Annual Progress Report
to
National Oceanic & Atmospheric Administration

NOAA Award# NA17RJ1362

Reporting period: 10/1/11 – 9/30/12

Ocean Environment Research
West Coast Fisheries Research

Oregon State University
Cooperative Institute for Marine Resources Studies
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Director’s Statement

The OSU/NOAA Cooperative Institute for Marine Resources Studies (CIMRS) represents a strong, long-term, NOAA-university partnership dedicated to research in marine science, graduate and public education, and cooperation with regional industries and communities that are dependent on marine resources. The Institute thrives because of the commitment of leaders from within the laboratories of its NOAA associates and the OSU Research Office. As a result, during the past few years, external research grant funding has grown, graduate student opportunities have diversified, and CIMRS has entailed many more OSU investigators from a broad range of disciplines to work together and address research problems of environmental, economic and social importance.

The research focus of CIMRS addresses living and non-living marine resources and is thus linked to programs that require environmental sampling or observing within the ocean and programs that characterize seafloor habitats. This focus encompasses the broad field of marine fisheries (including fisheries oceanography, habitat research, and ecosystem-based management), geological/chemical oceanography, marine mammal acoustics, and the effects of climate change on marine ecosystems. It thus addresses ecosystem and climate mission goals in NOAA’s 5-year research plan and poises CIMRS research to contribute to NOAA’s 20-year research vision.

In FY12, after thirty years of developing and offering opportunities for joint research and outreach to a growing community of University and NOAA scientists, the Institute was afforded authentic status through their success in an open competition for a Cooperative Institute to support NOAA’s Northwest research facilities in the area of marine resources. CIMRS was selected to begin a five-year award for research under four primary themes: Marine Ecosystems and Habitat; Protection and Restoration of Marine Resources; Seafloor Processes; and Marine Bioacoustics. Research growth and success will provide impetus for renewal for an additional 5-year term.

In the Spring of FY 12, it became clear that not all projects under this award would be completed by September 30, 2012. A one-year no-cost extension was applied for and approved with monthly spending updates provided to the Program Officer.
CIMRS Organization

CIMRS is administered through the OSU Research Office with oversight from an Executive Board made up of members from the participating NOAA laboratories and collaborating OSU colleges and programs under the terms of a Memorandum of Agreement between OSU and NOAA. The role and responsibilities of the Executive Board are to: 1) make recommendations to the President of the University for the Directorship of CIMRS; 2) review and approve the general policies, research themes, and priorities of CIMRS; and 3) conduct an annual evaluation of CIMRS programs and activities, including the budget, with appropriate recommendations.

A Science Advisory Council (SAC) gives input on research directions, progress, and policy to the Director. The Science Advisory Council’s responsibilities are to offer advice on the general research and educational goals of CIMRS that promote cooperation between university and federal agency researchers to make the most of collaborative opportunities at Hatfield Marine Science Center, in the Pacific Northwest, and globally. CIMRS relies on the Council for guidance on emerging OSU research initiatives and NOAA mission goals for which CIMRS is well placed to merge synergy.
### 2011/2012 Executive Board

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
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<tbody>
<tr>
<td>Rick Spinrad (Chair)</td>
<td>Vice-President for Research, Oregon State University</td>
</tr>
<tr>
<td>George Boehlert</td>
<td>Director, Hatfield Marine Science Center, OSU</td>
</tr>
<tr>
<td>Mark Abbott</td>
<td>Dean, College of Earth, Ocean, &amp; Atmospheric Sciences, OSU</td>
</tr>
<tr>
<td>Stella Coakley/ Larry Curtis</td>
<td>Associate Dean, College of Agricultural Sciences, OSU</td>
</tr>
<tr>
<td>John Bengtson</td>
<td>Director, National Marine Mammal Laboratory, AFSC, NOAA</td>
</tr>
<tr>
<td>Patricia Livingston</td>
<td>Director, REFM, Alaska Fisheries Science Center, NOAA</td>
</tr>
<tr>
<td>Stephen Brandt</td>
<td>Director, Oregon Sea Grant, OSU</td>
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<tr>
<td>Chris Sabine</td>
<td>Director, Pacific Marine Environmental Laboratory, NOAA</td>
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<tr>
<td>Sherman Bloomer</td>
<td>Dean, College of Sciences, OSU</td>
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<tr>
<td>John Stein</td>
<td>Science Director, Northwest Fisheries Science Center, NOAA</td>
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<tr>
<td>Michael Banks</td>
<td>(Ex Officio) Director, CIMRS, OSU</td>
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### 2011/2012 Science Advisory Council

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<tr>
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<tr>
<td>David Noakes (Chair)</td>
<td>Professor, Dept. of Fisheries and Wildlife, OSU</td>
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<tr>
<td>William Pearcy</td>
<td>Professor Emeritus, College of Earth, Ocean, &amp; Atmospheric Sciences, OSU</td>
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<tr>
<td>Jerri Bartholomew</td>
<td>Assoc. Professor, Dept. of Microbiology, OSU</td>
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<tr>
<td>Clare Reimers</td>
<td>Professor, College of Earth, Ocean, &amp; Atmospheric Sciences, OSU</td>
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<tr>
<td>Michael Blouin</td>
<td>Professor, Dept. of Zoology, OSU</td>
</tr>
<tr>
<td>Clifford Ryer</td>
<td>Fisheries Biologist, FBE, RACE Division, AFSC, NOAA</td>
</tr>
<tr>
<td>William Chadwick</td>
<td>Professor, CIMRS, OSU</td>
</tr>
<tr>
<td>Paul Wade</td>
<td>Research Biologist, National Marine Mammal Laboratory, AFSC, NOAA</td>
</tr>
<tr>
<td>Kurt Fresh</td>
<td>Estuarine and Ocean Ecology Program Manager, FE Division, NWFSC, NOAA</td>
</tr>
<tr>
<td>Laurie Weitkamp</td>
<td>Research Fisheries Biologist, Con Bio Division, NWFSC, NOAA</td>
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<tr>
<td>Michelle McClure</td>
<td>Director, FRAM Division, NWFSC, NOAA</td>
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<tr>
<td>Dawn Wright</td>
<td>Professor, Dept. of Geosciences, OSU</td>
</tr>
<tr>
<td>Michael Banks</td>
<td>(Ex Officio) Director, CIMRS, OSU</td>
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Research Personnel

The following table describes CIMRS research personnel on NA17RJ1362.

<table>
<thead>
<tr>
<th>Position Category</th>
<th>#Staff</th>
<th>B.S.</th>
<th>M.S.</th>
<th>Ph.D.</th>
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<tr>
<td>Research Scientist</td>
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<tr>
<td>Postdoctoral Fellow</td>
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<td>--</td>
<td>--</td>
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<tr>
<td>Research Assistants</td>
<td>17</td>
<td>8</td>
<td>9</td>
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CIMRS researchers spent over 204 days at sea in FY 12 with an average of 15 days/researcher.

Administrative Support Staff

<table>
<thead>
<tr>
<th>Position</th>
<th>FTE</th>
<th>Supported by Award</th>
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<tr>
<td>Director</td>
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<td>Partial</td>
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<tr>
<td>Administrator</td>
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</tr>
<tr>
<td>Travel Specialist</td>
<td>0.5 FTE</td>
<td>No</td>
</tr>
<tr>
<td>Purchasing Specialist</td>
<td>0.5 FTE</td>
<td>No</td>
</tr>
<tr>
<td>Office Specialist</td>
<td>0.5 FTE</td>
<td>No</td>
</tr>
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</table>
CIMRS Outreach Activities

Educational and scientific outreach is important in all aspects of CIMRS research. Websites are a venue that reach an enormous audience. CIMRS investigators feature their collaborative research efforts in the fields of fisheries oceanography, geophysical and acoustic monitoring of spreading centers, ocean exploration, and bioacoustic monitoring of marine mammals at several sites hosted by NOAA and CIMRS. In FY12, the CIMRS website was re-designed to be more user-friendly and is now hosted from a new and shorter URL, http://oregonstate.edu/cimrs/.

Owing to the collaborative nature of CIMRS, a large component of outreach provided by CIMRS investigators is on the award winning website, http://www.pmel.noaa.gov/vents, which continues to feature educational curricula, video clips of in situ seafloor experiments, and animated 3-dimensional fly-through videos of seafloor ridges. Our new CIMRS website provides links to relevant areas of the PMEL website. Also in FY12, CIMRS researchers collaborated with Adventures in Climate Change in creating an online gallery of Bering Sea planktonic organisms and potential effects of climate change on these organisms: http://www.adventures-in-climate-change.com/slideshows/ocean-drifters/ocean-drifters.htm.

The Visitor Center at OSU’s Hatfield Marine Science Center also lends a convenient outlet for educational displays and programs which may be viewed by 150,000 attendees annually. CIMRS investigators have collaborated with Oregon Sea Grant educational staff to design and prepare interactive exhibits, covering the entire range of CIMRS research. Among the permanent exhibits, “Rumbleometer” and “Ring of Fire” demonstrate submarine volcanism research on the seafloor. “Hydrothermal Vents” and “Burning Ridge” bring the seafloor to life with real volcanic rock specimens and a 3-D mid-ocean ridge model. “Dive and Explore” allows visitors to simulate piloting a remotely operated vehicle to the seafloor and back with a joystick while viewing computer-generated and real video clips of the seafloor. “Sensing the Sea” discusses remote sensing techniques and allows visitors to “experiment” with physical, biological, and anthropogenic sounds propagating through a saltwater tank, simulating sounds researchers monitor in the global oceans. “Patterns from Sound” further educates visitors on marine acoustics research. In addition to these permanent exhibits, a real hydrophone and an interactive earthquake/seismic kiosk are on display. The newest exhibit, “Ocean Conditions: Predicting Salmon Runs,” is an interactive display of the data collected by OSU and NOAA collaborators to predict future salmon runs in the Pacific Northwest. This exhibit is undergoing revisions based on evaluations of user data, as discussed under the section titled, “The Effects of Ocean Variability on Marine Survival of Salmonids.”

CIMRS researchers provide valuable volunteer hours at K-12 Science Fairs and related activities throughout the year. CIMRS also provides submissions to the NOAA OAR “Hot Items” publishing venue for rapid distribution of new and exciting research discoveries. For example: CIMRS and JISAO Researchers Forecast & Discover Eruption at Axial Volcano, http://www.nrc.noaa.gov/ci/hotitems/2011/cimrs-10.pdf
Projects under Grant NA17RJ1362

All projects within this award meet the following NOAA Strategic Plan goals:

(Goal 1) Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management.

(Goal 2) Understand climate variability and change to enhance society’s ability to plan and respond.

OAR Projects

Ocean Environment Research

This multidisciplinary project seeks to quantify the effects of submarine volcanic and hydrothermal activity on the ocean. Continuous acoustic monitoring of spreading centers in the world’s oceans allows investigators to detect and study the chemical, physical, geological and biological effects of tectonic activity on the global ocean and to follow free-ranging populations of large cetaceans. Specific focus areas are Seafloor Mapping and Geographical Information Systems, Seafloor Imaging, Navigation and Volcanology, T-Phase Event Detection, Hydrothermal Emissions, Marine Mammal Acoustic and Fisheries Oceanography.

Seafloor Mapping and Geographical Information Systems

OSU RESEARCH STAFF: Andra Bobbitt, Sr. Faculty Research Assistant; T-K Andy Lau, Applied Mathematician, Professional Faculty

NOAA COLLABORATOR: Stephen R. Hammond, PMEL

Sr. FRA Andra Bobbitt continues to manage the GIS system for the Vents program, which includes sea-going systems for research expeditions. The portable GIS data and software have enabled rapid comparison of time-series data in situ which was critical in last year’s discovery of a recent lava flow at Axial Volcano. Using the GIS mapping technology, scientists at sea were able to quickly determine the extent of the flow and alter expedition plans to further investigate the event. Bobbitt continues to attend the annual ESRI (GIS) International User Conference in San Diego, California to keep abreast of developments of the GIS system used for Vents Program data. The ESRI International User Conference is unique in that much of the conference consists of technical sessions which are essentially mini-courses for educational development of the GIS professionals. Much effort in this past year has been devoted to bringing past data into a more organized and consistent storage within the GIS structure. Future plans consistent with
GIS trends will be to make more data available to colleagues and the general public via interactive maps on the internet.

Applied Mathematician T-K Andy Lau decoded and organized the 2003-2011 acoustic data files provided by the International Monitoring System (IMS). Lau processed some IMS data for Dr. Matsumoto’s Ocean Noises study. Lau created a 2-minute by 2-minute bathymetry grid of the globe by using data from NOAA National Geophysical Data Center. This bathymetry database is used as a background map for plotting seismic event locations.

Lau further supported research by developing programming procedures to match seismic event positions with earthquake locations to determine the Fore-, Main-, and After-shock (FMA) events. The program created by Lau displays FMA events using the bathymetry grid.

Lau also supported T-phase operations. He worked with colleagues in the Navy and NOAA Marine Operations Center – Pacific to obtain a new instrument for decrypting SOSUS data and new equipment for storing and loading encryption keys. Lau updated the procedures for loading the keys and new records management. He revised a program for storing beamformed data displays in digital image files instead of hardcopy printouts. In addition, he monitored SOSUS data for seismic events, catalogued data, and located the origins of the seismic events. Lau has provided data results to researchers at Whidbey Naval Station.

PUBLICATIONS:

Seafloor Imaging, Navigation and Volcanology

OSU RESEARCH STAFF: William Chadwick, Professor, Sr. Research.; Susan Merle, Sr. Faculty Research Assistant

NOAA COLLABORATOR: Robert W. Embley, PMEL

Axial Seamount has been the site of a long-term interdisciplinary seafloor observatory in the NE Pacific for over a decade. Last year, these monitoring efforts paid off when it was observed that Axial Seamount erupted in April 2011. This year, researchers focused on publishing those results. Three companion papers on the Axial eruption appeared in the July 2012 issue of Nature Geoscience, along with a “News and Views” piece that explored the significance of the results. Dr. Chadwick was lead author on one of the papers and co-author on the other two. The papers described eruption precursors that were detected from seafloor pressure and seismic monitoring,
as well as high-resolution mapping of the new lava flows from an autonomous underwater vehicle. These results are timely because Axial Seamount will be a node site on the upcoming regional cabled observatory, part of the Ocean Observatories Initiative (OOI).

In the western Pacific, researchers are continuing to analyze data and publish results from expeditions to the Mariana arc in 2009 and 2010.

In March 2012, Sr. FRA Merle completed the requirements for a Graduate Certificate in Geographic Information Science from Oregon State University, Department of Geosciences. The certificate required coursework in geographic information systems and science, remote sensing of the environment, ethics, advanced applications of GIS, and an internship project.

MEETINGS:


PUBLICATIONS:


**T-Phase Event Detection**

OSU RESEARCH STAFF: *Robert Dziak*, Professor., Sr. Research; *Haru Matsumoto*, Assistant Professor, Sr. Research; *Matthew Fowler*, Faculty Research Assistant; *Joe Haxel*, Sr. Faculty Research Assistant

NOAA COLLABORATOR: *Stephen R. Hammond*, PMEL

CIMRS researchers focused on four main experiments this past year: 1) Review of all US Navy hydrophone data for T-phases of seismo-acoustic events originating from northeast Pacific Ocean spreading centers, 2) characterization and retrospective forecast the 2011 eruption of Axial Seamount; 3) analysis of Arctic and Antarctic hydrophone data for ice generated noise and to evaluate its environmental impact; and 4) deployment/recovery of hydrophones at West Mata volcano, Lau basin. The enormity of data and timing of revisions in these projects require continuation of progress during the no-cost extension.

In FY12, a major focus of the Vents Ocean Acoustics Project was the analysis of US Navy hydrophone recorded earthquakes detected throughout the Northeast Pacific Ocean which leads to the identification of volcanic and tectonic events off the Washington, California, and Oregon coasts. Unfortunately, since 2009 the Navy arrays along the Pacific Northwest coasts have been offline, severely limiting earthquake detection capability. To help augment this limitation, CIMRS researchers have supplemented the Navy array with deployments of ocean bottom hydrophones within the summit caldera of Axial Seamount, a large submarine volcano located on the Juan de Fuca Ridge. This research was rewarded during April 2011 with the recording of a large eruption of lava within the caldera. The ocean bottom hydrophone recorded seismic precursors to the eruption allowing us to develop models for short-term forecasting of future eruptions. The results of this work were published in the July 2012 issue of *Nature Geosciences*. CIMRS investigators will continue to deploy this array at Axial Seamount to provide insights into volcanic processes prior to installation of the cabled observatory in 2015.

Two hydrophone arrays have been deployed in the Arctic (Vents; 2009-present) and Antarctic (Ocean Exploration [OE] & Vents Programs; 2005-2010) with the goal of recording ice and anthropogenic sources of ambient noise and seismo-volcanic activity as well as evaluating presence/absence of cetacean species. The Arctic study resulted in a publication in FY12 on the
seasonal occurrence and sound levels of ice noise, airgun noise (due to oil exploration), and cetacean species (blue and fin whales) in the European Arctic off Greenland. CIMRS’s Antarctic ocean acoustic datasets are still being analyzed and are providing fascinating insights into the dynamics of sea ice in these regions. CIMRS investigators have found that the ambient noise field in the southern ocean between South America and Antarctica is dominated by the sound generated by the breakup of sea-ice and icebergs but that airgun noise (from research vessels) can also dominate for short periods of time. The noise from ice breakup, however, is loud enough to be detected on a CIMRS hydrophone at the equator, and therefore ice breakup is a very significant source of global ocean sound. Interestingly, CIMRS researchers were able to show that the sound of vocalizing whales in the Antarctic in the 15-28 Hz band (likely blue and fin whales) has been increasing over time, probably due to an increase in these animal populations following the ban on commercial hunting in 1972.

Acoustics researchers were also involved in deployment of two hydrophones at West Mata volcano in the Lau basin. The first was a long-term hydrophone mooring (Vents & OE) deployed near the southern flank of the volcano for all of FY12 to record the variation of explosion intensity of the volcano and measure the levels of sound introduced into the environment by this geological event. CIMRS researchers also have installed a debris sensor on the mooring to observe the size and frequency of landslide events occurring along the flanks of this submarine volcano and assess any possible tsunami hazard. The second hydrophone is a “deep-ocean” hydrophone specifically designed to work at full ocean depths (11,000 m), newly developed by CIMRS researchers. The deep-ocean hydrophone was deployed at West Mata for its first wet-test using a remotely operated vehicle (ROV) during the OE-sponsored September 2012 Submarine Ring of Fire cruise in the Lau basin to record underwater volcano sounds. The data collected from the deep-ocean hydrophone will be useful for studying the in situ signal characteristics of submarine magmatic explosions, a feat rarely achieved. The goal is to deploy it at the Challenger Deep location in the Mariana Trench for depth-dependent ambient noise measurements from 0 m to 11,000 m.
MEETINGS:


PUBLICATIONS:


Hydrothermal Emissions

OSU RESEARCH STAFF: Leigh Evans and Ron Greene, Faculty Research Assistants

NOAA COLLABORATOR: John E. Lupton, PMEL

During this reporting period, FRA Ron Greene participated in a seagoing expedition to the Chile Triple Junction on R/V Melville from April 20 – 30, 2012 and the Northern Lau Basin on R/V Southern Surveyor from May 12 – June 5, 2012. FRAs Greene and Evans participated in an expedition continuing a water-column time series using the Jason remotely-operated vehicle at the NeMO site on the Juan de Fuca Ridge from August 16 – 26, 2012. Greene completed his work on the NeMO expedition on August 22, 2012.

Greene and Evans processed and completed mass spectrometer measurements for helium isotopes on 10 vent fluid samples and ~300 water-column samples during this fiscal year. These included samples from Juan de Fuca Ridge collected in 1993 and 2011 and samples from the Tonga-Kermadec Arc and Northern Lau Basin collected in 2002, 2009, 2010 and 2011.
The lab's newly developed capabilities in analyzing three isotopes of neon at very low abundance added to what is known about rock samples collected in 2008 from the Lau Basin. Along with earlier helium isotope work, neon isotopes confirm that a mantle hotspot signature is present in both the Rochambeau Rifts and the Northwest Lau Spreading Center. This is further evidence for incursion into this region of material derived from the Samoan mantle plume.

PUBLICATIONS:


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**Marine Mammal Acoustics**

**OSU RESEARCH STAFF:** *David Mellinger*, Associate Professor, Sr. Research; *Sara Heimlich*, Faculty Research Assistant; *Sharon Nieukirk*, Sr. Faculty Research Assistant

**NOAA COLLABORATOR:** *Catherine Berchok*, AFSC

CIMRS researchers in collaboration with NOAA AFSC deployed a hydrophone in the Beaufort Sea in 2012. The instrument is intended to be recovered in 2013 and will provide information on seasonal variation of ambient noise levels in the deployment area. FRA Heimlich and Sr. FRA Nieukirk examined data in support of hydrophone deployments that NOAA is making in the Bering and Beaufort Seas. Subjects of interest were ocean noise, humpback whales, bowhead whales, right whales, and fin whales.
NMFS Projects

West Coast Fisheries Research

Oceanographic and habitat conditions significantly affect, and can even govern, the productivity of Northwest salmonids and groundfish. This research program focuses on causal relationships among ocean habitat, climate, human activities (including, in the case of groundfish, fishing patterns and regulations), and ecosystem structure on health, distributions, and marine survival of salmonids and groundfish, particularly in coastal regions of the US Pacific Northwest. Fishers have known for generations that specific habitat features favor high abundances of unique marine resources and that fish stocks respond clearly and sometimes suddenly to shifts or fluctuations in the climate or fishing patterns. Thus, it is critical that fisheries scientists and oceanographers determine which physical and biological processes influence fish population distributions, growth, and survival. This research will help to anticipate any shifts in Northwest salmonids and groundfish growth and survival in the cases of the ocean entering a different climate state, changes in fishing practices, or land-use changes in coastal watersheds. Specific focus areas are: The Effects of Ocean Variability on Marine Survival of Salmonids, Watershed and Estuarine Processes, Fisheries Habitat Investigations, and Stock Assessment Improvements.

The Effects of Ocean Variability on Marine Survival of Salmonids

OSU RESEARCH STAFF: Dr. Jay Peterson, Research Associate; Jennifer Fisher, Faculty Research Assistant; Dr. James Ruzicka, Research Associate; Shawn Rowe, Assistant Professor, Oregon Sea Grant; Toby Auth, Tristan Britt, Jennifer Menkel, A. Jason Phillips, Faculty Research Assistants; C. Tracy Shaw, Sr. Faculty Research Assistant; Angela Sremba, Graduate Research Assistant

NOAA COLLABORATORS: Ric Brodeur, Rick Brown, Bill Peterson, Tom Wainwright, NWFSC

Plume Habitat and Pelagic Fish Ecology

Since 1996, a bi-weekly sampling program has sampled the NH Line spanning the continental shelf off Newport, Oregon. During this reporting period, Research Associate Dr. Jay Peterson was chief scientist on 11 sampling trips and responsible for the acquisition of hydrographic and biological data on those trips. J. Peterson was also responsible for the processing and management of the hydrographic data from all sampling trips. FRA Jennifer Fisher participated as chief scientist on ~7 sampling trips. J. Peterson and Fisher continue to measure egg production rates of the copepod Calanus marshallae collected during sampling to test the hypothesis that cold ocean conditions are more productive than warm ocean conditions, using copepod egg production as an index of coastal productivity. Fisher further explored this
relationship by correlating egg production with basic-scale and local drivers of productivity. In addition, Fisher provided summary graphs of zooplankton biomass and community composition and primary productivity collected during sampling for the PaCOOS quarterly updates and the annual CalCOFI “State of the California Current” report.

Fisher maintained an MS Access database of zooplankton abundance and physical oceanographic data. She continued the retrospective analysis of the NH Line’s 17-year time series. Specifically, she investigated the seasonal and inter-annual patterns of zooplankton species composition and community differences between stations located 5, 25 and 65 miles from shore (ongoing). Initial analysis indicates that the zooplankton communities are different across the shelf. However, the communities appear to be responding synchronously to basin-scale physical forcing. This indicates that large-scale transport processes control zooplankton species composition along the Northern California Current and in the coastal upwelling zone of this region; whereas upwelling itself may control only local productivity.

Fisher explored the use of meroplankton as indicators of changing oceanographic conditions and indicators of the source waters to the region. Meroplankton appear to not respond to changing ocean conditions unlike the copepods that have proven to be good indicators of ocean productivity. However, the larvae of certain crustacean species (e.g., *Emerita analoga*) appear to be good indicators of northward ocean transport in this region. Fisher also explored the use of euphausiid eggs as indicators of ocean ecosystem health.

Fisher acted as chief scientist on the night shift of *R/V Oceanus*, July 17 – 23, 2012, conducting net tows and CTD casts from the Columbia River to Newport, OR.

J. Peterson served a primary role in deriving, updating and maintaining the information on the NWFSC “Ocean Conditions” website. The website provides information on an array of indicators relevant to the marine survival of juvenile salmon, updated every 6 months with a mid-year section on current ocean conditions as of June of each year. As a collaborative effort with NOAA scientists, Fisher ran principal components analysis on the indicator data and the resulting plots are now presented in the salmon forecast section of the website.

J. Peterson’s other activities in this reporting period included contributing data and text for quarterly PaCOOS reports on the California Current Large Marine Ecosystem and quarterly updates for the “Climate Impacts and Outlook” publication released by the Western Governors’ Association and NOAA; participating in instructional and outreach activities to disseminate the results of the aforementioned efforts to public stakeholder groups; and helping in the design and development of an interactive “Ocean Conditions: Predicting Salmon Runs” display at the Hatfield Marine Science Center Visitor Center that helps the general public learn about how CIMRS’s scientific efforts help the management of salmon stocks.
MEETINGS:


PUBLICATIONS:


2012: Ecosystems respond to local forcing as la nina wavers and wanes. *CalCOFI Report*, 53. (Accepted.)


**Trophic Ecology Study**

Research Associate Dr. Jim Ruzicka has been developing a suite of inter-annual and generic end-to-end ecosystem models of the Northern California Current ecosystem and a toolbox of analysis algorithms to derive ecosystem metrics from base-models and scenario manipulations. The main goals of this work have been: 1) to produce an accurate end-to-end model of the Northern California Current (NCC) upwelling system that includes accounting for basic upwelling physics and the propagation of model uncertainty in scenario analyses; 2) to use the model to characterize the state and process rates of the NCC system between years and relative to other US GLOBEC study regions (Georges Bank, central Gulf of Alaska, Antarctic Peninsula); and 3) to use the NCC model to investigate alternate trophic network restructuring and forcing scenarios (juvenile salmon example). The analysis algorithms include algorithms to conduct sensitivity analyses of functional group variability; quantify the propagation of parameter uncertainty; conduct alternate trophic network structure scenarios of steady-state models; and run dynamic models over time that are driven by upwelled nutrient time-series data. Model analysis work has been conducted to study the effects of jellyfish blooms, Pacific hake, and Pacific sardine on juvenile salmon production. These effects include both direct and indirect competition for resources which are best revealed by data-based model analysis.

Two papers are in preparation for submission covering results of this project that will be completed during the no-cost extension period:


**Ruzicka, J.J.**, Daly, E. (in prep.) An ecosystem modeling approach to study trophic dynamics within the Northern California Current: inter-annual variability in bottom-up energy supply and top-down predation pressure upon juvenile salmon.
MEETINGS:


PUBLICATIONS:


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**Zooplankton Ecology: Interactive Exhibit, “Ocean Conditions: Predicting Salmon Runs”**

As part of this project, an interactive exhibit was developed for display at the Hatfield Marine Science Center (HMSC) Visitor Center to communicate how NOAA fisheries scientists forecast salmon populations using Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current, as varying ocean conditions play a significant role in juvenile salmon survival and population size. NOAA scientists base a forecast of salmon return populations on a series of ocean conditions such as sea surface temperature and chlorophyll as a proxy for prey abundance. Such forecasts can be used by policy makers and fishery managers when setting annual catch limits.

At the HMSC Visitor Center in Newport, Oregon, this exhibit shares with a public audience the forecasting process, the data on which it is based, and the relation of ocean conditions to endangered species. The exhibit allows the visitor to manipulate remote sensing data to understand the changing ocean condition over time, introduces the visitor to life cycle, and environmental requirements of Salmon, and then asks them to predict good ‘run’ years based on
their explorations of data. The exhibit has been very successful, but evaluations indicated a number of user experience features that could be improved.

The relatively low baseline knowledge performance observed as part of this interactive exhibit experience indicates that this topic is indeed new to visitors, and the increased performance in the evaluation conditions indicates that the exhibit could be one way to present the information. However, the text does need to be addressed both in terms of content for two of the four multiple-choice questions and perhaps all of the open-ended questions, as well as for general wordiness and level of vocabulary.

For exhibit design, Dr. Shawn Rowe will add more sections with increasing complexity to the next version, which visitors will be able to access in any order they choose, such as: 1) instructions on reading satellite images; 2) viewing idealized data of only Sea Surface Temperature (SST) satellite data; 3) viewing and predicting with real SST satellite data and buoy data as tiebreaker for one salmon species; 4) adding chlorophyll satellite data and copepod data where available; and 5) a wrap-up section explaining the true complexity of prediction and the multiple variables used. More conspicuous “Back” and “Forward” buttons will be implemented; feedback on user answers will be more specific; and predictions will be shown only when the user clicks on “Show Me” rather than automatically upon advancing the exhibit.

OSU researchers will make improvements to data visualizations by: changing color scales to more culturally-familiar ramps (e.g. dark purple to light yellow for temperature, ranges of green for chlorophyll); adding geographic labels and image titles; and including scale bars with culturally-familiar units (i.e. Fahrenheit vs. Celsius). Images of chlorophyll and temperature will not be overlaid but rather displayed side-by-side in the section of the exhibit dealing with prediction using both measures. Temperature alone will be displayed in the first section allowing users to begin predicting with few ocean condition variables.

The next round of evaluation will focus on data visualization interpretation and ask about the range of geography covered as well as meaning of colors. OSU researchers will also ask visitors a more open-ended question about what types of salmon come to mind, as well as whether they fish, recreationally or professionally and how often as another measure of baseline knowledge about salmon.

Progress will continue with input from CIMRS researchers on the no-cost extension.

*Pelagic/Demersal Fish Habitat Studies*

FRAs Toby Auth and Tristan Britt carried out research in support of pelagic and demersal fish habitats. Britt participated in several cruises collecting biological samples using bongo nets, CTD, and fishing nets. In the laboratory, Britt sorted through biological samples collected in the
field. Micronekton from SAIP midwater trawl samples collected in 2011 were sorted, identified, enumerated, and measured. Identification of *Sebastes* to species level was completed whenever possible, and genetics will be a good tool to help determine individuals that cannot be identified to species by morphology in the lab. Britt managed and further developed an MS Access database for invertebrates and juvenile fishes collected as part of the project. She updated indices (NOI, PDO, UI, ET, TGI, and many others) to the database and made other small modifications to prevent data entry errors. Nekton data (catch and measurement) for 2012 are currently being entered into the SAIP database. There are 590 trawls and over 196 taxa recorded.

On the May 24-27, 2012 cruise onboard *F/V Miss Sue*, Auth was chief scientist, conducting two transects with five stations per transect, 10-55 nautical miles offshore from Newport, OR and the Columbia River collecting CTD, bongo, and mid-water trawl collections for water quality, phytoplankton, zooplankton, ichthyoplankton, and juvenile and adult fishes. During the cruise along the Willapa Bay transect at two stations located 9 and 14 nautical miles offshore, an additional four CTD casts and eight surface trawls were conducted to collect water quality and pelagic organism data for the predator and prey field studies. Auth authored cruise report for this May 2012 SAIP Prey Field/Predator cruise.

During the year when Auth was not at sea, he was in the lab analyzing samples collected on many different cruises, including ones from the Newport Hydrographic Line. During this period, ichthyoplankton from all 17 of the bongo samples collected from the NH Line (stations 5-25 nautical miles) aboard *R/V Elakha* in 2012 January-March were sorted, identified, enumerated, and measured. Data from these cruises were then entered into the database and analyzed for their relation to salmon prey abundances to create a predictive ichthyoplankton index for same-year salmon returns. In addition, Auth sorted, identified, enumerated, and measured all fish larvae from the entire 97 bongo samples collected as part of the 2011 SAIP project and 30 out of the 40 bongo samples from the 2012 SAIP project and entered the results into the database. Auth also downloaded and analyzed all data from the 56 CTD casts made from the four 2012 SAIP Prey Field/Predator cruises, along with all of the 72 minilog samples from the midwater trawls, and entered this data, along with all station data from all cruises, into the database.

Auth also developed a detailed synoptic list of all past, current, and possible future ichthyoplankton studies conducted in the Northern California Current region. He collaborated with Dr. Lorenzo Ciannelli (Oregon State University) in providing larval flatfish synoptic occurrence, concentration, and distribution updates for 2011 and Amanda Gladics (Oregon State University) in providing larval rockfish synoptic occurrence, concentration, and distribution updates for 2010-11.

Between October 2011 and May 2012, FRA Jason Phillips identified, measured, and weighed over 130 taxa representing 62 families of fish (adult, juvenile, and larval) and invertebrates that
were captured in the May 2011 Pre Recruit Survey cruise (102 trawls). Phillips preserved commercial species in ethanol for genetic analysis and took macro photographs of taxa during identification to use for an identification key. After the species were verified genetically, Phillips updated the Pre-recruit MS Access database and entered information from fish collected in 2011. He wrote several scripts using R software to analyze commercial fish captured in 2011 and presented preliminary results at the 2012 Western Groundfish conference. Phillips prepared the cruise report for the NWFSC Pre-recruit Survey, summarizing catch and select species distributions.

During this reporting period, Sr. FRA Shaw counted ~3 years’ worth of preserved zooplankton samples and processed chlorophyll samples collected in 2011 and 2012. All data from these sets of samples have been error-checked and entered into an MS Access database. Shaw is a member of PICES Working Group 23 which focuses on comparative ecology of krill in coastal and oceanic waters around the Pacific Rim. This group was active from October 2007 to October 2011 with its final meeting in Khabarovsk, Russia in October 2011. Since its conclusion, Shaw has coordinated the final reporting of this Working Group, compiled information, and prepared a draft final report. She has also worked on the Working Group’s manuscript on Pan-Pacific comparison of *Euphausia pacifica* egg production.

Shaw participated on the PODS cruise on NOAA R/V *Bell M. Shimada*, February 16 – March 7, 2012, during which she conducted net tows for zooplankton distribution and abundance and collected water samples for chlorophyll, nutrient, and harmful algal bloom analyses. She also participated on a NOAA research cruise in September 2012 and collected zooplankton samples to look at distribution and abundance and collected water samples for chlorophyll and nutrient analyses.

To explore the potential for population structure of *Euphausia pacifica* in the North Pacific Ocean, GRA Angela Sremba identified regions of variability within the mitochondrial genome and developed microsatellite markers for future population genetic studies. For comparison to *E. pacifica*, Sremba sequenced mtDNA for two other species of krill, *T. raschii* and *E. superba*.

To date, Sremba has sequenced near complete mitochondrial genomes for *E. pacifica* and *T. raschii* as well as five mitochondrial genomes of *E. superba* using 454 next generation sequencing. Based on these data, regions of high variability within the mitochondrial genome of all three species were identified, which can be used in future studies to explore population structure. Population structure is measured by comparing genetic diversity between populations. These regions of variability within the mitochondrial genome can be targeted to describe the genetic diversity within a population for comparison to other populations.
Sremba developed five microsatellite markers from nuclear genome for *E. pacifica* using a next-generation sequencing technique. Microsatellite repeats were identified and primers were designed using MsatCommander. Sremba tested primers for 41 microsatellite loci. Five microsatellites amplified successfully. Twenty individuals from each population (NH, BS, S, YS) were screened for five microsatellite loci.

Late in the summer of FY11, FRA Jennifer Menkel was injured during a rogue wave incident aboard the *R/V Wecoma*. Ms. Menkel was released to work only minimal hours during the FY 12 period. During this period, she was restricted to non-lab work but tried to prepare a paper summarizing research results; however, she has been unable to complete the paper for submission.

Progress on remaining data analysis and presentations of results at national/international meetings that were delayed will continue during the no-cost extension.

**MEETINGS:**


**PUBLICATIONS:**


Watershed and Estuarine Processes

Estuarine Habitats and Salmonid Life History

OSU RESEARCH STAFF: Andrew Claxton, Faculty Research Assistant

NOAA COLLABORATOR: Kym Jacobson, NWFSC

In this reporting period, FRA Claxton worked on two major projects that examine parasitism and habitat use of subyearling Chinook salmon in the Columbia River estuary. Claxton contributed to the manuscript, “A comparison of beach and wetland habitat usage by subyearling Chinook salmon (Oncorhynchus tshawytscha) in the Columbia River estuary using parasite assemblages.” The manuscript is currently being reviewed for final approval before being submitted to the journal, Hydrobiologia. It focuses on the importance of wetlands habitats as rearing grounds for salmon within the seaward 60 kilometers of the Columbia River estuary.

For the second project, “Large scale patterns of subyearling Chinook salmon (Oncorhynchus tshawytscha) habitat use inferred from parasite assemblages,” Claxton completed necropsy of 400 subyearling Chinook salmon collected in 2010 and 300 subyearling Chinook from 2011, allowing for a 2-year comparison among reaches of the Columbia River estuary. This project examines differences in parasite assemblages among several hydrogeomorphic reaches in entire 235 kilometers of the Columbia River estuary beginning with salmon collected from Bonneville Dam. Preliminary results show that salmon from just below the dam have few parasites, but, as they move further downstream, they begin to accumulate parasites acquired through the consumption of freshwater macroinvertebrates. Near the river mouth salmon are heavily infected.
with nematodes which were acquired through trophic interactions involving benthic amphipods in the main stem of the river and lower estuary.

In May and June 2012, Claxton assisted with specimen collections in the Columbia River. Claxton also necropsied 60 coho salmon (*Oncorhynchus kisutch*) for a manuscript tentatively titled “Parasites of wild and hatchery coho salmon (*Oncorhynchus kisutch*) from Bingham Creek, Washington.” Work on this paper will continue on the no-cost extension.

MEETINGS:

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**Monitoring Freshwater Habitat for Salmonids**

OSU RESEARCH STAFF: Robert Kennedy*, Assistant Professor, Sr. Research, Forest Ecology & Society

* Dr. Kennedy is currently Assistant Professor at Boston University, Department of Earth and Environment.

NOAA COLLABORATOR: Chris Jordan, NWFSC

Research in the second year of this project (this reporting period) fell into two broad categories: Refinement in the Puget Sound and Extension of methods to other evolutionarily significant units (ESUs).

**Puget Sound research**

In the course of refining results for Puget Sound, a major sub goal was development of a web-based tool to allow non-remote sensing specialists to interact with the land cover change maps.

A key focus during Year 1 had been adding value to existing disturbance maps. Those maps were derived using automated algorithms that tapped into the 20+ year archive of Landsat satellite imagery and, before this project, had two key weaknesses. They were focused on forests only, were only capable of delineating where and when a loss of forest had occurred, but could not determine what had caused the change. From the perspective of potential impacts on in-stream habitat, distinguishing agent of change is critical. For example, both short and long term sediment and chemical delivery to streams would differ if a tree-removal operation resulted in an urbanized setting or was eventually returned to forest through standard silvicultural practices. In addition, moving beyond forest to include all land cover types was an important goal, as salmonids must pass through many non-forest cover types during their life cycle.

During Year 1, a method was developed to predict change agent using a combination of indices derived from the satellite record and other spatial data, wrapped into a non-parametric statistical
modeling framework trained using information collected by expert interpreters. At the end of Year 1, the method was determined to be successful, but that two improvements were needed. First, a better interface was needed to build the training samples – the portal through which the interpreters assessed and recorded their interpretations of cause of change. Second, based on evaluation of the error structure of the maps, it appeared that another cycle of modeling with interpretation of additional change areas would improve modeling efficacy. Thus, these two advances were goals for the Puget Sound work in this reporting period.

Development of a web-based attribution interface
To improve quality and speed of interpretation of change, a web-based interface was developed to integrate the core components of interpretation (Figure 1). Patches selected for interpretation are draped onto a GoogleEarth backdrop, which allows ready assessment of the land use context of the change. GoogleEarth also provides historical airphotos (where available) that can also be used to confirm the timing and type of change observed in the satellite series and labeled by the automated algorithm. However, the airphotos available in GoogleEarth typically only exist every few years at best. Thus, the core tool used to label change is the time-series of satellite imagery itself (Figure 1d), complemented by a trace of the spectral values (Figure 1c) that allows interpretation of the full history of the patch: before, during, and after the change. Taken together, the context from the GoogleEarth image and the temporal progression from the satellite time series allow interpreters to understand what caused the change. This information is also entered directly into the interface (Figure 1b), using simple drop-down menus that speed the process and improve consistency among interpreters.
Augmentation of Puget Sound attribution results

Earlier, tests of the attribution method involved 1016 initial patches, augmented by 182 in a second modeling cycle. Although this training sample represented approximately only 1% of the total number of disturbance patches mapped, results applied to the other 99% of patches were extremely promising. Moreover, the statistical modeling method used (RandomForest) provides a means of assessing not only the most likely change agent for each patch, but whether that agent could be confused with other change agents. Evaluating these confused classes, it appeared that many of the erroneously labeled patches were close to being correct, and that another cycle of new patches could improve the modeling and mapping.

Thus, in Year 2 more than 500 new patches were labeled by trained interpreters. The interpreters used the new attribution interface, improving timing and detail relative to the prior runs.
Extension of methods to other ESUs
The second key focus of this fiscal year’s work was extending the yearly land cover mapping method to other ESUs (evolutionarily significant units) in the Pacific Northwest. Two ESUs were targeted that were similar in type to the Puget Sound: Willamette Valley and the Lower Columbia Valley. Additionally, an experimental run was conducted for the Middle Columbia ESU, which includes land cover and land use regimes quite different from those on the west side of the Cascades. Taken together, these ESUs represent a large area, and the creation of 20+ years of land cover maps for this area is unprecedented (Figure 2).

![Figure 2. Land cover predicted for the year 2006 for the Puget Sound, Lower Columbia, Willamette Valley, and Middle Columbia ESUs. Yearly maps from 1985 to 2008 exist for all of these areas at a 30m cell size. Note that the maps for Middle Columbia area considered provisional because conditions in this ESU differ markedly from west-side ESUs, where the initial methods were developed.]
Willamette Valley and Lower Columbia
Mapping for the Willamette Valley and Lower Columbia appeared largely successful, resulting in yearly land cover maps from 1985 to 2008 for the entire area. Figures 3 and 4 illustrate examples of urbanization (near Battleground, WA) and regrowth (from 1985 forward, four years after Mt. St. Helens volcanic eruption).

Figure 3. Land cover progressions for selected years showing urbanization around Battleground, WA. For simplicity, we show only maps at every five years, but yearly maps exist for each area.

Figure 4. Land cover progressions for selected years showing regrowth of vegetation around Mt. St. Helens. For simplicity, we show only maps at every five years, but yearly maps exist for each area.
**Middle Columbia**
The Middle Columbia ESU is fundamentally different from those situated west of the Cascades. Dry conditions dominate most of the ESU, changing land cover types in nearly all categories. Except at high elevation, forests are sparser, and much of the landscape is dominated by the shrub/scrub cover type, which is a minor component of west-side cover. Agriculture plays a prominent role as well, occupying a larger percentage of the landscape than west-side ESUs, including a wide range of crop types with diverse seasonal trajectories that contrast sharply with the cycles of the natural vegetation. Therefore, application of methods developed in west-side ESUs was considered to be in an experimental phase.

As expected, the diversity of agricultural crops introduced variability in the spectral signatures that weakened mapping in agricultural areas. Of particular note is confusion between winter wheat and urban cover types (in the Palouse) and overmapping of deciduous forest in agricultural areas in the Yakima Valley. These problems are not unlike those encountered for specific classes on west side mapping, which were investigated and largely corrected using simple rules that take advantage of the probabilistic voting structure for classes produced by RandomForest. The researchers anticipate that similar corrections could be made here, perhaps in conjunction with the use of improved agricultural maps derived from the recently-released cropland data layer (CropScape: [http://nassgeodata.gmu.edu/CropScape/](http://nassgeodata.gmu.edu/CropScape/)).

**Linking disturbance data with fish data**
Ultimately, these land cover change data are needed to evaluate possible impacts on fish populations. Through the fall of 2011, Dr. Robert Kennedy provided data and feedback to Eric Ward (NWFSC), who built statistical models of impacts on fish recruitment in Washington state that incorporated land cover information.

**MEETINGS:**
Kennedy traveled to NWFSC in Seattle in October 2011 to present initial Puget Sound results to managers at an RITT meeting.
Fisheries Habitat Investigations

*Climate and Habitat Effects on Productivity of Alaska Groundfishes and Crabs*

OSU RESEARCH STAFF: *Louise Copeman*, Research Associate, Post-doc; *Courtney Danley*, Faculty Research Assistant

NOAA COLLABORATORS: *Tom Hurst, Ben Laurel, Cliff Ryer*, AFSC

The oceanographic regimes of the Bering Sea and Gulf of Alaska vary on several time scales in response to regional climatic fluctuations. Imposed upon this regional variation is the longer-term changes in global climate, and warming trends have already been observed in the Gulf of Alaska and Bering Sea. In addition, the threat of ocean acidification has the potential to cause significant disruptions in marine ecosystems through direct impacts on resources species and alteration of lower trophic level dynamics. Fish communities respond to this environmental forcing via the physiological and behavioral traits of individual species as well as the cumulative set of trophic interactions between species. Recent analyses have demonstrated the importance of evaluating species-specific responses, as these responses cannot be generalized across diverse communities.

At sub-population scales, spatial variation in habitat quality is a significant driver of local and regional population productivity. The habitat characteristics of demersal fishes and crabs include a variety of factors including water depth, thermal regime, sediment characteristics, physical complexity of the benthic environment, species composition of infauna and epifauna, and the distribution and abundance of predators and prey. However, most assessments of habitat requirements for individual species consider a small subset of these factors. CIMRS researchers are exploring the climate and habitat factors that influence population productivity of Alaskan fishery resources.

In FY12, research was focused on three primary topics: 1) Effects of ocean acidification on walleye pollock and Pacific cod; 2) Habitat selection of juvenile flatfishes; and 3) Lipid class dynamics in marine crabs.

1) *Effects of ocean acidification on walleye pollock and Pacific cod*

During this reporting period, FRA Courtney Danley successfully reared larval walleye pollock under varying conditions in the laboratory. These larvae were raised in 100L black cylindrical flat-bottom upwelling tanks. These tanks simulated four different ocean water pH conditions that currently exist.
2) Habitat selection of juvenile flatfishes
In FY12, Danley successfully reared larval rock sole in the laboratory using strip-spawned eggs from adults collected from Pillar Cove, Kodiak, Alaska. The larvae were raised at two temperatures (4 and 9 °C) in a series of 100L black, cylindrical flat-bottom upwelling tanks at densities of 20 fish per liter. Two temperatures were used to ensure a variable-sized larvae during the time of experimentation on habitat selection (90 – 130 days post hatch).

During the summer of 2012, Danley successfully completed two experiments in collaboration with two interns that addressed habitat selection in juvenile Alaskan flatfish. These included experiments examining vertical distribution of larval rock sole along thermoclines and post-settlement habitat selection (sediment types) at varying spatial scales. These data are currently being analyzed.

3) Lipid class dynamics in marine crabs
In collaboration with AFSC scientists, Research Associate, Post-doc Dr. Louise Copeman, has been examining the lipid composition of juvenile tanner crabs in different nursery areas and habitat types.

During the summer of 2012, Copeman in collaboration with Cliff Ryer (AFSC) collected field samples of: sediments, fluff, worm tubes and crabs from different nursery embayments in Kodiak Alaska. These samples were analyzed for dietary differences in crabs from different nursery embayments/habitat types.

Copeman supervised a 3-month laboratory feeding experiment on juvenile tanner crabs that examined the effect of dietary essential fatty acids on juvenile tanner molting, lipid composition and growth rate. Over 60 samples from this study have been analyzed for lipid classes and fatty acids. Preliminary data have been compiled.

PUBLICATIONS:

Seabird Bycatch Avoidance for West Coast Groundfish Fisheries

OSU RESEARCH STAFF: Rob Suryan, Assistant Professor, Sr. Research, HMSC

NOAA COLLABORATORS: Kim Rivera, Alaska Region; Shannon Fitzgerald, AFSC

Recognizing that the distribution of endangered short-tailed albatross (Phoebastria albatrus) overlaps the U.S. West Coast fishing grounds, NOAA Fisheries and the U.S. Fish and Wildlife Service initiated a process under the Endangered Species Act to evaluate and minimize the effect of West Coast groundfish fisheries on this species. New regulations to minimize seabird mortality in West Coast fisheries could emerge from this process. Furthermore, a recent analysis of data from the West Coast Groundfish Observer Program indicates that black-footed albatross are being incidentally killed in West Coast longline fisheries (NMFS, Northwest Fisheries Science Center 2008).

Sr. Research Dr. Rob Suryan updated all albatross distribution, and the OSU/WSG team received fisheries data from NOAA and completed all U.S. West Coast fisheries overlap analyses. The draft manuscript below has completed co-author review and nearly all internal reviews (including the NOAA groundfish program). Suryan and colleagues are currently working on the final manuscript revisions. This draft document was provided also to the U.S. Fish and Wildlife Service Region 1 endangered species branch office.

Manuscript in prep:

Seasonal and Age Class-Specific use of Bering Sea Canyon and Shelf Habitat by Short-tailed Albatrosses: Implications for Fishery Interactions

One seabird species that forages extensively over Bering Sea canyon habitat is the endangered short-tailed albatross (Phoebastria albatrus; STAL). Historically, this species was the most abundant albatross in the North Pacific, numbering over one million individuals, and undoubtedly a major consumer of prey in the Bering Sea and Aleutian Islands where this species spends the majority of its summer, post-breeding season. Satellite tracking and vessel-based sightings of STAL demonstrate the extensive use of Bering Sea slope and canyon habitat. STAL within the Bering Sea, however, also appear to use shelf habitat more frequently than other regions of their range, causing a greater potential for interaction with large-scale fisheries. Indeed, in the fall of 2010 and 2011, this potential was reaffirmed when three STAL were hooked and killed in the Bering Sea longline fishery. OSU researchers and NOAA colleagues suspected more extensive use of shelf habitat may be by younger age class individuals,
specifically first- and possibly second-year birds. This potential age class effect, however, was based on few samples of first- and second-year birds (n = 3). The scientists have now satellite tracked over 20 first-year birds in the Bering Sea (some of these through their second year of life) and can adequately test this initial finding and assess hypotheses of interaction causing mortality in commercial fishery operations.

Dr. Suryan has compiled and begun analyzing tracking data of first and second year albatrosses. Additionally, the final data sharing agreement between NOAA AFSC observer program and OSU has been signed. Suryan has submitted a fisheries data request and is awaiting transfer of data. The delay in establishing the data sharing agreement curtailed progress on this project, requiring continuation on a one-year no-cost extension.

Do Albatrosses Use Molting Areas in the Aleutian Islands? Important Bird Areas within Productive Fishing Grounds

Albatrosses are well-known for making repeated long-distance flights, often crossing entire ocean basins throughout the breeding and non-breeding season. The summer, non-breeding season, however, is also a period when North Pacific albatrosses (short-tailed albatross, *Phoebastria albatrus*; black-footed albatross, *P. nigripes*; Laysan albatross, *P. immutabilis*) replace feathers, known as the molting period. Replacement of flight feathers, in particular, is energetically costly, time consuming, and, therefore, can have a significant impact on whether an albatross must skip breeding in a given year. The flight efficiency of a large-bodied albatross can be dramatically compromised while undergoing molt; therefore, locating regions of increased foraging efficiency during this period might be critical to reproduction and survival. Suryan and colleagues have evidence that suggests albatrosses may be using “molting areas” in the Aleutian Islands. If this hypothesis is supported, the importance of certain regions of the Aleutian Islands as critical albatross molting habitat should be considered. These results have important implications for understanding the post-breeding season ecology of albatrosses and the conservation of important at-sea habitats.

Suryan has completed all analyses except those data from the NOAA current drifters to calculate retention time of passive drifters within Aleutian passes and compare these results with albatrosses. This work continues during the no-cost extension.
Sr. FRA Chris Romsos and Chris Goldfinger continued progress on this project. The goals during this reporting period were to produce map, report, and web content for the Pacific Fisheries Management Council’s 5-Year Review of West Coast Groundfish.

New data on seabed type (habitat) and bathymetry (including imagery) were collected for the period 2002 – 2011 by Romsos. The data search was broad in organizational scope, covering all State, Federal, and academic sources of seabed data and was completed in Spring 2012. The results of the data collection phase were compiled into map products in Spring 2012 and published in the final report (Summer, 2012) comparing the researchers’ current level of knowledge to what was known at the last review of West Coast Groundfish EFH (2005). See Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat Report to the Pacific Fishery Management Council Phase 1: New Information, Section 3.2.1 & Appendix C.

Romsos also wrote a comparative review of NOAA’s Habitat Use Database (HUD) as a second area of focus under this project in Spring 2012. The review explores and describes the structural details of the HUD as well as key taxonomic additions and new habitat preference information updated after 2005. See Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat Report to the Pacific Fishery Management Council Phase 1: New Information, Section 3.5 & Appendix I

In Fall 2012, Romsos developed and continues to maintain an online data catalog and registry for the distribution of map plates and data archives related to this project. The Catalog is live online at: http://efh-catalog.coas.oregonstate.edu/overview/

Exploration of Sponge/Coral Reefs

Mobilization and demobilization occurred in Newport, Oregon, the homeport for OSU’s R/V Pacific Storm. Leg 1 of the cruise includes a multibeam acoustic survey of portions of areas near the Mendocino Ridge and the Klamath Canyon. The multibeam survey mobilization began July
6, 2012. The multibeam system was a Reson 8160 (leased) pole mounted to *R/V Pacific Storm*. The multibeam cruise was planned to conclude on July 16 for a total of 10 days inclusive of mobilization and demobilization.

Project roles for Leg 1 are as follows: Goldfinger served as Team Leader, and Romsos acted as Chief Scientist for the sonar mapping operations. The Goldfinger lab planned to process the acoustic data and classify habitat types in order to identify likely targets for visual surveys of deep-sea coral and sponge communities to be used during Leg 2.

**Mapping Cruise Schedule:**
- July 6-8, 2012. Mobilization in Newport or Toledo, Oregon
- July 8-15, 2012. At-Sea
- July 16, 2012. Demobilization in Newport or Toledo, Oregon

**Cruise summary**
Oregon State University arranged through a vendor, Harvey Lynch, Inc to lease a Reson 8160 multibeam sonar for a short seafloor mapping cruise during July 2012. The cruise was to be conducted onboard the OSU owned and operated *R/V Pacific Storm*. The sonar gear was located in Texas and was sourced from a third party (unknown to OSU at the time of contracting). The sonar was to be shipped from the Harvey Lynch facility in Stafford, Texas to OSU Ship Operations in Newport, Oregon for pickup. The cruise was unfortunately cut short after ~ 32 hours of operations due to leaking of the leased sonar. The vessel returned to port, and an investigation into the sonar leakage was conducted. OSU investigation has determined that the sonar was damaged prior to shipping to OSU and began to leak when first deployed. OSU is now engaged in a contract dispute with Harvey Lynch, Inc. and is contending that lease charges should be zero and that the vendor should reimburse OSU for the ship time and salaries expended. No useful data were collected on this cruise.

**Alternate Cruise**
With *R/V Pacific Storm* mobilized for seafloor mapping, the researchers arranged an alternate cruise using the navigation and motion sensors onboard and a demonstration multibeam system provided and operated by Kongsberg/Simrad west coast representatives. Rich Patterson of the Seattle Kongsberg office provided a Simrad 2040, a next-generation chirp multibeam sonar. This system was mobilized on *R/V Pacific Storm* on July 16, 2012. The vessel departed port on July 17 and conducted two mapping operations. The primary target was Stonewall Bank, a shallow rocky bank ~ 12 miles SW of Newport, OR in Federal waters. The survey, approximately 5 by 10 nautical miles, was completed in two days. The second target was a small rocky bank known aptly as “the Postage Stamp”. This bank was located after a brief search and mapped in 12 hours.

The alternate cruise provided several important results. First, Stonewall Bank is a highly productive rockfish area in the inner continental shelf and one that had not yet been mapped.
Mapping of the “Postage Stamp,” provided a needed control site for the Oregon Marine Reserve project. Lastly, this cruise was a test of a new multibeam system that, through chirp processing, is capable of mapping waters as deep as 700m with a small, light, pole mounted system at very high resolution. In this respect, the cruise was very successful and demonstrated the value of this new technology in seafloor mapping.

Progress on the project required a continuation on the one-year no-cost extension due to the equipment failures and delay in processing associated data.

Stock Assessment Improvements

*Impacts of Climate on Long-term Growth Patterns of Yellowfin sole in the Bering Sea: Empirical Modeling and Incorporation into Stock Assessment Models*

OSU RESEARCH STAFF: Bryan Black*, Associate Professor, Sr. Research
*Dr. Black is currently Assistant Professor at University of Texas at Austin, Department of Marine Science.

NOAA COLLABORATORS: Thomas Helser, Mary E. Matta, Thomas Wilderbuer, AFSC

In this project, Dr. Black and colleagues extended an existing otolith growth-increment chronology for eastern Bering Sea yellowfin sole. The original chronology spanned 1981-2006, and the updated chronology now spans 1963-2006, which is an unprecedented length for a continuous growth history of a fish species in the Bering Sea. The collaborating NOAA and OSU researchers also related this chronology to more than 7,000 observations of yellowfin sole size (weight and length) in the eastern Bering Sea collected during trawl surveys spanning 1987 and 2006. In so doing, the collaborating researchers demonstrated that anomalies in otolith growth, as captured by the otolith chronology, correspond to anomalies in yellowfin sole body size.

In this fiscal year, Dr. Black and collaborating AFSC researchers submitted a manuscript for review in *Fisheries Oceanography*. From a management and assessment perspective, such growth variations are relevant to the calculation of biological reference points, which define limits beyond which stocks cannot be exploited or targets about which exploitation is expected to fluctuate. Two common biological reference points that use average animal weight explicitly in their calculations are “yield per recruit” and “spawning per recruit.” Large changes in weight-at-age and associated individual-based demographic parameters imply that reference points will change. Indeed, the Intergovernmental Panel on Climate Change projects increased ocean temperatures in the Bering Sea, which may result in increased body size, provided that other limiting factors such as prey abundance and maxima of thermal tolerance are not reached first. The implication is that biological reference points based on past population dynamics and productivity may need revision for these future scenarios of non-stationary climate changes.
PUBLICATIONS:

Black, B.A., M.E. Matta, T.E. Helser, and T.K. Wilderbuer. Otolith biochronologies as multidecadal indicators of body size anomalies in yellowfin sole (*Limanda aspera*). *Fisheries Oceanography.* (Submitted.)

*Population Dynamics and Stock Assessment of West Coast Groundfish*

**OSU RESEARCH STAFF:** Kelly Benoit-Bird, Associate Professor, CEOAS; Neal McIntosh, Faculty Research Assistant, CEOAS

**NOAA COLLABORATORS:** Michelle McClure, Jeff Bash, Lawrence Hufnagle, NWFSC

Due to the departure of Research Associate Megan O’Connor before completion of this project, progress will continue under the no-cost extension by FRA Neal McIntosh. McIntosh will be processing acoustic and trawl survey data and the historical age-1 hake data geostatically, as well as completing the analysis of the *in situ* target strength data collected in 2004.

**OSU RESEARCH STAFF:** Kevin Thompson, Graduate Research Assistant; Selina Heppell, Associate Professor, Dept of Fisheries and Wildlife

**NOAA COLLABORATOR:** Grant Thompson, AFSC

GRA Kevin Thompson’s progress toward research and training in quantitative fisheries has continued. In this reporting period, K. Thompson completed his preliminary written exams required by the Department of Fisheries and Wildlife. Following that, K. Thompson held and passed his oral exam required by OSU Graduate School on October 20, 2011. In attendance were the entire academic committee consisting of Selina Heppell (OSU FW), Tom Hurst and Grant Thompson (NOAA), Lorenzo Ciannelli (OSU CEOAS), Sarah Gaichas (NOAA), and his graduate representative, Andrew Plantinga (OSU). K. Thompson has completed all academic requirements regarding classes and exams for his PhD program.

Regarding research, K. Thompson has completed analyses for the first chapter of his dissertation as it was outlined in the research proposal assessing the role of environment on the consumption of walleye pollock by Pacific cod, sablefish, and Pacific halibut in the Gulf of Alaska. A draft manuscript of this chapter is in preparation and is currently being edited by Selina Heppell. This work was presented at the Mote Marine Science Symposium in Sarasota, Florida as well as at the required annual FATE meeting held in the NOAA SWFSC Laboratory in Santa Cruz, CA. Work on the second chapter of the dissertation, regarding the effects of including novel environmental factors determined as significant in the first chapter into multispecies models is being developed.
This project will be extended in the no-cost extension as Kevin Thompson’s research progress continues.

MEETINGS:

Stock Structure of North Pacific Minke Whales

OSU RESEARCH STAFF: Scott Baker, Professor, Marine Mammal Institute; Debbie Steel, Faculty Research Assistant, Marine Mammal Institute

NOAA COLLABORATOR: Paul Wade, AFSC

As part of the Implementation* process for North Pacific common minke whales, one of the primary tasks is to assign relative plausibility to stock structure hypotheses. These plausibility rankings determine the weight each hypotheses (or ‘trials’) are given in determining which RMP variants are acceptable (an RMP variant consists of specifications for where and when whaling is to occur). There are three stock structure hypotheses that were considered plausible at the first intercessional workshop: Hypothesis I) a stock in the Sea of Japan and Yellow Sea and one in the Pacific Ocean; Hypothesis II) one stock each in the Yellow Sea, Sea of Japan, and Pacific Ocean; and Hypothesis III) one stock in the Yellow Sea, one in the Sea of Japan, a ‘J-like’ stock along the Pacific coast of Japan, and two ‘O-like’ stocks in the Pacific nearshore and offshore waters. Finding conclusive evidence to fully resolve the stock structure is unlikely given that no samples have been collected on the putative breeding grounds during winter when presumably ‘pure’ stocks would exist. Instead, the primary information on population structure comes from biological information on conception dates and genetic data collected from year-round coastal bycatch and seasonal commercial and scientific hunting during migration. Whales in the Yellow Sea only have autumn conception dates; whales in the Sea of Japan and along the Pacific coast of Japan have a mix of autumn and winter conception dates; and whales from the rest of the Pacific only have winter conception dates. Hypotheses II and III are both equally consistent with data on conception date, but Hypothesis I is not, and so is considered Low plausibility. Results from both mtDNA and microsatellite genotypes show significant differences in most pairwise comparisons between spatial areas. Of primary importance for distinguishing Hypotheses II and III are the significant differences seen between three regions in the Pacific Ocean – the coast of Japan, nearshore waters >10nm from the coast, and offshore waters, as well as the significant differences seen between either coast of Japan. One explanation proposed for these significant differences is that there are differing proportions of just two stocks (‘J-stock’ and ‘O-stock’) in each of these four areas. However, allozyme and microsatellite allele frequencies only show strong evidence for mixing of stocks in other regions (i.e., along the Korean coast of the Sea of
Japan, and north of Hokkaido). The four areas in question do not show strong evidence for mixing of stocks. Therefore, Hypothesis II is considered to have Low plausibility. Only Hypothesis III, which has differentiated stocks in each of these four locations, is in agreement with the genetic data, and therefore has High plausibility.

*Requirements and Guidelines for Implementations under the Revised Management Procedure (IWC 2005).*
## FY2012 Publications

Twenty-six journal articles were published in FY12; all peer-reviewed.

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