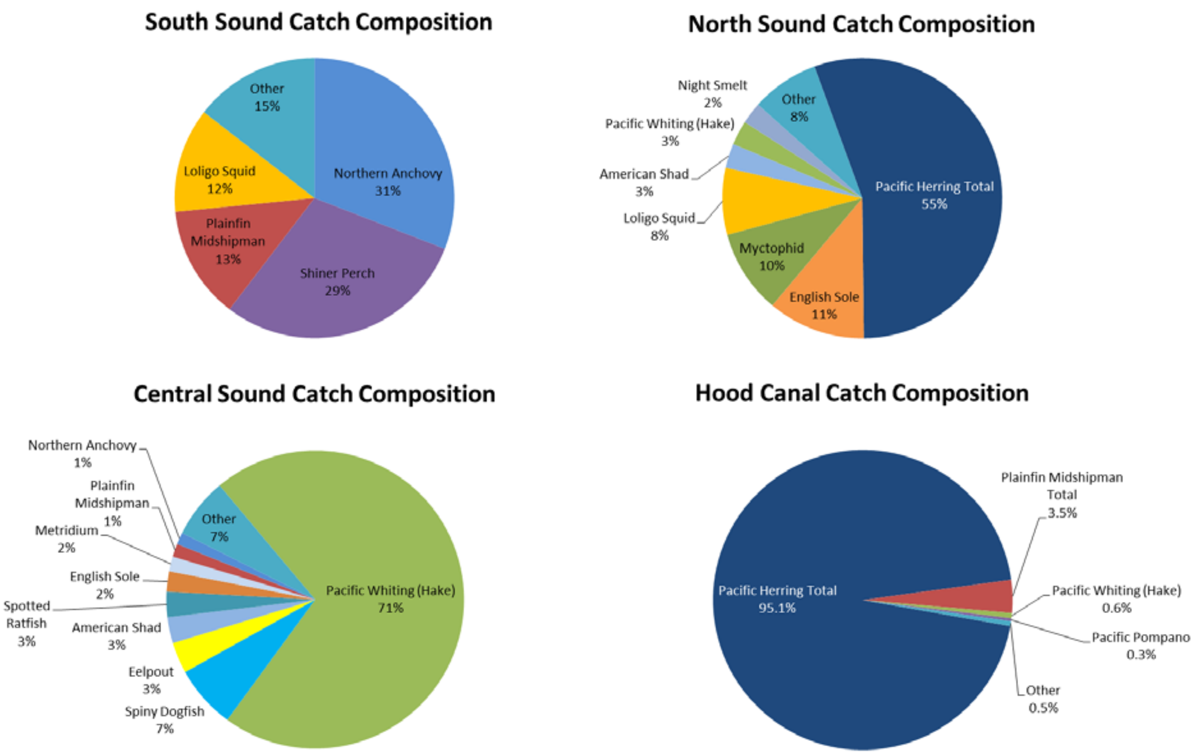



Figure 19. Trawl catch composition by region for samples taken during February of the Puget Sound Mid-Water Acoustic Trawl Survey.

A total of 24 vertical plankton tows were taken during February. Samples were preserved in buffered formalin and are currently stored at the WDFW waiting processing.

In a broad effort to reach out to collaborators the trawl survey has provided research specimens for Paul Hershberger, USGS (Pacific Herring, *Ichthyphonus* research), Sandie O'Neill and Jim West, WDFW (American Shad, ecology and toxicology), Virginia Butler (archaeology, University of Portland), Gary Winans (forage fish genetics, NOAA), Lorenz Hauser (Pacific Herring genetics, UW), and Katherine Maslenikov (fish collections) at the UW Burke Museum. A number of samples were also retained by the WDFW for use in evaluating age, sex ratio, and maturation stage of the sampled portion of each population.

The next sampling phase of the Puget Sound Mid-water Acoustic/Trawl survey began April 4$^{th}$. Subsequent sampling events will occur every other month through February of 2017 with a final completion report delivered to the State Legislature in June.

**High-resolution modeling of fish habitat associations, and predictive models --** In collaboration with the SeaDoc Society and Tombolo Laboratories, PSMFS Unit staff worked 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 pilot study was completed in early 2015, with strong correlations established between rockfish occurrence and habitat variables such as slope, depth, and benthic position index. The next step is to expand this study to areas of Puget Sound with high-resolution bathymetry data to cross-validate the model in areas lacking a true habitat map (see below). This second phase of investigation recently received funding from NOAA and will help to pave the way for a Puget Sound-wide model that can be used to evaluate rockfish critical habitat designations made by NOAA in 2015.

**ROV survey for ESA-listed rockfish, and their habitats, in Puget Sound –** Dan Tonnes at NOAA's NWFSC was able to secure supplemental funding to allow a 2-year remotely-operated vehicle survey of large portions of Puget Sound beginning in 2015. Because past efforts had focused on the San Juan Archipelago, this new study was limited to Central Puget Sound, the Whidbey Basin, Hood Canal, and South Puget Sound (in total, referred to as Puget Sound proper). The goal of this study was to develop valid population estimates for ESA-listed rockfish species in this undersampled portion of the U.S. DPSs. The stereological survey of Puget Sound conducted in 2012 did not encounter ESA-listed rockfish in significant numbers, thus this supplemental survey was needed to provide baseline population estimates necessary to evaluate recovery of these species, per the conditions of the ESA. A secondary goal of this survey was to catalog and quantify high-relief, rocky habitat in Puget Sound proper in an effort to better define attributes of Critical Habitat for these ESA-listed rockfish species.

WDFW staff worked with Chris Rooper at NOAA's Alaska Fisheries Science Center to design a survey using a Maximum Entropy model to predict the potential distribution of listed rockfish habitat. The model inputs included all verified locations of Yelloweye and Canary Rockfish, a 30m x 30m bathymetry grid of Puget Sound, and bottom current velocities (resampled to 30m x 30m). From the bathymetry grid we extracted bottom depth, and measures of slope and bottom roughness (rugosity). Based on these attributes, combined with the bottom current velocities at the locations of ESA rockfish, the MaxEnt model predicts a probability surface representing the potential species distribution within the study area. The probability surface was parsed into high, medium, and low probability bins, which were used to stratify the study area. We used the encounter rates for ESA rockfish from previous ROV surveys in the San Juan Islands to model expected coefficients of variation and partitioned sampling effort among the three strata as follows: 60% high, 20% medium, 20% low. High probability habitats composed 7% of the study area, whereas medium and low probability strata composed 12% and 81% of the study area, respectively. We planned to conduct 900, half-hour ROV transects, 450 in each year. Using a random point generator in ArcGIS sampling locations were generated proportionally to each of the three strata, with additional buffer stations to accommodate potential need to drop stations in response to various field conditions (e.g., map inaccuracies, hazards to navigation)..

In 68 total survey days between February and December of 2015 we sampled 387 stations; 249 high, 82 medium, and 56 low, representing 86% of the planned survey stations and over 90% of the high and medium stations (Figure 20). Technical issues with the ROV and poor weather conditions prevented completion of the remaining stations. All three species of ESA rockfish were encountered during the 2015 survey year, with all encounters occurring on high probability habitats. In total we encountered 35 yelloweye rockfish at 19 stations, 7 canary rockfish at 4 stations, and 1 bocaccio.

The 2016 phase of this survey began February 29th and will continue until all stations have been sampled or until funding is no longer available.

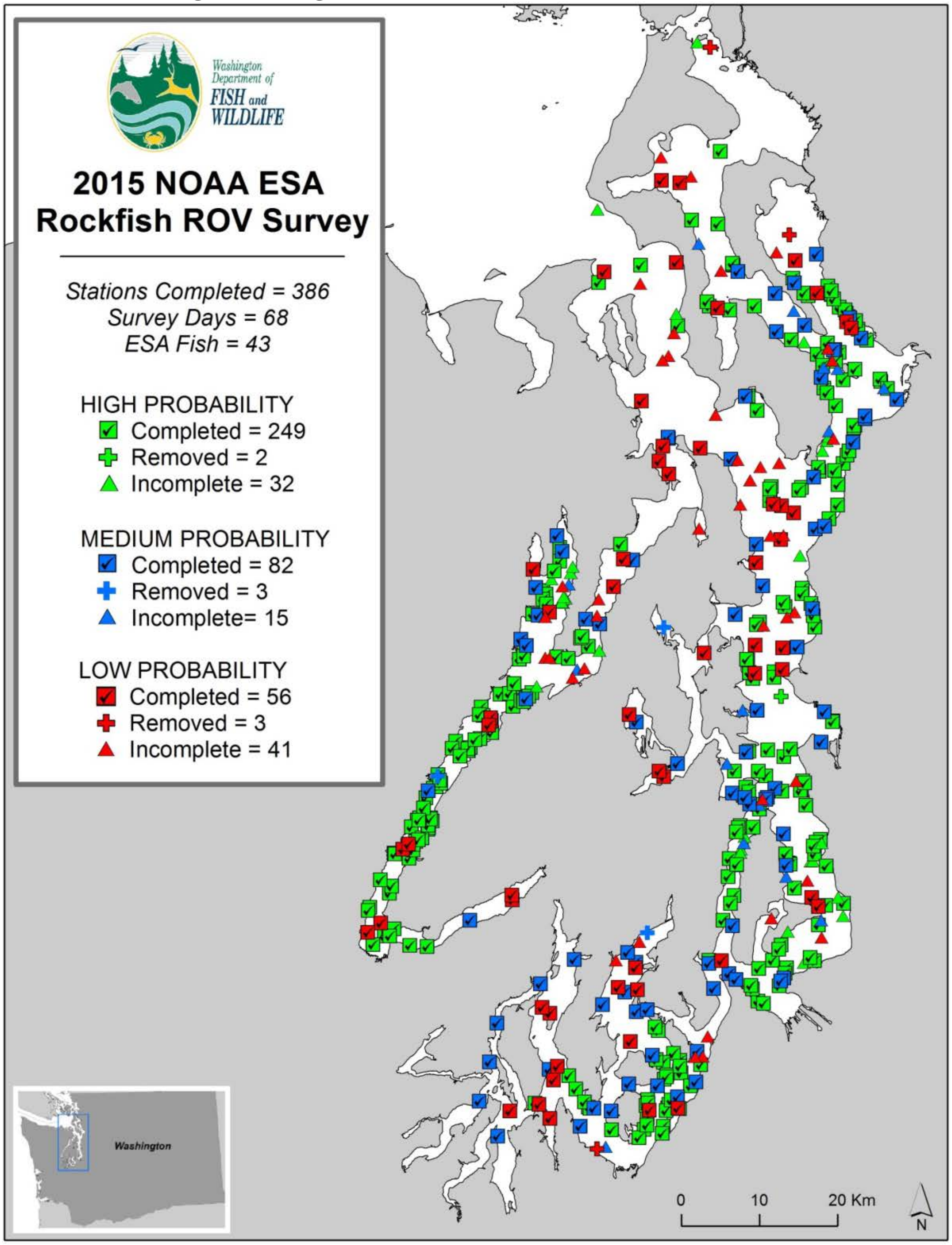



**Figure 20.** Planned survey stations for the ESA-listed rockfish, and habitat, survey in Puget Sound. Stations are symbolized by their end-of-survey status.

**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 in waters shallower than 105 ft. A portion of this money was set aside for WDFW to assist with planning of removal efforts and evaluation of the final results. In August of 2015 a celebration ceremony was held to commemorate completion of these net removal efforts, which resulting in 5,660 fishing nets being removed from the Sound and 813 acres of benthic habitat restored. The Northwest Straits Foundation and the PSMFS Unit have now moved on to pursue funding for removal of deep-water nets (>105 ft deep) in coming years after a successful pilot attempt to remove several such nets using an ROV instead of scuba divers.

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 through 2016. 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. To date reports for several dozen nets have been responded to, resulting in the removal of numerous free-floating nets, a handful of sunken/entangled nets, and ample opportunity for public outreach regarding when nets are derelict and when they are legal fishing.

**Publications**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Lowry, D, Pacunski, RE, Blaine, J, Tsou, T, Hillier, L, Beam, J, Wright, E, and A Hennings. (In prep). Assessing groundfish occurrence, abundance, and habitat associations in Puget Sound via a small remotely operated vehicle: results of the 2012-13 stereological survey. Washington Department of Fish and Wildlife Technical Report. Expected completion September 2016.

Pacunski, RE, Lowry, D, Hillier, L, and J Blaine. (2016). A comparison of groundfish species composition, abundance, and density estimates derived from a scientific bottom-trawl and a small remotely operated vehicle for trawlable habitats. Washington Department of Fish and Wildlife Technical Report. FPT 16-03. 36 pp.

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McNeil, B, Griffing, D, Larson, S, and D Lowry. (In press). Feeding behavior of subadult sixgill sharks (*Hexanchus griseus*) at a bait station. *Mar Biol.* Online.

The IUCN Red List of Threatened Species. (2015). www.iucnredlist.org.
    Cortes, E, Lowry, D, Bethea, D, and CG Lowe. *Sphyrna tiburo* – bonnethead shark.
    Larson, S, Lowry, D, and D Ebert. *Hexanchus griseus* – bluntnose sixgill shark.
    Lowry, D, Larson, S, and D Ebert. *Notorynchus cepedianus* – broadnose sevengill shark.
    Lowry, D, and K Goldman. *Carcharhinus limbatus* – blacktip shark.

Larson, S, Farrer, D, Lowry, D, and DA Ebert. (2015). Preliminary observations of population genetics and relatedness of the Broadnose Sevengill Shark, *Notorynchus cepedianus*, in two Northeast Pacific estuaries. *PLoS One*. 10(6): e0129278.

Langness, M, Dionne, P, Masello, D, and D Lowry. (2015). Summary of Coastal Intertidal Forage Fish Spawning Surveys: October 2013- October 2014. Report to the Washington Department of Natural Resources Marine Spatial Planning Funding Board. Washington Department of Fish and Wildlife Technical Reports. Report Number FPA 15-01. January 2015. 50 pp. + appendices.

Lowry, D, Stick, K, Lindquist, A, and YW Cheng. (2015). Evaluation of creel survey methods to estimate recreational harvest of Surf Smelt in Puget Sound, Washington. *N Amer J Fish Man*. 35 (3): 403-417. DOI 10.1080/02755947.2015.1009658.

**Conferences and Workshops**

In 2015-16 staff of the PSMFS Unit presented at, and/or arranged symposia at, several regional scientific meetings, and education/outreach events as indicated below.

2015 Annual Meeting of the American Fisheries Society, Aug. 16-20. Presenters: Dayv Lowry, Jen Blaine, Andrea Hennings, Lisa Hillier, Taylor Frierson. Symposia co-organizers: Dayv Lowry, Robert Pacunski, Jen Blaine.

19th Western Groundfish Conference, Feb. 8-11. Presenters: Dayv Lowry, Bob, Pacunski, Phil Weyland, Jen Blaine, Donna Downs, Theresa Tsou, and Jamie Fuller.

Seattle Aquarium Discover Science Days, Nov. 15-15, 2015. Presenters: Dayv Lowry, Robert Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, Taylor Frierson, Adam Lindquist, Phil Campbell, Erin Wright, and Amanda Phillips.

# Committee of Age Reading Experts

## 2015 Committee Report

Prepared for the Fifty-seventh Annual Meeting of the

Technical Subcommittee of the Canada-USA Groundfish Committee

April 26 –27, 2016


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## 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, 2015. This reporting period includes information from the 2014 Committee Report and Executive Summary prepared by outgoing CARE Chair Elisa Russ. CARE Officers through June 30, 2015 (elected at the April 2013 meeting) are:

- Chair - Elisa Russ (ADF&G)
- Vice-Chair - Chris Gburski (AFSC)
- Secretary - Lance Sullivan (NWFSC)

The 2015 CARE Conference Minutes* have been approved by the CARE members and were subsequently added to the CARE websites 'Previous Meetings' section. The Secretary prepared the first draft minutes for the 2015 CARE Conference and was reviewed by the officers (Chair, Vice-Chair and Secretary) prior to the final draft, distributed by the Chair, to members for review and approval.

*All tables and appendices refer to the 2015 CARE Conference Minutes (pp. 14 – 68).

### 3. CARE Conference

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 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, Alaska Fisheries Science Center (AFSC) Sand Point facility, and hosted by the Age and Growth Program 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, April 4-6, 2017 at the same location, NOAA, AFSC, Sand Point facility, Seattle, WA. The following CARE officers were elected at the April 2015 meeting and took office July 1, 2015:

- 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, 2015 by the Chair Elisa Russ. 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 min)
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). Thomas Helser gave the presentation for Stephen Wischniowski..
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.* (20 min)

   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:**

CARE members from 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. He was unable to attend CARE. There was no representative at CARE from SWFSC or CDFG. Details from agency reports are available in the CARE minutes having been finalized and will be published to the CARE website. Sonya El Mejatti (ADF&G-Kodiak) requested CARE members to provide their agency contacts to facilitate age structure exchanges. The requested information included: 1) year, 2) agency acronym and description, 3) lab address, 4) project lead (name, email, phone number), and 5) number of age readers. It was first brought to attention at the close of the CARE Conference business day on Friday, April 17th, 2015 with final responses due by June 15, 2015. The idea was to combine both the annual agency production numbers with each agencies contact list in one spreadsheet performed on a yearly basis. Multiple agencies responded including ADF&G-all sites, CDFO, IPHC, NWFSC/PSMFC, ODFW and WDFW.

**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 (AFSC), Craig Kastelle (AFSC) and Cindy Tribuzio (AFSC/NMFS-ABL). 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. See **Appendix II** for long-term storage of otoliths results.

**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 VI** for final report.

**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). Barbara Campbell (CDFO) is also a member although she was unable to attend the working group meeting at the 2015 CARE meeting due to a conflict with the 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 the 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 the 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 (ABL) 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://care.psmfc.org/

Jon Short requested 2014 production numbers and will update the CARE website with 2014 production numbers, 2014 and 2015 age structure exchanges, current CARE officers and the 2015 CARE meeting minutes, now approved. Nikki Atkins continued to maintain the CARE Forum in 2015 (link on CARE 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 (ADF&G) 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 many checks during the early years up until approximately age 10 years and then uneven growth increments >10 years. 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. A request was made to CARE members by the Vice-Chair Chris Gburski in February 2015 for issuing any additional age structure exchange identification numbers, for exchanges already started in 2014. In 2015, there were four exchanges initiated. All 2014 and 2015 exchanges are in-progress of being finalized and will be added to the CARE websites 'Structure Exchange table'. See 2014 and 2015 exchanges on p. 14.

**D. Recommendations C.A.R.E. ~TSC**

In 2015, recommendations were made by CARE to CARE, CARE to TSC, and TSC to CARE (TBD). 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 C.A.R.E. 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 C.A.R.E. 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 (**TBD**)

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.

**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

**CARE Age Structure Exchanges initiated in 2015**

| Exchange ID No. | Species | Originating Agency | Coordinator | Coordinating Agencies |
|---|---|---|---|---|
| 15-001 | Black Rockfish | ODFW | L. Kautzi | ODFW, NWFSC - PSFMC |
| 15-002 | Pacific Goeduck | ADF&G - Homer | K. Politano | WDFW, CDFO |
| 15-003 | Pacific Goeduck | WDFW | B. Stevick | ADF&G (ADU), CDFO |
| 15-004 | Pacific Goeduck | CDFO | J.  McArthur | ADF&G (ADU), WDFW |

# Committee of Age Reading Experts

**Eighteenth Biennial Meeting**

**CARE Meeting Minutes**

## AFSC Sandpoint Facility, Seattle, WA, USA

## Jim Traynor Conference Room

## April 14 – 17, 2015

## *Tuesday, 14 April*

Crustacean age determination workshop began with instructor Dr. Raouf Kilada.

## *Wednesday, 15 April*

## I. Welcome and Opening Statements for CARE business meeting

### A. Call to Order (Elisa Russ – ADF&G, 2015 CARE Chairperson):

Elisa Russ called the committee meeting to order on April 15, 2015, at 8:35 a.m., in the Jim Traynor Conference Room and announced the CARE officers for 2015, as follows:

1. Chairperson – Elisa Russ (ADF&G − Homer)
2. Vice Chairperson – Chris Gburski (AFSC)
3. Secretary – Lance Sullivan (NWFSC – PSMFC)

Russ also mentioned that a social event was planned for Wednesday evening, at the Elliot Bay Brewing Company, Seattle, WA. Russ thanked AFSC for hosting the 2015 CARE meeting and acknowledged the contributions of the Crustacean Age Determination Workshop to CARE, and proposed partnerships with not just West Coast affiliates, but also with East Coast groups. Russ concluded by thanking CARE members for submitting their PowerPoint and poster presentations for the 2015 CARE meeting.

## B. Host Statements:

### 1. Opening Statements (Dr. Thomas Helser – AFSC, Age and Growth Program Manager)

Dr. Tom Helser began with an introduction and housekeeping statements. Helser mentioned that he has kept track of the status of stock assessments and economic studies throughout the years, and that the Data Analysis Lab has been using the micromill for bomb radiocarbon studies. Helser concluded by thanking Elisa Russ, Craig Kastelle, and Chris Gburski for security clearance approval; Crustacean Age Determination Workshop participants; and Mark Blaisdell and Sherrie Wennberg for IT assistance.

### 2. Host Information (Chris Gburski – AFSC, CARE Host)

Chris Gburski announced that there are lunch possibilities off-site and a cafeteria on-site, government-issued IDs are required to be shown to the security guard, and that directions to the Elliot Bay Brewing Company (social event) are located at the back of the room.

## C. Introductions:

### 1. Round-table Introductions

CARE attendees/members introduced themselves by stating agency information, as well as a brief statement about the work they are doing for their agency.

### 2. Attendance, Address, Phone, and E-mail

Attendance sign-in sheet was passed around for all attendees/members to provide their name, agency, e-mail, and office phone number (**Table 1:** 2015 CARE Attendance List).

## D. Approval of the 2015 Agenda:

Elisa Russ announced that there was a change to the 2015 CARE Agenda, which comprised Joanne Groot (CDFO) giving the overview for her agency instead of Steve Wischniowski. After this change the 2015 CARE Agenda was approved (**Appendix I:** 2015 CARE Agenda).

# II. Agency Overviews and Updates

## A. Canadian Department of Fisheries & Oceans (CDFO) – Joanne Groot:

Joanne Groot began discussing the current staffing at the CDFO (9 full-time staff, including 8 age readers and 1 database technician; 1 casual, part-time employee hired via Strategic Program for Ecosystem-based Research and Advice [SPERA] funding)

and mentioned that Shayne MacLellan and Darlene Gillespie are still working with the agency under an alumnus status, although Darlene has also retired. Groot was placed in the Acting Senior Lab Technician position after Darlene retired in mid-January. CDFO's organization is broken down into 2 senior level positions (one at a Biologist level [research/administrative/supervisory]; the other at an upper level technician level [lab administration/organization/production ageing]) and the others are at the technical level (production ageing). Groot mentioned that the CDFO is continuing to age a variety of species (N = 13,000 groundfish, N = 83,000 salmon, N = 25,000 herring, and N = 1000 shellfish); in the last two years, the lab has aged N = 6000 arrowtooth flounder (last aged in 2005) and N = 3500 petrale sole (last aged in 2003); and was asked to age new species (Pacific cod, shortraker rockfish [*Sebastes borealis*], dover sole, and shortspine thornyhead).

The SPERA project uses dendrochronology techniques to develop a series of multi-decadal chronologies from herring (shallow depth), Pacific hake (mid-depth), and sablefish (demersal). The chronologies compare and contrast growth patterns across species, habitats and spatial scales to identify patterns of synchrony and the underlying oceanographic drivers of ecosystem productivity. The CDFO recently purchased a micromill for isotope analysis and acquired a new Leica DMS 1000 camera/microscope set-up to replace the ageing "Neopromar" projectors used for salmon scale ageing. The CDFO has investigated the break-and-bake vs. break-and-burn methods for ageing flatfish, Pacific hake, and sablefish, but has mainly focused on break-and-baking all flatfish species for production ageing. Another project CDFO currently pursues involves experimenting with the thin-section method for shortraker rockfish and shortspine thornyhead. Over the past two years, the CDFO has also published a series of technical manuals outlining the CDFO Lab's ageing methods and procedures, including a Chinook Salmon Scale Age Determination manual, and has drafted a Pacific hake ageing manual which is near completion, and also is currently compiling an otolith atlas of species from the British Columbia coast. Groot said that three CDFO staff attended the 2014 Western Groundfish workshop, where two posters were presented. Darlene went to Shimizu, Japan, to attend the Tuna Ageing Workshop and was involved with the Tuna age exchange. Furthermore, Shayne and Darlene attended the Chinook Salmon Ageing Workshop in Juneau, Alaska, to standardize the criteria used to age Chinook salmon scales between agencies. Lastly, CDFO participated in a shortraker rockfish exchange with NMFS and ADF&G for the 2015 CARE meeting.

## B. International Pacific Halibut Commission (IPHC) – Joan Forsberg:

Joan Forsberg began with staffing and stated that Dana Rudy started working for the IPHC last year and became a full-fledged, onsite production age reader; four other age readers are employed (onsite – Robert Tobin, Chris Johnston, Joan Forsberg; Linda Gibbs-offsite); all readers age full time during "otolith season," which is from June to October. Forsberg mentioned that the IPHC typically ages N = 30,000-35,000 otoliths per year (e.g., commercial samples, setline and NMFS trawl survey samples, tag recoveries and ADF&G sport fish samples) with an extra N = 12,000 aged in 2014 from archived setline survey collection that had previously only been surface-aged. These archive collection samples were re-aged in 2014 by both surface and break-and-bake method. In regards to collection techniques, Forsberg said that commercial samples were transferred from pill boxes (in the field) to Tray Biens in the office; setline and

NMFS trawl survey samples were collected directly into Tray Biens; and tag recovery and ADF&G sport fish otoliths stored in dry coin envelopes (in the field) and transferred into Tray Biens in the office.

Forsberg also mentioned that all of the otoliths to be aged were cleared and stored in glycerin-thymol solution and most otoliths were stored offsite, at the National Archives on Sand Point Way, Seattle WA. Forsberg further stated that a couple of collections were stored dry for various reasons. First, a new collection of otoliths (target of N = 100 otoliths per year per IPHC regulatory area) started in 2010 was stored dry while not coming into contact with water or other solutions for future elemental work. Second, archived juvenile otoliths from 1926 to 1986 were removed from glycerin-thymol, cleaned with water, and stored dry upon discovering that samples ≤2 years old were deteriorating. Current techniques that IPHC employs include the break-and-bake (for surface-aged trawl survey fish aged >5 years and all setline survey, commercial AK sport, and tag recovery otoliths) and surface-reading (for trawl survey fish aged <5 years) methods.

Forsberg reported that the IPHC is pursuing three projects, as follows: 1) re-ageing break-and-bake samples collected between the 1920s and 1990s that were previously only surface aged (results published in IPHC annual in-house Report of Assessment and Research Activities); 2) an increment study investigating changes in size at age (SAA) in Pacific halibut; and 3) entering age data from earlier survey years, namely from the early 1900s through the 1960s (ongoing for last three years). The IPHC found the following, in regards to re-ageing break-and-bake samples: 1) historic and new surface ages were similar due to no apparent changes in ageing protocols or differences due to equipment; 2) historic versus present-day biases in surface and break-and-bake ages were similar; 3) there were very few Pacific halibut over 15 years old in samples from earlier decades; SAA changes are not an artifact of changes in ageing methodology; and 4) no additional re-ageing is currently necessary. For the increment study, samples from three different regions (Bering Sea, Gulf of Alaska, and southeast Alaska/British Columbia) and four different birth years (1977, 1987, 1992, and 2002) were used to determine the trend in Pacific halibut SAA. Indeed, the IPHC found that for the two birth years compared so far, the data indicate a decline in SAA between 1977 and 1992. Also, Pacific halibut were found to be larger in the Bering Sea than in the Gulf of Alaska for both years. Baked otolith sections were mounted on slides and polished using a MetaServ 250 polish/grinder, photographed with a Leica DFC290 digital camera, and increments were measure with Image Pro Premier software.

## C. Alaska Fisheries Science Center (AFSC) – Dr. Tom Helser:

Dr. Tom Helser first discussed the staffing at the AFSC Age and Growth Program, which includes 13 full-time employees (FTEs), 1 contractor, a PhD student currently working on walleye pollock, and others studying otolith microchemistry. Equipment is being used in the Wet/Prep Lab includes a new Struers high speed sectioning saw and

Buehler dual-wheel polishing instrument. The AFSC has five imaging systems and a computer-aided micromill (Carpenter Microsystems CM-2) in the Image Analysis Lab. Helser stated that the Age and Growth Program uses an age data exploration tool to show growth data-spatial variation and reported that AFSC successfully moved samples to

University of Washington's Burke Museum. Helser also reported that the AFSC uses a web-based tool, called the Age and Growth Prioritization System (AGPS), for that populates and prioritizes age requests (N = 50,000 to 60,000; approximately N = 35,000 requests are completed annually. Bomb radiocarbon age validation was performed on Pacific cod and walleye pollock collected in the 1970s and on big and longose skates. Helser also mentioned that the AFSC has been working with the IPHC on Pacific halibut age validation and the Age and Growth Program has submitted a third manuscript for bomb radiocarbon studies. Several studies on otolith trace element microchemistry are currently in progress: 1) validation of ageing criteria in eulachon; 2) discrimination among juvenile Pacific cod nursery areas, and 3) ontogenetic shifts in habitat use of giant grenadier. Other active research projects include ageing arctic species (Arctic cod and saffron cod), performing NPRB-funded stable oxygen isotope, $^{18}$O, studies, and applying sclerochronology methods to archived finfishes in the Eastern Bering Sea, Gulf of Alaska and Arctic Sea. Biochronologies are being developed for Bering Sea flatfish, Pacific Ocean perch (POP) and Arctic surf clams, and Gulf of Alaska black rockfish, northern rockfish, and POP.

## D. Alaska Department of Fish and Game (ADF&G) – Elisa Russ, Sonya El Mejjati, Kevin McNeel:

Elisa Russ began with the report for the ADF&G – Homer, Commercial Fisheries Division (CFD – Central Region) lab and giving a small introduction about what her job entails. Russ stated that she works with commercial fisheries in the Prince William Sound (PWS) and Cook Inlet (CI) management areas, overseeing the groundfish age determination, port sampling, and observer programs for her region; her duties also focus on fisheries management; and she also mentioned that she ages scallops. Andy Pollak is the primary production age reader and works primarily with walleye pollock and demersal and pelagic shelf rockfish (DSR, PSR) species. Russ provides training, precision testing, resolves ages, and does production age reading as needed. Russ stated that the Homer CFD staff collects N = 1200 pollock otoliths per year from the PWS trawl fishery and a new CI experimental seine fishery; and has sampling goals of N = 550 each from each management area for sablefish, lingcod, and rockfish species, including DSR species (primarily yelloweye and quillback rockfish), PSR species (primarily black rockfish), and slope species (primarily rougheye and shortraker rockfish). Precision testing is done on 20% of ages produced. PSR rockfish samples come from the CI directed rockfish fishery while remaining rockfish samples are collected from bycatch retained to other directed fisheries (e.g. longline sablefish and Pacific halibut). Russ mentioned that there was disagreement in ageing criteria for Pacific cod within ADF&G but there may be future resolution to this issue; currently N = 10 Pacific cod samples are collected per landing but all age structures are currently being archived until age criteria and budget constraints are resolved to allow tackling the backlog. All pollock, DSR and PSR collected from commercial fisheries are aged at the Homer lab. Homer CFD transitioned to collecting lingcod otoliths from fin rays several years ago and all lingcod, sablefish, and slope rockfish otoliths collected from commercial fisheries, as well as those species and some DSR and PSR collected from fishery-independent surveys, are sent to Kevin McNeel at the ADU for age determination. The Homer CFD lab uses break-and-bake method to age their otoliths.

Russ also gave a report for the ADF&G – Homer, Sport Fish Division (SFD), stating that no one was able to attend the 2015 CARE meeting. The Gulf of Alaska Bottomfish Assessment program employs two seasonal age readers for a total of approximately eight months annually. Willy Dunne (Fishery Biologist I) is responsible for age interpretation of all rockfish species caught in recreational fisheries. Marian Ford (Fish and Wildlife Technician III) is responsible for the processing, mounting and ageing of all lingcod structures. Barbi Failor (SFD program supervisor) ages salmon sharks as needed.

Joan Brodie (substituting for Sonya El Mejjati), stated that the ADF&G – Kodiak branch has three full-time agers (Mike Knutson went to graduate school and was replaced by Kayla Bevaart). Age determination is generally completed between January-April (3-4 months annually). Species aged in 2015 were black rockfish, dark rockfish, Pacific cod, lingcod, and a small number of walleye pollock (due to a new fishery), and dusky rockfish. For rockfish species, the break and burn method is used. For Pacific cod and walleye pollock, both halves are utilized for the break-and-bake method – in 2015, the method was changed (formerly break-and-burned one half) to using break-and-bake, which has saved a great deal of time. Precision testing is completed on 40% of the majority of samples and at 100% for new age readers. All differences from precision tests are resolved.

Kevin McNeel gave the report for the ADF&G – Juneau Age Determination Unit (ADU). The ADU employs two primary production age readers, April Rebert and Kristin Politano, who production age sablefish, lingcod, yelloweye rockfish, shortraker rockfish, shortspine thornyhead, and other species. Additionally, Rob Dinneford provides second age reads, morphometric measurements, and support, including specimen processing and preparation. Dion Oxman was also present at the CARE Conference and is the program supervisor for the ADF&G Mark, Tag, and Age Laboratory under which the ADU is housed. The ADU is the groundfish and invertebrate age reading program. Kevin provides training, production age reading, as needed, and precision testing. The ADU received N = 8484 specimens in 2014, representing 11 groundfish species from statewide commercial and survey sampling efforts. Sablefish and yelloweye rockfish (N = 4158 and N = 1060 final ages were produced, respectively) were the only groundfish species 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. With training, quality control, and data production, ADU age readers evaluated N = 10,803 groundfish specimens in total. 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 workshop on image analysis using Image Pro Premier software. In total, N = 7509 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.

The ADU continued to participate in CARE, and exchanged data and specimens regarding bomb radiocarbon validation studies and the identification of signature years with other CARE agencies, and also participated in age structure exchanges, including shortraker rockfish and lingcod. The ADU was also involved in planning the 2015 CARE crustacean age determination workshop. McNeel stated that an Isomet 5000 high-speed saw was recently purchased to increase production ageing for geoduck and shortraker rockfish. The ADU gave two oral presentations during the 2015 CARE presentation sessions on April 15th and one poster was presented. The Juneau ADU also provided a laptop with access to an Oracle database and expressed a desire to make data accessible.

## E. Northwest Fisheries Science Center (NWFSC-PSMFC) – Patrick McDonald:

Patrick McDonald discussed changes to e-mail systems (using NOAA- versus PSMFC-issued e-mail addresses) and mentioned that there are currently six age readers now (5 FTE agers and a team lead, Patrick McDonald). Original staffing included 6 FTE agers and a team lead, but Brooke Higgins left. The NWFSC intends to provide PSMFC the funding necessary to backfill the vacant position in May/June 2015. He also mentioned that the NWFSC continues to production age mostly the same species, namely sablefish, Pacific hake, darkblotched rockfish, canary rockfish, Pacific Ocean perch, petrale sole, and dover sole. The NWFSC-PSMFC lab began ageing new species to support the current year's NWFSC stock assessment, such as black, widow, and China rockfish (never aged before). McDonald reported that the lab ages N = 20,000 to 25,000 structures per year. Currently, the lab mainly does surface reads before the break-and-burn procedure. The break-and-bake method is not presently employed, although it was used to age arrowtooth flounder many years ago. Otolith weight data is recorded for all or a subsample of the specimens that are production aged. The lab also prepares spiny dogfish spines and lingcod fin rays for other agencies to age. NWFSC purchased a New Age micromill and polisher for age validation studies. Canary and black rockfish have been discussed as initial candidates for the coring and subsequent validation work. In May, Cassie Whiteside and Lance Sullivan will be trained to use the micromill by Craig Kastelle and seek guidance from the Micromilling Lab at Oregon State University. Dr. Tom Helser asked about nearshore support (SWFSC vs. NWFSC). Elisa Russ mentioned initiating CARE age structure exchanges for new species (black rockfish); Lisa Kautzi (ODFW) mentioned that she has been working with Patrick on black rockfish. Patrick mentioned that NWFSC had an unofficial exchange with Sandy Rosenfield (WDFW) on China rockfish. Russ stated that, ultimately, exchanges between agencies should, actually need to be, documented for CARE so the entire group can benefit from that information, since that is a core objective of CARE in order to achieve the mission.

## F. Southwest Fisheries Science Center (SWFSC):

No report; Patrick McDonald (NWFSC − PSMFC) mentioned that he sends Pacific sanddab and bocaccio rockfish samples to John Field, SWFSC Supervisory Fish Biologist.

## G. Washington Department of Fish and Wildlife (WDFW) – Andrew Claiborne:

Andrew Claiborne discussed organizational changes, which include Lance Campbell being elected unit lead for both the Fish Ageing and Otolith Thermal Mark Labs; Andrew is the new team lead for the Fish Ageing Lab; there is one new age reader (Anna Hildebrandt), three other full-time employees (Sandra Rosenfield, Jennifer Topping, and Lucinda Morrow), and one part-time employee. Otolith microchemistry work has been done with species caught in the Puget Sound and Columbia River. The WDFW ageing lab has also worked on validating laser ablation and back-calculation models. Overall, the ageing lab produces between N = 60,000 and 120,000 ages per year (N = 10,000 ages per year for groundfish stock assessment and management; N = 5000 to 10,000 ages per year for freshwater species stock assessment, management, and invasive species control; and N = 45,000 to 100,000 ages per year for salmonid forecasting, run reconstruction, research, management). Andrew currently works on steelhead trout, Chinook, and sockeye salmon for forecasting, along with Lance. The WDFW's age database is being initiated, making a transition to a digital barcode system, although there has been difficulty in agreeing on the format. The WDFW ageing lab has a new microscope that uses Image Pro. Andrew reported that a new species, eulachon, is being aged for otolith microchemistry studies; a juvenile survival history project is being started by Lance and Anna; black, China, yelloweye, and rougheye rockfish continue to be aged by the lab. The Salish Sea Marine Survival Study involves otolith chemistry and scale morphology work for Puget Sound and coastal populations of Chinook salmon. This work will describe juvenile life history strategies in surviving adults and compare early marine growth between populations, years, and ocean conditions. In addition to eulachon, the WDFW ageing lab may potentially age Puget Sound Pacific cod and John Day River smallmouth bass. Andrew mentioned that Bethany Stevick is working with shellfish (Bethany stated that she has been working on geoduck and has aged N = 800 specimens in the last 5 months). The WDFW purchased an Isomet 5000 high speed saw for improving production ageing efficiency. Andrew asked if anyone has done rock scallop ageing and Joanne Groot asked about species exchanged from the Puget Sound, namely for toxin studies.

## H. Oregon Department of Fish and Wildlife (ODFW) – Lisa Kautzi:

Lisa Kautzi reported that she is the only age reader at ODFW, and for the past two years has been ageing commercial and sport black rockfish and kelp greenling. She mentioned that she changed from using break-and-burn to the break-and-bake ageing method for black rockfish, with break-and-burn used as a backup. Lisa stated that kelp greenling were very challenging and she has aged N = 3800 structures in 2014. Lisa has fulfilled age requests for special projects on blue rockfish, copper rockfish, and kelp greenling, with N = 7400 ages produced during this time. Kautzi would like to move the otolith collection out of its current location, because it is in a tsunami zone, and to the new agency building in Salem, OR. Questions were raised on the logistics for long-distance storage; Dr. Tom Helser suggested that she talk with Katherine Maslenikov (museum curator) at the Burke Museum for archiving and database suggestions.

### I. California Department of Fish and Wildlife (CDFW):

No report; McDonald (NWFSC – PSMFC) stated that Brenda Erwin is the contact person for the CDFW.

## III. CARE to CARE Recommendations from 2013 – Review

A. Recommends the manual working group post-archived editions of the CARE Manual on the website with a link to the year of publication.

Manual for post-archived editions has not happened yet. It will be left on the docket for the next CARE meeting. Betty Goetz mentioned she could not answer if digital archives exist. The committee agreed to modify old techniques to clean up the document; create an acknowledgments section; and re-examine the CARE Manual.

B. Recommends the Manual/Glossary committee continue revision and expansion of the CARE Manual on Generalized Age Determination.

Continue revisions of CARE Manual; CARE recommended the following:

1. Lingcod Otolith Ageing – finalize draft and incorporate into manual.

   Kevin McNeel and Shayne MacLellan edited the final document and the manual committee will review tomorrow.

2. Thin Sectioning Method – edit updated draft.

   The CARE Manual working group edited the updated draft during the 2013 CARE meeting. Charles Hutchinson submitted the section on Thin Sectioning for rockfish otoliths and it needs to be generalized to include techniques for all species.

3. Rockfish Ageing Procedures

   a. Edit to avoid redundancy with Thin Sectioning section – will continue to be revised to avoid redundancy.

   b. Revise/move some information to Otolith Ageing Procedures where appropriate.

4. Add section on baking otoliths under General Ageing Procedures

   Elisa Russ (ADF&G – Homer; CARE Chair) started by asking if any agencies use break-and-bake procedures and requested that agencies e-mail which species are broken-and-baked, as well as any other techniques used, such as surface reading.

Russ brought up the CARE website to look at the record for certain species and proposed a change to the code for break-and-burn (B&BN) vs. break-and-bake (B&BK) technique; Dr. Tom Helser (AFSC) suggested changing the format of the tables for species on the CARE website. Kevin McNeel (ADF&G – Juneau) mentioned including a statement in the manual that refers to the table on the CARE website. Russ would like to have production numbers by the end of April. Jon Short (AFSC) mentioned that modifying the table format would be difficult and suggested listing current methods and contacting agency about updated techniques. Russ asked if listing all methods would be acceptable for the last 10 years. Craig Kastelle (AFSC) said it would be useful to look at changes in techniques from a stock assessment perspective. Goetz mentioned changing the title of the section on baking otoliths to simplify things – motion was accepted. Helser asked if any publication information could be provided for species; Short mentioned there is a reference list on the CARE website; Russ said an update on publications would be recommended. McNeel stated that Tim Frawley (ADF&G – Juneau [offsite]) would be willing to help with hyperlinking references on the CARE website. Russ asked who would like to meet with Short to work on the website – Helser (AFSC) and Dion Oxman (ADF&G − Juneau) volunteered. Sandy Rosenfield (WDFW) asked if any stock assessors have visited the CARE website; Russ recommended adding a counter to keep track of visitors to the website.

5. Ergonomics – write short section to be included with general information on equipment.

   A section was submitted (Betty Goetz [AFSC] mentioned that she has a copy); Elisa Russ (ADF&G – Homer) asked for volunteers to work on the ergonomics section (Goetz accepted the task).

6. Walleye Pollock Ageing Procedures – draft new section; collaborate between agencies.

7. Sablefish Ageing Procedures Section – revise.

   Delsa Anderl (AFSC) said 2017 will be the end date for revisions and mentioned that several people have retired, which has delayed the process.

8. Remove documentation sections in the beginning of manual as is – incomplete.

   a. See Recommendation A to post archived editions.

   b. Add Acknowledgments Section.

C. Recommends CARE Forum be continued.

Elisa Russ mentioned that activity on the forum typically increases immediately after CARE meetings and recommended revising the notification process.

D. Recommends the Website committee load a new version of Joomla for the CARE website, or other recommended CMF (e.g., WordPress or Drupal).

Future plans include:

1. Edits such as consistent capitalization on Species Information page.

Jon Short (AFSC) stated that he has not had time to work with the program to update the website and Dion Oxman (ADF&G – Juneau) said that he will recruit new people to help out.

2. Update agency production numbers.

   Jon Short mentioned that he is compiling new production numbers using a specific Excel template that was distributed this year which he recommended; said compiling information can be time-consuming when provided with different formats. Russ referred to prior discussion about using hyperlinks to Species Information page; Sandy Rosenfield (WDFW) recommended adding links to agency websites.

3. Add webpage for age structure inventories.

   Elisa Russ made a recommendation for moving forward with adding webpage for age structure inventories (for agencies that choose to participate) for this year and suggested that CARE members can agree to the website section by e-mail.

E. Recommends further study of otoliths stored long term in glycerin-thymol.

1. Report on observations regarding the media in 2015,

   Reports and discussion scheduled on agenda for this meeting.

2. Provide recommendation to manual committee in 2015 regarding storage.

   CARE will save the recommendation on glycerin-thymol storage to manual committee in 2015 for Working Group Reports (See **Section VII**).

F. Recommends 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.

Russ and Goetz will work together and bring the recommendation to make additions to the charter, on Friday, April 17th.

## IV. CARE to TSC Recommendations from 2013

At the 2013 CARE meeting, the manual working group drafted a section of 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.

CARE members recommended making TSC aware of ergonomics (motion was acknowledged by TSC). Safety and ergonomics were topics addressed by agency leads.

## V. TSC to CARE Recommendations from 2013

TSC acknowledges CARE's concerns regarding ergonomic injuries caused by extended period of ageing fish and has recommended that the Parent Committee request agencies to investigate ergonomic remedies to minimize ergonomic injuries.

Dr. Tom Helser (AFSC) mentioned that his agency has purchased ergonomic equipment, such as adjustable-height desks, foot operated focusing, and ergonomic eyepieces, and that the use of ergonomic equipment has been addressed by other departments at the AFSC. He also pointed out that a doctor's recommendation for ergonomics is required by AFSC. Patrick McDonald (NWFSC – PSMFC) mentioned that the Newport Ageing Lab has adjustable work stations, as well as ergonomic eyepieces and baffles for the scopes. Elisa Russ (ADF&G – Homer) said that her agency has ergonomic eyepieces. Andrew Claiborne (WDFW) stated that his agency is slowly purchasing ergonomic equipment for the ageing lab. Joan Forsberg (IPHC) said that her agency has ergonomic equipment, and that they are not just for age readers. Russ then asked if a doctor's note was required for agencies to purchase ergonomic equipment – all agencies, except for the AFSC, do not require a doctor's note. Lisa Kautzi (ODFW) said her agency has purchased an adjustable work station for only one employee due to medical reasons; other work stations are stationary. Joanne Groot (CDFO) said her agency has purchased adjustable tables and chairs, as well as ergonomics for scopes and their usage was approved by upper level staff. Kevin McNeel (ADF&G – Juneau) said that his agency also purchased height-adjustable workstations, ergonomic eyepieces, and standing stress mats for their microscopes.

## 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 (e.g. circuit boards) and medical pathology (e.g. microscope slide reading).

Ergonomic injury recommendation from 2013 was accepted by CARE.

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.

In regards to the issue of storing otoliths long-term, it has been difficult to gain agreement due to varying opinions among agencies. For the IPHC, Pacific halibut are stored in glycerin solution; either in vials (collected 1920s through 2000) or Tray Biens (2001-present). The IPHC has stored otoltihs in glycerin solution since the 1920s, with thymol added as a preservative for at least the past 40 years; the agency does not have documentation on exactly when thymol began to be routinely added to the glycerin solution. In 2014, IPHC agers re-aged over 8,000 otoliths collected between 1926 and 1985; Dana Rudy (IPHC) removed these otoliths, which were stored in vials, and transferred them to Tray Biens prior to re-ageing. Forsberg reported that most of the otoliths examined were in good condition. Some of the otoliths from the 1920s and 1930s ($\leq$5%) had a chalky coating that obscured surface growth patterns, however, most of the otoliths with chalky coatings were still readable when broken and baked. However, the IPHC age readers were unsure about the cause of chalkiness, whether it was due to partially dissolved otolith material, mold, combination of both or other factors; surface staining on otoliths from tannins in corks did not obscure patterns on the surface or in baked sections. Age zero- and 1-year otolith collections (juvenile Pacific halibut) retrieved in early 2000s after 40 years of storage in glycerin solution were washed and dried for bomb radiocarbon studies, and were found to be decalcified;

however, otoliths from larger Pacific halibut stored in that medium for a similar time period were not degraded. The IPHC's small fish otolith collection was consequently transitioned from storage in glycerin solution to dry storage. Forsberg also stated that the IPHC continues to use glycerin-thymol for long-term storage; it takes about 4 weeks to rehydrate a dry otolith; and clearing using glycerin-thymol solution helps with the contrast when using the break-and-bake and/or surface-ageing methods.

Delsa Anderl (AFSC) said that her agency's collection is archived at the University of Washington's Burke Museum. She mentioned that, since 2009, the AFSC converted to storing all otoliths exclusively in glycerin-thymol versus some species in ethanol due to flammability and associated transportation issues. Anderl also addressed the matter of chalky otoliths, a topic brought up during the 2013 CARE meeting by Sandra Rosenfield (WDFW). Anderl reported that the AFSC chose to review otoliths for two flatfish species (arrowtooth flounder and yellowfin sole) and two roundfish species (sablefish and walleye pollock) from collection years ranging from 1980s to present; flatfish were historically stored in glycerin-thymol while roundfish were stored in ethanol until 2009, then stored in glycerin-thymol (therefore, some earlier roundfish otolith samples taken for this review were stored in ethanol). These otoliths were randomly sampled and scored based on a scale of four criteria ranging from pristine to deteriorated with surface pattern discernment (and presence of chalkiness/degradation) as a guide. Analyses attempted to determine whether otoliths exhibited a species- specific condition, whereby some years were pristine while other years were not, and/or processor-dependent condition, in which vials and otoliths may have been cleaned improperly. Anderl wanted to know what the Japanese used to preserve sablefish otoliths because the clarity of the annuli was the best she has seen, and would like to do further studies to determine what factors could contribute to chalkiness. She mentioned that she received mixture information for glycerin-thymol from IPHC and Elisa Russ (ADF&G – Homer) stated that Lance Sullivan (NWFSC – PSMFC [CARE Secretary]) will include the glycerin-thymol recipe in the 2015 CARE minutes.

Reports submitted by AFSC and IPHC are contained in **Appendix II**, and recipe for glycerin-thymol solution provided by IPHC is **Appendix III**.

Joanne Groot (CDFO) stated that her agency currently stores otoliths in 50:50 solution of glycerin: water with added thymol because the otoliths became brittle when stored in ethanol, while team leads from WDFW, ODFW, ADF&G, and NWFSC conveyed that their agencies store otoliths dry. Rosenfield said that Shayne MacLellan reported that Pacific hake otoliths had no problem with glycerin-thymol, but there was a problem with juvenile sablefish otoliths. To preserve the integrity of juvenile sablefish otoliths, WDFW stored them dry. Russ asked a final question to the group about rehydration (for clearing otoliths for surface ageing); Lisa Kautzi (ODFW) suggested rehydration well ahead of ageing without using water, due to the risk of bacterial growth, or glycerin-thymol because it takes too long; Lisa recommended using ethanol in Tray Biens once otoliths are transferred into the cells to allow structures to rehydrate quickly (at least a week) without concerns about bacterial growth. Kevin McNeel (ADF&G – ADU) said the Juneau lab would sometimes use ethanol to rehydrate difficult-to-age specimens and/or to evaluate otolith edge.

Dr. Tom Helser (AFSC) stated that evidence is inconclusive regarding the long-term effects of glycerin-thymol on otolith integrity and emphasized that studying such long-term effects would be a significant undertaking that is not a priority. Elisa Russ (Chair) agreed and polled the group and determined the best course of action was to create a 2015 CARE to TSC recommendation to remove the 2014 TSC to CARE recommendation, to create a set of best practices for otolith storage, due to no consensus on best storage protocol within CARE.

# VII. Working Group Reports/Activity Since CARE 2013

## A. 2014 TSC Meeting (Elisa Russ)

1. Replies to TSC regarding 2013/2014 recommendations.
   a. Note in Section VI that prior recommendations were reviewed and 2014 TSC to CARE discussed.
2. Long-term otolith storage; review from 2013; glycerin-thymol observation reports.
   a. Reports were presented during 2014 TSC to CARE review; **Section VI. B.**

## B. Age structure exchanges (Chris Gburski)

Ten age structure exchanges for six species by six agencies were completed and documented. Exchanges initiated in 2014 can be documented through June, and agencies will be provided CASE (CARE Age Structure Exchange) IDs by the Vice- Chair and may submit CASE documentation (Excel file) when completed. It was suggested that agencies look into utilizing CASEs for training as well as calibration on any given species. Discussion revealed that there had been a few age structure exchanges that had occurred but had not been catalogued in the CASE system. Elisa Russ (Chair) expressed the importance of participating in as well as documenting exchanges, especially so that information is available to CARE members. Craig Kastelle (AFSC) said that age structure exchanges were essential for CARE's mandate, and the importance was stressed in the early development of CARE, and shows work of CARE members as a useful product, thereby allowing stock assessors to compare age determination between agencies. Dr. Kray Van Kirk (ADF&G – Juneau) mentioned that a conversion matrix is implemented for sablefish, in terms of determining the extent to which agencies age similarly and developing a proxy for age reader precision.

## C. Website (Jon Short)

Dion Oxman (ADF&G – Juneau) and Dr. Tom Helser (AFSC) agreed to join the group for discussion tomorrow. The progress of archived structures being added to the CARE website will be addressed, as well as updating the website with agency location, contacts, and links.

## D. Forum (Nikki Atkins)

Although Atkins was absent from the meeting, the CARE Forum will still be maintained by her.

## E. CARE manual (Elisa Russ)

CARE manual committee tasks will be discussed tomorrow and current submitted drafts will be reviewed by the working group. Current members Elisa Russ (ADF&G – Homer), Betty Goetz (AFSC), and Barb Campbell (DFO) will be joined by new members Lisa Kautzi (ODFW) and Chris Gburski (AFSC).

### F. Charter Committee (Elisa Russ)

Elisa Russ (ADF&G – Homer) and Betty Goetz (AFSC) will review the charter tomorrow.

### G. Sablefish (Delsa Anderl)

Working group meeting and final results tabled until CARE 2017, however, input on sablefish manual section will be provided during this meeting. Current sablefish ad hoc working group members are Delsa Anderl (AFSC), Patrick McDonald (NWFSC – PSMFC), Kevin McNeel (ADF&G – Juneau), Barb Campbell (DFO), and John Brogan (AFSC).

## VIII. Topics for Discussion/New Business

#### A. Summary of 5th International Otolith Symposium (IOS) 2014 – Craig Kastelle (AFSC)

Craig Kastelle gave a brief summary of the 5th IOS, which was held October 20 – 24, 2014, in Peguera, Mallorca, Spain. There were over 300 scientists in attendance, with more than 300 presentations (e.g., oral, poster, speed [5-minute talks], and continuous slide shows) given. Some of the main points from the presentations were as follows:

- Large diversity of uses and science based on otoliths
- Otolith studies go beyond fisheries management
- Otoliths are often centered around the black box concept (i.e., analogous to a flight recorder)
- Otolith studies involved four themes (environmental, population, community, and individual indicators)

Also during the symposium, two workshops were held, in which age validation and otolith morphometrics (i.e., shape analysis) techniques were demonstrated. A majority of the groups focused on otolith morphology and microchemistry. Key ideas from the symposium included: 1) bomb radiocarbon chronologies have a lag at depth; 2) efforts to validate the first year's growth; 3) cyclical patterns in magnesium (Mg) and rubidium (Rb) across the lifespan of an individual fish; 4) Mg in otoliths may be related to temperature; and 5) a new species identification key from otoliths is soon to be published (by Nolf). Future work on Atlantic cod will be performed, based on findings that future growth and survivability of an individual can be determined by early otolith size and growth rates, and interestingly, Atlantic cod from two adjacent geographic regions had translucent growth zone formation 6 months apart (by Gronkjaer).

**B. Other conferences since 2013 that members attended –** no other conferences attended

### C. Species information on the website – need Agency updates and verification

Discussion regarding how to tie together species, agency, and age determination techniques on the website perhaps linked with contact information.

**D. Additional topics –** none proposed

**E. Non-agenda items –** none proposed

**IX. Oral Presentations –** Abstracts located in **Appendix IV**.

### 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)

Dr. Raouf Kilada gave a presentation on age determination of crustaceans. Historically, work on other hard structures (i.e., otoliths, vertebrae and shells) can determine age. Molting prevents accurate ageing, thereby requiring methods in ageing crustaceans to be indirect. Growth studies are done in captivity, using mark-release experiments via tagging (PIT, etc.); length-frequency analysis (e.g., fish ectoparasites); and lipofuscin (LF) concentration via fluorescence intensity and a LF index (which requires a lot of training on a spectrophotometer). Direct age determination of crustaceans is done via the use of eyestalks, which requires dissection and removal of brain tissue. Cutting axes for processing eyestalks are perpendicular (longitudinally and latitudinally). The base of the eyestalk funnel gave the best age estimates. Cuticle layers (epi-, exo-, and endocuticle) making up the eyestalk are clear for snow crab. For red king crab, Tanner crab, squat lobsters (red and yellow), swimming blue crab, red swamp crayfish, American lobster, and snow crab, the gastric mill ossicles (uro-, zygo-, and mesocardiac) were used as another direct ageing method. Dr. Kilada confirmed that gastric mills have cuticle layers (endocuticle), therefore validating their use as structures to be directly aged. Ageing errors were addressed using endocuticle bands, with validation performed via calcein stain and correlating the instar to band counts using length-frequency analysis. Upon the conclusion of his presentation, Dr. Kilada answered questions from the CARE members. The first question concerned whether growth zones are retained after molting. Dr. Kilada stated that, given using calcein as a marker for birth year, the exuviae of gastric mill ossicles are not molted, as seen in American lobster. Furthermore, he pointed out that the size-at-age using carapace length for snow crab, American lobster, and Northern shrimp (a hermaphroditic species) validated that growth bands are the actual age of crustaceans. He also mentioned that the zygocardiac is used for determining the age of swimming blue crabs, although a strong correlation may not yield enough evidence to age crustaceans using this method. Studies for Lakes Bardaweel and Timsah species may estimate age at 3 years instead of 2 years. Dr. Kilada stated that there was a corroboration of band counts in red king crab species from Canada and Norway; other species studied included nephrops, krill (results were inconclusive), rock crab, and European lobster; and future studies on core isotope (i.e., strontium) ratios between marine and freshwater will be addressed. Dr. Tom Helser asked about what "guesstimates" imply; Dr. Kilada replied that they are used to distinguish from estimates. Helser also asked if bomb radiocarbon has been used; Dr. Kilada said that $^{14}C$ has been obtained from clams, but he is hesitant to use $^{14}C$ dating techniques on eyestalks and gastric mill ossicles, which are apatitic not aragonitic.

### 2. **Irina Benson – *Preliminary Results on the Use of Otolith Microchemistry for Developing Ageing Criteria for Eulachon (Thaleichthys pacificus).*** (20 minutes)

Irina Benson presented preliminary results on the otolith microchemistry of Eulachon (*T. pacificus*). Trace elemental analysis is used as a temporal record of ambient water temperature, in which barium (Ba) was the primary element of interest. The Ba concentrations fluctuate with season (summer upwelling brings a seasonal increase in Ba concentrations, as well as an uptake increase). When analyzing trace element concentrations, peaks involving barium-to-calcium (Ca) ratios were used to age eulachon (via the Clark hypothesis). Three geographical regions (Bering Sea, SE Alaska, and Oregon) were selected as the sampling areas. Laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS) was used to take rasters (scanning lines) of material from thin sections, going from the core to the proximal edge. Benson said that the analysis was corrected for background noise and instrument drift. Using Ba:Ca peaks to determine age varied with geographical region and sometimes it made interpreting graphs difficult. Another problem that Benson encountered involved the surface having a clear age, but the graph did not correlate; there was some uncertainty about not counting the first year. She also pointed out that the otoliths may have had either a smaller first year or non-annular marks (shown on the graph), which further complicated interpreting the results. Canonical discriminant analysis (CDA) compared the elemental ratio signatures in otoliths from three separate geographical areas (coefficient of each elemental ratio) and was used to measure its discrimination power. Benson concluded by giving the preliminary conclusions, as follows: 1) CDA – specimens from three areas were different based on elemental profiles, 2) Ba signatures suggested annular fluctuations due to summer upwelling – elemental signatures may be useful as annual markers, 3) additional oceanographic studies needed to determine seasonality of chemical signatures in different areas, and 4) the size of first annulus on eulachon otoliths may be variable in different geographical areas. There were no questions posed by CARE members.

## B. Topic Session 2: Age Validation Studies

### 1. **Tom Helser – *Estimation of Ageing Bias Using Bomb Radiocarbon $\Delta^{14}C$ Signatures in Fish Otoliths: Beyond Plot and Cluck.*** (30 minutes)

Dr. Tom Helser presented his research on the estimation of ageing bias using bomb radiocarbon signatures in otoliths from pre-1990s fish capture dates. Helser also published articles that pertained to age validation of otoliths from fish that absorbed $^{14}C$ from atomic bomb testing, whereby it entered the hydrologic cycle via river influx and upwelling. He reported that $^{14}C$ increased in the 1950s and decreased in the 1960s and radiocarbon dating techniques were used to validate ages of canary rockfish using reference chronologies for Gulf of Alaska (GOA) Pacific halibut and Pacific Ocean perch (POP). Sources of error included: 1) ageing error due to a shift in points, 2) measurement error (i.e., small variances that were controlled for); and 3) process error (i.e., mixing species in the same environment). Helser developed a robust tool to investigate the assumption of process error. Objectives of the study involved fitting the functional response to the GOA Pacific halibut reference chronology and rockfish test samples, estimating ageing bias and its uncertainty, and testing for the effects of oceanographic factors on upwelling, latitude, and wind stress, the latter of which creates stability. Statistical methods involved using Bayesian inference via a Markov Chain Monte Carlo (MCMC) simulation for diagnostics, where the unbiased sample was centered on 0 (determines probability of ageing bias). The results consisted of functional responses indicating no significant differences in pulse between the reference and test species. When the functional response was centered on zero, there was no bias between the reference chronology and POP. On the other hand, the functional response was not centered on zero for canary rockfish, which may not be indicative of bias due to a difference in the geographical regions. Helser concluded his presentation by saying that using the correct reference chronology with test samples is necessary for bomb radiocarbon dating; a multi-level Bayesian approach provided the framework for hypothesis testing; and the functional form of $\Delta^{14}C$ signatures vary by species, latitude, upwelling, and other factors. There were no questions.

2. **Stephen Wischniowski (presented by Tom Helser) – *Incorporation of Bomb-Produced $^{14}C$ into Fish Otoliths: An Example of Basin-Specific Rates from the North Pacific Ocean.*** (15 minutes)

   Dr. Tom Helser presented in place of Stephen Wischniowski on the incorporation of bomb-produced $^{14}C$ into otoliths. The method assumptions included species used for the reference chronology that received radiocarbon from the same system or source as the test species to be validated. Only the first year's material was measured. The goal of the research was to develop a new known-age bomb- produced $^{14}C$ reference for eastern Bering Sea Pacific halibut and other species, when compared to GOA Pacific halibut. Helser concluded by stating that regional differences in $^{14}C$ incorporation were likely due to basin-specific oceanographic processes (latitudinal gradient) and mixing rates. No questions were posed for Helser.

3. **Craig Kastelle – *Use of the Stable Oxygen Isotope, $^{18}O$, in Otoliths as an Indicator of Fish Life History Events and Age Validation.*** (25 minutes)

   Craig Kastelle presented his research on the use of stable oxygen isotope, $^{18}O$, as an indicator of fish life history events and age validation, including habitat usage, estimating water temperature, developing age determination criteria, estimating probability of ageing error, and investigating climate change effects. Four species (Pacific cod [PCOD], saffron cod, small yellow croaker, and yellow fin sole) were used in the study. In regards to the age validation of PCOD, the peaks of $^{18}O$ determined age, as well as life history. By estimating the probability of ageing error (bias), cycle of $^{18}O$ used to determine the "true age"; ageing error was determined by age, for 2 to 5 years, and all ages combined using a sample size of N = 40 over the age range with four replicate age readings. Kastelle found that fractionation in otoliths is inversely related to temperature. As $^{18}$O was measured sequentially across an otolith, the readings spanned the fish's life history and a seasonal cycle, or trend, should be seen. To obtain $^{18}$O samples, Kastelle micromilled material along specific trajectories, where each track goes progressively from center to edge, representing life history. Once the micromilled otolith was sampled, the resultant powder's $^{18}$O content was analyzed with secondary ion mass spectrometry (SIMS), a high resolution sampling technique. Several factors affecting $^{18}$O in otoliths included the $^{18}$O content of water, fish migration, and milling resolution (especially in later years). The $^{14}$C milling on PCOD otoliths yielded results that differed from GOA Pacific halibut reference, so an $^{18}$O plot was made to confirm life history or ontogenetic migrations. Upon concluding his presentation, Dr. Tom Helser mentioned that as a fish descends the water column, $^{14}$C signal and uptake declines. Beth Matta confirmed that juveniles reside in shallow regions, which could result in the trend of $^{14}$C seen in the plot, relative to the Pacific halibut reference curve.

*(**Note:** Due to time constraints, Kevin McNeel's and Kristin Politano's presentations were rescheduled for Thursday, April 16, 2015.)*

## C. Topic Session 3: Age-Based Models for Fisheries Stock Assessment and Management

### 1. Dr. Kray Van Kirk – *Ageing and Stock Assessment: Uncertainty in Data and Analyses* (20 minutes)

Dr. Kray Van Kirk gave a presentation on ageing and stock assessment, with respect to uncertainty in data and analyses. He reviewed the meaning of stock assessment, which is defined as an effort to determine the response of a given population (stock) to fishing. Stock assessors analyze commercial catch, biological, and survey data. Dr. Van Kirk stated that the stock assessment model predicts a response when changing parameter values; parameter values are changed to match model output to observed data. He also said that although the stock assessment construct shows trends in abundance, catch, and exploitation rates, it is meaningless without the age structure. For example, in confounding scenarios where catch and exploitation rate increase while abundance decreases, stock assessors need to answer "Why?" by looking at recruitment, fishery selectivity, and mortality. Stock assessors are able to track cohort strength and attempt to quantify recruitment (birth), growth, fisheries removals, and death, which in turn may inform fisheries management decisions and regulations based on factors learned (e.g., recruitment, maturity, gear selectivity, and senescence). Age variability occurs when there are discrepancies when agers have a difficult time ageing otoliths (e.g., sablefish extremely variable relative to length). Dr. Van Kirk stressed the importance of second reads and age validation, which are critical to stock assessment. The real- world effects of obtaining precise age estimates is palpable, whereby including ageing error highly impacts fish populations. Ignoring ageing error has huge impacts on management since ageing is a critical, pivotal foundation for stock assessments. After Dr. Van Kirk concluded his presentation, he answered questions from the audience. Delsa said the AFSC has an ageing error matrix and emphasized importance of interagency exchanges. Dr. Van Kirk said exchanges would help eliminate ageing error for species. Dr. Raouf Kilada said the ageing error matrix is not relevant to crustaceans, which was confirmed by Dr. Van Kirk. Dr. Tom Helser asked about comparing two subsamples of length-at-age from commercial samples. In response, Dr. Van Kirk could not distinguish between precision and accuracy if the known length-at-age has not been determined. Sandy Rosenfield asked Dr. Van Kirk if he sends outliers back to ageing agencies to re- examine (e.g., to distinguish sampler error versus ageing error); Kray questioned whether or not to throw out such an age. Rosenfield followed this question by asking if the level of ageing difficulty is included in the ageing error matrix and Dr. Van Kirk's answer was that the difficulty is inherent as there needs to be a separate ageing error matrix for each species and it needs to be recalculated every time a new age reader is added to the mix. Russ mentioned her agency has encountered variability in age data with fish at a given length. Irina Benson suggested looking at the same samples Helser mentioned and conduct analyses after plotting normalized distribution and for these analyses age readers should have minimum of 10 years' experience for that species.

*Thursday, 16 April*

# X. Working Groups and Workshops

## A. Crustacean Workshop (Age and Growth Laboratory)

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 – Juneau) assisted Elisa Russ (CARE Chair) in the organization and planning of the workshop, and also assisted Dr. Kilada in conducting the workshop. Some 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. The 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.

## B. Working groups (Traynor Room or Room 2079)

### 1. CARE Manual/Glossary Subcommittee

The members of the manual working group are lead Elisa Russ (ADF&G – Homer), Betty Goetz (AFSC), and new members Lisa Kautzi (ODFW) and Chris Gburski (AFSC). Barbara Campbell (CDFO) is also a member although she was unable to attend the working group meeting at the 2015 CARE meeting due to a conflict with the sablefish working group. The Manual/Glossary Committee working group members develop and update age-reading chapter sections and definitions for age-reading terms as suggested and contributed by CARE members. These chapter sections and definitions are subsequently approved by CARE members and added to the CARE Manual/Glossary.

The subcommittee addressed 2013 manual recommendations, drafted 2015 recommendations, and delegated tasks. Tasks include compiling edits and finalizing the lingcod section that the 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 the manual working group meeting, provided additional suggestions/information on ergonomic equipment from the perspective of a new age reader and will supply equipment list to Betty by end of April], and draft the walleye pollock section (research and provide draft at 2017 meeting – Elisa).

An Acknowledgments Section will be prepared for manual version generated after the 2015 CARE meeting and the manual subcommittee will work with the website subcommittee to post archived editions of the manual. The manual working group will review the sablefish section once submitted by the sablefish working group. The manual working group will work with Dr. Cindy Tribuzio (AFSC/NMFS – ABL) on a new spiny dogfish section for the manual since she has drafted an 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

The CARE Website Subcommittee members are Jon Short (AFSC) lead webmaster, Nikki Atkins (NWFSC – not present), and new members Dr. Thomas Helser (AFSC) and Dion Oxman (ADF&G – Juneau). The CARE website (http://care.psmfc.org/) working group administers the website including appearance, operation, and access to the site, through the cooperation of the PSMFC website and webmaster. 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. Atkins continued to maintain the CARE Forum in 2014 (link on website).

The website subcommittee meeting also included Tim Frawley (ADF&G – Juneau; recruited by Dion Oxman) 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 (ADF&G) 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 subcommittee 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 include Patrick McDonald (NWFSC – PSMFC), Kevin McNeel (ADF&G – Juneau), Barbara Campbell (CDFO), John Brogan (AFSC) and new members Lance Sullivan (NWFSC – PSMFC) and Kristin Politano (ADF&G – Juneau). 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 otoliths to continue work on calibration and age determination criteria.

## 5. Shortraker Rockfish 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 – Juneau), 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 many checks during the early years up until approximately age of 20 years and then uneven growth increments after age 20. 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. Hands-on microscope work and calibration (Traynor Room)

1. Sign up for dual scope station use (**Table 2:** 2015 CARE Hands-On "Scope Time" Session), microscope imaging station and micromill demonstration (**Table 3:** Microscope Imaging Station and Micromill Demo Sign Ups).

**D. Poster Session –** Poster presentations available for viewing all day and formal session with presenters will be 3 – 4 p.m. Abstracts are in **Appendix IV**.

**XI. Oral Presentations –** continued from April 15, 2015 (Abstracts in **Appendix IV**.)

## A. Topic Session 2: Age Validation Studies

**1. 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*** $^{14}C$. (20 minutes)

Kevin McNeel presented his study on assessing yearly growth increment criteria, using bomb radiocarbon. He went over precision and accuracy diagrams, as well as methods to prepare otoliths for $^{14}C$ analyses via accelerator mass spectrometry. A yelloweye rockfish and Pacific halibut reference curve were both used due to reference curve shape likely depending on various biotic and abiotic factors. McNeel stated that the results indicate an overall agreement of ages with $^{14}C$ data, but sample size must be adequate, or large enough to compare with the reference curve. Dr. Raouf Kilada asked about using the reference curve for a benthic versus pelagic species and that the minimum sample size was nine samples or individuals; McNeel said that the reference curve should match the species found at a given depth of the water column. Elisa Russ asked about whether specimens were of a known age which McNeel confirmed for the halibut reference curve, but not for the yelloweye rockfish.

2. **Kristin Politano –** ***Using Otolith Measurements to Refine Quality Control Procedures.*** (20 minutes)

   Kristin Politano presented research done by the ADU on using otolith measurements to refine quality control procedures. Measurements of length, height, and weight were taken from otoliths after at least 2 weeks of drying and prior to age reading. The data was entered into the Oracle database via digital integration (with noted features), N > 250,000 structures. Politano mentioned that taking otolith measurements will improve quality control, which involves two stages. **Stage I** aims to develop a better age proxy using otolith morphometric analysis versus somatic length (change in fish length slows with age). It was determined that mean otolith length and height at age exhibit a similar relationship to somatic length, however mean otolith weight at age exhibits a nearly continual increase and is therefore a better proxy. **Stage II** aims to identify outlying age estimates, assuming that morphometric data is accurate. Data filter models of otolith weight and somatic length at age were developed and a "Goldilocks" method used to identify the correct standard deviation (±2) as a cutoff for detection of outliers that would include natural variability of population, as well as identify most gross outliers (transcription, translation, and calibration errors). These quality control procedures have been implemented to screen 100% of primary ages for yelloweye rockfish, sablefish, lingcod, shortraker rockfish, rougheye rockfish, and geoduck. Outliers are flagged for a blind reading by primary reader and if error per specimen exceeds species-specific control limits, the specimen is flagged for resolution. The next steps are to refine the model, evaluate it against validated specimens, explore other uses for otolith morphometrics (species ID), and report the data in OceanAK (ADF&G centralized portal for fisheries management data). Politano concluded by saying that otolith weights are useful in quality control procedures, data and database structure information are available, and models need to be refined. Bethany Stevick (WDFW) asked about age-at-length error being included in the model; Politano said that error is not included. Bethany also asked if error checking is done to account for human error; Politano confirmed this and referred to quality control procedures and re-reads for outliers. Colin Jones (WDFW) asked about collecting consistent data from a particular otolith side and Politano said that examining otolith morphology for each species is a goal of the project. Dion Oxman (ADF&G – Juneau) also mentioned environmental factors would be good to look at for comparison for a given otolith side. Dr. Raouf Kilada asked about using the relationship between age and somatic growth; McNeel said a multivariate model would be useful.

*Friday, 17 April*

# XII. Recommendations

## 2015 CARE to CARE

To start off the 2015 recommendations, Betty Goetz (AFSC) suggested updating the CARE website on the history of CARE after each meeting by highlighting key accomplishments. Goetz mentioned a focus was included in the history of CARE and also recommended the CARE Secretary might take responsibility for recording the history of CARE. Elisa Russ (ADF&G – Homer) suggested that she, Lance Sullivan (NWFSC – PSMFC), and Chris Gburski (AFSC) could work together to document the 2015 meeting's key notes. Gburski confirmed that working as a small group would be helpful to put together the 2015 record of the CARE meeting.

Russ then finalized the following 2015 CARE to CARE recommendations with the group:

A. Recommends the Manual/Glossary subcommittee continue the revision and expansion of the CARE Manual on Generalized Age Determination with the following sections:

1. Lingcod Otolith Ageing section – finalize the draft in May 2015 (*thanks to ADF&G – Juneau ADU staff*) and submit to membership for approval in 2015;
2. Thin Sectioning Method section – add a section under the General Ageing Procedures; finish the draft, finalize edits, and submit to membership for approval prior to 2017 meeting;
3. Rockfish Ageing Procedures section – finish draft, finalize and submit to membership for approval prior to 2017 meeting,
    a. Edit to avoid redundancy with Thin Sectioning section,
    b. Revise/move some information to General Otolith Ageing Procedures section where appropriate;
4. Add section on baking otoliths under General Otolith Ageing Procedures – research methodologies with agencies where techniques are employed and submit draft for 2017 meeting;
5. 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 in 2015;

    *(**Note**: Goetz added that she is soliciting input on the risks of age reading and prevention measures using ergonomics);*

6. Walleye Pollock Ageing Procedures section (new) – collaborate between agencies and submit draft at 2017 meeting (use the AFSC manual as a starting point);

7. Sablefish Ageing Procedures section – draft will be completed by the Sablefish working group by end of 2015 then, after edits and revision, it will be submitted to the CARE Manual working group by June 2016 for finalization with submission to membership for approval prior to 2017 meeting;
8. Spiny Dogfish Ageing Procedures section (new) – prepare draft for 2017 meeting (following publication of CARE member's, Dr. Cindy Tribuzio, spiny dogfish age determination manuscript and use techniques described); and
9. Remove documentation sections regarding changes to CARE Manual (also incomplete),
   a. Add Acknowledgements section – submit to membership for approval for 2017 meeting;
   b. See Recommendation B to post archived editions.

B. Recommends the CARE Manual working group submit archived editions of the CARE Manual to the website committee for posting on the CARE website to preserve historical records.

C. Recommends that the CARE Forum be continued.

D. 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,
   1. One option is to add links to the existing species information page and the ageing method table;
   2. Another option is to create a more sophisticated database back-end that would allow users to search by species, ageing techniques, validation method, author, etc.;
   3. 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.

E. Additional recommendations for the website to be completed prior to 2017 meeting are as follows:
   1. Add information at the top of the Species Information page to "Check with specific agency about changes in historical techniques"; report that "Methods listed are for most recent reporting year," or adjust in conjunction with changes incorporated in Recommendation F;
      a. Consider 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 agency.
   2. Edits such as consistent capitalization on the Species Information page;
   3. Update agency production numbers annually
      a. Include methods for current year and use appropriate codes (B&BN = Break-and-burn, B&BK = Break-and-bake);

   b. Update Species Information page to include new codes;

4. Add table for agency contacts with e-mail address – if possible, hyperlink from Ageing Method table (Agency field);

5. Add a webpage for age structure inventories (links may be in a spreadsheet or hyperlinks) for participating agencies, including protocol (*not everyone will have inventories*).

F. Recommends the Website committee research the possibility of converting the CARE website and CARE Forum to a different technology (Joomla is out-of-date and it requires a major undertaking to update to new version), as follows:

1. Consider moving to an ASP.NET website and research options available on the PSMFC web server; however, the amount of work involved and cost will be assessed prior to implementation;

2. Another option is to consider a WordPress website (as of 2012, PSMFC switched from a Joomla to a WordPress website); if, instead CARE website committee decides 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)

G. Recommends the Charter Working Group revise the charter and submit it to CARE membership for approval in 2015; changes to include:

1. Information on timelines including preparation of TSC report following same year CARE meeting;

2. Submission of production numbers (species aged table); and

3. Chair coordination with host agency regarding meeting logistics.

*(**Note:** It was noted that the Chair has to have executive summary completed immediately upon conclusion of the 2015 CARE meeting).*

## 2015 CARE to TSC

A. Recommend removing the TSC to CARE 2014 recommendation to produce a set of best practices for short- and long-term otolith preservation and storage. Currently, there is no consensus on the best storage protocol between, or even within, agencies because method suitability may be dependent on species, fish age, and/or archive space availability;

1. Reports from agencies using glycerin-thymol, including recommended recipe for solution, will be included in TSC report;

2. Agencies will continue to research whether current methods of long-term storage are adequate for preserving otolith integrity.

B. Recommend that new age readers are oriented to available ergonomic equipment, and its proper use for minimum strain. Further recommend that the purchase and use of ergonomic equipment should continue to be implemented and supported by agency managers, and proactive standard operating procedures be in place to prevent workplace injuries;

1. Reports on the 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**) or ergonomic specialists Available for evaluation of workstation, need to ensure that is available for all agencies.

C. Recommend that CARE continues to explore and develop new methods of shellfish age determination.

D. Recommends 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)* – **See XIII. B.**

## XIII. Concluding CARE Business

### A. Administration nominations

1. Nominate Chris Gburski (AFSC) as Chair – Accepted
2. Nominate Lance Sullivan (NWFSC – PSMFC) as Vice Chair – Accepted
3. Nominate Kevin McNeel (ADF&G – Juneau) as Secretary – Accepted

### B. Schedule and location of 2017 meeting

1. CARE meeting will be held during the first week of April in 2017.
   a. It was recommended that the 2017 CARE meeting be held as early as possible, due to TSC meeting being held during last week of April, and CARE Chair must prepare CARE report prior to the TSC meeting. Elisa Russ (ADF&G – Homer) initiated the CARE recommendation to TSC that they consider having their meeting no earlier than the last week of April. Russ also suggested having the meeting in Seattle (Craig Kastelle [AFSC] recommended having the meeting in a different location; Delsa Anderl [AFSC] recommended the IPHC facility, but Joan Forsberg said that space is limited).
2. CARE 2017 meeting will be held at AFSC, in Seattle, WA.
   a. Russ gave thanks to AFSC for providing and ensuring the availability of facilities; Anderl and Kastelle will spread responsibility to ensure AFSC will host CARE meeting in 2017.

## XIV. Working Groups and Hands-on Workshop

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

# XV. CARE Business Meeting Adjourned by outgoing CARE Chair Elisa Russ.

## XVI. Crustacean Age Determination Workshop Resumes until end of day.

A. May adjourn earlier depending on student needs.
B. Workshop final report located in **Appendix VI**.

**Table 1.** 2015 CARE Attendance List (April 14 – 17, 2015, Seattle, Washington, U.S.A.)

| Last name | First name | Agency | Location | Country | Email |
|---|---|---|---|---|---|
| Pollak | Andrew | ADF&G | Homer | USA | andrew.pollak@alaska.gov |
| Russ | Elisa | ADF&G | Homer | USA | elisa.russ@alaska.gov |
| Dinneford | Rob | ADF&G | Juneau | USA | rob.dinneford@alaska.gov |
| Frawley | Tim | ADF&G | Juneau | USA | tim.frawley@alaska.gov |
| McNeel | Kevin | ADF&G | Juneau | USA | kevin.mcneel@alaska.gov |
| Oxman | Dion | ADF&G | Juneau | USA | dion.oxman@alaska.gov |
| Politano | Kristin | ADF&G | Juneau | USA | kristin.politano@alaska.gov |
| Smith | Quinn | ADF&G | Juneau | USA | quinn.smith@alaska.gov |
| Van Kirk | Kray | ADF&G | Juneau | USA | kray.vankirk@alaska.gov |
| Webb | Joel | ADF&G | Juneau | USA | joel.webb@alaska.gov |
| Bevaart | Kayla | ADF&G | Kodiak | USA | kayla.bevaart@alaska.gov |
| Brodie | Joan | ADF&G | Kodiak | USA | Joan.brodie@alaska.gov |
| El Mejjati | Sonya | ADF&G | Kodiak | USA | sonya.elmejjati@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 |
| 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 |

**Table 1 (continued).** 2015 CARE Attendance List (April 14 – 17, 2015, Seattle, Washington)

| Last name | First name | Agency | Location | Country | Email |
|---|---|---|---|---|---|
| Forsberg | Joan | IPHC | Seattle | USA | joan@iphc.int |
| Gibbs | Linda | IPHC | Seattle | USA | linda@iphc.int |
| Johnston | Chris | IPHC | Seattle | USA | chris@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 |
| 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

| **Dual Microscope Station 1** | | | |
|---|---|---|---|
| *Thursday, April 16, 2015* | | | |
| **Time:** | **Species:** | **Participants/Agencies:** | **Comments:** |
| 8:30 a.m. – 10:30 a.m. | China Rockfish | Cassandra Whiteside (NWFSC) | Calibration |
| | Quillback Rockfish | Andy Pollak (ADF&G) | |
| | Yelloweye Rockfish | | |
| 1:30 p.m. – 3:30 p.m. | Rex Sole | Chris Johnston (IPHC) | Calibration |
| | | Joan Brodie (ADF&G) | |
| | | Linda Gibbs (IPHC) | |
| | | Dana Rudy (IPHC) | |
| | | John Brogan (AFSC) | |
| | Greenland Turbot | Chris Johnston (IPHC) | Calibration |
| | | Joan Brodie (ADF&G) | |
| | | Linda Gibbs (IPHC) | |
| | | Dana Rudy (IPHC) | |
| | | John Brogan (AFSC) | |
| 4:30 p.m. – 5:30 p.m. | Pacific Tomcod | Rob Dinneford (ADF&G) | Calibration |
| | | Andy Pollak (ADF&G) | |
| | | Craig Kastelle (AFSC) | |
| | | Lance Sullivan (NWFSC) | |
| *Friday, April 17, 2015* | | | |
| **Time:** | **Species:** | **Participants/Agencies:** | **Comments:** |
| 1:30 p.m. – 3:30 p.m. | Canary Rockfish | Andy Pollak (ADF&G) | Calibration |
| | | Patrick McDonald (NWFSC) | |

**Table 2 (continued).** 2015 CARE Hands-On "Scope Time" Session

| **Dual Microscope Station 2** | | | |
|---|---|---|---|
| *Thursday, April 16, 2015* | | | |
| **Time:** | **Species:** | **Participants/Agencies:** | **Comments:** |

| | | | |
|---|---|---|---|
| 8:30 a.m. – 10:30 a.m. | Mixed Species | Chris Johnston (IPHC)<br>Dana Rudy (IPHC)<br>Linda Gibbs (IPHC) | Calibration |
| 10:30 a.m. – 12:00 p.m. | Pollock | Andy Pollak (ADF&G)<br>Sonya El Mejjati (ADF&G)<br>Betty Goetz (AFSC)<br>Chris Gburski (AFSC)<br>Joan Brodie (ADF&G) | Calibration |

| **Dual Microscope Station 3** | | | |
|---|---|---|---|
| *Thursday, April 16, 2015* | | | |
| **Time:** | **Species:** | **Participants/Agencies:** | **Comments:** |
| 8:30 a.m. – 10:30 a.m. | Lingcod | Joan Brodie (ADF&G)<br>Kristin Politano (ADF&G)<br>Sonya El Mejjati (ADF&G) | Calibration |
| 10:30 a.m. – 12:00 p.m. | Sablefish | Patrick McDonald (NWFSC)<br>Kevin McNeel (ADF&G)<br>Lance Sullivan (NWFSC)<br>John Brogan (AFSC)<br>Kristin Politano (ADF&G) | Calibration |
| 1:30 p.m. – 3:30 p.m. | Goeduck | Kristin Politano (ADF&G)<br>Bethany Stevick (WDFW)<br>Colin Jones (WDFW) | Calibration |

**Table 2 (continued).** 2015 CARE Hands-On “Scope Time” Session

| **Dual Microscope Station 4** | | | |
|---|---|---|---|
| *Thursday, April 16, 2015* | | | |
| **Time:** | **Species:** | **Participants/Agencies:** | **Comments:** |

| | | | |
|---|---|---|---|
| 8:30 a.m. – 10:30 a.m. | Pollock | Chris Gburski (AFSC) | Calibration |
| | | Joan Brodie (ADF&G) | |
| | | Sony El Mejjati (ADF&G) | |
| | | Betty Goetz (AFSC) | |
| 10:30 a.m. – 12:00 p.m. | Lingcod | Kristin Politano (ADF&G) | Calibration |
| | | Joan Brodie (ADF&G) | |
| | | Rob Dinneford (ADF&G) | |
| 1:30 p.m. – 3:30 p.m. | Lingcod | Sonya El Mejjati (ADF&G) | Calibration |
| | | Rob Dinneford (ADF&G) | |
| | | Sandra Rosenfield (WDFW) | |
| | | Lance Sullivan (NWFSC) | |
| | | Patrick McDonald (NWFSC) | |
| 3:30 p.m. – 4:30 p.m. | None Reported | None Reported | None Reported |

**Table 3.** 2015 CARE Microscope Imaging Station and Micromill Demo Sign Ups

| **Microscope Imaging Station – Shortraker Rockfish Ad Hoc Working Group** | | | |
|---|---|---|---|
| *Thursday, April 16, 2015* | | | |
| **Time:** | **Species:** | **Participants/Agencies:** | **Comments:** |
| 8:30 a.m. – 10:30 a.m. | Shortraker Rockfish | Kevin McNeel (ADF&G) | Calibration, exchange, and Training |
| | | Charles Hutchinson (AFSC) | |
| | | Elisa Russ (ADF&G) | |
| | | Betty Goetz (AFSC) | |
| | | Kristin Politano (ADF&G) | |
| | | Joanne Groot (CDFO) | |

| | | | |
|---|---|---|---|
| | | Delsa Anderl (AFSC) | |

| **Micromill Demonstration by Craig Kastelle (AFSC)** | | | |
|---|---|---|---|
| *Friday, April 17, 2015* | | | |
| **Time:** | **Participants:** | **Agencies:** | **Comments:** |
| 10:30 p.m. – 11:30 p.m. | Andrew Claiborne | WDFW | None |
| | Bethany Stevick | WDFW | |
| | Joanne Groot | CDFO | |
| | Barb Campbell | CDFO | |
| | Rob Dinneford | ADF&G | |
| | Lance Sullivan | NWFSC | |
| | Patrick McDonald | NWFSC | |
| | Andy Pollak | ADF&G | |
| | Elisa Russ | ADF&G | |

Appendix I: 2015 CARE Agenda

**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**

## C.A.R.E. Agenda

### *Tuesday April 14, 2015*

Crustacean age determination workshop – see workshop agenda[1]

### *Wednesday April 15, 2015*

I. Welcome and Opening Statements for C.A.R.E. 2015 Meeting (8:30 a.m. – 9:00 a.m.)

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[2] (9:00 a.m. – 9:45 a.m.)

A. CDFO (Steve Wischniowski)
B. IPHC (Joan Forsberg)
C. AFSC (Tom Helser)
D. ADF&G (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 a.m. – 10:15 a.m.)

[1] Participation in the Crustacean Age Determination Workshop was limited – workshop full
[2] No PowerPoint; 5 minute updates (staffing, organizational, new species/projects, etc.)

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 C.A.R.E. 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 a.m. – 10:30 a.m.) – Posters may be set up prior to the meeting commencement or during breaks today.***

## VII. Working Group Reports / Activity Since CARE 2011 (10:30 a.m. – 11:30 a.m.)

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 a.m. – 12:00 p.m.)

A. Summary of 5$^{th}$ 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 p.m. – 1:15 p.m.)***

## IX. Oral Presentations – 3 Topics (1:15 a.m. – 5:00 a.m.)

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. Dr. 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 a.m. – 3:30 a.m.)***

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 p.m. – ?)***

## *Thursday, April 16, 2015*

X. Working groups & Workshops (8:30 a.m. – 5:00 p.m., 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

## *Friday April 17, 2015*

XI. Recommendations (8:30 a.m. – 9:00 a.m.)

A. 2015 CARE to CARE
B. 2015 CARE to TSC

XII. Concluding CARE business (9:00 a.m. – 10:00 a.m.)

A. Administration nominations
B. Schedule and location of 2017 meeting

XIII. Working groups & Hands-on Workshop (10:00 a.m. – 12:00 p.m.)

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 p.m.)

XV. Crustacean Workshop Resumes (1:00 p.m. – 5:00 p.m.)

A. May adjourn earlier depending on student needs

## Appendix II: Long-Term Storage of Otoliths in Glycerin-Thymol Solution[3]

### I. Results of a Preliminary Review on the Condition of Whole Otoliths Stored in Glycerin Thymol from Archived Collections at the Alaska Fisheries Science Center

Delsa M. Anderl, Age & Growth Program, Alaska Fisheries Science Center

At the 2013 Committee of Age Reading Experts (CARE) workshop, Sandra Rosenfeld, age reader from Washington Department of Fish and Game, presented a problem she had recently observed with their historic otolith collection stored in glycerin thymol. Some otoliths appeared to show signs of deterioration. She questioned whether glycerin thymol is a proper medium for long-term otolith storage. Currently, a number of ageing labs use glycerin thymol including the Alaska Fisheries Science Center.

Two agencies, the International Pacific Halibut Commission (IPHC) and the Alaska Fisheries Science Center (AFSC) volunteered to do a cursory review of samples from their archived otolith collections. The IPHC has an extensive archive of halibut otoliths stored in glycerin thymol. AFSC stores flatfish otoliths in glycerin thymol and all other species in ethanol until 2009–2010 when all otoliths thereafter were stored exclusively in glycerin thymol.

AFSC otoliths are archived at the Burke Museum storage facility located within the Fisheries Building complex at the University of Washington. Collection years range from the 1980s to present and include specimens collected from scientific field surveys and from fishery observers. Otoliths are stored in glass or plastic vials in collection boxes holding up to 140 otoliths and organized in cells of 10 columns and 14 rows. For this preliminary review, only survey collected otoliths were examined.

[3] Reports by A. Delsa Anderl, AFSC, and B. Joan Forsberg, IPHC

Two flatfish species were chosen to review: arrowtooth flounder (N = 231), yellowfin sole (N = 221) and two roundfish species: sablefish (N = 276) and walleye pollock (N = 246). Collection years chosen spanned from 1984 to 2011. See **Tables 1 – 4** for the breakdown of collection years per species.

At the Burke Museum storage facility, otolith boxes are stacked on metal shelves according to collection year followed by species. Boxes for examination were chosen from the top- most box down from a collection year of the chosen species. Otoliths to be ranked for degree of deterioration were chosen from each box starting with the first cell in the first column followed by every other cell down the same column. Typically, 7 otoliths were examined from each box until a total between 200 – 250 otoliths per species were ranked.

## Criteria used to rank the amount of observed otolith deterioration were as follows:

1 = Otolith appeared pristine with no apparent deterioration and surface pattern was clear.

2 = Otolith appeared slightly dull but the surface pattern is apparent (**Figure 1**). This is considered good condition and will not affect cross-section ageing.

3 = Strong appearance of a cloudy/chalky surface so that any pattern (if a surface pattern was ever discrete) is obscured by the cloudy appearance (**Figure 2**). This may be early signs of deterioration.

4 = Surface layers are easily scraped/rubbed off the otolith (**Figure 3**).

The findings of this preliminary review are summarized in the following tables:

| ARROWTOOTH FLOUNDER | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | Ranks | | | | n | Rank 3-4 |
| Years | 1 | 2 | 3 | 4 | | |
| 1984 | | 30 | 5 | | 35 | 14.3% |
| 1987 | 10 | 16 | 8 | 3 | 37 | 29.7% |
| 1993 | | 23 | 14 | 3 | 40 | 42.5% |
| 1999 | | 16 | 5 | | 21 | 23.8% |
| 2005 | 3 | 39 | | | 42 | 0.0% |
| 2009 | 4 | 38 | | | 42 | 0.0% |
| 2010 | | 14 | | | 14 | 0.0% |
| Rank totals | 17 | 176 | 32 | 6 | 231 | 16.5% |

**Table 1.** Results of the total number of arrowtooth flounder otolith deterioration ranked according to collection year. Blank cells represent no specimens found for that rank.

| YELLOWFIN SOLE | | | | | | |
|---|---|---|---|---|---|---|
| | Ranks | | | | n | Rank 3-4 |
| Years | 1 | 2 | 3 | 4 | | |
| 1987 | 4 | 21 | 17 | | 42 | 40.5% |
| 1993 | | 14 | 17 | | 31 | 54.8% |
| 1999 | 3 | 22 | 16 | | 41 | 39.0% |
| 2005 | 4 | 31 | 7 | | 42 | 16.7% |
| 2009 | | 32 | 10 | | 42 | 23.8% |
| 2010 | 9 | 11 | 3 | | 23 | 13.0% |
| Rank totals | 20 | 131 | 70 | 0 | 221 | 31.7% |

**Table 2.** Results of the total number of yellowfin sole otolith deterioration ranked according to collection year. Blank cells represent no specimens found for that rank.

| SABLEFISH | | | | | | |
|---|---|---|---|---|---|---|
| | Ranks | | | | n | Rank 3-4 |
| Years | 1 | 2 | 3 | 4 | | |
| 1985 | 36 | 9 | 9 | | 54 | 16.7% |
| 1987 | 6 | 35 | 1 | | 42 | 2.4% |
| 1993 | 18 | 24 | | | 42 | 0.0% |
| 1999 | 20 | 20 | 1 | | 41 | 2.4% |
| 2005 | 13 | 29 | | | 42 | 0.0% |
| 2009 | 20 | 16 | 7 | | 43 | 16.3% |
| 2011 | 7 | 2 | 3 | | 12 | 25.0% |
| Rank totals | 120 | 135 | 21 | 0 | 276 | 7.6% |

**Table 3.** Results of the total number of sablefish otolith deterioration ranked according to collection year. Blank cells represent no specimens found for that rank. Samples collected before 2009 were stored in ethanol.

| WALLEYE POLLOCK | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | Ranks | | | | n | Rank 3-4 |
| Years | 1 | 2 | 3 | 4 | | |
| 1987 | 3 | 32 | | | 35 | 0.0% |
| 1993 | | 42 | | | 42 | 0.0% |
| 1999 | | 41 | 1 | | 42 | 2.4% |
| 2005 | | 42 | | | 42 | 0.0% |
| 2009 | 2 | 41 | | | 43 | 0.0% |
| 2011 | 5 | 37 | | | 42 | 0.0% |
| Rank totals | 10 | 235 | 1 | 0 | 246 | 0.4% |

**Table 4.** Results of the total number of walleye pollock otolith deterioration ranked according to collection year. Blank cells represent no specimens found for that rank. Samples collected before 2009 were stored in ethanol.

**Figure 1.** Example of an otolith condition assigned a rank 2.

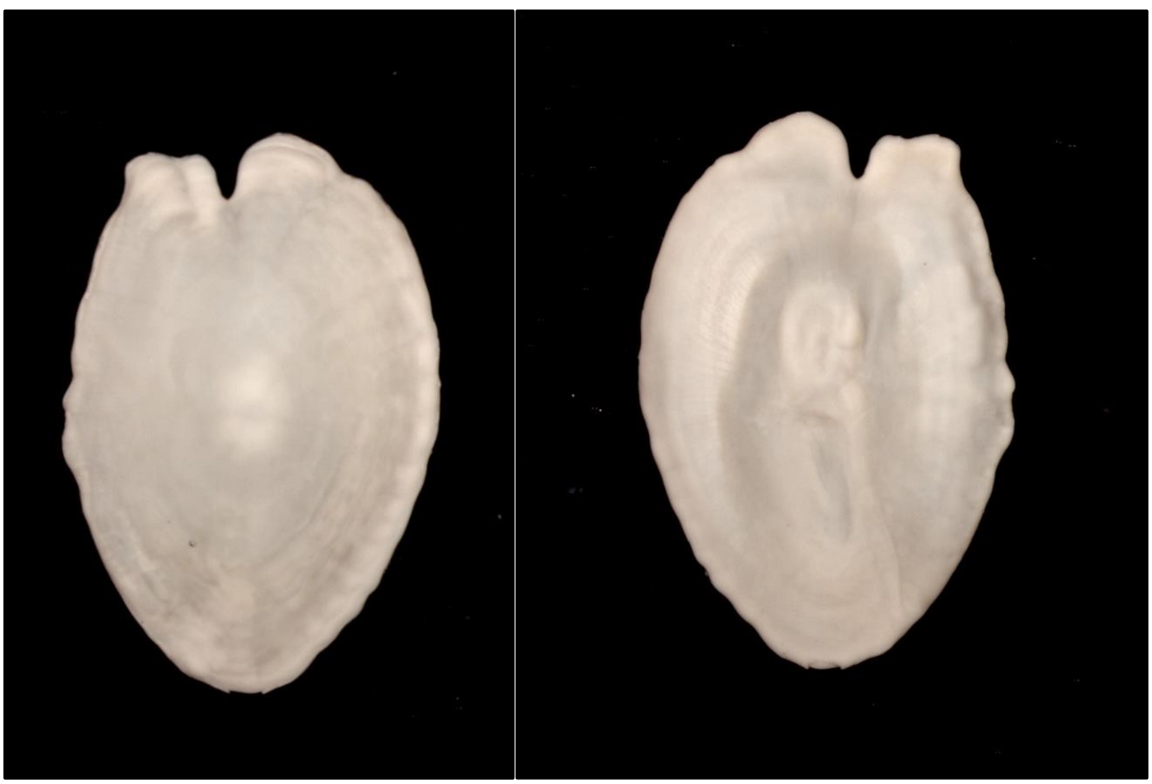

**Figure 2.** Example of an otolith condition assigned a rank 3.

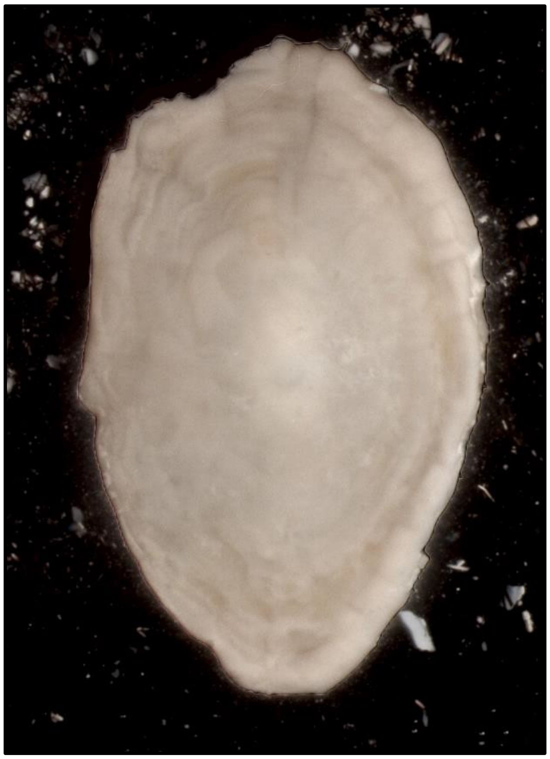

**Figure 3.** Example of an otolith condition assigned a rank 4.

## II. Longterm storage of otoliths in Glycerin Solution at the IPHC

Joan Forsberg, International Pacific Halibut Commission (IPHC)

## Background

Pacific halibut otoliths have been cleared in glycerin solution (50% glycerin/50% water) to increase readability of the growth patterns since the 1920s. Otoliths are also stored in glycerin solution after reading. Prior to 2002, otoliths were kept in open trays with individual cells while they were being aged. After otoliths were aged, they were stored in vials that held around N = 25 otoliths, stacked one on top of the other, with numbered paper labels between to separate and identify individual otoliths. The vials were then filled with glycerin solution to completely cover the otoliths. After the transition to the break-and-bake method for all otoliths, stacking in vials was no longer a suitable storage method because the otolith halves could become separated. Baked and aged otoliths are now stored in plastic trays that have individual cells to keep otoliths separate and lids that fit over the trays. The cells of the plastic trays are filled with enough glycerin solution to cover the otoliths. Vials from the historical collection were topped up with glycerin solution periodically; most recently in the early 1980s and again in 2010. Until the late 1980s, glass vials with cork stoppers were used for otolith storage. The corks did not provide an airtight seal so water evaporated from the glycerin solution over time. Thymol (an antifungal agent) has been added to the glycerin solution used for clearing and storing otoliths at IPHC for many years, but it is not clear when it began to be added routinely. The oldest samples in the IPHC's archives (collected in 1925) have been in glycerin solution for almost 90 years.

## Observations of otolith condition

In 2014, IPHC agers re-aged over N = 8,000 otoliths collected between 1926 and 1985:

| Year(s) | Regulation Area(s) | Number aged |
|---|---|---|
| 1926 | 2B | 567 |
| 1929 - 1930 | 3B/4A | 943 |
| 1936 | 2B | 471 |
| 1947 | 2B | 562 |
| 1951 | 2B/3A | 1,320 |
| 1964 - 1965 | 2B/3A/4A | 1,595 |
| 1976 - 1977 | 2B/3A/4A | 1,551 |
| 1985 | 2B/3A | 1,061 |

Most of the otoliths examined were in good condition. Some of the otoliths from the 1920s and 1930s (≤5%) had a chalky coating that obscured surface growth patterns. However, most of the otoliths with chalky coatings were still readable when broken and baked. The chalky coating could be partially dissolved otolith material, mold growth, or a combination of both. In one vial from the 1926 *F/V Scandia*, the otoliths appeared to have decalcified and consolidated into small, round lumps. There was also mold growth in the vial (**Figure 4**).

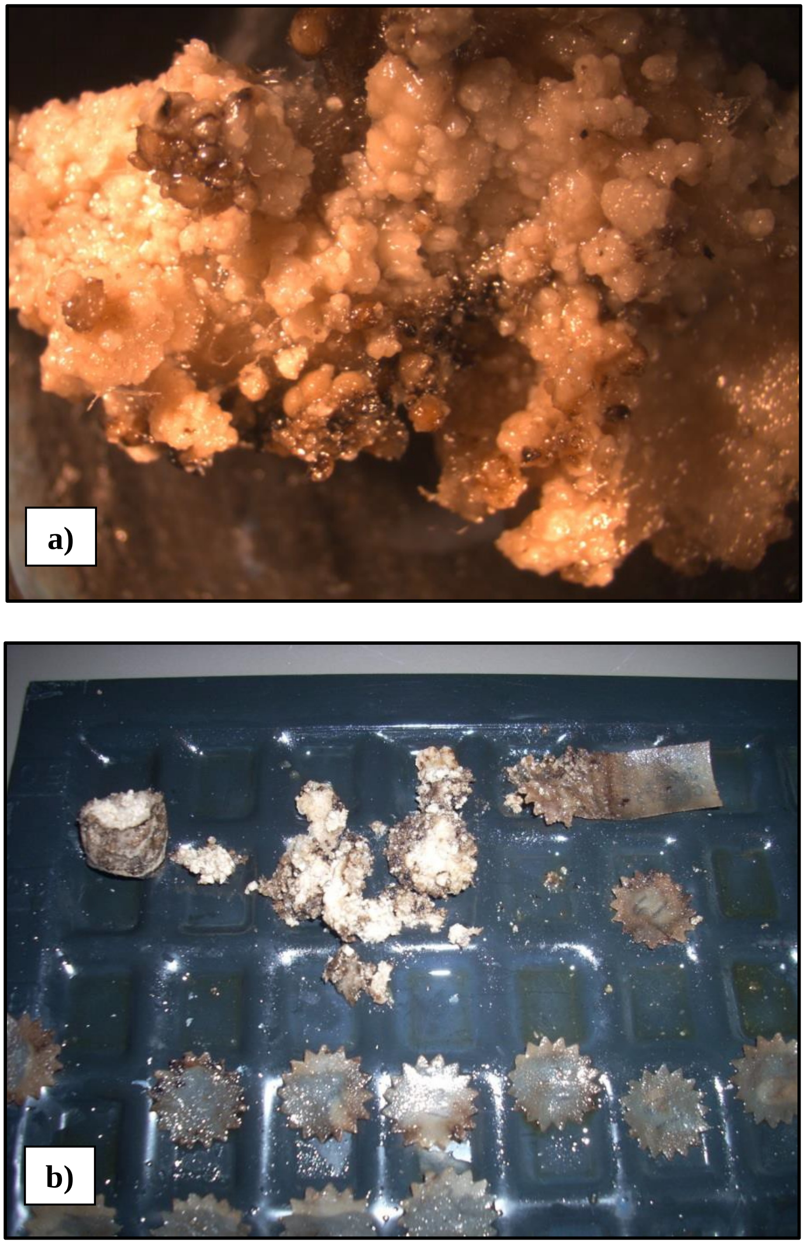


**Figure 4.** a) 'Blobs' from dissolved otoliths in vial with heavy mold. b) The paper labels between the dissolved otoliths had also dissolved.

Some of the otoliths stored in glass vials with cork stoppers had significant surface staining from the tannins in the cork, but were still very legible both in surface and baked section views (**Figure 5**).

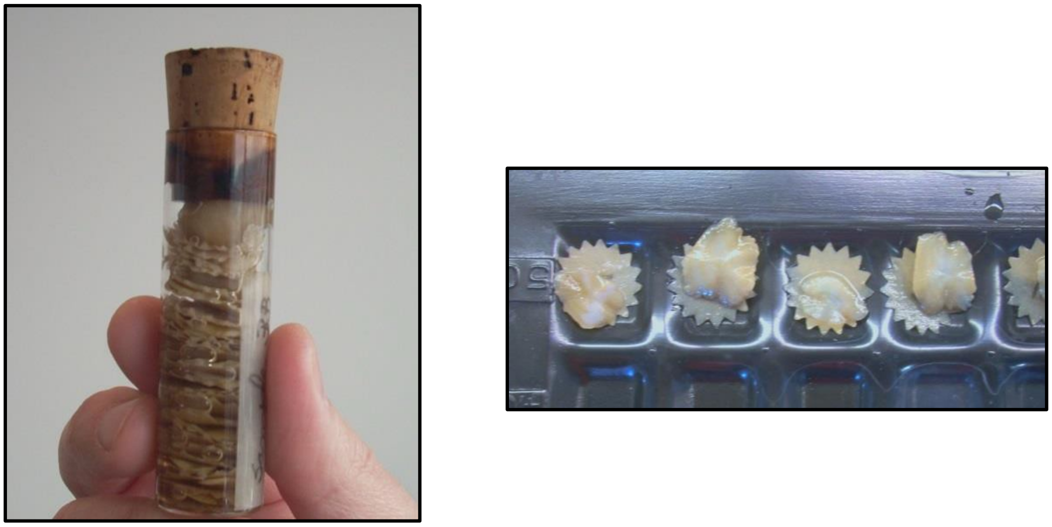

**Figure 5.** Otoliths with surface staining from cork stopper.

Below are some images of otoliths stored in glycerin for 89, 79, and 68 years (**Figures 6 – 8**, respectively). Surfaces and baked sections are clear and show no signs of deterioration.

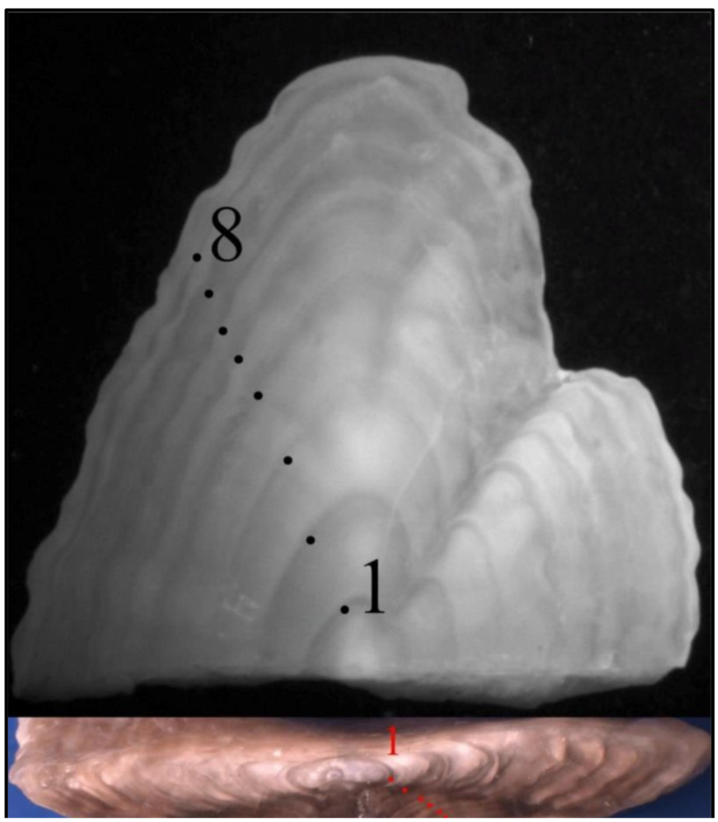


**Figure 6.** Unbaked and baked halves of an 8-year-old otolith from 1926.

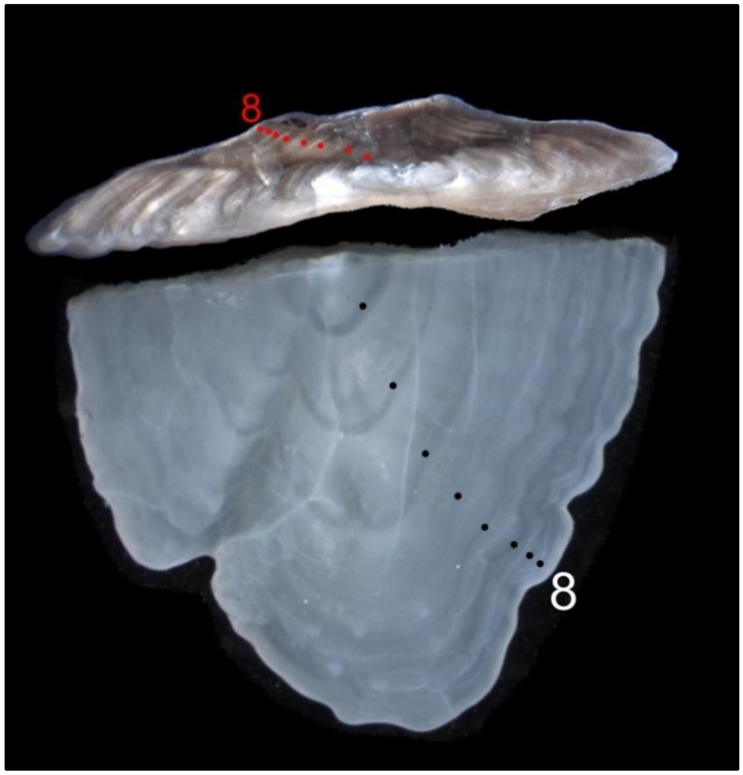


**Figure 7.** Unbaked and baked halves of an 8-year-old otolith from 1936.

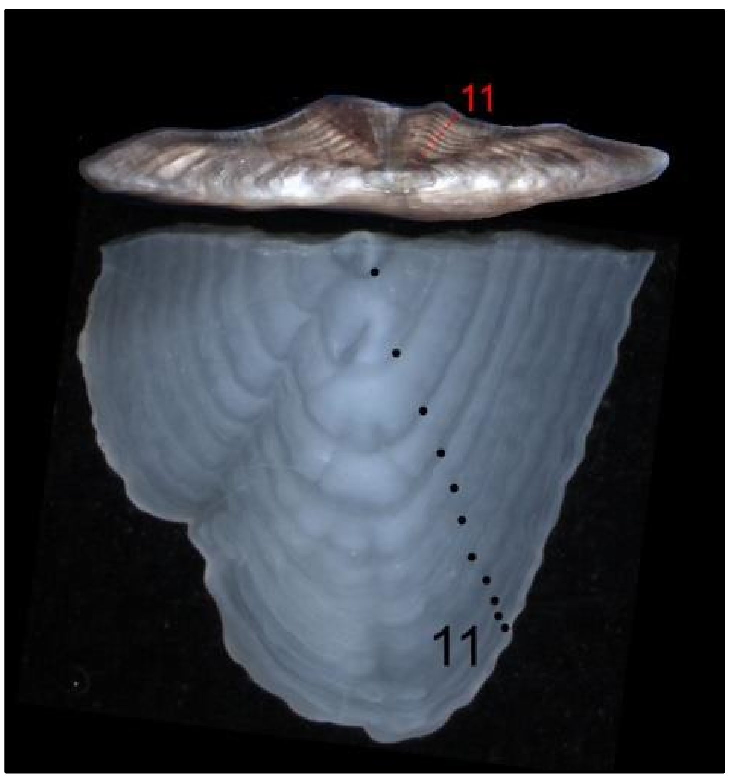


**Figure 8.** Unbaked and baked halves of an 11-year-old otolith from 1947.

Otoliths from juvenile halibut that had been stored in glycerin solution for up to 40 years and were retrieved for a study in the early 2000s were found to be decalcified; however, the condition of otoliths from larger halibut stored in glycerin for similar periods of time did not appear to be degraded. The IPHC's small fish otolith collection was consequently transitioned from storage in glycerin solution to dry storage.

Clearing in glycerin solution is necessary for surface ageing and since readers still rely on the surface to assist with interpretation of baked patterns, storage in glycerin solution is necessary at least until otoliths have been aged. Baked sections of cleared otoliths also have better contrast between growth zones than baked sections made from dry otoliths.

## Fading of burn patterns

In 2013, IPHC readers also re-aged over N = 3,000 otoliths collected in 1998, most of which had previously only been surface-aged. Readers looked at some of the otoliths that had been broken and burned in 1998 and found that quite a few of the burnt sections had faded. We looked at otoliths collected more recently (2001 and 2007) and found that the otoliths broken and burned or baked in those years had not faded and still had good contrast.

## Conclusion

The otoliths we examined were from setline surveys, which tend to catch halibut >40 cm. Most of the otoliths observed were from age classes ≥4 years and these appear to hold up well after long term storage in glycerin solution (with thymol). We observed otoliths from N = 24 halibut between 2 and 3 years of age among the re-aged samples and they were still legible and not deteriorating.

**Appendix III: Glycerin-Thymol Recipe**

## Below are the materials and instructions to make glycerin-thymol solution (courtesy of Joan Forsberg, IPHC):

## Materials needed:

1/2 gallon glycerin
1/2 gallon water
5.5 grams thymol (crushed)
20 ml ethanol

**Instructions:**

1. Crush thymol into coarse powder.
2. Dissolve thymol in ethanol by stirring/agitating mixture.
3. When dissolved, add thymol/alcohol solution to glycerin.[4]
4. Shake vigorously to mix.
5. Add water to the glycerin mixture and shake to mix.

[4] Do not add the thymol solution to the water first or the thymol will precipitate out of solution.

**Appendix IV: 2015 CARE Oral and Poster Presentation Abstracts**

# 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

## 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. Dr. 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*

## Oral Presentation Abstracts

### Direct determination of age in shrimps, crabs, and lobsters

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[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.

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**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 (LA-ICP-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.

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Estimation of Ageing Bias Using Bomb Radiocarbon $\Delta^{14}C$ Signatures in Fish Otoliths: Beyond Plot and Cluck

Thomas E. Helser and Craig Kastelle

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## 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.

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### 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]

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[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 N = 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.

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### 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]

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## 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.

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### 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, 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 N = 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.

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**Using otolith measurements to refine quality control procedures**

Kristin Politano, Kevin McNeel, April Rebert

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## 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 $L\infty$ 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 ± 2 SD 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]

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## 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.

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## 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]

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## 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 ΔDIC 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.

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### Age validation of Pacific cod (*Gadus macorcephalus*) using high resolution stable oxygen isotope ($\delta^{18}O$) signatures inotoliths

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].

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[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 $^{18}O$ ($\delta^{18}O$). This approach is based upon the principle that variability in marine carbonate $\delta^{18}O$ is inversely related to water temperature, and thus seasonal changes in temperature would be reflected in otolith $\delta^{18}O$ values. We sequentially microsampled

Pacific cod otoliths, from the core to the margin, to measure $^{18}O$ ($\delta^{18}O$). This provided up to ten $\delta^{18}O$ measurements per posited annual growth zone, and approached 45 sequential samples per specimen. We developed individual life history signatures of $\delta^{18}O$ from N = 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 $\delta^{18}O$ values) and determine if the number of $\delta^{18}O$ 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 $\delta^{18}O$ maxima and minima as an indication of "true fish age." The relationship between $\delta^{18}O$ in Pacific cod otoliths and known water temperature was also independently verified ($r^2 = 0.74$). 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.

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**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]

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[4]South Carolina Department of Natural Resources, Marine Resources Research Institute, Charleston, SC
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[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 radiocarbon 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 radiocarbon dating.

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## 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 ($^{14}C$) 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 $\Delta^{14}C$ associated with a year of growth band formation based on skate age estimates. We used Bayesian statistics to compare these values to reference $\Delta^{14}C$ a marine teleost otolith chronology produced that exists for California.

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### 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 N = 84 dry stored *G. macrocephalus* 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 and 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.

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**Re-ageing of archived otoliths from the 1920s to the 1990s**

Joan E. Forsberg (presenter) and Ian J. Stewart

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## 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.

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Pre**paring baked thick sections of Pacific halibut otoliths**

Chris Johnston

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## 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: Laboratory Ergonomics Checklist

## 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

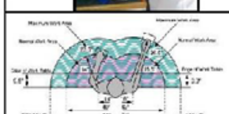
Step One: If you work with a safety specialist or safety committee, see if the following information if available for your laboratory: (1) list of musculoskeletal injuries; and (2) worker complaints or concerns about performing specific tasks.

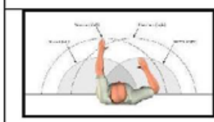
Step Two: Contact the workers and supervisor and discuss the purpose for performing the ergonomic survey. Ask the supervisors and workers if there are any issues or concerns that they have regarding laboratory work tasks.

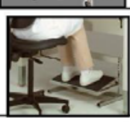
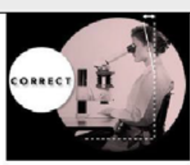
Step Three: Complete the Laboratory Checklist for the tasks being completed in the laboratory. Answer N/A if the question does not apply to the task.
Include all meaningful comments for each area.

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.

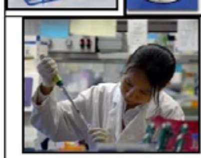
## Laboratory Ergonomics Checklist

| | | Yes | No | Change/Modification | Comments |
|---|---|---|---|---|---|
| | **Standing Bench** | | | | |
|  | 1. Is the height of the bench appropriate for the work performed?<br>a. Work can be positioned close to elbow height (~ 36-40")<br>b. Work can be performed with shoulders relaxed | ☐ | ☐ | ☐ Adjustable height benches<br>☐ Adjustable chair<br>☐ Temporary standing platforms<br>☐ 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<br>☐ 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?<br>a. 4" deep knee clearance<br>b. 4" high and 4"deep foot clearance | ☐ | ☐ | ☐ Work at open bench cut outs<br>☐ Remove supplies and equipment from bench cut out areas<br>☐ 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<br>☐ Use footrest<br>☐ 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<br>☐ 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<br>☐ Use gel pads on surface to protect elbows<br>☐ 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?<br>a. Minimum 15" depth<br>b. Minimum 20" width | ☐ | ☐ | ☐ Redesign benches to provide cut-outs for seated work<br>☐ Provide sit-stand chairs to improve knee clearance when working<br>☐ Clear out cutouts if cluttered with supplies or equipment | |
|  | 9. Are work items within close reach?<br>a. Maximum 24" | ☐ | ☐ | ☐ Reposition tools and supplies within 24" distance<br>☐ 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<br>☐ Provide sit-stand stools<br>☐ 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?<br>a. Seat height appropriate for work at height of benches?<br>b. Feet supported on floor, ring or footrest? | ☐ | ☐ | ☐ Provide chairs with adjustable height and angle seats and backrests<br>☐ Provide chairs with foot rings<br>☐ Provide footrests | |
|  | 12. Are armrests adjustable or removable if they interfere with work? | ☐ | ☐ | ☐ Adjust armrests to provide support with shoulders in neutral postures<br>☐ Remove armrests | |
|  | 13. Are appropriate footrests or footrings provided? | ☐ | ☐ | ☐ Provide industrial footrest<br>☐ Install foot ring on chair<br>☐ 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<br>☐ Adjust height<br>☐ Adjust angle<br>☐ Reposition worker<br>☐ Adjust posture<br>☐ Adjust seat height<br>☐ Adjust seat angle<br>☐ 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<br>☐ Move closer to front of counter<br>☐ Reposition worker<br>☐ Adjust posture<br>☐ Sit closer to bench | |
|  | 17. Can the microscope be positioned to promote neutral head, neck, shoulders and arm postures when used? | ☐ | ☐ | ☐ Reposition microscope<br>☐ Use microscope adapters<br>☐ Positioning plate<br>☐ Ergo adapter<br>☐ Scopease<br>☐ Optical wedge<br>☐ Extended eyetube<br>☐ Eyepiece adapter<br>☐ Use video system | |
|  | 18. Are arms supported by worksurface, chair armrests, or pads for prolonged work? | ☐ | ☐ | ☐ Use arm supports<br>☐ Use pads<br>☐ Adjust armrests<br>☐ Adjust worker position | |
|  | 19. Can the worker use the microscope controls with arms supported and relaxed? | ☐ | ☐ | ☐ Reposition microscope<br>☐ Use microscope adapters<br>☐ Use arm supports/pads<br>☐ Adjust armrests<br>☐ Adjust worker position | |
|  | 20. Is there sufficient legroom and foot support when using the microscope? | ☐ | ☐ | ☐ Work at bench cut-out<br>☐ Clear cut-out of clutter<br>☐ Provide footrest<br>☐ Provide foot ring | |
| | 21. Are microscope work breaks provided? | ☐ | ☐ | ☐ Institute work rotation<br>☐ 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<br>☐ Institute work breaks<br>☐ 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<br>☐ Electronic<br>☐ Latch-mode<br>☐ 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<br>☐ Position supplies within close reach<br>☐ Use pipette racks and organizers | |
|  | 26. Are vials, tubes and receptacles as low profile as possible? | ☐ | ☐ | ☐ Provide short beakers and vials<br>☐ Provide short tips and tubes<br>☐ provide short/angled waste receptacles | |

# Appendix VI: Crustacean Age Determination Workshop Final Report

Crustacean Age Determination Workshop

April 14-17, 2015 – Seattle, Washington

With support from: BSFRF Bering Sea Fisheries Research Foundation

## Workshop Report

The Crustacean Age Determination Workshop sponsored by the Committee of Age Reading Experts (CARE) with support from the Bering Sea Fisheries Research Foundation was held at the Alaska Fisheries Science Center in Seattle, Washington April 2015 in association with the biennial CARE meeting. Twenty-one biologists and sclerochronologists from the Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Department of Fisheries and Oceans Canada, Alaska Department of Fish and Game, and NOAA National Marine Fisheries Service participated in the workshop facilitated by Dr. Raouf Kilada of the University of New Brunswick. The objective of the workshop was to train participants to process calcified structures and identify growth bands for age determination in shrimp, crab, and lobster.

The workshop consisted of three phases: 1) dissecting and preparing structures, 2) removing thin-sections, and 3) band detecting and interpretation. This method was applied to three species – spot shrimp, snow crab, and, for the first time, Dungeness crab. Structures included spot shrimp eyestalks, snow crab zygocardiac ossicles, and Dungeness crab eyestalks and zygocardiac ossicles. Growth bands were visible in thin-sections of all structures (see images on the following page).

The workshop organizers would like to thank the following individuals and organizations who made the workshop possible:

*Structure Preparation*

*Embedding and Thin Sectioning*

*Imaging and Interpretation*

- **Dr. Raouf Kilada**, for sharing his expertise and conducting a successful workshop
- **The Bering Sea Fisheries Research Foundation**, for supporting Dr. Kilada's participation in the workshop.
- **The NOAA Alaska Fisheries Science Center – Age and Growth Laboratory**, particularly **Craig Kastelle and Chris Gburski**, for hosting the workshop.
- **The Committee of Age Reading Experts**, chaired by **Elisa Russ**, for their time and assistance in organizing the workshop.
- **The Technical Subcommittee of the Canada-USA Groundfish Committee,** for supporting integration of the workshop with the biennial CARE meeting.