Annual Progress Report
to
National Oceanic & Atmospheric Administration

NOAA Award# NA11OAR4320091

Reporting period: 7/1/14 – 6/30/15

Oregon State University

Cooperative Institute for Marine Resources Studies

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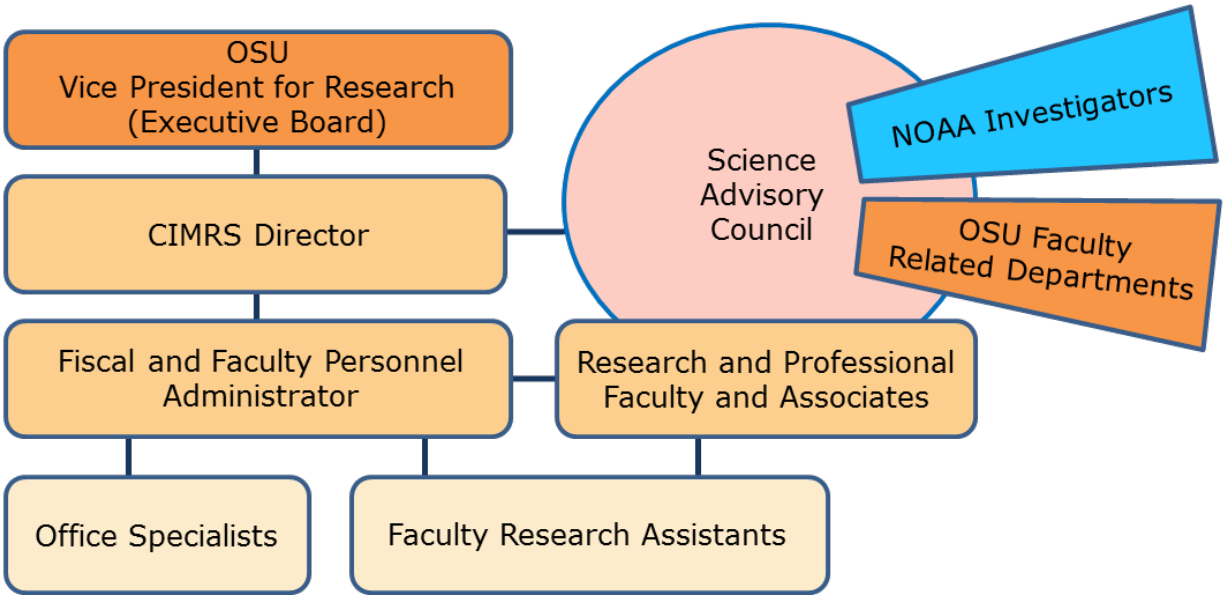
ORGANIZATION

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 Understanding between OSU and NOAA/NMFS. A Science Advisory Council (SAC) gives input on research directions, progress, and policy to the Director.



2014/2015 EXECUTIVE BOARD

Ron Adams (Chair) Vice President for Research, Oregon State University	**Shelby Walker** Director, Oregon Sea Grant, Oregon State University
Mark Abbott Dean, College of Earth, Ocean & Atmospheric Sciences, Oregon State University	**Patricia Livingston/Jeff Napp** Director, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NOAA
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Stella Coakley/ Larry Curtis/Dan Edge Associate Dean, College of Agricultural Sciences, Oregon State University	**Chris Sabine** Director, Pacific Marine Environmental Laboratory, NOAA
Robert Cowen Director, Hatfield Marine Science Center, Oregon State University	**John Stein** Director, Northwest Fisheries Science Center, NOAA
Michael Banks (Ex Officio) Director, Cooperative Institute for Marine Resources Studies, Oregon State University	

2014/2015 SCIENCE ADVISORY COUNCIL

David Noakes (Chair) Professor, Department of Fisheries and Wildlife, Oregon State University	**Chris Parrish** Associate Professor, College of Engineering Oregon State University
Jerri Bartholomew Professor, Department of Microbiology, Oregon State University	**Clare Reimers** Professor, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University
William Chadwick Professor Sr. Res., Cooperative Institute for Marine Resources Studies, Oregon State University	**Clifford Ryer** Fisheries Biologist, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA
Louise Copeman Asst. Prof., Sr Res., College of Earth, Oceans, and Atmospheric Sciences, Oregon State University	**Paul Wade** Research Biologist, National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA
Kurt Fresh Estuarine and Ocean Ecology Program Manager, Fish Ecology Division, Northwest Fisheries Science Center, NOAA	**George Waldbusser** Assistant Professor, College of Earth, Oceans, and Atmospheric Sciences, Oregon State University
Sarah Henkel Assistant Professor Sr. Res., Department of Integrative Biology, Oregon State University	**Laurie Weitkamp** Research Fisheries Biologist, Conservation Biology Division, Northwest Fisheries Science Center, NOAA
Michelle McClure Director, Fishery Resource Analysis and Monitoring Division, Northwest Fisheries Science Center, NOAA	Michael Banks (Ex Officio) Director, Cooperative Institute for Marine Resources Studies, Oregon State University

Research at CIMRS

CIMRS partnership brings university scientists together with scientists from NOAA Northwest Fisheries Science Center, Alaska Fisheries Science Center, and Pacific Marine Environmental Laboratory.

Current research themes are:

- Marine Ecosystems and Habitat;
- Protection and Restoration of Marine Resources;
- Seafloor Processes; and
- Marine Bioacoustics.

CIMRS' diverse and richly multidisciplinary range of applied and basic research investigations include marine chemistry and geophysics, ocean acidification and hypoxia, trophic dynamics and modeling, fisheries stock/habitat assessment and behavioral ecology, longer term prediction of physical (mesoscale/upwelling/plume/estuarine) and biological (predator/prey, lipid composition) inter-relationships and climate, zooplankton ecology, genomics, passive acoustic monitoring of marine mammals, socio-economic issues related to fisheries, and spatial planning.

The advancement of basic knowledge about ocean ecosystems from local to global scales, the conservation of endangered species, maintaining sustainable commercial and recreational stocks, and predicting and mitigating natural hazards associated with the solid earth (*e.g.*, earthquakes and volcanoes) and climate change (*e.g.*, changing weather, sea level rise, and ocean acidification) are in line with NOAA's mission. Over the next decade, CIMRS expects to assist NOAA in meeting existing and emerging environmental and ecological challenges through research, education and outreach. Our research efforts will promote technological and scientific advancements that lead to ecological health, marine geophysical dynamics, sustainable marine resources, and socioeconomic benefits.

In FY15, CIMRS researchers spent ~200 days at sea. In addition, CIMRS researchers conducted 20 sampling days on the Newport Hydrographic Line.

RESEARCH PERSONNEL

The following table describes CIMRS research personnel in FY15

Position Category	# Staff	# B.S.	# M.S.	# Ph.D.
Research Scientist	4	--	--	4
Research Associates	3	--	--	3
Research Assistants	12	12	5	0
Total Support >50%	**19**	**12**	**5**	**7**
Research Assistant < 50%	**1**	**1**	**0**	**0**

2014-2015 PUBLICATIONS
ALL PEER-REVIEWED

Institute Lead Author	NOAA Lead Author	Other Lead Author
6	**3**	**13**

TASK 1: ADMINISTRATION, EDUCATION, AND OUTREACH

ADMINISTRATIVE STAFF

Position	FTE	Supported by Award
Director	0.5	Partial
Administrator	1.0	Partial
Purchasing Specialist	0.5	No
Travel Specialist	0.25	No

INSTITUTE DIRECTOR ACTIVITIES

National Service

Chair of the National Cooperative Institute Directors' Executive Committee:

- Summer Executive Meeting with Dr. Kathy Sullivan (NOAA Administrator) and Dr. Rick Spinrad (NOAA Chief Scientist), August 15 2014
- PMEL lab review, Seattle, September 9-11 2014
- Coordinate CI directors annual meeting dates and agenda, Sept 2014
- LEAD21 Kansas City 2nd session, October 6-9 2014
- Visit to Hampton University, Virginia Institute of Marine Sciences and University of Maryland Eastern Shores to lecture and mentor students for HMSC NSF REU and NOAA's Education Partnership Program, Oct 22-29 2014
- NOAA Science Advisory Board Cooperative Institute Review, Nov 18 2014
- Visit to NWFSC and PMEL headquarters in Seattle with Rich Holdren and Bob Cowen to champion CIMRS futures especially with new prospects given OSU's Marine Studies Initiative investment, Nov 25 2014
- OAR update call with Craig McLean, December 12 2014
- NOAA budget briefing, February 17, 2015
- LEAD21 Washington DC last session, February 23-26 2015
- In person meeting with Dr. Rick Spinrad RE CI21, February 26 2015
- Final preparation for CI Directors meeting, March 9, 2015
- Conference with Phelipe Arzayus RE CI21, March 11, 2015
- Lead preparation of a letter to Senate and House Commerce, Justice, and Science Subcommittee, March 17th, 2015:

  Waleed Abdalati, Thomas Ackerman, Steve Ackerman, Don Anderson, Fernando Miralles-Wilhelm, Daniel Baden, Michael Banks, Hugo Berbery, Otis Brown, Allen Burton, David

Checkley, Christian Kummerow, Randy Peppler, Larry Langebrake, Mark Merrifield, Robert Moorhead, Jorge Sarmiento, Peter Ortner, Shirley Pomponi, Susan Sugai. *National Cooperative Institutes request for support for NOAA-University collaborative research in the FY 2016 budget. Formal letter to Chairmen Shelby and Culberson, Ranking Members Mikulski and Fattah, Washington DC.*

- CI annual Directors and Administrators meeting, March 24-5 2015
- CI Directors Hill advocacy, March 26 2016
- Panel member SAB review of JIMAR (HI), May 27-30 2015
- CI21 Summit with NOAA Chief Scientist Dr. Rick Spinrad, NOAA CI Program leadership, CI Directors, other academics, some private sector, Silver Spring, June 17th 2015

University Service

- OSU Centers, Institutes and Programs quarterly meetings
- HMSC Executive Committee bi-weekly meetings
- College of Agricultural Sciences Leadership meeting, Feb 2 2015
- Review of CIMRS post docs and faculty, May June 2015
- CIMRS Executive Board meeting, April 1 2015
- CIMRS Science Advisory Council meeting, April 9 2015
- NOAA SAB review of CIMRS, April 28&9 2015

Research

The Institute Director's research was supported in 2014-15 through grants and state funds awarded through OSU's Coastal Oregon Marine Experiment Station, Department of Fisheries and Wildlife where he holds a faculty appointment at the rank of Professor.

Marine Fisheries Genetics & Conservation				
Principal Investigators	**Funding Agent**	**Title**	**Term**	**Funds**
Banks	Confederated Tribes of the Siletz Indians	Defining Unique Salmonid Breeding and Rearing Groups in the Siletz River Basin	2012-15	$276,217
Banks/Hydrodysky/Davis	LMRCSC (NOAA)	Microsatellite Markers Isolation (EST-SSR's) for Association Tests of Reproductive Phenotypes (GnRH, FSH and LH) in the Context of Environmental Variability for Chinook Salmon.	2014-15	$45,094
O'Malley/Johnson/Banks	US ARMY CORPS OF ENGINEERS	Genetic pedigree analysis of South Santiam River spring Chinook salmon: An evaluation of adult outplanting strategies and founder effects	2014-15	$240,862
Banks/Johnson/O'Malley	US ARMY CORPS OF ENGINEERS	Genetic pedigree analysis of McKenzie River spring Chinook salmon: An evaluation of adult outplanting strategies	2014-15	$232,406
		TOTAL		$794,570

Publcations:

Bellinger M.R, M.A. Banks, S.J. Bates, E.D. Crandall, J.C. Garza, G. Sylvia, P.W. Lawson 2015. Geo-referenced, abundance calibrated ocean distribution of Chinook salmon (*Oncorhynchus tshawytscha*) stocks across the west coast of North America. *PLOS ONE* In Press

Harvey, B.N., D.P. Jacobson, M.A. Banks**.** 2014. Quantifying the uncertainty of a juvenile Chinook Salmon race identification method for a mixed race stock. North *American Journal of Fisheries Management.* 34:1177-1186.

Sard N.M, K.G. O'Malley, D.P. Jacobson, M.J. Hogansen, M.A. Johnson, and M.A. Banks. 2015. Factors influencing spawner success in a spring Chinook salmon (*Oncorhynchus tshawytscha*) reintroduction program. *Canadian Journal of Fisheries and Aquatic Sciences* http://www.nrcresearchpress.com/doi/pdfplus/10.1139/cjfas-2015-0007

Lorenzen, K., S. Smith, M. Banks, C. Ik Zhang, Z. Sohou, V. N. Sanjeevan. 2015. Chapter 13: Fish Stock Propagation. United Nations World Ocean Assessment. In Press.

Administrative Tasks

Dr. Banks and the CIMRS Administrator were responsible for submission of 13 proposals under the new Institutional award during the period 7/1/14 – 6/30/15. This matches the number of submissions from FY14. CIMRS Administrator Jessica Waddell attended the Annual CI Directors' Meeting in Silver Spring, MD in March 2015.

In late April, CIMRS held a successful two-day program review of research and administration as required for renewal of a five-year award with NOAA. The review featured research from all four themes, Marine Ecosystems and Habitat, Protection and Restoration of Marine Resources, Seafloor Processes, and Marine Bioacoustics with one full day at the OSU Hatfield Marine Science Center and one day on the main Corvallis campus. Chair of the review panel was David Lodge, Dartmouth College, with panel members Craig Moyer, Western Washington Univ., Julia Parrish, Univ. of Washington, Randy Peppler, Interim CI Director, Cooperative Institute for Mesoscale Meteorological Studies. The review agenda is attached as an addendum to this report. Initial rating from this review was assessed as "Outstanding."

CIMRS Education

CIMRS Graduate Students Supported through Joint Projects

A number of graduate student projects are being supported with contributed grant funds from NOAA Fisheries.

Ph.D. Candidates

OSU Department of Fisheries and Wildlife

Kevin Thompson 2008-2016
Project: Predator Diets and Multi-species Models
Major Professor: Selina Heppell
NOAA Fisheries Rep: Grant Thompson, AFSC

Linsey Arnold 2012-2017
Project: Management Strategy Evaluations for Rockfish
Major Professor: Selina Heppell
NOAA Fisheries Rep: Grant Thompson, AFSC

Brandon Chasco 2014-2016
Project: TBA
Major Professor: Selina Heppell
NOAA Fisheries Rep: Eric Ward, Eli Holmes, NWFSC

OSU College of Agriculture Sciences, Applied Economics

Christopher Cusack 2009-2016
Project: Bioeconomic, Spatial, Multi-species Fishery Simulator
Major Professor: David Sampson
NOAA Fisheries Rep: Cindy Thomson, SWFSC, Andi Stephens, NWFSC

OSU College of Earth, Ocean, and Atmospheric Sciences

Caren Barceló 2009-2017
Project: Community dynamics of marine fish assemblages in northern neritic and pelagic environments
Major Professor: Lorenzo Ciannelli
NOAA Fisheries Rep: Ric Brodeur, NWFSC

Graduate Students Advised by CIMRS Faculty

CIMRS Faculty also advise students on projects independent of NOAA funding. The Hatfield Marine Science Centers offers a wide variety of scholarships, fellowships and awards that help

supplement student research (http://hmsc.oregonstate.edu/academics/hmsc-scholarships-fellowships-and-awards) .

Niki Diogou:	"Acoustic occurrence patterns of sperm whales in the Gulf of Alaska and their environmental drivers Univ. of Aegean, Greece, J-1 Scholar, Holger Klinck
Selene Fregosi:	"Passive-acoustic monitoring of mid-frequency cetaceans using gliders and floats" Dept. Fisheries &Wildlife, Holger Klinck
Michelle Fournet:	"Humpback whale acoustic ecology and the impacts of large vessel noise on non-song vocal behavior in Glacier Bay National Park" Dept. Fisheries &Wildlife, Holger Klinck
Samara Haver:	"Soundscapes in the Atlantic Ocean" Dept. Fisheries &Wildlife, Holger Klinck
Susan Schnur:	"Volcanic Construction and Destruction at the Summit of NW-Rota-1 Seamount: 2004-2010", College of Earth, Ocean, and Atmospheric Sciences, Bill Chadwick

CIMRS Undergraduate Students Projects

The Hatfield Marine Science Center has successfully received long-term funding from the National Science Foundation for a summer Research Experience for Undergraduates (REU) program (http://hmsc.oregonstate.edu/academics/internships/research-experiences-undergraduates-reu). Several CIMRS faculty have teamed up with undergraduate students from around the country who wish to explore research opportunities in the marine field. In the summer of 2014, Ross Meyer, University of Idaho interned with Dr. Joe Haxel and Dr. Bob Dziak for a project: "Comparing surf-generated ambient sound levels between reef and sandy seafloor environments off the Oregon Coast." Ross has returned again in summer of 2015 to continue his project.

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 websites hosted by NOAA and CIMRS. Research activities, contributions, and news stories throughout the year are posted on CIMRS website, http://hmsc.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/eoi, which continues to feature educational curricula, video clips of *in situ* seafloor experiments, and animated 3-dimensional fly-through videos of seafloor ridges. Two new blogs have been created by CIMRS investigators this year: www.blogs.oregonstate.edu/acoustics/ and Newportal: A gateway to oceanographic information from the Newport Line and beyond

CIMRS research efforts are featured at OSU Hatfield Marine Science Center's (HMSC) Visitor Center, which is dedicated to the lifelong exploration and discovery of coastal and marine

sciences and resources. Many educational exhibits and programs at the Visitor Center correspond with current research conducted by the multiple federal labs co-located with HMSC and 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. "Mysteries of the Deep" 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. "Patterns from Sound" exhibit educates visitors on marine acoustics research. In addition to these permanent exhibits, a real hydrophone and an interactive earthquake/seismic kiosk are on display. "Sensing the Sea" describes various technological methods of monitoring ocean conditions, from satellites to hydrophones. "Riding the Ocean Currents" is a multimedia exhibit that illuminates the relationship between ocean currents and plankton larval dispersal off the Oregon coast; the exhibit includes digital screens depicting ocean currents at various depth, 3-D sculptures of crab larvae, and microscopes showing actual larvae. "Sustainable Fisheries" includes an overview of project CROOS whose goal is to improve salmon management through tracking genetic stocks.

CIMRS researchers provide valuable volunteer hours at K-12 Science Fairs and related activities throughout the year including Marine Science Day that draws over 3,000 visitors to the Hatfield Marine Science Center to discover current research projects at the campus.

> Plankton Day Camp. Oregon Sea Grant education component for K-8 students. July 28, 2014
> (Jennifer Fisher)
>
> Career Science Investigation (CSI). Oregon State Sea Grant education component geared towards teaching High School students about marine science career opportunities. April 3, 2015 (Jennifer Fisher)

Additionally, in the fall of every year, OSU's Department of Fisheries and Wildlife offers a class in coastal ecology and resource management. Usually at least one CIMRS researcher is asked to contribute a lecture.

> Lecture on developing an ecosystem approach to fisheries management. Oregon State University. Coastal Ecology and Resource Management class. October 15, 2014 (Jay Peterson)

TASK 2

(Projects support NOAA Strategic Plan Goal of Healthy Oceans and Climate Adaptation and Mitigation)

Theme: Marine Ecosystem and Habitat

Amendment 37: Coast-wide Genetic Stock Identification – Ecosystem Effects on Adult Chinook Salmon Distribution and Abundance

Funded: $102,767

OSU RESEARCH STAFF: *Michael Banks*, Director, CIMRS; *Jonathan Minch*, Faculty Research Assistant, Hatfield Marine Science Center

NOAA TECHNICAL LEAD: *Pete Lawson*, Conservation Biology, NWFSC

PROJECT BACKGROUND: Genetic Stock Identification (GSI) is a uniquely useful tool for salmon management because it enables identification of nearly all hatchery and natural origin fish sampled and results are available in a few days. This is in contrast to the traditional Coded Wire Tags, which provide data on about 5 percent of hatchery fish only. Ages of GSI-sampled fish are determined from scales. GSI in combination with fine-scale at-sea sampling allows determination of which stocks are present in the fishery with a high degree of certainty and to map dynamic stock-specific distributions. It is anticipated that 2400 tissue samples will be analyzed from collections of Oregon Chinook salmon from three areas in August and September. Genetics labs from Alaska to California have created a database of genetic microsatellites from Pacific salmonids through a consortium called Genetic Analysis of Pacific Salmonids (GAPS).

PROJECT PROGRESS: The work accomplished under the subaward to the Oregon Salmon Commission (OSC) for the period July 1, 2014 through June 30, 2015 included 1) fleet management, 2) fishermen charters, 3) sampling supplies, and 4) database maintenance. The OSC entered into contracts with the fleet manager, fishermen and Fish Trax Systems, Inc. (website maintenance) to perform the tasks for this project.

Fleet management: The fleet manager coordinated with the Newport area fishermen through one-on-one training to prepare fishermen and give them their supplies for the sampling season. The fleet manager was in daily contact with the fishermen for fish count updates and was also in contact with the OSC to ensure that all work stayed within budget guidelines. At the end of each fishing trip, the fleet manager met with each fisherman for an interview to download their GPS track logs, enter them in the database, and restock their supplies (barcode tags, envelopes, batteries, etc.). The envelopes with samples were sent to the lab for processing. Fishermen were sent to sea on a rotating basis to ensure that everyone had equal opportunity for participation. When at sea sampling, fishermen contacted the fleet manager daily with an update on the number of fish sampled.

Fishermen: Chinook salmon and associated fine-scale at sea environmental data were collected in Oregon, during the 2014 fishery season in accordance with the West Coast Salmon Genetic Stock Identification Collaboration sampling plan. Of the 14 contracted fishermen, 13 participated in the project by collecting biological samples and fisheries data using standardized sampling protocols. Fishermen collected 1,220 samples from July through October 3rd, 2014. All

samples were taken off the coast of Newport. A similar sampling strategy, but extended to two ports, has been coordinated for 2015 to enable continuation of data collected. By the end of May 2015, 12 fishermen were contracted for the Coos Bay area and 13 fishermen in the Newport area and are ready to begin fishing and sampling for this year's 2015 project.

Database Maintenance: The fleet manager accessed the database regularly to enter the fishermen information. These data were then available for the lab to access and connect with the biological samples. Fishermen were able to access their own fishing data and compare it with the aggregate throughout the season. Project managers and scientists accessed the data to compare with data from previous years and to see if any patterns were developing. An in-season report was prepared and included a summary of each time period from July through October with the number of fish sampled and their genetic river of origin. Central Valley Fall Chinook were the dominant component of harvest for each time period. This report has been posted to the Pacific Fish Trax website (http://www.pacificfishtrax.org/). This site also includes the public portal for viewing aggregate data by time, regions, fish size and river of origin. Individual fishermen data is available through a specific log-in allowing them to view their own fishing data. The 2014 sampling adds to the work that has been completed since 2006. Collecting several more years of data will strengthen the database and should improve our understanding of the ocean ecology of salmon by integrating stock-specific distribution patterns over space and time with biological and environmental data. A three dimensional sub-settable depiction has been created which visualizes the bathymetry off the Oregon coast overlaid with 2010 to 2013 CROOS catch data. The image can be subset based on stock, month, and year criteria. This 3D graphic will be available at pacificfishtrax.org

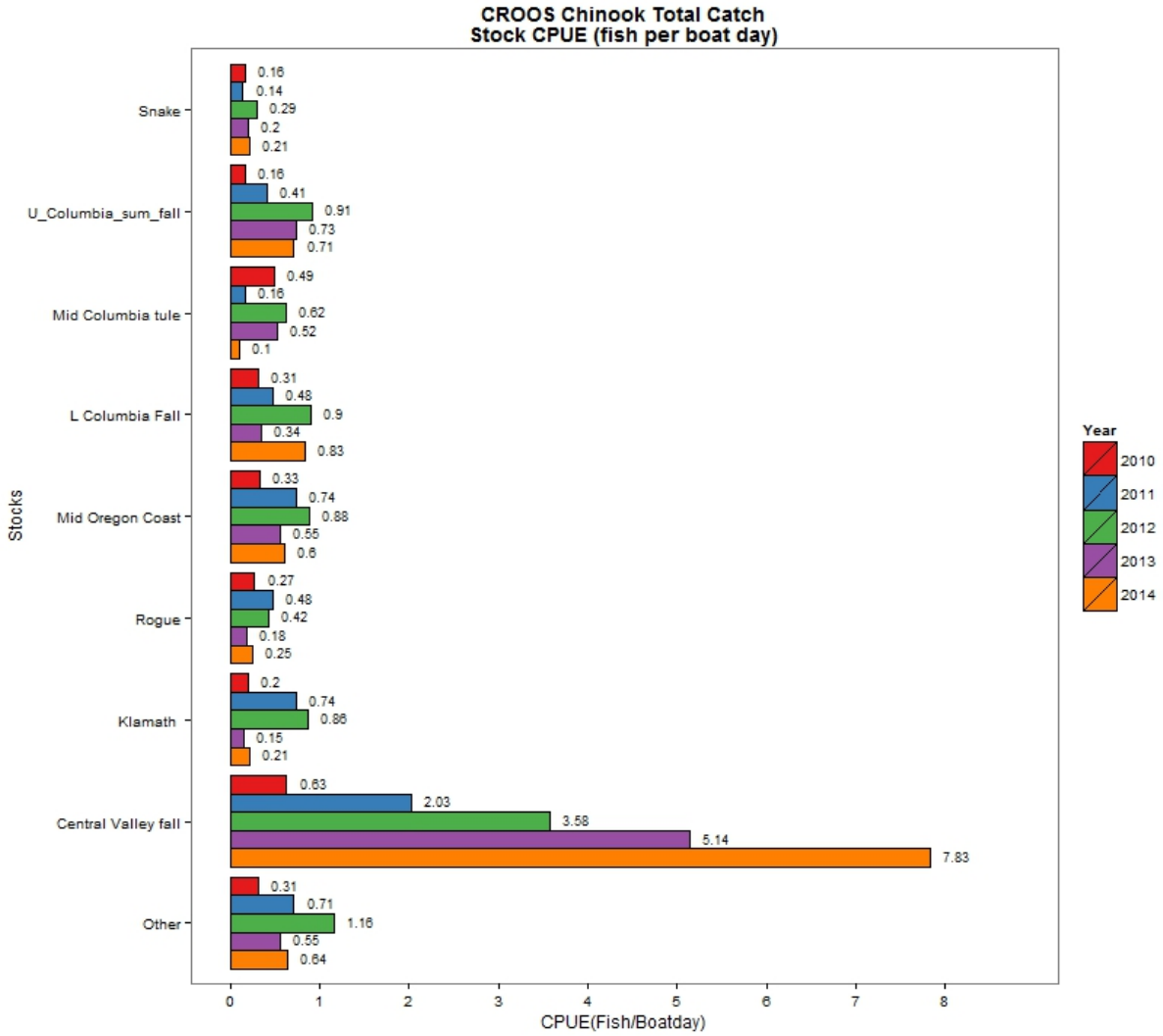
Genetic Characterization using the GAPS database: Work accomplished in this reporting period includes DNA extraction and polymerase chain reaction amplification of the GAPS13 microsatellites to identify most likely source of sampled Chinook. Further analysis includes assessing encounter rates of different stocks as a function of effort and evaluating trends over location, time and years sampled since 2010. For Oregon waters in 2014, a total of 1220 samples were collected and provided to the genetics laboratory by Project CROOS participants. Starting 7/1/14, and through the full season, DNA was extracted from all 1220 of these Oregon tissue samples using a silica-based method that utilizes multichannel pipettes, PALL glass fiber filtration plates, and buffer, centrifuge and transfer protocols as described in Ivanova et al. (2006). A panel of 13 microsatellites known as GAPS13 (from Seeb et al. 2007) were amplified from these DNA samples using the polymerase chain and utilizing protocols detailed in Seeb et al. (2007) and multiplex modification protocol developed by Jonathan Minch. This panel includes: *Ogo-2, -4* (Olsen et al. 1998); *Oki100* (Canadian Department of Fisheries and Oceans, unpublished); *Omm1080* (Rexroad et al. 2001); *Ots-3M* (Greig and Banks 1999); *Ots-9* (Banks et al. 1999); *Ots-201b, -208b, -211, -212, -213* (Greig et al. 2003); *OtsG474* Williamson et al. (2002); and *Ssa408* Cairney et al. (2000). Most likely region and run of origin were assessed utilizing the 'assign individual to baseline population' option available in the statistical package ONCOR (Kalinowski 2008 www.montana.edu/kalinowski/Software/ONCOR.htm) and each individual was assigned to the reporting group in which it had the greatest probability. Data for most likely region of origin for Oregon samples were deposited in the Pacific Fish Trax database in near real-time. The data below shows 2014 compared to the preceding four years:

Project CROOS
Yearly Historical Data

CROOS Sample Statistics

	2010	2011	2012	2013	2014
Number days fished	1209	565	928	318	71
Fish caught per boat day (CPUE)	3.55	3.74	8.70	6.53	16.02
Number legal-sized fish sampled	4046	3523	8301	2437	983

The table show the annual combined CPUEs for 2010, 2011, 2012 , 2013 and 2014. Overall, CPUE in 2014 was higher than catch rates in other years. The bar graph shows CPUEs for 9 stock groups estimated from GSI sampling. Central Valley fall stock was caught at a higher rate in 2014 as compared to previous years.



PUBLICATIONS:

Bellinger M.R, **M.A. Banks**, S.J. Bates, E.D. Crandall, J.C. Garza, G. Sylvia, P.W. Lawson. ·2015. Geo-referenced, abundance calibrated ocean distribution of Chinook salmon (*Oncorhynchus tshawytscha*) stocks across the west coast of North America. *PLOS ONE* (In Press).

Amendment 38: Modifying ISIIS for Autonomous Vehicles

Funded: $21,042

OSU RESEARCH STAFF: *Robert Cowen*, Professor, CEOS

NOAA TECHNICAL LEAD: *Chris Sabine*, PMEL

PROJECT BACKGROUND: A primary NOAA OAR mission requirement is to understand and predict changes in climate, weather, ocean, and coasts. However, NOAA has few programs that address this goal in the Arctic environment, and the Arctic presents unique technical challenges that limit the agency's capacity to conduct regional science and stewardship operations. The Program for Innovative Technology for Arctic Exploration (PITAE) will utilize and develop new and innovative sensors and platforms to address this gap in NOAA's present scientific capabilities. One important goal for effective assessment of the Arctic environment and ecosystem is the operation of high-resolution sensors on autonomous platforms near sea ice. Traditional ship-based observations are ill-suited to understanding this complex environment, and the baseline understanding of the physics, chemistry, and ecosystem associated with sea ice is largely unknown. Additionally, the character of the ice edge environment may also be changing, as climatic pressures cause sea ice to melt back earlier, retreat over larger and larger areas, and freeze up later. The resulting loss of multiyear sea ice and overall thinning of the ice matrix has complex implications for the physical and chemical systems and the attendant food web. Autonomous platforms in conjunction with high resolution sensing technologies represent a unique opportunity to improve the basic understanding of the ice-associated system, and to cost-effectively monitor the expected continuing change.

However, some of these new platforms and sensors are previously untested in the extreme conditions of the Arctic environment, and require moderate development before they can be effectively deployed. Additionally, some of these new platforms and sensors are not compatibly designed, and will need to be adapted and integrated. This program will support focused engineering efforts towards two specific goals: (1) to improve the operational capabilities of autonomous platforms, such as gliders and drones, to operate in the Arctic environment, and (2) to develop the compatibility of cutting-edge, high-resolution sensing technologies with these platforms. Ultimately, the mission and main deliverable of this program is the effective operation of autonomous platforms and high-resolution sensors in ice-associated environments. This program will implement phased testing and development objectives in order to achieve these goals. During FY2014, the requested funding for OSU was used to accomplish the "Phase I" goal to examine the feasibility of placing an ISIIS (In situ Ichthyoplankton imaging System) on an autonomous platform.

PROJECT PROGRESS: In this Phase I, two components of the project were completed:

(i) conducted a "Needs Assessment" in association with NOAA and UW scientists and engineers to evaluate what imagery specifications are required to achieve quantitative assessments of plankton.

(ii) initiated our evaluation of the key components of ISIIS that will dictate design criteria for a glider and examined feasibility of meeting those criteria.

A scoping meeting was held in Seattle October 23-24, 2014. Participants included: Cal Mordy, Miriam Doyle and Jim Osse (JISAO, Univ. Washington), Bob Cowen (Oregon State University (Hatfield Marine Science Center), Charles Cousin (BellaMare LLC, San Diego), Cedric Guigand (Univ. of Miami, Rosenstiel School of Mar. and Atmos. Sci.), Christian Meinig, Phyllis Stabeno (NOAA Pacific Marine Environmental Laboratory (PMEL) , Jessica Cross (Univ. of Alaska Fairbanks ,CIFAR), Janet Duffy-Anderson, Morgan Busby, Patrick Ressler (NOAA Alaska Fisheries Science Center, AFSC)

The goal of the meeting was three-fold: 1) Initiate collaboration between all parties; 2) Explore scientific and engineering feasibility for successful deployment of ISIIS with an Autonomous Underwater Vehicle (AUV); and 3) Develop project plan and road map for engineering and funding and deployment of ISIIS on Chukchi Sea cruise, Summer 2015.

Relevant background information on the PITAE program was shared along with an overview of the different Arctic Ecosystem research programs with which NOAA's PMEL and AFSC are involved (ARCTIC EIS, DBO, RUSALCA, CHAOZ, ARCWEST, SOAR). The rationale for new sampling technologies for Arctic ecosystem science was explored, and the advantages of autonomous systems identified. Specifically, we reviewed the scientific and technological advantages of the ISIIS in this regard, and evaluated engineering possibilities for deploying an adapted version of the system on an AUV. Data on the planktonic stages of fish collected with plankton nets by the Ecosystem and Fisheries Oceanography Coordinated Investigations program (EcoFOCI: PMEL and AFSC) on previous cruises in the Chukchi and Beaufort Seas were presented and considered with respect to enhanced capture with ISIIS of ichthyoplankton data, as well as data on a broad taxonomic range of other planktonic organisms. The engineering feasibility review included determination of design criteria to meet scientific and technical objectives, and generation of ideas and plans for constructing prototype models of a newly adapted AUV and Imaging System. Existing and potential future funding opportunities for this project were discussed and near term plans were outlined for continued use of PITAE support. Logistics and support were discussed for deployment of ISIIS in its present form (towed vehicle) in conjunction with plankton net sampling on the summer 2015 RV Ron Brown cruise in the Arctic. Although this initial deployment is important for developing an ISIIS image library for planktonic organisms in the Arctic pelagic environment, support for this effort remained elusive. Options for 2016 are being reviewed now. The Platform discussions centered on two aspects:

- ISIIS capabilities, specific requirements (volume/speed)
- Glider – how they work, potential modifications to accommodate 'speed' requirements. Discussion of how to create 'boost' dives to achieve *ca.* 3 knot speeds.

Key Design Criteria were established:

- 100 m depth capability (200 m if possible)
- min ~3 knot (1.5 ms^{-1}) burst speed (for duration of image depth profile), 4 knots (2 ms^{-1}) preferred
- Field of view: ~13 cm (10-13 cm)
- Depth of field: 40-50 cm
- Number of image profiles: min – 40, preferred 45-60
- Duration: (dependent on frequency of image profiles), 2-4 weeks (but at very low rate of image profiling, several months could be possible)
- Onboard image segmentation, time stamped and stored internally

In follow-up discussions it was suggested that it may be able to achieve reasonable sampling capabilities within the power requirements under two conditions: 1) if we do a boost dive every 3rd normal dive, we can do 360 of those boost dives, cover 750 km range, and stay out 48 days OR 2) if we do one boost dive every 50 normal dives, we can do 56 ISIIS dives, and cover 1500 km in 120 days. Possible uses in considering design/need are consistent with the following science applications:

1. Sampling near sea ice interface and up to 1-2 km under the ice
2. Spatial sampling array (10s km X 300-600 km)
3. Time series sampling (seasonal)

Next steps under discussion are preliminary designs along with estimated budgets for these designs, and field tests assuming future funding.

Amendment 41: Climate and Habitat Effects on Productivity of Important Alaska Fishery Species

Funded: $83,275

OSU RESEARCH STAFF: *Louise Copeman*, Asst. Professor, Sr. Res., CEOS/CIMRS, *Eric Hanneman*, Bioscience Research Technician, CIMRS

NOAA TECHNICAL LEAD: *Tom Hurst*, Fisheries Behavior Ecology, AFSC

Effects of ocean acidification on Alaskan fishes

PROJECT BACKGROUND: This project directly addresses NOAA Ocean and Great Lakes Acidification Research Plan's goal of evaluating the ecological effects of ocean acidification. Walleye pollock, Pacific cod, and northern rock sole are principle components of the nation's most valuable fisheries. This work evaluates the physiological effects of ocean acidification that could lead to changes in population productivity of these critical resource species.

PROJECT PROGRESS: Bioscience Research Technician Eric Hanneman successfully reared larval and juvenile walleye pollock, northern rock sole and Pacific cod under varying conditions in the laboratory. These juveniles were raised in 100L black cylindrical flat-bottom upwelling tanks for experiments on the effects of ocean acidification on larval growth and development.

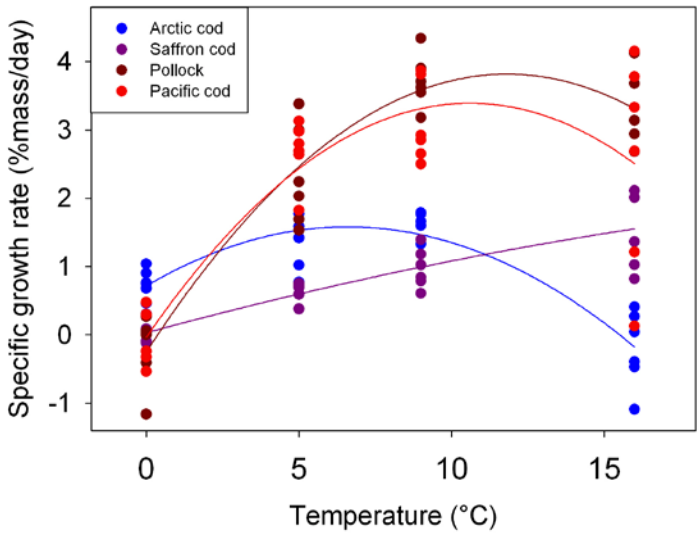
Hanneman reared larval northern rock sole in order to examine the effects of ocean acidification on early life stages. In this experiment, northern rock sole were reared at ambient and low pH, and three lower pH levels in order to investigate the effects of reduced pH on growth and survival.

Hanneman also contributed to improvements in the husbandry aspects of the research. An experiment was designed to concurrently test the effects of two different rotifer enrichment feeds, and the effects of high and low aeration, on the growth and survival of larval walleye pollock.

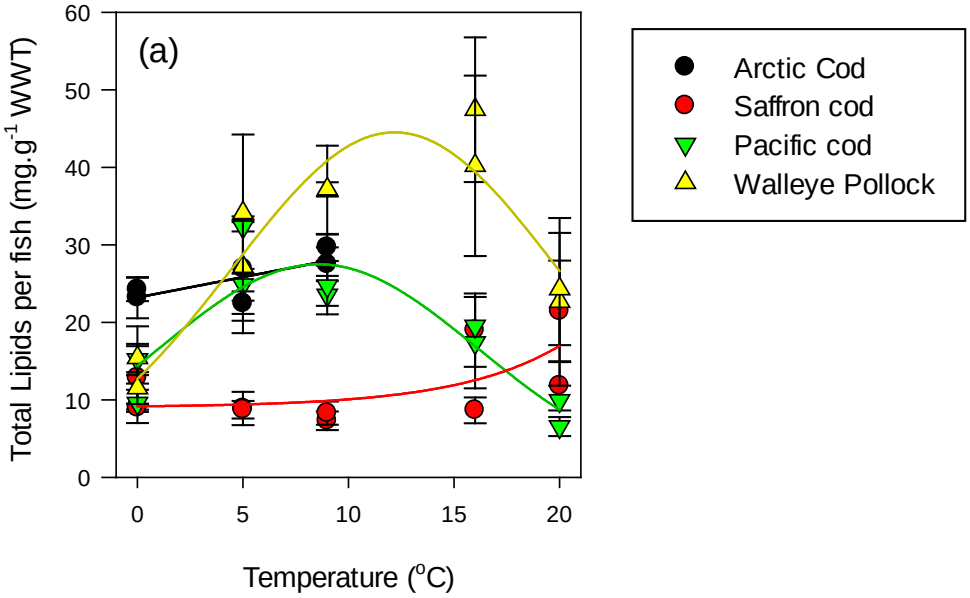
Optimal Thermal Habitats of Juvenile Gadids

PROJECT BACKGROUND: This research is designed to characterize the optimal thermal habitat of important fishery management species in Alaskan waters (walleye pollock, Pacific cod and saffron cod) using a standardized series of common garden experiments. These investigations will provide important habitat information by providing: 1) a scalable habitat metric for mapping species likelihood in data poor regions, and 2) a measure of habitat quality for regions already identified for summer and overwintering residency. The proposed research will provide vital input data for future efforts aimed at modeling how gadids populations might respond to changing thermal habitat across local and regional scales.

PROJECT PROGRESS: Copeman et al. completed all temperature-growth experiments on juvenile Arctic cod, saffron cod (Kodiak Alaska and Prudhoe Bay Alaska populations), walleye Pollock and Pacific cod. The figure below demonstrates the variable temperature-growth response of four different Alaskan Gadid species. It was found that Arctic cod have a growth advantage at very low temperatures but have high mortality and low growth at warmer temperatures. Temperate species such as walleye Pollock and Pacific cod show much high growth potential at warmer temperatures.



Copeman et al. completed lipid analyses on all species of fish used in temperature-growth experiments. Data analyses on total lipids and lipid classes from these fish is under analysis and is in preparation of a peer-reviewed manuscript for submission. The figure below demonstrates the variation in lipid storage in the 4 Alaskan Gadid species as a function of culture temperature. Results showed that juvenile Arctic cod are very fatty at low temperatures but had high mortality at high temperatures. In contrast, Walleye Pollock had very high fat levels and showed maximum fat storage at temperatures as high as 12 C.



PUBLICATIONS:

Laurel B.J., M. Spencer, P. Iseri, **L.A. Copeman.** (2015) Temperature-dependent growth and behavior of juvenile Arctic cod (*Boreogadus sadia*) and co-occurring North Pacific gadids. *Polar Biology (In Review).*

Copeman L.A., B.J. Laurel, A. Sremba, K. Klinck, R. Heintz, J. Vollenweider, K.M. Boswell, T. Helser, M. Spencer. (2015) Ontogenetic and spatial variability in trophic biomarkers of juvenile saffron cod (*Eleginus gracilis*) from the Beaufort, Chukchi and Bering Seas. *Polar Biology* (Accepted with Minor Revisions).

Amendment 42: Ecological Indicators of Ocean Conditions in the northern California Current

Funded: $158,568

OSU RESEARCH STAFF: *Jennifer Fisher*, Faculty Research Assistant, CIMRS; *Xiuning Du*, Research Associate, CIMRS

NOAA TECHNICAL LEAD: *Bill Peterson*, Fisheries Ecology, NWFSC

PROJECT BACKGROUND: The northern California Current (NCC) is an ecologically important region supporting numerous fish, bird and marine mammal populations. Based on long-term data sets focused on the hydrography and lower trophic-level dynamics within the NCC, it is clear that variations in climate, basin-scale forcing and regional and local processes all influence the food-web. Ocean ecosystem indicators provide information on the 'condition' of the ecosystem and have been successfully used to help predict future returns of culturally and economically important species (salmon) as well as provide an understanding of what factors may control the success of other managed fish species (e.g., sablefish, sardine) and top predators such as sea-birds.

PROJECT PROGRESS: Research cruises along the Newport Hydrographic (NH) Line were conducted bi-weekly over the last year, with a few exceptions due to inclement weather and sea-conditions, and the lack of availability of the research vessel (R/V *Elakha*) in November 2014 due to needed repairs. There were seven target stations sampled from 1 to 46 km from shore along the NH Line. At each station, measurements of hydrography (temperature, salinity, depth, dissolved oxygen, fluorescence) were made throughout the water column using a CTD (Seabird Model 25); water samples were collected for analysis of chlorophyll and nutrient concentrations, as well as phytoplankton community composition including Harmful Algal Bloom species detection; and zooplankton were sampled using a vertically towed plankton net as well as a larger, obliquely-towed, bongo-style net. All the water and net samples were pre-processed at sea and then brought back to the lab for final analysis. The past year sampling effort provided valuable information for an unusual year when the pelagic ecosystem has been strongly influenced by anomalously warm ocean conditions (the "Warm Blob") impacting the entire West Coast and by a developing El Niño event in the equator.

All physical and biological data are archived in a Microsoft Access database at the Northwest Fisheries Science Center's Newport, Oregon location. Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current.
http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm

Currently a collaboration with NWFSC IT and outreach specialists will launch a blog "Newportal: a gateway to oceanographic adventures from the Newport Line and beyond". The blog will feature up to date data and observations from the NH line and will broadcast more general information to the public. The target date for the blog to be operational is June 30, 2015.

CONFERENCES:

Oral presentation, 2014-2015 Pacific Anomalies Science and Technology Workshop, Scripps Institute of Oceanography, May 5-6, 2015

Changes to the hydrography and zooplankton in the northern California Current in response to 'the blob'

Jennifer L. Fisher, William T. Peterson, Jay Peterson
http://sccoos.org/projects/anomalies_workshop/

Oral presentation, Eastern Pacific Ocean Conference, Mt Hood, OR, September 17-20, 2014
Interannual variations in phytoplankton community structure in relation to upwelling and the Pacific Decadal Oscillation in the northern California Current
Xiuning Du, William T. Peterson, Linda O'Higgins
http://easternpacificoceanconference.org/EPOC_2014_Program.pdf

PUBLICATIONS:

Peterson, W. T., **J. L. Fishe**r, **J. O. Peterson, C. A. Morgan**, B. J. Burke, K. L. Fresh. 2014. Applied fisheries oceanography: Ecosystem indicators of ocean conditions inform fisheries management in the California Current. *Oceanography* 27(4):80-89, doi: 10.5670/oceanog.2014.88

Du X., Peterson W. T., **O'Higgins L**. 2015. Interannual variations in phytoplankton community structure in the northern California Current during the upwelling seasons of 2001-2010. *Marine Ecology Progress Series*, 519: 75-87. doi:10.3354/meps11097

Peterson W.T. and **Du. X**. 2015. Egg production rates of the copepod *Calanus marshallae* in relation to phytoplankton biomass and species composition in the coastal upwelling zone off Oregon, USA. (*In review, Progress in Oceanography*)

Amendment 44: Sanctuary Seafloor Maps
Funded: $15,000

OSU RESEARCH STAFF: *Chris Goldfinger*, Professor, College of Earth, Ocean, and Atmospheric Sciences; *Chris Romsos*, Faculty Research Assistant, College of Earth, Ocean, and Atmospheric Sciences
NOAA TECHNICAL LEAD: *Nancy Wright*, West Coast Regional Sanctuary Office

PROJECT BACKGROUND: NOAA's Olympic Coast National Marine Sanctuary program (OCNMS) has been collecting sidescan and multibeam seafloor data since 2000 and classifying habitats according to Greene et al.'s classification scheme. The data have been collected in a patchy network of geographic space and inadequately edge-matched. Each survey edge overlaps another survey at a different scale and often with a different sediment type classification. CIMRS investigators utilize the existing sidescan, multibeam and backscatter data to re-map and standardize a methodology to be used on all the available sonar data. They apply existing ground-truth information to determine sediment types and apply the modeled sediment types in Geocoder or Fledermaus software as appropriate. They re-characterize and reclassify the seafloor according to Greene et al. for ~ 5 of the datasets of the 20 total. Design work was created for a Seafloor Atlas on a scalable basis using OCNMS data in ArcGIS that connects to the shoreline and has the capability of incorporating new data as it is collected by OCNMS and other entities in WA.

PROJECT PROGRESS: In May 2015, OSU delivered a WebEx Video report to OCNMS personnel regarding this project. The first phase of the project consisted of technical cleanups of

as many of the 31 datasets as possible with available resources. There was success at making improvements on 19 of them at the time of the video report, others continue as of this writing. Significant improvement was made on several key datasets particularly those with severe navigation problems that had rendered the data unusable. Relatively simple smoothing of the navigation and re-mosaicing of these made the datasets quite usable. Others were improved by reprocessing with Geocoder sonar software, which removes most of the beam pattern and gain change noise in the data, and produces a new mosaic with better imagery where swaths overlap. Other datasets where original data were not available were improved by image processing, adjusting histograms, de-speckling and other methods. All data were then adjusted overall to make all datasets more similar visually for better visualization and interpretation.

The second main task has been quality control of the original OCNMS habitat maps derived from the 31 sonar surveys. These surveys have been added to the existing version 4.0 habitat map, and attempts have been made to resolve conflicts at boundaries, resolve classification differences, and clean up the GIS representation of these data. This work is also still ongoing. The third task has been to create a new Washington Seafloor Atlas web presence that incorporates these new data. This work is mostly complete in Beta form, and is awaiting comments from the OCNMS and Washington participants in the project. This task will be completed with receipt of appropriate feedback on content and the look and feel shell of the system. Some of this latter aspect may be done by or in collaboration with Washington DNR IT personnel.

Although the primary deliverables are nearly complete, work will continue under this funding to complete as many of the dataset improvements as possible in summer, 2015.

Amendment 46: Survey of Pelagic and Demersal Habitats

Funded: $28,796

OSU RESEARCH STAFF: *Jay Peterson*, Research Associate, CIMRS; *Jennifer Fisher*, Faculty Research Assistant, CIMRS

NOAA TECHNICAL LEAD: *Bill Peterson*, Fish Ecology, NWFSC

PROJECT BACKGROUND: This project aims to examine both the nearshore and the offshore habitats of fish and their food resources off the Oregon coast. CIMRS investigators continue to conduct a fishing vessel-based survey of YOY groundfishes along the NH-Line along with the plankton and physical oceanography sampling program. The project provides valuable information on the status of pelagic habitat relevant to early life history stages of many commercially and ecologically important species. Further, the project builds upon a long-term data set critical for detecting trends over time scales relevant to climate variability.

PROJECT PROGRESS: A series of pelagic and demersal habitat surveys were conducted from November 7-9, 2014 and March 3-5, 2015 aboard the FV Lady Law. The surveys sampled the Newport Hydrographic (NH) Line out to 65 (November) and 85 (March) nautical miles. In total, 12 stations were sampled in November and 13 in March. The sampling for pelagic habitat included full water column hydrography (temperature, salinity, dissolved oxygen, transmissivity,

fluorescence) using a CTD; water samples for nutrients, chlorophyll and phytoplankton species; and net samples for mesozooplankton and krill. Additionally, bottom trawl samples were conducted at 6 stations to quantify demersal fish and characterize the demersal habitat. The hydrographic data have been processed and entered in an MS Access database along with several of the biological and nutrient samples. Remaining samples are preserved and being stored until resources become available to process them. The sampling opportunity provided a valuable chance to combine resources and capabilities of the commercial fishing fleet with those of the scientific community. The information gathered comes during a period of a developing El Niño and anomalously warm conditions (the "Warm Blob") impacting much of the West Coast marine ecosystem. Data from these surveys will provide important information as to the impacts of extremely anomalous conditions on the northern California Current ecosystem.

Amendment 48: Ocean Indicator Surveys in the northern California Current Ecosystem

Funded: $126,781

OSU RESEARCH STAFF: *Jay Peterson*, Research Associate, CIMRS

NOAA TECHNICAL LEAD: *Bill Peterson*, Fish Ecology, NWFSC

PROJECT BACKGROUND: The northern California Current (NCC) is an ecologically important region supporting numerous fish, bird and marine mammal populations. Based on developing long-term data sets focused on the hydrography and lower trophic-level dynamics within the NCC, it is clear that variations in climate, basin-scale forcing and regional and local processes all influence the food-web. The ecosystem indicators provide information on the 'condition' of the ecosystem and have been successfully used to help predict future returns of culturally and economically important species (salmon) as well as provide an understanding of what factors may control the success of other managed fish species (e.g., hake, sardine) and top predators such as sea-birds. For this project pelagic surveys of waters off northern California and Oregon collect data primarily over the continental shelf, with a few transects extending out to the edge of the EEZ.

PROJECT PROGRESS: A pelagic survey was conducted from April 27 – May 8, 2015 aboard the R/V Pacific Storm. Sampling was conducted along an array of transects spanning the Oregon and Washington continental shelf and extending out to the edge of the EEZ (200 nautical miles) on the Newport Hydrographic (NH) Line off central Oregon. In total, 45 stations were sampled. The sampling included full water column hydrography (temperature, salinity, dissolved oxygen, transmissivity, fluorescence) using a CTD; water samples for nutrients, chlorophyll and phytoplankton species; and net samples for mesozooplankton and krill. The hydrographic data have been processed and entered in an MS Access database and the biological and nutrient samples are preserved and being stored until resources become available to process them. The sampling opportunity provided valuable information during an important time of year (Spring Transition), and in a year when the ecosystem is being strongly influenced by a developing El Niño and anomalously warm conditions (the "Warm Blob") impacting the entire West Coast.

Amendment 50: Long-term Observations of Physical and Biological Oceanographic Conditions in Coastal Waters off Oregon: Hydrography and Zooplankton
Funded: $100,000

OSU RESEARCH STAFF: *Jay Peterson*, Research Associate, CIMRS
NOAA TECHNICAL LEAD: *Bill Peterson*, Fish Ecology, NWFSC

PROJECT BACKGROUND: This project which monitors ocean conditions and zooplankton communities continues to produce a combined northern California Current copepod anomaly index annually. In addition, copepod abundance anomalies are calculated on a seasonal basis (spring, summer, fall) for comparison to sablefish, whiting, rockfish and Chinook and Coho salmon time series of recruitment and survival. CIMRS investigators monitor ocean conditions off the coast of Oregon sampling hydrography and plankton along the Newport Hydrographic Line (44.6°N) on a biweekly basis.

PROJECT PROGRESS: Research cruises along the Newport Hydrographic (NH) Line were conducted bi-weekly over the last year, with a few exceptions due to inclement weather and sea-conditions, and the lack of availability of the research vessel (RV Elakha) in November 2014 due to needed repairs. There were seven target stations ranging from 1 to 46 km from shore along the NH Line that were sampled. At each station visited, measurements of hydrography (temperature, salinity, depth, dissolved oxygen, fluorescence) were made throughout the water column using a CTD (Seabird Model 25). Water samples were collected for analysis of chlorophyll and nutrient concentration. Zooplankton were sampled using a vertically towed plankton net as well as a larger, obliquely-towed, bongo-style net. The zooplankton samples were preserved and brought back to the lab for analysis. All CTD data and a selection of the zooplankton samples, chlorophyll and nutrient samples have been processed and analyzed and entered into a Microsoft Access database located in Newport, Oregon. All remaining samples are archived until resources become available for processing.
The data have contributed to updates on "Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current" website
http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm .

Theme: Protection & Restoration of Marine Resources

Amendment 45: Dynamics and Management of Pacific Ocean Perch
Funded: $102,099

OSU RESEARCH STAFF: *Selina Heppell*, Professor, Department of Fisheries and Wildlife;
NOAA TECHNICAL LEAD: *Paul Spencer*, AFSC

PROJECT BACKGROUND: Project objectives include building an individual-based model (IBM) to characterize the interaction of maternal effects, environmental variability and

oceanographic conditions, and assess the impact of this interaction on population productivity and recruitment variability. The IBM will further serve as the operating model in a management strategy evaluation (MSE) to test stock assessment estimates of population productivity and other management reference points, as well as management performance (i.e., yield, variability of yield, and avoidance of stock depletion) when the interaction between maternal effects and environmental variability are not accounted for in the assessment.

PROJECT PROGRESS: IBM development is underway. A preliminary model was created in the modeling platform HexSim, however, it became necessary to switch platforms to resolve problems interfacing with the Regional Ocean Modeling System (ROMS). ROMS output for the Gulf of Alaska is provided by the Alaska Fisheries Science Center in Seattle, WA in the form of velocity vectors for currents as well as information on nutrients, phytoplankton and zooplankton. A base model is now programmed using the C language, which is anticipated to work better with ROMS.

Model development is in the early phase and there are no results yet to report.

MEETINGS/PRESENTATIONS:

Arnold, L.M. An individual-based model for evaluation of maternal effects and spatio-temporal environmental variability on dynamics and management of Pacific ocean perch, *Sebastes alutus. FATE Science Meeting*, La Jolla, CA January 15, 2015.

Amendment 51: Stock Assessment Research Review of Pacific Hake

Funded: $16,878

OSU RESEARCH STAFF: *David Sampson*, Professor, Department of Fisheries and Wildlife
NOAA TECHNICAL LEAD: *Michelle McClure*, FRAM/NWFSC

PROJECT BACKGROUND: The coastal stock of Pacific hake (*Merluccius productus*), known commonly as Pacific whiting, annually migrates between U.S. and Canadian waters. The stock is managed jointly by the U.S. and Canada under provisions of the Pacific Whiting Treaty, which established a Joint Management Committee that sets the annual total allowable catch of whiting, a Joint Technical Committee (JTC) that conducts stock assessments and other technical analyses to provide the scientific basis for harvest management decisions, and a Scientific Review Group (SRG) that provides independent peer review of the technical work of the JTC. The SRG includes two members appointed by the U.S. government, two members appointed by the Canadian government, and two members nominated by the Treaty's Industry Advisory Panel. Dr. Sampson was appointed to the SRG as one of the industry-nominated reviewers. In addition to the regular members of the SRG, the 2015 review panel included Dr. François Gerlotto, who was provided as an independent reviewer by the Center for Independent Experts.

PROJECT PROGRESS: Dr. Sampson's primary activity for this project was participation in a four-day meeting of the SRG held at the Morris J. Wosk Centre for Dialogue in Vancouver, British Columbia on 24-27 February 2015. Additional activities included participation in a telephone conference call on 13 February 2015 to review the Terms of Reference for the SRG review and the agenda for the review meeting, preparing for the meeting by reading the draft

2015 stock assessment document and the supporting reports and analyses that had been provided, contributing text to the SRG's report to the Joint Management Committee, and subsequently finalizing the SRG report by email correspondence.

The 2015 assessment for the coastal Pacific hake stock and related analyses had been conducted during the summer and fall of 2014 and early winter 2015 by the members of the JTC, consisting of two stock assessment biologists (Allan Hicks and Ian Taylor) from the Northwest Fisheries Science Center, National Marine Fisheries Service, two stock assessment biologists (Nathan Taylor and Chris Grandin) from the Pacific Biological Station, Fisheries and Oceans Canada, and a consulting academic (Sean Cox) from Simon Fraser University. The assessment was an update of the 2014 assessment, with the addition of one more year of landings and age-composition data for the commercial fishery. Because the standard acoustic survey had not been conducted during 2014, there were no additional survey data to inform the 2015 assessment. The JTC made no changes to the fundamental structure of the assessment model.

In addition to producing the standard stock assessment, the JTC also reported on additional work conducted since the 2014 SRG meeting on the JTC's simulation-based evaluation of the performance of the stock assessment and management process. A description of this management strategy evaluation (MSE), which the JTC reported on at the 2014 SRG review meeting, is in the process of being published as a book chapter (Hicks et al., *In Press*).

Stock Assessment Review

The review of the stock assessment, which occurred during the first two days of the meeting, was structured around a series of presentations by JTC members and members of the research survey team who were involved in conducting the hydro-acoustic surveys and working up the survey data for the assessment. The formal presentations included an overview of research conducted during 2014 by the hydro-acoustic survey team, summaries of the 2014 U.S. and Canadian fisheries, an overview of the data sources used in the 2015 assessment, an overview of the draft 2015 assessment, and an overview of some planned work related with the MSE. Following the presentations there were general discussions between the members of the SRG and JTC regarding potential issues associated with either the data inputs or how the JTC had chosen to structure the Stock Synthesis assessment model.

As had been the case during the 2014 SRG meeting, much of the discussion at the 2015 review again focused on concerns with the method used to spatially interpolate the acoustic survey data between the survey transects and extrapolate from the data into the regions at the ends of the transects. About 30% of the 2013 estimated survey biomass was associated with regions that extend beyond the area covered by the survey.

During the first two days of the review meeting the SRG developed several formal requests to the JTC to prepare additional summary information and conduct some additional analyses, with the goal of clarifying that the assessment model provided a suitable representation of the status of the Pacific hake stock and its likely behavior during the next few years. The JTC was very responsive to the requests for additional information and analyses, and Dr. Sampson commended them for their willingness to explain their work and to share with others their understanding of the behavior of this complicated fish stock and its fishery.

During the morning of the fourth day of the review the SRG, JTC and Advisory Panel advisors discussed the findings and conclusions of the review, formulated recommendations to the Joint Management Committee (JMC) on harvest management advice and future research activities, and prepared some of the SRG report. The review concluded at about 1 pm on February 27th.

SRG Report Preparation

The SRG report summarizing the review meeting was prepared jointly by the members of the SRG, with John Holmes, the Canadian co-chair, taking the lead on assembling the draft report and circulating it to the rest of the SRG. The 2015 SRG meeting occurred one week later than in 2014, which meant that the time-line for completing the SRG report was severely compressed. According to the Treaty, the 2015 SRG report should have been sent to the JMC by March 1st, the Sunday after the conclusion of the SRG meeting. The SRG attempted to complete their report by this unrealistic deadline, but failed to do so. The report was finalized by email correspondence following the SRG meeting and was sent to the JMC on March 5th.

Dr. Sampson is in full agreement with the findings and conclusions as stated in the Joint U.S.-Canada Scientific Review Group Report, which can be obtained on-line from the following web-site, http://www.westcoast.fisheries.noaa.gov/fisheries/management/whiting/pacific_whiting_treaty.html.

Documents reviewed during this panel session:

Gerlotto, F., 2014. Center for Independent Experts (CIE) Panel Review of the Joint Pacific Sardine and Hake (SaKe) acoustic-trawl surveys: Review report.

Hicks, A.C., Cox, S., Taylor, N., Taylor, I.G., Grandin, C., and Ianelli, J. *In Press*. Conservation and yield performance of harvest control rules for the transboundary Pacific hake (*Merluccius productus*) fishery in U.S. and Canadian waters.

International Joint Technical Committee for Pacific hake, 2015. Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2015. Draft document dated 02/09/2015.

Melvin, G.D. 2014. Center for Independent Experts (CIE) Panel Review of the Joint Pacific Sardine and Hake (SaKe) acoustic-trawl surveys: Summary Report of Panel Proceedings.

Rose, G.A., 2014. Center for Independent Experts (CIE) Panel Review of the Joint Pacific Sardine and Hake (SaKe) acoustic-trawl surveys: Review report.

Volstad, J.H., 2014. Center for Independent Experts (CIE) Panel Review of the Joint Pacific Sardine and Hake (SaKe) acoustic-trawl surveys: Review report.

Theme: Seafloor Processes

Amendment 28: Impacts of Submarine Volcanism and Hydrothermal Venting on the Global Ocean and Deep-Sea Ecosystem
Funded: $1,514,635

OSU RESEARCH STAFF: *William Chadwick*, *Robert Dziak*, Professors, Senior Research, CIMRS; *Haru Matsumoto*, Assistant Professor, Senior Research, CIMRS; *Andy Lau*, Professional Faculty, Applied Mathematician, CIMRS; *Joe Haxel*, Research Associate, Post-Doc; *Andra Bobbitt*, *Susan Merle*, Senior Faculty Research Assistants, CIMRS; *Leigh Evans*, *Matt Fowler*, Faculty Research Assistants, CIMRS; *Michelle Fournet*, Graduate Student
NOAA TECHNICAL LEAD: *Jeremy Mathis/Chris Sabine*, PMEL

Volcanic and Hydrothermal Event Detection in the Northeast Pacific

PROJECT BACKGROUND: The efficient propagation of sound in the oceans highlights the beneficial use of underwater acoustics for studies involving geophysical seafloor processes, assessing the health of marine ecosystems, marine mammal and fish behavior, and climatic processes near the polar regions. Project analysis of hydroacoustic recordings from fixed and mobile platforms provides information on submarine volcanic events and gas fluxes, long-term ambient noise levels, marine mammal vocalizations, signals radiated by sea ice and glacial decomposition, as well as anthropogenic contributions to regional soundscapes all in support of NOAA's Goal for Healthy Ocean and Ecosystems.

PROJECT PROGRESS: Professor Robert Dziak performed analysis and published a manuscript on ice-generated noise levels and other sound source contributions to the soundscape of the Bransfield Strait near the Antarctic Peninsula. He also lead research analysis and published a study of long-term gas flux and catastrophic slope failure recorded by a hydrophone moored near West Mata volcano in the southwest Pacific Ocean.

Assistant Professor Haru Matsumoto continued his development of innovative acoustic technologies for use on fixed and mobile platforms. He is currently developing a hydrophone for deployment on a winch buoy that can remain submerged for extended time periods, then come to the sea-surface to transmit data back to shore in real-time. Additionally, he is developing hydrophone and data acquisition systems on buoyancy driven gliders for acoustic marine mammal detection.

Assistant Professor Joseph Haxel continued analysis and preparation of a manuscript for a study using the 20 year U.S. Navy SOSUS archive, mapping a fin whale vocalization activity index throughout the north Pacific and comparing energy levels with vessel generated noise. He also began development for data processing algorithms for acoustic data collected during a glider mission along the shelf break of the Pacific Northwest coast.

Assistant Professor Holger Klinck lead planning and logistics for the deployment of 10 hydrophone moorings located within US EEZ waters and forming the NOAA Ocean Noise Reference Station network. The principal objective of this project is to monitor long-term changes and trends in the Arctic underwater ambient sound field. Calibrated autonomous underwater hydrophone packages (AUHs) are being used to precisely record underwater ambient sound levels with 16 bits resolution (i.e., with 96 dB dynamic range) in the 10 Hz to 2,500 Hz frequency range.

Associate Professor David Mellinger lead efforts to further software development of marine mammal acoustic detection and density estimation algorithms with intent toward making them freely available to users through a variety of existing software platforms.

Applied Mathematician T-K Lau continues to develop software that allows estimates of gas flux from submarine volcanoes by using hydrophone records of volcanic explosions. Lau also performed daily review of SOSUS records of significant earthquake and volcanic activity from the Juan de Fuca Ridge in the northeast Pacific Ocean until access to the data was removed in fall 2014.

Faculty Research Assistant Matt Fowler assisted Matsumoto in construction and development of hydrophone instruments and moorings and new development of acoustic sensors for mobile platforms. Faculty Research Assistant Anna Semple prepared fiscal reports and performed data analysis on a variety of acoustic data sets. She also co-lead the development of a social media outreach effort for the program.

CRUISES:

M. Fowler**,** November 29 – December 21, 2014, *R/V* Revelle, expedition to NW Rota volcano as a mooring technician supporting Acoustics and EOI programs.

PUBLICATIONS:

Dziak, R.P., D.R. Bohnenstiehl, E.T. Baker, **H. Matsumoto**, J. Caplan-Auerbach, R.W. Embley, **S.G. Merle**, S.L. Walker, **T.-K. Lau**, and **W.W. Chadwick, Jr.** (2015): Long-term explosive degassing and debris flow activity at West Mata submarine volcano. *Geophys. Res. Lett.* 42(5), 1480–1487, doi: 10.1002/2014GL062603.

Dziak, R.P., D.R. Bohnenstiehl, K.M. Stafford, **H. Matsumoto**, M. Park, W.S. Lee, **M.J. Fowler, T.-K. Lau, J.H. Haxel, and D.K. Mellinger** (2015): Sources and levels of ambient ocean sound near the Antarctic Peninsula. *PLoS ONE* 10(4), e0123425, doi: 10.1371/journal.pone.0123425.

Embley, R.W., **S.G. Merle**, E.T. Baker, K.H. Rubin, J.E. Lupton, J.A. Resing, **R.P. Dziak**, M.D. Lilley, **W.W. Chadwick, Jr.**, T. Shank, **R. Greene**, S.L. Walker, **J. Haxel**, E. Olson, and T. Baumberger (2014): Eruptive modes and hiatus of volcanism at West Mata seamount:, NE

Lau basin: 1996–2012. *Geochem.Geophys.Geosyst.* 15(10), 4093–4115, doi: 10.1002/2014GC005387.

Research on the Near- and Far-field Physical and Chemical Impacts and Consequences to Ocean Ecosystems Caused by Submarine Volcanoes and Hydrothermal Venting
and
Interpreting Digital Seafloor Bathymetry and Imagery, From Ship-based sonar, Deep-Towed Sidescan, Optical Sensors, Submersible and Remotely Controlled Vehicles

PROJECT BACKGROUND: CIMRS researchers study and document interactions between submarine volcanic events, hydrothermal systems, and chemosynthetic ecosystems. Time-series studies are focused at Axial Seamount, the most active submarine volcano in the NE Pacific. Axial has been a long-term research site because it is the only site in the world where a repeatable (and apparently predictable) cycle of inflation and deflation has been documented at a submarine volcano. The seamount is a node on the Cabled Array component of the National Science Foundation's Ocean Observatories Initiative (OOI), which is opening up new research opportunities. For example, CIMRS researchers collaborated with NOAA/PMEL Engineers to design and build bottom pressure/tilt instruments that were installed on the OOI cabled observatory. In April 2015, those instruments detected the start of an eruption at Axial Seamount that had been previously forecast, based on the inflation/deflation time-series.

Another focus of CIMRS research is exploration of submarine volcanoes and hydrothermal vent ecosystems in the subduction zones of the western Pacific (the Mariana & Kermadec arcs, and the Lau Basin). Part of this research is the use of repeated sonar mapping for detecting depth changes on the seafloor due to volcanic eruptions. These depth changes can be either positive (due to the addition of erupted material) or negative (due to collapses or landslides on unstable slopes). Documenting and quantifying these changes enables the calculation of eruption volumes and rates, yields opportunities to explore the interaction between constructive and destructive events at submarine volcanoes, and gives insight into the processes of how volcanoes grow underwater.

Another aspect of this exploration is investigating the fate and consequences of hydrothermal outputs into the global ocean. A powerful tool in this research is the Helium Isotope Lab located in Newport. Helium-3 comes from the earth's mantle and is inert and conservative, so it is an unambiguous tracer of hydrothermal discharge. Thus, this isotope of helium can help identify vent sites in unexplored areas as well as track emissions across entire ocean basins.

These projects contribute to the NOAA mission of science, service, and stewardship through the Healthy Ocean Goal of sustaining marine habitats and biodiversity within healthy and productive ecosystems. CIMRS research also supports OAR's main science goal of gaining a holistic understanding and making useful predictions of future states of the Earth-Ocean system. Likewise, CIMRS research falls under 3 of the 5 PMEL research themes: Marine Ecosystem Research, Ocean and Coastal Processes Research, and Research Innovation.

PROJECT PROGRESS: Work under these projects continued in FY15 with a focus on Axial Seamount in the NE Pacific, NW Rota and other seamounts in the Mariana Arc, and West Mata Seamount in the NE Lau Basin.

Professor Chadwick, Senior Faculty Research Assistant Bobbitt, Faculty Research Assistant Evans and Senior Faculty Research Assistant Merle participated in a research expedition to the Marianas on R/V Revelle with ROV Jason, November 29-December 21, 2014. Chadwick served as Co-Chief Scientist on the cruise and led geologic studies, Bobbitt and Merle shared data processing and data management duties, and Evans collected and chemically analyzed gas-tight vent fluid samples. Bobbitt also produced a comprehensive cruise report after the expedition and submitted data to the Marine Geoscience Data System for archiving. Research on the cruise included collecting multibeam sonar data and collection of vent fluid and microbial samples from hydrothermal vents during ROV Jason dives to better understand the microbial ecosystems that form the base of the food chain at seafloor hot springs.

Research results from data collected on previous expeditions and other on-going work were presented at 2014 Fall Meeting of the American Geophysical Union (AGU) in San Francisco and were published in peer-reviewed journals. The meeting presentations included CIMRS co-authorship on six posters (note: Chadwick, Bobbitt, Merle, and Evans were all at sea and could not attend the meeting).

MEETING PRESENTATIONS:

Baumgardt, E., S. L. Nooner, and **W. W. Chadwick Jr.** (2014), Magma Dynamics at Axial Seamount, Juan de Fuca Ridge, from Seafloor Deformation Data. Abstract V31B-4744 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

Caplan-Auerbach, J., **R. P. Dziak**, **W. W. Chadwick Jr.**, and **T.-K. Lau** (2014), Analysis of submarine landslides at West Mata volcano, NE Lau Basin, using hydroacoustic data. Abstract V11B-4708 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

Dziak, R. P., and **S. G. Merle** (2014), Axial, Brownbear and Cobb Seamounts: Examples of the growth and demise of the submarine volcanic edifice through time. Abstract presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

Embley, R. W., J. A. Resing, B. Tebo, E. T. Baker, D. A. Butterfield, **W. W. Chadwick Jr.**, R. E. Davis, C. E. J. de Ronde, M. D. Lilley, J. E. Lupton, **S. G. Merle**, K. H. Rubin, T. M. Shank, S. L. Walker, R. J. Arculus, **A. M. Bobbitt**, N. J. Buck, F. C. Tontini, P. V. Crowhurst, E. Mitchell, E. Olson, V. Ratmeyer, S. Richards, K. K. Roe, P. Kenner-Chavis, A. Martinez-Lyons, C. Sheehan, and R. Brian (2014), Extensive hydrothermal activity in the NE Lau Basin revealed by ROV dives. Abstract OS53C-1052 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

Embley, R. W., R. J. Stern, **W. W. Chadwick Jr.**, Y. Tamura, and **S. G. Merle** (2014), Sediment wave-forms and modes of construction on the seafloor around Mariana (and other)

arc volcanoes. Abstract V11B-4701 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

Haney, M. M., **W. W. Chadwick Jr., S. G. Merle**, N. J. Buck, D. A. Butterfield, M. L. Coombs, L. G. Evers, K. Heaney, J. J. Lyons, C. K. Searcy, S. L. Walker, C. Young, and R. W. Embley (2014), The 2014 submarine eruption of Ahyi Volcano, Northern Mariana Islands. Abstract V11B-4727 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.

PUBLICATIONS:

Caplan-Auerbach, J., R. P. Dziak, D. R. Bohnenstiehl, **W. W. Chadwick Jr.**, and T.-K. A. Lau (2014) Hydroacoustic investigation of submarine landslides at West Mata volcano, Lau Basin. *Geophys. Res. Lett.* 41, doi:10.1002/2014GL060964.

Chadwick, W. W., Jr., S. G. Merle, N. J. Buck, J. W. Lavelle, J. A. Resing, and V. L. Ferrini (2014) Imaging of CO2 bubble plumes above an erupting submarine volcano, NW Rota-1, Mariana Ar., *Geochem. Geophys. Geosyst.* 15(11): 4325–4342, doi:10.1002/2014GC005543.

Geist, D., G. Bergantz, and **W. W. Chadwick, Jr.** (2014) Galápagos Magma Chambers, in The Galápagos: A Natural Laboratory for the Earth Sciences, edited by K. S. Harpp, E. Mittelstaedt, N. d'Ozouville and D. W. Graham, Geophysical Monograph 204, pp. 55-70, American Geophysical Union, Washington DC.

de Ronde, C. E. J., S. L. Walker, R. G. Ditchburn, F. C. Tontini, M. D. Hannington, **S. G. Merle**, C. Timm, M. R. Handler, R. J. Wysoczanski, V. M. Dekov, G. D. Kamenov, E. T. Baker, R. W. Embley, J. E. Lupton, and P. Stoffers (2014) The anatomy of a veiled submarine hydrothermal system, Clark volcano, Kermadec arc, New Zealand. *Econ. Geol*. 109: 2261–2292, doi:10.2113/econgeo.109.8.2261.

de Ronde, C. E. J., **W. W. Chadwick, Jr.**, R. G. Ditchburn, R. W. Embley, V. Tunnicliffe, E. T. Baker, S. L. Walker, V. L. Ferrini, and **S. M. Merle** (2015), Molten sulfur lakes of intraoceanic arc volcanoes, in Volcano Lakes, edited by D. Rouwet, B. Christenson, F. Tassi and J. Vandelbroulemuck, Springer-Verlag, Berlin Heidelberg.

Dziak, R. P., D. R. Bohnenstiehl, E. T. Baker, **H. Matsumoto**, J. Caplan-Auerbach, R. W. Embley, **S. G. Merle**, S. L. Walker, A. T.-K. Lau, and **W. W. Chadwick Jr.** (2015) Long-term explosive degassing and debris flow activity at West Mata submarine volcano. *Geophys. Res. Lett.* 42, doi:10.1002/2014GL062603.

Embley, R. W., **S. G. Merle**, E. T. Baker, K. H. Rubin, J. E. Lupton, J. A. Resing, **R. P. Dziak**, M. D. Lilley, **W. W. Chadwick Jr.**, T. Shank, R. Greene, S. L. Walker, **J. Haxel**, E. Olson, and T. Baumberger (2014) Eruptive modes and hiatus of volcanism at West Mata seamount, NE Lau Basin: 1996-2012. *Geochem. Geophys. Geosyst.* 15: 4093-4115, doi:10.1002/2014GC005387.

Embley, R. W., Y. Tamura, **S. G. Merle**, T. Sato, O. Ishizuka, **W. W. Chadwick Jr.**, D. A. Wiens, P. Shore, and R. J. Stern (2014) Eruption of South Sarigan Seamount in the Commonwealth of the Northern Mariana Islands: Insights into hazards from submarine volcanic eruptions. *Oceanography* 27(2): 24-31, doi:10.5670/oceanog.2014.37.

Theme: Marine Bioacoustics

Amendment 26: Pinniped Acoustic Controlled Exposure Study: PACES Phase II
Funded: $69,946

OSU RESEARCH STAFF: *Holger Klinck*, Assistant Professor, Senior Research, CIMRS; *Samara Haver*, Graduate Student
NOAA TECHNICAL LEAD: *Jason Gedamke*, Ocean Acoustics, Office of Science and Technology, NMFS

PROJECT BACKGROUND: The Pinniped Controlled Exposure Study (PACES) aims to develop and test a new methodology by using an animal-borne active acoustic tag to conduct controlled sound exposure experiments on free-ranging, naïve marine mammals in their natural habitat. Controlled sound exposure experiments are essential to evaluate the effects of anthropogenic noise on marine mammals and can help scientists and regulators understand the behavioral responses and physiological consequences to anthropogenic noise (i.e. naval sonar sounds and seismic airgun pulses), but currently available data are very sparse, limiting the ability for regulating agencies to make informed decisions. Specific goals of PACES – Phase II are to continue and complete a detailed analysis of all data collected during the Phase I field trials and to develop an improved tag design with potential for longer term deployments and deployment on cetacean species of interest.

PROJECT PROGRESS: Results of this pilot project showed that the prototype tag does elicit behavioral responses in tagged individuals. Responses during the ascending phase of a dive consisted of a dive inversion, with the animal diving as deep as or deeper than its original dive depth (seven of nine exposures). Change in dive depth following exposure was significantly larger than change in depth for non-exposure inversions. A single exposure at the bottom phase of a deep dive followed the same pattern. Dive inversions were observed following white noise, sperm whale clicks, killer whale whistles, and sonar exposures, but not following common dolphin whistles. Responses to exposures received during the descending phase of a dive resulted in an increased descent rate in nine of ten exposures. All eight exposures during shallow dives, where the animals were likely limited by bathymetry from diving any deeper, were characterized by increased flow noise following exposure, an indicator of increased swim speed. Results showing differential responses to specific exposure stimuli were inconclusive. Tag improvements and additional field efforts are needed to validate the tag's use in behavioral response studies to specific acoustic stimuli. There is potential to use this technology to study physiological effects of extended deep dives on marine mammals as well as frequency dependent hearing because of its ability to induce prolonged, unplanned dives in response to man-made sounds.

The new version of the tag will have an integrated depth sensor, eliminating the need for an external depth recorder, and will combine several of the components implemented separately in the prototype tag into one potted, rechargeable system. Completion of this development effort is planned for FY16.
Results of the pilot study have been published in a recent M.Sc. thesis by Selene Fregosi (2015). A peer-reviewed publication is in preparation for submission to Journal of Experimental Biology.

PRESENTATIONS:

Fregosi, S.**, Klinck, H.**, Horning, M., **Mellinger, D.K.**, Costa, D.P., Mann, D.A., Sexton, K., Huckstadt, L, and Brandon L. Southall. Integration of an active acoustic playback system with an animal-borne sensor suite for behavioral response studies. 5th International Bio-logging Science Symposium, Strasbourg, France, 22-27 September 2014.

Fregosi, S. Development and evaluation of an animal-borne active acoustic tag for conducting behavioral response studies. 18th Annual Meeting of the Northwest Student Chapter of the Society for Marine Mammalogy, Bellingham, WA, USA, 3 May 2014.

PUBLICATIONS:

Fregosi, S. (2015) Development and Evaluation of an Animal-borne Active Acoustic Tag to Conduct Minimally Invasive Behavioral Response Studies on Marine Mammals. Masters of Science Thesis. Oregon State University, Corvallis, Oregon, June 2015, 98 pages.

Amendment 27 & 34: Advanced Methods for Passive Acoustic Detection, Classification, and Localization of Marine Mammals

Funded: $150,575

OSU RESEARCH STAFF: *David Mellinger*, Associate Professor, Senior Research, CIMRS; *Sara Heimlich, Curtis Lending*, Faculty Research Assistants CIMRS

NOAA TECHNICAL LEAD: *Jonathan Klay*, Computing and Network Services, PMEL

PROJECT BACKGROUND: Over the last decade, significant progress has been made in the development of marine mammal passive acoustic detection, classification, and localization (DCL) algorithms and software. This project brings together leaders in the field in a focused collaboration to develop advanced DCL methods and to implement them in widely-used and critical software. Methods for detecting and classifying clicks from odontocetes and tonal sounds from odontocetes and mysticetes (whistles and moans, respectively) are tested using data sets drawn from candidate species that produce these signal types. Advanced localization algorithms are being developed with a focus on species that produce highly directional echolocation clicks; these make traditional multi-sensor localization difficult, whether it used sonobuoys, cabled arrays, and or arrays of floating recording buoys. To be maximally beneficial to the community, these new advanced algorithms must be widely available in multiple software systems. This project develops standardized interface specifications for detection, feature extraction, classification, and

localization that will make adding new DCL methods relatively simple for both this project and the wider marine mammal DCL community.

PROJECT PROGRESS: Progress in FY15 is detailed below in several categories. *Detection/classification algorithms: tonal sounds.* Advanced automated detection/classification methods have been developed and applied to fin, sei, Bryde's, minke, and humpback whales (Fig. 1). The minke algorithm includes detection of minke boing calls, while the other detections are more generic: for humpback song units between 200 Hz and 1200 Hz, and for fin, sei, and Bryde's whale calls between approximately 15 Hz and 50 Hz. Humpback whale song unit processing is also done using the Generalized Power Law (GPL) detector (Helble 2012). Improvements include a common parallel-processing front end.

Another approach to whistle classification has concentrated on increasing the purity of the automatically generated whistle clusters prior to training hidden Markov models. We also completed work on exploiting ridge information in spectrograms to help identify delphinid whistles (Kershenbaum and Roch, 2013). By looking at a spectrogram as a topological map, it is possible to examine the direction in gradient vectors and look for coherent regions where the signs of the gradient vectors swap. This algorithm has been incorporated into our whistle extraction algorithm *Silbido* (Roch et al., 2011a). Work on unsupervised clustering of whistles was also refined. The techniques have been evaluated on spinner (*Stenella longirostris*), common (*Delpinus* spp.), and bottlenose dolphins (*Tursiops truncatus*); all show potential for stable unsupervised whistle component clustering (Fig. 2).

Detection/classification algorithms: odontocete clicks. An iterative normalized least mean squares (NLMS) method and a subspace-based method – to separate a raw audio stream into 'noise' and 'signal' components – were developed for noise reduction in ocean recordings. Although the methods are not capable of completely separating clicks from noise, they do improve the signal-to-noise ratio of the clicks and help improve detection performance. A new detector was developed using NLMS and the noise-subspace method combined with the existing energy ratio mapping algorithm (ERMA) detector (Klinck and Mellinger 2011). This combination improved overall performance at detecting clicks of Blainville's beaked whales in noise. A paper on this was written (Lu et al. in prep.).

Blainville's beaked whales generate homing pulses, termed buzzes, prior to prey capture attempts. Buzz clicks not only are produced as a significantly faster inter-click interval ($ICI_{buzz} << ICI_{forage}$), but the structure of the click is also different (Jarvis et al. 2008). A class-specific support vector machine (CS-SVM) classifier (Jarvis 2012) was developed specifically for *Md* buzz clicks. However, since buzzes have a much lower source level than foraging clicks, the detection threshold of the buzz classifier must be set correspondingly lower. Running the buzz class, with its very low threshold, continuously can cause an unacceptably high number of false alarms. To avoid this problem, the buzz classifier is launched only after a *Md* foraging click-train has been detected (i.e., 80% of all the clicks detected in the past 20 s have been classified as *Md* foraging clicks). Then the buzz classifier runs for only 30 minutes, the average vocal period of an *Md* dive. See Figs. 3-5.

Localization and tracking. Humpback song unit automated localizations are being investigated via cross correlation of GPL outputs, rather than spectrograms or raw time series, and are showing promise. GPL processing appears to work in the presence of Navy MFAS activity.

Two model-based localization methods have been developed for baleen whale localization. One uses detection start times and associations to determine time difference of arrivals, while the second uses cross-correlation of call *sequences* between hydrophone pairs. The Matlab implementation of the first method was initially pursued on this effort with new capabilities (e.g., depth estimation) and refinements being done in collaboration with an LMR project (see Related Projects, below). By automatically associating sequential localizations to individual whales, additional information on the species is available such as acoustic ecology (e.g. call rates) and kinematic behavior (e.g. speed, depth, heading rates). This may be termed 'tracking' of individuals and serves to automate what humans do visually when presented time sequences (time) of whale localizations presented on nautical charts (space).

For minke, fin, sei, Bryde's, and humpback whales, rudimentary kinematic tracking of individual whales enabled automatic call interval analysis. Call intervals automatically obtained not only helped confirm the species, but also added information on the species' call rates and behavior.

Last year a number of advances were made on localization of beaked whales using time differences of arrival (TDOAs) gained from widely spaced sensors (Baggenstoss in press). A difficulty that occurs in localization is the large number of ambiguous solutions (Fig. 6), arising from false time-delay measurements arise when the TDOA is measured between clicks or click-trains from different sources, different propagation paths, or different periods of a given click train. The method developed here is an efficient algorithm that can efficiently track multiple whales in real time. Our approach uses a multi-hypothesis tracker (MHT) with pruning to maintain a large number (thousands) of candidate tracks. With each new update, each track is updated as a Kalman filter using several potential associations, then candidate tracks are pruned. Examples are shown in Figs. 7-8. The track position of a DTAGged whale obtained from the MHT algorithm compared favorably to the ground truth position data from the tag (Figs. 9-10).

Software: The architecture for writing detection, classification, and localization modules has been completed and communication between Ishmael and PAMGUARD and a test module has been established. The architecture provides a translation library for each DCL platform supported that marshals data into a format that can be shared with other processes. Modules run as separate programs that share a limited region of memory with the DCL platform. This allows modules written on platforms that require separate processes (e.g. Matlab, R) to be gracefully handled. Users designing classification modules will configure the DCL platform to send data to their module and make calls to a standard interface library. Results are sent back to the DCL platform in a similar manner. The plug-in architecture has been demonstrated with pass through (identity function) modules in Java and C. Ongoing work is developing interfaces to handle event processing such as passing detections or localizations to PAMGUARD/Ishmael for further processing.

Subawardee Marie Roch at San Diego State University developed new noise compensation techniques to mitigate for effects of site and equipment variation and published the findings of

the results (Roch *et al.*, 2015); a side project applying techniques developed from this project on acoustically distinguishing endangered false killer whale populations from pilot whales has been accepted for publication (Baumann-Pickering *et al.*, in press). Progress has been made on the application programming interface (API) for detection, classification, and localization and the system can now perform basic tasks in both Ishmael and PAMGUARD acoustic streams. Adjustments are being made to the API based on joint meetings between our two labs. Significant improvements to precision in the *silbido* tonal detector have been made and presented at the 2015 Intl. Workshop on Detection, Classification, Localization, and Density Estimation (DCLDE). In addition, large scale experiments that expand upon the techniques developed in Roch et al. (2015) were presented. The ADCL project was the only group to participate in the 6 terabyte high-frequency data challenge.

A paper on whistle clustering and classification was submitted and is currently being revised ("Automated identification of common subunits within delphinid vocalizations"). Support also enabled participation in a review and prospectus on vocal sequence analysis (Kershenbaum *et al.*, in press), something that has the potential to inform future work on context-aware classification, one of the central focuses of discussion during the DCLDE workshop.

PUBLICATIONS:

Baumann-Pickering, S., Simonis, A. E., Oleson, E. M., Baird, R. W., and Roch, M. A.2015 (in press). "False killer whale and short-finned pilot whale acoustic identification," *Endang. Species Res.*

Kershenbaum, A., Blumstein, D. T., Roch, M. A., Akçay, Ç., Backus, G., Bee, M., Bohn, K., Cao, Y., Carter, G., Cäsar, C., Coen, M., DeRuiter, S. L., Doyle, L., Edelman, S., Ferrer-i-Cancho, R., Freeberg, T. M., Garland, E. C., Gustison, M., Harley, H. E., Huetz, C., Hughes, M., Bruno, J. H., Ilany, A., Jin, D. Z., Johnson, M., Ju, C., Karnowski, J., Lohr, B., Manser, M. B., McCowan, B., Mercado III, E., Narins, P. M., Piel, A., Rice, M., Salmi, R., Sasahara, K., Sayigh, L., Shiu, Y., Taylor, C., Vallejo, E. E., Waller, S., and Zamora-Gutierrez, V. (in press). "Acoustic sequences in non-human animals: A tutorial review and prospectus," *Biological Reviews.*

Roch, M. A., Stinner-Sloan, J., Baumann-Pickering, S., and Wiggins, S. M. (2015). "Compensating for the effects of site and equipment variation on delphinid species identification from their echolocation clicks," *J. Acous. Soc. Am.* 137(1):22.

Amendment 39/40: Real-time Acoustic Observing System for Marine Mammals

Funded: $39,999

OSU RESEARCH STAFF: *Holger Klinck*, Assistant Professor, Senior Research, CIMRS

NOAA TECHNICAL LEAD: *Brad Hanson*, Conservation Biology, Northwest Fisheries Science Center, NMFS

PROJECT BACKGROUND: The goal of this project has been to develop a small, easy to deploy, and cost-efficient near-real-time acoustic observing system which can be used by NOAA/NMFS Centers and other users to acoustically monitor the marine environment and

specifically endangered marine animals in real-time. The system is largely built on existing proven technology. The surface buoy (only 1.4 m in diameter) is based on the successful NOAA/PMEL PICO buoy design (Meinig 2008). The acoustic recorder and detector unit will be deployed on a standard Ocean Bottom Hydrophone (OBH) platform also routinely manufactured by NOAA/PMEL.

PROJECT PROGRESS: The hardware development of the prototype controller unit and acoustic recording/detection system has been completed. The killer whale detection algorithm is currently being tested on the bench. The hardware development of the controller unit for the surface buoy has been completed. This unit is communicating with the bottom-moored acoustic system via an underwater modem data link. This unit furthermore controls an Iridium satellite modem - which has already been acquired and tested - to transfer scientific and engineering data back to shore. The hardware development of the low-noise audio pre-amplifier has been completed. This component was optimized for the high-frequency hydrophone. This frequency response of the hydrophone and pre-amplifier (50 Hz to 50 kHz) covers the frequency range of all vocalizations produced by killer whales (pulsed calls, whistles, and echolocation clicks) as well as numerous other marine mammal species. The low-noise, high-frequency hydrophone has been acquired and tested. The underwater modems to establish a communication link between the bottom and surface units has been acquired and tested. All custom-made electronic components have been successfully developed, built, and tested. Commercially available components (hydrophone, underwater modem, Iridium modem) have been acquired and tested. The pressure housing and the batteries for the acoustic recorder/detector unit have been built. The various components of RAOS are shown in Figure 1.

Over the last several months researchers developed the necessary software to control and operate each of the components. The software to establish communication between the two units via underwater modem data link and to shore via Iridium satellite link was just recently completed. A first in-water test is planned for mid-July 2015. A one-week evaluation and performance test is planned for the end of August 2015

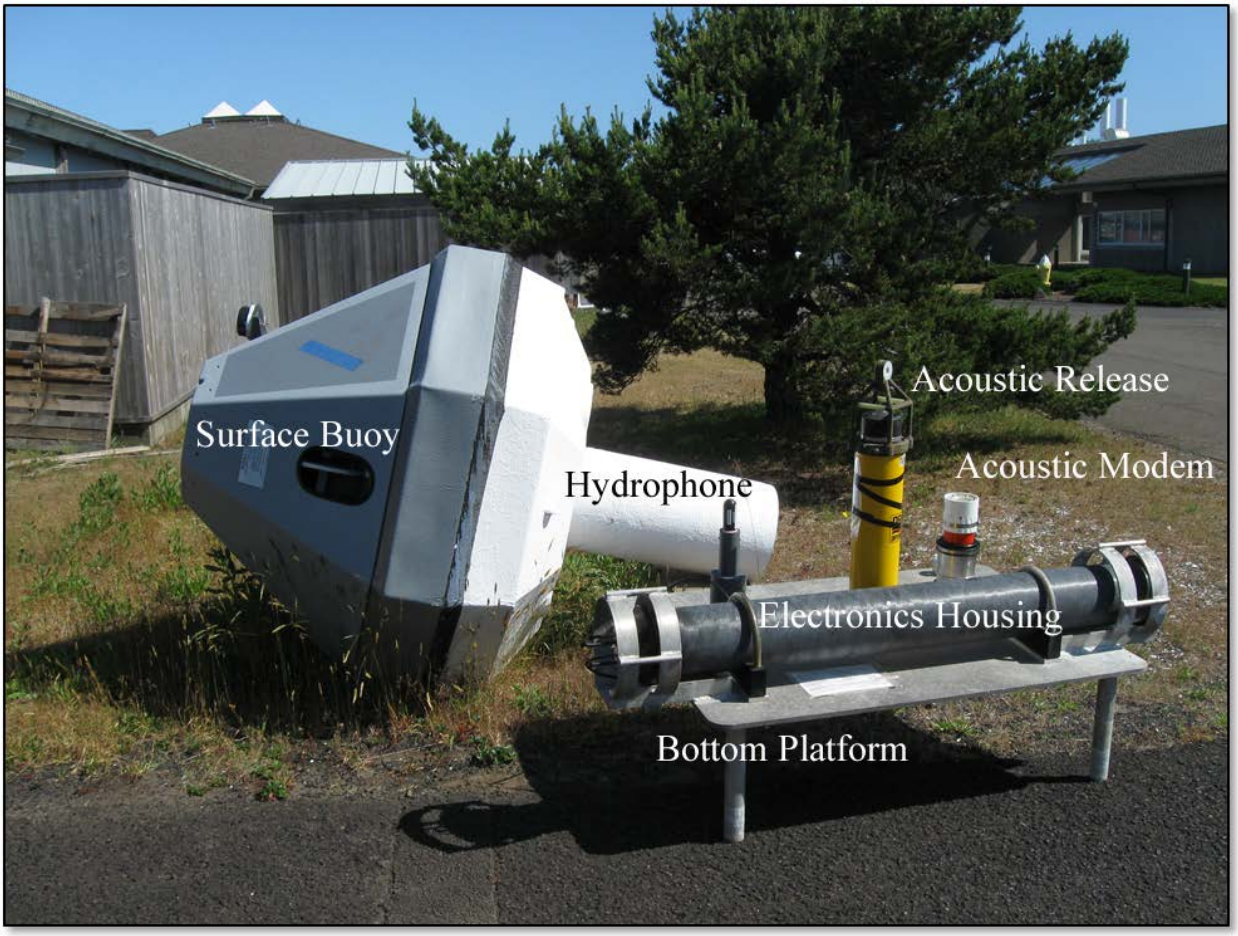


Figure 1: Components of the RAOS system.

TASK 3

(Projects under Task 3 support NOAA Strategic Plan Goal of Resilient Coastal Communities and Economies)

Theme: Protection and Restoration of Marine Resources

Amendment 33: Pacific Northwest Fishing Community Oral Histories: A Collaborative, Educational Project for Researchers, Students, and Community Members

Funded: $5,500

OSU RESEARCH STAFF:	*Flaxen Conway*, Professor, College of Earth, Ocean, and Atmospheric Sciences; *Sarah Calhoun*, Graduate Student, Marine Resources Management, College of Earth, Ocean, and Atmospheric Sciences
NOAA TECHNICAL LEAD:	*Suzanne Russell*, Conservation Biology, Northwest Fisheries Science Center, NMFS

PROJECT BACKGROUND: Oral histories are a methodology to collect previously undocumented and unique, in-depth information. Oral histories capture and preserve the heritage and culture of an individual, family, community of place, or a community of interest that spans over several places. Oral histories can identify key issues and concerns, identify and record an individual's or a community's inherent and observed knowledge, and inform the public, local community leaders and members, and management entities. This project is a collaborative process that engages students and teachers at the high school level, university graduate students, and faculty and agency researchers, thereby providing an educational experience to a broad range of project participants and community members. The intent of the project is to collect come oral histories now and, with each of these groups, set up a system for the continued collection of oral histories over time.

PROJECT PROGRESS: Professor Conway, graduate student Sarah Calhoun, and NMFS NWFSC Social Scientist Suzanne Russell initiated, trained, and mentored local high school students near Astoria and four members of the local, non-profit Newport Fishermen's Wives group in Newport, Oregon to establish a foundation to collect oral histories over the long term.

Suzanne Russell and Sarah Calhoun had a brief radio appearance in Warrenton, OR in September 2014 to talk about 'Voices from the West Coast' oral history project. During this time, Russell and Calhoun conducted two oral history interviews to help engage and further train the high school students on how to conduct interviews and proceed with next steps. Unfortunately, due to lack of organization and communication efforts from the high school students and their mentors, no significant progress has been made in Astoria/Warrenton OR.

Calhoun was supported hourly on this project during the 2014 summer months to coordinate with the Newport Fishermen's Wives and others in the collection and transcription of interviews. During this time, Calhoun gained experience working with mentors, community members, and students, and has been integral in conducting, transcribing, and cataloguing interviews, managing photos and videos, and contributing to the development of outreach materials.

Over the past academic year Calhoun conducted and transcribed 27 oral history interviews. The Newport Fishermen's Wives (NFW) group completed three additional interviews. These, along with the two conducted in Warrenton with the high school students, brings the total to 32 interviews to date. This is good but slow progress; these kinds of collaborative efforts take time as even the most well-intentioned volunteers/members of the team are busy with their own work, careers, etc. therefore the intention is to keep a core group interested and to gain more interest over time.

Over the course of the year there were surges of interest for the oral histories project. The first came in late fall 2014 when coastal communities in Oregon became concerned about the planned closure of the US Coast Guard Helicopter Facility in Newport. The NFW group became very active to fight against this closure, and requested that Calhoun assist by capturing themes from public meetings and presenting a summary for the NFW to use in their efforts. Ultimately this resulted in a postponement of the helicopter decision.

Calhoun has continued coordination with NFW, organized project documents, and completed coding of the collected interviews. She has made significant progress with collection efforts and completed qualitative data analysis of the transcribed interviews.

It should be noted that for Calhoun's graduate research an additional objective of the project was to document if and how women's roles in the commercial fishing industry and family business have changed since the mid-1990s, and if and how these changes have influenced the vulnerability and resilience of the fishing community. This study has been very well received, and was used to revitalize involvement of NFW periodically over the last year. For example, a group interview was conducted with a subset of NFW to collect additional data and garner support for the project in February 2015.

Planned and spontaneous efforts continue to bring about an increase of interest in preserving the history of Oregon's coastal communities. In Newport, additional members of the NFW group have come together to begin collection efforts for the upcoming year. This includes an interest in expanding the project to include collaboration with the Maritime Museum in Newport, OR.

PRESENTATIONS:
Calhoun completed the following poster and oral presentations:

- Student poster presentation at the State of the Coast Conference October 2014
- Student poster presentation at Oregon Sea Grant Scholars' Day November 2014
- Oral presentation at Society for Applied Anthropology Annual Meeting March 2015. NOTE that this presentation resulted in an invitation to submit a manuscript to the journal *Marine Policy* for publication based on the oral history data collected around women's roles and the involvement of Newport Fishermen's Wives in Oregon's fishing industry.

Amendment 43: Towards Optimizing

Funded: $77,075

OSU RESEARCH STAFF: *Dan Gillins*, Associate Professor, College of Engineering

NOAA TECHNICAL LEAD: *Mark Armstrong*, NGS/NOS

PROJECT BACKGROUND:

This project aims to develop reliable methods for determining ellipsoid and orthometric heights (elevations) accurate to plus or minus 2 to 5 centimeters at 95% confidence with Global Positioning System (GPS) and Global Navigation Satellite Systems (GNSS). This research is critical to many of NOAA's missions, projects, and research that rely on accurate vertical control, including the mapping of marine, shoreline, and seafloor environments, the monitoring of tectonic plate movement in western states, the measurement of tidal heights, and the prediction of sea level rise and flood hazards. Improved vertical control should lead to improved understanding and predictions of these environments and phenomena.

The National Geodetic Survey (NGS) published guidelines to take advantage of the economics of GNSS to determine ellipsoid heights (NOS/NGS 58) and orthometric heights (NOS/NGS 59) in 1997 and 2008, respectively. These guidelines require long-duration observations on densely-spaced marks. Since then, many GNSS advancements have occurred, including improved antenna designs, satellite orbit modeling, and hybrid geoid modeling.

Figure 1: GNSS equipment setup over a survey mark

This project aims to reevaluate the guidelines set for in NGS 58 and NGS 59 in two phases, the first of which is complete, and the second of which is ongoing. Phase I was a careful collection of both static and real-time GNSS data on 18 passive marks in Oregon. Phase II is the ongoing post-processing and evaluation of the data collected in Phase I, in order to provide NGS with empirical results and recommendations on how to optimally determine heights at desired accuracies using modern GNSS equipment and technologies. Key findings from this project will be shared in scholarly journals and with the engineering surveying community, and should help NGS to update, and/or expand the guidelines in NGS 58 and NGS 59.

PROJECT PROGRESS: **Phase I Progress (Complete)**

Phase I was the careful collection of both static and real-time GNSS data on 18 marks in Oregon. The field survey to collect this data began on October 7, 2014 and ended on November 7, 2014. All data has been organized and is ready for submission to NGS.

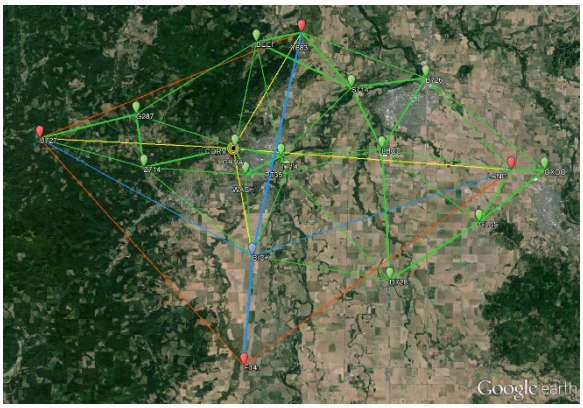


Figure 2: Phase I field survey network of marks

The field survey was performed with NGS 58 and NGS 59 guidelines (network mark spacing, mark-to-mark connections, and occupation requirements) in mind, so that solutions determined through alternative post-processing methods can be compared with solutions for which NGS 58 and NGS 59 guidelines are strictly followed. The network of marks (*see Figure 2)* included in the field survey was centered about Oregon State University and the city of Corvallis in Oregon's Willamette Valley. It spanned approximately 30 miles east-west and 20 miles N-S, and includes 18 passive marks (a combination of steel rods driven to refusal and brass disks set in concrete). Over the course of 15 field survey days, each mark was observed at least three times for 10 or more hours with modern GNSS antenna/receivers on fixed-height tripods. Each antenna/receiver simultaneously logged real-time data every second during the 10 or more hours of static data collection.

Phase II Progress (Ongoing)

The evaluation of coordinate solutions (horizontal and vertical positions) determined through new post-processing methods first requires the establishment of highly accurate "ground truth"

coordinates for each of the 18 marks. To establish these coordinates, solutions from two entirely independent and well-regarded post-processing methods were compared.

The first of these methods involved OPUS-Projects, a user-friendly, web-based GPS post-processing tool recently released by NGS. The solution from the OPUS-Projects method adhered to NGS OPUS-Projects recommendations and made use of the nearly ninety 10-hour long static observations collected during Phase I, as well as static data archived by NGS from seven continuously operating reference stations (CORS), one of which was located within the field survey network, three of which were located elsewhere in Oregon, and three of which were located elsewhere in the region.

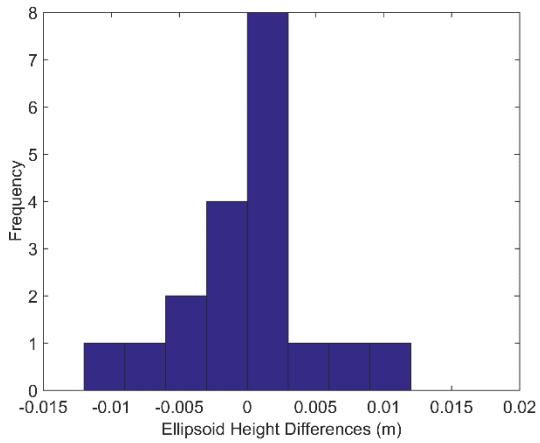


Figure 3: OPUS-Projects solution minus NGS 58 solution

The second method was an independent network adjustment processed with third-party software packages that adhered to all NGS 58 guidelines except that 5-hour connections between survey marks were used throughout the network where 1-hour or even half-hour connections would have satisfied the guidelines. This network made use of static data archived by NGS for just the CORS station located within the field survey network.

When solutions for the 18 survey marks from the two methods were differenced, ellipsoid heights (vertical coordinates) differed by no more than 1.1 centimeters and had an average difference of 0.0 centimeters (*see Figure 3*). This encouraging result suggested either solution could be used as ground truth coordinates for future comparisons with solutions determined through alternative methods.

Two of the most user-friendly alternative methods for the determination of accurate heights are the Online Positioning User Service (OPUS) Static (-S) and Rapid-Static (-RS) tools made available by NGS. These tools were evaluated through the submission of 10, 7, 5, 4, 3, 2, and 1-hour, as well as 40-minute and 20-minute static files (generated by dividing 10-hour static files), and the comparison of their solutions with the ground truth solution. Early results suggest that a 4-hour static observation submitted to OPUS-S will achieve plus or minus 2 centimeter accuracy in ellipsoid height (*see Figure 4*).

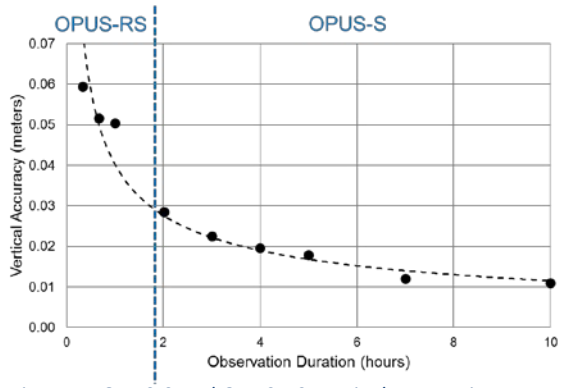


Figure 4: OPUS-S and OPUS-RS Vertical Accuracies

The real-time data logged every second during the 10 or more hours of static data collection at each station enabled an evaluation of the Oregon Real-Time GPS Network (ORGN), a statewide real-time network managed by the Oregon Department of Transportation. Aggregated 5 and 30-second, as well as 1, 3, 5, 7, and 10 minute ORGN real-time solutions were composed from the 1-second data and compared with the ground truth solution. Early results suggest that achieving a 4 centimeter level accuracy at 95% in ellipsoid height in real-time is not currently possible with the ORGN (*see Figure 5*).

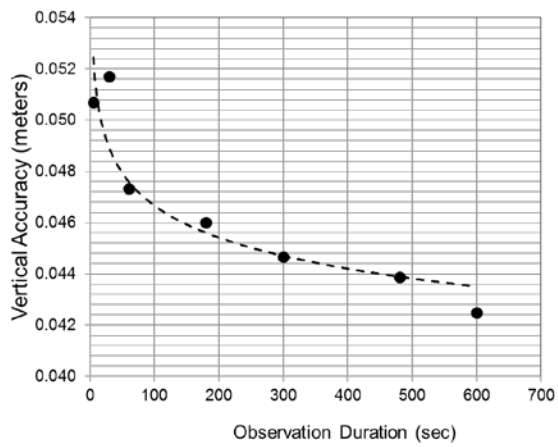


Figure 5: ORGN Vertical Accuracy

These early findings regarding OPUS-S 4-hour and ORGN solutions suggest another possible post-processing method for evaluation: the constraining of real-time network vectors to vectors derived from longer duration observations and the use of OPUS. Such a network design may provide the most optimal method for determining accurate heights in a project area. This evaluation, along with ongoing evaluations of real-time network and real-time kinematic solutions, as well as OPUS-Projects composed of static observations with durations less than 10-hours, will be performed over the 2015 summer.

APPENDIX B: OTHER AGENCY AWARDS

PI Name	Project Title	Lead NOAA Collaborator	Awarding Agency	Funding Amount
M. Banks	Ocean Survival of Salmonids	Kurt Fresh NWFSC	Dept of Energy/ BPA	$279,979

ADDENDUM TO FY14

Amendment 30: Effects of PDO, ENSO, Climate Change on the Northern California Current Ecosystem

Funded: $100,000

OSU RESEARCH STAFF: *Michael Banks*, Director, CIMRS
NOAA TECHNICAL LEAD:*Kurt Fresh*, *Bill Peterson*, Fish Ecology, NWFSC

PROJECT BACKGROUND: This research project is directed at investigating how the variations in the two "flavors" of ENSOs—the so-called Eastern Pacific (EP) and Central Pacific (CP, or modoki) El Niños— have affected ecosystem structure and function in the NCC over the past 50 years. The impact of ENSO events on the NCC has been variable over this time period. Another component of this research is to look at low-frequency physical forcing related to the PDO and NPGO and ecosystem responses. Elucidating the nature of the mechanistic process(es) that link a changing climate, physical drivers operating at a diversity of scales such as PDO and El Nino, with changes in different ecosystem components such as zooplankton and salmon production is plausible and essential to apply climate understanding in fisheries management and anticipate and predict whether current statistical relationships between large-scale climate indices and the ecosystem of the NCC can be expected to persist with future climate changes.

PROJECT PROGRESS: In October 2013 the first open announcement posted for the Post-doctoral position that would conduct research in this project. With the lack of qualified applicants the closing date of the position opening was extended and efforts were made to target announcement of the opening to institutions/organizations that were suggested by members of the Search Committee. This produced at least three qualified applicants who were interviewed in mid-December. The Search Committee was unanimous in their selection of the best candidate and the position was offered but declined by the candidate. The Search Committee's recommendation was not to offer the position to either of the remaining two candidates interviewed. An issue that surfaced (expressed by the candidates) was the lack of secure continued funding for the project. It is anticipated that the position will be re-opened in the next year.