

Oregon State University Hatfield Marine Science Center 2012 - 2013 Annual Report



Oregon State
UNIVERSITY

RESEARCH

EDUCATION

OUTREACH



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DIRECTOR'S MESSAGE

Janet Webster, Interim Director



Transitions can be smooth sailing or rough seas. As the Interim Director, I was charged with the latest transition of leadership at HMSC as well as keeping the enterprise moving ahead. All in all, the transition has been smooth with the occasional challenge and plenty of accomplishments.

The Search: The search for a new director of HMSC consumed many throughout the fall. A large search committee representing various units at HMSC and on the main campus sifted through resumes and hosted four candidates for visits. Dr. Bob Cowen was selected and will join HMSC in July 2013 as the third resident director of HMSC, following in the footsteps of Lavern Weber (1976-2002) and George Boehlert (2002-2012). Next year, you will be reading Bob's review of the year.

The Dock: The Misawa dock floated onto Agate Beach in June 2012. On March 10th, a section of it was dedicated commemorating the 2011 Tokoku Tsunami. The Japanese Counsel General, Hirofumi Murabayashi, and former Newport mayor, Mark McConnell, honored those who died in the horrific natural disaster and reminded the audience of the power of the sea. The new tsunami evacuation trail was officially opened and now serves as our route to safety as well as an educational tool for all who use it and read the signage lining the route. Both the dock exhibit and the trail represent a strong collaboration with the lead coming from the HMSC Director's Office and Oregon Sea Grant. The Facilities crew did a great job with logistics of both projects.

The Carpet: Carpet may be mundane, but new carpet can signal the completion of much needed renovation. The Education Wing renovation is now complete after two years of work on the labs and classrooms. The classrooms are fully equipped with technology for more robust approaches to teaching. The labs are outfitted for better learning experiences. Thanks to donors for help with this renovation. There is also new carpet and paint in the renovated Post-Doc Office and the Director's Suite. The cost is minimal for the improved working conditions and increased pride in the place.

The Interns: As June arrived, so did the Invasion of the Interns. HMSC faculty, researchers and managers hosted 35 students from across the country welcoming them into their labs, offices and the field. Various programs and agencies support these interns. The Director's Office staff members mentored three interns with assignments that included organizing the HMSC archives, documenting the seawater system and developing a healthier workplace. Our very successful National Science Foundation Research Experience for Undergraduates brought ten interns to

campus working on projects as diverse as measuring benthic respiration rates and nutrient inventories to analyzing the diet of northern anchovies. We received word that the REU program was awarded one of three five-year grants from NSF. Fortunately, there will be more interns in our future as these students add vibrancy to our work place and give us the chance to teach future scientists.

The Assessment: We continued planning for our future by taking one of the recommendations from previous reviews and undertaking an intensive assessment of HMSC's educational needs and opportunities. This was also a response to OSU President Ray's call for HMSC to accommodate 500 or more students by 2020. Dr. Rob Suryan led the assessment team in a series of interviews, focus groups and surveys to delve into what people at HMSC, OSU and Newport think we should and could offer in terms of a broader educational experience. The report will be released in August with the observations that our strengths are experiential learning and applied marine studies. Programs should compliment those offered on the Corvallis campus and at the Oregon Coast Community College. Growing the teaching commitment of HMSC faculty is critical to expand opportunities and attract more students to Newport to complete their university educations.

The Place: The Hatfield Marine Science Center is a remarkable place. I have worked here for 24 years and while at times jaded about our incredible setting on the edge Yaquina bay and so close to the Pacific Ocean, I was constantly reminded in these past months of what makes this place remarkable. It is the people who apply their creativity to exploring the questions about our environment and our communities, and proposing answers and solutions. We usually think of the HMSC researchers who this year worked on questions including seafood traceability, forecasting of salmon populations, hypoxic ocean conditions, blue whale genetics, ocean acidification effect on oysters, seafloor deformation and more. But others also make HMSC what it is and this includes the students who work hard in various labs. I had the opportunity to recognize our students at the 19th Markham Symposium in June. This annual event marks the end of the academic year and celebrates the research efforts of HMSC students. Over \$80,000 was awarded to students for the FY14 year and many of these presented posters or lively, five-minute talks. One final group of people, the staff, is essential to making HMSC an effective place to work. The Director's Office staff, the facilities and business office employees, and the various office people run HMSC by paying the bills, organizing our lives, keeping the seawater flowing and the lights on. I have been honored to serve as the Interim Director and work with all of these people. In the following annual report, you can learn much more about what they do and how much they contribute to Newport, Oregon State University and our world.

George W. Boehlert, HMSC Director from 2002-2012

Dr. George W. Boehlert served as Director of the Hatfield Marine Science Center (HMSC) from 2002- 2012. His distinguished tenure was marked by numerous accomplishments, some of which are now cornerstones of HMSC’s activities, and others that have laid a solid foundation for realization of HMSC’s full potential as Oregon State University’s (OSU) marine lab.

George came to HMSC from the National Oceanic and Atmospheric Administration (NOAA) where he directed NOAA’s Pacific Marine Environmental Lab in Monterey, CA since 1993. A 1972 graduate of the University of California (UC) at Santa Barbara, George went on to earn his doctorate in marine biology from the Scripps Institute of Oceanography at UC San Diego. He came to OSU as faculty in 1979 before joining NOAA’s National Marine Fisheries Service in Hawaii in 1983. His career as a scientist is exemplified by numerous publications and by



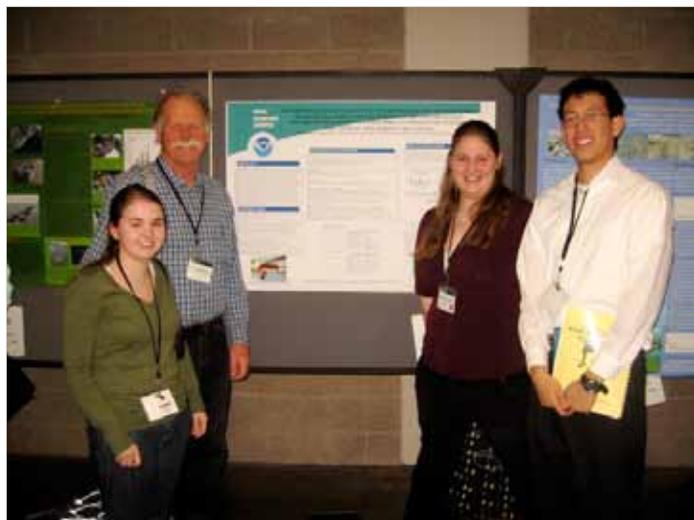
leadership and professional service in his field, most notably in the North Pacific Marine Science Organization (PICES).

As HMSC Director, George brought many new initiatives to HMSC and to the Oregon Coast, partnering extensively with local leadership to advance a vision of marine science and education as central to economic development. He founded the Yaquina Bay Ocean Observing Initiative, and was an active

member of the Yaquina Bay Economic Foundation. These organizations helped to shape the economic development strategy underlying the Port of Newport’s successful bid for the NOAA Marine Operations Center - Pacific facility. George envisioned the Central Coast’s role in wave energy research, and helped to found the Northwest National Marine Renewable Energy Center, a partnership of OSU and the University of Washington. He served as Principal Investigator for federal grants studying potential environmental effects of wave energy installations and helped to garner support from local government and industry leadership for marine research endeavors on the Oregon coast.

In 2002, HMSC boasted a strong research program and a budding academic program built by George’s predecessor Lavern Weber,

HMSC director from 1976-2002. George recognized the vast potential of HMSC’s collaborative research enterprise for students from OSU and beyond. With the hire of an Academic Program Coordinator, he began building an academic program designed to synergize with HMSC’s interdisciplinary, interagency research programs. Toward this goal, George envisioned a realignment and expansion of HMSC’s academic programs, which was championed by OSU President Ed Ray in 2012. His proposal to the National Science Foundation funded the Research Experience for Undergraduates (REU) program, HMSC’s flagship internship, which anchors an extensive summer internship program.



George’s legacy includes his many accomplishments within OSU as well as extensive service to the coastal community. He was a decisive and resourceful leader, with a sharp intellect and clever wit. He will be remembered for the tenacity he brought to all endeavors, transparency in his actions, his strong support of HMSC’s collaborative culture and his vision for the institution and it’s community. His practical wisdom and keen sense of adventure will serve him well in retirement as he enjoys fishing, hunting, hiking and gardening with his family and his faithful dogs.



I. RESEARCH

A. Oregon State University



Programs by Stations and Institutes

Coastal Oregon Marine Experiment Station Gil Sylvania, Director

<http://marineresearch.oregonstate.edu>

Oregon State University's Coastal Oregon Marine Experiment Station (COMES) includes faculty, staff, and students located at the Hatfield Marine Science Center and the Seafood Laboratory in Astoria. COMES is the largest applied marine research organization in Oregon and the largest Agricultural Branch Experiment Station in the United States dedicated solely to coastal and marine issues. COMES was established in 1988 with support from the Oregon legislature to conduct interdisciplinary and cooperative research to understand, utilize, and sustain Oregon's marine resources, industries, and coastal communities. Under the leadership of Lavern Weber and an advisory board chaired by Captain Barry Fisher, the Station began with three faculty and a handful of graduate students. Eighteen years later the Marine Experiment Station has grown to include 11 tenured faculty, 15 staff and research associates, more than 35 graduate students, and over \$3 million annually in external grants and funds. COMES also works closely with an Advisory Board that includes members representing coastal communities, the fishing and seafood industry, and other businesses and organizations with a stake in supporting research vital to coastal communities and the State of Oregon.

The research programs of COMES encompass six primary areas: *Aquaculture* (Chris Langdon), *Fisheries Science* (David Sampson), *Fishery Management and Policy* (Susan Hanna--emeritus), *Marine Mammals* (Scott Baker, Markus Horning), *Marine Economics and Marketing* (Gil Sylvania), *Salmon and Marine Fisheries Ecology and Genetics* (Jessica Miller, Michael Banks, Kathleen O'Malley), and *Seafood Science and Technology* (Cristina Dewitt, Jae Park, Yi-Cheng Su). Approximately half of the COMES faculty have joint positions within their academic homes, Marine Mammal Institute, or the Oregon Department of Fisheries and Wildlife. Much of the research involves diverse cooperators including OSU faculty, other national and international research institutes, and industry, state, and federal government including National Marine Fisheries Service and Oregon Department of Fish and Wildlife. COMES also helps sponsor workshops and conferences which further the mission of the Station in supporting wise use of marine resources.

The year 2012-2013 marked a period of solid growth. Christina Dewitt, who joined COMES in January 2011 as the new Director of the Astoria Seafood Laboratory continues to initiate new programs including development of a proposal to create the National Center for Innovations in Seafood Safety (NCISS)

and to advance national/international efforts to support seafood science and technology. Chris Langdon, Director of the Molluscan Broodstock Program (MBP) is working with the shellfish industry and the state to continue a transition of MBP into an industry/government supported program given the loss of federal funding. COMES is also working with the Agricultural Research Service to replace a shellfish genetics researcher that will work cooperatively with the MBP program. COMES continues to work closely with the Marine Mammal Institute and co-administers joint faculty. In addition COMES helped lead the transition of the Seafood Consumer Center/Community Seafood Initiative into a newly reorganized non-profit Fish Trax Systems Inc. focused on developing information and knowledge systems to support fishery and community development (see below).

In 2012-2013 COMES programs generated over \$12 million in economic impacts and produced an equivalent 30-40 new jobs for Oregon and Pacific Northwest coastal communities. These impacts are the result of research leading to improved utilization of marine resources, increased production of commercially harvested and cultured seafood, development of value-added seafood products, and improved policies for resource management. COMES published over 60 manuscripts and reports including more than 50 in refereed journals and books. COMES graduated 12 students including 7 MS and 5 Ph.Ds. COMES faculty also gave over 80 presentations and organized a number of major workshops and conferences. For 2012-2013 it is estimated that for each \$1 millions in state dollar expended, COMES faculty leveraged an additional \$3 million in federal grants and private support.

COMES "Signature Programs" in 2012-2013 include:

The Pacific Whiting Project: Since 1990, COMES has worked with industry to pioneer this seafood industry. COMES research has supported product development, improvements in quality and utilization, and greater benefits from optimizing resource management including conservation of the resource. Today, Pacific whiting is Oregon's largest fishery (by volume) and generates between \$30-\$40 million per year in coastal income.

Fish Trax Systems, Inc: In the spring of 2013 the Seafood Consumer Center/Community Seafood Initiative, a 501 3c became reorganized as Fish Trax Systems Inc. CSI was a unique partnership between COMES, Craft 3 (formerly Enterprise Cascadia), and the Seafood Consumer Center. SCC/CSI had supported coastal businesses and value-added seafood production, conducted seafood cooking classes, organized consumer and industry workshops, provided more than \$2M in investments/loans to coastal seafood companies, and assisted the Oregon Dungeness Crab Commission in certification by the Marine Stewardship Council (MSC). Over time their work increasingly focused on research and development of the comprehensive electronic fisheries information system known as Fish Trax. The Fish Trax electronic systems were developed as part of a larger research project known as CROOS (Collaborative Research on Oregon Ocean Salmon – see below). These systems support efforts to collect, share, and transform real time data to

be used to improve research, management, and marketing and support fishing industries and coastal communities in Oregon, the nation, and the world.

Molluscan Broodstock Program (MBP): MBP conducts research and outreach with industry partners to improve oyster broodstock and associated economic benefits. Hundreds of million of juvenile oysters produced in the Pacific Northwest are derived from MBP families housed in COMES facilities. The program is responsible for an annual increase of oyster production exceeding \$6 million in farm-gate value.

OSU Surimi Research and Technology School: The Astoria seafood laboratory is a world leader in surimi research and education. Surimi researchers have generated millions of dollars in benefits to the local seafood industry in improved product quality, protein utilization, and recovery. The Surimi Schools trained more than 100 international and domestic students in 2012-2013 throughout the world and led another successful international Forum to discuss the status and future of the industry.

Salmon and Marine Ecology Initiative: A Partnership between Coastal and Eastern Oregon in salmon ecology research. The program is producing new genetic and ecological research for improving utilization and conservation of salmon and other marine species. The program is responsible for spearheading Project CROOS, Oregon's largest collaborative fishing research project which has trained and employed over 150 salmon fishermen in Oregon. CROOS also partners with the California and Washington salmon scientists and industry and collectively works with more than 300 vessels as part of the cooperative West Coast Genetic Stock Identification project (WC-GSI).

OSU-COMES Seafood Research & Education Center

Christina DeWitt, Director

The OSU Seafood Laboratory has a distinguished history in maximizing the utilization and thereby sustainability of the marine resources managed and harvested from the Oregon coast. Research at this facility continues to support the fishing and seafood communities by investigating those processes that improve safety, extend shelf-life and enhance utilization of Oregon's marine resources.

The laboratory currently has 3 research faculty, Drs. Jae Park, Yi-Cheng Su, and Christina DeWitt. This past year faculty have mentored and supported 12 graduate students, one post-doctoral scholar and one international graduate student intern. The laboratory also hosted two visiting scientists.

Current seafood safety projects initiated by Dr. Yi-Cheng Su are focused on discovering processes that reduce and/or eliminate *Vibrio parahaemolyticus* and Norovirus from oysters. In addition, Dr. Su has been working with National Fisheries Institute and tuna canners to evaluate the potential for

Staphylococcal enterotoxin formation during processing.

Dr. Jae Park is conducting research that is focused on enhancing the sustainability and value of seafood products by discovering those processes that increase the shelf-life, quality and nutrition of surimi seafood products. Dr. Park's group is also involved in research to extract further value from Oregon seafood by investigating the potential of seafood protein recovered from underutilized species and/or processing inefficiencies to reduce the uptake of oil by fried products. He also has initiated preliminary investigations to further utilize fish blood as an enzyme inhibitor for both surimi and fresh fish. The preliminary results were utilized to submit a collaborative grant involving all three faculty at the OSU Seafood Laboratory. Finally he worked with the equipment manufacturer Laitram on steam cooking/ setting of surimi.

The director for the laboratory, Dr. DeWitt, has projects evaluating high pressure processing for improving quality and safety of muscle food products, has been working with FDA and the USDC on behalf of the Western Fishboat Owners Association and Oregon Albacore Commission to develop a simple easy-to-use vessel record form that will satisfy recent HACCP requirements and can be applied fleetwide, has initiated a project to evaluate nano-scale ice for improving seafood quality, and is working with an international collaborative to develop a white paper on the state of seafood science and education. In the latter capacity, Dr. DeWitt has given testimony at a Sea Grant meeting in Washington, D.C. and has met with the head of the National Institute of Food and Agriculture in Washington, D.C.

Dr. Su and Dr. DeWitt visited Taiwan to evaluate potential for collaborative research between OSU Seafood Laboratory and National Kaohsiung Marine University, National Pingtung University of Science and Technology, and National Taiwan Ocean University. The seafood laboratory has also hosted and toured researchers from Chile and New Zealand for similar collaborative purposes. OSU Seafood Laboratory has also hosted a business group (Russia) toured by the Astoria/Warrenton Chamber of Commerce, both high school and grammar school students, and also participated in the Astoria/Warrenton Chamber of Commerce after hours Open House.

There are currently two visiting scientists at the OSU Seafood Laboratory. Mr. Tao Yin joined the lab in Fall 2012 and is a Ph.D. student from China's Hualzhong Agriculture University. He is spending one year working in Dr. Park's laboratory. Dr. Young Tae Hahm is a visiting professor in the Department of Biotechnology at Chung-Ang University in Seoul, South Korea and arrived at OSU Seafood Laboratory in January 2013.

The following students graduated from the OSU Seafood Laboratory in this report period: Samanan "Sand" Poowakanjana completed his doctoral thesis under Dr. Park: "*Rheological and spectroscopic characterization of surimi under various comminuting and heating conditions*". Chern "Lin" Koh completed her master thesis under Dr. DeWitt: "*Evaluation of DNA recovery methods for the detection of soy in foods using real-time PCR*". Jing Mou completed her master thesis under Dr.

Su: “*Survival of Listeria monocytogenes, Salmonella spp., and Staphylococcus aureus in raw yellowfin tuna during refrigerated and frozen storage.*” Dr Poowakanjana is now employed at a seafood company in Thailand, Ms. Koh works for BioOregon as a QA/RD Specialist, and Ms. Mou just accepted an internship at a small salmon processing plant in Kaltag, Alaska to help them with the administration and monitoring of their QC program.

In addition to research, outreach is also being conducted by faculty via the OSU Surimi Research & Technology School and the Surimi Forum. These efforts, spearheaded by Dr. Jae Park, have made the seafood laboratory in Astoria the world leader in surimi research and education. The OSU Surimi Story and School was highlighted this past summer at the Smithsonian Folklife Festival held on the Mall in Washington, DC. Dr. Park, Angee Hunt, two students and industry volunteers represented OSU Seafood Laboratory and spent two weekends over the Fourth of July holiday talking to visitors about Surimi. The Forum held this year in Astoria had approximately 120 national and international attendees and the School about 60 attendees. The school was also held overseas in Thailand with 110 attendees. The school will be in France Fall 2013.

Further outreach is being conducted by Dr. Su who delivered two AFDO accredited HACCP courses for seafood processors (approximately 20 attendees/session) and will be holding another in Fall 2013.

Teaching efforts are also underway by OSU Seafood faculty. Dr. Park taught for the first time at OSU Seafood Laboratory 3-credit graduate Surimi course and Dr. DeWitt will be teaching a 3-credit graduate Seafood Technology course Fall 2013. There is a move underway at the University to integrate all the Experiment Stations in undergraduate teaching efforts through experiential exposure/efforts through both classes and research scholar activities. We expect OSU Seafood Laboratory to be more involved with undergraduate students in the future as well.

Cooperative Institute for Marine Resources Studies (CIMRS)

Michael A. Banks, Director

The OSU/NOAA Cooperative Institute for Marine Resources Studies’ main mission is to bring together research partners from a variety of colleges, departments and agency organizations to address complex multidisciplinary issues relating to the living and non-living components of the marine environment. The Institute thrives because of the vision and commitment of leaders from within the laboratories of its NOAA associates, OSU faculty, and the OSU Research Office. As a result, external research grant funding has steadily increased; graduate student opportunities have diversified; and many more investigators are joining together from a broad range of disciplines to address research problems of environmental, economic and social importance. No other OSU research institute provides both grant administration and personnel support and review in the manner as is provided by an academic department.

Through bridging across Colleges, Institutes, and Departments, the collaborative structure of CIMRS facilitates new ways in which basic research can be applied to understand factors affecting marine resources and their management. As an integral part of the OSU Hatfield Marine Science Center, in FY13, CIMRS provided administrative home for 27 research staff and 6 research faculty working on collaborative projects with NOAA investigators who also serve as OSU courtesy faculty. Recent research highlights include:

- 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>
- \$1,658,460 raised from external fund sources by CIMRS principal investigators; and
- 29 peer reviewed manuscripts published in FY 13.

Eighteen NOAA Cooperative Institutes (CIs) distributed throughout the nation, including CIMRS, have withstood significant fiscal challenges this year owing to the prevailing national economy. Affirming that the collaborative research provided by CIs is essential for NOAA to execute its core mission and allow the Agency direct access to the nation’s most nimble and cost-effective intellectual resources, CIMRS led a CI Directors’ visit to Capitol leadership within Federal, State & NOAA to champion high value of the CIs and the need for protection from fiscal sequestration. All 18 CIs are still providing their best in research excellence and have committed to making similar Capitol visits on an annual basis.

Significant non-NOAA funding sources in FY13 include Bonneville Power Administration, National Science Foundation, and Office of Naval Research.

For a comprehensive list of funded research projects, please see the CIMRS Annual Report, available at <http://oregonstate.edu/cimrs/>

For Collaborative Research with *Oceanic and Atmospheric Research Office/Pacific Marine Environmental Laboratory Ocean Environment Research Division/VENTS Program*.....See Section on PMEL, Vents Program

For Collaborative Research with *National Marine Fisheries Service/Northwest Fisheries Science Center*.....See Section on NWFSC

For Collaborative Research with *National Marine Fisheries Service, Alaska Fisheries Science Center, Fisheries Behavioral Ecology Program including three primary projects: 1) Effects of ocean acidification on walleye pollock and the Pacific cod; 2) Habitat selection of juvenile flatfishes; and 3) Lipid class dynamics in marine crabs.*See Section on AFSC

Graduate Students supported through Fellowships and Joint Research Projects: The goals of NOAA's strategic plan are to build sustainable fisheries, to recover protected species, and to sustain healthy coasts. These goals require the support of sound scientific research to build the knowledge base for maintaining economically viable fisheries and, at the same time, minimize anthropogenic impacts on marine ecosystems.

PhD Candidates –Department of Fisheries and Wildlife

Kevin Thompson, 2008-2013
Project Title: Predator Diets and Multi-species Models
Major Professor: Selina Heppell
NOAA Fisheries Rep: Grant Thompson, AFSC

Linsey Arnold, 2009-2014
Project Title: Management Strategy Evaluations for Rockfish
Major Professor: Selina Heppell
NOAA Fisheries Rep: Grant Thompson, AFSC

PhD Candidate –College of Agriculture Sciences

Christopher Cusack, 2009-2014
Project Title: Bioeconomic Spatial, Multi-species Fishery Simulator
Major Professor: David Sampson
NOAA Fisheries Rep: Cindy Thomson, SWFSC, Andi Stephens, NWFSC

PhD Candidate –College of Earth, Ocean, and Atmospheric Sciences

Caren Barceló, 2009-2015
Major Professor: Lorenzo Ciannelli
NOAA Fisheries Rep: Ric Brodeur, NWFSC

Marine Mammal Institute (MMI)
Bruce Mate, Director and Professor
C. Scott Baker, Associate Director and Professor
Markus Horning, Associate Professor

The Marine Mammal Institute is an international center of excellence in marine mammal ecology, with an interdisciplinary team that efficiently and comprehensively answers ecological questions through collaboration. Its research mission is to better understand marine mammal conservation and management issues, such as population identity, estimates of abundance, critical habitat assessment, migration patterns, behavior, and interactions with human activities. The Marine Mammal Institute (MMI) is one of the leading academic institutes of its kind and is committed to improving conservation practices and understanding worldwide.

The MMI currently consists of approximately 25 faculty, staff, and graduate students in four research groups. The research focus areas are the Whale Telemetry Group (WTG), headed by Bruce Mate; the Cetacean Conservation and Genomics Laboratory (CCGL), headed by C. Scott Baker; the Pinniped Ecology Applied Research Laboratory (PEARL), headed by Markus Horning; and the Oregon Marine Mammal Stranding Network

(OMMSN), coordinated by Jim Rice.

During April 2013, the Marine Mammal Institute (MMI) interviewed seven candidates for two new faculty positions: 1) a Cetacean Ecologist who will develop a strong whale telemetry research program and 2) a Marine Mammal Behavioral Ecologist/Sea Grant Extension Specialist who will develop a strong behavioral ecology research program to engage stakeholders and the public on management issues. Offers to the selected candidates are underway. The positions will be based at the HMSC. Future plans include hiring additional faculty with backgrounds in information technologies, physical oceanography, acoustics, engineering, and veterinary medicine.

The MMI works with international and national government agencies, commissions, foundations, trusts, non-profit organizations, universities, research institutions, and industries such as fishing, shipping, and oil and gas development. MMI's research is valued and supported by agencies, policy makers, scientists, media, educators, industry, and the general public. MMI researchers present their results through published works and at conferences and meetings, and the MMI has a highly visible educational outreach program. These public education programs include exhibits in the HMSC Visitor Center, a curriculum to foster the interests of middle-school youth in math and science, and public participation projects such as the OMMSN, Whale Watching Spoken Here, and an annual Natural History Expedition to the San Ignacio Lagoon.

MMI benefits from a close association and collaborative relationship with all of the dynamic programs and agencies that are located at HMSC and is administered by Oregon State University's College of Agricultural Sciences (CAS). Current MMI faculty and graduate students are appointed through the Department of Fisheries and Wildlife. A more detailed description of the MMI, by research group can be found under the CAS section of this report.

Northwest National Marine Renewable Energy Center (NNMREC)

Sarah K. Henkel, Assistant Professor

Program Objective: Activities of the Northwest National Marine Renewable Energy Center that occur at the Hatfield Marine Science Center include evaluating potential environmental, ecosystem, and human dimension impacts of wave and offshore wind energy installations by conducting baseline ecological research on marine habitats and organisms in areas that may be affected by renewable energy development and focusing on the compatibility of marine energy technologies in areas with sensitive environments and existing users.

2012 Projects:

- Oregon Marine Renewable Energy Environmental Science Conference. Drs. George Boehlert and Sarah Henkel convened this conference in collaboration with the Bureau of Ocean Energy Management November 28-29, 2012.

The primary goal of the conference was to evaluate environmental research needs associated with wave and offshore wind energy development in the Pacific Northwest. The conference had three major objectives: i) showcase research recently completed or currently underway that addresses environmental questions associated with marine renewable energy; ii) synthesize new research and existing information with the aim of distilling it into products that agencies and resource managers could use to carry out their planning and management duties; and iii) identify gaps in our understanding of the technologies and potentially affected systems to focus future research efforts. Day one featured invited speakers selected by the Steering Committee to showcase how state and federal agencies utilize environmental information, to present expert synthesis of our current knowledge on key topics, and to feature environmental studies providing information on the newest research. The first day of the conference was an open event to encourage broad participation ranging from technical experts and agency scientists to the general public. The second day of the conference was an “Experts’ Workshop” where invited scientists with technical expertise on marine ecosystems and environmental effects of marine renewable energy met to review the gap analysis and provide advice on future priority studies to address the gaps. Conference proceedings have been published: Boehlert, G., C. Braby, A. S. Bull, M. E. Helix, S. Henkel, P. Klarin, and D. Schroeder, eds. 2013. Oregon Marine Renewable Energy Environmental Science Conference Proceedings. U.S. Department of the Interior, Bureau of Ocean Energy Management, Cooperative Agreement with Oregon State University M12AC00012. OCS Report BOEM 2013-0113. 134 pp.

- Characterization and Monitoring of Environmental Conditions at the Ocean Test Facility Site: This work included characterization of baseline acoustics (noise) in the project area, electromagnetic fields, and benthic habitat and organisms at the Ocean Test Facility site near Yaquina Head, Oregon. The monitoring buoy (Ocean Sentinel) and wave energy converter (WEC) device under test were deployed in July 2012 and acoustic outputs of the device and habitat conditions and organism distributions were quantified after installation. More details about the biological sampling can be found under the Benthic Ecology section below. The NNMREC Adaptive Management Annual Report on all the 2012 activities will be available on the NNMREC website.

Oregon Sea Grant

Stephen Brandt, Director

Oregon Sea Grant’s mission is to develop and support an integrated program of research, outreach, and education that helps people understand, rationally use, and conserve marine and coastal resources. Our activities respond to the needs of ocean users and act to stimulate the Oregon economy.

Funding for Sea Grant comes from federal and state

appropriations, as well as contributions from local governments and industry. The major support is a grant from the National Oceanic and Atmospheric Administration.

Program activities are conducted in several interdependent and critical topical areas including healthy coastal ecosystems, sustainable coastal development, safe and sustainable seafood supply, hazard resilient coastal communities, and marine education.

Oregon Sea Grant’s very competitive grants program is the pre-eminent marine research enterprise funding research in academic institutions throughout Oregon. This research addresses issues of high importance and societal relevance, and places priority on prediction (rather than explanation) and meaningful collaboration with industry, agencies, communities, and other stakeholders.

The program provides professional, technical, and public education, as well as Extension services through the Sea Grant Extension program. In addition, Sea Grant supports undergraduate and graduate students as Sea Grant Scholars to study important marine and coastal problems.

Everything the program does, finally, is driven by an ethic of public service, and the program uses various approaches to engage our constituents. The users of Oregon’s marine resources are key contributors to the program. An advisory council of marine industry and coastal community leaders provides external review of program emphasis and continued progress. Oregon Sea Grant Communications works collaboratively with program Extension faculty and educators to engage, inform, and assist a range of stakeholders, such as K-12 teachers and students, community and industry groups, and state resource managers, by developing and providing research-based information. Communications deploys a wide range of media tools, including, as appropriate, print, digital, and electronic media. The communications specialists cooperate with other information offices at Oregon State University and with colleagues in the national Sea Grant network.

Multidisciplinary and interdisciplinary in operation, the program involves faculty and students in several Oregon institutions of higher education. Recent participants in the program also include the University of Oregon, Oregon Health and Science University, Portland State University, and Eastern Oregon University. In addition, Oregon Sea Grant maintains close relationships with several research facilities on the Oregon coast: the OSU Seafood Laboratory in Astoria, the OSU Hatfield Marine Science Center in Newport, and the Oregon Institute of Marine Biology in Charleston. Sea Grant manages the Visitor Center of the Hatfield Marine Science Center as a public science learning facility and learning laboratory.

Web site: <http://seagrant.oregonstate.edu/>

Research Programs by Academic Unit

College of Agricultural Sciences

Department of Botany and Plant Pathology

Gayle Hansen, Associate Professor - Senior Research

Mission and Objectives: During the 2012-2013 academic year, Gayle Hansen, our semi-retired marine algal taxonomist and biogeographer, continued collecting and identifying voucher specimens for her checklist and biogeographic study of the seaweeds of Oregon and Washington. However, this year, with collaborators from Asia, she also worked on seaweeds from both China and Japan. Her study of Japanese seaweeds began with her investigations of the bio-fouling on Japanese tsunami debris and with the need for the identification of those marine algal species that are potentially invasive here in the Northeast Pacific.

2012-2013 Research Projects:

- **A vouchered checklist of Oregon’s seaweeds and their local and world-wide distributions:** Gayle continues to update her database and checklist of vouchered Oregon seaweeds through her own collections and through visiting and data-basing collections of seaweeds at other institutions. This past year, she finalized the voucher specimens of seaweeds gathered during her studies with ODFW on Oregon’s subtidal marine reserves at Redfish Rocks and Otter Rock. These were the first subtidal taxonomic surveys of seaweeds carried out in Oregon, and they added about 20 new species distribution records to the Oregon seaweed checklist. A final subtidal survey of the seaweeds at Cascade Head Marine Reserve is scheduled for this summer. (Reports provided to ODFW)
- **Oregon’s estuarine *Fucus* species:** Since the early 1990’s, Gayle has been collecting an unusual estuarine *Fucus* species that is devoid of a midrib and only fertile in the winter. With help from colleagues in Portugal (Joao Neiva and other molecular biologists that specialize in *Fucus*), she was able to determine that this species, previously called “*Fucus cottonii*”, is actually an estuarine form of our native *Fucus gardneri*. (Published in the *European Journal of Phycology*)
- **On the identity of coralline rhodoliths collected near the University of Washington marine lab in Friday Harbor:** Rhodoliths are loose-lying coralline algae that are “Jack-like” in structure. They are notorious for generally being sterile and very difficult to identify, and they are very rare in the Northeast Pacific. Years ago, while working at the Friday Harbor Laboratories, Gayle made a collection of fertile rhodoliths that she preserved for later study. Recently she found experts in Mexico specializing in this exact group of algae. Together, Nestor Robinson, his colleagues and Gayle described the morphology and distribution of *Lithothamnion*

muelleri along the American continent. The Friday Harbor collection was the northern limit of this widespread rhodolith-forming species, previously known only from Central America, South America and Australia. (Published in *Algae*, the *Korean Journal of Phycology*)

- **The seasonality of macroalgae and Cyanobacteria at Hainan Island, China:** With Eduard and Tamara Titlyanov and other colleagues from Russia and China, Gayle assisted with the writing and analysis of a 4-year study on the intertidal macroalgae and Cyanobacteria of Sanya Bay, Hainan Island, China. The detailed collections from this tropical bay revealed a clear overall seasonality between the rainy and dry months of each year and also clear changes in the intertidal zones. During the dry months (vs. the rainy months), more species occurred in all intertidal zones except for the splash zone which contained only 1 Cyanobacterium. Throughout both rainy and dry seasons, the Rhodophyta (red algae) dominated the mid and low intertidal zones while the Cyanobacteria dominated the upper intertidal and splash zones. Although 56% of the species occurred throughout the year, seasonality did occur in 44% of the species with 37% of the species limited to the dry season and 7% limited to the wet season. Although heavily impacted by development and aquaculture, the floristic biodiversity of Sanya Bay continues to be similar to that of other unpolluted regions in the Indo-Pacific. (Submitted to *Journal of the Marine Biological Association of the United Kingdom*)
- **Marine algae on Japanese tsunami debris and the risk of invasion to Oregon shores:** The 2011 Japanese Earthquake and Tsunami generated massive amounts of debris that washed out to sea. An unknown amount was picked up by currents crossing the North Pacific. Starting in June 2012, recognizable tsunami debris items began arriving in Oregon and Washington that bore hitch-hiking marine biota of Japanese origin. Gayle studied the marine algae from 12 of these items and evaluated their risk of invasion to our shores. She identified a total of 50 algal species from the debris including 21 brown algae, 18 red algae, 10 green algae, and 1 blue-green. The larger debris items like floating docks bore the most species, and each new item brought in new Japanese species with 52% of the species occurring on only 1 debris item. Possibly due to the increase in nutrients near our coast, 76% of the species, on arrival, were fertile and dropping spores, increasing the risk of recruitment. Moreover, 50% of the species were ephemerals, species that can reproduce repeatedly throughout the year if the conditions are appropriate, and 68% of the species were early successional forms that can quickly invade new habitats if the conditions are appropriate. Oregon’s pristine near-shore water has moderate temperatures ranging from 7-12° C. Since these temperatures are within the native temperature range of the Japanese species (7-23° C), the conditions here may be appropriate for recruitment. The current distribution of the 50 species lessens the threat slightly. About 50% of the species are already widespread around the world, 10% occur on both sides of the North

Pacific, 30% are Asian species that have already spread to other areas, and 10% are species still limited to Asia. Of the 50 species, 19 are already in Oregon, and 34 are already in the Northeast Pacific (primarily in California). In Oregon, we are mainly concerned about the 31 species that are not yet here. Among these are 5 marine algal species that are on the Global and Mediterranean Invasive Species Lists and known to be highly invasive: *Undaria pinnatifida*, *Codium fragile* subsp. *fragile*, *Grateloupia turuturu*, *Polysiphonia morrowii*, and *Antithamnion nipponicum*. The risk of invasion from these species and others on the debris seems to be very high. However, the rapid clean-up and removal of debris items from the beaches by Oregon and Washington state agencies has reduced the risk considerably. Although we have not yet seen signs of recruitment of the Japanese debris species in Oregon, we cannot be complacent. It is likely that we may not detect them for years to come.

Outreach: Gayle has given several seminars on the “Algae of Japanese Tsunami Debris”, and took part in the HMSC Open House and Japanese Dock Dedication where she presented a poster and display on “The Marine Algae of Japanese Tsunami Debris”. This year she also led an intertidal field trip for the public to Seal Rock describing the economic uses of our native seaweeds. At bookstores along the Oregon coast, she continues to sell her poster entitled “Oregon Seaweeds, A Sampler”. This poster shows 40 of the most common native seaweed species from Oregon and is useful for students and naturalists beginning to learn the seaweed flora.

Department of Fisheries & Wildlife

Ecological and Conservation Genetics of Fishes Kathleen O’Malley, Assistant Professor

The Ecological and Conservation Genetics Laboratory (ECGL) is dedicated to the study of how genetic and environmental factors interact to shape life history variation among populations of marine and freshwater organisms, particularly salmon and Dungeness crab. The goal is to advance our understanding of the primary processes underlying the genetic diversity within and among populations distributed along the West coast and assist fishery management and conservation efforts. The ECGL employs cutting-edge molecular techniques as means to identify factors important to retaining genetically healthy populations. Three primary areas of research are:

- Understanding the genetic basis of run timing in Pacific salmon
- Assessing the population genetic structure of Dungeness crab
- Evaluating fitness differences between hatchery and wild salmon

Run timing in Pacific salmon: To better understand the run time diversity observed within and among Pacific salmon species, the ECGL is working towards identifying the primary genes and environmental cues influencing the time at which adults

return to spawn in their natal rivers. Photoperiod (day length) is a long-term, stable environmental cue that animals can use to regulate seasonal behaviors (i.e. reproduction, dormancy and migration). Most plants and animals (including humans), have a daily molecular oscillator, known as the circadian clock, that is primarily entrained by photoperiod, and thus provides a genetic mechanism for long-term timekeeping to forecast optimal timing of these seasonal behaviors.

In collaboration with the MFGL (M. Banks), the ECGL recently identified variants in three circadian clock genes that discriminate between the fall and federally-listed threatened spring runs of Chinook salmon in the Feather River, California. These three genetic markers will prove to be a valuable tool in managing and restoring the spring run in this river as well as guiding the reintroduction of spring run into other river systems. Findings from this study, which was funded by the California Department of Water Resources, will be published in the journal *Evolutionary Applications* this year.

Population genetics of Dungeness crab: The Dungeness crab fishery is the most valuable ‘single-species’ fishery in Oregon. Despite the high economic and social value of this species, no stock assessment work has been conducted on coastal Dungeness crab populations and the commercial fishery is managed based solely on a sex, size, and season strategy. However, there has been increasing interest to collect more data and improve how the fishery is currently managed as indicated in the Oregon Nearshore Strategy Report (2005) and with the conditional sustainable certification of the Oregon commercial Dungeness crab fishery by the Marine Stewardship Council (MSC). In response, the Oregon Department of Fish and Wildlife (ODFW) developed the Oregon Dungeness Crab Research and Monitoring Plan (2013) which outlines historical and current biological, ecological and socio-economic research and monitoring efforts on the Oregon Dungeness crab resource and future plans to address information gaps in each of the three areas.

The EFGL is currently conducting a one year study to evaluate the population genetic structure of Dungeness crab off the Oregon coast. In collaboration with the ODFW, tissue samples were collected from 800 Dungeness crabs distributed from Astoria south to Brookings during the 2011 Pre-Season Test Fishery. Each crab has been genotyped at 10 microsatellite markers to estimate genetic diversity among samples. Since this is the first coast-wide population genetic study of Oregon Dungeness crab using microsatellite genetic markers, results from this study will provide important baseline information on the biology of one of Oregon’s most commercially valuable species and contribute to biological (e.g. stock structure) and socio-economic (e.g. marine spatial planning) research efforts identified in the new ODFW plan. Findings from this study will also help fill three information gaps identified in the plan that would be of value to the management of the fishery: recruitment studies, movement studies, and connections between estuary and ocean populations. Finally, the data generated from this research project can be used to help establish a “Limit Reference Point,” one of the five “conditions” associated with the Oregon Dungeness crab fishery’s

recent MSC certification.

The EFGL plans to expand on this study, which was co-funded by the Oregon Wave Energy Trust Fund and the Oregon Dungeness Crab Commission, by examining samples from a broader geographic range and multiple years. For example, over 4,000 Dungeness crab tissue samples were collected off the coasts of Washington, Oregon and California during the 2012 Pre-Season Test Fishery with assistance from each state fish and wildlife agency. The EFGL is currently seeking funding from Oregon Sea Grant to analyze these samples at the same 10 microsatellite markers. Understanding the inter-annual variation in genetic diversity among Dungeness crab from a broad geographical range will help inform decisions regarding ocean spatial planning, such as selection of wave energy development sites and marine reserves as well as long term management of Oregon's most valuable single-species commercial fishery.

Fitness differences between hatchery and wild salmon: Recent studies have shown that naturally spawning hatchery fish have a lower reproductive success compared to wild fish. This difference may result from lack of sexual selection (i.e. mate choice) in the hatchery. Parental mate choice is based on the premise of genetic compatibility to produce offspring of greater fitness. Previous studies suggest that fish choose mates that are genetically dissimilar at genes critical to immune response using olfactory cues. Consequently, their offspring have increased variation at these immune-relevant genes and are able to mount an immune response against a larger array of pathogens; favoring their overall survival.

This past November, Amelia Whitcomb, a master's student co-advised by Drs. Kathleen O'Malley and Michael Banks, completed her thesis research investigating the genetic characteristics of parental mate choice in naturally spawning hatchery-reared and wild coho salmon. Findings from this study suggest that increased diversity at genes involved in immune response may influence offspring survival. Brynn Perales, an REU intern collaborating with A. Whitcomb, conducted a complementary study which examined how diversity at immune genes influences the reproductive success of male coho salmon that use an alternate "sneaker" mating strategy. This research was funded by Oregon Sea Grant.

To experimentally test how diversity at immune genes affects survival, the EFGL initiated a collaborative project with the ODFW and NOAA to perform a disease challenge study on juvenile Chinook salmon. The primary objective of this research is to test for relationships between pathogen resistance with hatchery/wild origin and variability at 10 immune genes. This study is funded by the U.S. Army Corps of Engineers.

Service, Advising and Outreach: This past year, Kathleen has been an active member of the Center for Genome Research and Biocomputing (CGRB) faculty community. She served on the Search Committee for a new faculty hire in the area of Bioinformatics, is a member of the Scientific Program Committee for the CGRB Fall 2013 Conference and was recently appointed

to the CGRB Scientific Advisory Board. Kathleen continues to serve on four graduate student committees. This past year, members of the ECGL presented their research at various meetings and conferences including the Oregon Hatchery Research Center's Advisory Board Meetings, Oregon Sea Grant Scholars Day, Western Society of Naturalists Meeting, American Fisheries Society National Meeting, Salmon Coast-wide Genetics Meeting and HMSC's Marine Science Day.

Fisheries Population Dynamics **David Sampson, Professor, COMES**

David's research focuses on quantitative analyses of marine fisheries, with the goal of improving the quality, accuracy, and understanding of the procedures and results that are used in the management of Oregon's fisheries for groundfish (e.g., flatfish and rockfish). His other research focus seeks to understand the fishers' activities in fisheries systems, such as their choices of fishing locations and fishing gear.

David's position is half-funded by the Oregon Department of Fish and Wildlife (ODFW) and one of his main duties for ODFW is service as Oregon's representative on the Pacific Fishery Management Council's (PFMC) Scientific and Statistical Committee (SSC). The SSC develops procedures for including science-based information in the Council's fishery management process, reviews scientific documents brought to the Council, and provides advice to the Council regarding the scientific basis for fishery management decisions. During the year David contributed ideas and text to SSC reports to the Council resulting from five regular meetings of the SSC and several extra meetings of the groundfish and economics subcommittees. He also participated in a week-long workshop that discussed alternative harvest control rules for the West Coast sardine fishery, in light of new information regarding the possible influence of environmental factors on sardine population dynamics, and in a week-long stock assessment review of a set of new data-moderate stock assessments. During the spring he taught a one-day workshop on fish stock assessment to Oregon's three Council members and several staff from ODFW.

In July 2012 David began a new two-year project that is refining the bioeconomic simulator that he developed while on a leave of absence from OSU and working in Italy. The project is funded by the National Marine Fisheries Service (NMFS). The simulator mimics the behavior of multiple fish stocks, occupying multiple spatial regions, with harvesting by multiple fishing fleets. The project will apply the simulator to two West Coast fishery management issues: (1) exploring alternative rebuilding strategies for overfished stocks and (2) setting annual catch limits that give adequate consideration for risks such as over-running a catch limit because of inaccurate monitoring of landings and discards. The work during the past year focused on the technical issue of how to model the amount of fishing that occurs and its spatial distribution.

David continued to serve as the External Coordinator for

the Center for Independent Experts (CIE), which provides independent peer reviews of fishery stock assessments and other forms of marine science to the NMFS. As the CIE External Coordinator, David helps administer all CIE review panels pertaining to Atlantic and Gulf of Mexico resources. His duties include finding suitable candidates for the panels and reviewing and editing the panelists' reports. During the year David assisted the CIE with the administration of eight reviews involving 24 external reviewers.

During 2012/13 David worked with four graduate students. Brandon Owashi, a master's degree candidate in the Department of Fisheries and Wildlife, completed his second year at OSU. For his thesis research he is exploring the influence of spatial variation on the performance of two data-poor stock assessment methods that are used for setting catch quotas by the Pacific Fishery Management Council. La'Treese Denson, a master's degree candidate in the Department of Fisheries and Wildlife, started at OSU in Winter 2012. For her thesis research she is exploring issues associated with conducting age-structured (data rich) stock assessments that are spatially structured. Chris Cusak, a doctoral degree candidate in the Department of Agricultural and Resource Economics, is helping David with the bioeconomic simulator project. Chris's work on the project will provide a basis for some chapters of his PhD thesis. Noelle Yochum, a doctoral degree candidate in the Department of Fisheries and Wildlife, transferred to David's supervision in autumn 2012. She is measuring the mortality rates of incidentally caught crabs using the Reflex Action Mortality Predictor (RAMP) approach that was developed by Michael Davis and Al Stoner, formerly at the HMSC with the Alaska Fisheries Science Center's Fisheries Behavioral Ecology Program. The past year Noelle began a field project with Dungeness crabs that is attempting to validate the RAMP method by independently measuring bycatch mortality from crabs have been tagged and released.

During Autumn 2012 David taught the 4-credit course "Dynamics of Marine Biological Resources", which examines the mathematical details of some of the population dynamics models commonly used in fisheries science and stock assessment. Lectures were given at the HMSC and televised to the main OSU campus.

Invasive Species

John Chapman, Research Associate

John Chapman's research concerns the patterns, processes and effects of marine biological invasions and potential conservation or mitigation responses. His 2012-2013 year activities and accomplishments included, the discovery of a keystone invader in San Francisco Bay, California, a biological survey of the R/V *Oceanus* immediately on its arrival in Yaquina Bay, the landfall and biological survey of non-native Japanese species associated with the 2011 Japanese earthquake and tsunami, a major advance in burrowing shrimp ecology, a Japanese sponsored biological survey of Japan, and visits by numerous national and international experts on introduced species and associated topics.

John and HMSC volunteer Ralph Breitenstein surveyed the R/V *Oceanus* at the end of its 9,789 km, 28 day passage from Woods Hole, Massachusetts, in the Atlantic Ocean, through the Panama Canal on 21 February 2012. The *Oceanus* had previously operated in the Mediterranean Sea and Atlantic Ocean (including the Caribbean Sea). John worked with Ralph Breitenstein and J. T. Carlton to document the sequential acquisition of the barnacles *Balanus trigonus* and *Amphibalanus venustus* and the oyster *Ostrea equestris* on the *Oceanus* on its high and low latitude transoceanic, intraoceanic, and interoceanic travels before she was surveyed in Yaquina Bay. John, Ralph and Jim discovered a close correspondence between hull fouling accumulations and the detailed two year *Oceanus* working history that revealed *B. trigonus* settlement in every tropical port visited by the *Oceanus* and also their subsequent survival through two Woods Hole winters and passage through the freshwater Panama Canal. Their analyses revealed the port by port accumulation of live hull fouling organisms between the Mediterranean, Atlantic and Pacific Oceans that arrived in Yaquina Bay. These results indicate that marine hull fouling species are continuously transplanted globally between most ports of call by most ship passages and will appear in Aquatic Invasions this year.

John's major research efforts since 2005 have revealed that the estuary burrowing shrimp, *Upogebia pugettensis* are declining over their entire range and in California in particular due to an introduced Asian parasite. *U. pugettensis* are approaching extinction in Canada, Washington, many estuaries in Oregon and California due to effective castration by the introduced Asian bopyrid isopod, *Orthione griffensis*. *O. griffensis* arrived in the mid 1980s and its populations exploded in the late 1990s. *U. pugettensis* was the only known host of *O. griffensis* north of Pt. Conception, California. A general hope was that *O. griffensis* would become extinct if *U. pugettensis* become extremely rare. John's discovery of an alternative potential host for this deadly new parasite in San Francisco Bay was a byproduct of his continuing efforts to test these ideas.

Nearly all shallow water macro invertebrates discovered in the northeast Pacific over the last 30 years have been human borne introductions from elsewhere in the world and San Francisco Bay, California may be the most invaded estuary in the world. Two unidentified male *Upogebia* recovered from sediments pumped aboard the US Army Corps dredge *Essayons* from the 10 m deep Pinole Shoal Channel of San Pablo Bay in San Francisco Bay, California on 10 June 2010 appeared to be a striking contradiction of that pattern. Only two *Upogebia* species, *Upogebia affinis* (Say, 1818) and *Upogebia pugettensis* (Dana, 1852) were previously known in the eastern Pacific North of Morro Bay, California. Such low taxonomic diversity usually permits ready distinctions of native and nonindigenous origins of newly discovered species. However, incomplete taxonomy, limited sampling and inconclusive collection records placed the specific identity and continued presence of *U. affinis* in San Francisco Bay and the restriction of *U. pugettensis* to intertidal habitats of San Francisco Bay in doubt. John completed analyses of the 125 known *Upogebia* species in the world in spring 2012 to discover that the San Francisco Bay shrimp were *Upogebia*

major, an introduction from Asia. *U. major* are native hosts to *Orthonoe griffenis* in Asia and thus their occurrence in San Francisco Bay could permit the persistence of *O. griffenis* even if it drives *U. pugettensis* to complete extinction.

This shrimp conservation project was interrupted by the arrival of an 188 ton dock from Misawa Japan, on Agate Beach, Newport, Oregon at around midnight on 5 June 2012. The disastrous *Tōhoku Earthquake and Tsunami* of March 11, 2011 set in motion an extraordinarily rare event: the launching of a vast raft field into the North Pacific Ocean from a known source at an exact time. The first evidence of such a possibility was a dock from Misawa. John sampled the spectacular Japanese biota fouling remaining on the float from Misawa with Jessica Miller and Gayle Hansen on June 6 and since, has participated at all other levels of response, mitigation and education. Many images, products and reports of the activities that followed this event are posted on line. Some of the OSU sites include:

<http://blogs.oregonstate.edu/floatingdock>
<http://www.flickr.com/photos/80098236@N07/>

The *Tōhoku Earthquake and Tsunami* raft field of marine-origin debris (MOD) includes docks, buoys, floats, and vessels and terrestrial-origin debris (TOD) such as house wood and refrigerators. A portion of this field, became highly dispersed over 10s of millions of square kilometers and departed the Western Pacific with living Japanese marine protists, invertebrates, algae, and fish. Few data were available to accurately predict the transit duration, track, or landing point (if any) of any given rafted object (as witnessed by the fate of four dislodged large docks from the Port of Misawa), which species would survive long-distance journeys through a presumably largely oligotrophic environment, or how long such species could survive. John has worked since June 2012 in collaboration with an extended group of US Canadian and Japanese scientists, volunteers and government agencies to assess the nature and diversity of species arriving on Japanese Tsunami Marine Debris [JTMD] (including guilds that are, to date, absent or rare), the genetic characterization and reproductive condition of selected taxa, dispersal track history through shell chemical analyses, and the presence of endoparasites and endocommensals, among these communities. These studies address the nature of prehistoric rafting transoceanic anthropogenic dispersal vectors and provide critical data for a model of biotic acquisition, loss, and enhancement in ocean crossings and also test the invasion potentials of selected species. This research will be summarized in the plenary talk by James T. Carlton at the International Conference on Marine Bioinvasions in Vancouver, Canada this coming August. These research activities also attracted international attention for HMSC and OSU and were broadcast or published in scores of national and international venues (Oregonian, LA Times, London Times, BBC, NBC, Radio Free Asia).

In addition to the increasing demands from the JTMD research efforts, John worked in collaboration with Andrew Thurber (COAS) and with 2012 summer REU intern Charlie Dean to test whether *Upogebia pugettensis* feed on microbiota that they culture on their tube linings. This is an important question

because *Orthonoe* appear to find the host habitat rather than the host. Their preliminary pulse-chase experiments clearly revealed that organic penetration into the tube walls occurs due to the shrimp activities. The isotopically unique signal of *U. pugettensis* relative to other mudflat species in its habitat (Figure 1) thus appear to be partially explained by these results but these results also partially corroborate hypotheses that the uncanny ability of *Orthonoe* to find *U. pugettensis* is due to its unique habitat.

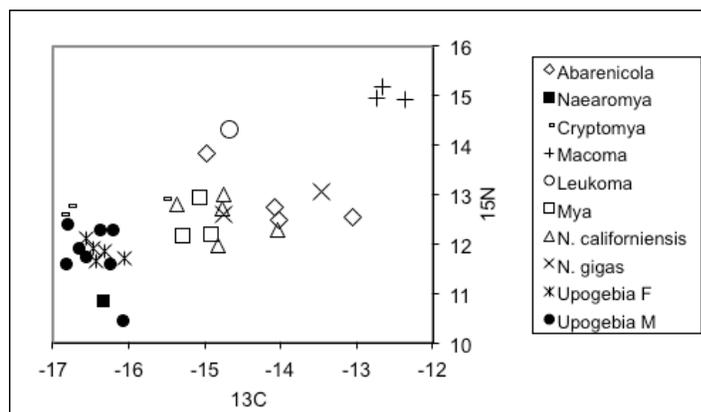


Figure 1. $^{13}\text{C}:$ ^{15}N isotope ratios among the epibentic feeding (*Macoma nasuta*), the free suspension feeding (*Leucoma staminea* and *Mya arenaria*), the deposit feeding *Abarenicola*, *Neotrypaea californiensis* and *N. gigas*, the commensal suspension feeders *Naearomya* relative to *Upogebia pugettensis*.

In late December 2012 John participated in the sampling of the second dock from Misawa that landed on a remote beach in the Olympic National Park in Washington. These activities again attracted national and international attention and also revealed the spectacular dispersal and completely unpredicted persistence of Asian species on marine tsunami debris.

John applied in November 2012 for US funding to survey the new docks in Misawa Fishing Port docks, where the two North American docks above were from. The survey was needed to determine how many species were cast into the ocean by the 2011 tsunami. These critical data are required for estimates of the species survival on ocean crossings. This joint US/Japanese proposal was denied. However, the Japanese participants in this original proposal used their matching funds to partially complete the expedition nevertheless. Lincoln County Commissioner Terry Thompson and Los Angeles County Museum Curator, Leslie Harris paid their own ways to accompany John in March 2013 to survey of the Misawa floats and floating marine structures to the south that were also the most likely sources of 2011 tsunami debris. The survey was largely successful and widely covered in Japanese and Asian news.

Marine and Anadromous Fisheries Ecology **Jessica A. Miller, Assistant Professor**

The Marine and Anadromous Fisheries Ecology program examines the life history of marine and anadromous fishes, particularly Pacific salmon, in order to advance ecological and

evolutionary understanding and assist fishery management and conservation efforts. The program incorporates field studies, laboratory experiments, and analytical chemistry. Field studies focus on movements and migration patterns of marine and anadromous fishes and the role that coastal and estuarine habitats play in their early life history. Laboratory studies are designed to test and validate assumptions associated with analytical approaches, such as the chemical composition of fish ear bones (otoliths), that we use to elucidate migratory patterns in marine and anadromous fishes.

Three students graduated this year! Dr. José Marin Jarrin defended his dissertation (*The role of surf zones in the early life history of Chinook salmon*) and is currently a post-doctoral research associate at Central Michigan University. James Losee completed his MS degree (*Does interannual variability of trophically transmitted parasites in Chinook and coho salmon relate to physical and biological processes in the Northern California Current?*) and is working as a Fisheries Biologist at the Washington Department of Fisheries & Wildlife. Andrew Claiborne completed his MS degree (*Size-dependent survival of Columbia River hatchery and naturally-reared Chinook salmon *Oncorhynchus tshawytscha* during early marine residence*) and is also employed as a Fisheries Biologist at the Washington Department of Fisheries & Wildlife.

During Fall 2012 and Winter 2013, we were busy tracking Japanese Tsunami Marine Debris (JTMD) arriving along the west coast of the United States as part of a National Science Foundation grant to characterize the marine biota arriving on JTMD. Our goal was to sample the biota arriving on items along our coast to determine the non-native species present and estimate the abundance and reproductive condition. We have tracked >50 unique debris items and maintain a blog on our efforts at <http://blogs.oregonstate.edu/floatingdock/>.

We welcomed two interns this summer, Laury Perry from Portland State University and Jessica Porquez, a post-baccalaureate student from Chapman University. Laury was a participant in the National Science Foundation Summer REU program at HMSC and Jessica was a Living Marine Resources Cooperative Science Center (LMRCSC) intern. The LMRCSC is a NOAA-funded collaboration to promote under-represented communities in marine science. Current graduate students Erin Fedewa, MS, and Marisa Litz, PhD, are hard at work in the laboratory. Erin is examining how climate variation influences growth and survival of early life stages of northern rock sole (*Lepidopsetta polyxystra*) in the Gulf of Alaska. For her dissertation, Marisa is characterizing the lipid and fatty acid profiles of prey available to juvenile salmon as they begin their ocean migration with the goal of relating ocean conditions and prey quality to salmon growth.

Jessica Miller co-taught Early Life History of Fishes with Lorenzo Ciannelli in Fall 2012. Jessica was also invited to participate in two regional workshops on Pacific salmon, including a review of the Delta Juvenile Fish Monitoring Program and a synthesis on the role of predation on salmonids in the Central Valley, CA. These workshops provided an opportunity

to learn more about how salmon respond in other highly modified watersheds, which provides a valuable perspective on our work on the Columbia River. Over the year, lab personnel contributed oral and poster presentations at local, regional, and national meetings, including a plenary presentation at the Alaska Marine Science Symposium and a webinar on our JTMD research.

Marine Fish Ecology

Selina Heppell, Associate Professor

Scott Heppell, Assistant Professor

Research activities: This year, the Heppell Lab wrapped up two major projects running through our lab at HMSC and continued several others. Our collaboration with Sarah Henkel, “*Ocean Bioaccumulation Survey for the City of Newport*” was completed and submitted to the City of Newport, with assistance from Vincent and Kristin Politano. This project compared the levels of several contaminants inside and outside the Nye Beach outfall area; in general, we found minimal evidence of contamination in fish, crabs, and molluscs, with follow-up analysis of snails recommended. Wade Smith successfully defended his PhD based on the incorporation and detection of elemental signatures in the vertebrae of young of the year sharks and rays. The field component for Tom Calvanese’s rockfish movements and habitat use in an MPA at Redfish Rocks near Port Orford, Oregon project has been completed, and data analysis is ongoing. Amy Jo Lindsley’s trapping of juvenile rockfish in Yaquina Bay to estimate seasonal settlement in the estuary is currently active, with a busy field season in progress. We continue our analytical work on Pacific ocean perch (POP) reproductive biology, spearheaded by Linsey Arnold, which had fieldwork based in the Gulf of Alaska. These projects have been funded by Oregon Sea Grant (rockfish), the National Science Foundation (skates and rays) and the Alaska Fisheries Science Center and the North Pacific Research Board (POP), and HMSC Markham Award (juvenile rockfish). In addition, we are in the process of developing a fixed-specimen display of Humboldt squid, based in part on the MS work of Tanya Chesney (here’s hoping the squid show up this summer!). We also have continued our evaluation of the abundance and diversity of fish species associated with the Dynamic Revetment along the estuary path at HMSC. This project has included involvement of multiple undergraduates during our monthly sampling. Finally, Annaliese Hettinger, a post-doctoral scholar in Bruce Menge’s lab, has been using space in our lab to take fluorescence pictures of macroalgae for her studies.

Teaching Activities: Scott and Selina Heppell continue to participate in the Fisheries and Wildlife Fall teaching program, and use HMSC classroom and laboratory facilities for these courses. This year both Scott and Selina participated in Chris Langdon’s *Coastal Ecology and Resource Management* course, and Scott taught *Fishery Biology* during the fall term. In addition, Scott was the instructor for the Marine Fishes section of *Marine Biology* class during spring term 2013.

Other activities: We have been active participants in discussions

with Rob Suryan, Itchung Cheung, and Janet Webster about future academic developments at HMSC, including a reinvigoration of Marine Team, which provides for student-led research and activities not normally found in the classroom and is available for both undergraduate and graduate students. Scott gave an on-campus seminar for Fisheries and Wildlife students about HMSC as an academic destination. During summer of 2012 we hosted a COSEE intern, Jon Robertson, who worked primarily with Vince Politano at HMSC.

Marine Fisheries Genetics

Michael Banks, Associate Professor

Our research in population genetics among Pacific salmon and other West-Coast fishery species seeks to determine how population structuring relates to the physical, biological and human components of the environment. We develop methods to resolve differences among hybridized, admixed, or recently diverged populations, and statistical means for determining component estimates that are typically mixtures of various stocks or sub-populations. We apply candidate and population genomic tools to determine how fish sense and use smell (olfaction), electromagnetism (orientation), seasonal photoperiod changes (time) and other faculties to mediate migration and population structuring among stocks, environment and climate. We also use genetic pedigrees to study population ecology.

Amelia Whitcomb, co-advised by Dr. Kathleen O'Malley, who recently completed her MS is now continuing work in sustainability of fish and wildlife resources in Olympia, in Washington Department of Fish and Wildlife's Genetics Laboratory. Her research findings, in which she used major histocompatibility complex (MHC) and non-MHC immunity markers to study evidence for mate choice differences among coho salmon that had either hatchery or wild ancestry, are currently being prepared for review for publication in *Canadian Journal of Fisheries and Aquatic Sciences*.

Two manuscripts have been published in the journal *Molecular Biology Reports*, providing near-complete mtDNA genomes for krill species providing first fruits from the Roch 454 Junior Genome Sequencer recently installed in lab. This work, in collaboration with HMSC resident NOAA Senior Scientist Bill Peterson, was achieved by post doc Mattias Johansson (now at University of Wisconsin-Milwaukee), graduate student Angie Sremba (PhD candidate studying with Scott Baker) and REU student Elizabeth Duda (hosted in our lab).

Our work in discrimination among alternate Chinook runs of the Sacramento River system has produced two manuscripts. One, senior-authored by Michael Banks, covers a blind test of three different microsatellite panels and is in review for *Animal Genetics*. The second, senior-authored by Kathleen O'Malley, applies clock gene markers to spring and fall sub-population discrimination challenges on the Feather River and is in press for *Evolutionary Applications*.

Likewise the Coast-wide Genetic Stock Identification Collaborative has produced manuscripts. One, senior-authored by William Satterthwaite (from NOAA's Southwest Fisheries Science Center), uses Genetic Stock Identification to compare Klamath River versus California Coastal Chinook salmon in terms of their ocean spatial distribution, size-at-age, and fishery exposure and is in press for *Canadian Journal of Fisheries and Aquatic Sciences*. Two other manuscripts senior-authored by Renee Bellingier utilize new methods to calibrate stock specific capture findings in the context of fishery effort as a means of assessing migration distribution patterns for Chinook salmon stocks encountered off the coast of Western North America; these are in revision.

Our co-authored manuscript for the *Canadian Journal for Fisheries and Aquatic Sciences* that results from collaboration with the Genetic Analysis of Pacific Salmon group has been published. Paul Moran of the Northwest Fisheries Science Center is senior author of this manuscript which is entitled: *Traditional life-history "races" in Chinook salmon are specific to the Columbia River and do not represent the species as a whole*.

PhD students Nick Sard and Chanté Davis have completed their course work, finalized their thesis committees and are now preparing their first research for peer review publication. Nick's covers findings from a pedigree study of four consecutive-year samples of juvenile Chinook that result from spawning among spring Chinook outplanted above Cougar dam. Offspring from outplants in 2010 and 2011 provide insight into relative fitness of hatchery and wild hybrid offspring. Chante's work provides a first comprehensive study of population sub-structuring among Chinook salmon of the Siletz River.

Incoming projects include a population sub-structuring study among steelhead from the Siletz River and how steelhead populations distributed further afield are affected by climate extremes. Still pending is a yet to be funded study of population structuring among mullet sampled from marine waters nearby to Taiwan, Japan and the Philippines.

Marine Mammal Institute

Cetacean Conservation and Genetic Laboratory

C. Scott Baker, Professor; Research Staff: Beth Slikas, Postdoctoral Fellow (now with Marine Biological Laboratory, Woods Hole, MA); Debbie Steel, Faculty Research Graduate Students: Becca Hamner (PhD), Renee Albertson (PhD), Angie Sremba (PhD), Alana Alexander (PhD), Dori Dick (PhD, Geosciences), Sophie Pierszalowski (Msc), John McClung (MSc). Visiting Graduate Students: Ana Lúcia Cypriano de Souza (PhD), Pontificia Universidade Católica do Rio Grande do Sul, Brazil

The Cetacean Conservation and Genetic Laboratory (CCGL) is committed to a greater understanding of the molecular ecology and conservation genetics of whales, dolphins, and porpoises around the world. Its research on large whales, beaked whales,

and dolphins pursues four inter-related themes: reconstructing the past, assessing the present, conserving the future, and discovering new species.

Reconstructing the past of whales and whaling

- The CCGL is contributing to a Comprehensive Assessment of humpback whales in the South Pacific (Oceania) and southern right whales around New Zealand. Results of this work were presented to the annual meetings of the Scientific Committee of the International Whaling Commission (IWC) in June 2012 and June 2013.
- Angie Sremba completed her study of modern genetic diversity of the critically endangered Antarctic blue whale using a collection of samples made available through the IWC (Sremba et al. 2012).

Assessing the present status of great whale populations

- In the North Pacific, CCGL is collaborating with the *Structure of Populations, Levels of Abundance and Status of Humpbacks* (SPLASH). CCGL has completed sequencing of the mtDNA control region and microsatellite genotypes for more than 2,600 individual humpback whales representing 9 feeding grounds and 8 breeding grounds in the North Pacific.
- In the South Pacific, the population structure and migratory interchange of humpback whales is under investigation in collaboration with members of the South Pacific Whale Research Consortium (SPWRC) and the Southern Ocean Research Partnership (SORP) with support of the Government of Australia and other contributing nations.
- In collaboration with Ocean Alliance, Alana Alexander has now completed DNA profiling of more than 600 individual sperm whales using samples collected during the 5-year Voyage of the Odyssey. This will provide the first circumequatorial survey of population structure and genetic diversity in this charismatic species.
- Dr. Baker has made important contributions to the oversight of the IWC's *Implementation Review* of the North Pacific minke whales. Populations of minke whales in the western North Pacific are the target of Japan's controversial scientific whaling program. The *Review* brings together information on this exploitation to assess the potential catches that would be allowed under the IWC's Revised Management Scheme.

Conserving the future of great whales and dolphins

- With support from a Pew Marine Conservation Fellowship, Dr. Baker has helped coordinate a large-scale study of dolphin population in Oceania, *A Pattern of Dolphins* (aPOD), in collaboration with members of the SPWRC. In the Solomon Islands, Dr. Baker has worked with Marc Oremus to assess the impact of the live capture or Indo-pacific bottlenose dolphins and the recent resumption of the traditional "drive-kill" of spotted and spinner dolphins.
- With funding from the Marine Mammal Commission, Becca Hamner has continued her PhD research on the endangered Hector's and Maui's dolphins endemic to the coastal waters of New Zealand. Becca has confirmed the genetic distinctiveness of the critically endangered North Island Maui's subspecies and the genetic isolation between the

regions populations of Hector's dolphins around the South Island (Hamner et al. 2013).

Discovering new species

- Scott Baker uses molecular methods to identify species of the rare and cryptic beaked whales. Using bones collected in the remote Gilbert Islands of the Republic of Kiribati, Dr. Baker and his colleagues identified three species of beaked whales (Baker et al. 2013), one of which appears to be a previously unrecognized species, with an unusual distribution near islands in the central Pacific and Indian Oceans.
- Dr. Baker and his colleagues at the University of Auckland used molecular methods to identify the first complete specimen of what may be the world's rarest whale, the "spade-tooth" whale (Thompson et al. 2013).

**Marine Mammal Institute
Oregon Marine Mammal Stranding Network
(OMMSN)**

Coordinator: Jim Rice

The Oregon Marine Mammal Stranding Network is a collaborative, largely volunteer organization that comprises members from Oregon universities, state and federal agencies, and the general public. MMI's Jim Rice has served as coordinator for the three coastal regions (northern, central, and southern Oregon coasts) since 2006 and oversees a network of trained volunteers in the central coast region. The objectives of the OMMSN are, to promote the scientific investigation of marine mammal stranding events; to provide for the welfare of live stranded animals (by mitigating harassment and disentangling marine mammals from debris and fishery gear); to advance public education about marine mammal strandings; and to report data to NMFS for inclusion in a national database used to establish baseline information on marine mammal morbidity and mortality. Stranding events offer a wealth of information about marine mammals to researchers and resource managers including seasonal distribution, toxic contaminant levels, impacts of human interactions, and surveillance of known and emerging diseases. Jim Rice responds to hundreds of stranding events each year and is also actively engaged in public outreach programs, volunteer training, necropsy teaching sessions, and collaborations with the OSU College of Veterinary Medicine by providing pathology samples for analysis and study materials for veterinary students. The Stranding Network has traditionally received \$100,000 per year through a federal Prescott grant to carry out this coordination activity. Unfortunately, this grant program has been cut from NOAA's budget and so the stranding network is in need of new sources of funding for its continued existence.

**Marine Mammal Institute
Pinniped Ecology Applied Research Laboratory**

Markus Horning, Associate Professor; Graduate Students: Stephen Meck (M.S., Dept. Fisheries & Wildlife), Norma Vazquez (M.S., Dept. Fisheries & Wildlife), Sheanna Steingass (M.S., Dept. Fisheries & Wildlife); Undergraduate Student: Mee-ya Monnin (Dept. Fisheries & Wildlife)

The Pinniped Ecology Applied Research Laboratory (PEARL) is dedicated to the study of ecology, behavioral physiology and conservation biology of pinnipeds (seals, sea lions, and walrus) in polar, temperate, and sub-tropical regions. Long-term PEARL research goals include the integration of diverse approaches to monitor and predict vital rates and population trends of pinnipeds in the North Pacific and polar regions.

- From October through December 2012, PEARL successfully completed its second and last field season in Antarctica studying the *Thermoregulation in free-living Antarctic seals: the missing link in effective ecological modeling* through a grant from the National Science Foundation's Office of Polar Programs. This study will fill a major knowledge gap by providing data essential to modeling all aspects of pinniped life history, in particular for ice seals. Through May 2014, we will be focusing on data analysis and manuscript preparations. This project is carried out in collaboration with Jo-Ann Mellish (University of Alaska Fairbanks) and Allyson Hindle (University of Colorado Denver). OSU project participants include M. Horning and OSU undergraduate student M. Monnin.
- Building on the success of the first generation life-long implanted monitors for marine homeotherms (LHX tags), we are developing the next generation of LHX-2 devices, under National Science Foundation funding. This telemetry technology allows remote monitoring of pinnipeds throughout their entire lives to aid in classification of detected mortalities. LHX-2 development is conducted in collaboration with Wildlife Computers, Inc. (Redmond, WA), with the additional participation of Dr. John Parmigiani from the Computational Mechanics and Applied Design Laboratory (OSU School of Mechanical, Industrial, and Manufacturing Engineering). Dr. William Hanshumaker (HMSC) is coordinating education and outreach efforts under this grant. These efforts include the development of a project specific website and curriculum elements by contractors Seymour Creative Communications and MarEPOsa. The website (www.sealtag.org) also presents a standards-based curriculum for school grades 6–12 with classroom activities that combine engineering principles and our biological research on Steller sea lions. OSU project participants include M. Horning, J. Parmigiani, and W. Hanshumaker.
- In early 2013, the PEARL concluded the first phase of a long-term research project, *The impact of predation on juvenile survival and population recovery of Steller sea lions in the Gulf of Alaska*, (funded by the North Pacific Research Board and the Pollock Conservation Cooperative Research Center). The first phase of this project was initiated in 2001 with the development of specialized, life-long electronic monitors to determine dates, locations and causes

of mortality in juvenile Steller sea lions. Since 2005, 36 juvenile sea lions received these Life History Transmitters (LHX tags). Data returns from a subset of these sea lions showed a high incidence of predation on young sea lions in the Gulf of Alaska. Conducted in collaboration with the Alaska Sea Life Center in Seward, AK. OSU project participants include M. Horning, S. Meck and N. Vazquez.

- Starting in 2013, we will initiate Phase 2 of this long-term project monitoring depredation and reproduction in Steller sea lions in the Gulf of Alaska, using 2nd generation LHX-2 tags currently being developed (funded by the North Pacific Research Board, the North Pacific Fisheries Foundation, and the Pollock Conservation Cooperative Research Center).

PEARL student activities

- PEARL graduate student Stephen Meck (M.S., Dept. Fisheries & Wildlife) successfully defended his thesis entitled "*Range-use Estimation and Encounter Probability for Juvenile Steller Sea Lions (*Eumetopias jubatus*) in the Prince William Sound-Kenai Fjords Region of Alaska*" on March 21, 2013. Stephen received support from the HMSC Mamie Markham 1st Year Student Award and the North Pacific Research Board.
- Two M.S. students in Fisheries & Wildlife — Norma Vazquez and Sheanna Steingass — have completed all classwork and are continuing on their respective research projects.
- From July through December 2012, OSU undergraduate intern Mee-ya Monnin once again joined our Antarctic project. She spent her summer internship calibrating and preparing equipment and joined our Antarctic field team from October through December. Mee-ya is conducting an honors thesis entitled "*A comparison of surface to volume ratios between pups and juveniles in the Antarctic Weddell seal (*Leptonychotes weddellii*)*", using morphometric data she collected on Weddell seals during her internship.

**Marine Mammal Institute
Whale Telemetry Group**

Bruce Mate, Director; Faculty Research Assistants: Tomas Follett, Craig Hayslip, Ladd Irvine, Barbara Lagerquist, Martha Winsor

The Marine Mammal Institute's Whale Telemetry Group (WTG) has pioneered the development and field use of satellite-monitored radio tags to study the movements, populations, prey selection, critical habitats, and dive characteristics of multiple whale species throughout the world. Recruitment is underway for a Cetacean Ecologist, Principal Investigator faculty member to join the Whale Telemetry Group (WTG). Information about the selected candidate will be available next fiscal year.

- The results of tagging western gray whales (WGWs) in Russia have demonstrated that many of the whales from that region, previously thought to be the most endangered large-whale stock in the world, are migrating into the eastern North Pacific and comingling with the fully recovered gray whale population there. Additional efforts by others to conduct

photo identification matches both in the lagoons of Mexico and along the migration route, demonstrate that even more whales participate in these trans-ocean-basin migrations.

- A WTG team led by Ladd Irvine and Craig Hayslip tagged Pacific Coast Feeding Group (PCFG) gray whales during fall 2012. Subsequently these whales were tracked to Mexican breeding and calving areas and back to summer foraging areas of California, Oregon, Washington, and Alaska. This work provided information about the importance of areas off the coast of Baja as well as the breeding and calving lagoons. Researchers collected valuable data regarding the amount of time that individual whales spend in various parts of their seasonal range. Data from this project will be combined with data from other taggings during 2009 and will allow researchers to generate an in-depth look at home ranges and core areas in the Pacific Northwest. The Pacific Northwest ranges are particularly relevant to issues such as wave energy, the Makah petition to take gray whales, and the comingling with possible western gray whale migrants.
- A project to look at the effects of sound as a possible deterrent for whales was led by Barbara Lagerquist, who studied gray whale movements off Yaquina Head on the Oregon Coast during the 2012-13 migration period. Using experimental application of sound and quiet control periods, the shore-based observer team plotted the movements of the migrating whales through the area. These data are now being analyzed and will be reported shortly. Results will be of interest to the offshore wave energy industry and the Navy, which conduct activities in the Pacific Northwest.
- In 2012, the WTG led by Ladd Irvine tagged four sperm whales in the Gulf of Mexico near the site of the Deepwater Horizon oil spill before the season was closed out by Hurricane Isaac. The team will tag additional animals in 2013 in an effort to determine whether there are spill-related changes in the sperm whales' distributions.
- Bruce Mate taught 130 volunteers during a workshop for the Whale Watching Spoken Here program run by Oregon State Parks. The trained volunteers work at 26 sites along the Oregon coast and help up to 40,000 visitors per year spot gray whales during the annual winter and spring migrations.
- Members of the WTG attended meetings of the International Whaling Commission, the International Union for the Conservation of Nature, and specialty meetings on oil spills, acoustics, and technology.

Shellfish and Fish Aquaculture and Conservation
Christopher Langdon, Professor

Over the previous 17 years, a major focus of the COMES Aquaculture program at HMSC has been the USDA-funded Molluscan Broodstock Program (MBP) that improved yields of Pacific oysters through genetic selection. Due to elimination of Congressional Special Projects (“earmarks”) in 2011, funding for MBP was lost. In 2013, a group of West Coast oyster growers came together to support the continuation of a scaled-down version of MBP (industry’s MBP or iMBP) that will maintain genetic gains as well as continue to improve desirable traits.

The Aquaculture program continues to help the shellfish industry address acidified seawater conditions on the West coast that have seriously impacted larval production from hatcheries and wild populations. In fall 2010, a four-year NSF grant was obtained in collaboration with CEOAS lead PI George Waldbusser and co-PI’s Burke Hales and Brian Haley, to study the effects ocean acidification on several species of marine bivalve larvae, including both Pacific and Native oyster species. A specially designed flow-through system will be built in the Aquaculture labs that will allow bivalves and other filter-feeding organisms to be exposed to seawater types of different carbonate chemistries. This research will improve our understanding of how long-term changes in global conditions will affect shellfish and other marine calcifying organisms.

Funding from NOAA’s National Estuarine Research Reserve System (NERRS) was obtained to support PhD student Matt Gray’s studies on the effects of different environmental factors on the feeding physiology of West Coast Native oysters (*Ostrea lurida*). The feeding physiology of Native oysters will be compared with that of Pacific oysters in order to assess the contribution of shellfish aquaculture to water clarification. These studies will help restoration managers evaluate the contribution oysters make to removal of suspended sediment and phytoplankton from coastal waters.

On the West Coast, aquaculture of commercially important fish species, such as sablefish, lingcod, yellowtail, white bass and rockfish, will become increasingly important in meeting our food demands as harvests of wild fish stocks become limited. The major bottleneck in the aquaculture of marine fish species is the successful rearing of their larval stages. In 2011, a USDA grant was obtained from the Western Regional Aquaculture Center (WRAC) to support PhD student Matt Hawkyard’s studies using encapsulated micronutrients to deliver nutrients to West Coast fish larvae, in cooperation with researchers at Hubbs Sea World, NOAA and USDA. In 2012, additional funding was obtained from AFRI/USDA to extend the study of microparticulate delivery of nutrients to marine fish larvae, in collaboration with researchers from Norway and the NMFS Alaska Fisheries Science Center at HMSC.

Lastly, the excellent aquaculture facilities at HMSC have facilitated participation in a large BP-funded toxicology program led by OSU’s Bill Stubblefield that focuses on the biological responses of marine bivalve and echinoderm larvae to oil and dispersants associated with the Gulf Oil Spill. This project will help us better understand the potential impacts of future oil spills and to improve responses to reduce environmental impacts.

Seabird Ecology

Robert Suryan (Ph.D.), Associate Professor-Senior Research
Amanda Gladics (M.S.), Faculty Research Assistant
Cheryl Horton (B.S.), M.S. Student, Fisheries and Wildlife
Amelia O’Connor (B.S.), M.S. Student, CEOAS Marine
Resource Management
Jessica Porquez (B.S), incoming M.S. Student, CEOAS
Marine Resource Management

Stephanie Loredo (B.S), Environment for the Americas Intern

The Seabird Oceanography Lab (SOL) at OSU's Hatfield Marine Science Center (HMSC) is involved in research focusing on marine and estuarine avian ecology and integrated ecosystem studies while providing research opportunities for students and developing educational programs. Now completing its seventh year, SOL continued to expand the breadth of research projects while continuing to offer the annual spring course, Introduction to Marine Life in the Sea – Marine Birds (BI/FW 111) as well the summer course, Marine and Estuarine Birds (FW 499). Research conducted by SOL spanned the North Pacific, including projects in Japan, Alaska, and Oregon. During this report period, our lab was awarded over \$400,000 in funding, authored/co-authored five publications, two final reports, and gave or contributed to 17 presentations at scientific meetings, seminars, and public forums. Our local field study near Newport, Oregon, was featured in several news stories as were our studies of albatrosses (see list below). We also contributed seabird expertise to marine spatial planning off the Oregon coast and participated in educational and public outreach activities. Research projects during the past year included: 1) Foraging patterns and marine habitat use of short-tailed albatrosses (*Phoebastria albatrus*); 2) Experimental translocation of short-tailed albatross chicks for re-colonization of historical breeding sites in Japan; 3) Seabird tracking and prey patch dynamics near the Pribilof Islands, Alaska; 4) Seasonal patterns in the broad-scale distribution of seabirds and prey in the Bering Sea; 5) U.S. West coast fisheries and seabird interactions; 6) Use of remote sensing data to identify biological hotspots with respect to seabird distribution and marine spatial planning; 7) Common murre (*Uria aalge*) reproductive biology and foraging ecology at Yaquina Head, Oregon; 8) Common murre population dynamics on the Oregon Coast; 9) Marine predator diets in the northern California current and responses to changing foraging conditions; 10) Seabird colony and at-sea distribution along the Oregon coast, 11) Developing an integrated sensor array to detect avian and bat interactions with offshore energy devices.

Information on these and other SOL projects can be viewed at the new SOL website, <http://hmsc.oregonstate.edu/seabirdoceanographylab/>. Maps and information about our past albatross satellite tracking studies can be viewed at <http://www.wfu.edu/albatross/> and follow the link to short-tailed albatross studies.

Short-tailed Albatross, Japan: This is a collaborative study between the Yamashina Institute for Ornithology, the Ministry of Environment, Japan, the U.S. Fish and Wildlife Service, and Oregon State University to determine the at-sea distribution and marine habitat use of this endangered species (currently ~3,400 individuals, but thought to be extinct during the late 1940s). Before this research began, there was little information on the at-sea distribution of this species during the breeding and non-breeding season. The satellite tracking efforts, now in the twelfth year, are filling this knowledge gap and allowing researchers, managers, industry, and governments to make more informed decisions regarding the at-sea conservation of this species.

Another component of this study is the experimental translocation of short-tailed albatross chicks for re-colonization of historical breeding sites. The 2011-2012 breeding season was the fifth and final year of the translocation and hand-rearing project. Most notably there was a marked increase in visitation of the new colony site by hand- and naturally-reared birds, including two pairs actively engaged in courtship displays. Amid great excitement in Japan, a breeding attempt by a hand-reared bird was observed at the new colony site during 2012-2013. The initiation of the first breeding attempt by a hand-reared bird at the new colony site is a clear success of the translocation project. Unfortunately, however, the egg did not survive. There is great optimism that the pair will return to the new colony and attempt to breed again in the coming years.

Our current focus is assisting with monitoring hand-reared bird attendance and breeding attempts at the new colony, as well as data analysis and manuscript preparation on satellite-tracking data collected on chicks after fledging (leaving the colony). Our primary research questions in these analyses are whether translocated and hand-reared chicks are indeed surviving and whether they are migrating similarly to naturally-reared individuals. Additionally, these juvenile birds have been tracked into U.S. waters and our analyses will help evaluate critical habitats for this species and potential fishery interactions. This latter contribution is particularly important because this age class has very different movement and distribution patterns than adults/sub-adults and therefore overlap a larger variety of fisheries. Some of these data were summarized and analyzed as part of Amelia O'Connor's master's thesis, and will be incorporated into one of her thesis chapters.

Additionally, the first breeding attempt on Mukojima by a hand-reared bird garnered national attention in Science Magazine (<http://www.sciencemag.org/content/338/6113/1400.2.full>), as well as many news media outlets in Japan (<http://scienceportal.jp/news/daily/1202/1202281.html>, http://ajw.asahi.com/article/behind_news/social_affairs/AJ201212130050, http://yamashina.blog.ocn.ne.jp/blog/2012/12/5_5f39.html)

Short-tailed Albatross, Alaska: Our research on albatrosses in Alaska includes two main studies: 1) Albatross potential use of molting areas in the Aleutian Islands and 2) seasonal and Age class-specific use of Bering Sea canyon and shelf habitats and overlap with fisheries. Passes among the Aleutian Islands and surface waters over the outer Bering Sea shelf and canyon habitats are important post-breeding foraging areas for short-tailed albatrosses. Use of Bering Sea canyons, however, are non-uniform, with some, such as Navarin Canyon near the U.S. and Russia border, used much more extensively than others. Many of these areas are support extensive commercial trawl and longline fisheries. M.S. student Amelia O'Connor conducted a fine-scale analysis of associations between immature short-tailed albatrosses (< 3 years) and fishing vessels. She found that albatross associations with fishing vessels were concentrated along the Bering shelf break, especially near canyons, but are likely due to coincident habitat use rather than vessel attraction. Also that locations of short-tailed albatross bycatch in fisheries

are not always within albatross high use areas. Her analyses will be included in a chapter of her master's thesis. Results from both of these projects will have important implications for fisheries management, offshore energy development, and other aspects of marine spatial planning, including identification of marine important bird areas.

Seabird tracking and prey patch dynamics near the Pribilof Islands, Alaska: SOL joined the seabird tracking component of Patch Dynamics study with the Bering Sea Integrated Ecosystem Research Program (BSIERP) – a large-scale study funded by the North Pacific Research Board and National Science Foundation. Investigators with the seabird component are attempting to identify the underlying mechanisms of why seabird (thick-billed murre, *Uria lomvia*, and black-legged kittiwakes, *Rissa tridactyla*) breeding population trends have varied among islands over past decades and how they might respond to future climate change in the Bering Sea. Field crews used state of the art tracking devices attached to birds and we are processing these data to determine foraging ranges, time activity budgets, and dive profiles of birds from three colonies with contrasting productivity, population dynamics, and physical settings within the Bering Sea marine environment. These results are then being integrated with at-sea measures of prey fields and biophysical oceanographic measures. Data analysis and synthesis were completed in 2011-2012, and the focus for this project in 2012-2013 was manuscript preparation and submission.

Seasonal patterns in the broad-scale distribution of seabirds and prey in the Bering Sea: SOL is contributing seabird and data integration programming expertise to broad-scale surveys of seabirds and prey in the Bering Sea. Fisheries acoustic and trawl data have been collected and analyzed by scientists with NOAA Alaska Fisheries Science Center and the University of Washington and seabird distribution data aboard the same ships by the U.S. Fish and Wildlife. This project is also a component of BSIERP with the goal of understanding how environmental variables affect seabird distribution during and after the breeding season and how the birds might respond to climate change in the Bering Sea.

West Coast Fisheries and Seabird Interactions: In collaboration with Washington Sea Grant, SOL is working to reduce seabird interactions with commercial fisheries along the U.S. West Coast. As part of this project data from at-sea surveys and seabird tracking studies were integrated with data on the distribution of fishing effort to determine fishing sectors, areas, times with the greatest overlap with albatrosses. This analysis identified fisheries and regions most in need of targeted mitigation and found that the longline sablefish fishery north of Monterey was the highest priority. During 2012-2013, a manuscript describing this analysis was submitted, revised and accepted for publication in Fisheries Research.

During 2012-2013, we applied for and received funding for expanded research and outreach effort, including funding to hire a faculty research assistant (Amanda Gladics). We have begun outreach efforts to fleet, agency, and non-governmental stakeholders and conducted port visits in Washington, Oregon

and California to distribute seabird bycatch outreach materials and meet with vessel skippers and owners. Following up on bycatch mitigation distribution conducted in 2009, we have distributed 25 free streamer lines and information on how to deploy them to 10 individual fishing vessels for voluntary use. We are working closely with fleet leaders to arrange to conduct research on seabird mitigation measure effectiveness and to determine appropriate performance measures for the west coast fleet. We have commitments from several vessel owners to collaborate on the research and intend to initiate field work for this research in the coming months.

We will continue to work directly with the longline fishery for sablefish on the West Coast over the next two years to promote the conservation of seabirds through reduced bycatch, help prevent bait loss for fishers, and thereby increase targeted fish catch-per-unit-effort. Not surprisingly, this is a complex task, but we are optimistic that with some additional research on the unique gear and vessel types in the fishery and minor modifications to seabird bycatch avoidance techniques developed by Washington Sea Grant for Alaska fisheries, we will help reduce seabird bycatch in the West Coast longline fisheries.

Spatial Ecology and Biological Hotspots: SOL collaborated with the Farallon Institute for Advanced Ecosystem Research to develop new analytical approaches for satellite remote sensing data that will improve our ability to identify, over large spatial scales, persistent areas of high use (“hotspots”) for seabirds and enhance food web productivity, in general. Results of this study were published in Marine Ecology Progress Series. We have provided data from this analysis to other users for additional application and testing and co-edited a theme section on mechanisms supporting biological hotspot formation in Marine Ecology Progress Series. We also are co-convening a workshop on integrating individual tracking and vessel-based strip transect survey data at the October 2013 North Pacific Marine Science Organization (PICES) annual meeting.

Common Murre Reproductive Biology and Foraging Ecology: Yaquina Head is home to over 60,000 common murre during the breeding season – one of the largest murre colonies on the west coast. The Bureau of Land Management manages the Yaquina Head Outstanding Natural Area, located in Newport. SOL continued research and monitoring at this colony during the 2013 breeding season, our seventh consecutive year of data collection. Between our studies and those conducted by Dr. Julia Parrish (University of Washington), we now have a 12 year time series at this site, and hopes of continuing this long-term coastal research and monitoring program. The long-term diet data set from this colony along with local and basin-scale environmental metrics were analyzed and included as a chapter in Amanda Gladics' M.S. thesis, which is in preparation for submission to a peer reviewed journal. Additionally, we are combining the long term diet data with stable isotope analysis of murre chick feather samples (2004-2013) to gain additional insights on sources of variability in murre chick-rearing diets. Preliminary analysis of the stable isotope data was presented at the PICES 2012 annual meeting, and is in preparation for submission to a journal theme section for a predator-forage fish workshop in September 2013.

Seabird colonies at Yaquina Head are quite dramatically affected by both “top-down” forces of predation/disturbance and “bottom-up” forces of varying prey availability and changing ocean conditions. This colony is adjacent to the Newport Hydrographic Line, providing a perfect opportunity for integrating upper trophic level predators into marine ecosystem studies off Oregon. Yaquina Head also is a very popular public attraction viewed by approximately 350,000 visitors annually. Data collected at this site are also included in the annual California Cooperative Oceanic Fisheries Investigations State of the California Current report.

Media highlights of this study included a chick mortality event caused by juvenile pelicans on the Yaquina Head colony that were actively pursuing murre chicks <http://ecotrope.opb.org/2012/07/at-yaquina-head-pelicans-roughing-up-murres/>

Common murre population dynamics on the Oregon Coast:

There are over 600,000 murres nesting on the Oregon coast, representing 66% of the entire murre population along the U.S. and Canada west coasts. Colony sizes vary by orders of magnitude and there appears to be movement among colonies indicating a meta-population structure. Bald eagle abundance has steadily increased in recent decades and murre colonies have been greatly affected by eagle predation. This is especially true along the northern half of the Oregon coast, where eagles are most abundant. Understanding the overall effect of bald eagle predation on common murre populations will also require understanding region-wide changes in distributions of murres among breeding sites. During 2012-2013, SOL M.S. student Cheryl Horton collected video and on-site observation of bald eagle and secondary predator disturbances at three common murre nesting colonies on the Oregon coast to study murre-eagle interactions. Analysis of differences in disturbance rates and common murre reproductive success at these case study colonies should inform her broader analysis of possible meta-population restructuring of murres on the Oregon coast.

Marine Predator Diets and Changing Foraging Conditions:

This study is comparing the dietary overlap under varying oceanographic conditions of multiple species of forage fish predators, including common murre (*Uria aalge*) Chinook and coho salmon (*Oncorhynchus tshawytscha* and *O. kisutch*), black rockfish (*Sebastes melanops*), and Pacific halibut (*Hippoglossus stenolepis*). We are integrating our on-going studies of common murres at Yaquina Head with collaborative fisheries research to help detect and understand food web wide adjustments resulting from biophysical changes in ocean dynamics off the Oregon coast. Sampling for this study was completed in fall of 2011. Data from this project were analyzed and included as a chapter in Amanda Gladics’ M.S. thesis in 2012. During 2012-2013, we revised the thesis chapter and submitted the manuscript for publication.

Seabird Distribution on the Oregon Coast: As with terrestrial wind farms, electrical power lines, and mobile phone towers, etc., proper placement of any structure is critical to minimize the impact to resident and migratory birds off the Oregon coast.

Working with the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration during 2011-2012, we finished a report that integrated datasets of breeding colony sizes and locations along the coast with vessel-based surveys of seabird distribution at sea. Results of this project are being used to help inform coastal marine spatial planning decisions and serve as an information gap analysis for planning future studies where data are deficient. The report is available online in OSU scholar archives at <http://hdl.handle.net/1957/30569>

We have extended this work in 2012-2013 to include additional field surveys of seabird distribution, including regular surveys on the Newport Hydrographic line on board the RV *Elakha*. Members of SOL, Amanda Gladics and Amelia O’Connor, also contributed to long-term efforts to survey at-sea seabird distribution in the northern California Current by serving as at-sea observers on board a NOAA research cruise on RV Ocean Starr.

A Synchronized Sensor Array for Remote Monitoring of Avian and Bat Interactions with Offshore Renewable Energy Facilities:

We completed the first year of a project to design, test, and deploy an integrated sensor array that will continuously monitor interactions (including impacts) of avian and bat species with wind turbines. In contrast to land-based wind facilities, animal casualties in off-shore wind energy installations can only be efficiently assessed over the long term using an on-board detection system with data transmitted remotely to shore-based data processing centers. We are developing a synchronized array of sensors including accelerometers, contact microphones, visual and infrared spectrum cameras, and bioacoustic monitors. On-board, custom-designed data post-processing and statistical-based software will detect impacts from other disturbances and trigger the event recording. Remote access to the recorded images and sensor data will make it possible to quantify interactions, including collisions, and identify organisms involved to the lowest taxonomic grouping possible. When completed, the sensor array can be used on a single turbine for site characterization or on multiple turbines distributed throughout a wind facility to assess cumulative impacts. It is anticipated that all or parts of the array can be used for a variety of offshore structures, including wave energy devices.

Department of Agricultural and Resource Economics

Marine Resource Economics & Marketing

Gil Sylvia, Associate Professor

Research during the past year has concentrated on seafood marketing, bioeconomic modeling, fisheries management and policy, education of fishery managers, and coastal community development. Outreach and public service has been directed at improving fisheries management, publishing and presenting marketing and management research, and assisting west coast industry and agencies in developing cooperative and cost-effective fisheries research. Many of these interdisciplinary

projects include close cooperation with the Astoria Seafood Laboratory, the Community Seafood Initiative/Fish Trax Systems Inc., Oregon Department of Fish and Wildlife, the Cooperative Institute of Marine Resource Studies, the World Bank, and economists and biologists of the National Marine Fisheries Service.

Research projects include: 1) developing optimal traceability and accountability systems for handling, marketing, and sustaining fisheries and seafood using real time information systems; 2) developing education programs for fishery managers; 3) conducting consumer surveys to determine perspectives and values for developing seafood traceability systems; 4) exploring ecosystem services associated with marine reserves; 5) developing case studies for improving education in stock assessment and international seafood trade; 6) managing the Project CROOS Group (Cooperative Research on Oregon Ocean Salmon) for using genetic and traceability systems for improving the science and management of ocean salmon; and, 7) developing fisheries bioeconomic models for the country of Ghana, the larger Western Africa region, and the World Bank and FAO.

We continued to work closely on numerous ventures with the formerly named Community Seafood Initiative, now known as Fish Trax Systems, Inc. The focus of Fish Trax, which is a suite of electronic fish information systems using near real time information, is to support fish marketing, science, and fishery management (www.pacificfishtrax.com, <http://www.fishtrax.com>, <https://marketplace.fishtrax.org>). A new product called Fish Trax Marketplace, developed by the CSI/FTS is now being licensed and commercialized. In addition, we are working with a small international group to develop standards for advancing fishery electronic information systems. The highly interdisciplinary CROOS project is ongoing and is funded from a variety of sources and involves COMES faculty, the Oregon Salmon Commission, National Marine Fisheries Service, Oregon Sea Grant, CSI, and ODF&W. The projects goals include using genetic and oceanographic analysis to reduce harvests of weak salmon stocks while avoiding large area closures, develop new approaches for salmon management, and using digital technology for information tracking systems for management and marketing. The project remains the largest collaborative research program ever undertaken by the Oregon salmon industry and involves more than 150 fishermen and vessels. We have developed a larger and more comprehensive West Coast group (West Coast Salmon -- Genetic Stock Analysis) conducting genetic salmon research from Washington to Central California. In cooperation with a consulting company (the Research Group, Corvallis) we have developed an integrative bioeconomic fishery model to be used by the World Bank in developing and analyzing investments to reform fishery management in the country of Ghana. The model is designed to be usable by fishery managers and stakeholders. A phase II development is expected in 2014 including training of managers for using the model.

These research projects have generated over \$2 million in extramural funding and are supporting three graduate students in the Departments of Agricultural and Resource Economics and

Marine Resource Management.

College of Education

Dr. Shawn Rowe, Free-Choice Learning Lead, Oregon Sea Grant; Associate Professor, Science Education, College of Education; Co-Director Center for Ocean Sciences Education Excellence, Pacific Partnerships

As of Fall 2012, the College of Science's Department of Science and Mathematics Education was merged with the OSU College of Education. The mission of the newly formed College as stated on the website is "to develop multi-culturally competent researchers, scholars, learning leaders and practitioners who make a difference by promoting innovation, social justice, and lifelong learning with a focus on STEM and cultural and linguistic diversity. Our research and professional preparation fosters scholarship, intellectual stimulation, openness, flexibility, and a sense of community". This move positions Free-Choice Learning Faculty and students at the intersection of understanding and researching science learning and the increasingly diverse needs and motivations of learners. Dr. Shawn Rowe represents College of Education faculty and efforts at HMSC and was awarded tenure this year.

Dr. Rowe continued to oversee research and evaluation work by students from programs in science and math education, environmental sciences and marine resource management involving HMSC and Oregon Coast Aquarium visitors. Between July 2012 and June 2013, Rowe and/or students presented research findings from their work at the HMSC at the annual meeting of the Mathematics and Science Partnerships Program, the ASLO Ocean Sciences meeting, the Visitors Studies Association, the North American Association for Environmental Education, the 6icom Conference on Multimodality, the Journées Hubert Curien International Conference on Science Communication, the National Marine Educators Association, the Sea Grant Biannual Meeting, and the Museums and the Web Conference. Dr. Rowe also participated as a speaker and organizer in two HMSC Science on Tap Events.

Research efforts: Research continued using the VC as a laboratory for both exploratory and experimental research. Research in the 2011-2012 academic year was funded by the National Science Foundation, the Oregon Department of Education, and student scholarships from the Holt Marine Education Award and the Mamie Markham Award. Holt award recipient Katie Stofer completed her research using eyetracking technologies to study complex scientific visualizations, presenting findings at the HMSC seminar and Markham Symposium. Markham Award recipient Laura Good completed research with volunteers in the VC focusing on documenting volunteer practices for engaging visitors at a variety of exhibits.

Professional development for scientists and educators: This year represented the wrap up of two long-term NSF funded professional development projects for scientists and educators

led by Shawn Rowe at OSU. The Center for Ocean Science Education Excellence, Pacific Partnerships (COSEE PP) and the Communicating Ocean Sciences Informal Educators Network (COSIA) have supported work over the last 5 years for developing, carrying out, and evaluating professional development at HMSC for both ocean scientists and marine educators at HMSC and regionally. In 2012, workshops for graduate students at OSU, HMSC, and the Oregon Institute for Marine Biology focused on better presentations and poster preparation. Professional development for K-12 educators continued with Oregon Sea Grant and College of Education participation in the Oregon Coast Regional STEM Education Center (described elsewhere in this report).

Conference and academic presentations:

Filippini-Fantoni, S., Jaebker, K., Bauer, D., Stofer, K. (2013). Capturing visitors' gazes: Three eye tracking studies in museums. Joint paper presented at Museums and the Web Conference, Portland, Oregon, April 18, 2013.

Good, L. (2013, Jun) Unpacking docent practice: Explaining the what and whys of docent interpretive practice in a science center. Presented at the HMSC Markham Awards Symposium, Newport, OR.

Good, L. (2012, Oct) Documenting docent visitor interactions and interpretive practice at a marine science center. Presented at the Oregon Sea Grant Scholars Day Symposium, Oregon State

Dover-Good, L. (2012, Aug) Museum Visitors and Volunteers as Co-researchers in Interactional Multimodality. Presented at the 6th International Conference on Multimodality, Institute of Education, University of London, UK.

Pattison, S., Rowe, S. & Norris, S. (2012, June). Mediated discourse: Shaping the future of visitor studies research. A symposium presented at the Annual Meeting of the Visitor Studies Association, Raliegh, NC.

Rowe, S. (2012, August). Cyberlab: Data collection for large-scale, long-term multimodal analyses. A paper presented at the 6th International Conference on Multimodality, London.

Stofer, K. (2013). Visualizations, visualizers, and visualizees: A communication puzzle. Presented at the Hatfield Marine Science Center Markham Awards, Newport, OR, June 19, 2013.

Stofer, K. (2013). Studying experts' and novices' meaning-making from data visualizations for communication. Seminar presented at Hatfield Marine Science Center, Newport, OR, February 14, 2013.

Stofer, K. (2012). Understanding Expert and Novice Meaning-Making from Global Data Visualizations Using Interviews and Eye-tracking. Digital poster presented at the Geological Society of America Annual Conference, Charlotte, NC, November 4, 2012.

Stofer, K. (2012). Exploring customization and continuity through technology in science center exhibits. Poster presented at the Oregon Sea Grant Scholars Symposium, Corvallis, OR, October 8, 2012.

Stofer, K. (2012). Improving global ocean data visualizations by understanding expert and novice meaning-making, Presented at the Journées Hubert Curien International

Conference on Science Communication, Nancy, France, September 6, 2012.

Stofer, K. (2012). Video recording and playback for stimulated recall in a science center. Presented at the 6th International Conference on Multimodality, London, UK, August 23, 2012.

Invited presentations:

Rowe, S. (2013, January). Free-Choice Learning, Next Generation Science Standards, and Ocean Literacy. An invited presentation to the Ocean Research Advisory Panel, Office of Naval Research, Washington DC.

Rowe, S. (2012, October). Sea Grant and Free Choice Learning projects as Examples of engaged and integrated programs that intersect the academy's missions. Invited panelist for the 2012 University Outreach and Engagement Strategic Conference, Oregon State University, Corvallis, OR.

Rowe, S. (2012, September). Making Social Science an Integral Aspect of Core Sea Grant Activity. Invited speaker for 2012 National Sea Grant Week, Girdwood, AK.

Rowe, S. (2012, September). Behavior Change Evaluation: Going Beyond Reporting Metrics to Maximizing Return on Investment. Invited speaker for 2012 National Sea Grant Week, Girdwood, AK.

College of Forestry

Department of Forest Ecosystems and Society

Marine and Terrestrial Linkages

Bryan Black, Associate Professor - Senior Research

As of Oct 1, 2012:

Assistant Professor
Department of Marine Science
University of Texas at Austin
Marine Science Institute
750 Channel View Drive
Port Aransas, TX 78373
bryan.black@utexas.edu

Dr. Black's research addresses the long-term responses of marine, terrestrial and freshwater ecosystems to climate variability, natural disturbances, and human activities. Trained as a forest ecologist, Dr. Black's original research interests involved the ecology and development of forest ecosystems over the past three to four hundred years. Research in this area has included i) characterizing the composition, structure, and disturbance regimes of pre-European settlement forests ii) evaluating the effects of Native American populations on those forests, and iii) quantifying the forest changes that have followed European settlement in the context of land use history and altered disturbance regimes. Dendrochronology (tree-ring analysis) is an important tool for investigating stand dynamics and the effects of disturbance and climate on forest growth. Dr. Black is now applying tree ring techniques to the growth increments of long-lived marine and freshwater organisms. These multidecadal

chronologies reflect the effects of climate, disturbance, and human activities on growth, and for particularly long-lived species, allow for the reconstruction of climate prior to the start of instrumental records. These growth increment chronologies can also be used to compare diverse taxa and ecosystems. Freshwater mussel, Pacific rockfish, Pacific geoduck, and tree-ring chronologies interrelate with one another, demonstrating how the same climatic variables simultaneously affect marine, terrestrial and freshwater environments.

Through Oct 1, 2012, Dr. Black's lab has led a number of research projects including:

- Reconstructions of stream temperature and flow from the growth increments of long-lived freshwater mussels. Collaborator: Jayne Brim-Box, Confederated Tribes of the Umatilla; Jason Dunham, USGS Corvallis.
- Evaluating the importance of wintertime ocean variability to ecosystem function in the central California Current. Collaborators: Steven Bograd, NOAA SW Fisheries Science Center; Bill Sydeman, Farallon Institute for Advanced Ecosystem Research.
- Relationships between somatic growth (fish size) and otolith growth increment chronologies for yellowfin sole in the eastern Bering Sea. Collaborators: Beth Matta, Tom Wilderbuer, and Tom Helser, NOAA AK Fisheries Science Center.
- Long-term relationships between climate and fish growth in the Leeuwin Current, western Australia. Peter Colson, Murdoch University.
- Long term relationships among climate, population size, and growth for Atlantic cod. Collaborators: Christoph Stansky, Johan Heinrich von Thunen Institute, Hamburg, Germany.

Graduate Committee Member:

- James Johnston, Ph.D. student, OSU Forest Ecosystems and Society
- Vanessa vonBiela, Ph.D. student, University of Alaska Fairbanks, Fisheries
- William Jones, Ph.D. student, UCSD Scripps Institute of Oceanography, Fisheries Oceanography

Current grants:

- BA Black, WJ Sydeman and SJ Bograd. History and Future of Coastal Upwelling Modes and Biological Responses in the California Current. National Science Foundation Biological Oceanography. \$337,992 9/11-9/13.
- BA Black and K Chadwick. Tree-ring analysis of historical and contemporary advanced regeneration and survival of whitebark pine stands impacted by mountain pine beetle. \$20,000. 9/11-9/13
- BA Black. The importance of winter-mode climate variability to ecosystem structure and function in the Pacific Northwest. United States Geological Survey and United States Forest Service. \$50,000. 7/11-7/13.

College of Earth, Ocean, and Atmospheric Sciences

Benthic Ecology and Biogeochemistry

George Waldbusser, Assistant Professor

George Waldbusser's laboratory at the Hatfield Marine Science Center has primary research objectives related to ocean acidification impacts on marine bivalves and the biogeochemistry of sediment habitats in relation to species interactions.

Dr. George Waldbusser is the lead P.I. on a \$2M project funded through the National Science Foundation's Ocean Acidification program to determine the mechanisms of larval bivalve sensitivities to ocean acidification. In the past year the research team including Co-PIs Drs. Burke Hales, Chris Langdon, and Brian Haley has carried out a number of experiments to determine what components of the marine carbonate chemistry system bivalve larvae are most sensitive to during initial shell formation. Successful experiments have now been replicated on the Pacific oyster, *Crassostrea gigas*, and the Mediterranean mussel, *Mytilus galloprovincialis*, with experiments planned this summer for Butter clams, *Saxidomus gigantea*, and the California mussel, *Mytilus californianus*. The team has also just wrapped up an experiment on the Olympia oyster, *Ostrea lurida*, managing to exposure newly fertilized eggs to the same treatment conditions under the careful work of Dr. Langdon and his graduate student Matthew Gray. A component of this work has been to develop the methods to allow for the manipulation of sea water chemistry using mineral acids and bases to create unique sea water chemistry values (refined and perfected by my graduate student Elizabeth Brunner under Dr. Hales' guidance), some of which replicate carbonate chemistry in the geologic record. Chemical manipulations are currently carried out on discrete water samples carefully handled and treated, but a new control system is near completion that is capable of longer-term exposure to these unique carbonate chemistries. These successful experimental trials are providing important insight into the mechanisms of larval bivalve sensitivity to ocean acidification.

The Waldbusser lab has also completed a series of experiments to measure short-term responses of larval bivalves to rapid changes in CO₂ at different stages of larval development in support of an Oregon Sea Grant funded project. The careful experimental work of graduate students Iria Gimenez and Becky Mabardy has allowed exposures of larvae to different rates of increasing and decreasing CO₂ concentrations over 8 hour periods at several key developmental stages of Pacific oyster larvae. Ms. Gimenez has developed and tested methods to characterize the response of larvae at these short time scales. Ms. Mabardy, resident at HMSC, as a component of this work has also undertaken a US West Coast shellfish industry survey of perceptions and understanding of ocean acidification, as well as specific data needs.

In a related study, funded in part by the National Fisheries Conservation Consortium, Ms. Brunner and a 1st year graduate

student in my laboratory, Stephanie Smith, recently exposed developing Pacific oyster larvae to different levels of CO₂ and sampled them frequently during the first 48 hours to life for electron microscope imaging of the first shell formation. Recently published work by the NSF project team has highlighted the reasons why oyster larvae may be so sensitive to elevated CO₂, and this additional work will help document the important developmental biology during this life stage.

Tori Klein who had carried out her thesis OSU Honor's College research at HMSC, has successfully defended her thesis and is now completing edits on her written document. She found in an experiment of maternal effects of CO₂ exposure that under a short exposure window of gravid female Pacific oysters, larvae from these mothers developed less successfully and grew more slowly.

Finally, the Waldbusser lab set up two activities at the HMSC Marine Science day, one an illustration of filter feeding by marine bivalves, and one demonstrating alkalinity and pH concepts in marine carbonate chemistry.



HMSC Marine Science day with (from close to far on the left side of table), Becky Mabardy, Iria Gimenez, Stephanie Smith, and Elizabeth Brunner.

Marine Geochemistry **Clare Reimers, Professor**

Research in Clare Reimers' Marine Chemistry laboratory is focused on the role of seafloor processes in ocean chemical cycles, the biogeochemical influences of hypoxia and anoxia, and developing new electrochemical tools for ocean observing networks.

During 2012-2013, the Reimers lab continued a NSF-supported project to determine the contributions of individual biogeochemical processes driving oxygen utilization, and carbon oxidation within the benthic boundary layer of the Oregon shelf environment. Of special concern are the influences of varying conditions of bottom water O₂, and turbulence stemming from surface and internal waves, and upwelling/relaxation cycles. Research cruises in April and October 2012 on the R/V *Oceanus*

and a two-week experiment in OSU's Hinsdale Wave Research Facility in March 2012 were important components of the project. Masters student, Andrea Albright, and Faculty Research Assistants, Rhea Sanders and Kristina McCann-Grosvenor are working on key aspects of this project.

The second major Reimers lab project, funded by the Office of Naval Research, continues the development and evaluation of revolutionary microbial fuel cells designed as self-refueling power sources for fixed seafloor sensors (benthic microbial fuel cells, BMFCs). Two BMFC-powered Compact Acoustic Modem/Sensor systems were deployed at 890 m water depth near the Monterey Accelerated Research System (MARS) Observatory. These systems successfully harvested power from seafloor chemical gradients, and transmitted sensor data to the MARS Observatory and to surface vessels for seven months. They were recovered in November 2012, and are being refurbished for a future experiment. Highlights of this work have been submitted by Research Associate, Paul Schrader, as a conference proceeding paper for the OCEANS'13 MTS/IEEE meeting in San Diego.

Reimers spent much of the summer of 2012 leading a proposal writing effort for OSU to be the lead institution on a project to finalize the design and coordinate the construction of as many as three new coastal research vessels to bolster the marine science research capabilities of the United States. This proposal was successful, and Reimers is now part of the project team working to finalize the design for the 175-foot long, technically enhanced *Regional Class* ships, select a shipyard, oversee construction, and coordinate the system integration, testing, commissioning and acceptance, and transition to operations. OSU received nearly \$3 million to coordinate the initial design phase of the project – and if funds are appropriated for all three vessels, the total grant is projected to reach \$290 million over 10 years. As part of the submission, OSU proposed to be the operator of the first vessel and to retire the R/V *Oceanus*, about the time the new research vessels become available.

College of Science

Department of Zoology

Benthic Ecology

Sarah K. Henkel, Assistant Professor

Program Objective: The Benthic Ecology Lab at HMSC characterizes invertebrate and fish communities found in and on sedimentary and rocky substrates in order to understand habitat associations and species interactions in the face of broad-scale oceanic change as well as local human activities. Another significant component of Sarah Henkel's work is public, stakeholder, and political outreach and education on potential ecological impacts of wave energy development in Oregon.

Current Research Projects:

- Characterization and Monitoring of Benthic Conditions at the Ocean Test Facility Site for wave energy: This project

describes substrate characteristics of the proposed area for deployment of the NNMREC Test Facility as well as characterizes seasonal and interannual dynamics of benthic invertebrates and fish. Sampling using a box core and beam trawl has been conducted seasonally since 2010; sampling followed installation of the facility in 2012 and continues to be conducted to provide context for future testing events. (Funded by the U.S. Department of Energy)

- Survey of Benthic Communities Offshore the Pacific Northwest: This project is focused on describing benthic invertebrates found in both soft and hard substrate habitats on the Outer Continental Shelf. The goal of this project is to establish species-habitat relationships to predict invertebrate communities that may be found in areas targeted for future renewable energy development. In summer 2012, the original sampling was augmented by adding 2 additional box core sites and an additional ROV site to survey habitat and macroinvertebrates in rocky habitats using the ROV *Hammerhead*. A new post-doctoral associate, Lenaig Hemery, was hired to analyze the ROV footage and conduct habitat suitability modeling on selected species. Lenaig began work in April 2013. (Funded by BOEM)
- Seasonal Patterns in Condition and Feeding Ecology of Juvenile Flatfish: This project examines the growth condition and gut content of juvenile flatfish across depths and seasons in the nearshore. Additionally, gut contents are analyzed using the bomb calorimeter to determine the nutritional quality of commonly consumed prey species.
- Ocean Bioaccumulation Study: This project analyzed nearshore benthic species for concentrations of heavy metals and organic pollutants that might be attributed to the Georgia Pacific (G-P) outfall pipe adjacent to Nye Beach, OR. Target animals were flatfish (speckled sanddab), Dungeness crab, *Crangon* shrimp, *Mytilus* mussels, & olive snails). Animals were collected from stations around the outfall pipe (mixing zone stations) as well as stations north of Yaquina Head and south of Yaquina Bay. Organisms were processed for trace metals, PCBs & congeners, phenolics, and PBDEs. Overall, there was little evidence for bioaccumulation of contaminants of concern. Specifically, there was no indication of elevated levels of PCBs, phenolic compounds, or PBDEs in the organisms tested. Only mussels and olive snails had higher concentrations of tested metals in animals collected from beaches near the mixing zone as compared to reference locations. It is likely that the level of urbanization around the beach near the mixing zone could be an alternative explanation for higher concentrations of these metals. (Funded by the City of Newport)
- Evaluation of Recovery of Ecosystem Structure and Functions within the MOC-P Mitigation Basin, Newport, Oregon: This project is led by graduate student Nate Lewis. The goal of this project is to evaluate eelgrass recovery along with organism utilization of a replanted eelgrass bed and compare findings to seasonal dynamics at reference beds to determine the ecological success of the replant project.

Teaching:

- BI 450-Marine Biology Spring Term: Sarah taught the

Marine Conservation and Policy week and served as the lead instructor for the 2-week projects section at the end of the term, supervising 11 projects conducted by 1-3 students each.

Mentees:

- Robin Baker: NSF REU (2013). Project: Seasonal trends in infaunal invertebrate populations in natural and replanted eelgrass beds in Yaquina Bay.
- Caitlyn Clark: NSF REU (2011) and University Honors College Student (2011-3). Project: Seasonal patterns in condition and feeding ecology of juvenile flatfish
- Stephanie Labou: M.S. Marine Resource Management Program, expected completion Summer 2013. Thesis: Recent shifts in mollusc abundance and species composition on the continental shelf of the PNW.
- Nate Lewis: M.S. Marine Resource Management Program, expected completion Winter 2014. Thesis: Recovery of ecosystem structure and function recovery in out-planted native eelgrass beds.

Marine Ecology

Bruce Menge, Distinguished Professor; Sally Hacker, Professor; Mark Novak, Assistant Professor; Francis Chan, Assistant Professor, Senior Research

Mission and objectives: Three labs in the Zoology department maintain research activities at HMSC, those of Bruce Menge, Sally Hacker, and Mark Novak. The research focuses on the dynamics of coastal ecosystems, including marine inner shelf, rocky intertidal, estuarine and sand dune habitats, and species interactions in coastal communities. The research is funded by several sources including private funds from the David and Lucile Packard and the Gordon and Betty Moore Foundations in support of the PISCO project, with Bruce Menge, Jack Barth, and Francis Chan as co-PIs (and NOAA Administrator Jane Lubchenco as a former co-PI) and Sally Hacker as a Senior Research Associate. Other funding comes from grants from Sea Grant, EPA, NOAA and NSF, and OSU.

Research projects have several goals: PISCO is focused on benthic-pelagic coupling in the inner shelf region of the west coast of North America, with the goal of determining the nature, magnitude and consequences of links between oceanographic conditions and processes in the inner shelf region (i.e., 0 to 20 km offshore) and coastal ecological systems in the rocky intertidal and shallow benthos. Using ship-based sampling, moorings, ROV surveys, and direct studies on rocky shores, we study the influence of nutrients, phytoplankton blooms, temperature, oxygen, and waves on patterns of abundance, growth and interactions in intertidal and subtidal ecosystems along the coast. Understanding the impacts of climate change on these ecosystems using long-term datasets developed by PISCO is a primary goal.

Menge, Hacker, and Chan have an NSF-funded project investigating the influence of ocean acidification on coralline algae, specifically the common and abundant turf-forming species *Corallina vancouveriensis*. The goal is to determine the

susceptibility of this alga to decreasing acidification resulting from increasing CO₂ in the atmosphere. The importance of this question is that we have learned that *C. vancouveriensis* is the facilitator of recruitment by habitat-forming intertidal kelps, implying that if abundance of the coralline is reduced or it is eliminated, rocky shores would lose a primary component of low intertidal regions, kelp, and potentially much of the biota associated with it. Research includes field observations and experiments, and lab experiments carried out at HMSC in a newly fabricated ocean acidification mesocosm. Menge and Chan also have funding from a separate NSF grant to investigate the influence of ocean acidification on the ecology of mussels and sea urchins. This is part of a 13 PI, six institution consortium of research groups on the US west coast, ranging from Oregon to southern California. This research also involves field and laboratory studies, and will also use the HMSC ocean acidification mesocosm.

Novak is in the process of setting up new experiments in one of HMSC's temperature control rooms designed to investigate the feeding behavior of Oregon's native whelks. These predatory snails feed on a variety of different mussels, barnacles, limpets and other snails, and have long been an important set of species with which to study predator-prey interactions. The lab is using video-cameras to record and thereby quantify how long it takes an individual whelk to feed on each type of prey species (this can take hours to days, depending on the predator and the prey's size, and the water temperature) in order to estimate how long these feeding events might last in the field. These experiments therefore play a key role in determining how predators go about choosing which prey to consume, and how fast they do so, and thereby contribute to our understanding of the processes that stabilize nature's species rich and complex food webs.

Activities: In addition to the ocean acidification mesocosm mentioned above, all of the projects listed above use HMSC laboratory sea water space to stage field work, using space in April-June each year, and to carry out additional experiments in other parts of the year. A post-doctoral fellow, Dr. Annaliese Hettinger, is overseeing the ocean acidification experiments at HMSC, which will also involve graduate students Jeremy Rose, Elizabeth Cerny-Chipman, and Chenchen Shen. Another graduate student, Allison Barner, will be carrying out separate laboratory experiments for her research on "no analogue" algal communities, or species combinations that may be driven by climate change that have no historical precedent. A Hacker graduate student, Jeremy Henderson, recently defended his thesis research on the invasive eelgrass, *Zostera japonica*, within Yaquina Bay and using tanks at HMSC. Another Hacker graduate student, Reuben Biel, is conducting beach grass experiments involving mesocosms setup on the HMSC property. The goal of the experiments is to understand how beach grasses respond to elevated temperatures due to climate change. Other personnel involved besides the PIs, postdocs, and students include Angela Johnson, Shawn Gerrity, and Jonathan Robinson. HMSC is also used periodically throughout the year as the base for field studies along the Oregon coast, and the PISCO studies of hypoxia and coastal inner shelf oceanography use the R/V *Elakha* and the

R/V *Kalipi*. In addition, Hacker's studies of eelgrass and mud shrimp species interactions on mudflats adjacent to HMSC, and her studies of dune ecosystems are also based out of the Science Center.

Kyle Coblenz (a Ph.D. student starting this fall) and Isaac Shephard (a Honors student in his freshman year) have been overseeing the experimental setup for the Novak lab.

Graduate Students, Postdocs and Research Faculty:

Francis Chan (PISCO, Assistant Professor, Senior Research): focuses on coastal biogeochemistry, ocean acidification and hypoxia. This work is based on cruises on the R/V *Elakha* and moorings along the coast deployed from the R/V *Elakha*. See <http://www.piscoweb.org/outreach/topics/hypoxia>.

Annaliese Hettinger (NSF Postdoctoral Scholar): Carries out studies of effects of ocean acidification and other environmental stresses on the eco-physiology, photosynthesis, and productivity of macrophytes.

Jeremy Rose (Menge Graduate Student, supported by an NSF Predoctoral Fellowship): Jeremy is investigating the impact of ocean acidification on intertidal marine invertebrates that form calcified hard parts. He uses the HMSC as a staging ground for field studies and for laboratory experiments.

Alison Iles (Menge Graduate Student, supported by an NSERC Predoctoral Fellowship and a Mamie Markham Graduate Fellowship): Alison is investigating the impact of temperature and other stresses on the impact of predators on their intertidal prey, and what the consequences are for the strength of interactions in food webs. She uses the HMSC as a base for field studies and for laboratory experiments. She defended her PhD thesis in November 2012.

Reuben Biel (Hacker Graduate Student, supported by teaching assistantship and a Mamie Markham Graduate Fellowship): Reuben studies beach grass systems, focusing on the effects of climate on dune geomorphology and coastal protection. His activities at HMSC include mesocosm experiments studying the effect of temperature on beach grass growth. He will defend his PhD in 2016.

Jeremy Henderson (Hacker Graduate Student, supported by teaching assistantship and a Mamie Markham Graduate Fellowship): Jeremy worked on the effects of disturbance on invasive eelgrass, *Zostera japonica*, within Yaquina Bay. His work included mesocosm and field research based out of HMSC. He defended his MS thesis in June 2013.

Allison Barner (Menge and Hacker Graduate Student): Allie is interested in studying the interactions that might occur in "no-analogue" assemblages of marine macrophytes on rocky shores, and how these might alter the structure and dynamics of rocky intertidal communities. She is also interested in investigating the influence of climate change on the diversity of these systems.

Chenchen Shen (Menge Graduate Student): Chenchen is investigating how the interaction between molluscan grazers and coralline algae might be influenced by ocean acidification. Predictions of possible effects are complicated by the fact that both corallines and molluscan grazers are calcifiers, so the impacts of acidification must be investigated on both components separately and when they are interacting.

Elizabeth Cerny-Chipman (Menge Graduate Student): Elizabeth is interested in how climate change might alter the interaction between whelks and mussels. The organisms are both calcifiers, so face challenges from ocean acidification, but are also sensitive to thermal stress, which is also changing.

Jessica Reimer (Menge and Hacker Graduate Student): Jessie is investigating the inputs of kelp and other ocean-derived subsidies to sandy beaches, and how far inland these inputs penetrate into coastal ecosystems.

Kyle Coblenz (Novak Graduate Student): Kyle is starting his Ph.D. work this fall, but has spent much of the summer getting to know the Oregon coast by working as a field assistant.

Leah Segui (Novak Graduate Student): Leah is also starting his Ph.D. work this fall, but will be spending the month of September working along the coast and at HMSC to familiarize herself with the system.

Isaac Shephard (Novak Honors Student): Isaac just completed his freshman year at OSU and has spent the summer working as a field assistant. He is developing an honors project investigating the effects of environmental change on species interactions, and is planning to conduct several experiments using HMSC's facilities.

College of Veterinary Medicine

Department of Biomedical Sciences

Timothy Miller-Morgan, DVM, Lead, Aquatic Animal Health Program/Extension Veterinarian – Aquatic Species, Oregon Sea Grant Extension; Assistant Professor, Department of Biomedical Sciences and Aquatic Animal Disease Diagnostician, Veterinary Diagnostic Laboratory, College of Veterinary Medicine

Dr. Miller-Morgan represents the College of Veterinary Medicine's Department of Biomedical Sciences at the Hatfield Marine Science Center. He also serves as an aquatic animal health/disease professional within the Veterinary Diagnostic Laboratory. His primary duties are to provide clinical services -- generally in the area of population health -- to ornamental fish retailers, wholesalers, importers, and producers.

He is the first College of Veterinary Medicine faculty to be permanently based at the HMSC. Miller-Morgan is currently working with Jerry Heidel, Director, Veterinary Diagnostic

Laboratory; Luiz Bermudez, Chair, BMS; and Jan Spitzbergen; to develop an aquatic medicine program within the veterinary college.

Miller-Morgan teaches and lectures in a number of courses within the College of Veterinary Medicine, including a lecture in VMB 753, *Veterinary Virology – Introduction to viral diseases of ornamental fish*, a section of VMB 728, *Special Species Medicine*, a course offered to junior veterinary students in which he introduces students to the practice of pet fish medicine as a component of a traditional veterinary practice. He is a co-instructor for VMC 738, *Animal Care- Introduction to Fish Husbandry and Handling* and teaches VMB 727, *Ornamental Fish Medicine*, a 40-hour course that teaches senior veterinary students the basic skills they need to begin practicing fish medicine.

Dr. Miller-Morgan was a founding member and executive board member of the new professional veterinary organization the American Association of Fish Veterinarians.

Miller-Morgan and Heidel are also involved in NOAA-funded project to characterize the health status of recently imported wild-caught marine ornamental fish and model shipping stress in these fish in order to decrease shipment and post-shipment morbidity and mortality. Through a partnership with a marine ornamental importer in Los Angeles, they have used the results to develop recommendations for best management practices for marine ornamental importers. They have developed a one-hour seminar for aquatic animal health practitioners outlining their key findings and industry recommendations. This seminar has been presented at the AVMA Annual Conference, and the Sustainable Ornamental Fisheries Conference in Kerala, India.

Dr. Miller-Morgan also participates as a Co-PI on a project to investigate Koi Herpes Virus (KHV) Latency. With this project funded by Project KHV of the Associated Koi Clubs of America he hopes to characterize the latency state and location of KHV-infected koi and refine the diagnostic testing that would allow identification of clinically healthy fish that are virus carriers, an outcome that would help significantly reduce risks to koi importers in the United States. Two manuscripts have been published based upon the current findings of this project.

Dr. Miller-Morgan worked with the University of Hawaii – Aquaculture Program to develop an online training program in aquaculture and aquaponics. This unique and global program, Aquaculture Training Online Learning (ATOLL), is designed to help train entry-level fish farm workers and individuals interested in developing backyard aquaponics systems. Dr. Miller-Morgan developed 4 modules and co-developed three other modules with Dr. Allen Riggs, aquaculture veterinarian for the State of Hawaii. There were 138 students in the first cohort hailing from the U.S., Morocco, Mexico, Brazil, Palau, Costa Rica, Malaysia, Finland, Singapore, Bahamas, Portugal, Chile, Belgium, Zimbabwe, Vietnam, Ecuador, and Russia.

The work to develop best health practices and biosecurity

standards in the ornamental pond fish sector of the industry has resulted in several invitations for Dr. Miller-Morgan to speak at international industry meetings about the implementation of such programs. He recently traveled to Israel, Malaysia and Singapore to speak to members of the ornamental fish industry and assess biosecurity techniques, Japan to survey fish health management techniques within the Japanese koi industry, and India to address members of the nascent but rapidly expanding Indian ornamental fish industry. This last visit resulted in a request from the Indian Government for the Ornamental Fish Health Program and the OSU College of Veterinary Medicine to develop collaboration to improve the Indian ornamental fish industry's fish health management infrastructure. A previous visit to Israel has resulted in collaboration with a large Koi and goldfish producer that has resulted in the development of a paid internship opportunity for OSU undergraduate students with an interest in fish culture and biosecurity. We are currently exploring opportunities collaborate on developing industry training opportunities for fish health management and biosecurity.

Drs. Miller-Morgan and Bermudez have mentored two veterinary students, Ryan Hill and Andrew McDade, as they developed and completed two research projects with one of our ornamental fish industry collaborators. Their projects focused on identifying the potentially pathogenic bacterial flora isolated from recently imported ornamental fish and the potential antibiotic resistance associated with these isolates. Further, they examined the potential for shifts in bacterial isolates and antibiotic resistance over the period of time these fish are held in the import facilities. This work has resulted in two papers that have been submitted for publication.

B. Federal and State Agencies

Environmental Protection Agency (EPA)

Pacific Coastal Ecology Branch, Western Ecology Division

Office of Research and Development - National Health and Environmental Effects Laboratory

Walt Nelson, Branch Chief

The Newport EPA research laboratory is part of the Western Ecology Division, located in Corvallis, Oregon. The mission of the Pacific Coastal Ecology Branch (PCEB) is to provide research support to EPA Program Offices, such as the Office of Water, and to the Regional Offices, such as EPA Region 10 with headquarters in Seattle, WA. The research mission of PCEB is to develop procedures to assess the cumulative and interactive effects of a wide range of human activities on the ecological resources of estuaries of the Pacific Northwest.

The broad research focus for the Pacific Coastal Ecology Branch is to define ecological processes and to develop and evaluate

models to predict stress-response relationships for Pacific Northwest estuaries at a range of spatial and temporal scales. PCEB contributes to three of the EPA national strategic research programs. Research is conducted under the Safe and Healthy Communities (SHC), the Safe and Sustainable Waters (SSWR), and Air, Climate and Energy (ACE) Research Plans.

The goal of SHC research is to develop the tools and approaches for estimating the effects of habitat alteration on important ecosystem services associated with tidal wetlands of the Pacific Northwest. One reason that many ecosystems are in decline is that ecosystem services are not clearly recognized as having value to people. As a consequence, the value of ecosystem services may not be adequately considered in management and policy decisions. However, ecosystems are being increasingly recognized as providing significant economic, social, as well as environmental benefits (e.g. biodiversity, recreation, nursery habitat) to society.

Human activities within an estuary (shipping, recreation, aquaculture), or within the lands surrounding the estuary (urbanization, agriculture, logging), may alter estuarine habitats either directly (shoreline alteration, channelization, landfill) or indirectly through such problems as excessive nutrients or introduction of invasive, non-native species. Global climate change may also bring many changes to coastal systems. The alteration of tidal wetland habitats by human actions will also alter the sum of the ecosystem services provided by these systems.

Research has been focused on highly valued services such as healthy fish, shellfish, and wildlife populations, and will evaluate the likely changes in terms of these and other ecosystems services resulting from impacts of current and future alterations of tidal wetland habitats. The research is designed to serve as a proof of concept for an ecosystem services approach to improving EPA decision-making by enhancing the ability to identify, quantify and value the ecological benefits of EPA policies with respect to tidal wetlands. The primary products of the research will be generally applicable GIS-based tools capable of estimating the ecosystem services provided by different combinations of habitat types, habitat conditions, and habitat areal coverage in PNW estuaries at scales from single system to the entire Pacific coast.

PCEB research under ACE is focused on evaluating the effects of climate change on estuarine ecosystems. Estuarine species and ecosystems are threatened by global change through increases in temperature, sea level rise, ocean acidification, changes in surface flow from altered precipitation, and altered land use in coastal watersheds. To assess the vulnerability of near-coastal species, an approach is being developed that predicts species' overall vulnerability to climate change and vulnerability to specific climate stressors based on their biogeographic distributions and natural history attributes. This approach is being applied to multiple invertebrate and fish groups from Baja California through the Beaufort Sea, with the goal to develop a public website both as a decision support tool and for public outreach. A beta version of the Coastal Biogeographic Risk Analysis Tool

(CBRAT) was developed in the past year. CBRAT development is a cooperative effort with the USGS, and is being coordinated with other research efforts evaluating the direct effects of sea level rise and resulting changes in salinity and other water quality parameters on estuarine wetlands in the Pacific Northwest.

PCEB research under SSWR is focused on the problem of human activities that have resulted in increased nutrient loading to many of the Nation's surface waters, causing widespread impairment of beneficial human and aquatic life uses. A key priority of the EPA is the development of numeric nutrient criteria for all of the nation's surface waters. In response to this need, PCEB is developing approaches to aid in the development of numeric nutrient criteria for estuaries, and in development of tools to assess compliance to these protective standards. Research under this task includes developing methods to distinguishing "natural" ecological conditions from anthropogenic impacts and development of load-response relationships between nutrients and multiple estuarine biotic endpoints. In addition, the research will develop tools to examine the interactions between nutrient enrichment and other factors, such as climate change, that may modulate the impact of nutrients on aquatic ecosystems. The application of decision support tools will allow regulators to evaluate the impact of nutrient management scenarios on estuarine water quality and sustainability of estuarine resources.

EPA research staff at HMSC consists of 17 federal employees, including 2 EPA postdoctoral fellows, and 8 technical and clerical contract support staff. Scientists from the U.S. Geological Survey and the U.S. Dept. of Agriculture, Agricultural Research Service are co-located with EPA scientists. Dr. Gayle Hansen, a marine algologist, is located with PCEB through a guest worker agreement with OSU. Scientists from the Shellfish Program of Oregon Dept. of Fish and Wildlife utilize laboratory space at PCEB. PCEB interacts with the HMSC and wider university community both in research and educational programs. A number of PCEB staff scientists hold courtesy faculty appointments with OSU academic departments, and participate in teaching and serve on graduate student committees.

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service

Alaska Fisheries Science Center

Fisheries Behavioral Ecology Program

Clifford H. Ryer, Program Manager

Alaska Fisheries Science Center's Fisheries Behavioral Ecology Program (FBEP) is based in Newport because of world class experimental seawater laboratories on the campus of the Hatfield Marine Science Center. The 9 members of FBEP staff, and their university collaborators, conduct laboratory research in Newport and field studies in Alaska aimed at understanding the

role that behavior, physiology and ecology plays in regulating distribution, abundance, growth and survival of fish species, and their interactions with fishing methods and fishing gear. The overarching goal of the Program is to provide the critical information needed to improve survey techniques, to improve predictions of recruitment, forecast potential effects of climate change and to conserve populations of economically significant marine resource species along with their habitats. Research in the Program during the last year was concentrated in four primary areas, with funding from NOAA initiatives on Habitat, Arctic Research, and Ocean Acidification, and with grants from the North Pacific Research Board.

Larval fish biology and recruitment: Larval ecology and recruitment processes continue to be an area of focus for the Program. Over the past several years, the Program has developed the necessary protocols to hold broodstock, collect eggs and rear the larvae of important Alaska fish species including walleye pollock, Pacific cod and northern rock sole. As part of the program's arctic initiative, Arctic cod have recently been added to this assemblage of broodstock species. These species represent a diverse set of life histories and have allowed FBEP scientists to conduct experiments examining how temperature, food availability, prey quality, climate change and ocean acidification impact growth and survival in the first 3 months of life. Experiments are designed under a multi-factorial framework, focusing on critical periods in development (egg, yolk-sac larvae, metamorphosis and settlement) in an effort to understand how behavior, physiology and the environment interact. Currently, FBEP scientists are focusing upon the settlement behavior of northern rock sole, using laboratory experiments to elucidate behavioral shift in the lab that explain patterns of settlement seen in Kodiak nursery embayments. Continued research in this area will include the development of tools to quantify fish condition (i.e., behavioral and biochemical indices) and integrate age-0 survey data to link these early life history processes with recruitment.

Fish nursery grounds and predation processes: Nurseries are geographic areas and/or specific juvenile habitats, which disproportionately contribute recruits to adult populations. Often such nurseries are characterized by rapid growth and low juvenile mortality rates. Many species of fishes and crabs in the Gulf of Alaska, Bering Sea and Arctic Ocean utilize shallow water nursery grounds, which lend themselves to the study of basic ecological, behavioral and trophic interactions between juveniles and their predators. The ultimate goal is to understand and conserve important nursery habitats, to reduce impacts of fishing practices, and to forecast the future health of commercially important resource species in the Gulf of Alaska. Habitat studies are partnered with researchers from Oregon State University, the University of Alaska and NOAA laboratories in Kodiak and Juneau. Current species of interest, with respect to juvenile habitat studies, include northern rock sole, Arctic cod, Pacific cod, Pacific halibut, Tanner crab and snow crab. This line of research is particularly germane in the context of our Arctic research program. Arctic ecosystem are already experiencing dramatic changes which effect nursery habitats for keystone

Arctic species such as Arctic cod and snow crab. One of the most pervasive effects of accelerating climate change is loss of sea ice and rising summertime water temperatures. The FBE program is actively researching the potential effects of these changes on the growth and survival of juvenile fish and crabs. Another climate related project is a collaborative effort by FBE and OSU researchers to examine the ecology of juvenile fishes and crabs that utilize near-shore areas off of Oregon where hypoxic (low oxygen) conditions occur periodically during summer months. More explicitly, this project focuses on the effects of low oxygen upon the behavior, growth and survival of juvenile English sole and Dungeness crab.

Responses of fishes to ocean acidification: FBEP continues to investigate the impacts of ocean acidification on Alaskan commercial fishery species. It is thought that early life-history stages of fish will likely be more susceptible to possible deleterious effects of decreasing pH. As a consequence research focuses upon egg, larval and juvenile stages of commercially important Alaskan species. Current experiments are examining growth rates of larval rock sole, walleye pollock and juvenile Pacific cod to explore the interactive effect of pH, temperature, and prey availability.

Bycatch Mortality: FBEP continues to investigate the mechanisms that control mortality in fish and crab species when they are discarded from fishing operations involving trawl, longline, and pot gear. Indices of animal condition based upon reflex actions have been developed over the last several years to predict capture-related delayed mortality in Pacific cod, Pacific halibut, sablefish, snow crabs, Tanner crabs and Pacific spot prawns. Importantly the FBE program is partnered with OSU researchers to examine bycatch mortality in both sub-legal and legal Dungeness crab, which constitutes an extremely important fishery in California, Oregon, Washington as well as Alaskan waters.

Northwest Fisheries Science Center

NOAA Fisheries' Northwest Fisheries Science Center (NWFS) has its headquarters in Seattle, and five research stations in Washington and Oregon. The NWFS's Newport Research Station is located on Oregon State University's Hatfield Marine Science Center campus and conducts critical research on groundfish and salmon, and the ecosystems in which they live.

Operations, Management, and Information Division (OMI):

Captain Rick Brown, NOAA (ret.), Resource Management Specialist; Patty George, Administrative Support Specialist; C. Barry Semple, IT Specialist, System and Network Administrator; Jim H. Miller, IT Specialist

NWFS's OMI Division provides facilities management and science mission infrastructure support for the NOAA presence at HMSC consisting of the Captain R. Barry Fisher building (BFB),

Newport Aquaculture Lab (NAL), Research Support Facility (RSF) and numerous smaller buildings on the site. NWFS / OMI closed out the 2011 last option year of the operations and maintenance contract held by Oregon State University. A new contract solicitation for a new five-year period of performance was competitively awarded to OSU in October of 2012 to continue the maintenance of the 3 NOAA buildings to benefit all occupants and users of these buildings. During the winter of 2012/2013 a major maintenance project included the repair, painting or replacement of many of the exterior doors of the Newport Aquaculture laboratory and Research Support Facility. New doors were also installed for NAL 173 and 175 salt water laboratories.

The OMI IT department continued to provide onsite IT Systems/ Network Administration and Desktop Support to NWFS personnel during the past year. Recent improvements include integrating DoD CAC-card authentication and the deployment of large scale SANs and robotic tape libraries to meet the ever growing demand for data storage and safe archiving.

The OMI Safety and Environmental Compliance Office in Seattle continued to provide lab safety training for staff and students, waste removal, inspections and consultations supporting environmental compliance and safety for the NOAA buildings on the HMSC campus. There were announced inspections by NOAA and NMFS SECO personnel of the NWFS buildings this reporting period with only minimal findings due to proactive safety inspections, training and compliance that the OMI SECO promotes in the NOAA buildings at the HMSC site.

NWFS OMI staff continued to work closely with OSU to bring all personnel and foreign national visitors that work in the NOAA buildings into compliance with Federal Security identification policies under Homeland Security Presidential Directive 12 with the latest requirements from the Western Regional Security Office. With the new Marine Operations Center Pacific in Newport, OMI staff has been able to coordinate the issuing of Government Common Access Cards (CAC's) for personnel at HMSC that work in the NOAA buildings on the HMSC campus.

Conservation Biology Division (CB):

Dr. Peter Lawson; Dr. Laurie Weitkamp; Heather Stout

Dr. Peter Lawson, Dr. Laurie Weitkamp and Heather Stout represent the Conservation Biology Division (CB) in Newport. Dr. Lawson's principal research interests focus on effects of climate and habitat change on coastal ecosystems with particular application to the population dynamics of Oregon Coast coho salmon. Recently he has also been studying ocean ecology of Chinook salmon sampled by the commercial troll fishery. Dr. Weitkamp's primary research interests include the marine and estuarine ecology of Pacific salmon, life history variation, and conservation. Heather Stout's interests focus on the role of estuarine and other wetland habitats in threatened Oregon Coast coho salmon recovery.

Coho Salmon Ecology: Climate conditions influence both freshwater and marine survival of coho salmon. Dr. Lawson, in

collaboration with researchers at the University of Washington and NOAA Fisheries' Alaska Fisheries Science Center, has developed statistical and simulation models of coho salmon life-history interactions with climate. These models will help improve understanding of the variability in coho population sizes and potential implications of climate change in this species. Ongoing investigations are looking at patterns in climate variability and the implication of these patterns to salmon population viability. Coho salmon populations in freshwater are structured by the spatial stream network and are dependent on adequate quantity and quality of habitat. In cooperation with Dr. Kelly Burnett and Dr. Steve Wondzell (U.S. Forest Service), Dan Miller (Earth Systems Institute), and Dr. Ashley Steele (U.S. Forest Service) Dr. Lawson is embedding a habitat-based coho salmon life-cycle into a dynamic landscape model. This work will enable investigations of the effects of upslope and in-stream habitat change on coho salmon populations with applications to salmon recovery planning, habitat protection and restoration strategies. Integration with climate models will further enhance understanding of coho salmon population dynamics. The work is funded in part by a grant from the Oregon Watershed Enhancement Board.

Dr. Weitkamp, with assistance from FE Division, Pacific States Marine Fisheries Commission (PSMFC) and OSU staff, has been leading a project to examine the estuarine ecology of juvenile salmon in the lower Columbia River estuary. This program documents the abundance and condition (i.e., food habitats, parasite and pathogen loads, length and weight, origins and growth rates) of juvenile salmon and associated fish community in the estuary during the annual spring outmigration (mid April to late June). The condition of salmon caught by this study are being compared to studies sampling salmon both further upstream and in the ocean to document how salmon change as they make the critical transition between freshwater and marine environments and understand factors affecting their survival. Fish abundance and condition, and species composition are compared between years to determine interannual variation in the estuarine fish community and develop an index of juvenile salmon abundance.

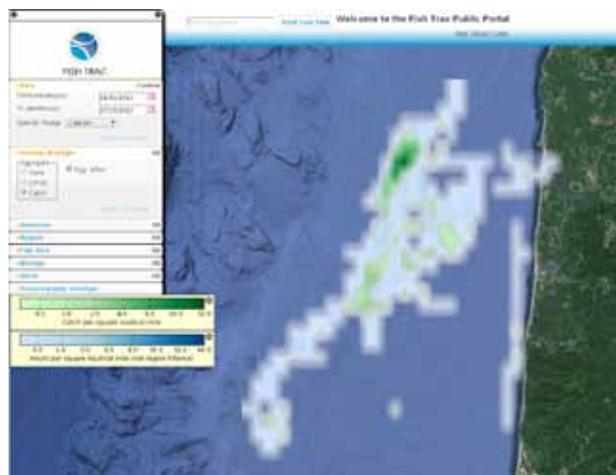
Salmon Harvest Management: Dr. Lawson continues to provide technical advice to fishery management agencies through the Scientific and Statistical Committee of the Pacific Fishery Management Council (PFMC). Dr. Weitkamp and Dr. Lawson also continued to serve on the Coho Technical Committee of the Pacific Salmon Commission (PSC). As part of her PSC responsibilities, Dr. Weitkamp is leading the US effort to produce descriptions of each U.S. Management Unit with respect to management, fisheries, and hatchery and wild salmon production. A major effort for both the PFMC and the PSC has been to develop methodologies for incorporating genetic stock identification (GSI) in fisheries management. Another management-related project is exploring the relationship of a variety of environmental and climate indicators to the survival and abundance of salmon in the California Current System. Results could be used to improve stock size predictors, which are integral to the process of setting annual fishing seasons.

The Collaborative Research on Oregon Ocean Salmon project (Project CROOS) is a collaborative project with fishermen, industry, OSU, Sea Grant Seafood Initiative and others. The project goal is to develop techniques for applying GSI, global positioning system, geographic information system, satellite remote sensing, and other technologies to ocean sampling of Chinook salmon. With the aid of the fishermen, scientists are able to determine exact time and location of capture for each sampled Chinook, along with stock information, oceanographic and biological data, to produce a fine-scale data base of fishery catch data. This database will initially be used to improve harvest management of Klamath River and Sacramento River fall Chinook and will provide a new tool for understanding the ocean ecology of Chinook and coho salmon. The project also includes development of a web site, <http://www.pacificfishtrax.org>, for dissemination of information in near real-time. Applications include management, marketing, and traceability for quality control. Active development includes "portals" to allow fishermen, scientists, managers, and the public useful and appropriate access to the data. Dr. Lawson is the chief salmon biologist for the project. His role has been to advise on study design, consult on database management, advise on web site design, and solicit and coordinate biologists and oceanographers collecting and analyzing data. He also serves as liaison between Project CROOS and NOAA Fisheries Service, extending the project to the entire West Coast. In 2010 Project CROOS sampled the full season weekly from May through September. A parallel effort in California provided the first fine-scale coast-wide picture of salmon stock distributions through a fishing season. Broad-scale sampling continued in 2011 and 2012.

Salmon Recovery Planning: Recovery planning for salmon populations listed under the Endangered Species Act is a complex process involving both scientists and policymakers. NOAA Fisheries recovery teams are creating recovery plans for all listed salmon in several broad geographic areas (for more information about the process, see <http://www.nwfsc.noaa.gov/trt/oregonnccal.cfm>). The first step in this process was to develop biological goals for the recovery of salmonid species, a task that was assigned to "Technical Recovery Teams" (TRTs). Dr. Lawson (co-chair), Dr. Weitkamp, Heather Stout, and Dr. Tom Wainwright (FE Division) and members of the Oregon and Northern California Coast TRT have produced two reports defining populations and biological recovery criteria for listed coho salmon along the coast from the Columbia River to Punta Gorda, California. Team members were from the NOAA Fisheries Northwest and Southwest regions, Oregon Department of Fish and Wildlife, California Department of Fish and Game, U.S. Forest Service, U.S. Department of Interior, tribal agencies, and universities. With the completion of its biological recovery criteria report the TRT completed the initial phase of its work, which was utilized in the Biological Review Team Analysis.

Biological Review Teams: Dr. Lawson is chair of a Biological Review Team (BRT) which has reassessed the status of the Oregon Coast Coho Salmon Evolutionarily Significant Unit. Dr. Weitkamp and Dr. Wainwright also participated, and Heather Stout staffed this BRT. Based on the BRT's findings NMFS

recently announced that the Oregon Coast Coho Salmon ESU will continue to be listed as Threatened under the Endangered Species Act (ESA). Dr. Lawson is also a member of the Recovery Implementation Science Team, which provides technical advice and oversight for recovery planning and activities throughout the Pacific Northwest



FishTrax public portal (fp.fishtrax.org/portal) showing catch and effort for Chinook salmon sampled through mid-July near Newport by Project CROOS in 2013. Samples are being collected in Washington, Oregon, and California.

**Environmental Conservation Division (EC):
Dr. Mary Arkoosh, Supervisor, Immunology and Disease**

Drs. Mary Arkoosh and Joe Dietrich represent the Environmental and Fisheries Sciences (EFS) Division at the HMSC and are part of the Ecotoxicology Program. Their research focuses on the influence of environmental stressors (e.g. pollution, infectious diseases and the hydropower system) on fish health. They have just recently compiled two book chapters reviewing the literature that examines the effects of two prevalent pollutants, polycyclic aromatic hydrocarbons (PAHs; Myers et al. in press) and persistent organic pollutants (POPs; Johnson et al. in press), on fish health. Previous research by EFS scientists and collaborators has shown that exposure to environmental stressors can lead to a suppressed immune system and to an increase in disease susceptibility in juvenile fish. However, little is currently known regarding the extent and relative significance of altered immune function or delayed-disease induced mortalities associated with stressors on the structure and fitness of host populations and communities. In an attempt to examine the relationships between environmental stressors, individual health and population risk, their studies have followed the framework proposed by the U.S Environmental Protection Agency for ecological risk assessment. Once a hazard is identified, the ecological risk assessment framework follows a three step process: (1) exposure assessment or field studies to determine how much of the stressor the fish is exposed to, (2) dose-response assessment or laboratory studies to determine if altered health is observed in salmon after exposure to the stressor, and ultimately (3) risk characterization, or determining what the extra risk is to salmon populations exposed

to the stressor.

NOAA’s Marine Aquaculture Policy states that “aquaculture is an important component of NOAA’s efforts to maintain healthy and productive marine and coastal ecosystems, protect special marine areas, rebuild overfished wild stocks, restore populations of endangered species, restore and conserve marine and coastal habitat, balance competing uses of the marine environment, create employment and business opportunities in coastal communities, and enable the production of safe and sustainable seafood.” Accordingly, EFS staff at HMSC has initiated studies to examine how to improve the production of two important commercial species, salmon and sablefish (black cod), through immunogenetics and examining the efficacy of vaccination, respectively.

Staff and collaborators from many disciplines are involved with these studies and they include the following: Stacy Stickland, Ahna VanGaest, Alex Krupkin, and Greg Hutchinson from Frank Orth, Dr. Ed Little from USGS Columbia Environmental Research Center, Dr. Larry Curtis and Kathleen O’Malley from Oregon State University, Cameron Sharpe from Oregon Department of Fish & Wildlife, Drs. Nat Scholz, Rick Goetz, William Fairgrieve and Lyndal Johnson, Mark Myers, Sandy O’Neil and Gina Ylitalo from the NOAA’s Northwest Fisheries Science Center EFS Division. Agencies and individuals who funded the projects are Shirley Zylstra and Tory Henderson from the US Forest Service, Scott Hecht and Tony Hawkes from NOAA’s Office of Protected Resources, Michael Cox from US Environmental Protection Agency, David Leonhardt from the Portland District Army Corp of Engineers, and Michael Rust from NOAA’s Office of Aquaculture.

AQUACULTURE: In collaboration with OSU, EFS staff at HMSC is providing technical support to a larger ODFW study that provides a continuing assessment of the potential for developing hatchery Chinook salmon stocks that produce juveniles similar to “wild type” fish. Wild type juvenile Chinook salmon are considered most appropriate for future reintroduction to their historic habitats. EFS staff are examining the disease susceptibility in offspring of hatchery and wild-origin fish to the bacterial pathogen, *Aeromonas salmonicida*. Differences observed in disease susceptibility or resistance may be due to the major histocompatibility complex (MHC). The MHC is a family of genes that encode for MHC I and II molecules that present antigenic material to host immune cells. Earlier studies have observed a correlation between MHC II allelic variation and resistance to *A. salmonicida* in Atlantic salmon, suggesting a relationship between MHC II alleles and Atlantic salmon fitness. Many other immune-relevant genes also contribute to the complexity of immune response and likely affect offspring fitness, but may experience different selection pressures. Given the complexity of the immune response, the disease challenge is an initial first step in determining if introducing wild-origin fish into hatchery programs may contribute to fitness differences within and among populations of hatchery and wild salmon.

Their research has also expanded into examining infectious

diseases of commercially important sablefish and the efficacy of newly developed vaccines against these diseases. Success of the sablefish commercial culture program depends, in part, on the production of large, healthy fish in minimal time. To prevent potential stock losses due to disease, current industry practice involves vaccinating the sablefish before entry into marine netpens and this contributes to additional time in land-based tanks. The vaccines are injected once the sablefish are at least 20 g and can handle the stress of the injection. However, vaccines can also be administered by immersing fish within a bath of the vaccine. The immersion is less stressful, can be administered when fish are a smaller size, and can be less labor intensive. The staff will be examining if an immersion vaccine for sablefish is as efficacious as the currently-used injection vaccine and can be administered prior to the 20 g fish size. Thus, the time in land-based tanks could be reduced and maximum production mass could be achieved earlier.

ENVIRONMENTAL STRESSORS

Sublethal and lethal effects of long-term fire-retardants on ocean- and stream-type Chinook salmon: EFS scientists are investigating products used by the Forest Service for fighting wildland fires; PHOS-CHEK 259F and PHOS-CHEK 95A. Previously, they examined the sub-lethal and lethal (acute toxicity) effects of the fire retardants on stream-type Chinook salmon that were exposed as yearlings during the physiologically stressful time of smoltification, i.e. immediately prior to saltwater entry. The results indicate that sub-lethal exposure adversely affected seawater survival for stream-type Chinook. This adverse effect was observed immediately after exposure to the PHOS-CHEK formulations. This work has recently been published in *Environmental Toxicology & Chemistry* (Dietrich et al. 2013). The permanence or time-to-recovery from sub-lethal effects are currently unknown. Currently, they are determining the acute toxicity of the fire retardants PHOS-CHEK 259F and PHOS-CHEK 95A as well as two additional fire retardants (PHOS-CHEK P100 and D75) on both ocean-type and stream-type Chinook at different stages of their development. In addition, they are investigating the impact of fire retardant exposure on seawater survival and time to recovery in ocean- and stream-type Chinook following sub-lethal exposures to the fire retardants. A principal element of the sub-lethal exposures is the determination of no-effect concentrations of the fire retardants.

The combined effect of temperature stress and pesticide exposure (malathion) on the disease susceptibility of subyearling Chinook salmon: The EFS scientists examined the effect of acute and sub-lethal exposure of the pesticide, malathion, on subyearling Chinook salmon that have experienced a temperature stress. Although temperature stress has been shown to increase the acute toxicity of malathion in Bluegills, the effect of temperature stress on either acute or sub-lethal toxicity of malathion to juvenile Chinook salmon was currently unknown. They found that malathion was significantly more acutely toxic to sub-yearling Chinook salmon when exposure occurred at a higher temperature. Since pesticides are generally applied in the summer months, the likelihood of both stressors (malathion

and temperature) occurring concurrently is realistic. Sub-yearling Chinook salmon exposed to a sub-lethal concentration of malathion at a higher temperature had about a 10% increase in disease susceptibility relative to fish exposed to malathion at a lower temperature. However at 11°C, disease susceptibility was independent of malathion exposure. This research has been coordinated through NOAA's Office of Protected Resources. This work has been submitted to *Environmental Health Perspectives* for publication.

Fish Ecology Division (FE)

Dan Bottom, Richard Brodeur, William Peterson, and Tom Wainwright

Fish Ecology Division staff in Newport are part of the NWFSC's Estuarine and Ocean Ecology Program, led by Dr. Kurt Fresh (NWFSC, Seattle). Research programs involve extensive collaboration with scientists from other NWFSC laboratories as well as the NOAA Alaska and Southwest Fisheries Science Centers, Oregon State University, Oregon Graduate Institute, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, University of Washington, Canadian Department of Fisheries and Oceans, University of California at Santa Cruz, Woods Hole Oceanographic Institute and University of Maryland.

Affiliated scientists:

Cooperative Institute for Marine Resources Studies (CIMRS): Senior Research Assistants: Leah Feinberg, Cheryl Morgan and Tracy Shaw

Research Assistants: Toby Auth, Jason Phillips, Tristan Britt, Andrew Claxton, Elizabeth Daly, Jennifer Fisher, Alyssa Hopkins, Jesse Lamb, Jennifer Menkel and Mary Beth Rew

Research Associates: Dr. Jay Peterson and Dr. Jim Ruzicka

Oregon State University Graduate Students: Marisa Litz and James Losee

Visiting Scholars: Dr. Toru Kobari, Fisheries Biology and oceanography, Faculty of Fisheries, Kagoshima University, Japan; Dr. Kelly Robinson, University of Southern Mississippi, Drs. Jun Shoji and Yasu Kamimura, Hiroshima University, Japan.

FE Division staff is involved in a number of basic and applied research programs in coastal and estuarine areas of the Pacific Northwest:

Columbia River Plume Study: Ocean conditions and juvenile salmonids: This project, funded by the Bonneville Power Administration and NOAA and involving researchers from NOAA, OSU, and Oregon Health and Sciences University, focuses on the interactions and ecological linkages within and between the California Current, the Columbia River plume, and coastal upwelling to investigate the effects of the plume and ocean conditions on the distribution, abundance, stock composition, growth, and survival of juvenile salmonids.

Ultimately, this ecosystem-based research (described in more detail below) will be applied to management of fish stocks off the Oregon coast.

A main effort of this project examines the correlation between salmon growth and survival and the unique physical and biological characteristics of the continental shelf waters off Washington and Oregon. As part of this study, scientists are collecting information on the distribution and abundance of salmon and other species in the upper water column, both in the Columbia River plume and in coastal waters. These data will be related to ocean conditions and compared to data collected in the 1980s. Scientists are measuring salmonid growth, condition, pathogen load, food habits, parasites, and prey fields and relating them to ocean conditions. There are many scientists who have been involved with these studies this past year including Bill Peterson, Ric Brodeur, Jim Ruzicka, Kym Jacobson, Cheryl Morgan, Jesse Lamb, Marisa Litz, Mary Beth Rew, Elizabeth Daly and Tom Wainwright. The ultimate goal of these studies is to determine whether the plume represents a favorable feeding location for juvenile salmon. Ongoing studies are looking beyond actual prey availability to examine prey quality using lipid and fatty acid composition and caloric content.

James Losee and Kym Jacobson have been using parasites transmitted through the diet of juvenile salmon to provide information on the trophic interactions and habitat use of salmon beyond the 24 h window allowed by stomach content analysis. They found that several metrics of salmon growth and health were highest among salmon with high parasite species richness. This indicates that a diverse diet in both the freshwater and marine environments is important to growth of coho and Chinook salmon. In addition, Losee and Jacobson found that the marine parasite communities of juvenile coho and Chinook salmon are correlated with variability in local and basin scale indices of ocean climate as well as indices of copepod community composition on the shelf. These findings reinforced the hypothesis that variability in ocean conditions and zooplankton composition alter the prey of yearling coho and Chinook salmon during early marine residency. Jacobson, Andrew Claxton, and Losee have also been studying a model system for using trophically transmitted parasites to identify hatchery vs. naturally-produced juvenile salmon. The first river system of coho salmon studied in Washington state show clear differences and offer strong support for this technique as a tool for other systems.

The project also includes collaborations on otolith analysis (Jessica Miller, HMSC), genetics (NWFSC, Seattle), and biochemical analysis of growth rates (NWFSC, Seattle).

Long Term Coastal Monitoring: This research program involves euphausiid, copepod, and ichthyoplankton studies, as well as ecological indices. A research program, under the leadership of Bill Peterson involves at-sea sampling 2–3 times per month at stations from 1 to 25 miles west of Newport (a.k.a. the Newport Line). 2013 marks the 18th year of these efforts. At each station, Jay Peterson, Tracy Shaw, and Jennifer Fisher measure temperature, chlorophyll, salinity, and dissolved oxygen

profiles and collect samples for later analysis of nutrients, phytoplankton, zooplankton, meroplankton and ichthyoplankton. Shaw and Leah Feinberg are analyzing data from the time series to determine factors that control euphausiid recruitment in the Oregon upwelling zone. Bill Peterson continues to measure egg production rates of the copepod *Calanus marshallae* collected during these cruises to test the hypothesis that cold ocean conditions are more productive than warm ocean conditions, using copepod egg production as an index of coastal productivity.

Long-term coastal monitoring provides valuable information on the range of environmental variability in the northern California Current and the potential impacts of this variability on key species. FE scientists found that from 1996–1998 zooplankton biomass was low and there was a high incidence of subtropical species in coastal waters. Euphausiids (commonly known as ‘krill’), a key forage item for rockfish, salmon, Pacific whiting, seabirds, and whales, were low in numbers and spawned only once per year, in late summer. Beginning in 1999, commensurate with cool ocean conditions, zooplankton biomass began to increase and euphausiids spawned from April through September. From late 2002 through 2007, the ocean warmed, productivity declined and copepod biodiversity increased to levels approaching those of the El Niño events (1983 and 1997/1998). The summer of 2005 was particularly unusual in the northern California Current as a perturbation of the normal climate forcing delayed the onset of coastal upwelling season, which led to a collapse of the food chain and high death rates of many fishes (including salmon) and seabirds. Cool ocean conditions returned in 2007 and persisted through mid-2009, after which a small but significant El Niño resulted in another period of warm ocean conditions. Cool conditions returned to the California Current in 2010 and have remained cool into 2013.

The program is now in its 13th year of sampling adult euphausiids. Data from preserved samples suggest that euphausiid biomass has been reasonably stable off the Oregon Coast during this time period. This suggests that the environmental variability during this time period is within the tolerance range of the local euphausiid species. Laboratory studies of living zooplankton continue to be a key focus of the euphausiid research program, including measurements of euphausiid brood sizes, molting rates, and feeding rates using live animals that are collected during each cruise. This work is carried out by Leah Feinberg, Tracy Shaw, and Jennifer Menkel. Shaw continues to conduct experiments on euphausiid vital rates, and participated in a Korean research cruise in the Yellow Sea in April 2013 to teach Korean scientists how to conduct euphausiid feeding experiments. Lipid analysis of copepods, the mixed zooplankton community, and the seston have been carried out in conjunction with Jessica Miller’s lab since June 2012.

Bill Peterson, Cheryl Morgan, and Jennifer Fisher continued analysis of historic zooplankton data sets to describe long-term changes in hydrographic conditions and zooplankton abundance off the Oregon Coast. Recent analysis of these data show a high correlation between coho salmon survival and zooplankton species and copepod community composition: when waters

off Newport are dominated by species with subarctic Pacific (cold water) affinities, salmon growth and survival is high, but when the zooplankton community has anomalously high concentrations of warm water species, salmon do poorly. Changes in the sign of the Pacific Decadal Oscillation (PDO) clearly manifest themselves in Oregon waters, but with varying time lags: water temperatures lag the PDO by several months, changes in copepod biodiversity lag the PDO by 4–6 months, but changes in copepod biomass lag the PDO by two years. Similarly, the response of forage fish abundances and juvenile salmon abundance lag a change in PDO by 1–2 years.

We have improved our methods of calculating biomass by using length-based biomass estimates for *Calanus* spp. and *Pseudocalanus* spp. which is a vast improvement over standardized biomass estimates using stage-specific weight constants. These new estimates will be used by a group of interdisciplinary and inter-agency scientists to evaluate how the copepod biomass and community data relate to upper trophic levels including salmon returns, pacific whiting abundance, and seabird success.

Dr. Toru Kobari, from the department of Fisheries Biology and Oceanography, Faculty of Fisheries, Kagoshima University, Japan visited the Peterson lab as part of his sabbatical from May–Sept. 2012. His research focused on the role zooplankton play in the transfer of primary production to higher trophic levels in marine ecosystems. In the past two decades, the quantitative evaluation of the energy flow has been emphasized to better understand how marine ecosystems respond to climate change and global warming. To date, primary production can be globally estimated with remote sensing techniques and validated with *in situ* experiments. Although secondary production has been estimated with various methods (natural cohort, artificial cohort, molting rate, egg production, nucleic acids ratio, enzyme activity and empirical models), there is little information on which method is relevant for the natural zooplankton population or community. Dr. Kobari worked with members of the Peterson lab to compare copepod and euphausiid egg production rates obtained from *in situ* measurements versus those obtained from nucleic acid ratios from samples collected at two stations along the Newport line.

Meroplankton Studies: Jennifer Fisher identified and enumerated crab larvae from a 13 year time series of samples collected along the Newport Hydrographic line from stations located 1 and 5 miles from shore. Larval densities and the community structure were correlated with physical oceanographic variables to determine the factors influencing the larval crab community. Although these years exhibited differences in oceanographic forcing including the phase of PDO, upwelling intensity and the timing of the spring transition, there was little change in larval density or in the structure of the larval community over this 13 year period. We also showed that most species of crustaceans are retained nearshore across years regardless of changing oceanographic conditions. Fisher, Bill Peterson and Hal Batchelder (OSU CEOAS) are currently working on a project funded by the Oregon Sea Grant

to investigate the realized and potential larval connectivity of crustaceans along the Oregon coast. This project is in the first year and preliminary results are expected this winter.

Ecological Indicators: Bill Peterson, Jay Peterson, Cheryl Morgan and Jennifer Fisher recently updated a report, “Ocean conditions and salmon survival in the northern California Current off the coasts of Oregon and Washington: taking an ecosystem approach to salmon management” that is published on the web. This report includes 15 indicators of ocean conditions in the northern California Current and shows how they are used to forecast returns of coho and Chinook salmon. This web-page, maintained by the Northwest Fisheries Science Center, provides forecasts of salmon survival and salmon returns, using large-scale indices (PDO and El Niño Southern Oscillation), local physical measurements (water temperature and salinity; date of spring transition, upwelling strength) and local biological indicators (biomass of cold-water and warm-water copepods, copepod biodiversity, copepod community composition, date of biological spring transition, and catches of juvenile Chinook (in June) and coho (in September) salmon during the BPA surveys discussed above). The webpage is updated twice annually with a mid-year section on current ocean conditions as of June of each year. We are also working with Brian Burke (NWFSC/FE) on a more quantitative analysis of these ocean indicators to forecast salmon returns using multivariate statistical techniques, including principal components analysis (PCA). This analysis has provided a stronger fit, and the forecasted adult returns of all three salmon species using this technique corresponds well with the actual returns. A summary of these indices can be found at <http://www.nwfsc.noaa.gov> and click on “Salmon Forecasts.”

Ichthyoplankton Studies: Ric Brodeur and Toby Auth examined ichthyoplankton samples collected by the Peterson lab along the Newport Line to investigate seasonal and interannual variability in fish recruitment. The data from the last decade of sampling have been added to a historical database to examine long-term trends in ichthyoplankton abundance. Long-term changes have been established in ichthyoplankton densities, diversities, and dominant species in relation to regional and local environmental forcing factors using Generalized Additive Modeling. The dominant ichthyoplankton species have been examined using a life history approach to determine resilience and risk to overfishing. They have been working with Jay Peterson to document changes in the ichthyoplankton community associated with the 2010 El Niño and subsequent La Niña. Larvae collected along the central Oregon to northern California coasts during the El Niño period of 2010 were more abundant, had far more coastal distributions, and greater concentrations of offshore taxa found nearshore, than prior to 2010 or during the La Niña period of 2011. Auth and Brodeur completed a review of ichthyoplankton studies conducted in the Northern California Current since the 1940s which will come out in CalCOFI reports in 2013. Another project funded by the Fisheries and the Environment Program examined the relationship between winter larval fish biomass and salmon survival the following summer to provide an early indicator of

salmon recruitment. Results show that the larval fish biomass in winter is strongly correlated with juvenile salmon survival in the following May. Combining the interannual biomass of prey resources available after spring transition could potentially improve the predictive ability of the index to predict salmon marine survival and this index has been added to the ecological indicators web page.

Juvenile Marine Fish Studies: Bob Emmett (NWFSC, Hammond) and Ric Brodeur lead a study initiated in 2004 to examine seasonal variation in abundances of juvenile fishes, including rockfish. This project has been funded by NOAA's Stock Assessment Improvement Program and examines fishery independent catch rates as an indication of relative success or failure of commercially important fish species off the Oregon Coast. Cruises are conducted monthly off Newport, Heceta Head, the Columbia River, and Willapa Bay. Toby Auth, Tristan Britt, and Andrew Claiborne conduct the sampling and process the biological and physical data. Surveys since 2004 (five each year) have found high numbers of juvenile rockfishes, but also found many juvenile hake and jack mackerel, species not known to spawn off Oregon. This project completed its last field season in the summer of 2012. Brodeur and collaborators are using genetically identified juvenile rockfishes to examine their diets both visually and by the use of stable carbon and nitrogen isotope ratios. Several surveys and the diets of piscivorous predators suggest that the 2011 year class of rockfish was relatively weak compared to other years the past decade but other juvenile fishes such as arrowtooth flounder increased that year. We examined the predation potential of large predatory Humboldt squid on the ecosystem using stable isotope analysis and isotope mixing models. We completed a coastwide prerecruit survey in the summer of 2013 to examine large-scale (Southern Washington to Central California) indices of fish recruitment. Preliminary results suggest that 2013 was a strong recruitment year for juvenile rockfishes, but a relatively weak one for flatfishes and Pacific whiting north of Cape Mendocino compared to previous years.

GLOBEC Investigations: The US GLOBEC Program was initiated in the 1990s as part of an international effort to understand global ocean ecosystem dynamics. FE Division has actively participated in the GLOBEC Northeast Pacific Program and in regional and global synthesis phases of the program. The program is in its final wrap-up phase, with continued work in four studies: 1) synthesis of salmonid studies, including distribution and abundance, trophodynamics and diseases and parasite studies, along with determination of habitat requirements of juvenile salmon, 2) population dynamics of euphausiids, 3) synthesis of relationships between the Oregon upwelling and other upwelling systems and comparisons between zooplankton dynamics in the Kuroshio and California Currents, and 4) a comparison of end-to-end energy budgets across regions. In the first study, Dr. Hongsheng Bi (Univ. of Maryland) developed statistical models of habitat requirements of juvenile salmonids and, with Bill Peterson, Jesse Lamb and Cheryl Morgan, developed statistical models that predict coho survival based on measurements of water temperature, chlorophyll, and zooplankton biomass and species composition. The third

study involves scientists from Georgia Institute of Technology, University of Maine, Oregon State University, NOAA's Pacific Fisheries Environmental Laboratory in Monterey and NOAA's Geophysical Fluid Dynamics Laboratory at Princeton University. A germane aspect of that study is the demonstration that zooplankton species composition in the northern California Current (NCC) is controlled to a large degree by the types of source waters that feed the NCC. When the PDO is in positive phase, about 40% of the source waters come in from offshore, whereas when the PDO is negative, nearly all of the water enters from the north. The former case brings subtropical (warm-water) species to Oregon, the latter, sub-arctic (cold water) species. Dr. Ryan Rykaczewski (Univ. South Carolina), a visiting scholar with FE Division from mid-June 2011 through mid-October 2011, continues work on the "bifurcation problem" to identify the mechanisms that control the source waters which feed the Northern California Current. Rykaczewski and Bill Peterson are also working on climate change scenarios for the NCC as well as the impacts of ten past El Niño events on zooplankton of the northern California Current. Jim Ruzicka has collaborated with researchers from universities across the U.S. to develop energy-budget food web models aimed at understanding top-down and bottom-up controls of fish production in a variety of marine ecosystems.

Manuscripts have been submitted for a special GLOBEC Synthesis issue of *Oceanography* which will be published in 2013. Bill Peterson is a co-author on several of these manuscripts, including one that investigates climate impacts on animal populations and communities in coastal marine systems (lead author Hal Batchelder) and one that investigates mechanisms of Pacific Ocean climate and ecosystem variability (lead author E. Di Lorenzo). Another GLOBEC synthesis-related manuscript, *Euphausia pacifica* brood sizes: a North Pacific synthesis (lead author Leah Feinberg) was accepted by the *Journal of Plankton Research* in June 2013.

Ecosystem Modeling: Jim Ruzicka and Tom Wainwright have developed a number of models of coastal plankton dynamics and food-web dynamics. Ruzicka continues development of an end-to-end model for the Northern California Current that describes the flow of production through the entire food web, from the input of nutrients to the production of top predators. This model is part of the GLOBEC pan-regional synthesis program (above) and is being used in the comparison of large-scale ecosystem structure and dynamics of the coastal Gulf of Alaska, the Northern California Current, the Southern Ocean, and Georges Bank. It is also being used in comparing coastal management scenarios as part of NOAA's California Current Integrated Ecosystem Assessment (described below). The primary efforts of this project are 1) the development and validation of a data-based end-to-end trophic model; 2) quantification of the propagation of uncertainty through the model; 3) analysis of the model to derive a suite of ecosystem state and process rate metrics for inter-regional and inter-annual comparisons; and 4) use of the model to predict system response to alternate perturbation and physical forcing scenarios. A new project funded this past year aims to examine interactions between jellyfish and forage fish in five

ecosystems heavily impacted by jellyfish including the Northern California Current, Gulf of Mexico and Bering Sea. Ruzicka, Ric Brodeur and visiting scientist Dr. Kelly Robinson are working with an international team of scientists on modeling scenarios.

Harmful Algal Blooms: Bill Peterson was funded by the NOAA Ocean and Human Health Initiative program to conduct work on Harmful Algal Blooms (HAB) in Oregon's coastal waters. Alyssa Hopkins worked on this project through the University of Oregon from March 2011-Dec. 2012. This research has found a high incidence of *Pseudo-nitzschia* in samples collected year-round. They worked closely with members of the HAB groups at the University of Washington and the NWFSC in Seattle, and with HAB scientists from Oregon State University and NOAA's Miami Laboratory. Hopkins enumerated phytoplankton density and species compositions from samples collected along the NH line. She also analyzed these water samples for domoic acid concentration using the ELISA method. Water samples for HPLC analysis were collected at all stations on the NH line from the spring of 2012 through Dec. 2012. These samples are being processed by M. Zirbel at OSU. Standard preservation methods are not adequate to enumerate nanoplankton, but the HPLC method describes the entire phytoplankton community based on their pigment suite. Collection of water samples for pigment analysis is ongoing for two stations on the Newport Hydrographic line, NH05 and NH25.

Radioecological Studies: An interdisciplinary team of scientists from Oregon State University (Jason Phillips and D. Nelville) and NOAA (Ric Brodeur) have examined samples of albacore tuna and other plankton and nekton caught off the west coast of the United States for levels of radiation that can be traced to the Fukushima reactor disaster in Japan in 2011. They found distinct signatures Cesium-134 in albacore that could have originated only from the Fukushima release. The radiation levels in fish analyzed to date are far below anything that would pose a risk to humans who consume the fish, but the findings have revealed new information about where Pacific albacore travel during their migratory lives. Ongoing studies are examining multiple trophic levels (jellyfish to marine mammals) to determine radioactivity levels in the California Current.

Columbia River Estuary Studies: FE and Conservation Biology Division scientists have been regularly sampling the pelagic environment in the lower Columbia River estuary for forage fishes and juvenile salmon. This program is led by Laurie Weitkamp (NWFSC, CB Division) and Kym Jacobson, with assistance from Marisa Litz, Andrew Claiborne, Andrew Claxton, and others. Information generated from this research includes the timing of various stocks of juvenile salmon through the estuary and into the ocean, the size and health of juvenile salmon in the lower estuary, the relative abundance of different forage fish species, length-age frequency distributions, and comparisons to offshore catches of forage fishes. Ultimately this study should identify if estuaries provide a "critical" habitat for a resource (forage fish), which strongly influences salmonid marine survival and the role the lower estuary plays in juvenile salmon life histories.

A team of researchers led by Dan Bottom and supported by funds from the U.S. Army Corps of Engineers has been evaluating the effects of flow management and historic habitat change on juvenile salmon in the Columbia River estuary since 2002. A primary goal of the research is examine the estuary's importance as a rearing area for juvenile salmon and to support ongoing estuary restoration activities that are intended to benefit the recovery of 13 at-risk salmon stocks in the Columbia River basin. The study evaluates fish and prey assemblages within selected tidal wetlands; analyzes historical changes in flow, sediment input, and salmon rearing opportunities throughout the tidal river; and evaluates the effects of habitat change and flow regulation on estuarine food chains supporting juvenile salmon. Kym Jacobson and Andrew Claxton examined parasite communities of juvenile salmon to provide independent indices of juvenile salmon diet, habitat use, and habitat health within the Columbia River estuary. Scientists also use models to compare the relative effects of river modifications and flow regulation on salmon habitat availability and to evaluate the effectiveness of alternative scenarios for restoring estuarine habitat.

In 2010 the NOAA research team secured funding from the U.S. Army Corps of Engineers to expand their research activities into the upper tidal fluvial portion of the estuary, which extends ~233 km from the river mouth to Bonneville Dam. During the first two years of study, a continuous series of bimonthly salmon surveys were completed to determine the genetic stock composition and distribution of juvenile Chinook salmon migrating through the estuary. These results identified key reaches and habitat complexes in the tidal fluvial reaches of the estuary that are utilized by a high diversity of Columbia River salmon stocks. Since 2012, research has focused on salmon use of off-channel habitats between the Willamette River and the Lewis River confluences in the upper estuary. The research team initiated a series of juvenile salmon and prey-resource studies within this region to identify factors that affect salmon habitat opportunities, abundance, life history, and performance (i.e., foraging success, bioenergetics, growth). These results will aid development of estuary restoration strategies to support salmon recovery efforts throughout the Columbia River basin.

Integrated Ecosystem Assessments: Beginning in the winter of 2012, FE Division researchers worked with a team of scientists from Seattle (NWFSC) and the Santa Cruz and La Jolla labs (SWFSC) to develop an Integrated Ecosystem Assessment of the California Current to provide managers with a timely report on the status and trends of the marine ecosystem from the physical oceanography up to the top trophic levels including humans. A suite of indicators will be vetted and tracked over time to understand the way natural and anthropogenic changes affect components individual and collectively. Bill Peterson and Jay Peterson have been providing physical measurements and lower trophic level biological indicators mainly from the Newport Line. Tom Wainwright led efforts to summarize status and trends of salmon stocks and biology and associated risks. Ric Brodeur has worked with scientists from OSU to look at coastal pelagic species and develop community indicators based on our pelagic

fish surveys. Jim Ruzicka is working with NWFSC's Ecosystem Science Program (Seattle) to apply food-web models to marine management scenarios.

Endangered and Threatened Species Recovery: Tom Wainwright serves as a member of NOAA's Oregon Coast Coho Workgroup, where he collaborates with other NWFSC scientists (Pete Lawson, Laurie Weitkamp and Heather Stout, CB Division) and ODFW scientists on applying biological criteria to develop Endangered Species Act (ESA) recovery approaches. Wainwright has also been appointed to NOAA's Eulachon Recovery Team, which is responsible for advising on the development of a recovery plan for southern eulachon, which was listed as a threatened species under the ESA in 2010. As part of that effort, he is applying geospatial statistical models to characterize marine habitat of eulachon, and is synthesizing data on the effects of ocean variability on eulachon population dynamics.

Fishery Resource Analysis and Monitoring Division (FRAM):

Michelle McClure, FRAM Director, Seattle

West Coast Groundfish Observer Program: The West Coast Groundfish Observer Program trains and coordinates observers for commercial fishing vessels operating along the coasts of Washington, Oregon, and California. Fisheries observers sail as biologists aboard commercial fishing boats and are responsible for collecting catch and discard estimates, species composition data, and biological specimens. They also provide crucial data for quota tracking in the catch share fishery.

Since January 2011, the program has managed observer coverage in 11 fisheries, such as nearshore fixed gear fisheries, open access vessels, trawl and fixed gear vessels fishing individual fishing quotas, and trawlers targeting pink shrimp. In contrast to some other fisheries, which have coverage rates between 2% and 30%, the West Coast Groundfish Trawl Catch Share program requires 100% observer coverage. In addition, the Observer program collects biological data for numerous federal and state agencies. Administered through a cooperative agreement between NOAA Fisheries and the Pacific States Marine Fisheries Commission, program staff is stationed in Morro Bay and Eureka, CA; Newport and Astoria, OR; and Seattle, WA. Several staff members are stationed at HMSC, including coastal logistics coordinator B. Alex Perry (left recently); Eric Brasseur, who provides gear and other logistical support; training coordinator Jennifer Cramer; and data debriefers Jason Eibner, Christa Colway, Bo Whiteside, and Toby Mitchell.

To ensure that an ample number of trained observers for the catch share and non-catch share programs are available, the program has conducted three three-week training courses for new observers and four four-day briefings over the past year. The program also provides safety training for FRAM's at-sea survey staff.

Resource Surveys:

Groundfish Bottom Trawl Survey: Each year the West Coast Groundfish Bottom Trawl Survey team conducts the survey along the continental shelf and slope off of the Washington, Oregon, and California coasts. The survey provides annual snapshots of groundfish stock, including changes in relative abundance and distribution as well as a look at groundfish stocks over time. Several members of the survey team are stationed at the HMSC: biologists Keith Bosley, John Buchanan, Aaron Chappell, Dan Kamikawa, Doug Draper, and Peter Frey, who transferred to Seattle in early 2013.

The survey results are critical for fishery managers, who use the information along with other stock-related data to evaluate groundfish status, and ultimately to make decisions on the continued viability of the fishery, such as the setting of catch shares, bycatch levels, and protected habitats.

The survey uses chartered fishing vessels from the West Coast commercial fishing industry. This approach takes advantage of the skills of fishing captains familiar with the challenges of fishing in the waters off the West Coast and fulfills the cooperative research provisions of the Magnuson-Stevens Sustainable Fisheries Act. Newport-based fishing vessels *Ms. Julie*, *Noah's Ark*, and *Excalibur* conducted the 2012 survey. That survey began with the annual at-sea safety training and orientation at HMSC.

Utilizing a stratified random site selection design with stations from 55 meters to 1,280 meters in depth, the 2012 Survey sampled 758 stations with 701 successful tows. Catches were sorted to species, aggregate or other appropriate taxonomic level and then weighed using an electronic, motion compensated scale. More than 600 distinct fish and invertebrate species (or groups) were identified within the survey area. Biological sampling included determination of sex as well as collection of lengths, weights, otoliths, maturities and stomachs. Summaries indicate that 24,782 individual weights and 91,162 length measurements were taken for fish and 902 individual weights and 973 carapace widths were taken for crabs. Gender was recorded for 846,166 fish specimens and 24,746 otoliths or age structures were collected. Gender was also recorded for 970 crab specimens.

The 2013 groundfish survey is currently underway and will conclude in late October. It also began with at-sea safety training and orientation at the HMSC in May. The fishing vessels *Noah's Ark* and *Last Straw* embarked upon the first pass of the survey, while the *Excalibur* will conclude the survey with a single pass in late October. In addition to FRAM survey members and scientists, graduate students from Oregon State University and biologists from the Oregon Department of Fish and Wildlife are participating in the 2013 annual bottom trawl survey.

Integrated Hake Acoustics Survey: FRAM's Fisheries Engineering and Acoustic Technologies (FEAT) team conducts the joint U.S.-Canada integrated acoustic and trawl survey of Pacific hake. Covering the area from San Diego up to Canada, this annual survey is the primary data source for the U.S.-Canada

Pacific hake stock assessment.

Due to both stock uncertainty and recommendations from members of the International Hake Treaty, an extra hake survey was done in 2012; assessments in back-to-back years are atypical and present no small number of logistical challenges. This additional survey was made possible by partnering with the Southwest Fisheries Science Center's biannual sardine survey, making it the first Joint Pacific Hake-Sardine Integrated Acoustic-Trawl Survey. A total of 116 midwater trawls and 118 transects covering a linear distance of 4,621 nautical miles were done for the hake biomass estimate.

In addition, the FEAT team carries out post-cruise analyses of the collected data. The scientific team in Newport includes scientists Julia Clemons, Alicia Billings, Doug Draper, Cassandra Whiteside, Eric Brasseur, and Dan Kamikawa.

As a result of the added survey, fishery managers more than doubled the overall catch share for hake, greatly increasing the value of the hake fishery and its economic impact. Validating the success of the first joint survey, another hake/sardine survey is underway in 2013. This year's Joint Hake-Sardine Survey began in June and will run through August aboard the *Bell M. Shimada* and the *Forum Star*, which was donated by the fishing industry.

Both surveys (Hake and Sardine) use similar acoustics technology to detect schools of fish: fishing or sampling to confirm the acoustic signal and species. The ground truthing (fishing or sampling to confirm the acoustic signal and species) for hake takes place during daytime midwater trawling; for sardine, the ground truthing takes place at night with a pelagic trawl.

Conventional narrow-band, split-beam technology is used in the acoustic survey. Acoustic transducers mounted on a retractable centerboard at the bottom of the NOAA Ship, *Bell M. Shimada* collect acoustic data on hake, and the biomass estimates are then verified by trawl catches. An echo-integration technique, based on the linearity principle, is used to relate acoustic intensity with the number of fish in the sample volume.

The FEAT team investigates other advanced sampling technologies on an ongoing basis, such as AUVs and multi-beam technology that provides a larger sample volume and broadband technology that delivers a much wider spectrum, higher spatial and temporal resolutions, and a significantly improved signal-to-noise ratio. They work to develop new sampling devices that are non-extractive and which integrate both acoustic and optic information on fish distributions.

Population Ecology Program: In support of FRAM's lead federal responsibility for stock assessments of Pacific coast groundfish, the Population Ecology program plays a key role in compiling stock assessments and then inserting the findings into the federal fishery management process. Three members of the program are stationed at the HMSC: Andi Stephens, stock assessment analyst; Stacey Miller, stock assessment coordinator; and Curt Whitmire, information technology specialist.

In general, stock assessments estimate productivity, current status, and allowable catch levels for Pacific coast groundfish resources, along with past and near-future trends in abundance. For species that have been declared overfished, staff members conduct rebuilding analyses, which involve projecting the status of resources into the future under a variety of alternative harvest strategies. These analyses provide information to policymakers about the tradeoffs between levels of catch and the length of time needed to rebuild these species. The assessment and rebuilding data are peer-reviewed and provide the scientific basis for the management of the groundfish fisheries off the U.S. West Coast, including the setting of Overfishing Limits (OFLs) and Allowable Biological Catches (ABCs), as mandated by the Magnuson-Stevens Act and its subsequent amendments.

During 2012, a benchmark, or full, assessment of Pacific hake was conducted; this was the first time such a review was done under the terms of an international agreement with Canada which governs the science and management of the stock.

Owing to the Pacific Fishery Management Council's (PFMC) biennial assessment review cycle, 2012 also provided the Population Ecology program an opportunity to make progress on a variety of research projects that improve fishery science and management. These projects included efforts to increase the efficiency and accuracy with which assessment inputs are assembled and processed, to develop and test new methods for coping with and describing uncertainty in stock assessments, and to prepare contributions to broader analyses for the PFMC, such as Integrated Ecosystem Assessments and the review of the Essential Fish Habitat.

Preparations were also begun for assessments scheduled for 2013, including full assessments for Pacific hake, petrale sole, darkblotched rockfish, rougheye rockfish, aurora rockfish, and shortspine and longspine thornyheads. In addition to these assessments, a new approach to conducting more-streamlined assessments (referred to as 'data-moderate') will be attempted for several species, including the previously unassessed rex sole and sharpchin rockfish.

In addition to their stock assessment work, Population Ecology members at HMSC participated in a wide variety of research projects. They collaborated with analysts from OSU and the Southwest Fisheries Science Center to create a multispecies, bio-economic model for evaluating management tradeoffs, and with social scientists from other Northwest Fisheries Science Center (NWFSC) divisions on the development of social vulnerability indicators for West Coast fishing communities. They lead and contributed to OSU and HMSC courses on the Stock Synthesis assessment software and the R programming language. While collaborating on a coupled population-habitat model of Coho salmon with scientists from the Conservation Biology Division, they improved techniques for portraying fishery-related data, particularly confidential, in spatially-explicit ways. They also contributed to national coral reports and stock assessment reporting, supporting efforts to evaluate the ability of advanced sampling technologies (e.g., autonomous underwater vehicles,

remotely-operated vehicles) to measure habitat-specific densities of various demersal fishes.

Cooperative Fish Ageing Project (CAP): The Cooperative Ageing Project (CAP) provides direct support for U.S. West Coast groundfish stock assessments by providing ages derived primarily from otoliths, fish ear bones that can be read in much the same way as tree rings. Pacific coast groundfish, particularly rockfish, can live to be more than 100 years old. These long-lived species commonly reach their maximum length within the first 20-30% of their maximum lifespan, which can limit the usefulness of individual fish length data. While otoliths (and other ageing structures) are more difficult to collect and read, they yield accurate age readings, which are critical for understanding rates of fish growth, year-class strength, and the vulnerability of segments of each stock to fisheries and survey monitoring.

Housed at HMSC, the project is funded by FRAM through a grant to the Pacific States Marine Fisheries Commission. The CAP team routinely provides 20,000 to 30,000 ages annually. Ageing specialists located at the HMSC include Patrick McDonald (leader), Nikki Atkins, Brooke Higgins, Tyler Johnson, Betty Kamikawa, Lance Sullivan, and Cassandra Whiteside. During 2012, the CAP team provided ages for several species being assessed in 2013, including Pacific hake, petrale sole, darkblotched rockfish, rougheye rockfish, and aurora rockfish.

Although the complete list of species to be assessed for the Pacific Fishery Management Council in 2013 will not be finalized until September, work is already underway to insure that age determinations will be ready for those species that have been identified.

In addition to routine ageing efforts, ageing specialists participate in FRAM-directed surveys and collaborate with stock assessment scientists and staff from other ageing labs to improve current ageing methods, evaluate alternate ageing approaches, and better understand uncertainty associated with age determination. The CAP team continues to work with NWFSC assessment scientists to investigate rapid age determination methods using otolith morphometrics. Possible benefits of this method should include faster and more precise ageing with no reduction in accuracy, thus decreasing subjective analysis. It is now part of our practice to weigh all otoliths before they are aged. Additionally, the CAP team continued to provide age data for vermillion and sunset rockfish caught from FRAM's Southern California Shelf Rockfish Hook and Line Survey. The ages will provide information to compare growth between the two stocks and shed light on potential biological differences that may support managing the stocks separately.

Marine Habitat Ecology: The Marine Habitat Ecology (MHE) team of Waldo Wakefield along with Mark Lomeli and Matthew Yergey (collaborators from the Pacific States Marine Fisheries Commission) is responsible for conducting fish habitat studies off the U.S. West Coast. Located at HMSC, the team works with agency scientists, academic scientists, and the fishing industry to

develop and evaluate fishing gear modifications that reduce the impacts of fishing on bycatch species and marine habitats. Over the last year, the MHE team has been working with a team of NW and SW Fisheries Science Center scientists, scientists and managers from academia, the NOAA Fisheries Regional Offices, and the Pacific Fishery Management Council in support of the Council's required periodic review of Essential Fish Habitat (EFH) for the 91 species of Pacific coast groundfishes managed under the groundfish fisheries management plan.

The previous 5-year review of EFH, based on data from 2002 to 2005, was approved in May 2006; the current 5-year review was initiated in 2010. New information was evaluated for potential modifications of current EFH designations. Sources of information included published scientific literature and unpublished scientific reports; solicitation of data from interested parties; and the review of previously unavailable or inaccessible data sets. Coast-wide maps were updated for (1) bathymetry and interpreted groundfish habitat types; (2) the distribution and extent of groundfish fishing effort (as potential impact to EFH); (3) the distribution and relative abundance of biogenic habitat (i.e., sponges and corals); and (4) spatial management boundaries (as potential mitigation of impacts). The Essential Fish Habitat Review Committee Phase 1 Report was presented to the PFMC, its advisory bodies, and the public, at the Council's September 2012 meeting, where it was adopted by the Council.

In April 2013, FRAM delivered a Groundfish Essential Fish Habitat Synthesis Report to the Council; this report provides summaries and characterizations of the information included in the Phase 1 Report. The Synthesis Report distills the large volume of data in the Phase 1 Report into a format that will help the Council and its stakeholders use the data effectively when considering revisions to current EFH designations. This 5-year review represents a major update of the groundfish habitat assessment for the California Current and will have research and management applications well beyond satisfying the regulatory guidelines associated with EFH.

In collaboration with the Pacific States Marine Fisheries Commission, the MHE team is conducting a fishing vessel-based survey of young-of-year groundfishes along the Newport Hydrographic Line, a long term cross shelf sampling line off of Newport, OR. The NWFSC's comprehensive groundfish bottom trawl survey was not designed to quantitatively sample the young-of-the-year (YOY) life history stage. The project, begun in 2012, examines the distribution, abundance, and behavior of this critical life-history stage of these ecologically and commercially important species with respect to seasonality and across a depth gradient. This research is important for several reasons: the study area may act as nursery habitat for a variety of juvenile groundfish species, the area has seen an increase in periods of low dissolved oxygen over the past 50 years, and the area is a test site for alternative energy development.

This work addresses gaps in year class strength in stock assessments, increases the understanding of impacts of increasing hypoxia on these vulnerable early life history stage fish, and acts as a baseline in marine spatial planning. The project benefits

significantly from collaboration of the local fishing industry, which provides outreach opportunities concerning the early life stages of commercially important groundfishes and their habitats. Sampling is conducted biweekly from May to September with monthly sampling during fall and winter, as close as possible in time to ongoing NWFSC zooplankton and ichthyoplankton surveys. Juvenile are collected with a 2-m wide x 0.5-m high video beam trawl system and then flash frozen. A high-definition video camera system equipped with scaling lasers provides a video image of the seafloor and associated fauna. This project is part of ongoing collaborations with Dr. Lorenzo Ciannelli's lab in the College of Earth, Ocean and Atmospheric Sciences at Oregon State University on the effects hypoxia on juvenile groundfishes.

In another key regional collaboration with the Pacific States Marine Fisheries Commission, Oregon Department of Fish and Wildlife, Alaska Fisheries Science Center, and the fishing industry, the NWFSC has been able to pursue an array of conservation engineering projects that are relevant to goals of reducing bycatch and habitat impacts from mobile fishing gear in the West Coast groundfish trawl fishery. In the past two years, these projects include: 1) reducing Chinook salmon, rockfish, and Pacific halibut bycatch in the West Coast groundfish fisheries by using bycatch reduction devices; 2) reducing bycatch in the ocean shrimp fishery (juvenile groundfishes, ESA listed eulachon, megafaunal invertebrates); 3) providing loaner video camera systems to the fishing industry; and 4) examining selectivity characteristics of codends that differ in mesh size and configuration in the bottom trawl fishery.

Much of MHE's current work has been in response to concerns within the fishing industry over IBQ (Individual Bycatch Quotas) for Pacific halibut allocated in the Pacific coast Groundfish Trawl Rationalization Catch Share Program, which began in 2011, (through amendments to the Groundfish Fisheries Management Plan) established formal Annual Catch Limits (ACLs) and individual catch share quotas. It has been projected that these complex fishery management measures will create increased demand for bycatch solutions in the groundfish trawl fishery. In addition to ACLs, fishing opportunities may also be limited by hard caps or IBQs for non-groundfish species (e.g., ESA Chinook salmon in the Pacific hake fishery and Pacific halibut in the bottom trawl fishery). Bycatch of overfished species in the West Coast groundfish trawl fishery has the potential to constrain the fishery such that a substantial portion of available harvest may be left in the ocean.

Learn more about FRAM (Fishery Resource and Analysis Monitoring), visit us at www.nwfsc.noaa.gov/research/divisions/fram.

Oceanic and Atmospheric Research Division
Pacific Marine Environmental Laboratory (PMEL)
Acoustics Program
Bob Dziak, Director

In May of 2013, the NOAA/PMEL Vents Program was re-

organized into two separate programs: Earth-Ocean Interactions and Acoustics. Dr. Bill Chadwick was named Director of Earth-Ocean Interactions, and Dr. Bob Dziak was named Director of Acoustics. The reason for this change was to allow each group's management to independently focus on executing their program's mission, pursuing partnerships and funding opportunities, and overseeing resource allocation. PMEL provides administrative, engineering and computer services support for both programs. The Acoustics Program performs marine acoustics research and develops marine acoustic technology in support of NOAA's long term goals of healthy oceans and resilient coastal communities and economies. By coordinating with other federal agencies, academic institutions and international researchers the Acoustics Program leverages the knowledge and skillsets of partners to efficiently meet its mission objectives and contribute to the larger community. The Acoustics Program's primary goals are:

1. To acquire long-term data sets of the global ocean acoustics environment
2. To identify and assess acoustic impacts from human activities and natural processes on the marine environment
3. To develop "Next Generation" acoustic tools, techniques, and technology and propagate them from research to operations

The Acoustics Program HMSC staff within OSU's Cooperative Institute for Marine Resources Studies (CIMRS) includes PIs Bob Dziak, Joe Haxel, Holger Klinck, Haru Matsumoto and Dave Mellinger. The research support staff includes both federal and CIMRS employees, Andra Bobbitt, Matt Fowler, Sara Heimlich, Jonathan Klay, Vicky Krutzikowsky, Andy Lau, Sharon Nieukirk, Anna Semple and Lu Yang.

2012-2013 highlights of Acoustics research endeavors and accomplishments include:

- During a 5-year hydrophone experiment along the Antarctic Peninsula, Acoustics scientists recorded the full life cycle sounds of mega-iceberg A53a—from grounding tremors at its origin to icequakes as it broke apart in the warmer waters of the southern ocean. The acoustic data showed that cryogenic sounds can be significantly louder than anthropogenic noises. Cryogenic noise should be considered a major contributor to the overall ocean noise budget in the southern ocean. These results are detailed in a recent paper published in *Oceanography*. News stories about the study were featured on [KLCC Public Broadcasting](#), [Discovery News](#), [National Geographic](#), [Science Daily](#) and [Voice of America](#).
- Using hydrophone records of volcanic explosion sounds and melt inclusion data, Acoustics scientists were able to produce the first estimate of the yearly amount of carbon dioxide gas emitted from a submarine volcano. Results published in *G-cubed*, show that the 500 m deep volcano NW Rota-1 (located in the Mariana Island group) expels ~0.4 Tgrams of CO₂ per year, or roughly 1% of the global CO₂ contribution from subaerial arc volcanoes.
- Autonomous hydrophones recovered from Fram Strait and Greenland Sea, were analyzed for whale (blue, fin,

sperm, and sei) vocalizations and long-term patterns of anthropogenic ambient noise due to ship traffic and oil exploration (seismic airguns). It was found that noise from ships and oil exploration dominate the Spring and Summer months. However, blue and sperm call detections also peak in Spring and Summer months, whereas fin whale calls peak in the winter when anthropogenic sounds are lowest. Also it was revealed that large numbers of sei whales ranged farther north than previously known. These results were published in the Journal of Acoustical Society of America.

- Work has begun on the Office of Naval Research (ONR) funded Arctic winch project. The winch will be installed on a mooring and provide a way for passive-acoustic sensors to acquire data under the ice. When the surface is “ice free” the winch will extend so that an Iridium satellite connection can be made in order to send data near real-time. The acoustic sensor will feature a low-frequency directional and a broadband omni-directional hydrophone that will enable the study of ambient noise levels, marine mammals, and earth/icequakes. Additionally, the mooring will be equipped with environmental sensors (e.g. CTD, fluorometer) to measure oceanographic profiles in the upper 200 m of the water column. The EcoFOCI program is closely coordinating with the Acoustics program to gather the environmental data. The first long-term deployment is scheduled for the summer of 2015 in the northern Bering Sea.
- Acoustics program scientists and engineers continue development and use of autonomous ocean gliders and other near real-time AUV platforms equipped with sensors for a variety of acoustic monitoring missions. This year there are plans to conduct two experiments to evaluate new technology and techniques. The first experiment is designed to determine the effects sea glider of movement on acoustic sensitivity. Researchers will compare the acoustic data gathered by profiling floats versus acoustic data gathered by sea gliders. The other experiment is threefold: integrate an autonomous surface vehicle with a hydrophone; test the combined system’s efficacy in detecting marine mammals; and understand the abilities and limitations of the autonomous surface vehicle.
- With support from NSF, Acoustics scientists deployed eight autonomous hydrophones in the equatorial Atlantic in 2011-2012. Those hydrophones will be recovered in 2014. The goal of this project is test models of earthquake predictability on Atlantic transform faults as observed at other transform faults in the Pacific. We will also use this hydrophone data to characterize the cetacean populations present at the equatorial Atlantic as well as the level of ambient noise introduced into the ocean by shipping and seismic exploration activity.
- A portable hydrophone deployed near West Mata submarine volcano near Western Samoa was recovered in August 2012. This data will be used to characterize the long-term behavior and outflow of gas from this explosively erupting volcano, as well as the link between explosive activity and large debris flows down the flank of the submarine volcano caused by the eruptions. The results of this study will be presented at the American Geophysical Union meeting in December of 2013.

- A U.S. Department of Energy-supported environmental monitoring plan is in development for baseline characterization of ambient sound levels, including both natural and anthropogenic sources, in support of the Northwest National Marine Renewable Energy Center’s grid-connected South Energy Test Site (SETS). An initial science plan has been presented to regulatory agencies and is awaiting approval prior to passive acoustic mooring deployments and drifting hydrophone recordings at the proposed SETS off South Beach, Oregon.



Acoustic recordings of ambient noise levels were made near the WET-NZ wave energy conversion device (foreground) and OSU’s Northwest National Marine Renewable Energy Center’s Ocean Sentinel (background) mobile ocean test berth platform at the North Energy Test Site (NETS) off Yaquina Head in September 2012.

- The submarine seismic and volcanic state of the entire NE Pacific continues to be monitored by means of unique access to the US Navy’s real-time SOSUS hydrophone arrays. However, several key elements of the array have gone offline since 2007, and the Acoustics group has supplemented the Navy array with deployments of ocean bottom hydrophones (OBH) within the summit caldera of Axial Seamount. On 6 April 2011, Axial Seamount once again erupted and the OBH recorded seismic precursors that can be used to forecast future eruptions. These seismic results were published in *Nature Geosciences* in July 2012 along with two companion papers by EOI scientists that described deformation and mapping of new lava flows. Moreover, several Acoustics program scientists are part of the NSF-sponsored Cascadia Initiative, which is a community-wide project to install 70 ocean bottom seismometers across the Juan de Fuca plate. These data are being used to complement the existing SOSUS coverage.
- Acoustics program researchers are examining SOSUS data and see if a correlation exists between fin whale vocalization behavior and long-term variations in deep ocean ambient sound across the North Pacific from 1991-present. The project, sponsored by the NOAA/NMFS Office of Science and Technology, will use data from PMEL- US Navy SOSUS hydrophone archive. The relationships between fin whale vocalizations and variations in the ambient sound field can be mined from the archived hydrophone data by extracting the time and space variability of deep ocean ambient sound levels (1-125 Hz) and the spatio-temporal distribution and acoustic signature of fin whale vocalization.

The Acoustic program also has a significant marine mammal acoustics focus group, with all program personnel involved at various levels of the work. 2012-2013 highlights include:

- Development of new data-collection platforms and innovative analysis techniques for studying marine mammal species.
- Construction of computational algorithms for detecting and classifying whistles and clicks of odontocete cetaceans (toothed whales, dolphins, and porpoises) using acoustic feature extraction followed by machine learning. This effort was done in collaboration with researchers in the Department of Electrical Engineering and Computer Science at OSU and with researchers at San Diego State University.
- Methods were investigated for estimating the population density of marine mammals from acoustic data off Portugal and Hawaii. This research involved developing high-quality datasets for training and testing these algorithms.
- The group's collaboration with researchers at the University of Washington has led to several deployments of an acoustically-equipped Seaglider™. Data from these deployments were examined for the distribution and dive behavior of cetaceans off the coast of Kona, HI and Andros Island in the Bahamas.
- Several Acoustics (bio-) group personnel participated in the sixth International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics, which was held in June 2013 at St. Andrews, Scotland, and in the semi-annual meetings of the Acoustical Society of America.

Pacific Marine Environmental Laboratory (PMEL) Earth-Ocean Interactions Program

Bill Chadwick, Director

In May 2013, the NOAA/PMEL Vents Program was re-organized into two separate focused programs: (1) Earth-Ocean Interactions and (2) Acoustics. Former Vents Director Steve Hammond retired, Bill Chadwick was named Director of Earth-Ocean Interactions, and Bob Dziak was named Director of Acoustics. The Earth-Ocean Interactions (EOI) program will continue to focus on hydrothermal venting and improving society's understanding of ocean ecosystems, living marine resources, and factors causing oceanic environmental change. The EOI Program staff at HMSC includes Principal Investigators Bill Chadwick (CIMRS), Bob Embley, and John Lupton (NOAA). The EOI research support staff includes Andra Bobbitt, Leigh Evans, and Susan Merle (CIMRS). Ron Greene retired from OSU/CIMRS in June 2013, but will be working part time, and Jonathan Klay (NOAA) continues to provide computer support for both the EOI and Acoustics programs. Additional EOI staff (both federal and cooperative institute) is stationed at PMEL in Seattle.

Highlights of accomplishments by Earth-Ocean Interaction investigators in 2012-2013 include:

- In July 2012, EOI scientists published three companion papers in *Nature Geoscience* about the 2011 eruption at Axial Seamount. The papers describe deformation and seismic monitoring of the eruption as well as high-resolution

mapping of the new lava flows. Both the deformation and seismic data showed long-term and short-term precursors to the 2011 eruption that could be used to forecast future eruptions at Axial Seamount. This is particularly important because Axial will be the site of a cabled observatory, as part of the Ocean Observatories Initiative (OOI) that will make real-time monitoring of the volcano possible for the first time. As part of this effort, EOI scientists have designed and built (with PMEL engineers) some of the instruments that are being deployed and connected to the OOI cabled network, including three Bottom Pressure Recorder/Tilt instruments (being deployed in July 2013).

- Several papers with EOI authors were published in a special issue of *Economic Geology* on mineralization at submarine arc volcanoes. Several of these papers report the results from a joint project with New Zealand (GNS) that used the autonomous underwater vehicle ABE to make the first comprehensive near-bottom survey at an arc volcano (Brothers). The water-column measurements, multibeam bathymetry and magnetic field data collected with ABE showed the relationships between the active venting sites, morphology and deep alteration zones on the caldera's edge and the young post-caldera cone.
- EOI investigators participated in a very successful research cruise to the NE Lau Basin between Fiji and Samoa in September of 2012, funded by the NOAA Ocean Exploration and Research Program. This expedition on the R/V *Revelle* used the remotely operated vehicle *Quest 4000* from the MARUM Center at the University of Bremen (Germany) to explore new sites of submarine hydrothermal venting and recent volcanism that had been discovered by water column and towed camera surveys in recent years. This was an interdisciplinary, multi-national expedition with scientists from Australia, New Zealand as well as NOAA, Oregon State University, Oregon Health and Science University, The University of Hawaii, the University of Washington and Woods Hole Oceanographic Institution. One of the highlights was the discovery that eruptive activity previously observed at West Mata volcano in 2009 had stopped, and that the seamount had been colonized by ten new species of chemosynthetic organisms, including millions of shrimp. Images and video clips from the expedition can be seen at: <http://oceanexplorer.noaa.gov/explorations/12fire/>



A "bush" of barnacles and other vent animals living near high-temperature hydrothermal vents, living at Mata Ua seamount in the NE Lau Basin.

- The NOAA/PMEL Helium Isotope Laboratory here in Newport has continued work on gases in submarine volcanic rock and water-column samples from a variety of sites around the world. During the September 2012 R/V Revelle expedition to the NE Lau Basin, 20 vent fluid samples were collected from hydrothermal sites using special titanium gas-tight sampling bottles. These samples have since been analyzed for helium, helium isotopes, and neon and other gases (CO₂, methane, hydrogen, etc.). Most recently the helium laboratory completed the analysis of water-column samples collected along a segment of the Pacific Antarctic Ridge south of New Zealand, which is an extension of the East Pacific Rise spreading system. This study was conducted aboard a Korean icebreaker and was designed to search for hydrothermal activity along this remote section of the global mid-ocean ridge system. The analysis detected excess helium-3 in several samples, clearly indicating the presence of hydrothermal activity.

U.S. Department of Agriculture (USDA)

Agricultural Research Service (ARS)

Vacant, Research Geneticist

Brett Dumbauld, Aquaculture Ecologist

The Agricultural Research Service is the federal scientific research agency responsible for solving agricultural problems of national importance and developing solutions to a wide range of problems related to food and agriculture. ARS generally makes long-term commitments of resources to problems unlikely to have solutions with the quick commercial payoffs that would attract private funding. Since 2003, the ARS mission at HMSC has been to work with the shellfish aquaculture industry in the Pacific Northwest region to address issues such as summer mortality in oyster growing areas, to develop genetically improved stocks of commercially important shellfish, and to develop an improved understanding of the ecology of bivalve shellfish aquaculture in the estuarine environment, reduce mortality due to pests, and insure environmentally compatible shellfish culture practices. The USDA supports two research programs at HMSC, a shellfish genetics program led by Mark Camara (until his departure in May 2012) and a shellfish ecology program led by Brett Dumbauld.

The objective of the Shellfish Genetics Program is to employ both traditional quantitative genetics and molecular genetics to gain knowledge that can be used to improve breeding stocks for Pacific Northwest shellfish aquaculture. The program has worked in close collaboration with the Molluscan Broodstock Program (MBP), a USDA-funded oyster breeding program working to improve economically important traits such as growth rate/efficiency, reproduction, survival, disease resistance, and product quality until its recent loss of funding and we hope to continue that collaboration as other industry and state sources are acquired.

This past year, the Shellfish Genetics Program's accomplishments

include:

Estimating the additive genetic, non-additive genetic and environmental covariance matrices for larval and field performance in currently available germplasm of the Pacific oyster using a multi-year animal model approach: Oyster breeding currently relies on lengthy and labor-intensive field trials for selective breeding and focuses entirely on yield during grow-out. This research is designed to incorporate larval performance and product quality into breeding objectives using molecular testing and a rigorous evaluation of the genetic (co) variances of these characters. Washington Sea Grant funding enabled a large breeding experiment to be performed in collaboration with the University of Washington and Taylor Shellfish in order to address the issue of exposure of larval and juvenile oysters to acidified ocean water which is currently one of the most significant threats of global climate change to Pacific oyster production on the US West Coast. Oyster broodstock from nine families were obtained, conditioned and spawned with half of the resulting larvae exposed to elevated carbon dioxide. Larval performance and survival to juvenile seed was assessed and conditions experienced in both parental and larval phase appeared to carry over to the juvenile seed stage. Sub-samples of the surviving progeny are currently being genotyped to determine parentage and assess potential differences in survival due to family, treatment and life history stage.

Identifying genetic markers for economically important traits in Pacific oysters to enable marker assisted selection: Gene mapping experiments were conducted to identify genes that control the expression of previously identified traits related to reproductive effort in Pacific oysters. This research is designed to enable marker-assisted selection to reduce reproductive effort and the associated metabolic disturbances that result from increased temperature and food conditions and contribute to summer mortality in cultured Pacific oysters.

Developing a collaboration with other university researchers to apply "next generation" DNA sequencing and advanced bioinformatics and identify gene expression differences between high-reproductive effort and low-reproductive effort individuals of Pacific oysters: Genes identified by this work will provide candidate genes for subsequent qPCR analysis and QTL mapping, and will be informative for marker-assisted selection. In addition, several pools of larvae, challenged with *Vibrio tubiashii*, a pathogen associated with recent Pacific oyster larval mortality events, were analyzed with next-generation sequencing to identify differential gene expression between treatments as well as potential allele frequency changes before and after treatment.

The Shellfish Ecology Program has two objectives: 1) Develop effective population control strategies for two species of burrowing shrimp (*Neotrypaea californiensis* and *Upogebia pugettensis*) that cause substantial damage to oyster crops in Oregon and Washington and establish protocols for identifying sources of juvenile oyster mortality that constrain aquaculture production in West Coast estuaries. 2) Quantify the spatial extent and follow the trajectory of aquaculture practices on intertidal

estuarine habitats like eelgrass and open mudflat, examine the functional role of these habitats including aquaculture for fish and invertebrates, and assist the shellfish industry in developing farming practices and farm plans that are compatible with the habitat requirements of these species.

This past year, the Shellfish Ecology Program's accomplishments include:

Monitoring burrowing shrimp populations in four coastal estuaries and examining aspects of population dynamics that might be beneficial in designing integrated pest management practices to control them for shellfish aquaculture:

The average density of both mud and ghost shrimp has declined over time and mapping efforts in Yaquina Bay, OR and Willapa Bay, WA suggest that shrimp populations have also declined in size and extent. A collaborative project with Dr. John Chapman at HMSC indicates that increased prevalence of an introduced parasitic bopyrid isopod coincided with the decline in abundance of mud shrimp. These isopods effectively eliminate egg production in infected female shrimp and this reduced reproduction likely contributed to recorded population collapses in many estuaries from Washington to California. Declines in ghost shrimp populations however, cannot be attributed to parasites, so we are tracking annual recruitment to these shrimp populations and its contribution to subsequent year class strength to discern what other factors influence population trends. Recruitment of both shrimp species to Washington estuaries has been low since the mid 1990's, and this correlates directly with population declines there. Substantial recruitment of ghost and mud shrimp occurred to Oregon estuaries in 2010 and 2011 respectively, but not to our long term monitoring sites in Washington estuaries. Recruitment patterns were reversed in 2012 with fairly substantial recruitment of ghost shrimp to Willapa Bay and lower levels in Oregon estuaries. We are tracking survival of these shrimp to estimate their contribution to the population and actively working with the integrated pest management coordinator hired by the shellfish industry to establish an industry program to track shrimp recruitment to Willapa Bay. Although to date we have been unable to directly relate recruitment patterns to ocean conditions, we are actively pursuing this research and it is already clear that the shellfish industry will experience years when it is more critical to control shrimp than others. These results are important because they imply that in addition to finding alternatives to the current use of pesticides to control adult shrimp on shellfish beds in Washington state, a basic understanding of recruitment and the population ecology of burrowing shrimp as pests is essential to meeting the goal of integrated pest management on aquaculture beds.

Developing a standard tool to assess juvenile oyster mortality and growth: Shellfish growers report substantial differences in growth and unexplained losses immediately after planting their crops. We collaborated with the MBP program and the Whiskey Creek shellfish hatchery in Netarts, Oregon to have oysters from a high yield MBP family and those from a wild stock set on small ceramic tiles that can be easily photographed and monitored in the field. These tiles were deployed at numerous shellfish

growing sites in Willapa Bay where we observed a gradient in both growth and mortality from the mouth to the head of the estuary and a significant difference between oysters deployed off and on-bottom due to siltation and predation.

Examining the functional role of oyster aquaculture in the estuarine ecosystem: Aerial photography of Willapa Bay, Washington was used to create an intertidal aquatic vegetation GIS layer. Extensive ground-truthing and mapping was conducted to produce burrowing shrimp and sediment layers and improve an existing intertidal bathymetry layer. Interviews with shellfish growers were used to produce a current aquaculture use layer and we also digitized an 1892 map to create a historic native oyster layer for this estuary. An underwater video system and small traps were developed and are being used to track use of these intertidal habitats by fish and invertebrates including juvenile English sole and Dungeness crab which inhabit West Coast estuaries as nurseries during their first year of life. Results suggest that most fish including juvenile English sole, shiner perch, and sculpins are found in greater abundance in structured intertidal habitats (both eelgrass and oyster aquaculture) than in open unstructured mudflat. Abundance is also higher during daytime flood tides. Experiments to examine mortality of juvenile English sole in these three intertidal habitats revealed that predation pressure was high in all three habitats with staghorn sculpin and crabs being the dominant predators. We deployed small shell bags to examine Dungeness crab settlement across the estuarine landscape in 2012 and expanded this survey to also examine use of the introduced seagrass *Zostera japonica* by these crab in both Willapa Bay and Yaquina Bay, Oregon in 2013. Preliminary results suggest that crab settle in greatest abundance and use structured habitats closest to the estuary mouth and at lower tidal elevations closest to channels. Shore crabs (*Hemigrapsus oregonensis* and *H. nudus*) may also limit initial settlement and survival where they are abundant.

U.S. Fish and Wildlife Service

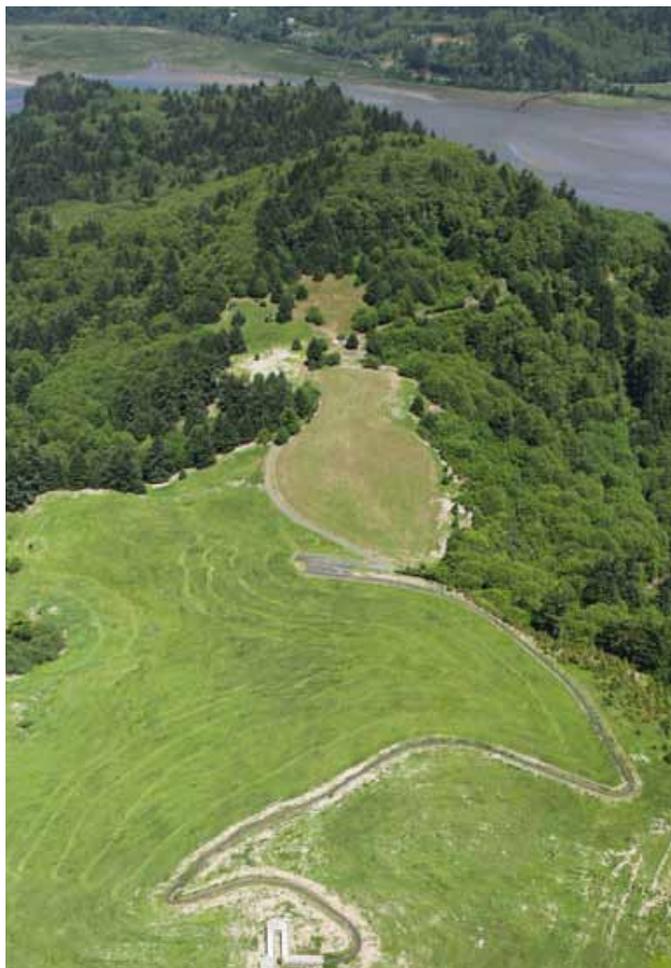
Oregon Coast National Wildlife Refuge Complex

Roy W. Lowe, Project Leader

The Oregon Coastal Field Office supports U.S. Fish and Wildlife Service (USFWS) employees from the National Wildlife Refuge System and the Division of Ecological Services. Oregon Coast National Wildlife Refuge Complex personnel are responsible for operations and management of six National Wildlife Refuges (NWR or Refuge) and two Wilderness Areas spanning the Oregon coastline. The refuges include three estuarine refuges (Bandon Marsh, Nestucca Bay, and Siletz Bay); two marine refuges (Three Arch Rocks and Oregon Islands); and a small old growth forest refuge at Cape Meares. In 2012-13, the Oregon Coast Refuge Complex had nine permanent employees, of which seven were stationed at the HMSC in addition to a temporary Biological Technician, a term Office Clerk and two Environmental Education Interns. Two of the Complex's permanent employees were stationed at the Refuge Complex's South Coast Office in Bandon, along with a term Restoration

Biologist, a Biology Intern, and numerous volunteers. Refuge staff focus primarily on six priorities: 1) land acquisition, 2) habitat management and restoration, 3) biological surveys, 4) monitoring, 5) research, and 6) environmental education and outreach.

The Refuge Complex has an active land acquisition program at Nestucca Bay Refuge. On May 31, 2013, the FWS purchased the 90.10-acre Harder Tract on Cannery Hill, which is now part of Nestucca Bay NWR. A portion of the purchase was funded by the Scenic Byways Program administered by the Federal Highway Administration. This parcel contains primarily forested lands including some mature Sitka spruce, with the primary refuge access road continuing north through the tract and on to the end of the headland.



Aerial view of grasslands on Nestucca Bay NWR in various stages of restoration to native prairie. Photo Credit David L. Ledig/USFWS

Since the completion of construction of the largest tidal salt marsh restoration project in Oregon at Bandon Marsh NWR in 2011, monitoring of the effects of the restoration on the local wildlife and ecology have been ongoing. During the reporting year USFWS staff and contractors collected field data on bird use, fish use, water quality (temperature and salinity), and ground water level fluctuation. Data was collected from within the restoration site at Ni-les'tun Unit and the reference site within

the Bandon Marsh Unit for comparison to each other, and with similar data collected at both sites before the restoration occurred. In addition, in cooperation with Oregon Department of Fish and Wildlife, an adult salmon trap was operated for six months in Fahys Creek on the refuge, and weekly spawning surveys were conducted to monitor the recovery of salmonids post restoration of this stream. Preliminary results of all these monitoring efforts show that fish and wildlife have responded to the restoration of tidal influence to the marsh in dramatic and positive ways, including large increases in shorebird and waterfowl visitation, juvenile salmon and other estuarine aquatic species using the constructed tidal channels, and new coastal cutthroat trout spawning in Fahys Creek.

Other activities related to the marsh restoration project include the planting of over 4,000 willow whips in March to facilitate the development of habitat structure in parts of the marsh, removal of many thousands of invasive scotch broom and gorse plants to promote native plant communities, and aerial photography of the restoration site in cooperation with the U.S. Coast Guard.

The restoration work at Bandon Marsh NWR, along with its strategic value due to its location within a large estuary on the Oregon Coast, has raised its profile within the conservation science community. Accordingly, USFWS has issued Special Use Permits to several research groups to conduct studies on refuge lands. The Service considers this an excellent method to leverage internal efforts to obtain ecological information that can aid refuge management programs. The following projects were active in the reporting year:

- University of Pennsylvania - Foraminifera response to salt marsh restoration
- Portland State University - Shifting habitat mosaics in estuaries driven by climate change
- US Geological Survey - Sea-level rise effects on salt marshes and endemic wildlife over the tidal range gradient of the Pacific coast
- US Environmental Protection Agency - Nitrogen uptake as an ecosystem service of estuarine wetlands

In March 2013, a wildlife intern based in Bandon was hired for a six-month period to help conduct the regular refuge-wide bird surveys, and help with other monitoring data collection. He was also able to repeat a herpetological survey of the Refuge that was conducted two years ago by a previous intern designed to inventory reptiles and amphibians occurring in various habitats.

Staff on the south coast conducted seabird and seabird predator monitoring work this year including placement of 15 automatic trail cameras on five islands to record mammal predators and breeding seabird response during the 2012 and 2013 seasons. This monitoring work is funded as part of the restoration plan to mitigate the impacts resulting from the M/V New Carissa oil spill, and is focused on near-shore islands that are most vulnerable to terrestrial mammal predators, including Chief's Island, which is administered by the Confederated Tribes of the Coos, Lower Umqua, and Siuslaw Indians, who are co-Natural Resource Trustees for the restoration plan. This photographic

monitoring has documented very interesting bird and mammal behavior that will be critical as USFWS develops its long-term predator management program. Other seabird-related work included surveys of Leach's storm-petrel colonies on four islands in July 2012 to add to our long-term database on that species' population trends, and completion of a botanical survey of multiple islands and headlands within Oregon Islands NWR by volunteer botanists.

At Nestucca Bay NWR, the coastal prairie restoration project continued with a fall 2012 seeding of native sand fescue on the first 5-acre parcel. After the site was hayed and treated with herbicides to control invasive grasses in 2011, another year of invasive grass control was needed before native fescue seeding could be successfully accomplished. The restoration expanded in summer 2012 to include approximately 20 additional acres, on which invasive grass control was begun. Pending an acceptable level of invasive grass control, the additional 20 acres is planned for seeding and planting of native forbs in plug form in fall 2013. Additional work is being done to enhance the native early blue violet populations on an adjacent remnant prairie of approximately one acre. This project is a partnership between the USFWS, the Institute for Applied Ecology (IAE), and several dedicated volunteer and school groups to convert degraded grasslands from non-native pasture grasses to native coastal grasses and forbs with an emphasis on the species and structure required to support the federally listed threatened Oregon silverspot butterfly.

USFWS personnel conducted annual aerial surveys of surface nesting seabirds (e.g. common murre, Brandt's cormorant, and double-crested cormorant) at colonies on 03 and 04 June 2013. Digital photographs are taken of each colony from the air and the breeding populations of each species are estimated by counting the birds on the photographs. An annual aerial survey of California brown pelicans was conducted on 13 and 14 September 2012 to estimate the summer population before fall migration. Six sub-species of Canada geese including delisted Aleutian Canada geese and dusky Canada geese, a species of special concern, were monitored and counted in the Nestucca Valley from mid October 2012 to mid April 2013. Also, a special monitoring effort to document the presence of previously marked Semidi Islands Aleutian Canada geese was conducted at Nestucca Bay. Other wildlife surveys conducted by USFWS biologists included the monitoring of peregrine falcons, bald eagles, black brant, and wintering waterfowl along the Oregon coast. The Refuge Complex continued (fourth year of study) to conduct tufted puffin research at Haystack Rock in Cannon Beach, and recruited a volunteer to assist with the project. This project is an applied ecological study that advances knowledge and tests new techniques for assessment of a declining, at-risk, seabird species. Haystack Rock is part of the Oregon Islands NWR and this project will provide the refuge with additional data needed to assess seabird status and conservation issues within the refuge. The project will also yield results that will be important to Oregon Department of Fish and Wildlife (ODFW) and the USFWS if the tufted puffin becomes a candidate for state threatened or endangered species status. Refuge personnel

also assisted with the Hatfield Marine Science Center (HMSC) Dynamic Revetment Project by conducting weekly bird and marine mammal surveys to document use and presence within the revetment and control sites along the Hatfield Marine Science Center Estuary Trail.

The Environmental Education program continues to reach out to new schools and more students. This year, Oregon's annual Junior Duck Stamp Competition received 350 artwork entries from public, private, and home schools across the state. The 2013 Oregon "Best of Show" winner was Sarah Hansen, a 16-year old who practices art at the St. Louis Art Studio in Forest Grove. She submitted a pastel rendition of a female Wood Duck, entitled "Resplendence".

The Shorebird Superhero Program was conducted in Coos, Benton and Lincoln counties this year reaching 700 4th and 5th grade students. Students learned about the importance of estuaries, shorebird behavior, adaptations, migration, and conservation and ended the program with a field trip to Yaquina Estuary or Bandon Marsh NWR. We were fortunate to have outstanding weather and literally tens of thousands of shorebirds for the field trips. Some students saw Peregrine Falcons and Merlins attack and kill shorebirds, truly a once in a lifetime experience. Volunteers are a crucial part of the work at the Refuge Complex. The program continues to grow and expand, with volunteers in multiple positions including maintenance, biological work, interpretation, environmental education, and administration. Last year we had 132 volunteers who gave 12,753 hours of their time, which is valued at \$251,617.

Newport Field Office **Laura Todd, Field Supervisor**

The Newport Field Office (NFO) Ecological Services office is co-located with the Oregon Coast National Wildlife Refuge Complex at HMSC. The NFO administers the Ecological Services program of the Service on the Oregon coast with a staff of five permanent employees and various volunteers throughout the year. The responsibilities of the NFO include administration of Endangered Species Act requirements such as listing, recovery, private and state lands conservation for listed species, candidate conservation, consultation with Federal agencies, and technical assistance. The Oregon Coastal Program is also administered out of this office with staff also co-located at the Bandon Marsh National Wildlife Refuge. The purpose of the program is to provide funding and technical assistance to support habitat restoration assessment, habitat restoration projects, and public education. In addition to these two main functions, the NFO also occasionally assists with National Environmental Policy Act responses, wetland dredge/fill permit responses, planning efforts, spill responses, and a variety of technical assistance requests.

In 2012-2013, the Newport Field Office celebrated a number of accomplishments:

- Completed 8 restoration or habitat assessment projects under the Coastal Program which enhanced or restored: 11 miles

of stream and riparian habitats; 469 acres of wetlands; and 10 acres of upland. These were all implemented according to the Oregon Coastal Program Strategic Plan, which was finalized in 2012 (<http://www.fws.gov/oregonfwo/FieldOffices/Newport/CoastalProgram/CoastalProgram.asp>).

- To improve the population numbers and distribution of the threatened Oregon silverspot butterfly, we released pupae and caterpillars at three locations on the central Oregon coast, with the assistance of numerous volunteers. To improve habitat, volunteers and Service staff also planted early blue violets, the host plant for Oregon silverspot larvae, and nectar plants on the central Oregon and southern Washington coast.
- Contributed to Western snowy plover recovery efforts throughout the state including predator control, nest protection and monitoring, habitat restoration, law enforcement, and public education.
- Fully implemented the administrative rules for the Habitat Conservation Plan for Western Snowy Plovers (HCP) developed by Oregon Parks and Recreation Department to manage plover on Oregon's beaches. No dogs, vehicles, or flying apparatus are allowed on plover beaches as of February 1, 2012.
- Supported a number of recovery projects and habitat restoration for sensitive species on the Oregon Coast under the Endangered Species Recovery Implementation Fund, including projects for western lilies, pink sand-verbena, sea turtles, plovers, and butterflies.

U. S. Geological Survey

Biological Resources Discipline, Western Fisheries Research Center - Newport Duty Station

Deborah Reusser, Duty Station Leader

The Newport Duty Station is part of the Western Fisheries Research Center (WFRC), located in Seattle, Washington, and is co-located in the US EPA Pacific Coast Ecology Branch building at the Hatfield Marine Science Center. The mission of WFRC is to provide research and technical assistance to support the best possible stewardship of the Nation's natural resources, emphasizing fish populations and aquatic ecosystems of the West.

USGS scientists in Newport focus their research on defining and developing analysis tools to determine how climate change is affecting the distribution and availability of suitable habitat for many marine and estuarine species on the Pacific Coast. The goal is to provide insights and tools toward a better understanding of what these effects will be. In 2013, USGS released two Open File reports providing: 1) analyses on *Potential Climate-Induced Runoff Changes and Associated Uncertainty in Four Pacific Northwest Estuaries* (<http://pubs.usgs.gov/of/2012/1274/>) and 2) *Tidal Wetlands of the Yaquina and Alsea River Estuaries, Oregon: Geographic Information Systems Layer Development and Recommendations for National Wetlands Inventory Revisions* (<http://pubs.usgs.gov/of/2012/1038/>).

The Newport Duty Station also provides software development and computer programming expertise to several national programs. Two of these programs are The National Atlas of the United States (www.nationalatlas.gov) and the Coastal Biological Risk Assessment Tools (CBRAT; cbrat.nationalatlas.gov). The National Atlas is a comprehensive, interactive, web-based tool for exploring facts about America and its people. Using maps as the medium, the National Atlas strives to provide a fun and engaging learning experience for students of all ages. The goal is that these efforts add clarity to what is often a difficult to conceptualize world of geographic information numbers and data, and by so doing help to further the scientific missions of the organizations from whom the data for these maps originates. In 2013, new web map services (WMS) and web feature services (WFS) were released providing access to the base data at 1 million scale for geographic information specialists and are now available to the public at webservices.nationalatlas.gov. In addition, a new web application has been released that allows you to trace America's rivers upstream to their source or downstream to their where they empty. Trace a stream near you at (<http://nationalatlas.gov/streamer/Streamer/streamer.html>).

CBRAT is being developed jointly by U.S. EPA and USGS and contains biological and geographic distribution information about marine and estuarine species on the US Pacific Coast from the Beaufort Sea to the Gulf of California. Biological information of use to the scientific community regarding the nature, distribution and abundance of species tends to primarily reside scattered within the pages of various scientific journals and expert knowledge. The database gathers together these scattered bits of information into a searchable interface, adding much needed usability to a wealth of biological information. As information is formalized and validated for a species, it will be accessible by the public. Our current group of target species is the crabs, bivalves and rockfish in the Northeast Pacific. Several workshops have been held to gather much needed information on the abundance and distribution of crabs and bivalves in the Northeast Pacific. Another workshop is being considered for the rockfish. Web based tools are also being developed to evaluate relative risk to a variety of climate change factors for these species. These tools will be made available through the website. USGS staff at HMSC currently consists of 3 federal employees and one student contractor. USGS interacts with the HMSC and wider university community both in research and educational programs.

Oregon Department of Fish and Wildlife

Marine Resources Program

Caren Braby, Program Manager

As part of the Oregon Department of Fish and Wildlife (ODFW) Fish Division, the Marine Resources Program (MRP) assesses and manages Oregon's marine habitat, biological resources and fisheries (primarily groundfish, shellfish, ocean salmon, coastal pelagic species, such as sardines, and highly migratory species,

such as albacore tuna). In addition to direct responsibilities in state waters (from shore to three miles offshore), the MRP provides technical support and policy recommendations to state, federal, regional, and international decision-makers who develop management strategies out to 200 miles offshore that affect Oregon habitats, fishery stocks and coastal economies. The program's work focuses on three major categories:

- marine resource policy, management, and regulation
- fisheries monitoring, sampling, and data collection
- research on marine fisheries, estuaries, ocean species, and habitats.

Staffing and Budget: MRP headquarters is in Newport at the Hatfield Marine Science Center on Yaquina Bay. MRP has offices along the coast in Astoria, Charleston, Brookings, and a marine mammal program based in Corvallis. Staffing consists of about 60 permanent and more than 60 seasonal or temporary positions. The annual program budget is approximately \$8.8 million: about 75 percent comes from a combination of license fees, commercial fish fund, general funds, and a small amount of lottery fund; the remaining 25 percent comes from federal grants.

Policy, Management and Regulation: The Oregon Department of Fish and Wildlife is authorized by the State Legislature in statute and the Oregon Fish and Wildlife Commission to administer the regulation, harvest, and management of commercial and recreational fisheries and management of other marine species, such as marine mammals, in Oregon. This work is done by the Marine Resources Program (MRP). Generally the MRP is involved in natural resource management from the innermost margin of estuaries to 200 miles offshore. This includes fishery management policy development and implementation at the local, state, regional and international scale.

U.S. ocean fisheries are managed at the federal level through the Magnuson-Stevens Fishery Conservation and Management Act (MSA). This federal law forms the framework around which the west coast states regulate fisheries in state and federal waters. The law established an area from shore to three miles offshore that generally falls under state jurisdiction for fishery management. From three miles to 200 miles, federal authority establishes fishery regulations for many species. In some cases (such as commercial Dungeness crab and pink shrimp fisheries), the act delegates full authority (in state and federal waters) to state management. States may set overriding fishery regulations as long as they are more conservative than those set in the federal process.

Fisheries Monitoring, Assessment, and Management: The MRP continued ongoing programs to monitor catch and effort in commercial and recreational marine fisheries. Staff conducts surveys and interviews to estimate the overall effort and document catch by fishermen and shellfishermen in the ocean, on the beaches, and in the estuaries. Biological measurements and structures are collected to document species, size, age and numbers (or pounds) of individuals being harvested. These data and biological samples are used by fishery managers at state,

regional, federal and international scales for fishery management decision-making. This includes in-season management (e.g. tracking progress toward catch limits), evaluating the success of management measures, and informing stock assessments.

This past year, the Oregon pink shrimp fishery was re-certified by the Marine Stewardship Council for sustainability. While the certification was an industry-led initiative, ODFW played an important role in the recertification process by providing research results from many years of fishery bycatch reduction work on fishing gear design, population dynamics modeling, and committing to continue this work into the future.

ODFW initiated a public outreach campaign this year, targeting sport groundfish anglers, to increase the use of descender devices by sport fishermen, to release prohibited rockfish species at depth and increase survival rate. This "no floaters" campaign has been successful and increased awareness, on how to increase the sustainability of this fishery.

Marine Reserves in Oregon: MRP has been directly involved in marine reserves implementation since 2008, resulting in a system of five reserve sites within Oregon's nearshore waters. The marine reserves prohibit all take of fish, invertebrates, wildlife and algae as well as ocean development. The protected areas have varying levels of protection; allowing or prohibiting certain specified take and prohibiting all ocean development. The five sites are being phased in, between 2012 and 2016, in order to allow for the adequate collection of two years of baseline data at each site prior to the cessation of harvest activities.

- **Monitoring:** Monitoring plans, for monitoring the ecological and human dimensions (economic, social, cultural) effects of the marine reserve system, were completed by ODFW in 2012. Data collection is conducted by MRP staff and external scientific research partners. Two years of ecological and human dimensions baseline data collection were completed in 2011 for the Redfish Rocks and Otter Rock sites and ongoing, long-term monitoring is currently underway. A first year of baseline data collection was completed in 2012 for the Cape Perpetua and Cascade Head sites. A second year of baseline data collection will be conducted in 2013. Monitoring reports are to be produced every two years by ODFW, starting with baseline monitoring reports for Redfish Rocks and Otter Rock due out in 2013.
- **Management:** Site management plans outline strategies for monitoring reporting and review; outreach; compliance and enforcement; and community and public engagement. The plans also highlight priorities and implementation efforts of local communities that complement that of the state. Site management plans have been completed by MRP staff and are being implemented for the Redfish Rocks and Otter Rock sites. Development of site management plans for the Cape Perpetua and Cascade Head sites will begin in 2013 and be completed in 2014. Development of a site management plan for Cape Falcon will begin in 2014.
- **Outreach and Community Engagement:** Starting in 2013, ODFW has increased its focus on marine reserves outreach

efforts. Current efforts are largely focused on providing and disseminating information in preparation for harvest restrictions taking effect for two of the sites in 2014. ODFW is currently exploring ways to leverage outreach, education, and community engagement efforts for marine reserves with outside NGO and academic partners. Through collaboration with these partners, ODFW hopes to spur a greater number, and a different variety, of on the ground community projects and programs related to marine reserves implementation than they would be able to accomplish internally.

For more information on Oregon's marine reserves or for copies of any of the marine reserves plans or reports, please visit the Oregon marine reserves website at www.oregonocean.info/marinereserves.

Coastal and Marine Spatial Planning: MRP staff completed ODFW's portion of the state's effort to amend the Territorial Sea Plan, for the purpose of siting areas for alternative ocean energy development. This effort was led by ODFW's sister agency, Oregon Department of Land Conservation and Development (DLCD). ODFW's work included a multi-year effort to assemble and analyze ecological information and provide policy recommendations for this marine spatial planning effort. The plan was adopted in January 2013, and relevant components of the plan will become part of Oregon's Coastal Zone Management Program. MRP staff is now involved in siting alternative ocean energy developments in federal waters. Siting in federal waters is being led by the Bureau of Ocean Energy Management. MRP's role in this process will continue to focus on providing marine ecological data and associated policy recommendations.

ShoreZone Habitat Mapping: MRP staff, in collaboration with the Oregon Department of Land Conservation and Development (DLCD), are finishing a project to map Oregon's ocean and estuary shoreline habitats using the ShoreZone mapping protocol. Used extensively in Washington, Alaska, and British Columbia, ShoreZone is a coastal habitat mapping and classification system in which aerial imagery is collected specifically for the interpretation and integration of geomorphic and biological features of the intertidal zone and nearshore environment. ODFW's contractor completed the first phase of the project, aerial imagery collection, in 2011. The aerial photos may be viewed at <http://www.coastalatlantlas.net/shorezone/>. Photo interpretation, habitat classification and mapping was completed for 80 percent of the 2,071 kilometers of shoreline photographed in June 2013. Staff has recently been awarded a grant to complete the final 20 percent of shoreline over the coming year.

Marine Mammals: ODFW's Marine Mammal Program is involved in research, monitoring and management of Oregon's seal and sea lion populations. The program addresses a variety of issues, most notably California sea lion and Steller sea lion predation on threatened and endangered salmonids in the Columbia River. During the 2013 field season staff participated in the permanent removal of four California sea lions from Bonneville Dam (two euthanized, two provided to the Queens Zoo in New York).

Other recent program activities include: conducting aerial surveys to document the status and trends of pinniped populations in Oregon; marking and attaching telemetry instruments to California sea lions and Steller sea lions to learn about their movements and foraging behavior; responding to marine mammal stranding incidents as part of the Northwest Marine Mammal Stranding Network; conducting long-term research on the survival of Steller sea lions as part of delisting and recovery efforts; analyzing pinniped fecal samples to better understand pinniped food habits; and tagging harbor seals with oceanographic sampling instruments as part of a Navy-funded research initiative. Federal, state, and tribal collaborators in program activities included: National Marine Fisheries Service; National Marine Mammal Laboratory; U.S. Army Corps of Engineers; U.S. Fish and Wildlife Service; Oregon State University; Portland State University; Washington Department of Fish and Wildlife; Columbia River Inter-Tribal Fish Commission; and local, state, and federal law enforcement agencies.



A Steller sea lion with a GPS phone tag.

Japan Tsunami Marine Debris (JTMD) Non-native Species Risk Assessment: ODFW shellfish biologists led a coastwide effort to assess and control the risk associated with non-native species attached to floating debris, generated by the Tohoku tsunami (March 2011). Marine debris items from Japan began to wash ashore along the Oregon coast in the summer of 2012, most impressively including a large commercial fishing dock which arrived on Agate Beach (Newport) in June 2012. The floating dock was inhabited by a large number of non-native aquatic species, including the invasive Wakame kelp (*Undaria pinnatifida*). ODFW staff members removed 4,260 pounds of living marine organisms from the sides and top of the dock, and the exposed surfaces were burned with propane torches to eradicate microscopic organisms. Since last June, ODFW has worked closely with OSU researchers, other academics, and federal and state partners to better understand and minimize the impacts of this event, as a variety of JTMD items continue to land on our shore. The spring of 2013 has brought a number of small vessels and innumerable pieces of milled lumber.

Fishery-Independent Research: Several research projects were led by MRP teams, focused on the study of nearshore species and habitat, as well as, how to improve bycatch reduction in Oregon fisheries. Highlights of research accomplishments include:

- Black rockfish population study: MRP researchers are working in the 12th year of a black rockfish mark-and-recapture project that uses PIT tags to determine the exploitation rate of this species in the recreational fishery. This project has recovered more than 2,500 tags over its history, making it one of the longest and most intensive tagging efforts of its kind.
- Visual survey tool development: MRP staff continued testing a video lander as a survey tool for nearshore and shelf rocky reef habitat. In 2013 researchers will evaluate how bait influences the fish viewed with the lander as well as the utility of a stereo video system to estimate fish lengths.
- Fishery bycatch reduction: MRP staff continued field studies of gear modifications aimed at further reducing the bycatch mortality of eulachon smelt in ocean shrimp trawls, including evaluation of modified footrope designs.
- Environmental hypoxic events: MRP staff continues to help assess the effects of recurrent hypoxic/anoxic conditions on the benthic communities found offshore of the central Oregon coast (in collaboration with Oregon State University's Partnership for the Interdisciplinary Study of Coastal Oceans program).
- North Coast ROV survey: MRP's Remotely Operated Vehicle (ROV) surveyed the four significant rocky reef complexes from Cascade Head to Tillamook Head for the first time. The data collected will be used to provide an initial estimate of fish abundance in these areas, ground-truthing of recently acquired seafloor mapping data, and provide a baseline data collection for reef fish and habitat in the soon-to-be-implemented Cascade Head Marine Reserve and its associated comparison site.
- Shellfish and Estuarine Habitat Assessment: The SEACOR project surveys estuarine areas important to commercial and recreational clam harvest. The primary goals of the SEACOR project are to identify where commercially and recreationally important clams are found, document their abundance and describe the habitat associated with each species. Staff members completed the assessment of shellfish populations and habitats for Yaquina Bay, during which they surveyed 1,016 acres and measured more than 35,000 clams. Data from the assessment of Yaquina Bay are still being analyzed. Staff is also analyzing results from the assessment of subtidal bay clam broodstock conducted in Tillamook Bay in 2012. The results of this study will be used by the Shellfish Program to better manage the commercial and recreational clam fisheries of Tillamook Bay, to investigate decadal changes in subtidal clam populations, and to evaluate the potential role of subtidal clam populations as a broodstock to replenish intertidal clam populations. SEACOR staff is currently conducting a two-year assessment of shellfish populations and habitats (2013-2014) in Netarts Bay, which will include both intertidal and subtidal components. Reports, maps, and other information produced by the SEACOR project can be found at http://www.dfw.state.or.us/MRP/shellfish/Seacor/news_publications.asp.
- Red Urchin surveys: MRP staff worked with commercial divers over a period of three days in the spring of 2013 to conduct surveys of subtidal red urchin populations at several

sites near Cape Arago and Gregory Point. Measurements were recorded for more than 1,000 urchins, and size frequency plots revealed that populations at all sites were dominated by a major cohort of large old individuals. Recruitment of smaller adults and juveniles has been infrequent over the past decade.

- Razor clam surveys: Each year MRP staff conducts population surveys of the Clatsop beaches populations of razor clams. This past year marks year 8 of this on-going study.
- Olympia Oyster Recovery: MRP staff continued to monitor the population status and levels of recruitment for native Olympia oysters (*Ostrea lurida*) at several key sites in Coos Bay.

Student and fellow involvement with ODFW: Each year, ODFW sponsors summer scholars, interns, fellows and students, to work on a variety of projects in marine resource management. This past year, we sponsored projects related to marine reserves, shellfish biology, fishery management, and marine policy. We look forward to continuing to sponsor projects each year, as funding and opportunity allow.

C. HMSC Visiting Scientists

HMSC Visiting Scientists

Maryann Bozza, HMSC Program Manager

Through the Visiting Scientist program, HMSC encourages and supports collaborative visits from researchers from across the nation and the world. During their stay, which can vary in length from days to months or years, visitors share knowledge through seminars and formal and informal interactions while advancing their own investigations, leaving both visitor and host richer for the exchange.

An important source of support for long-term visits is the Lavern Weber Visiting Scientist (LWVS) Fellowship endowment, named in honor of Lavern Weber, who directed HMSC between 1977 and 2002. Although there have been no LWVS during this reporting year, Dr. Fred Allendorf, a 2011 LWVS from the University of Montana, returned to continue work on collaborations forged during his fellowship. Several LWVS visits are planned for the coming year.

HMSC hosts many OSU faculty and graduate student researchers from the main campus in Corvallis, as well as visits from faculty, students, educators, elected officials and governmental representatives, agency scientists and natural resource managers from the region, the nation and the world. These interactions range from tours, meetings, seminars and workshops to research collaborations spanning months to years. They serve to facilitate collaboration and information exchange and advance regional initiatives including ocean renewable energy and ocean observing infrastructure. In the past year, an estimated 100 visits by individuals or groups hailed from all around the US including Illinois, Florida, Mississippi, California, the Pacific Northwest and Washington DC.

II. EDUCATION

Student Enrollment Statistics

Itchung Cheung, Academic Program Manager

Summer 2012	Credit	Course Title	2012-2013	Credit Hours
BI 150	4	Introduction to Marine Biology (Cheung)	5	20
BI 302	4	Biology and Conservation of Marine Mammals (Sumich)	5	20
FW 302	4	Biology and Conservation of Marine Mammals (Sumich)	0	0
FW 499	1	Field Techniques in Marine Mammal Conservation (Albertson)	0	0

Fall 2012	Credit	Course Title	2012-2013	Credit Hours
FW 407	1	HMSC Research seminar (Boehlert)	3	3
FW 507	1	HMSC Research seminar (Boehlert)	10	10
FW 421	4	Aquatic Biological Invasions (Chapman)	7	28
FW 426/526	5	Coastal Ecology and Resource Management (Langdon)	8	40
FW 454	5	Fishery Biology (Heppell)	12	60
FW 431	4	Dynamics of Marine Biological Resources (Sampson)	5	20
FW 464	3	Marine Conservation Biology (Heppell)	8	24
FW 419/519	3	Natural History of Whales and Whaling (Baker)	11	33
FW 474/574	4	Early Life History of Fishes	17	68
FW 554	5	Fishery Biology (Heppell)	1	5
OC 599	3	Math on the Beach (Smyth)	10	30

Winter 2013	Credit	Course Title	2012-2013	Credit Hours
BI 111	1	Introduction to Marine Life in the Sea (Cheung)	11	11
FW 111	1	Introduction to Marine Life in the Sea (Cheung)	10	10
FW 599	2	Special Topics: Genetic Monitoring of F & W (Baker)	10	20

Spring 2013	Credit	Course Title	2012-2013	Credit Hours
BI/FW111	1	Intro to Marine Life in the Sea: Marine Mammals (Sumich)	22	22
BI/FW111	1	Intro to Marine Life in the Sea: Marine Birds (Suryan)	19	19
BI 450	16	Marine Biology Lecture (Hacker)	22	352
FW 599	1	Special Topics: Advanced Fundamentals of Molecular Ecology (Baker)	1	1
MRM 525	3	Marine Spatial Planning (Distance Ed beam to HMSC)	4	12
VMB 727	2	Ornamental Fish Medicine (Miller-Morgan)	6	12



2012 SACNAS Conference in Seattle, WA - 2012 REU students



2013 Aquatic Sciences Meeting in New Orleans, LA - 2012 REU students and Mentors

Internships at HMSC

Itchung Cheung, Academic Program Manager

Internships are recognized as one of the best learning experiences a young person can have in preparing for almost any profession. For those contemplating careers in marine science education, research, or resource management, HMSC is an ideal place for an internship experience. Beyond the practical hands-on experience offered, interns at HMSC uniquely benefit from the many opportunities for interaction with scientists, educators, and resource managers representing a wide range of expertise. In 2012-13, forty students took advantage of internship opportunities offered by OSU and partner agencies at HMSC. Students secured positions by applying directly to the researcher or agency hosting the internship, or by applying to the growing number of internship programs at the center including the HMSC Visitor Center Education internship, NSF-funded Center for Ocean Science Education Excellence Pacific Partnerships (COSEE-PP) Promoting Research Investigations in the Marine Environment (PRIME) program, and the NSF-funded "Research Experience for Undergraduates" (REU) program. Twenty students were selected (through a competitive application process of 272 applicants) to participate in the REU program, which paired each student intern with a faculty mentor to work on a defined research project over a 10-week period during the summer of 2012. In addition, three undergraduate students participated in the HMSC Visitor Center Internship in marine science education, co-funded by the Oregon Sea Grant Undergraduate Scholars Program. Four community college students participated in the COSEE-PP PRIME. One OSU undergraduate student participated in the state-sponsored Professional and Managerial Internships in State Employment (PROMISE) program with the HMSC Academic Programs. One undergraduate student participated in the NOAA Hollings Scholar program. Five undergraduate students participated in the Oregon Sea Grant Undergraduate Scholars Program. Three undergraduate students interned through the EPA Growing Research Opportunities program (GRO). One REU intern from the previous summer (2011) returned to HMSC (Henkel Lab) supported by Undergraduate Research Opportunities Center (UROC) at California State University Monterey Bay. Four student interns (2 undergraduate/2 graduate) were supported at HMSC by the NOAA-supported Living Marine Resources Cooperative Science Center (LMRCSC). In addition several OSU undergraduate students participated in a number of HMSC associated internships: Marine Mammal Institute, Yaquina Head Outstanding Natural Area-BLM, Georgia Pacific, ODFW and NOAA.

Nine of the ten HMSC REU student interns and four CEOAS REU student interns from the Summer 2012 program presented research posters at a scientific meeting. Five presented at the 2013 Aquatic Sciences Meeting in New Orleans, LA (*). Six also presented at the 2012 Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) Conference, Seattle, WA (^). Four REU students attended both research meetings (°). One presented at the 2012 Western Society of Naturalists Meeting in Monterey, CA (°). Another presented at the 2012 Heceta Head Coastal Conference (˘) and at the

CalCOFI Conference in Pacific Grove, CA (*). In addition one of the interns presented at the 2013 Benthic Ecology Meeting in Savannah, GA (‡).

Only HMSC REU students presenting are listed. Four CEOAS REU students are not included.

Gonzalez, Adrian[°]; Dietrich, J.; Arkoosh, M.: Effects associated with exposure to PolyBrominated Diphenyl Ethers (PBDEs) in juvenile Chinook salmon

Hill, Andrew[˘]; Daley, L.; Brodeur, R.: High Diet Variability of Pacific Northwest Forage Fish

Nelson, Emma[°]; Suryan, R.: The Hunger Games: Provisioning Rates and Implications for Common Murre (*Uria aalge*) Chicks

Perales, Brynn[°]; Whitcomb, A.; O'Malley, K.: An evaluation of coho salmon (*Oncorhynchus kisutch*) jack mate choice based on immune-relevant genes

Schweiteman, Gail[°]; Copeman, L.; Ryer, C.: The effect of dietary lipids and fatty acids on growth rates of juvenile tanner crabs (*Chionoecetes bairdi*)

Sokoly, Diana[°]; DeWitt, T.: Effects of N:P Ratios on Nutrient Flux in Yaquina Bay, Oregon

Swenarton, MaryKate[^]; Laurel, B.: Behavior of age-0 Northern rock role (*Lepidopsetta polyxystra*) in a stratified water column

Turner, Kali[^]; Hurst, T.: The effects of ocean acidification on the behavioral responsiveness of juvenile walleye pollock (*Theragra chalcogramma*) to olfactory cues

Zimmerman, Tirsia^{*}; Laurel, B.: Dispersal of newly settled juvenile northern rock sole (*Lepidopsetta polyxystra*)

During the summer at HMSC students gained research experience at sea. For example, several students had an opportunity to participate in bi-monthly cruises aboard the 54-ft coastal research vessel Elakha. Andrew Hill accompanied his mentor, Ric Brodeur, on a trip to sample forage fish species.

At the end of the 10-week program, all of the REU interns prepared and delivered written reports and oral presentations of their research projects at a symposium attended by faculty, staff, and graduate students. Students also participated in weekly brown-bag lunch meetings at which they discussed their research experiences and plans; gave tours of their research labs; participated in workshops on R software and science communication; and attended a weekly research seminar series.

<i>REU Interns</i>	<i>Undergraduate Institution</i>	<i>Faculty Mentor</i>	<i>Project Title</i>
<i>Dean, Charles</i>	<i>Hood College</i>	<i>Chapman, John & Dumbauld, Brett</i>	<i>The trophic significance of microbial communities in the burrow of <i>Upogebia pugettensis</i>, the blue mud shrimp (Yaquina Bay, Oregon)</i>
<i>Gonzalez, Adrian</i>	<i>Oregon State University</i>	<i>Arkoosh, Mary & Dietrich, Joseph</i>	<i>Effects associated with exposure to PolyBrominated Diphenyl Ethers (PBDEs) in juvenile chinook salmon</i>
<i>Hill, Andrew</i>	<i>Portland Community College</i>	<i>Brodeur, Ric</i>	<i>High Diet Variability of Pacific Northwest Forage Fish</i>
<i>Nelson, Emma</i>	<i>University of Massachusetts Amherst</i>	<i>Suryan, Rob</i>	<i>The Hunger Games: Provisioning Rates and Implications for Common Murre (<i>Uria aalge</i>) Chicks</i>
<i>Perales, Brynn</i>	<i>California State University Monterey Bay</i>	<i>O'Malley, Kathleen</i>	<i>An evaluation of coho salmon (<i>Oncorhynchus kisutch</i>) jack mate choice based on immune-relevant genes</i>
<i>Schweiteman, Gail</i>	<i>Oberlin College</i>	<i>Ryer, Cliff</i>	<i>The effect of dietary lipids and fatty acids on growth rates of juvenile tanner crabs (<i>Chionoecetes bairdi</i>)</i>
<i>Sokoly, Diana</i>	<i>Texas A&M University, Corpus Christi</i>	<i>Dewitt, Ted</i>	<i>Effects of N:P Ratios on Nutrient Flux in Yaquina Bay, Oregon</i>
<i>Swenarton, MaryKate</i>	<i>Rutgers University</i>	<i>Laurel, Ben</i>	<i>Behavior of age-0 Northern rock sole (<i>Lepidopsetta polyxystra</i>) in a stratified water column</i>
<i>Turner, Kali</i>	<i>University of Idaho</i>	<i>Hurst, Tom</i>	<i>The effects of ocean acidification on the behavioral responsiveness of juvenile walleye pollock (<i>Theragra chalcogramma</i>) to olfactory cues</i>
<i>Zimmerman, Tirsa (Star)</i>	<i>Oregon State University</i>	<i>Laurel, Ben</i>	<i>Dispersal of newly settled juvenile northern rock sole (<i>Lepidopsetta polyxystra</i>)</i>
<i>HMSC Visitor Center Education Intern</i>	<i>Undergraduate Institution</i>	<i>Faculty Mentor</i>	<i>Project Title</i>
<i>Pitz, Nicholas</i>	<i>Oregon State University</i>	<i>Hanshumaker, Bill</i>	<i>Presentations, tours and development of new exhibits in the HMSC Visitor Center</i>
<i>Roman, Diane</i>	<i>St. Mary's College of Maryland</i>	<i>Hanshumaker, Bill</i>	<i>Presentations, tours and development of new wave energy erosion exhibit in the HMSC Visitor Center</i>
<i>Verwey, Brian</i>	<i>Oregon State University</i>	<i>Hanshumaker, Bill</i>	<i>Presentations, tours and development of new exhibits in the HMSC Visitor Center</i>
<i>Promise Intern</i>	<i>Undergraduate Institution</i>	<i>Faculty Mentor</i>	<i>Project Title</i>
<i>Sims, Stacy</i>	<i>Oregon State University</i>	<i>Cheung, Itchung</i>	<i>GIS Mapping of Research Debris in Yaquina Bay</i>
<i>NOAA-Hollings Scholars</i>	<i>Undergraduate Institution</i>	<i>Faculty Mentor</i>	<i>Project Title</i>
<i>Yaeger, Joyce</i>	<i>University of Miami</i>	<i>Weitkamp, Laurie</i>	<i>Estuarine and marine ecology of Pacific salmon, and the factors that affect their survival</i>

HMSC COSEE PP PRIME Interns	Undergraduate Institution	Faculty mentor	Project Title
Robertson, Jonathan	Portland Community College	Politano, Vincent (Scott & Selina Heppell)	Estuarine Fisheries Monitoring in Yaquina Bay, OR
Semple, Michaela	Oregon Coast Community College	Tait, Leigh	Ocean Acidification Impacts on Corallina Algae
Stinson, Thomas	Rogue Community College	Jacobson, Kym	Ecology of Host-Parasite Interactions of Anadromous and Marine Fishes
Zerbin, Misti	Lane Community College	Dumbauld, Brett	Assessment of Burrowing Shrimp Populations in Yaquina Bay, OR
Sea Grant Summer Scholars Intern	Undergraduate Institution	Faculty mentor	Project Title
Leuders, Kate	North Central College	DeWitt, Ted	Contributing to on-going research on wetland nutrient uptake in Oregon estuaries
Nance, Julie	Utah Valley University	Rowe, Shawn	Creating the plans for a new exhibit on climate change and assisting with Free-Choice Learning research in the HMSC Visitor Center
Norton, Reed	Oregon State University	Brown, Cheryl	Examining nutrient limitations of phytoplankton in Yaquina Bay to develop nutrient criteria to protect Oregon estuaries from anthropogenic inputs and their effects on water quality
Polis, Hilary	Oregon State University	Murphy, Melissa	Collecting and analyzing socioeconomic data associated with fishing activities near marine reserves
Sedoryk, Maryna	University of California Santa Cruz	D'Andrea, Tony	Oregon Department of Fish and Wildlife (ODFW) on the Shellfish and Estuarine Habitat Assessment of Coastal Oregon (SEACOR) project
Marine Mammal Institute Intern	Undergraduate Institution	Faculty mentor	Project Title
Mee-ya Monnin	Oregon State University	Horning, Markus	Thermoregulation of Weddell seals, <i>Leptonychotes weddellii</i> in Antarctica
Living Marine Resources Cooperative Sciences Center (LMRCSC) Interns	Academic Institution	Faculty mentor	Project Title
Denson, LaTreease	Oregon State University	Miller, Jessica	Marine and anadromous fisheries ecology lab
Fedewa, Erin	Oregon State University	Miller, Jessica	Marine and anadromous fisheries ecology lab
Hermosillos, Xana	Evergreen College	Miller, Jessica	Marine and anadromous fisheries ecology lab
Silver, Ashley	Hampton University	Miller, Jessica	Marine and anadromous fisheries ecology lab

Student Awards and Scholarships

Itchung Cheung, Academic Program Manager

Scholarships and awards given by HMSC through the generosity of various donors represent an important source of financial support for undergraduate and graduate student education and research in marine science. The 2013 Markham Research Symposium (named for the Mamie L. Markham Endowment,

which annually awards two years of financial support for approximately nine students pursuing research at HMSC) was held on June 19, 2013. Students who had made significant progress towards completion of their research gave brief presentations. Those students being awarded new monies for 2013-14 year displayed posters explaining their proposed research. Their awards are listed below:

Award	Recipient
HMSC Housing Scholarship - <i>To provide free or reduced-rate housing on-site for the duration of the term in which they are enrolled.</i>	Mark Burnap (\$250), Taylor Derlacki (\$125), Alysha Hartman (\$375), Carliss Salant (\$250), Claire Steele (\$250), Ian Throckmorton (\$125)
Mamie L. Markham First Year Student Award - <i>to provide financial assistance to an incoming, first year graduate student who plans to be resident at the HMSC after completing first academic year in Corvallis.</i>	Matthew Berger, Marine Resources Management (\$6,000) Advisor: Gil Sylvia Selene Fregosi, Wildlife Science (\$6,000) Advisor: Jessica Miller
Anja Robinson Shellfish Fellowship - <i>intended to support graduate students research in shellfish aquaculture</i>	No Award in 2013
Fred and Joan Crebbin Memorial Fellowship - <i>To foster education in the marine sciences by providing financial support to undergraduate or graduate students pursuing marine science related fields at OSU.</i>	Renee Albertson, Fisheries & Wildlife (\$3,000) Advisor: Scott Baker
Lillian Brucefield Reynolds Scholarship Fund - <i>for graduate students engaged in study of marine science at Hatfield Marine Science Center.</i>	Rebecca Hamner, Wildlife Science (\$1,000) Advisor: Scott Baker Cheryl Horton, Wildlife Science (\$1,000) Advisor: Rob Suryan
Curtis and Isabella Holt Education Fund - <i>intended to foster education in the marine sciences by providing financial support to undergraduate or graduate students pursuing marine science studies.</i>	Susan O'Brien, Environmental Sciences (\$10,000) Advisor: Shawn Rowe Saskia Madlener, Marine Resource Management (\$4,500) Advisor: Flaxen Conway
Walter G. Jones Fisheries Development Award - <i>intended to support an academically qualified graduate student pursuing research which contributes to fisheries development.</i>	No Award in 2013
William Q. Wick Marine Fisheries Award - <i>intended to encourage graduate student research in the area of marine fisheries ecology with special area of interest in Pacific whiting or intended to fund graduate research in marine fisheries and ocean related research</i>	Morgan Bancroft, Marine Resource Management (\$2,000) Advisor: Lorenzo Ciannelli Erin Fedewa, Fisheries Science (\$3,000) Advisor: Jessica Miller Marisa Litz, Fisheries (\$4,000) Advisor: Jessica Miller
HMSC Student Teaching Award - <i>intended to recognize undergraduate or graduate student teaching excellence and promise in marine science education at the Hatfield Marine Science Center.</i>	Renee Albertson (2013 Spring), Fisheries and Wildlife (\$250) Michelle Fournet (2013 Winter), Marine Resource Management (\$250) Cheryl Horton (2013 Spring), Wildlife Science (\$250)
Mamie L. Markham Endowment Award - <i>intended to assist student research utilizing OSU's Hatfield Marine Science Center.</i>	
Morgan Bancroft, Marine Resource Managements (\$7,500) Advisor: Lorenzo Ciannelli	Renee Bellinger, Fisheries & Wildlife (\$9,500) Advisor: Michael Banks
Reuben Biel, Zoology (\$7,000) Advisor: Sally Hacker	Erin Fedewa, Fisheries Science (\$6,000) Advisor: Jessica Miller
Matthew Gray, Fisheries (\$8,000) Advisors: Chris Langdon	Dustin Keys, Food Science (\$7,000) Advisor: Christina Mireles
Sophie Pierszalowski, Wildlife Science (\$7,000) Advisor: Scott Baker	

Course Descriptions

Itchung Cheung, Academic Program Manager

HMSC offers a wide range of courses within the interdisciplinary field of marine science through Oregon State University. Courses in Biology, Fisheries and Wildlife, Science and Math Education, Statistics, Oceanography, Veterinary Medicine and Zoology, are open to undergraduate students, graduate students and professionals, and generally attract 20-35 students per term.

Note: * = use of Interactive Television (ITV), online or online hybrid course.

Summer 2012 Courses

*BI 150. INTRODUCTION TO MARINE BIOLOGY (Cheung) (4)

An introduction and overview of marine life in the sea.

FW/BI 302. BIOLOGY AND CONSERVATION OF MARINE MAMMALS (Albertson-Gibb) (4)

An examination of the biology of whales, pinnipeds, and other marine mammals, include general adaptations to a marine existence; systematics and biogeography; reproduction; diving physiology; communication and echolocation; feeding and migratory behavior; and marine mammal/human interactions, including conservation issues.

FW 499. SPECIAL TOPICS IN FISHERIES AND WILDLIFE: Field Techniques for Marine Mammal Conservation (Albertson-Gibb) (1)

This course provides hands-on data collection and analysis related to marine mammal conservation issues. Students learn to use computer software programs for data organization and analysis after field collection from marine mammals.

Fall 2012 Courses

*FW 407/507. MARINE SCIENCE SEMINAR (G. Boehlert) (1)
See list of seminar series speakers.

FW 419. The Natural History of Whales and Whaling (Alexander) (3)

This course addresses the natural history of whales as a unique example of adaptation in an evolutionary lineage, and the history of whaling as a general example of the failings of international resource management.

*FW 426/526. COASTAL ECOLOGY AND RESOURCE MANAGEMENT (Langdon) (5)

This course is an intensive, team-taught class designed to lay the foundation for students' understanding of coastal and marine ecosystems and resources. Topics range from the coastal forests to the open ocean and emphasize the linkages between basic science and management. Lectures, laboratories, field experiences, and seminar discussions in CERM will expose students in a variety of venues to the ecology and issues surrounding use of natural resources on the Oregon coast.

FW 421/521. AQUATIC BIOLOGICAL INVASIONS (Chapman) (4)

An overview of the background, theory, evolution, ecology, politics and conservation of invasions by introduced species in aquatic environments.

*FW 431/531. DYNAMICS OF MARINE BIOLOGICAL RESOURCES (Sampson) (4)

Strategies of marine fishery management. A synthesis of the principles of population dynamics for single- and multi-species systems from the viewpoint of a marine resource manager.

*FW 454/554. FISHERY BIOLOGY (Sc Heppell) (4)

Principles and methods used in studying the biology of fishes; ecological requirements of freshwater and anadromous fishes; principles and practices in sport fishery management.

*FW/Z 464/564. MARINE CONSERVATION BIOLOGY (Heppell/Hixon) (3)

Lectures, group library research, and class debates on current issues regarding the conservation of biodiversity in the sea. Topics include overfishing, invasive species, eutrophication, marine pollution, and global warming, as well as means of addressing these threats.

*FW 474/574. EARLY LIFE HISTORY OF FISHES (Miller/Ciannelli) (4)

Lectures and labs introducing the unique considerations of eggs, larvae, and juvenile fishes as well as conceptual and quantitative models associated with the role of early life history in ecology, evolution, and fisheries science.

OC 599. SPECIAL TOPICS IN OCEANOGRAPHY: Math on the Beach (Chelton) (3)

This program combines an intensive review of applied mathematics with scientific lectures and field trips exploring the coastal environment.

Winter 2013 Courses

BI/FW 111. INTRODUCTION TO MARINE LIFE IN THE SEA (Cheung) (1)

A field-focused learning experience, this inquiry-based course is a basic overview of the marine life and environment on the Oregon coast, including rocky shores, sandy beaches, mud flats, bays, estuaries, and watersheds.

*FW 407/507. Fisheries & Wildlife Seminar (Staff) (1)

*FW 599. SPECIAL TOPICS IN FISHERIES AND WILDLIFE: Genetic Monitoring of Fisheries and Wildlife (Baker) (2)

*FW/OC 599. SPECIAL TOPICS IN FISHERIES AND WILDLIFE: Introduction to Animal Bioacoustics (Klinck) (3)

*FW 699. SPECIAL TOPICS IN FISHERIES AND WILDLIFE: Fundamentals- Molecular Ecology (Baker) (1)

Spring 2013 Courses

BI/FW 111. INTRODUCTION TO MARINE LIFE IN THE SEA: Marine Birds (Suryan) (1)

A field-focused learning experience, this inquiry-based course is a basic overview of the marine birds on the Oregon coast.

BI/FW 111. INTRODUCTION TO MARINE LIFE IN THE SEA: Marine Mammals (Sumich) (1)

A field-focused learning experience, this inquiry-based course is a basic overview of the marine mammals on the Oregon coast.

BI 450. MARINE BIOLOGY (Hacker) (16)

A comprehensive lecture and laboratory introduction to the flora and fauna of the marine environment approached from the level of the organism to ecosystem. Ecological patterns and processes characteristic of marine communities emphasized.

FW 599. SPECIAL TOPICS IN FISHERIES AND WILDLIFE: Advanced Fundamental Molecular Ecology (Baker) (1)

VMB 727. ORNAMENTAL FISH MEDICINE (Miller-Morgan) (2)

To provide advanced instruction in the common aspects of ornamental fish medicine to forth year veterinary students. To provide background in husbandry of ornamental fish so that students will be able to discuss husbandry problems with owners of these species. To discuss practice management as it relates to incorporating ornamental fish into a practice.

Miscellaneous Courses of Note at HMSC

ALS 199 – U-Engage: Marine Science – Lunar Forces, Edible Sea Vampires and Other Curiosities of the Sea (Cheung) (2) 2012 Fall Term

HMSC Mentor Awards

Itchung Cheung, Academic Program Manager

Recipients of the HMSC Undergraduate Mentoring Award for their efforts to mentor and foster a lab-wide support system for undergraduate researchers.

Hatfield Student Organization (HsO) Activities

Itchung Cheung, Academic Program Manager

Co-Presidents: Matthew Gray and Cheryl Horton

Vice President: Renee Bellinger

Secretary: Alana Alexander

Treasurer: Becca Hamner

Communications Officer: Alana Alexander

Historian: Morgan Bancroft

Philanthropy Chair: Brian Arnold

Donut Chair: Nick Sard

Recycling Chair: Amelia Withcomb

Faculty Co-Advisors: Itchung Cheung and Sarah Henkel
Activities:

HMSC Community Building, HsO Holiday Raffle, OIMB/HMSC Scholar Exchange, HMSC Donut Break, HMSC Cook-offs and HsO Travel Awards.

Aquatic Animal Health Program

Tim Miller-Morgan, Extension Veterinarian, Aquatic Pets, Oregon Sea Grant

The Aquatic Animal Health Program (AAHP), supported by Oregon Sea Grant and the College of Veterinary Medicine, has completed a busy tenth year solidifying existing programs and expanding into new areas. Tim Miller-Morgan is the program lead and extension veterinarian overseeing this program. We have two new hires in the past year. Colleen Newberg is the Senior Aquarist and Sidney Stetson is the Research Aquarist. Colleen manages the animal exhibits in the Visitor Center, Education Wing and the teaching and research laboratory at HMSC. Sidney Stetson manages the husbandry of our teaching and research animals and supports the AAHP and Free Choice Learning (FCL) projects involving live animals. Harrison Baker, Noel Heinsohn, and Kristen Simmons serve as our student Aquarists. All of these individuals also assist Dr. Miller-Morgan with outreach and education.

The Ornamental Fish Health Initiative is the major outreach initiative within the AAHP. The purpose of the Ornamental Fish Health Initiative (OFHI) is to provide educational programming and service to the ornamental fish industry in Oregon and it's designed to assist wholesalers, retailers, and hobbyists with the successful rearing, husbandry, and health care of ornamental aquatic animals in the aquarium or pond environment.

We continue to disseminate health and husbandry information to the ornamental fish industry through our new blog, Words from a Wet Vet, <http://blogs.oregonstate.edu/wetvet/> and our updated web site, <http://seagrants.oregonstate.edu/extension/fishhealth/index.html>. Miller-Morgan also frequently consults with local ornamental fish producers, importers, retailers, and hobbyists on health and husbandry issues, USDA Accreditation, and health inspections for interstate and international animal shipments. These consultations originate not only in Oregon, but come from areas throughout the Pacific Northwest and the nation. In addition, recent consultations with stakeholders in Norway, Brazil, India, Japan, Indonesia, Malaysia and Singapore and the Netherlands continue to give an international flavor to the program. Miller-Morgan travelled to the state of Kerala, India to speak and lead farmer/exporter training sessions at the Sustainable Ornamental Fisheries Conference in Kochi, Kerala, India and the International Ornamental Fish Technical and Trade Conference, Jakarta, Indonesia. At both meetings he was asked to discuss the collection and transport of wild-caught ornamental fish. Further, he was requested to lead training sessions for Indian ornamental fish producers and Indonesian ornamental fish exporters related to fish health management and biosecurity within the ornamental fish industry. Miller-Morgan continues to work with local kopi, goldfish, and aquarium clubs.

Dr. Miller-Morgan continues to work with the University of Hawaii – Aquaculture Program to develop an online training program in aquaculture and aquaponics. This unique and global program, Aquaculture Training Online Learning (ATOLL), is designed to help train entry-level fish farm workers and individuals interested in developing backyard aquaponics systems. Dr. Miller-Morgan developed 4 modules and co-developed three other modules with Dr. Allen Riggs, aquaculture veterinarian for the State of Hawaii. To date there have been over 200 students participating in the online courses hailing from the U.S., Morocco, Mexico, Brazil, Palau, Costa Rica, Malaysia, Finland, Singapore, Bahamas, Portugal, Chile, Belgium, Zimbabwe, Vietnam, Ecuador, and Russia.

Dr. Miller-Morgan has coordinated, co-coordinated and instructed in multiple industry and veterinary professional seminars and workshops throughout the year, including: Advanced Koi Health Management for Hobbyist and the Pond Professionals, Point Defiance Zoo and Aquarium, Tacoma, WA; Aquatic Veterinary Medicine Sessions (27 hours), American Veterinary Medical Association Annual Conferences in San Diego, CA; International Zoo, Exotic and Wildlife Medicine Workshop – Fish Medicine Session, HMSC, Newport, OR; Koi Health Basics Workshop for hobbyists and new pond professionals, Point Defiance Zoo and Aquarium, Tacoma, WA.

The AAHP continues to consult with ornamental fish importers, wholesalers and retailers regarding emerging health management issues and development and implementation of biosecurity protocols within these facilities. We are currently working with a number of ornamental fish facilities in the Pacific Northwest, Israel and Southeast Asia.

The Ornamental Fish Health Program’s teaching and research laboratory continues to host numerous students from the Oregon Coast Community College – Aquarium Science Program who seek hands-on training in fish and invertebrate husbandry and health management. These students participate in one of three guided learning programs under the supervision of Colleen Newberg: Volunteer Aquarist Aides (20 hour minimum), Practicum Experiences (50 hour minimum), or Internships (400 hour minimum). In the past year we have provided these learning experiences for 5 Volunteer Aquarist Aides (average of 148 hours), 3 practicum students and 2 interns. We have also hosted 3 summer interns, 1 from the Department of Animal Science and 2 summer AQS interns.

We also offer regular back-wing tours of our teaching and research facility and we have seen significantly increased demand for such tours. These interactive tours follow an outline and script developed by AAHP staff and students. During the past year we led or facilitated at least 40 such tours.

The AAHP also provides veterinary care, consultation, and training to the research community at the HMSC. Dr. Miller-Morgan serves as the clinical aquatic veterinarian for the HMSC and all other OSU facilities. We offer training seminars for new faculty, graduate students, educators and volunteers that address recognition of disease and distress in aquatic animals,

occupational health and safety and the requirements associated with institutional animal care and use.

Sea Grant Youth and Family Marine Education **Tracy Crews, Marine Education Manager, Oregon Sea Grant**

During the 2012/13 year, 9109 K-14 students and other youth participated in marine education programs hosted by Oregon Sea Grant (OSG) at the Hatfield Marine Science Center. The majority of the youth served come with organized school groups from as far away as Idaho and Montana. Programs ranged from short classes in the field or wet labs, to multiple days worth of programming.

This year, two Careers in Science Investigation programs were held for high school students on the HMSC campus. A total of 121 high school students participated in these programs where attendees participated in activities such as DNA extraction, data collection in the Yaquina Bay, and the construction of small Remotely Operated Vehicles.

Three day-long Home School Day events were also held at HMSC, serving 258 pre-K through high school students. One program which was held in October 2012 introduced a new format, educating family groups as a whole, while two events held in March 2013 followed the traditional grade-band model and focused on marine engineering activities.

During 2012, Sea Grant ran five summer Day Camps at HMSC, providing field experiences and hands-on programming for 77 campers, ages 5 and up. Oregon Sea Grant staff also partnered with other precollege programs at OSU (4-H, CAMP) and at other organizations (Upward Bound, OMSI) to provide additional field experiences for middle and high school aged youth during the summer.

A series of three two-hour, interactive Family Programs for ages 4 and up were also run for 41 participants at HMSC last summer by OSG staff. OSG also partners with staff from the Center for Microbial Oceanography Research and Education (CMORE) to run an OceanFest family program at Newport Intermediate School which was attended by thirty-five 3rd-6th grade students and their parents.

In addition to educational activities at HMSC, Oregon Sea Grant staff from HMSC also provided outreach at several other annual events including Newport Wild Seafood Weekend, Oregon Science Teachers Association Conference, National Science Teachers Association Conference, 12th Annual MATE International ROV Competition, and the Lincoln County School District Ocean Literacy Symposium.

Professional development opportunities were also provided at Hatfield Marine Science Center for 5th through 12th grade teachers from Oregon. One daylong program highlighted new NOAA Office of Exploration and Research curriculum “How Do We Explore?”, providing resources and hands-on activities to twenty-

four 5th-12th grade educators. In addition, Oregon Sea Grant partnered with the Marine Advanced Technology Education (MATE) Center to hold a professional development workshop on student built ROVs (Remotely operated Vehicles) at HMSC for ten 6th-12th grade teachers. During this workshop, teachers were paired with engineering mentors from NOAA MOC-P who assisted them in the wiring and building of small ROVs. These mentors then went into classrooms to assist students in the same engineering design process.

Oregon Sea Grant staff also coordinated the Second Annual Oregon Regional MATE ROV Competition, held in Lincoln City in May 2013. Several hundred elementary through college students participated in the Oregon Regional MATE ROV program creating student-built underwater robots of increasing complexity. Twenty-three of these teams then participated in the Oregon Regional MATE ROV competition which was made possible through the contributions of 26 volunteers from OSU, NOAA, EPA, and the Marine Technology Society. Two of these teams qualified and advanced to the MATE International ROV Competition in Federal Way, Washington in June 2013.

Ocean Literacy Symposium (OLS): OSG staff partnered with the Lincoln County School District and the Oregon Coast Aquarium to coordinate the second annual Ocean Literacy Symposium, held at HMSC, the Oregon Coast Aquarium, and other sites around Newport. This event is a day-long, ocean-themed professional development opportunity for 350 local teachers and administrators. Marine researchers, informal educators, and extension specialists provide teachers with current information and educational resources to effectively teach about ocean issues in their classrooms

Oregon Coast Regional STEM Center: OSG is also a partner in the Oregon Coast Regional STEM Center, providing Professional Development for 24 Lincoln and Tillamook County 3rd-8th grade teachers on STEM integration using Project Based Learning around natural resources topics. Activities included day long workshops, an online PLC, STEM Fair, and weeklong summer workshop. Projects undertaken during the first year by teachers and their students included climate change, alternative energy, salmon and watersheds. Participant feedback was very positive with over half of the participants signing up to continue the program next year.

Working under a NOAA B-WET grant, the Oregon Coast Education Program (OCEP) continued to partner Oregon Sea Grant with several other institutions (South Slough National Estuarine Research Reserve, Oregon Institute of Marine Biology, Oregon Coast Aquarium, High Desert Museum, Portland State University) to provide resources and professional development training for teachers seeking to teach about the coast and ocean, and to provide meaningful field experiences for students. In the spring of 2013, the first two OCEP-developed Coastal Education Modules were moved from a working wikispace site to the [OCEP Resources webpages](#) on the public Northwest Aquatic and Marine Educators website. OCEP held a 3-day workshop at the coast in August 2012 for 17 teachers, and provided logistical and funding support to trained teachers through the school year as they

planned and carried out their coastal education plans and field experiences. In June 2013, OCEP held two 3-day workshops at the coast for 21 teachers who will carry out their plans in the 2013-2014 year. The majority of teachers involved in OCEP during the 2012-13 fiscal year reside and teach in *inland* Oregon communities.

Oregon Coast Quests is a place-based education program at Oregon Sea Grant that uses clue-directed hunts to encourage people of all ages to get outside and explore the natural, cultural, and historical ‘treasures’ of Oregon’s coastal communities. This free-choice, self-guided learning activity is both low-cost and low-tech so as to reach young, underserved, and general populations.

This year, the program received a \$3,073 grant from the Siletz Tribal Charitable Contribution Fund to print 800 copies of the newest edition The Oregon Coast Quests Book. Editing and layout of the book was provided by Rick Cooper at OSG Communications. The 2013/14 edition contains updated directions for 26 Quests in Lincoln, Coos and Benton counties. Six of these Quests are new to publication, one Quest is available in both English and Spanish, and ten of the Quests were created by youth. The books are distributed to the public through 14 local retail locations and online through Powells.com, and funds from book sales support the Oregon Coast Quests program. So far, 400 books have been distributed. We expect the book to be used by the public until at least the end of 2014, and (as with previous editions) updates will be posted on the Oregon Coast Quests website.

Throughout the year, Oregon Coast Quests supported community members and organizations as they created, updated, and maintained Quests. Two new Quests were created during the 2012-2013 fiscal year:

- Heirloom Orchard Quest – Oregon Coast Quests worked with 14 7th/8th grade students at Eddyville Charter School to help them create a Quest in the apple orchard across the street from their school. The Quest was tested by an additional group of 14 7th/8th grade students.
- HMSC Nature Trail Quest – This Quest replaces an older hunt that had to be retired when the trail was partially closed due to erosion. The new Quest includes information about the dynamic revetment used to curb shoreline erosion. To date, more than 100 people have completed the HMSC Nature Trail Quest.
- In addition to helping people create, update and maintain Quests, Oregon Sea Grant staff provided outreach with Quests in HMSC Marine Education programs, Visitor Center programs, at Lincoln City Community Days, Newport’s Wild Seafood Weekend, and at the Lincoln County School District’s Ocean Literacy Symposium.

More and more schools are using Quests during field trips. For example, in just the last two weeks of school alone, 340 students went Questing during field trips:

- Two 3rd grade classes and one 4th grade class from Taft

Elementary headed out to do the Taft Pioneer Cemetery Quest and the Taft Stormwater Quest. (68 students)

- Five classes of Newport Intermediate students 6th graders did the South Beach State Park Quest and the Bayfront Quest. (125 students)
- A 5th grade class from Yolanda Elementary in Eugene came to Newport to do the HMSC Nature Trail Quest. (27 students)
- 4th through 8th grade students from Westside Village Magnet School in Bend went on the HMSC Sustainability Quest with their chaperones. (120 students)

The Oregon Coast Quests website continues to be a straightforward way to communicate with the public about Quest activities and news: <http://hmsc.oregonstate.edu/visitor/oregon-coast-quests> . Subscribers of the OSU “Quest-News” mailing list (n=310) received seven updates through the year sharing news and information about Oregon Coast Quests. In addition, Quests were the focus of two media articles:

- Article: “No Rest in This Quest” in Oregon Coast Today, April 2013.
- Article: “Questing for Fun and Knowledge” in OSG’s Autumn publication of Confluence.

III. RESEARCH AND EDUCATION SUPPORT

HMSC Director's Office

Maryann Bozza, HMSC Program Manager

The HMSC Director's Office, reporting to the OSU Research Office, manages the 49-acre HMSC campus and promotes interdisciplinary and interagency collaboration and cooperation. Director's Office functions include strategic planning and annual reports, administration of the numerous interagency committees that contribute to campus-wide policy and strategic decisions, and maintenance of HMSC's infrastructure including IT, buildings and seawater system infrastructure.

The past year was marked by change and transition at HMSC. Dr. George Boehlert, HMSC Director since 2002, retired in September 2012. The HMSC Community celebrated his retirement and his decade of service to HMSC with a retirement party on September 29, after which he graciously returned to serve as interim director through December 2012. With a new director not yet announced, Janet Webster stepped up to serve as interim director on Jan 1, 2013, in addition to her existing position as head librarian of OSU's Guin Library at HMSC. In addition to "keeping the boat afloat", she advanced a number of initiatives during her short tenure, including progress toward the educational program expansion at HMSC. On July 29, 2013, Dr. Robert Cowen, presently at the The Rosenstiel School of Marine and Atmospheric Science at the University of Miami will take the reins as HMSC's new director.

In 2011, the OSU Provost convened an implementation task team to explore the key questions raised by reviewers in the HMSC External Review, with the intent of strengthening HMSC's role in the overall strategic direction of the University. The next step of this strategic planning process was undertaken in 2012, with the Educational Needs Assessment as recommended by the Task Team. Headed by HMSC faculty Dr. Rob Suryan, the Assessment Team conducted focus groups, interviews and an electronic survey to collect input on HMSC's opportunities and challenges to expanding HMSC's Educational Programs. The Assessment will be completed in August 2013.

The second annual Marine Science Day event was held on Saturday, April 13, 2013 on the HMSC campus, with approximately 2000 attendees. As an all-day open house for OSU and the six federal and state agencies on the HMSC campus, as well as HMSC's South Beach marine science partners (Oregon Coast Aquarium and NOAA Marine Operations Center – Pacific), Marine Science Day consisted of tours, displays, demonstrations, and presentations. In addition to new Visitor Center exhibits and special activities, marine scientists and educators presented over 30 exhibits 'behind-the-scenes' at HMSC. The interactive event fostered a direct connection between marine scientists and visitors of all ages, and celebrated the research, education and outreach components of HMSC's mission, highlighting HMSC's collaborative partnerships.



HMSC's annual Tsunami Evacuation Drill was conducted in 2012 in two parts. The first, on October 14, evacuated to HMSC's closest site, Safe Haven Hill at the base of the Yaquina Bay bridge's southwest corner. A team of community partners led by Newport Police assisted by briefly closing Highway 101 so "evacuees" could cross safely to access the trail to the top of the hill. The second drill, conducted in conjunction with Great Oregon Shakeout, a statewide earthquake drill, evacuated to Community College Hill. It again included all of Newport's South Beach Peninsula's marine science and public-serving organizations located in the inundation zone.

The HMSC Director's Office collaborated with Oregon Sea Grant, the City of Newport and other partners to design and install an exhibit featuring a piece of the 'tsunami dock' that was released by the devastating March 2011 earthquake in Japan, landing on a Newport beach over a year later. The exhibit highlights the dock's journey, the potentially invasive species found aboard, and tsunami awareness and preparedness, and serves as the start of a tsunami interpretive trail to the top of Safe Haven Hill. HMSC's preparedness efforts were recognized in June 2013 with the designation of NOAA TsunamiReady Supporter, as part of the TsunamiReady Community designation earned by Lincoln County.

Finally, the Director's Office staff designed and launched a new website in May 2013, at hmsc.oregonstate.edu. This and other Annual Reports can be accessed under the 'About' tab.

Guin Library

Janet Webster, Librarian

The Marilyn Potts Guin Library fills a unique role at HMSC and in the Pacific Northwest: we are the resource for scientific information on Oregon's coastal and marine environment and strive to provide great service for all working in this environment and the broader NE Pacific Ocean. Some say that we are one of the best marine and estuarine libraries in North America. What does that mean? It's a combination of the expertise, collections and space.

The three person staff has a combined work history at the Guin

Library of over 64 years. That means we know what is where and how to get it so we can readily respond to the requests of our users and even anticipate some of them. This year, Judy Mullen has refined our scan and deliver service in concert with the Valley Library, OSU's main campus facility. This allows us to get materials quickly to people whether it's in print on our shelves or digitally stored. We have tracked down people who worked on an early OSU research vessel in search of its construction history. We help people identify what they find on the beach through our library resources as well as putting them in touch with HMSC experts.

Our collections grow but in ways that are difficult to see. The OSU Libraries had made a commitment to provide access to electronic books and journals when possible. Hence, our print new book shelf is sparse. In addition to our regular 'new book list', Susan Gilmont generates a 'new e-book list.' The technology is not perfect; in fact the e-book publishing world has a ways to go before all platforms are simple to use. This shift allows us to readily share books across the OSU campuses. The changeover to e-journals is almost complete. A few trade journals and some smaller associations' publications are still in print only. Some are just more readable in print. This transition is opening up space for other uses.

The third element that makes us one of the best is our space. We have been removing outdated books and those no longer relevant to the teaching and research at HMSC to make way for renovated reading and work spaces. The Guin Library was opened in 1990 and it's time to rethink how it works physically. We have the plans for our renovation that include two new meeting spaces and more reading room. We anticipate construction this fall.

Notable activities and events:

- The Oregon Estuaries Bibliographies have migrated to an easy to use web interface. Links to digital items are included. <http://guin.library.oregonstate.edu/oregon-estuaries>
- The HMSC Bibliography is also migrating so people will be able to search for HMSC authors and find their work. <http://hmsc.library.oregonstate.edu/>
- Susan Gilmont created a wonderful exhibit on Citizen Science in time for Marine Science Day.
- Judy Mullen developed an exhibit on Privacy in Peril that is the culmination of her exploration of the issue.
- Janet Webster received the Distinguished Service Award from the Oregon Library Association at its annual conference in 2013.
- Janet also served as the interim Director of HMSC from January through July of 2013. This suggests how well the library and its staff are integrated into HMSC and its ongoing operations.

Notable Publications from HMSC: We are changing how we report publication by HMSC authors. We are switching to a calendar year so this year's list is for 2012. It is available at <http://hmsc.library.oregonstate.edu/>. Here are some selected publications that highlight the breadth of research at HMSC.

Baker, E. T., Chadwick, William W., J. P. Cowen, Robert P. Dziak, K. H. Rubin, and D. J. Fornari. "Hydrothermal discharge during submarine eruptions: the importance of detection, response, and new technology." *Oceanography*. 2012. v.25 (1): 128-141

Chadwick, W. W., Jr., Dziak, R. P, Haxel, J. H., Embley, R. W and Matsumoto, H. "Submarine landslide triggered by volcanic eruption recorded by in situ hydrophone." *Geology*. 2012. v.40 (1): 51-54.

Tomaro, Londi M., Teel, David J., Peterson, William T., and Miller, Jessica. "When is bigger better? Early marine residence of middle and upper Columbia River spring Chinook salmon." *Marine Ecology Progress Series*. 2012. v. 452: 237-252

Rupp, David E., Wainwright, Thomas C., Lawson, Peter W. and Peterson, William T. "Marine environment-based forecasting of coho salmon (*Oncorhynchus kisutch*) adult recruitment." *Fisheries Oceanography*. 2012. V. 21 (1): 1-19.

Ortega-Ortiz, Joel G., Engelhaupt, Daniel, Winsor, Martha, Mate, Bruce & Hoelzel, A. R. "Kinship of long-term associates in the highly social sperm whale." *Molecular Ecology*. V.21(3)(Special Issues): 732-744.

Nieukirk, Sharon L , Mellinger, David K., Moore, Sue E., Klinck, Karolin, Dziak, Robert P. and Goslin, Jean. "Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999-2009." *Journal of the Acoustical Society of America*. 2012 v. 131 (2): 1102-1112.

HMSC Facilities

Jim Lewis, Facilities Manager

Fiscal year ending 2013 began in July with the impending expiration of HMSC Facilities operation and maintenance contract for NOAA's Barry Fisher building, Newport Aquaculture Lab and Research Support Facility. HMSC's successful bid included a fresh and comprehensive technical proposal prepared by HMSC facilities and an equally accurate and detailed financial proposal provided by Bob Moch in the AMBC, which resulted in HMSC being awarded a 5-year contract.

The cycle of upgrading aging finishes in labs, classrooms and offices continued in FY 2013. Upgrades included new cabinetry, asbestos abatement, floor coverings, paint, window treatment and office and classroom furniture. Not all of these improvements occurred in each space. The upgraded rooms include Education Wing classrooms 28, 30-32 and 34, East Wing DNA lab 151, post doc room 155 and dry lab 137.

Summer highlights in the Facilities group include the acquisition of key equipment chosen for their increased improvement in staff productivity and short return on investment. For custodial, a Kai-

Vac cleaning and disinfecting device was purchased as well as a propane power buffer for vinyl tile areas, an all-electric grounds truck, a suitcase type portable welder and a wood planer/mill for custom wood working projects. The most fun part was being invited to participate in the preparation of former director George Boehlert's retirement party. The facilities team assisted in the making of a memorable event.

In Fall our tsunami drill was well attended, complete with mock hazards including a downed power line prop. HMSC Facilities was fortunate to recruit CAS Dive Safety Officer Kevin Buch to conduct CPR/First Aide training for no fewer than 28 people in several HMSC departments. November and December brought some of the highest and most destructive King Tides on record to the nature trail. Along with the high water came a large amount of debris from up river including a 4'x10' 3000 pound concrete dock section and 32 polystyrene filled tires washing up on our eastern shore line. The tires are slated for use in an art project focusing on marine debris by the Artula Institute for Arts and Environmental Education near Bandon. The dock was towed across the bay to port dock 5 and disposed of by HMSC Facilities.

Early in the New Year, Facilities was surprised at the announcement of the delivery of a 104,000 pound polystyrene filled concrete dock section to be placed on the visitor's center lawn as an "exhibit". The piece was a remnant of the dock torn loose from its moorings in Misawa, Japan that landed at Agate Beach in June. Facilities helped to formulate a much better solution, with the piece being stored off site while being fitted to the original design specifications. Facilities coordinated the saw-cutting of the display piece to a manageable 11,000 pounds and its transport and placement atop a display pedestal designed and built by the crew. The Director's Office allowed another organization to take a similar sized piece to be displayed on Newport's bay front as a tsunami awareness display. The remaining 82,000 pounds of concrete and steel fell to a wrecking ball after Facilities removed and disposed of the 700 ft³ of polystyrene inside it.

The Facilities staff grew by one with the addition of Melody Pfister in January, and also welcomed several new employees as other members of the staff moved on.

Spring was the focus of several projects. A few highlights are lab 137 asbestos abatement, the re-fit and repair of a portion of building 917 for ocean acidification research, assistance in the set-up of Marine Science Day and the first phase of the cleaning of the ducting in the 900 building. Finally, a variety of diverse projects included the nature trail re-opening, designation of a transit authority bus stop for the Coast to Valley bus route, and major repairs to the mobile II housing unit such as sub floor replacement, new floor insulation, carpet, kitchen cabinets, and paint. These diverse projects have one element in common - a facilities crew whose teamwork, skill, hard work and can-do attitude helps set the stage for the research, education and outreach activities of OSU and HMSC's many partners.

Ship Operations

Stewart Lamerdin, Marine Superintendent

Oregon State University's (OSU) College of Earth, Ocean and Atmospheric Sciences (CEOAS) operate the 185- foot Research Vessel (R/V) *Oceanus* and the 54-foot R/V *Elakha*. OSU is one of 15 vessel-operating institutions in the University-National Oceanographic Laboratory System (UNOLS). The Ship Operations office and pier facility are located at the Hatfield Marie Science Center in Newport, Oregon. The R/V *Oceanus* is owned by the National Science Foundation (NSF) and is operated by OSU under a cooperative agreement.

The Office of Naval Research and NSF combined to fund 170 days of ship-time on the R/V *Oceanus* in 2013cy. This schedule represents 16 different individual cruises that took the ship from South East Alaska to as far south as the California border and out 200 miles. These cruises were led by scientists from numerous different institutions including OSU, University of Washington and University of Hawaii to name a few.

Planning for the 2014cy schedule for the R/V *Oceanus* is also well underway. At this time, the ship is expected to be at sea for approximately 200 days next year with cruises scheduled to take the ship north to the Columbia River and south to San Francisco and possibly work along the equator. OSU researchers will be leading a number of these cruises. In addition to a busy cruise schedule, the ship is also planning to complete a challenging shipyard period that is likely to last approximately two months. This shipyard period is part of a haul-out schedule required by federal regulations in order to keep the ship in the best possible condition. We hope to also address other maintenance related issues that can only be completed while the ship is out of the water.

In addition to a challenging cruise schedule in 2013, the operation also saw the retirement of one of its most talented and committed crew members. Chief Engineer Bob Ashley retired June 2013 after sailing over 30 years for OSU. Bob started as an Oiler on OSU's research vessel *Yaquina* in 1969, sailed on UW's *Thomas G. Thompson* (the predecessor to the current *Thompson*) for several years and returned to OSU's R/V *Wecoma* in 1988. He quickly worked his way up to Chief Engineer and continued in this capacity through the life of R/V *Wecoma* and then onto R/V *Oceanus* when she came to OSU in 2012. Bob's years of service to OSU, CEOAS and Ship Operations are much appreciated and he will be missed.



Bob Ashley (left) receiving a much-deserved token of appreciation from retired OSU Marine Superintendent Fred Jones (right).

The R/V *Elakha* is another research vessel operated by OSU. This 54-foot vessel supports research and education in Coastal waters, bays and estuaries from Southern Washington to Northern California. This year the *Elakha* has conducted a variety of research programs and educational activities including those for: HMSC, F&W, CEOAS, PISCO, School of Electrical Engineering & Computer Science (EECS), Zoology, Microbiology, and the OSU/NOAA Cooperative Institute for Marine Resource Studies (CIMRS). The R/V *Elakha* will likely be hauled out in the winter of 2013 at the Port of Toledo Boat Yard for scheduled maintenance and upgrades that should help to keep her operating smoothly well into the future.

The OSU ship operations department had a number of other exciting events that took place in 2013cy. Perhaps most significant was the awarding of a contract from the National Science Foundation to design and manage the construction of new oceanographic research vessels. The NSF intends to invest approximately \$300 million in updating the nation's aging fleet of oceangoing research ships and it has chosen Oregon State University to lead the effort. OSU will receive up to \$3 million to coordinate the design and supervise the construction of up to three, 175-foot research vessels. More details on this exciting project can be found at the following website: <http://ceoas.oregonstate.edu/ships/rcrv/>

Associated with this project however was a change in leadership at OSU's Ship Operations. Demian Bailey has moved on to lead the team responsible for the design and construction of the new vessels. His replacement, Stewart Lamerdin, came to OSU from Moss Landing Marine Labs (CA) where he also managed a marine operations department. We are fortunate that Demian will still be in the area and available to assist with this transition. We would also like to thank Demian for his service in support of Ship Operation and especially for his leadership during the very challenging time of the R/V *Wecoma's* retirement and the transition to operation of the R/V *Oceanus* by OSU.

Finally, the OSU Ship Operations facility itself (buildings and pier) remained busy in 2013cy supporting a variety of visiting vessels from institutions and agencies including: MBARI, USCG, US Army Corps of Engineers, SIO-UC San Diego, Moss Landing Marine Laboratories, Lamont-Doherty Earth Observatory-OMO, Stabbert Maritime and the University of Washington. The pier itself also supported a number of research projects. A list of some of these projects included the following projects:

- **Rob Suryan** – OSU-HMSC- Associate Professor -design a multi-sensor array for remotely detecting bird and bat strikes on offshore wind turbines.
- **Tracy Crews** – Oregon Sea Grant - collect mussels from man-made structures. We use the mussels for teaching classes and to feed our sea stars.
- **Walt Waldorf** – CEOAS - The Northwest National Marine Renewable Energy Center (NNMREC) for staging mooring gear.
- **Jessica Miller** – OSU-HMSC Associate Professor - capture larval anchovy. Sampling larval and juvenile anchovy and

invertebrates through the fall transition. Waterproof lights were placed inside plastic traps that were routinely fished at night.

- **Colleen Wall** – Grad Student (Burke Hales)-CEOAS - Water sampling for measuring pCO₂ and TCO₂ for thesis-related research
- **Amy Lindsley** – OSU F&W - Graduate Teaching Assistant – Fish trapping on the pier early in the am and some weekends.

If you have any questions about the vessels or the facilities here at OSU's Ship Operations, please do not hesitate to contact us directly at the following number: 541-867-0295. Additional information can also be found at the following website: <http://ceoas.oregonstate.edu/ships/> .

IV. PUBLIC OUTREACH & EXTENSION

OREGON SEA GRANT FREE-CHOICE LEARNING EDUCATION PROGRAM

Sea Grant, Visitor Center

Shawn Rowe, Free-Choice Learning Lead, Oregon Sea Grant Public Programming

The Visitor Center (VC) attracted just under 150,000 visitors from July 2012-June 2013. While visitors come from all over the world, nearly 90% of visitors came from the Pacific Northwest and over three hours drive from Newport. Public programs included special events, speakers, and public necropsies for Shark Day, Fossil Fest, and World Turtle Day, programs that bring in large numbers of visitors during winter months when tourist traffic is usually low. Special public programs were offered each month. The current schedule can be viewed on-line at: <http://hmsc.oregonstate.edu/visitor/exhibits-and-events>. Sea Grant VC volunteers and staff also participated in the 2013 Marine Science Day activities as well as the Lincoln County Science Fair. Four undergraduate summer interns helped develop and run public programs, research and evaluation efforts, and carry out their own projects to link HMSC researchers with public audiences in 2012. We continued also to offer daily educational programming consisting of: Guided tours of the Yaquina estuary, animal feeding demonstrations, and daily auditorium research programs.

New Exhibits: Sea Grant staff working with external funders, HMSC staff, OSU and HMSC faculty, and outside vendors created almost a dozen new exhibits and exhibit areas for the Visitor Center. The largest of these included three **interactive wave tanks** funded largely by National Science Foundation and with support from OSU's Research Office, the Oregon Wave Energy Trust and the Northwest National Marine Renewable Energy Center. The three tanks were complemented by new signage on wave energy in Oregon waters as well as K-12 classroom kits and professional development for teachers to use both the kits and the exhibit. Final updates were also made in partnership with Dr. Rob Suryan on an exhibit feature Albatross and research on reducing Albatross bycatch. Other new exhibits included exhibits on Upwelling (PISCO), Marine Mammal Life History Transmission Tags (Horning), two new remote sensing exhibits, and updated fossils and marine mammals display cases.

Exhibits in progress as of June include mathematical modeling of estuarine systems (Lerczak); Trawl industry history, current practice, and management, (Oregon Trawl Commission); new Aquatic Animal Health and Ornamental Fish including new coral reef tank and nursery; and new exhibits on Biomedical research using fish.

We began significant development of new and updated outdoor exhibits with the installation of the Japanese Tsunami Dock including signage on invasive species and tsunami danger, and updates to the existing wave energy buoy and solar panels in

front of the VC. A new Tsunami Evacuation Interpretive Trail was completed this year as a partnership among DOGAMI, State Parks, the City of Newport and the Port of Newport, Sea Grant, HMSC and ODOT. The trail leads from the front of the VC to the evacuation site at Safe Haven Hill.

Auditorium updates: Over Fall and Winter, the Hennings Auditorium received a major makeover beginning with cement cutting to cut slots in the stage to conceal cables from the podium and to create power and microphone connections in the middle of the stage for panel and other presentations. The stage was also carpeted, received new trim, and Bob Miller constructed a new cabinet to contain the AV equipment. We removed the last row of seats to create a transit aisle from one side of the auditorium to the other. Deep cleaning was followed by installation of new LED light fixtures, which required refitting all of the ceiling cans for the lights. Updates to the presenter podium and user interface for making presentations followed. The result is an improved experience for presenters as well as audiences and improved capacity for onsite and remote participation.

Bookstore: For many years, Oregon Sea Grant operated a bookstore in the VC. Like many independent bookstores nationally, the HMSC VC bookstore has struggled in recent years, eventually becoming a significant financial burden. In summer of 2012 HMSC staff and student surveys, visitor surveys, and an outside evaluation were conducted to determine best ways to continue to operate the bookstore. After lengthy consultation, Sea Grant decided to close the existing store and begin negotiations with several vendors who could potentially fill the space. As of June 2013, bids had been submitted and were under review.

Research - Further development and deployment of cyberlab data collection infrastructure and tools: With substantial funding from National Science Foundation, and building on the deployment of the human observation system associated with our Cyberlab research effort, we expanded coverage of the VC floor and integrated audio-data collection devices to achieve consistent data collection across a visit to the VC. Year 2 infrastructure development focused on complete coverage of the half of the VC – from the front entrance through the physical space occupied by the Wave Tank Build and Test Research Platform. Mark Farley continued to work closely with development partner Media Macros, Inc. to integrate changes in the identified face detection system so that it continues to work with the video collection system and database. In laboratory tests, the face detection achieves a relatively consistent 85% re-recognition rate. The full system is being installed in July 2013, and full time data collection begins at that time. We also continued to develop human studies and camera access protocols for research and evaluation purposes working closely with OSU's Institutional Review Board office to secure continuing approval for use of camera, audio, and face-detection system for research and education in a public educational venue. We believe that our IRB protocols will be of great interest widely in the field of informal science education and beyond.

Findings related to two Cyberlab related research efforts were

presented in 2013 in publication or academic presentations:

1) Eye-Tracking and data visualizations in exhibits on remote sensing, 2) combining visitor-worn data collection devices with other Cyberlab systems for studying docent/visitor interaction, and 3) needs assessment for climate change exhibit.

1) Eye-Tracking and data visualizations in exhibits on remote sensing. Eye tracking tools are an important and proven tool for understanding orientation in space, reading, and making sense of complex visual data like maps. In June 2013, Cyberlab Graduate Research Assistant Kathryn Stofer presented her dissertation findings related to comparisons of expert and novice users of complex visualizations of geo-science data using clinical interviews and eye-tracking technology.

2) Combining visitor-worn data collection devices with other Cyberlab systems for studying docent/visitor interaction. Research on the practice of docents working in informal science education institutions has been scarce. One of the promises of the Cyberlab observation system is the possibility to carry out research on docent practice as part of exploring visitor learning. In June 2013, Cyberlab Graduate Research Assistant Laura Dover Good presented her dissertation outlining findings related to analysis of docent practice at the Hatfield Marine Science Center Visitors Center. Her data collection employed interviews with docents as well as equipping visitors with data collection devices (over-the-ear worn video cameras) that provided video data that was reviewed in further interviews.

3) Needs assessment for climate change exhibit. Julie Nance, an undergraduate intern, completed a needs assessment related to content and format of an exhibit on climate change in Summer 2012.

Connecting to the Public School System: Under the direction of Bill Hanshumaker, we continued to develop programs to integrate formal K-12 science curriculum with the VC and free-choice learning efforts. A new Wave Energy curriculum was disseminated to educators statewide through the OCAMP project and partnership with the SMILE program at OSU.

HMSC Visitor Center Volunteers

Rebecca Harver, Volunteer Coordinator

During FY 12/13, the HMSC had 94 volunteers who contributed 10,713 hours of service to Visitor Center operations. New volunteers were recruited throughout the year, mostly through word of mouth. This recruitment method enabled us to add 18 individuals to the volunteer corps.

Volunteers are critical to the success of the Visitor Center. They greet many of the 150,000 annual visitors, orient them to the center, and provide educational information related to live animals and exhibits in addition to general marine science. Volunteers also contribute to daily operations by assisting with animal husbandry duties, creating and updating display signage, assisting in exhibit maintenance and development, assisting in administrative duties, and were integral to the training of the 2012 Oregon Sea Grant Summer Scholars. Additionally, throughout the summer of 2012, 12 volunteers contributed

210 hours of service interpreting at Port Dock 1 on Newport's Historic Bayfront. Port Dock 1 volunteers aided in alleviating visitor safety issues and educated visitors about topics including: working waterfronts, history of the area, and natural history information related to California sea lions and other wildlife. The volunteers' enthusiasm for life-long learning and desire to share information created memorable experiences for visitors.

Monthly meetings and training sessions were held throughout the year to provide volunteers with new information and to enhance communication between volunteers and staff members. Training topics included (among others): Oregon Marine Reserves, Beaver Creek State Park, marine life found on the dock from Japan, and information about the Surfrider Foundation. In November 2012, volunteers toured the NOAA Research Vessel Ka'imimoana. In February 2013, volunteers received a tour of the Research Vessel Marcus G Langseth while it was docked at the HMSC. Eight volunteers attended the 2012 Pacific Northwest Docent and Volunteer Association Conference during September 20 – 23, held at the Oregon Zoo in Portland, Oregon.

Volunteers' efforts were recognized on a daily basis and were also celebrated at a summer bbq at HMSC Director George Boehlert's home, a holiday potluck in December, at the annual Volunteer Appreciation Dinner and throughout National Volunteer Appreciation Week in April.

Civic Activities

Maryann Bozza, HMSC Program Manager

HMSC is an active member of the local and regional community. Locally, we engage the Oregon Coast community through outreach, including news media, a Visitor Center volunteer program and a local radio program. HMSC is also engaged in public processes, through partnerships with Lincoln County School District, the Port and City of Newport, Lincoln County and a number of local organizations.

The "Friends of HMSC" group serves to communicate our activities to a broader audience. Collectively, we serve as a marine science resource for state and national leadership, partner with marine industries including fisheries and ocean renewable energy, and serve on regional, national and international advisory boards including the West Coast Governor's Agreement on Ocean Health, the International Whaling Commission, and the Governing Council and several working groups of PICES, the International North Pacific Marine Science Organization.

The reputation of the Hatfield Marine Science Center in the community is enhanced by employees' active involvement in a wide range of civic and philanthropic activities. Throughout Lincoln County and beyond, faculty, staff, students and agency employees alike are known in their local communities for their volunteerism and service to schools, charitable and public service organizations, local government, youth recreation and sports, and in the visual and performing arts communities. Many boards and elected bodies had HMSC personnel serving in leadership

positions in 2012-2013, including Oregon Coast Council for the Arts, Newport Symphony, Partnerships in Education, City of Newport, Waldport City Council, Economic Development Alliance of Lincoln County and Yaquina Bay Economic Foundation.

Schools are a particular area of focus for HMSC researchers and staff volunteering their time, and volunteer activities during 2012-2013 included many HMSC scientists who served as mentors for teachers and students and organized a science fair hosted by the HMSC Visitor Center. Other community activities included invasive species removal, fundraising for the local food bank and American Cancer Society Relay for Life, and an HMSC-hosted blood drive.

As a visible and respected institution, the HMSC is also seen as a place for civic engagement, providing meeting space for various community-oriented meetings throughout the year. Visitors included elected officials (US Representative Bonamicci, State Senator Roblan, State Representative Gomberg, Newport Mayor Roumagoux and Lincoln County Commissioner Hall, and staff from the office of US Representative Schrader) or their staff for briefings on marine topics of interest to their constituents and leadership of federal and state agency partners. HMSC also participated in OSU Day at the Capitol on April 17, 2013.

Friends of HMSC

Maryann Bozza, HMSC Program Manager

The Friends of Hatfield Marine Science Center is a membership organization of donors and supporters of HMSC's research, outreach and education mission. Financial contributions from the Friends provide support for a wide range of programs, including public lectures, a newsletter (<http://hmsc.oregonstate.edu/upwelling-newsletters>) and other outreach activities, which serve to communicate HMSC research and marine science issues to a broad audience. Donations of volunteer time by members combined with financial contributions support a wide range of innovative marine science education programming for the general public and targeted audiences. Friends of the HMSC events in 2012-2013 included an event with a hands-on lab, a lecture and a reception featuring NOAA scientist Bill Peterson's research on zooplankton. In addition, the Friends hosted five "Science on Tap" events, including presentations on citizen science, ocean energy and bycatch, and a well-attended film screening (*Between the Tides: The Legacy of Ed Ricketts*).

The Friends of HMSC remain a key source of support for graduate student research at HMSC. In total, over \$80,000 was awarded this year to students in a diversity of departments and colleges within Oregon State University. All of these funds originated from private donations to the Hatfield Marine Science Center's programs over the past several decades; they now reside in endowments that will provide perpetual support to these important programs.



2013 Friends of the HMSC members only event at HMSC

Donor Honor Roll

Annual Support of the Hatfield Marine Science Center:

The Honor Roll recognizes HMSC's annual supporters who have made outright gifts or pledge payments totaling \$100 or more between July 1, 2012, and June 30, 2013. Donors making new pledges will be recognized in the appropriate level as their payments are received.

- Susan L. & George W. Boehlert
- Richard E. Bohn '76
- Pamela C. Weber & Ronald D. Bonham
- Ralph & Donelle Breitenstein
- Monita L. Hantze-Cheever & Jeffrey L. Cheever '78
- Finding 52 LLC
- Walter E. Frick '94
- Shirley M. & William T. Golden
- Janet Williams Hanus '71 & Joe Hanus
- John P. Hennessey, Jr. '78
- Karen Locke
- Mark Miranda
- National Fish and Wildlife Foundation
- Wendy Adams Niem '76 & Alan R. Niem
- Jerryann & Robert E. Olson
- Linda L. & Willard Osborn
- Jane St Ledger Partridge
- Gail B. & Steven H. Peterson '66
- Marcia R. Richard '12
- John F. Savage '75
- John Sherman
- Beverly A. Canada Smith
- Anne M. & Paul T. Stangeland '67
- Clare E. Reimers '78 & Willard W. Wakefield '84
- Lisa Cardamon Weber '90 & Tim Weber '86
- Janet Gray Webster '95 & Stephen A. Webster

Seminars presented at HMSC from July 2012 to June 2013

DATE	NAME	AFFILIATION	TITLE
July 5, 2012	Bob Lackey	OSU Professor & Senior Fisheries Biologist	<i>Role of Science in the Political Process</i>
July 12, 2012	Kristen Jenkins Voorhies	PhD Candidate, University of Chicago	<i>A Historical Gold Mine: The treasures of information found in death assemblages of Oregon and Southern California</i>
July 19, 2012	Vasily Radashevsky	Senior Scientist at the Institute of Marine Biology, Russian Academy of Sciences	<i>Biology of spionid polychaetes (Annelida: Spionidae) as it is seen from the Russian Siberia</i>
July 26, 2012	Laurie Weitcamp	NOAA NWFSC - Research Fish Biologist	<i>Pacific salmon: biology and issues</i>
August 2, 2012	Tom Hurst, Clare Reimers, Rob Suryan, Janet Webster	Hatfield Marine Science Center	<i>Research Ethics Faculty Mentor Panel</i>
August 9, 2012	Louise Copeman	Post-Doctoral Research Associate, Cooperative Institute of Marine Resources Studies, NOAA	<i>Marine Lipids Research at HMSC - applications for fisheries, trophic ecology and aquaculture</i>
August 16, 2012	Angie Sremba and Amelia Whitcomb	OSU/HMSC grad students	<i>“Circumpolar diversity and geographic differentiation of mtDNA in the critically endangered Antarctic blue whale (Balaenoptera musculus intermedia)”</i> <i>“Mate choice of wild spawning coho (Oncorhynchus kisutch) in the Umpqua River”</i>
September 27, 2012	John Chapman	OSU Department of Fisheries & Wildlife	<i>Asian species arrived in North America on Japanese marine tsunami debris</i>
October 4, 2012	Tiffany Garcia	OSU Department of Fisheries & Wildlife	<i>Invasion Biology and the Successful Establishment of American Bullfrogs: It Takes a Village</i>
October 11, 2012	Greg Krutzikowsky	Oregon Dept. of Fish and Wildlife	<i>Response to Whale Entanglements on the East Coast of North America</i>
October 18, 2012	Andrew Levings	Deakin University, Australia	<i>Australian fishermen make a major research contribution for a sustainable Giant Crab Fishery</i>
October 25, 2012	Jim Rice	Marine Mammal Institute, HMSC	<i>Marine Mammals Ashore - Stranding Trends and Responses in Oregon</i>
November 1, 2012	Janet Webster & Amanda Whitmire	OSU Libraries	<i>Where's Your Data?</i>
November 8, 2012	Staci Simonic	Dept. of Environmental and Molecular Toxicology, OSU	<i>What Goes Around Comes Around: Chasing Air Pollution from Asia to the U.S. West Coast</i>
November 15, 2012	Robert O'Malley	Dept. of Botany, OSU	<i>Mapping Improbability: A New Metric for Satellite-detection of Submarine Volcanic Eruptions</i>
November 29, 2012	Ric Brodeur	NOAA Northwest Fisheries Science Center	<i>The role of jellyfish in a changing ocean</i>
December 6, 2012	Chris Langdon	COMES and Department of Fisheries and Wildlife, HMSC, OSU	<i>Native and Pacific Oysters: a Tale of Two Species</i>
December 13, 2012	David Schiel	University of Canterbury, New Zealand	<i>Reversal of eutrophication and cataclysmic, earthquake-driven changes to an estuarine ecosystem in southern New Zealand</i>
January 10, 2013	Laurie Weitkamp	NOAA Northwest Fisheries Science Center	<i>Juvenile salmon and associated fishes in the lower Columbia River estuary: new insight from pelagic habitats</i>
January 17, 2013	Fred Allendorf	University of Montana	<i>How should we use genomics to identify units of conservation?</i>
January 24, 2013	Annaliese Hettinger	OSU College of Earth, Ocean and Atmospheric Sciences	<i>Consequences of global change for early life stages of Olympia oysters</i>
January 31, 2013	Clare Reimers	OSU College of Earth, Ocean and Atmospheric Sciences	<i>The Regional Class Research Vessel (RCRV) Project: OSU's Role in Renewal of the University National Oceanographic Laboratory System (UNOLS) Fleet</i>
February 5, 2013	Dirk Rosen	Exec. Director and Founder, Marine Applied Research and Exploration	<i>ROV Surveys of California Marine Protected Areas</i>

DATE	NAME	AFFILIATION	TITLE
February 7, 2013	Bill Cresko	University of Oregon	<i>The genomic architecture of rapid adaptation in threespine stickleback</i>
February 14, 2013	Katie Stofer	Free-Choice Learning Program, OSU	<i>More than Words: Studying experts' and novices' meaning-making from data visualizations for communication</i>
February 21, 2013	George Priest	Oregon Dept. of Geology and Mineral Industries	<i>New tsunami inundation mapping for the Newport-Toledo area -- Small to XXL Cascadia events</i>
February 28, 2013	Mark Farley, Kaety Hildebrand, & Rebecca Schiewe	HMSC Visitor Center	<i>So you have people on your working waterfront - what do they know and what can you teach them?</i>
March 7, 2013	Lisa Seeb	Aquatic & Fishery Sciences, University of Washington	<i>Pink salmon: Genomic islands in the stream of evolution</i>
March 14, 2013	George Waldbusser	CEOAS, OSU	<i>Understanding life-history and habitat feedbacks of ocean acidification on marine bivalves</i>
March 21, 2013	Kelly Robinson	Dept. of Marine Science, University of Southern Mississippi	<i>Drivers of coastal jellyfish in the northern Gulf of Mexico: the role of climate and fisheries harvest</i>
April 4, 2013	Bob Embley	NOAA Vents Program	<i>A Frontier of Planetary Exploration: Active Submarine Volcanism and Hydrothermal Vents in the SW Pacific</i>
April 11, 2013	Emilie Hooft	University of Oregon	<i>Magma plumbing at Newberry volcano and the northern Juan de Fuca ridge: Implications for the delivery and storage of melt</i>
April 18, 2013	Waldo Wakefield	Fishery Resource Analysis and Monitoring Division, Northwest Fisheries Science Center, National Marine Fisheries Service	<i>The Current Review of Essential Fish Habitat for Pacific Coast Groundfish</i>
April 25, 2013	Andrew Meigs	OSU College of Earth, Ocean and Atmospheric Sciences	<i>The back arc story of Cascadia</i>
May 2, 2013	Jochen Braunmiller	OSU College of Earth, Ocean and Atmospheric Sciences	<i>Earthquakes in the NE Pacific Ocean - More Than the Next Great Cascadia Earthquake</i>
May 9, 2013	Rick Davis	Oregon Health & Science University	<i>Sequencing the uncultured: New insights in the mechanisms of microbial carbon fixation and manganese oxidation at hydrothermal vents</i>
May 14, 2013	Kristen Jenkins Voorhies	University of Chicago	<i>More than a collectors item: using dead seashells to find historical baselines in subtidal marine molluscan communities</i>
May 16, 2013	Anne Trehu	OSU College of Earth, Ocean and Atmospheric Sciences	<i>Earthquakes and subducted seamounts beneath the continental margin off Newport</i>
May 23, 2013	Tom Wainwright	NOAA NWFSC	<i>Salmon & Climate: Scientific Challenges</i>
May 30, 2013	Martin Fisk	Professor of Oceanography, Oregon State University	<i>The Connection between Deep Sea Geology and the Exploration of Mars</i>
June 6, 2013	David Young	US EPA	<i>Expansion of Invasive Eelgrass <i>Zostera japonica</i> in Yaquina Estuary vs. Native <i>Z. marina</i> : 1997-2012</i>
June 13, 2013	Jarrod Santora	Research Scientist, NOAA & The Farallon Institute for Advanced Ecosystem Research	<i>Melding time and space: Dynamic mesoscale structure of biological hotspots and predator-prey relationships</i>
June 20, 2013	Gayle I. Hansen	Department of Botany and Plant Pathology, Oregon State University, Newport	<i>Marine Algae on Tsunami Debris: Results of the Survey to Date</i>
June 27, 2013	Rick Cardwell	Adjunct Professor, OSU Department of Toxicology	<i>Maintaining Your Principles, Protecting Your Soul, and Serving the Interests of Society while Working in the Real World as a Scientist</i>

VI. BUDGETS

State and Federal Agency Budgets at Hatfield Marine Science Center

	<u>\$ Amount</u>	<u>% of Total</u>
Environmental Protection Agency	2,375,000	10%
Oregon Department of Fish & Wildlife	6,205,680	26%
Vents Program - Federal	1,149,984	5%
Nat'l Marine Fisheries Service - NWFS	8,004,000	33%
Nat'l Marine Fisheries Service - AFSC	1,921,000	8%
US Department of Agriculture - ARS	603,996	2%
US Fish & Wildlife Service	3,552,014	15%
US Geological Survey	450,000	2%
Total State & Federal Agency Budgets	\$24,261,674	100%

FUNDING SOURCES

Direct State Funding

HMSC	1,546,517	
COMES	1,242,771	
MMI	175,888	
CIMRS	317,727	
Guin Library	239,756	
Extension Sea Grant	338,349	
CEOAS (Reimers)	0	
Total Direct State Funding	\$3,861,009	8.5%

Other State Funding

Matching Funds (Endowments)	286,523	
Student Fees (TRF)	64,909	
Total Other State Funding	\$351,432	0.8%

Sponsored Research and Education Programs

Nat'l Oceanic & Atmospheric Admin. (NOAA)	5,497,544	
Nat'l Science Foundation (NSF)	3,478,003	
U.S. Dept. of Agriculture (USDA)	200,575	
Office of Naval Research (ONR)	2,336,944	
Department of Defense	131,853	
Department of Energy (DOE)	589,119	
Department of Interior (DI)	468,456	
Other Federal Agencies	220,789	
Oregon Dept. of Fish & Wildlife (ODFW)	81,448	
Other Oregon Agencies	409,953	
California Dept of Water Resources	0	
Foundations & Other Organizations	1,920,075	
Sub-Contracts from other Universities	454,523	
Total Sponsored Research	\$15,789,281	34.7%

Other Funding

Self-Funding Units	1,190,810	
OSU Foundation (HMSC only)	93,436	
State & Federal Agency Budgets	24,261,674	
Total Other Funding	\$25,545,920	56.1%

TOTAL FUNDING:	\$45,547,641	100%
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BUDGETS

OSU at Hatfield Marine Science Center

	<u>\$ Amount</u>	<u>Unit</u> <u>Sub-Total</u>	<u>% of</u> <u>Total</u>		<u>\$ Amount</u>	<u>Unit</u> <u>Sub-Total</u>	<u>% of</u> <u>Total</u>
<u>Research Administration</u>				<u>College of Earth, Ocean & Atmospheric Sciences</u>			
Administration	621,784			Ship Support/Operations	3,025,980		
Visitor Center Support	113,708			Ship Support/Maintenance	748,615		
Non-Sponsored Research	0			Ship Special Projects	64,784		
Non-Sponsored Education	149,012			Ship Scientific Equipment	230,885		
Sponsored Education	0			Total Ship Operations:	\$4,070,264		
Sponsored Research	1,206,071			Sponsored Research-Reimers	226,896		
Total Research Administration:	\$2,090,576		9.8%	Total CEOAS:	\$4,297,160		20.2%
<u>Physical Plant</u>				<u>Sea Grant Education Programs</u>			
State Support	690,488			Extension	117,108		
Federal Support	839,032			Sea Grant	484,998		
Other Sponsored Activity	64,909			Visitor Center	125,456		
Total Physical Plant:	\$1,594,429		7.5%	Sponsored Programs	291,824		
<u>Coastal Oregon Marine Experiment Station (COMES)</u>				Self-Funded Programs			
Administration	186,786			Total Education Programs:	\$1,129,180		5.3%
Non-Sponsored Research	1,014,061			<u>Housing</u>			
Cost Shared to Sponsored Research	30,995			Self-Funded Operations	94,013		
Self-Funded Programs	385,837			Total Housing:	\$94,013		.442%
Physical Plant-State	10,929			<u>Bookstore</u>			
Extension	0			Self-Funded Operations	112,766		
Endowment	0			Total Bookstore:	\$112,766		0.5%
Sponsored Research	2,256,724			<u>Other</u>			
Total COMES:	\$3,885,333		18.3%	Guin Library	239,756		
<u>Cooperative Institute for Marine Resource Studies (CIMRS)</u>				OSU Foundation & Gifts	93,436		
Administration	271,826			Network Service/Computer Support	164,573		
Non-Sponsored Research	19,213			State Agencies (through OSU)	3,945		
Physical Plant-State	26,688			Federal Agencies (through OSU)	18,376		
Sponsored Research	4,517,064			Total Other:	\$520,085		2.4%
Total CIMRS:	\$4,834,790		22.7%	<u>TOTAL HATFIELD MARINE SCIENCE CENTER:</u>			
<u>Marine Mammal Institute</u>							
State End Match - Admin.	258,048				\$21,285,967		100%
State Support Director's Salary-Admin	134,815						
Self-Funded Fee Programs	200,527						
OSUF Funds	41,952						
Other Funds	1,662						
Non-Sponsored Research	41,073						
Sponsored Research	2,049,558						
Total MMI:	\$2,727,635		12.8%				