Annual Progress Report
to
National Oceanic & Atmospheric Administration

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Reporting period: 7/1/12 – 6/30/13

Oregon State University

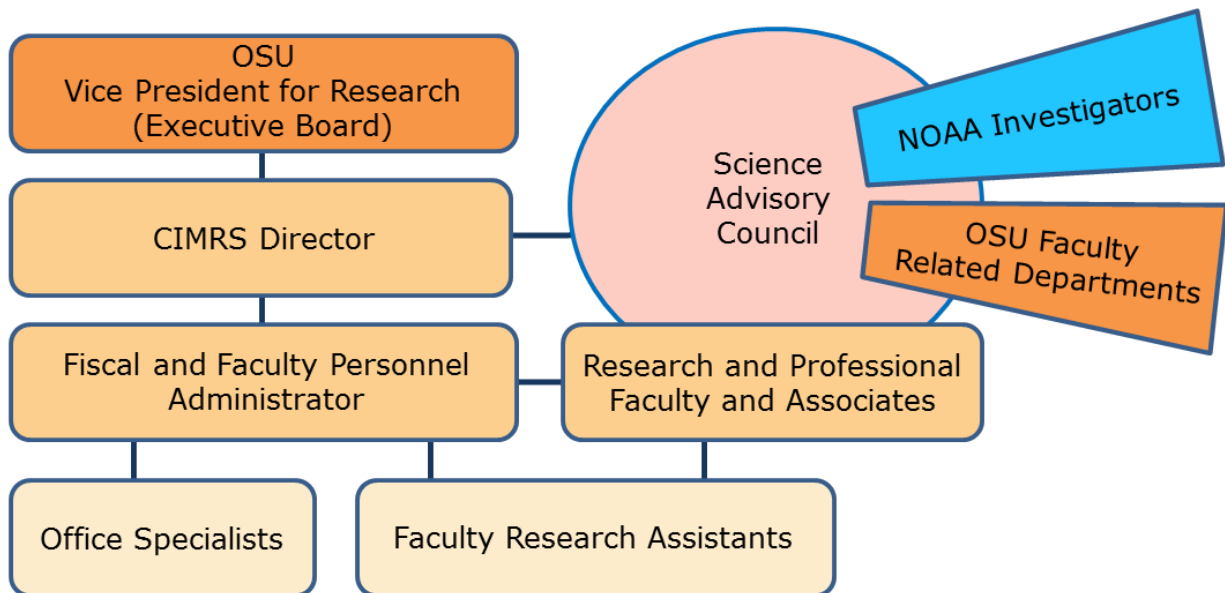# Cooperative Institute for Marine Resources Studies

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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.

2012/2013 EXECUTIVE BOARD

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Michael Banks (Ex Officio) Director, Cooperative Institute for Marine Resources Studies, Oregon State University	

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Michael Blouin Professor, Department of Zoology, Oregon State University	**Clifford Ryer** Fisheries Biologist, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, NOAA
George Boehlert Emeritus Professor of Fisheries, Department of Fisheries and Wildlife, Oregon State University	**Paul Wade** Research Biologist, National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA
William Chadwick Professor, Cooperative Institute for Marine Resources Studies, Oregon State University	**Laurie Weitkamp** Research Fisheries Biologist, Conservation Biology Division, Northwest Fisheries Science Center, NOAA
Kurt Fresh Estuarine and Ocean Ecology Program Manager, Fish Ecology Division, Northwest Fisheries Science Center, NOAA	**Dawn Wright** Professor, Department of Geosciences, Oregon State University
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 PERSONNEL

The following table describes CIMRS research personnel in FY13

Position Category	# Staff	# B.S.	# M.S.	# Ph.D.
Research Scientist	6	--	--	6
Postdoctoral Fellow	4	--	--	4
Research Assistants	24	9	14	1
Total	**33**	**9**	**14**	**11**

CIMRS non-Faculty researchers spent over 76 days at sea in FY13.

ADMINISTRATIVE STAFF

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

TASK 1: ADMINISTRATION, EDUCATION, AND OUTREACH

A meeting of the CIMRS Science Advisory Council was convened on 5 March 2013. A meeting of the CIMRS Executive Board was held on 20 June 2013.

CIMRS Director Dr. Banks and Administrator Jessica Waddell attended the Annual CI Directors' Meeting in Silver Spring, MD in March 2013.

Dr. Banks served on the NOAA CI Directors Executive Committee where his activities included:
- Lead author of notes and visit with OAR Assistant Administrator Bob Detrick (7/25/12)
    ALARM: Shortfalls Depreciate Critical Mission Achievements in the NOAA Enterprise
- Contribution to OAR Science Research Council meetings on 17 – 18 July 2012 in Seattle, WA and 10 – 11 October 2012 in Miami, FL.
- Contribution to a summer Meeting with NOAA Leadership in DC on 1 August 2012.

Dr. Banks served on the review panel for the Cooperative Institute for Ocean Exploration Research and Technology on 2 – 4 October 2012 at the Harbor Branch campus of Florida Atlantic University. On 19 July 2012, 4 February 2013, and 4 April 2013, he visited Seattle to meet with Directors from the three main NOAA participants in CIMRS research – John Stein, NWFSC; Chris Sabine, PMEL; John Bengtson, Pat Livingston and Steve Ignell, AFSC – to discuss strategy for sustaining CIMRS research capacity during times of budget shortfall.

He communicated CIMRS' 4th OAR 'HOT ITEM' to the CI Program Office on 2 April 2013:
"CIMRS Seafloor Research Recently Featured in Oceanography and Nature Geoscience"
http://www.ci.noaa.gov/InTheNews/HotItems/TabId/722/ArtMID/1835/ArticleID/10022/CIMRS-Seafloor-Research-Recently-Featured-in-Oceanography-and-Nature-Geoscience.aspx

Dr. Banks and Jessica Waddell held an update meeting with CIMRS Faculty 2 – 3 April 2013 to relay information from the CI meeting as well as internal OSU administrative information.

Dr. Banks represents CIMRS at OSU Provost's Marine Council (http://oregonstate.edu/leadership/provost/marine-council) where he is a member of the NOAA Fleet Relocation Action Coordination Team. He also contributes to quarterly OSU Research Office CIP (Center, Institute, and Programs) meetings at OSU and bi-weekly HMSC Executive Committee meetings, enabling consistent dialogue and exchange with leadership from COMES, MMI, CEOAS, HMSC, OR Sea Grant and OSU Libraries.

Ms. Waddell attended the annual CI Administrator's meeting, which was held this year in October at the Norman, Oklahoma NOAA/NWS Storm Prediction Center. Cherri Helms from

the OAR/CI Office attended as well as several administrators from CIs across the country. Dr. Banks and the CIMRS Administrator have been responsible for submission of 18 proposals under the new Institutional award during the period 10/1/12 – 6/30/13.

Administrative Program Specialist Hui Rodomsky continues to update and improve the CIMRS website. Ms. Rodomsky contributed to CI Program Office communications by reviewing draft communication plan and providing CI staff with feedback. Ms. Rodomsky also assisted Dr. Banks and Ms. Waddell in numerous administrative tasks such as drafting reports and outreach materials, tracking and maintaining the Institute's publications.

TASK 2

Theme: Marine Ecosystem and Habitat

Amendment 3: Coast-wide Genetic Stock Identification – Ecosystem Effects on Adult Chinook Salmon Distribution and Abundance
Funded: $15,591

OSU RESEARCH STAFF: *Michael Banks*, Director, CIMRS
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: Chinook salmon and associated fine-scale at sea environmental data were collected in Oregon, during the 2012 fishery season in accordance with the West Coast Salmon Genetic Stock Identification Collaboration sampling plan. Approximately 80 Oregon vessel operators had sampling contracts and more than 100 fishermen were trained in at sea sampling protocols. A total of 631 Chinook salmon samples were collected by Project CROOS participants in Oregon waters. Starting 7/1/13, and through the full season, DNA was extracted from a sub-sample 383 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. Analysis has also included historical data from CROOS fisherman and Coded Wire Tag (CWT) data to enable basic comparisons between the stock specific catch per unit effort data in units of fish per boat day. In season progress report that includes catch, effort, and stock specific catch per unit effort (on an hourly basis) are available for all time periods in 2012. For example see http://pacificfishtrax.org/media/Project_CROOS_2012_inseason_8.pdf.

PUBLICATIONS:

Satterthwaite W.H., Mohr, M.S., O'Farrell, M.R., Anderson, E.C., **Banks, M.A.**, Bates, S.J., Bellinger, M.R, Borgerson, L.A., Crandall, E.D., Garza, J.C., Kormos, B.J., Lawson, P.W., Palmer-Zwahlen, M.L. (In revision). Use of genetic stock identification data for comparison of the apparent ocean spatial distribution, size-at-age, and fishery exposure of an untagged stock and its indicator: California Coastal versus Klamath River Chinook. *Transactions of the American Fisheries Society*.

Amendment 4: Improving Ecosystem-based Fisheries Management and Integrated Ecosystem Assessments by Linking Long-term Climatic Forcing and the Pelagic Nekton Community in the Northern California Current
Funded: $109,075

OSU RESEARCH STAFF: *Lorenzo Ciannelli*, Associate Professor, College of Earth, Ocean, and Atmospheric Sciences; *Caren Barceló*, Graduate Research Assistant, College of Earth, Ocean, and Atmospheric Sciences

NOAA TECHNICAL LEAD: *Ric Brodeur*, Fisheries Ecology, NWFSC

PROJECT BACKGROUND: This project directly contributes to the goal of creating indices of ecosystem properties and processes that reflect the condition of the ecosystem and the potential for changes in the distribution and habitats of the economically and ecologically important fish stocks in the California Current. The Pacific Fisheries Management Council has started to incorporate ecosystem information into fisheries management. This includes a synoptic overview of the status and trends in the abundance of prey for groundfish, with an eye toward implementing more/less conservative fisheries management guidelines when prey are less/more abundant. This project summarizes changes in the status of the forage base for groundfish over the last ~15 years, thus providing critical ecosystem information for developing precautionary fisheries management guidelines. Specifically, the project identifies responses of fisheries resources to environmental forcing in order to provide assessors the raw materials to incorporate a climate index in stock-recruitment relationships.

PROJECT PROGRESS: This project aims to develop new indicators that describe how the pelagic nekton communities in the NCC have responded to climatic forcing during the period 1998-2011, with the twin goals of providing critical ecosystem information for fisheries management and expanding the availability of indicators for Integrated Ecosystem Assessments put together by NOAA.

In FY13, Graduate Research Assistant Caren Barceló calculated and mapped the annual and seasonal summaries of the abundance data for frequently captured species, as well as calculations of diversity, evenness and community statistics using 15 years of NWFSC's BPA Plume survey data along the Oregon and Washington coasts. Barceló analyzed the community structure of the plume survey data using Non-metric Multidimensional Scaling ordinations and is in the process of completing spatially explicit Variable Coefficient Generalized Additive Mixed Models (GAMM) in order to further understanding of the local effects of basin and local scale oceanographic variables on derived spatially explicit community and diversity indices. These calculations have been presented by Barceló at scientific meetings and publications listed below.

Barceló also calculated spatial statistics for top abundant species, such as sardine (*Sardinops sagax*), anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*). These spatial statistics include: weighted mean center of abundance, isotropy (the elongation of the spatial distribution of the species), as well as a calculation of overlap (Global Index of Collocation) between these species and an abundant jellyfish (*Chrysaora fuscensces*). Barceló presented the results of these analyses at scientific meetings. Annual and seasonal changes in the mean center of abundance are currently being analyzed in relation to basin and local scale environmental covariates, such as Columbia River discharge and the North Pacific Gyre Oscillation, respectively. Barceló plans to use remotely sensed satellite data (sea surface temperature and chlorophyll concentration) to characterize the habitat of the abundant pelagic species (anchovy, sardine, herring, as well as other species, such as saury and sunfish) in the next FY, results of which will be included in risk and exposure to climate change analyses.

Associate Professor Lorenzo Ciannelli assisted in the interpretation of results and preparation for presentations. Next FY, Ciannelli will oversee and guide Barceló's GAMM analyses and assist with drafting of manuscripts.

PRESENTATIONS:
Barceló, C., Brodeur, R., & Ciannelli, L. (2012). 97th Ecological Society of America Annual Meeting. Portland, OR. 5 – 10 August, 2012. Poster Presentation. "Changes in pelagic nekton diversity, ranges and community composition in the Northern California Current from 1998-2011."

Barceló, C. (2013). NOAA NWFSC Estuary and Ocean Ecology Annual Plume Meeting. Newport, OR. 29 – 31 January, 2013. Oral Presentation. "Long-term changes in the spatial &

temporal distribution and habitat associations of fish assemblages in the Northern California Current"

Barceló, C. (2013). 37th Annual Larval Fish Conference. Miami, FL. 2 – 6 June, 2013. Oral Presentation. "Improving integrated ecosystem assessments by linking long-term climatic forcing and the pelagic nekton community in the northern California Current."

PUBLICATIONS:

Brodeur, RD., **Barceló, C**., Robinson, KJ., **Daly, E**., **Ruzicka, JJ**. (In progress). Seasonal and interanual variability in the spatial overlap between forage fishes and large medusae in the northern California Current región. *Marine Ecology Progress Series, Special Issue*.

Wells, B., Schroeder, I., Santora, J., Hazen, E., Bograd, S., Bjorkstedt, E., Loeb, V., McClatchie, S., Weber E., Watson, W., Thompson, A., Peterson, W., Brodeur, R., Harding, J., Field, J., Sakuma, K., Hays, S., Sydeman, W., Losekoot, M., Thompson, SA., Largier, J., Kim, SY., Chavez, F., **Barceló, C**., Warzybok, P., Bradley, R., Jahncke, Goericke, R., Campbell, GS., Hildebrand, JA., Melin, SR, DeLong, RL., Gomez-Valdes, J., Lavaniegos, B., Gaxiola-Castro, G., Golightly, RT., Schneider, SR., Lo, N., Suryan, R., Gladics, A., Horton, C., **Fisher, J**., **Morgan, C**., **Peterson, J., Daly, EA**., **Auth, T**., Abell, J. (In press). State of the California Current 2012-2013: Hold the Anchovies. *CALCOFI Report, 54*.

Amendment 5: Interannual Variability in the Northern California Current: the Influence of Past El Niño Events on Salmon Populations and Pelagic Ecosystem Structure with Analysis of the Potential for Forecasting Future Ocean Conditions
Funded: $121,085

OSU RESEARCH STAFF:	*Michael Banks*, Director, CIMRS
NOAA TECHNICAL LEAD:	*Bill Peterson*, Estuarine and Ocean Ecology, NWFSC

PROJECT BACKGROUND: The research proposed will examine relationships between El Niño events and resulting variability in SST, sea level, hydrography, and the abundance and species composition of copepods, krill eggs, larvae and adults, ichthyoplankton and small pelagic fishes along with salmon returns, in waters of the NCC. Statistical relationships between El Niño events and physical and biological anomalies will be examined in order to develop a better understanding of the factors which may moderate or exacerbate the influence of El Niño (e.g., the timing of the arrival of physical El Niño signals, duration, and the magnitude of oceanic and/or atmospheric anomalies) on the *biological* components of the ecosystem. Trends for the biological components will be forecasted for 6-9 month time periods from ocean conditions that are testable and relevant to management decisions for fisheries, protected species and ecosystem health components in the California Current.

PROJECT PROGRESS: No activity during this reporting period.

Amendment 6: Integrated Ecosystem Assessment of the California Current Ecosystem
Funded: $42,103

OSU RESEARCH STAFF: *Toby Auth*, *Tristan Britt*, Faculty Research Assistant, CIMRS
NOAA TECHNICAL LEAD: *Ric Brodeur*, Fisheries Ecology, NWFSC

PROJECT BACKGROUND: CIMRS investigators conduct regular surveys of pelagic larval and juvenile fishes using chartered fishing vessels outfitted with a boom to collect ichthyoplankton and conduct CTD casts. These surveys are patterned after the successful pelagic fish surveys done at the SWFSC Santa Cruz laboratory for juvenile rockfishes. Target species include the pelagic phase of commercially-important juvenile rockfishes and flatfishes.

PROJECT PROGRESS: Faculty Research Assistant Toby Auth was Chief Scientist aboard *F/V Miss Sue* on 21 – 24 August and 20 – 24 September 2012. During these cruises, Auth conducted surveys on two transects with five stations per transect at 10 – 55 nautical miles offshore from Newport, OR and the Columbia River. The conducted surveys included CTD, bongo, and mid-water trawl collections for water quality, phytoplankton, zooplankton, ichthyoplankton, and juvenile and adult fishes. During each cruise along the Willapa Bay transect at two stations located 9 and 14 nautical miles offshore, an additional four CTD casts and eight surface trawls were conducted to collect water quality and pelagic organism data for the predator and prey field studies. Faculty Research Assistant Tristan Britt participated on the 20 – 24 September survey cruise. Britt was scheduled to participate on the 21 – 24 August survey cruise as well, but due to an injury, she was not able to go to sea. In the lab, she sorted through biological samples collected in the field and entered data into the database.

Amendment 7: Ocean Acidification Cruises
Funded: $148,428

OSU RESEARCH STAFF: *Lauren Juranek*, Assistant Professor, College of Earth, Ocean, and
                        Atmospheric Sciences
NOAA TECHNICAL LEAD: *Chris Sabine*, Director, PMEL

PROJECT BACKGROUND: The Pacific coastline of North America is home to economically important fish and shellfish industries. The potential impacts of ocean acidification on the ecologically and economically important biodiversity of the West Coast are unknown and of great concern to NOAA and other agencies, as well as a variety of other public and private stakeholders. Oceanographers at Oregon State University will study smaller-scale patterns on the Oregon continental shelf, where hypoxic and acidified conditions develop each summer as a result of the coupling of large-scale oceanographic processes with regional ecological and

geomorphological factors. This research provides additional data critical for developing proxy algorithms to allow the reconstruction of ocean acidification conditions (including pH and carbonate saturation states) from commonly measured parameters such as oxygen and temperature.

The cruise aboard UNOLS ship *R/V OCEANUS* located at Oregon State University's Hatfield Marine Science Center in Newport, Oregon completed a series of transects roughly orthogonal to the coast of Oregon, from the Columbia River south to the Hecate Bank/Cape Perpetua area south of Newport. The focus of the cruise was the deployment of a towed sensor package with the capacity to pump water onto the ship. Three transects with the towed package were done: at the Columbia River, at Cascade Head, and at Hecate Bank/Cape Perpetua. Over the course of the cruise, full water-column CTD stations were occupied at a number of sites along and between the planned transect lines occupied with the towed package. The water collected at CTD stations were analyzed for a variety of physical, chemical and biological parameters. Near surface seawater (temperature, salinity, pCO_2, ADCP) and atmospheric measurements (CO_2) were also made along the cruise track. The cruise was conducted between 16 – 24 July 2012, inclusive of time to pre-stage and de-stage the cruises in Newport, Oregon.

PROJECT PROGRESS: A survey cruise focused on the Oregon coast aboard the *R/V Oceanus* was mounted on 17 – 22 July 2012. Four cross-shelf transects were completed at Sunset Beach (46.2^o N), Cascade Head (45° N), Newport (44.7^o N), and Siuslaw River (44° N) locations. Each of these locations represents a unique study focus. At 46.2^{o}N, the Columbia River plume is a strong feature as it flows offshore and to the south but has not fully separated from the shelf. The influence of river-derived nutrients and stratification will play a stronger role in shaping the biogeochemical dynamics in this location. The transect at 45°N is at the mid-point of a long run of narrow shelf with simple, monotonically-increasing bathymetry. The influence of upwelled source water on this location is expected to be the strongest. At 44.7^{o}N, the shelf begins to broaden at the North of the Heceta Bank complex. The transect at 44°N is at the southern end and broadest expanse of the Heceta Bank complex, where water retention times are long and where the biological response to upwelling is expected to be the most strongly expressed.

Transects consisted of daylight towed profiling/pumping vehicle operations, where in situ CTD and optic measurements were made along with flowing sample-stream analyses of TCO_2, pCO_2, nitrate, phosphate, and silicate; night time CTD-bottle and zooplankton net-tow surveys; and flow-through O_2/Ar measurements were made throughout the diurnal cycle. Dr. Burke Hales' SuperSucker team collected data, with sensors aboard the towed vehicle, for determination of temperature, depth, salinity, dissolved O_2, chlorophyll and CDOM fluorescence, optical backscatter and beam attenuation, and photosynthetically active radiation. The researchers also made measurements of pCO_2, TCO_2, nitrate, silicate, and phosphate in the sample stream

delivered back to the ship. Assistant Professor Juranek collected a total of 30 bottle samples for analysis of dissolved gas ratios (O_2/Ar) and O_2 isotopes from the pumped Supersucker seawater supply on three of the survey lines (Cascade Head, Newport, and Siuslaw River). She also conducted proof-of-concept method development tests using a quadrupole mass spectrometer configured with a large contactor membrane and recirculating N_2 flow to continuously monitor O_2/Ar ratios from the pumped Supersucker water supply.

In situ profiling data and sampling lag time data have been processed and delivered to colleagues at PMEL. On the nighttime sampling, 18 stations were occupied and 180 depths were sampled for TCO_2, alkalinity, O_2, nutrients, and in situ CTD measurements. CTD-bottle O_2 and nutrient data have been analyzed and delivered to PMEL colleagues. Shipboard analyses from the profiling transects and O_2/Ar data are still being processed at OSU at the time of reporting.

Amendment 9: Climate and Habitat Effects on Productivity of Important Alaska Fishery Species
Funded: $144,885

OSU RESEARCH STAFF: *Louise Copeman*, Research Associate/ Post-Doc, CIMRS;
                        Courtney Danley, Faculty Research Assistant, 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 and socioeconomic 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: Faculty Research Assistant Courtney Danley successfully reared juvenile walleye pollock under varying conditions in the laboratory. These juveniles were raised in 100L black cylindrical flat-bottom upwelling tanks for behavioral experiments on the effects of ocean acidification.   In February, Danley transferred to the Department of Fisheries and Wildlife to work with Professor Carl Shreck. In April, Bioscience Research Technician Eric Hanneman was hired to take over the rearing duties for the projects. Hanneman reared larval walleye pollock and Northern rocksole for examination of ocean acidification effects on early life stages and will be contributing to improvements in the husbandry aspects of the research.

Habitat selection of juvenile flatfishes

PROJECT BACKGROUND: This project directly addresses Alaska Fisheries Science Center's Habitat and Ecological Processes Research Program research priority of characterizing habitat utilization and productivity for Essential Fish Habitat. This project is designed to characterize the habitat variables that contribute to variable settlement into nursery areas by Northern rock sole, an important fishery resource species. The investigation improves understanding of nursery function for rock sole by determining the role of settlement processes in habitat use for this species (Levels 2 and 3 of Essential Fish Habitat information).

PROJECT PROGRESS: Faculty Research Assistant Danley successfully reared larval rock sole, Pacific cod and walleye pollock in the laboratory using strip-spawned eggs from AFSC broodstock. The larvae were raised at two temperatures (4°C and 9°C) in a series of 100L black, cylindrical flat-bottom upwelling tanks at density of 20 fish per liter. Two temperatures were used to ensure a variable-sized larvae during the time of experimentation (5 – 130 days post hatch). Experiments examined the vertical distribution of the three Alaska fisheries species along thermoclines at varying stages of development (first-feeding larvae, flexion and pelagic juvenile stages). The effects of diel interactions with thermocline conditions were also tested. These data are currently being analyzed.

Lipid class dynamics in marine crabs

PROJECT BACKGROUND: This project directly addresses Alaska Fisheries Science Center's Habitat and Ecological Processes Research Program research priority of characterizing habitat utilization and productivity for Essential Fish Habitat. The project provides valuable data on critical components of juvenile Tanner crab habitat utilization such as patterns of movement and the effect of food quality on juvenile Tanner growth rates. Finally, through characterizing the nutritional components of nursery habitat that influence Tanner crab production throughout its range, it should be possible to scale- up these types of questions to other commercially important species such as the snow crab, *Chionoecetes opilio*.

PROJECT PROGRESS: In collaboration with AFSC scientists, Research Associate, Post-doc, Louise Copeman, has been examining the lipid composition of juvenile tanner crabs in different nursery areas and habitat types. During July 2012, Copeman in collaboration with Cliff Ryer (AFSC) collected an additional 80 field samples of tanner crabs from two different nursery embayments in Kodiak Alaska. These samples were analyzed for differences in the energetic condition of individuals from different nursery embayments/habitat types.

Copeman continued to supervise data analysis from a 3-month laboratory feeding experiment on juvenile tanner crabs that examined the effect of dietary essential fatty acids on molting, lipid

composition and growth rate. Over 60 samples from this study have been analyzed for lipid classes and fatty acids. During the spring of 2013, Copeman has been preparing to undertake another feeding study using modified diets to look at the impact of dietary ration, food quality and growth on juvenile tanner crabs.

Using coastal nursery habitat surveys in stock assessment and forecasting recruitment in gadid fisheries

PROJECT BACKGROUND: A workshop, "Using Coastal Surveys in Stock Assessments," was convened to evaluate the varying concerns of using coastal surveys that employ non-traditional stock assessment gear such as beach seines, visual surveys and small mesh trawls and determine how best to link these data with contemporary assessment approaches. The workshop brought together expertise and time series data from three regions with intensive gadid fisheries and inshore nursery survey data. These three regions are: 1) Gulf of Alaska – beach seine/small mesh trawl, 30+ Years; 2) Newfoundland – beach seine, 40+ Years; and 3) Norway – beach seine (Flødevigen survey), 100+ years. Analysis of catch data across regions is being examined with sequential year class analyses to determine the scale at which recruitment prediction is possible. In addition, the data sets are being used to examine considerations of population connectivity, life history differences, gear biases, estimating natural mortality, and microhabit usage. The proceedings of the workshop and results of analyses will be used in the preparation of a multi-authored manuscript evaluating the justifiability, feasibility and outcome of integrating coastal and offshore survey data for the purposes of stock assessment.

PROJECT PROGRESS: Research Associate, Post-doc Copeman participated in the 2-day Coastal Cod Workshop on 17 – 18 October 2012 held in Seattle, WA with scientists from USA, Canada, and Norway. Talks included a discussion of approaches to examine recruitment prediction from age-0 coastal cod surveys. These approaches will form the basis of two peer-reviewed manuscripts. The first manuscript, led by NOAA AFSC researcher Ben Laurel, will compare coastal cod nurseries across regions with the central questions being mechanistic i.e., "whether and how do coastal cod nurseries set year-class strength." The approach will be to compare fjord (Norway, Labrador) vs embayment (NE Newfoundland, NE Kodiak) systems to examine the relative importance of the 3 critical periods in these nurseries: delivery (May – June), post-settlement (July – October), and overwintering (December – March) processes. The analysis will use metrics of variance (annual catch abundance, growth, condition, etc.) at each of the corresponding critical periods in the coastal nurseries of each system. The variance measures serve as an index of mortality potential at each of the critical periods. Similar metrics will be applied to environmental data, such as annual temperature variance during larval delivery, post-settlement, and overwintering. Data will be bootstrapped to make them comparable. This general approach, in addition to some descriptive statistics, will be used to develop a conceptual

model for regional population dynamics in gadid systems with strong coastal nursery components.

The second manuscript, led by University of Oslo Postdoctoral Fellow Lauren Rogers, will focus on a comparison of the scale of genetic population structure and recruitment links in cod systems. The geneticists who participated in the workshop performed a meta-analysis of all available cod data to examine both isolation-by-distance and isolation-by-depth. The meta-analysis of the beach seine data (age-0 to age-1 links) will largely be based on the large spatial and temporal time series in Norway (site, fjord, region, coast, offshore) whereas the Newfoundland and Gulf of Alaska will be test cases at the extreme ends of the spectrum (fjord, offshore). Some of this analysis was presented at the workshop and it was proposed that the group also spatially plot the r-squares of the age-structured models to help visualize the scale of recruitment links in older, offshore cod. The analysis presented thus far looks promising--- points where recruitment links approach their maxima are also at the same scales at which coastal cod appear genetically structured.

PRESENTATIONS:
Copeman, L. 2012. Coastal Cod Workshop. 17 October 2012. Seattle, WA. Oral presentation. Marine lipids in relation to condition and coastal dietary markers in age-0 Gadids.

PUBLICATIONS:
Laurel, B.J., **Copeman, L.A.**, & Parrish, C.C. (2012). Role of temperature on lipid/fatty acid composition in Pacific cod (*Gadus macrocephalus*) eggs and unfed larvae. *Marine Biology, 159*(9): 2025-2034. doi: 10.1007/s00227-012-1989-3

Stoner, A., **Copeman, L.A.**, & Ottmar, M.L. (2013). Molting, growth, and energetics of newly-settled blue king crab: Effects of temperature and comparisons with red king crab. *Journal of Experimental Marine Biology and Ecology*, *442*: 10 – 21. http://dx.doi.org/10.1016/j.jembe.2013.02.002

Copeman, L.A., Laurel, B.J., & Parrish, C.C. (Accepted pending revisions). Effect of temperature and tissue type on fatty acid signatures of two species of North Pacific juvenile gadids: a laboratory feeding study. *Journal of Experimental Marine Biology and Ecology*.

Amendment 10: Otolith Microchemical Fingerprinting: Assessing Juvenile Pacific Cod Habitat Utilization in the Gulf of Alaska
Funded: $30,567

OSU RESEARCH STAFF: *Jessica Miller*, Assistant Professor, Department of Fisheries and Wildlife; *Thomas Murphy*, Technician

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

PROJECT BACKGROUND: This project provides information on Essential Fish Habitat Level 3: habitat-related growth and Level 4: habitat productivity for young-of-year Pacific cod in the individual nursery bays sampled. Differences in productivity across the Gulf of Alaska may be explained in part by contrasting oceanographic and chemical features, which in turn likely affect otolith elemental signatures. Otolith elemental signatures were analyzed in this study to determine whether habitats of juvenile Pacific cod are chemically unique within two large regions: the Eastern and Central Gulf of Alaska. Through sampling otoliths at nearshore sites within each region, the extent to which otolith chemical signatures can differentiate individual nursery bays was assessed. The temporal persistence of otolith signatures within sites were assessed by comparing a subset of samples collected during spring or summer with those collected during fall. Finally, because LA-ICPMS yields discrete samples from the otolith core to its edge, the ontogenetic shift in habitat use (*i.e.*, from the pelagic larval stage to the benthic nearshore juvenile stage) is expected to be reflected in the otolith signatures. A refereed manuscript on spatial variability in Pacific cod otolith elemental signatures is expected. This work will be presented at one or more scientific conferences. Results from this study may also form the baseline for future work tracing the natal origins of adults from the 2011 cohort.

PROJECT PROGRESS: Approximately 400 otoliths from 5 nursery areas were prepared for analysis, and two weeks of data collection at OSU's Keck Collaboratory for Plasma Spectrometry occurred. Professor Miller trained Alaska Fisheries Science Center researcher Beth Matta to collect elemental data on all juvenile otoliths and assisted with post-processing and analysis of data.

Results indicate that four elements – boron, strontium, magnesium, and barium – display variations that would be useful for discriminating among juvenile Pacific cod collected at different nursery sites in the Gulf of Alaska. Furthermore, increases in barium in some specimens may correspond to upwelling events or freshwater run-off into nursery bays. Next step in this project is to census this cohort later in life (at age-2), which will help to determine if older individuals can be retrospectively linked to a nursery areas based on their core otolith elemental signatures.

Amendment 12: Long-term Observations of Physical and Biological Oceanographic Conditions in Coastal Waters off Oregon: Hydrography and Zooplankton
Funded: $178,530

OSU RESEARCH STAFF: *Tracy Shaw*, Senior Faculty Research Assistant, CIMRS
NOAA TECHNICAL LEAD: *Bill Peterson*, Estuarine and Ocean 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: Senior Faculty Research Assistant Tracy Shaw served as chief scientist on six *R/V Elakha* cruises (1 day each) sampling the Newport Hydrographic line with water samples and net tows out to 25 miles off the coast of Newport, OR.   Sampling was conducted every two weeks at seven stations located 1, 3, 5, 10, 15, 20, and 25 miles from shore. Shaw coordinated scheduling of the cruises and managed the inventory of equipment and supplies. After each cruise, Ms. Shaw entered the sample inventory into Microsoft Access database. The database includes information on the time each station was sampled, ocean conditions at the station (water temperature, salinity, etc.), samples collected, and any equipment malfunctions or other out-of-the-ordinary events. Shaw processed 365 chlorophyll samples collected along the transects. Approximately 300 nutrient samples were collected and transported to OSU main campus for analysis. Shaw also counted all nighttime Bongo samples from *R/V Elakha*. She focused primarily on euphausiids, which were counted, identified to species and life stage (female, male, juvenile, etc.), and measured. Other species were also identified to the lowest taxonomic level possible, including gelatinous zooplankton (jellies, ctenophores, siphonophores, salps, etc.), pteropods, copepods, cephalopods, and shrimp. Once processed, the data was error-checked and entered into a Microsoft Access database. These data contribute to the regional salmon forecasts posted to the Ocean Ecosystem Indicators webpage (http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm). Shaw is currently drafting a manuscript on euphausiid abundance and distribution based on data from Elakha sampling.

While *R/V Elakha* was out of service, Shaw participated on the PODS cruise 1 – 10 March 2013 on the NOAA research vessel Bell M. Shimada, a Ship of Opportunity cruise working with orca researchers from the NWFSC. During the nights, Shaw conducted net tows for zooplankton distribution and abundance and collected water samples for chlorophyll and nutrient analyses.

Shaw was a member of PICES Working Group 23: Comparative ecology of krill in coastal and oceanic waters around the Pacific Rim, during its active period from October 2007 – October 2011. Each PICES working group must prepare a final report on its activities. Shaw has been engaged in drafting this final report, which included several rounds of editing with the staff of the PICES Secretariat, since December 2012. This report primarily provides comprehensive summaries of all euphausiid research conducted by the PICES member nations (Canada, China, Japan, Russia, South Korea, USA) from historical research to 2011. Shaw has been responsible for compiling information for this report, including communicating with euphausiid researchers in all of the member countries. She has first authorship on this report, which will be published in July or August of 2013.

Another goal of PICES Working Group 23 was to produce a Pan-Pacific comparison manuscript on egg production of *Euphausia pacifica*, since this species is found in the waters of all PICES member nations. In collaboration with others, Shaw was actively involved in drafting and editing this manuscript, which was accepted for publication in June 2013.

PUBLICATIONS:
Feinberg, L.R., **Shaw, C. T.**, Peterson, W. T., Décima, M., Okazaki, Y., & Ju, S.-J. (Accepted June 2013). *Euphausia pacifica* brood sizes: a North Pacific synthesis. *J. Plankt. Res*.

Amendment 13: Development of an Integrated, Multi-layer GIS Database for US West Coast Groundifsh
Funded: $30,000

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: *Waldo Wakefield*, Marine Habitat Ecology, NWFSC

PROJECT BACKGROUND: Pacific Coast Ocean Observing System is the ecosystem observing backbone of Integrated Ocean Observing System for the California Current Large Marine Ecosystem. The geographic focus is the U.S. Exclusive Economic Zone off the coasts of California, Oregon and Washington with international links to the portion of the California Current Ecosystem occurring in Canadian and Mexican waters. The system provides the information needed for management of fishery resources, protected marine mammals, marine birds, and turtles, and to forecast the ecosystem consequences of fisheries removals, environmental variability and climate change. To meet the needs of the Pacific Coast Observing System that provides ocean information for the sustained use of the California Current Large Marine Ecosystem and the 5-Year EFH Review Phases I and II, the PaCOOS computer server

must publish several terabytes of habitat maps and imagery. This is best accomplished by providing access to the data through web map services. Web map services create map images on demand for a client, and as such they are extremely process intensive on the server-side. Phase II of the 5-Year EFH review (*i.e,*. public nominations for EFH changes) will create a large increase in demand for the PaCOOS web map services, specifically for the data catalog and web maps developed under Phase I of the 5-Year review. The existing server did not have the processing capacity to handle data requests under the newly developed PaCOOS technology stack or the newly consolidated 5-Year EFH Review Data Catalog. This project was specifically designed to increase the capacity of the servers to maintain the functionality of the PaCOOS web map services that are vital to the 5-Year EFH Review.

PROJECT PROGRESS: A Dell Power Edge R815 Server and Power Vault MD1200 Disk Array were purchased on June 6th, 2012 (under expanded authority). During the months of June, July, and August of 2012, the server was in development status and not publically available. During the development phase the server was prepared by installing ArcGIS Server 10.1, the new custom internet mapping application (map viewer), the EFH review map and data collection, and the EFH-Catalog web site. This new suite of applications developed specifically for the EFH review Phases I & II was made publically available in the advance of the September 2012 Pacific Fishery Management Council Meeting, Boise, ID.

Link to new applications described above: http://efh-catalog.coas.oregonstate.edu/overview/

During the September Council Meeting, the live server was demonstrated to council subcommittees through presentations by NOAA Technical Lead Dr. Waldo Wakefield with assistance from Faculty Research Assistant Chris Romsos. Romsos also demonstrated the live server to the council and public on the council floor. This web catalog and mapping application has remained in a production (deployed) setting since September 2012 and has seen continued use by agencies and organizations developing Phase II proposals.

Amendment 16: Multi-beam Mapping of High Coral Bycatch Areas in Northern California and Southern Oregon
Funded: $69,000

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: *Elizabeth Clarke*, Science Synthesis and Coordination, NWFSC

PROJECT BACKGROUND: The objectives of the multibeam surveys are: 1) conduct multibeam mapping of areas near Klamath Canyon as defined by trawl survey coral hotspots; 2) produce high-resolution maps of bathymetry and backscatter for both new data collected during seagoing 2012 operations, and from existing EM 302 data in the vicinity of Mendocino Ridge; 3) characterize key features of surveyed substrates such as complexity, hardness, rugosity, and slope; and, 4) identify high-confidence targets for visual surveys of deep-sea coral and sponges in areas adjacent to the identified hotspots near Mendocino Ridge and Klamath Canyon.

Data from these surveys will include georeferenced distribution and abundance of demersal corals, sponges, and habitats, samples of corals and sponges for genetic and morphological studies, sediment samples for groundtruthing of seafloor maps, and continuously collected salinity, temperature, oxygen concentration, depth, and location. Resultant data will be added to a comprehensive database of similar data collected elsewhere off California available on the public website PaCOOS West Coast Habitat portal: http://pacoos.coas.oregonstate.edu/

PROJECT PROGRESS: No activity during this reporting period.

Amendment 17: Ocean Acidification Monitoring and Prediction in Oregon Coastal Waters
Funded: $156,820

OSU RESEARCH STAFF: *Burke Hales*, Associate Professor, College of Earth, Ocean, and Atmospheric Sciences; *Lauren Juranek*, Assistant Professor, College of Earth, Ocean, and Atmospheric Sciences; *Dale Hubbard*, Faculty Research Assistant, College of Earth, Ocean, and Atmospheric Sciences

NOAA TECHNICAL LEAD: *Libby Jewett, Dwight Gledhill*, Ocean Acidification Program, OAR

PROJECT BACKGROUND: A long-term monitoring system built around a combination of gliders and moorings, complimentary to ongoing efforts on ship-and shore-based facilities, is necessary to quantify long-term trends in ocean acidification and the biological response to these perturbations. Such a monitoring program must explicitly include not only CO_2 system measurements, but also the related hydrographic parameters upon which predictive algorithms will be based. Considerable focus of this project is to provide synthesis products (*e.g.,* maps of carbonate saturation state and pH) that are valuable to stakeholders. Refinements in algorithms to predict carbon system parameters will be coupled to more widely available T, S, O_2 data from glider and opportunistic ship surveys in order to expand the space/time coverage of these datasets.

PROJECT PROGRESS: Moored pCO_2 and pH instruments were deployed on the surface expression of NH10 in Fall 2012. NH10 was lost in a storm and the instruments were not recovered. pCO_2 and pH instruments were deployed on the NH10 surface expression in Spring 2013 for the summer season and will be recovered in Fall 2013. Near-bottom moored packages were deployed at NH10 and NH20 in January 2013 and were recovered in July 2013 (beyond this reporting period). Data has not yet been analyzed. Operations to install a MAPCO$_2$ buoy at NH10 were suspended for this year after losing instruments in the winter deployment. NOAA has re-directed funds through NANOOS for 2013 – 2014, and that work will be performed in coming months, independent from CIMRS.

A long coast-wide survey in August on NOAA *R/V Bell M Shimada* was mounted in August 2012. On this cruise, Assistant Professor Lauren Juranek provided nutrient and O_2 sampling and analysis. 81 stations were occupied, and 610 samples were analyzed for O_2 and 1061 for nutrients. Data have been analyzed and delivered to PMEL colleagues.

Theme: Protection & Restoration of Marine Resources

Amendment 8: Refinement and Application of a Bioeconomic Spatial Fishery Simulator
Funded: $125,747

OSU RESEARCH STAFF: *David Sampson*, Professor, Department of Fisheries and Wildlife; *Christopher Cusack*, Graduate Research Assistant, College of Agricultural Sciences

NOAA TECHNICAL LEAD: *Cindy Thomson*, Fisheries Economics Team, SWFSC; *Andi Stephens*, Population Ecology, NWFSC

PROJECT BACKGROUND: This project is to refine a generalized bioeconomic simulator that Dr. David Sampson originally constructed during 2009 – 2011 in his role as a Senior Fisheries Scientist at the European Commission's Joint Research Center in Ispra, Italy, while on leave of absence from Oregon State University. The simulator, which is coded in the open-source R language, mimics the population dynamics of one or more fish stocks that occupy a set of spatial regions and are harvested by multiple fishing fleets. The overall goal of the project is to complete a bioeconomic spatial fishery simulator that is more realistic than the current generation of simulation models and to use the simulator to help develop practical solutions to some of the complex problems involved in managing our fisheries. It is intended to be a flexible tool for exploring the effectiveness of fishery management policies in the face of uncertainty. It is distinct from the models that are typically used in guiding fisheries management in that it includes equations for modeling dynamic changes in the fishing operations. Most fisheries models, in contrast, take a strictly biological perspective and treat the mortality generated by fishing as a constant. Also, the simulator takes a more realistic approach than the economic-oriented fisheries models that employ very simple equations for the biomass dynamics of the fish stocks. For the biological components, the bioeconomic simulator uses the standard age-structured dynamics that are used in modern stock assessments, with explicit equations for growth in length and weight, maturation, age-dependent mortality, and the production of annual recruitment.

One aspect of the simulator, which is an important technical advancement over other bioeconomic fisheries models, is in how the simulator handles the aspect of spatial distribution of fishing. Because fish are not uniformly distributed, a skipper's choice of where to deploy his fishing gear is a major economic decision variable. Locations with high densities of fish could produce significant revenue, but the associated costs of fishing in these areas may lessen their desirability. Further, because fishing is a competitive process, locations with high fish densities are likely to attract numerous fishing vessels, which over time will tend to deplete any locally high fish abundance. To maximize profit flow, each fisher must weigh the potential costs and benefits of operating his fishing vessel among a suite of different possible fishing locations.

Each location will produce different catch rates and species mixes, which will be partly determined by the operations of other vessels fishing in that location; associated with each location will be different operating costs and potential economic rewards. Most previous bioeconomic fishery simulation models have used historical data to guide the allocation of effort to spatial regions. Random utility models are often used to determine the spatial proportions for effort. These approaches leave the overall level of effort unresolved.

In the bioeconomic simulator, the fishing vessels within in each fleet have uniform technical characteristics (e.g., catchability, selection, fish prices, and fishing costs) and for each time-step they choose where to fish and their distribution of fishing time (fishing effort) based on their anticipated profits during that step. They compete for fish with each other and with the vessels from other fleets. The spatial distribution of fishing effort is resolved using a Nash equilibrium solution. Under this solution, all fishing vessels produce their maximum profits given the set of choices made by all other fishing vessels for the amounts and distributions of fishing time. It is an equilibrium solution in the sense that no fishing vessel can unilaterally improve its profitability by changing its fishing effort or spatial distribution of fishing.

Another unique aspect of the simulator is in its explicit separation of fishing effort into two constituent parts: (1) the physical vessels and gear used for fishing and (2) the amount of time that they conduct fishing operations. Most bioeconomic fishery models treat fishing effort as a single variable and have a single equation to describe the dynamics of fishing effort, with the rate of entry being proportional to the level of profits. This single-variable approach misses the important feature that the amount of time spent fishing can change rapidly, whereas the number of fishing vessels in a fleet changes more sluggishly.

The work-plan for the project includes an exercise to validate the simulator's innovative approach to resolving the spatial distributions of fishing effort and application of the simulator in management strategy evaluations of two current West Coast fishery issues: the evaluation of alternative rebuilding schedules for overfished rockfish stocks and the issue of how to set appropriate buffers to account for the management uncertainty associated with achieving management targets.

PROJECT PROGRESS: In July 2012, David Sampson and NWFSC Technical Lead Andi Stephens met with SWFSC Technical Lead Cindy Thomson at the SWFSC laboratory in Santa Cruz, CA for a day and a half. The group discussed project organization and technical details concerning the refinements to be made to the model and its subsequent application. Sampson and Stephens also discussed the project with Aaron Mamula and Cameron Speir, who, along with Thomson, are on fisheries economics staff at the laboratory. They had been involved in a recent study that examined changes in fishing effort following implementation of the Rockfish Conservation Area off California. That study's approach and findings are quite relevant to the

current project's task of validating the Nash equilibrium approach for resolving fishing effort and its spatial distribution.

The bioeconomic simulator is coded in the R open-source programming language and it uses data structures and helper functions from the package FLR (Fisheries Language in R). During the initial months of the project, Sampson acquired updated versions of the FLR routines and modified the simulator code to work properly with the newer versions of the FLR functions, with assistance from Stephens. Graduate Research Assistant Christopher Cusack acquired a copy of the simulator code and started becoming familiar with that code and with FLR. During most of this 12-month reporting period, Sampson met weekly or bi-weekly with Mr. Cusack.

One of the refinements to the bioeconomic simulator was problematic and became the focus of considerable work by Sampson and Cusack. The issue was with the mechanism within the fishing location choice module for constraining the fishing time during the one-year time-step of the simulator. The approach outlined in the proposal used a cost penalty that increased asymptotically as the fishing-days variable approached its pre-specified maximum value. Unfortunately, when this approach was coded up and made operational in the simulator, it did not result in a stable algorithm. Sampson and Cusack decided to try a different approach and recast the fishing location choice problem as a constrained optimization problem, with explicit constraints on the amount of fishing time and the amount of catch. These constraints might or might not be binding under any particular set of simulated conditions. Cusack developed an algorithm that results in a solution for each fleet's fishing days and their spatial distribution. The solution satisfies the constraints and the Nash equilibrium condition (no fishing fleet can unilaterally improve its position), and it appears to be unique. Cusack is currently developing a formal mathematical proof that the algorithm works correctly and that the solution is unique. Subject to some further testing, this new algorithm will be used in the refined simulator for the validation exercise and subsequent applications with the simulator.

Because of the complications aforementioned, the project has not yet fully embarked on the tasks associated with applying the bioeconomic simulator to real data sets. However, Thomson has compiled data from PacFIN for vessels operating in the West Coast fishery for groundfish and all other fisheries. These data will provide an empirical basis for apportioning the set of West Coast vessels into a reasonably small set of fishing fleets, with each fleet having vessels that are more or less uniform in their traits. Also, Cusack is in the process of obtaining detailed data from the groundfish fleet in Oregon that will provide data that might be suitable for the exercise of evaluating the accuracy of the fishing location choice algorithm.

During May 2013, Sampson and Cusack traveled to St. Petersburg, Florida to attend the biennial conference of the North American Association of Fisheries Economists. Sampson and Cusack both gave oral presentations regarding the bioeconomic simulator project. Sampson gave a

general overview of the bioeconomic simulator, its approach, unique features, and planned applications; Cusack gave a technical presentation on the Nash equilibrium approach to resolving fishing effort and its spatial distribution.

PRESENTATIONS:

Sampson, D, C. Cusack, C. Thomson. (2013) North American Association of Fisheries Economists Forum 2013. St. Petersburg, FL. 21-24 May 2013. Oral Presentation. "Developing a bioeconomic spatial, multi-species fishery simulator." Abstract ID 60.

Cusack, C., D. Sampson. (2013) North American Association of Fisheries Economists Forum 2013. St. Petersburg, FL. 21-24 May 2013. Oral Presentation. "A Nash Equilibrium approach for predicting the spatial distribution of fishing effort in a multi-fleet, multi-area generalized equilibrium model." Abstract ID 89.

Amendment 18: North Pacific Minke Whale Implementation Review
Funded: $5,000

OSU RESEARCH STAFF: *Scott Baker*, Professor, Marine Mammal Institute
NOAA TECHNICAL LEAD: *Paul Wade*, National Marine Mammal Laboratory, AFSC

PROJECT BACKGROUND: This project supported Professor Scott Baker's continued participation in the ongoing Implementation Review for Western North Pacific Common Minke Whale by the International Whaling Commission. Baker previously contributed numerous reports to this Implementation Review and continues to provide relevant interpretation of analyzed data and of the subsequent scientific reports for management purposes.

PROJECT PROGRESS: Professor Scott Baker conducted review of scientific documents and communicated with NOAA Technical Lead, Paul Wade, on issues of uncertainty related to possible stock structure scenarios in preparation for (but not participation in) the Second Intersessional Workshop on the Implementation Review for Western North Pacific Common Minke Whale, convened by the International Whaling Commission and hosted by NOAA Southwest Fisheries Science Center from 19 – 23 March in La Jolla, CA. Baker's scientific contribution to this implementation review was completed by his participation in the meeting of the Scientific Committee of the International Whaling Commission from 6 – 14 June in Jeju, Korea (under a separate funding source).

Amendment 21: Stock Assessment Research Review of Pacific Hake
Funded: $16,795

OSU RESEARCH STAFF: *David Sampson*, Professor, Department of Fisheries and Wildlife

NOAA TECHNICAL LEAD: *Jim Hastie*, Population Ecology, 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 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 conduct 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.

PROJECT PROGRESS: Dr. Sampson's primary activity for this project was active participation in discussions at a four-day meeting of the Pacific Whiting treaty's Scientific Review Group held in Vancouver, British Columbia on 19 – 22 February 2013. The SRG meeting conducted a peer-review of the draft 2013 stock assessment for the coastal stock of Pacific whiting (hake) that occurs in the western waters off the U.S. and Canada and reviewed some preliminary work conducted during 2012 to evaluate the performance of the default harvest control rule that is used to determine the Pacific hake catch quota for the following fishing season. Sampson's other activities included preparing for the meeting by reading the draft 2013 stock assessment document and the provided supporting reports and analyses, contributing text to the SRG's report to the Joint Management Committee, and assisting in editing and finalizing the SRG report by email correspondence.

The 2013 assessment for the coastal Pacific hake stock and related analyses had been conducted during the summer and fall of 2012 by members of the Joint Technical Committee, 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. In addition to producing a standard stock assessment, the JTC also reported on a preliminary simulation-based evaluation of the performance of the Treaty's agreed harvest control rule for calculating the annual total allowable catch. Both the stock assessment and the management strategy evaluation were the subjects for review by the SRG during the February meeting in Vancouver.

Stock Assessment Review

The review of the stock assessment, which occurred during the first two days of the February 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 the 2012 hydro-acoustic survey, summaries of the 2012 U.S. and Canadian fisheries, an overview of the data sources used in the 2013 assessment, and a detailed overview of the draft 2013 assessment. Following the presentations there was a general discussion 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. Much of the discussion focused on the accuracy of the draft assessment's projection that the stock is currently growing rapidly due to the presence of two very strong incoming year classes (2008 and 2010). Supporting evidence for the strength of these year classes was provided by data from both the fishery and the survey, but past assessments have sometimes found signals of strong year classes that subsequently were shown to be falsely optimistic. Another point of discussion was the unusual pattern for the estimated survey selectivity coefficients, which indicated a pronounced and implausibly large jump between age-5 and age-6. The SRG developed a list of nine formal requests for 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 presenters entertained questions during their presentations and the atmosphere during the review was serious but appropriately relaxed. Having chaired two previous stock assessment review (STAR) panels for Pacific hake assessments (in 2008 and 2009), Sampson was very favorably impressed by the collaborative and non-confrontational approaches taken in conducting the assessment and presenting the results.

Management Strategy Evaluation Review

The review of the management strategy evaluation (MSE) occurred during the third day of the meeting. The JTC presentation provided a detailed overview of the work that had been completed during 2012 to develop a simulation framework for investigating the overall performance of the Pacific hake monitoring, stock assessment and management system. Because the MSE approach had not previously been applied to the Pacific hake fishery and had to be developed from scratch, the JTC operated to a relatively limited set of objectives. The objectives are: develop a computer simulation (described as an operating model) for mimicking the Pacific hake stock dynamics and generating assessment data with random measurement error; and conduct simulations and projections into the future based on the 2012 stock assessment data and model to evaluate the performance of the system. The JTC presented results for four scenarios: (1) a "no-fishing" scenario that illustrated the natural variability of the stock; (2) a "perfect-information" scenario in which catches were taken based on the default harvest control rule with

no uncertainty with respect to the current stock biomass or target rate of fishing mortality; (3) a scenario in which survey data (biomass estimates and age compositions) were available annually; and (4) a scenario in which survey data were available biennially. The JTC also presented results from a limited evaluation of the performance of harvest control rules that use alternative target rates of fishing mortality. The SRG found the results to be "an informative first step" and made a number of technical suggestions for extending the MSE to make the operating model more realistic and more fully incorporate the many sources of uncertainty that the current model considers as assumptions.

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 and formulated recommendations to the Joint Management Committee on harvest management advice and future research activities. The review concluded at about 1 pm on February 22nd.

SRG Report Preparation
The SRG report summarizing the review meeting was prepared jointly by the members of the SRG, with the two co-chairs taking the lead on assembling the draft report and circulating it to the rest of the SRG. Because there were no support personnel to transcribe the proceedings of the meeting, several members of the SRG were tasked to serve as rapporteurs. Sampson was responsible for taking notes on the discussions that occurred during the third day of the review. Greg Workman, one of the SRG co-chairs circulated an almost final draft of the report to the SRG members by email on February 27th, with the aim of finalizing the report by the close of business on March 1st.   Sampson sent in his final set of comments and suggested edits on time. The final version of the SRG report was submitted to the Joint Management Committee on March 3rd.

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.nwr.noaa.gov/fisheries/management/whiting/17_srg-feb-2013.html.

Theme: Seafloor Processes

Amendment 11: Impacts of Submarine Volcanism and Hydrothermal Venting on the Global Ocean and Deep-Sea Ecosystem
Funded: $1,028,517

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; *Andra Bobbitt, Joe Haxel, Susan Merle*, Senior Faculty Research Assistants, CIMRS; *Leigh Evans, Matt Fowler, Ron Greene*, Faculty Research Assistants, CIMRS

NOAA TECHNICAL LEAD: *Stephen Hammond*, OER Chief Scientist, PMEL

Volcanic and Hydrothermal Event Detection in the Northeast Pacific

PROJECT BACKGROUND: Hydroacoustic monitoring continues to be the primary tool in detecting and understanding the mechanics of submarine eruptions and diking events. When eruptive or magmatic activity is detected, *T*-wave data is used to assess the duration, spatial extent, and style of activity. The response community relies on this information to identify those earthquake sequences that are likely to be associated with eruptions and/or produce significant hydrothermal changes worthy of rapid response. Although not all earthquakes will be deemed worthy of response, an assessment of their character and a description of their position, intensity and duration remains important for interpreting observation made either *in situ* or during ship-based visits to ridge crest hydrothermal sites. By examining earthquakes of various sizes, and at a range of distances from different vent sites, the observation system's sensitivity to these events is better understood. Efforts also focus on examination of the possible remote triggering of seismic events by dynamic stress transients associated with the passage of seismic waves – a process that is poorly understood, particularly in the marine environment.

PROJECT PROGRESS: Professor Robert Dziak oversaw daily review of SOSUS hydrophone records for significant earthquake and volcanic activity along the Juan de Fuca Ridge system. Dziak planned recovery and redeployment of ocean bottom hydrophones, scheduled for September 2013, within the caldera of Axial Volcano, an active deep-sea (1500 m) volcano 300 miles of the Oregon coast. Ocean bottom hydrophones record microseismicity within the volcano associated magmatic activity and seafloor eruptions. The Lau basin hydrophone experiment was completed, and Dziak is currently analyzing the data and preparing for publication. Dziak co-authored two papers on hydrophone detected seismic activity in the Lau basin and plans to submit an abstract to the American Geophysical Union Fall Meeting 2013 on the detailed analysis of explosive eruptions of West Mata volcano.

In this FY, Dziak was invited by the Istituto Nazionale di Geofisica e Volcanologica (INGV) in Italy to discuss collaboration with INGV scientists to deploy hydrophone and seafloor pressure sensor in the submerged volcano that forms Naples bay and to present a departmental seminar on history of seafloor volcano monitoring in the northeast Pacific Ocean using SOSUS and portable hydrophone arrays. The invitational visit took place 20 – 29 September 2012 in Naples, Italy. Dziak also participated in a NOAA meeting hosted by NMFS to develop a NOAA-wide strategy on ocean noise. The meeting was held on 27 – 28 February 2013 at NOAA headquarters in Silver Spring, MD. Dziak provided US Navy hydrophone data archive for review of long-term observation of changes in ocean noise due to natural (seismo-volcanic activity, wind, weather, *inter alia*) and anthropogenic sources.

Assistant Professor Haru Matsumoto continued his development of innovative acoustic technologies for use on fixed and mobile platforms. Matsumoto oversaw construction of ocean bottom hydrophones for use at Axial Volcano. He is currently developing a hydrophone for deployment on a winch buoy that can remain submerged for extended time periods and subsequently surface to transmit data back to shore in real-time.

Applied Mathematician Andy Lau developed new software for location of microearthquakes within volcanic edifice. The algorithm is based on a" grid-search" method that seeks to minimize the difference between observed and predicted acoustic signal arrival times detected on an ocean bottom hydrophone array. The method is called "grid-search" because the minimization occurs by systematically moving a hypothetical earthquake location through a 3-D grid and finding the location where the difference between the observed and predicted arrival time is the smallest. This software is being used by Dziak and Senior Faculty Research Assistant Joe Haxel to locate earthquakes at Axial Volcano. Lau continues to develop software that allows estimates of gas flux from submarine volcanoes by using hydrophone records of volcanic explosions. This technique has been used at a volcano in the Mariana Islands and is now being employed at West Mata Volcano in the Lau Basin. Lau contributed to the Ocean Ambient Noise Levels Map by processing available acoustic data and interpolating sounds levels for the major oceans. 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 and converted the Ocean Bottom Seismometer data from its original format into CSS format for processing. Additionally, Lau assisted Dziak, Matsumoto, and Haxel in figure preparation for their respective manuscripts and assisted Dr. Chadwick with processing data to remove tidal signals from BPR data..

Haxel continued detailed analysis of ocean bottom hydrophone data from the caldera of Axial Volcano. Data encompasses a six year time span and thus provides a long-term view of seismic precursor activity at the volcano prior to its eruption in April 2011. Haxel combined seismic record with long-term seafloor deformation record to provide further insights into the flow of

magma into the shallow reservoir beneath the volcano's summit prior to eruption. He has summarized the results in a manuscript submitted to the journal *Geology*.

Faculty Research Assistant Matt Fowler oversaw preparation of ocean bottom hydrophones and seafloor pressure recorders for deployment at Axial Volcano in September 2013. Fowler assisted Dziak in manuscript and presentation preparation and Matsumoto in construction and development of hydrophone instruments and moorings in addition to new development of acoustic sensors for mobile platforms.

PRESENTATIONS:

Dziak, R. Department seminar at Istituto Nazionale di Geofisica e Volcanologica. Naples, Italy. 20-29 September 2012. Invitational Speaker. "Seismo-acoustic monitoring of seafloor volcanic activity."

Matsumoto, H, R.P. Dziak, M. Park, T-K Lau, W.Lee, D. Bohnenstiehl, K.M. Stafford, C.S. Reiss. Scientific Committee on Antarctic Research XXXII Meeting. Portland, OR. 18-19 July 2012. Oral Presentations. "Sound of climate change: Anthropogenic impact to the world ocean" and "Hydroacoustic detection of ice-tremor and ice-quakes from the grounding and calving of Iceberg A53a."

Matsumoto, H, R. P. Dziak, H. Klinck, D. R. Bohnenstiehl, J. Haxel, and C. Meining. International Hydroacoustics Workshop 2012, Comprehensive Nuclear-Test Ban Treaty Organization. Yokohama, Japan. 12-15 November 2012. Invitational Speaker. "Status of the autonomous hydrophone: towards a near real-time detection of acoustic events."

PUBLICATIONS:

Dziak, R.P., **Matsumoto, H.**, Park, M., Bohnenstiehl, D. R., **Fowler, M.**, **Lau, T-K**, & Stafford, K. M. (Submitted). Contribution to the ambient ocean sound field from breakup of sea-ice, icebergs and cetacean vocalizations near the Antarctic Peninsula, *Geochemistry, Geophysics, Geosystems*.

Dziak, R.P., **Fowler, M.**, **Matsumoto, H.**, Bohnenstiehl, D.R., Park, M., Warren, K., & Lee, W-S. (2013). Life and death sounds of iceberg A53a. *Oceanography*, *26*(2). http://dx.doi.org/10.5670/oceanog.2013.20.

Dziak, R.P., Baker, E.T., Shaw, A.M., **Chadwick, Jr., W.W., Haxel, J.H., Matsumoto, H.**, & Walker, S.L. (2012). Flux measurements of explosive degassing using a yearlong hydroacoustic record at an erupting submarine volcano. *Geochemistry, Geophysics, Geosystems, 13*(11), Q0AF07. doi:10.1029/2012GC004211.

Dziak, R.P., Haxel, J.H., Bohnenstiehl, D.R., **Chadwick, Jr., W.W.**, Nooner, S.L., **Fowler, M.J., Matsumoto, H.** & Butterfield, D.A. (2012). Seismic precursors and magma ascent before the April 2011 eruption at Axial Seamount. *Nature Geoscience, 5*(7):478-482. doi: 10.1038/NGEO1490

Haxel, J.H., **Dziak, R.P.**, **Lau, T.**-**K.**, **Chadwick, W.W.**, & Nooner, S.L. (Submitted). Seismic cycles, seafloor deformation and volcanic eruptions at Axial Seamount, Juan de Fuca Ridge. *Geology*.

Samaran, F., Stafford, K.M., Branch, T.A., Gedamke, J., Royer, J-Y, **Dziak, R.P.** & Guinet, C. (In review). Seasonal and geographic variation of southern blue whale subspecies in the Indian Ocean. *Plos One*.

Research on the Near- and Far-field Physical and Chemical Impacts and Consequences to Ocean Ecosystems Caused by Submarine Volcanoes and Hydrothermal Venting

PROJECT BACKGROUND: CIMRS researchers study and document interactions between submarine volcanic events and the hydrothermal vent biological community by "detection and response" efforts, often in collaboration with colleagues from NOAA and at universities in the U.S. and abroad. Volcanic and seismic events are detected on the spreading centers in the NE Pacific by hydroacoustic monitoring and in-situ instruments. Interdisciplinary and inter-agency rapid response efforts have been mounted to these events because they are unsurpassed opportunities for direct observations of the impacts and consequences of deep-sea volcanism. This hydroacoustic monitoring capability is unique to the NE Pacific and the CIMRS collaboration at the Hatfield Marine Science Center in Newport, OR. Many such events have been investigated in the NE Pacific over the last two decades. Axial Seamount remains a long-term research site because it is the only site in the world where a repeatable (and perhaps predictable) cycle of inflation and deflation has been documented at a submarine volcano and because the seamount is a focus site on the regional scale nodes component of the National Science Foundation's Ocean Observatories Initiative (OOI). Monitoring volcano-ecosystem interactions in the NE Pacific and exploration of the consequences of volcanic outputs into the ocean continue to be a focus of CIMRS collaborative research.

PROJECT PROGRESS: Professor William Chadwick and Senior Faculty Research Assistant Susan Merle participated in the Submarine Ring of Fire 2012 research expedition to Northeast Lau Basin (located between Samoa and Fiji) in 9 – 26 September 2012, funded by NOAA Office of Ocean Exploration and Research. Faculty Research Assistant Ron Greene prepared the seawater sampling tools and equipment for this expedition and assisted with shipping the equipment from Newport, OR to Suva, Fiji. During the expedition, an interdisciplinary team of 27 scientists and technical experts from the United States, New Zealand and Australia made remotely operated vehicle (ROV) dives to explore and collect samples at volcanic vents and seafloor hot springs. Twelve dives at nine sites were successfully made, with 98.5 hours of bottom time and 164 samples for geology, chemistry, biology and microbiology. Details of the expedition can be found at http://oceanexplorer.noaa.gov/explorations/12fire/logs/summary/summary.html. Chadwick was one of

the science observers who planned and led ROV dives, made geologic observations on the seafloor, and oversaw acquisition, editing, and archiving of digital still imagery and video. Merle assisted co-Chief Scientist, NOAA Geophysicist, Robert Embley with dive planning, producing dive maps with seafloor bathymetry, sample sites, and ROV acoustic navigation. Merle also oversaw the collection and processing of multibeam sonar data during the cruise. Merle was the lead data manager during the cruise and produced a detailed cruise report after the expedition. Faculty Research Assistant Leigh Evans analyzed and quantified vent fluid samples collected from this expedition.

Research results were published in peer-reviewed journals. Three companion papers and one "News and Views" commentary were published in the July 2012 issue of the journal *Nature Geoscience* about the 2011 eruption at Axial Seamount. Chadwick was first author on one of the papers and co-author on the other two. Chadwick had been Chief Scientist on the expedition to Axial that discovered the eruption in the summer of 2011, 3 – 4 months after the eruption occurred. The *Nature Geoscience* papers presented the results from monitoring instruments that were in place during the eruption and high-resolution mapping of the new lava flows. Oregon State University and NOAA issued a joint press release about the publication of the *Nature Geoscience* papers:
http://oregonstate.edu/ua/ncs/archives/2012/jun/undersea-volcano-gave-signals-eruption-2011
http://researchmatters.noaa.gov/news/Pages/osuvolcano.aspx. The press release was circulated by news organizations in Oregon, the US, and around the world. In addition, Dr. Bob Detrick, Assistant Administrator of OAR, highlighted this news item as one of the top OAR accomplishments in 2012 in his year-end email to all OAR employees.

Merle presented a poster at the 2012 Fall Meeting of the American Geophysical Union (AGU), which detailed results from a study of imaging CO_2 bubble plumes using a new multibeam sonar system from Northwest Rota, an active submarine volcano in the Mariana Arc. Chadwick co-authored another presentation at the AGU meeting related to the 2011 eruption at Axial Seamount, titled "Syn-emplacement CO_2 degassing of submarine lavas flows: constraints on eruption dynamics." In February, Chadwick submitted a first author manuscript (with Merle and Bobbitt as co-authors) for publication in the journal *Geochemistry, Geophysics, and Geosystems*. This paper presents results from geologic and high-resolution mapping of the lava flows from the previous eruption at Axial Seamount in 1998. The paper has been accepted and is now in press. Chadwick is also co-author with colleagues from Monterey Bay Aquarium Research Institute on another paper about geologic mapping of the entire summit of Axial Seamount, currently in revision.

Sixty dredged rock samples were collected from 60 locations at the Northern Fiji Basin (NFB) by Greene in FY12 aboard *R/V Southern Surveyor*. In FY13, the chemical analysis, quantitation, and interpretation of final 22 of 60 rock samples were completed by FRA Evans. Greene extracted seawater samples from 25 CTD casts as well as processed 150 helium water column

samples. This data supplement and extend the geographic coverage of previously published work of northern Lau Basin rock samples (Lupton et al 2009, doi:10.1029/2009GL039468).

Evans and Greene participated in the 2012 expedition to Axial Seamount aboard *R/V Langseth*, 16 – 26 August, 2012. This work was part of a time-series study of the vent fields within the caldera. Evans measured gas concentrations and subsampled the gases for helium and other gas analyses. Greene collected 34 helium water column samples from four vertical casts.

Greene extracted seawater samples that he collected in FY12 from The Chile Triple Junction cruise while aboard the *R/V Melville* from Punta Arenas Chile to Santiago Chile. The samples were from five casts in the Segment 1 region around 46.24^o S and 75.83^o W. Four of the five casts were modified vertical tows called Pogo's. The five CTD casts totaled 120 samples. Greene processed 114 of 120 samples via extraction and mass spectrometer labs.

Greene has been compiling summary spreadsheets for the many years of helium data. He has completed two summary spreadsheets for the four Mariana's expeditions and one for the northeastern Lau Basin. The NE Lau Basin spreadsheet contains data from12 expeditions. Greene also produced embedded plots for the helium signal for each cast next to the columns of data, and included the locations for each cast. These summary sheets will be available to others in the project, allowing simple access to helium data for a specific cast or cruise.

PRESENTATIONS:
Merle, S.G., W.W. Chadwick, R.W. Embley, and M. Doucet. American Geophysical Union Fall Meeting 2012. San Francisco, CA. 3 – 7 December 2012. Poster. "Bubble Plumes at NW Rota-1 Submarine Volcano, Mariana Arc: Visualization and Analysis of Multibeam Water Column Data."

PUBLICATIONS:
Caress, D.W., Clague, D.A., Paduan, J.B., Martin, J.F., Dreyer, B.M., **Chadwick, Jr., W.W.**, Denny, A., & Kelley, D.S. (2012). Repeat bathymetric surveys at 1-metre resolution of lava flows erupted at Axial Seamount in April 2011. *Nature Geoscience, 5*(7):483-488. doi: 10.1038/NGEO1496

Chadwick, W.W., Jr., Nooner, S.L., Butterfield, D.A., & Lilley, M.D. (2012). Seafloor deformation and forecasts of the April 2011 eruption at Axial Seamount. *Nature geoscience, 5*(7):474-477. doi: 10.1038/NGEO1464

Dziak, R.P., Baker, E.T., Shaw, A.M., **Chadwick, Jr., W.W., Haxel, J.H., Matsumoto, H.**, & Walker, S.L. (2012). Flux measurements of explosive degassing using a yearlong hydroacoustic record at an erupting submarine volcano. *Geochemistry, Geophysics, Geosystems, 13*(11), Q0AF07. doi:10.1029/2012GC004211.

Dziak, R.P., Haxel, J.H., Bohnenstiehl, D.R., Chadwick, Jr., W.W., Nooner, S.L., Fowler, M.J., Matsumoto, H. & Butterfield, D.A. (2012). Seismic precursors and magma ascent before the April 2011 eruption at Axial Seamount. *Nature Geoscience, 5*(7):478-482. doi: 10.1038/NGEO1490

Chadwick, W. W., Jr., Clague, D. A., Embley, R. W., Perfit, M. R., Butterfield, D. A., Caress, D. W., Paduan, J. B., Martin, J. F., Sasnett, P., Merle, S. G., & Bobbitt, A. M. (In press). The 1998 eruption of Axial Seamount: New Insights on submarine lava flow emplacement from high-resolution mapping. *Geochemistry, Geophysics, and Geosystems*.

Clague, D. A., Dreyer, B. M., Paduan, J. B., Martin, J. F., Chadwick, Jr., W. W., Caress, D. W., Portner, R. A., Guilderson, T. P., McGann, M. L., Thomas, H., Butterfield, D. A., & Embley, R. W. (In press). Geologic History of the Summit of Axial Seamount, Juan de Fuca Ridge. *Geochemistry, Geophysics, Geosystems*.

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

Deschamps, A., Tivey, M. A., Chadwick, Jr., W. W., & Embley, R. W. (2013). Waning magmatic activity along the Southern Explorer Ridge revealed through fault restoration of rift topography. *Geochemistry, Geophysics, Geosystems*, *14*(5), 1609 – 1625. doi:10.1002/ggge.20110

Geist, D., Bergantz, G., & Chadwick, Jr., W. W. (In press). Galápagos magma chambers. In N. d'Ozouville, D. Graham, E. Mittelstaedt & K. Harpp (Eds.), *The Galápagos: A Laboratory for the Earth Sciences*. Washington, D.C.: Geophysical Monograph, American Geophysical Union.

Lupton, J., Arculus, R.J., Jenner, F.E., Evans, L., Greene, R.. (2012). Helium isotope variations in the northern Lau and North Fiji Basins. Abstract V23B-2820 at American Geophysical Union Fall Meeting 2012. San Francisco, CA. 3 – 7 December 2012.

Interpreting Digital Seafloor Bathymetry and Imagery, From Ship-based sonar, Deep-Towed Sidescan, Optical Sensors, Submersible and Remotely Controlled Vehicles

PROJECT BACKGROUND: CIMRS collaboration has been particularly innovative and productive in 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

PROJECT PROGRESS: Senior Faculty Research Assistant Andra Bobbitt participated on the Submarine Ring of Fire 2012 research expedition in 9 – 26 September 2012 to NE Lau Basin aboard *R/V Revelle* utilizing the ROV QUEST. At sea, her primary responsibility was to manage the data collected using Geographic Information System (GIS) and co-log the ROV data during each dive along with Susan Merle. Since this ROV did not have automated comment logging and navigation smoothing capabilities, Bobbitt developed a method to merge typed log information (*e.g.* time and comments) with information the ROV data recorded during the dive (*e.g.* position and sensor data) using a simple spreadsheet. This method enabled a more robust data set for the data mapping, display and analysis utilizing GIS. Bobbitt further developed a methodology to smooth the navigation data to represent a more realistic track. While on shore, Bobbitt continues to manage the GIS system for the Vents Program, which includes this sea-going system for research expeditions.

Theme: Marine Bioacoustics

Amendment 19: Advanced Methods for Passive Acoustic Detection, Classification, and Localization of Marine Mammals
Funded: $151,199

OSU RESEARCH STAFF: *David Mellinger*, Associate Professor, Senior Research, CIMRS
NOAA TECHNICAL LEAD: *Jonathan Klay*, Vents Program, 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. The proposed 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 is reviewed in the areas of datasets, detection and classification algorithm development, software interfaces, and the subcontract.

I.   Datasets
One component of this research is to assemble standardized datasets specialized for automatic detection, classification, and localization (DCL). Such datasets should include multiple recordings of the species of interest so as to provide "common ground" data for training, testing, and comparing of DCL detection/classification algorithms.

The specialization involved comprises two things that distinguish such datasets from ordinary marine sound archives:
1) The recordings must be of variable quality. One obviously wants some very clear recordings – *i.e*., with high signal-to-noise ratio (SNR). Not as obviously, one wants very unclear (low-SNR) recordings, as these provide the "hard cases" that truly test a DCL technique. In particular, interference often comes from other species that may be similar acoustically and/or taxonomically to the target species. DCL methods used in the real

world will encounter sound with such low-SNR characteristics, and must perform acceptably well with it.

2) The recordings must have metadata labels. Labels indicate where in the recordings the desired calls are. For some call types such as baleen whale stereotyped calls and odontocete clicks, labels can be time-frequency boxes surrounding each call. For some call types such as odontocete whistles, labels are frequency contours surrounding a long, continuous vocalization. Label made in this project are as accurate as humanly possible, meaning that a human checks all calls (and non-calls). This results in relatively small amounts compared to automatically-screened recordings, but the data are of the highest quality and don't suffer from uncertainty about the correctness of the labels. Labels can include a "maybe" label for questionable calls; for such calls, one doesn't want to use the call for training a DCL method, and also don't want to count either finding or missing the call as a bad result when testing a technique.

Extant data were extracted from existing recordings; no new marine recordings were made. These recordings were labeled for this project and placed on a project FTP site. This site is unclassified, but it is open only to project participants, not to the public, because of the Navy origin of some of the recordings. Extant datasets include the following, with new (2012-13) datasets in bold:

Mysticete (baleen whale) datasets:
- Blue whale (*Balaenoptera musculus*) 'D' calls from southern California.
- **Blue (*Balaenoptera musculus*), fin (*B. physalus*), and humpback (*Megaptera novaeangliae*) sounds from the Southern California Offshore Range.**
- **Minke whale (*B. acutorostrata*) 'boing' calls from Hawaii.**

Ziphiidae (beaked whale) datasets:
- Cuvier's beaked whale (*Ziphius cavirostris*) clicks from southern California.
- Cuvier's beaked whale clicks from the Bahamas (AUTEC).
- **Cuvier's beaked whale (*Ziphius cavirostris*) clicks from the Southern California Offshore Range.**

Other odontocete (toothed whale, dolphin, and porpoise) datasets:
- Sperm whale (*Physeter macrocephalus*) clicks from the Bahamas (AUTEC).
- Bottlenose dolphin (*Tursiops truncatus*) clicks from southern California.
- Spinner dolphin (*Stenella longirostris*) clicks from Hawaii.
- Common dolphin (*Delphinus delphis*) clicks from southern California.
- Risso's dolphin (*Grampus griseus*) clicks from Southern California
- Melon-headed whale (*Peponocephala electra*) clicks from the Bahamas (AUTEC).
- **Killer whale (*Orcinus orca*) clicks and whistles from the Southern California Offshore Range.**

Localization dataset
- Minke whale (*B. acutorostrata*) 'boing' calls from Hawaii.

II.   Detection and classification (DC) algorithm development

Detection and classification may be broken down into stages:
1) *Time-frequency representation*. Calculation of a time-frequency representation (TFR) such as a spectrogram, wavelet-gram, Wigner-Ville representation, etc. In this project we are using the spectrogram.
2) *Conditioning*. This modifies the TFR to make the overall sound level constant, flatten the noise spectrum, remove some types of unwanted noise, etc. An example method used in this project for flattening the noise spectrum is spectrum equalization; and example method for noise removal is median (or other percentile) subtraction to lessen the intensity of clicks.
3) *Detection / segmentation*. In this step, identification is done of the times and frequencies at which sounds of interest occur. Clicks were detected by summing across frequencies and applying an energy threshold. Whistles were identified using the algorithm of Mellinger *et al*. (2011); briefly, it identifies peaks in the spectrum at each time step, tracks these peaks over time, and identifies any that persist long enough as detected whistles.
4) *Feature extraction*. Acoustic characteristics are measured of the time/frequency regions detected in the previous step. Whistles were characterized by minimum and maximum frequency, mean energy-weighted frequency, mean energy-weighted time offset, inflection points, etc., while clicks were characterized using cepstral coefficients in the method of Roch *et al*. (2011).
5) *Classification*. This step labels detected sounds with category labels, such as species names. A new aspect of this project is that features from both clicks and whistles are combined in the classification. Classification here is done using random forests, an expansion of classification and regression trees (CART). So far, the error rate has been reduced to 9.8% on the data sets of odontocete clicks and whistles.

III.   Software Interfaces

Much thought and many discussions have been held, principally with Marie Roch and colleagues from San Diego State University (SDSU), on developing applications programming interfaces (APIs) so that plug-ins for detection, classification, and localization can be developed. This has resulted in the attached document describing proposed programming class structures for these APIs. Chris Marsh of SDSU has developed an interface for detection in audio streams.

IV.   Subcontract

Work done under the subcontract to SDSU includes the above-mentioned applications programming interface (API) development, as well as work on clustering and classification of odontocete sounds. Whistles from four species of free ranging delphinids (*Tursiops truncatus, Stenella longirostris, Globicephala macrorhynchus,* and *Pseudorca crassidens*) were analyzed using a series of different methods, ranging from simple to complex. Clustering routines operated on full whistles or on subunits that have been delimited by salient features of the signal itself (*e.g.*, extrema), or by some external segmentation choice (e.g. a particular duration). The usefulness of the following methods was examined: (1) Manual clustering, (2) *K*-means clusters, (3) Adaptive resonance with dynamic time warping (DTW), and (4) Clique identification within a graph weighted by dynamic time warp distance.

Work was also done on how site and instrument variability affects the classification of two species that are readily distinguishable from their echolocation clicks: Risso's dolphins (*Grampus griseus*), and Pacific White-Sided dolphins (*Lagenorhynchus obliquidens*). Starting from the point of previously published methods [Roch *et al*. 2011], SDSU researchers examined the impact of how training and test data are partitioned during classifier development. Using data collected from high frequency acoustic recording packages (HARPs) deployed at six different sites throughout the Southern California Bight, SDSU researchers examined differences due to site and instrument variation and showed methods that compensate for instrumentation differences.

PRESENTATIONS:

Mellinger, D.K. 2013. 6th International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics. St. Andrews, Scotland. 12-15 June 2013. Oral Presentation. "Signal conditioning techniques for marine mammal vocalizations."

Stinner-Sloan, J., S. Baumann-Pickering, and **M.A. Roch**. 2013. 6th International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics. St. Andrews, Scotland. 12-15 June 2013. Poster Presentation. "The impact of site and instrument variability on the classification of echolocation clicks."

Frasier, K.E., **M.A. Roch**, E.E. Henderson, A. Alldredge, S. Baumann-Pickering, S. Rankin, E.M. Oleson, A. Kirker, and J.A. Hildebrand. 2013. 6th International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics. St. Andrews, Scotland. 12-15 June 2013. Oral Presentation. "A comparison of approaches for clustering tonal vocalizations of free ranging Delphinids."

PUBLICATIONS:

Lu, Y., Mellinger, D.K., Klinck, H., & Roch, M.A.. 2013. Joint classification of whistles and echolocation clicks from odontocetes. *J. Acoust. Soc. Am.* 133(5):3310(A).

Lu, Y., Mellinger, D.K., & Klinck, H. (2013). Joint classification of whistles and echolocation clicks from odontocetes. *Proc. Meetings Acoust*. 19:010014 (8 pp.), doi:10.1121/1.4801081.

Mellinger, D.K. 2013. Conditioning for marine bioacoustic signal detection and classification. J. Acoust. Soc. Am. 133(5):3311(A).

Mellinger, D.K. (2013). Conditioning for marine bioacoustic signal detection and classification. *Proc. Meetings Acoust*. 19:010017 (8 pp.), doi:10.1121/1.4800996.

Raich, R., Briggs, F., Lou, Q., Fern, X., & **Mellinger, D.K**. (2013). A framework for analyzing bioacoustics audio recordings as multiple-instance multiple-label data. *Proc. Meetings Acoust.* 19:010013 (5 pp.), doi:10.1121/1.4800995.

TASK 3

Theme: Protection and Restoration of Marine Resources

Amendment 14: Developing a Pilot Marine Debris Monitoring Program in Oregon
Funded: $47,981

OSU RESEARCH STAFF: *Jamie Doyle*, Extension Marine Community Development
Educator, Oregon Sea Grant
NOAA TECHNICAL LEAD: *Sherry Lippiat*, Marine Debris Program, NOS

PROJECT BACKGROUND: In partnership with Surfrider Foundation, SOLV, and Oregon Shores Conservation Coalition CoastWatch Program, Oregon Sea Grant, this project aims to develop and implement a pilot marine debris monitoring program in Oregon. Focus is on recruiting and training volunteers, analysis of debris, development of an Oregon database framework for volunteers reporting debris, adapting a data card, and increasing usage of data cards in Oregon during beach clean-ups. It is expected that these collaborations will establish a partnership framework within Oregon to continue long-term monitoring.

PROJECT PROGRESS: The Oregon Marine Debris Team (SOLV, Surfrider Foundation, Washed Ashore, Oregon Shores Conservation Coalition CoastWatch Program, and Oregon Sea Grant) held 16 workshops between March and May 2013 in 16 coastal communities on the Oregon coast (See the below table). The workshops gave an overview of marine debris needs related to scouting, planning a beach clean-up, and monitoring. A total of 120 individuals participated in the workshops, with a mean of 6 – 7 people per workshop. The workshops recruited residents to 1) volunteer for marine debris rapid response, such as phone trees, 2) volunteer for scouting on specific beaches, and 3) volunteer to adopt a beach to monitor in their area. The workshops also brought together residents interested in marine debris and Oregon State Parks local contacts, so that interested parties could contact each other in the future to build local capacity to address marine debris.

Date Workshop Held	Location(s) of Marine Debris Workshop	Date Workshop Held	Location(s) of Marine Debris Workshop
3/5/2013	Florence	3/26/2013	Pacific City
3/6/2013	Bandon	3/28/2013	Tillamook
3/7/2013	Port Orford	4/1/2013	Reedsport
3/9/2013	Gold Beach, Brookings	4/3/2013	Seaside
3/11/2013	Yachats	4/10/2013	Cannon Beach
3/13/2013	Coos Bay	4/16/2013	Rockaway
3/15/2013	Newport	5/11/2013	Astoria
3/25/2013	Lincoln City		

Amendment 20: Evaluating Possible Changes in Sperm Whale Habitat Use Near the Deepwater Horizon Site, Tagging, Indications of Population Health, and Wound Healing on Sperm Whales
Funded: $1,361,740

OSU RESEARCH STAFF: *Bruce Mate*, Professor, Marine Mammal Institute; *Tomas Follett*, *Craig Hayslip*, *Ladd Irvine*, *Martha Windsor*, Faculty Research Assistants; Marine Mammal Institute; *Adrienne Copeland*, *Erin Kunich*, *John McClung*, *Ken Serven*, Research Technicians.

NOAA TECHNICAL LEAD: *Tony Penn*, Damage Assessment Center, NOS

PROJECT BACKGROUND: Tagging of sperm whales within the past two years has revealed a SW-NE oriented oblong area around the Deepwater Horizon site that was not used by sperm whales in 2011 – 2012, suggesting a food web effect in that area. Because whales are large enough to cope with one-year long natural changes in biomass productivity (such as El Nino events), damages to their food chain may not show up as consequential until the changes have been in place for two years. Thus, 2012 was a critical year for observations on home ranges, body condition and calf production. This research focused on a search pattern across this region and tagging whales on either side of it to determine if whales are using the area and the relative abundance of prey in that region.

PROJECT PROGRESS: The OSU Marine Mammal Institute (MMI) attached implantable satellite tags to sperm whales in the northern Gulf of Mexico (GOM) during the summer of 2012 as part of a continuing effort to identify possible effects of the Deepwater Horizon oil spill on the GOM sperm whale population for National Resource Damage Assessment (NRDA) process. The cruise was conducted from 7 August to 6 September, 2012 to tag sperm whales in the northern Gulf of Mexico with satellite monitored radio tags while also measuring the prey field with EK60 echosounders using 38 kHz, 70 kHz and 120 kHz pole-mounted transducers. The cruise was conducted from the *M/V Sara Bordelon*, a 170' oil rig supply vessel based in Houma, LA. OSU research staff arrived in Houma on August 4th to start mobilization. Two MMI rigid-hulled inflatable boats, used for tagging, had been shipped in advance to Houma by flatbed truck, along with other tagging equipment. The boats, echosounder transducers, and two arrays were all installed on the ship prior to departure. Passive acoustic monitoring was conducted by subcontractor Continental Shelf Associates, Inc.

The *Sara Bordelon* departed on August 7th for a planned 30-day cruise with a 1-day stop after two weeks for re-supply and crew change. Faculty Research Assistant Ladd Irvine acted as chief scientist for the cruise and applied the tags to the whales. The other Faculty Research Assistants and Research Technicians filled the roles of biopsy sampler, photographer, small boat operator, and visual observers. Three volunteers donated their time to help with visual

observations, spotting whales from the bridge of the ship and relaying the information to the tagging boat. The cruise surveyed a large portion of the north central Gulf of Mexico collecting information on sperm whale distribution both visually and using passive acoustics, as well as recording the biomass density with the EK60. Due to technical difficulties with the passive acoustic system (the primary method of finding sperm whales) and Hurricane Isaac, only four whales were tagged during the cruise. Two of the four had been tagged in 2011, and one of the four had been tagged in 2010, allowing for inter-annual comparisons of the movements of the whales. Photographs were taken of all whales encountered to add to the existing GOM sperm whale ID catalogue and to identify previously tagged whales as a part of an ongoing project to evaluate wound healing at the tagging site after the tags come off the whales.

During and immediately after the cruise, Irvine and Faculty Research Assistant Martha Winsor assisted Professor Bruce Mate to prepare a draft NRDA final report to detail the results of sperm whale tracking from 2010 and 2011. The draft report was circulated to NRDA trustees and British Petroleum for comment and is being finalized. One of the primary findings was a ~4000 km^2 infrequently used area (void) running NE-SW between two groups of tagged whales which included the Deepwater Horizon site. It was likely that two subpopulations of sperm whales had been tagged, but it was unknown if the void was an established difference in habitat preference between the populations pre-2010 or a consequence of the Deepwater Horizon oil spill. In February 2013, Mate, Irvine, and Winsor wrote an addendum to the NRDA report detailing the results to date of the 2012 tagging. The 2012 sample size was too small to draw conclusions. However, the 2012 home range size of tagged whales appeared to be increasing compared to the previous two years.

Research Technician Copeland analyzed the EK60 data and summarized the general biomass results in an MMI internal report that was to be completed in summer 2013. The final model showed that biomass was lower when sperm whales were present, suggesting that there may be a prey depletion effect of the whale presence. She is currently attempting to isolate the acoustic signature of large squid (sperm whale prey) and fish within the data in order to better refine the model.

During winter 2012 and spring 2013, Faculty Research Assistant Hayslip isolated all photographs of previously tagged whales from the 2012 cruise and all previous sperm whale cruises to study the physical effect that the implantable satellite tags have on the whales and how the tag sites heal once the tags come off. The images will be sent to marine mammal veterinarians for their opinions on the wound site, and the results will be presented.

PRESENTATIONS:

Mate, B., Winsor, M., & Irvine, L. (2013). Gulf of Mexico Oil Spill and Ecosystem Science Conference. New Orleans, LA. 21 – 23 January 2013. Oral Presentation. "Habitat Use Patterns of Satellite-Tracked Sperm Whales in the Gulf of Mexico before, during and after the Deepwater Horizon Oil Spill."

Mate, Bruce. 2013. NRDA Webinar on Satellite Tracking of Sperm Whales Tagged in the Gulf of Mexico. 15 November 2012.

PUBLICATIONS:

Mate, B., Winsor, M., & Irvine, L. (2013). Satellite tracking of sperm whales tagged in the Gulf of Mexico 2010–2011: A follow-up to the Deepwater Horizon Oil Spill. Draft Final Report for Research Agreement NO.2010-2106 (Amendment 1) on data collected through February 29, 2012.

Mate, B., Irvine, L. & Winsor, M. (2013). Supplemental Report: 2012-Tagged Sperm Whales near the Deepwater Horizon Oil Spill.