
2005 - 2006 Annual Report

Oregon State University Hatfield Marine Science Center



2030 SE Marine Science Drive
Newport, Oregon 973665-5296

Telephone 541-867-0100
Fax 541-867-0138
Web Page: <http://hmsc.oregonstate.edu>

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I. RESEARCH

A. Oregon State University



Programs by Station and Institutes

Coastal Oregon Marine Experiment Station

Gil Sylvia, Superintendent

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 unit 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 by 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. Seventeen years later the Marine Experiment Station has grown to include 13 tenured faculty, 30 staff and research associates, 45 graduate students, and over \$3 million annually in external grants and funds. COMES also works closely with its Advisory Board that includes members representing coastal communities, the fishing and seafood industry, and other businesses and organizations with a stake in supporting research important to coastal communities and the State of Oregon.

The research programs of COMES encompass seven primary areas: Aquaculture (Chris Langdon), Fish Disease (Paul Reno), Fisheries Science (David Sampson), Fishery Management and Policy (Susan Hanna), Marine Mammals (Bruce Mate, Scott Baker, Markus Horning), Marine Economics and Marketing (Gilbert Sylvia), Salmon and Marine Fisheries Ecology and Genetics (Jessica Miller and Michael Banks), and Seafood Science and Technology (Michael Morrissey, Jae Park, Yi-Cheng Su). Approximately half of the COMES faculty have joint positions within their academic homes, Oregon Sea Grant, and/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. COMES recently hired three new faculty in Fisheries Ecology (Jessica Miller), Cetacean Biology (Scott Baker), and Pinniped Ecology (Markus Horning) which is expected to substantially boost the growth of COMES over the foreseeable future.

The year 2005-2006 was highly successful and marked continued growth of the Station. Based on the Oregon Invests database, in 2005-2006 COMES programs generated over \$12 million in economic impacts and produced 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 80 manuscripts and reports including 45 in refereed journals and books. COMES graduated 20 students including 12 MS and 8 Ph.D's. COMES faculty also gave over 100 presentations and organized 15 workshops and conferences. For 2005-2006 it is estimated that for each \$1 million in state dollar expended, COMES faculty leverage an additional \$3 million in federal grants and private support.

COMES "Signature Programs" in 2005-2006 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. Today, Pacific whiting is Oregon's largest (by volume) and most sophisticated fishery and generates between \$20-30 million per year in coastal income.

Community Seafood Initiative (CSI) CSI is a unique partnership between COMES, Shorebank Enterprise Pacific, Oregon Sea Grant, and the Seafood Consumer Center. CSI supports coastal businesses and value-added seafood production. Since 2002 CSI has assisted 40 fishermen and seafood processors in business and market planning, provided over \$1.6 million in investments and loans to coastal seafood companies, developed five new value added seafood products, delivered 55 seafood demonstrations, and is assisting the Oregon Dungeness Crab Commission in certification by the Marine Stewardship Council (MSC).

Molluscan Broodstock Program (MBP) MBP conducts research and outreach with industry partners to improve oyster broodstock and associated economic benefits. Billions of juvenile oyster produced in the Pacific

Northwest are derived from MPA families housed in COMES facilities. The program is responsible for an annual increase of oyster production exceeding \$5 million in farm-gate value.

Marine Mammal Endowed Program A world leader in satellite tagging/monitoring of marine mammals. The endowments total over \$7 million and together with industry and federal grants, the program supports basic and applied research in understanding behavior of whales and other marine mammals. This knowledge is used to minimize impacts between marine mammals and fishermen, oil companies, shippers, and developers. The program recently hired two new tenure-track faculty and is expected to be one of the fastest growing programs at HMSC over the coming decade.

OSU Surimi Research and Technology School 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 School trained 130 international and domestic students in 2005-2006 and the Astoria Surimi School alone generated over \$120,000 in local expenditures.

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. With the recent hire of Jessica Miller, this is expected to be one of the fastest growing COMES program.

OSU Seafood Laboratory – Michael Morrissey

The Community Seafood Initiative (CSI) is up and running at full speed in Astoria. What began as a partnership between the OSU Seafood Laboratory and Shorebank Enterprise Pacific now includes COMES, Oregon Sea Grant and the Seafood Consumer Center as partners as well.

The focus of the partnership is on product development to help small and mid-size businesses and communities hard hit by transitions in their resource-based economies. It is a unique partnership that combines the research capacity of the university – with the industry and consumer training and education capacity of the Seafood Center – with the capital investment capacity of a non-profit community development financial institution (CDFI).

Specific goals include product development, innovation and capital investment; research and implementation of new technologies and systems designed to increase economic value of Pacific fisheries; and providing educational

opportunities for the seafood industry, students, and fishing dependent communities. More information can be found in an article written about CSI in Agricultural Progress magazine in the Fall 2004 issue or at the CSI website at: www.heads-up.net/csi.

Three of Dr. Morrissey's students received their degrees during the past twelve months. These include Sergio Almonacid who defended his doctoral thesis in Bioresource Engineering, Tomoko Okada who defended her doctoral thesis in Food Science and Technology, and Rosalee Rasmussen who defended her Masters in Food Science and Technology. Research opportunities have included collaboration with the Pacific Shellfish Institute, Integral Consultants, the University of California, Davis and the University of Alaska to investigate the cadmium levels in oysters along the Pacific coast, as well as studies on the effects of processing on known cadmium levels. Preliminary study indicating a possible decrease in cadmium as a result of high pressure processing in oysters. In addition, his laboratory has focused on the extraction of oil and omega-3 fatty acids from Pacific sardines. Pacific sardines are a relatively new fishery to the area and, although they are high in omega-3 fatty acids, the majority of the fish are sold for use as tuna bait. We've developed a method for isolation and extraction of the omega-3 fatty acids in sardines utilizing an enzymatic hydrolysis reaction and determined the optimal processing parameters for production of a fish oil concentrate, as well as work on developing an immobilized-enzyme system to entrap lipase in a chitosan-alginate-CaCl₂ hydrogel for the purpose of concentrating omega-3 PUFAs from sardine oil. The use of immobilized lipase systems for increasing omega-3 PUFA concentration in sardine oil provides new process opportunities for the growing Pacific sardine industry. Additional applied research occurred in the area of product development for the Community Seafood Initiative (CSI). Some of these products include frozen shellfish products that are microwaveable. The CSI team is evaluating the commercial feasibility of these products through the Stage-Gate process which allows a team of experts or gatekeepers to make sure different criteria are met before the next stage in product development happens.

Dr. Morrissey enjoyed two trips abroad, as external advisor to the European SEAFOODplus project which represents 17 counties and some 60 institutions covering a wide range of seafood research projects. He traveled to Granville, France in October and another to Tromsø, Norway in June where he presented work being undertaken in product development..

In February, Dr. Morrissey helped organize and run the 2nd annual CSI Micro-canners Workshop in Astoria as well as a symposium on risks and benefits of seafood consumption held at the AAAS meeting in St. Louis. Dr. Morrissey also presented papers at the Pacific Fisheries Technologists

Meetings in Anchorage in March.

OSU Seafood Laboratory – Jae Park

During this period, we completed the 6th Surimi Industry Forum and 14th OSU Surimi School (May 2-4) successfully. The highlight was the Surimi Industry Forum with over 120 attendees including four CEOs of the United States' leading manufacturers of surimi or surimi seafood. We had 25 sponsors this year and recognized two companies (American Seafoods and Takasago International) with 10-year sponsor plaques.

Professor Jin Kim made his annual return to resume his continuous research effort in December. He is currently working on the biochemical characterization of fish gelation recovered from surimi byproducts.

Angela Hunt's job has been expanded to 0.7 FTE and she is continuing her research and surimi school administration vigorously. Her job is funded by Dr. Park's Surimi School management.

Norman Kok completed his MS degree from Food Science and Technology and returned to his research institute (SE Fisheries Development Center, Singapore) in December. His thesis title was "Biochemical and physical properties affecting fish balls".

MS student Zach Reed received a Surimi School Scholarship Award during the sponsor's presentation hours. Visiting Professor, Jin Kim returned to his country, Korea, at the end of February. A new visiting scientist Ms. Raquell Llorente came from AZTI (food research institute) in Bilbao, Spain in April for a two-month visit.

Two MS students (Kang and Reed) are going to move to Astoria soon to join one Ph.D. student (Park) and my research assistant (Hunt) for their never-ending research. We look forward to a productive summer.

OSU Seafood Laboratory – Yi-Cheng Su

Dr. Su continued his research on reducing bacterial pathogens in seafood for safe consumption. He investigated the antibacterial activity of wine against *Vibrio parahaemolyticus* and *Vibrio vulnificus* in oysters and potential inactivation of these pathogens in contaminated raw oysters by wine consumption. Red and white wines have been reported to exhibit antimicrobial activities against many human pathogens. Alcohol consumption was linked to a reduced rate of illness in a Salmonella food poisoning involving

contaminated tuna sandwiches. A study of an oyster-borne Hepatitis A outbreak found that the risk of illness was reduced among those who consumed the implicated raw oysters with beverages contained >10% of alcohol.

Preliminary studies conducted at Dr. Su's lab found that both red and white wines were equally effective in inactivating *V. parahaemolyticus* and *V. vulnificus*. Populations of both pathogens were reduced by 99.99% after 60 seconds in wine. These results suggest that drinking wine when eating raw oysters might result in inactivation of *V. parahaemolyticus* and *V. vulnificus*. More studies are being conducted to determine the effectiveness of wine on inactivating *V. parahaemolyticus* and *V. vulnificus* in laboratory contaminated oysters.

Results of the studies were presented at the 2006 Pacific Fisheries Technologists annual conference in Anchorage, AK, in March 2006.

Dr. Su has also been working with the Pacific Shellfish Institute in Olympia, WA to determine the effectiveness of electrolyzed water treatment on reducing *Vibrio* contamination in oysters. This is a two-year project funded by The Gulf Oyster Industry Program of the National Sea Grant, to develop intervention methods to reduce *Vibrio* contamination in raw oysters.

Two new M.S. students and one post-doctoral fellow, Dr. Tsai-Hsin Chiu, joined Dr. Su's lab in September 2005. Dr. Chiu has been conducting molecular biology study on pathogenic *V. parahaemolyticus* isolated from Oregon and Washington coastal water. Results of the study will provide information about the distribution of *V. parahaemolyticus* in the Pacific Northwest region. Graduate student Jingyun Duan presented a poster on "Antimicrobial activity of wine against *Vibrio parahaemolyticus*" at the conference and received an award for the best graduate student poster presentation. Currently, Dr. Su's research team is investigating effects of low temperatures on seawater and electrolyzed water depuration for reducing *Vibrio parahaemolyticus* in oysters. This project is sponsored by Interstate Shellfish Sanitation Conference (ISSC) and The Gulf Oyster Industry Program of National Sea Grant to develop intervention procedures to reduce *Vibrio* contamination in raw oysters.

Dr. Su was invited to give a series of lectures on seafood quality and safety at Shanghai Fisheries University in China. He was also a guest speaker of the Symposium on Taiwan America Agricultural Cooperative Projects in November 2005. He also received a scholarship from the National Fisheries Institute to examine the "Application of electrolyzed oxidizing water as a post-harvest strategy to control

histamine formation in fish”.

In April he also attended a Seafood HACCP Train-The-Trainer workshop and became a certified HACCP trainer. He will be offering Seafood HACCP courses to the industries in the near future.

Cooperative Institute for Marine Resources Studies

Clare Reimers, Director

Rich Holdren, Interim Director

Now in its twenty-third year, the OSU/NOAA Cooperative Institute for Marine Resources Studies (CIMRS) develops and offers opportunities for joint research and outreach to a growing community of University and NOAA scientists dedicated to marine science, graduate education, and learning partnerships with regional industries and communities that are dependent on marine resources.

The Institute’s 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 and the OSU Research Office. As a result during the past few years external research grant funding has tripled, graduate student opportunities have diversified, and many more investigators from a broad range of disciplines are joining together to address research problems of environmental, economic and social importance.

The collaborative structure of CIMRS facilitates new ways in which basic research can be applied to understand factors impacting marine resources and their management. For example, as is highlighted in this report, geologic oceanographers engaged in seafloor mapping are preparing the first habitat maps for the entire U.S. West coast that will help predict distributions and abundances of living marine resources. These maps may also serve as a foundation for defining boundaries of future marine reserves.

An integral part of the OSU Mark O. Hatfield Marine Science Center (HMSC), CIMRS is now the administrative home for 32 research staff and 4 research faculty working on collaborative projects with NOAA investigators who also serve as OSU courtesy faculty. CIMRS research faculty generated over \$500K in FY 2005 alone for independent research projects funded from a variety of funding sources. No other OSU research institute provides both grant administration and personnel review in the manner of an academic department.

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. To accomplish these goals a Fisheries Oceanography Graduate Fellowship program was started within CIMRS in 2003 with funds provided by the Alaska Fisheries Science Center of NOAA/NMFS. This program seeks to recruit highly talented M.S. or Ph.D. students to oceanography, fisheries or wildlife science, resource economics, zoology, environmental science or a related field at Oregon State University, with an intended focus

on ecological and natural resource issues in the Northeast Pacific, Aleutian Islands, and Bering Sea. It is anticipated that this program will eventually support 5-7 fellows concurrently. In 2003 three fellowships were awarded after applicant proposals were solicited, reviewed, and ranked according to merit by a 7-member Fellowship Committee.

Research Projects

Collaborative Research with
National Marine Fisheries Service/Northwest Fisheries Science Center

2006 Continuing Fellows and Projects

| | |
|---------------|--|
| Julie Keister | Investigations of Variability of Mesoscale Energy off the Coast of Central Oregon and Northern California; Major Professor: Tim Cowles, COAS |
| Rob Suryan | Comparative Foraging Ecology of Five Species of Pacific Seabirds: Multi-scale Analyses of Marine Resource Utilization Major Professor: Dan Roby, F&W |

A growing number of graduate student projects are being supported with contributed funds through grants from the Northwest Fisheries Science Center. The CIMRS director works to match qualified students with projects and courtesy faculty based at the Hatfield Marine Science Center.

| Degree | Student | Dept | Thesis |
|-----------------------|-------------------|---|---|
| Ph.D. | Todd Miller* | Fisheries and Wildlife | Trophic Dynamics within Varying Conditions of the Northern California Current |
| Ph.D | Douglas Reese* | College of Oceanic and Atmospheric Sciences | Community Characteristics, Spatial Distributions, and Habitat Preferences of Marine Fauna within the Northern California Current Ecosystem |
| Ph.D | Claudia Bravo* | Environmental Molecular & Toxicology | Toxicology of Polycyclic Aromatic Hydrocarbons: Dibenzo [a,l] pyrene (DB[a,l]P) in Rainbow Trout, <i>Oncorhynchus mykiss</i> |
| M.S. | Maria Juan Jorda* | Marine Resource Management | Development of a Physical Database and GIS Coordination at Heceta Bank, Oregon |
| M.S. | Natalie Reed* | Marine Resource Management | Cold-water Corals and Sponges: Habitat Preferences on Oregon's Continental Margin |
| M.S. | Marissa Litz | Fisheries and Wildlife | Abundance, distribution, and spawning behavior of the northern anchovy, <i>Engaulis mordax</i> , off the cost of Oregon and Washington |
| M.S. | Brooke Martin | Fisheries and Wildlife | Purification and Characterization of Vitellogenin, and use for Enzyme Linked Immuno-absorbent Assay (ELISA) for gender and maturity status in Black rockfish (<i>Sebastes melanops</i>) |
| M.S. | Josie Thompson* | Fisheries and Wildlife | Life history of the Longnose Skate (Raja rhina) from the U.S. West Coast and Vulnerability to Fishery Impacts |
| M.S. | Emily Waschak | Fisheries and Wildlife | Estimating Key Life History Parameters for Selected Species of Rockfish |
| * = Degrees Completed | | | |

See Section on NWFSC

Collaborative Research with
*Oceanic and Atmospheric Research Office/Pacific marine
Environmental Laboratory
Ocean Environment Research Division/VENTS PROGRAM*

Acoustic Monitoring

Robert Dziak, Assoc. Professor, Sr. Res.; Matt Fowler,
Joe Haxel, Faculty Research Assistants; Andy T.K. Lau,
Professional Faculty; Haru Matsumoto, Research Associate

Discoveries in the research this year have given insight into the mechanisms required to produce large hydrothermal plumes. It appears that release of large hydrothermal plumes require rapid injection of magma moving down the rift zone a long distance in the first 1-3 days of event swarms. To further our understanding of this mechanism, we received funding to build four Ocean-Bottom Hydrophones (OBH) and will deploy these hydrophones at the Axial submarine volcano on the Juan de Fuca Ridge for one year. This project will be part of the NeMO seafloor observatory and will be used to detect microseismicity from the volcano that may have gone undetected by SOSUS and to evaluate the depth of the magma chamber as well as any variation in hydrothermal activity associated with earthquake activity.

Due to the inaccessibility and extreme environment of the Drake Passage and Bransfield Strait between South America and the Antarctic Peninsula, little is known about the submarine volcanic activity or even the ocean acoustic environment of the region. In observance of the International Polar Year (IPY) in 2007-2008, NOAA's Ocean Exploration Program has funded a one year deployment of Autonomous Underwater Hydrophones (AUH) to record seismicity and other natural acoustic sources along the Antarctic Peninsula and western Scotia Sea. An array was deployed in November to December of 2005 and will be recovered in November 2006. We have acquired funding from the Korean Polar Research Institute to redeploy the hydrophones an extra year until 2007. In addition, National Geographic Foundation will fund this year's expedition to survey the shallow hydrothermal systems within the active, submerged volcanic caldera at Deception Island in the Bransfield Strait.

This was the fifth and last year of the OSU-NOAA-WHOI cooperative hydrophone experiment with several significant activities and accomplishments. We continued our collaboration with French colleagues at the University of Brest-Occidental and have re-configured our hydrophone array to focus on a hydrothermal area called Lucky Strike

which is located just south of Azores. Colleagues from the University of Brest have provided ship time once again for us to deploy hydrophones for another year (until late 2007) near the Lucky Strike hydrothermal field on the Mid-Atlantic Ridge just south of the Azores Islands. As before, this array will be used to detect earthquakes from the ridge and associate earthquakes to any variation in hydrothermal vents and ecosystems at Lucky Strike. The hydrophones previously detected a magmatic earthquake swarm at the Lucky Strike Seamount/hydrothermal field along the Mid-Atlantic Ridge 2001. This was the first detection of a probable volcanic earthquake swarm along the deep ocean portion of the Mid-Atlantic Ridge. The hydrophones also detected massive magmatic explosions from a submarine volcanic eruption from the South Atlantic near a remote island called Tristan de Cunha. Detection of otherwise unobserved volcanic activity throughout the oceans is critical to understanding the contribution of seafloor volcanism to the global pace of volcanic activity. Lastly, since the beginning of the hydrophone project, 17,381 earthquakes have been located throughout the Atlantic Ocean basin as compared to 8,677 earthquakes located by land-based seismic networks. This demonstrates the increased sensitivity of the hydrophones for detecting oceanic earthquakes, and provides more information on magmatic activity and patterns of crustal deformation of Atlantic Ocean plate boundaries. The NSF Mid-Atlantic Ridge project also provided additional funding to support continued deployment of a 6-element hydrophone array along the East Pacific Rise from 2006-2008. This eastern Pacific hydrophone array has been deployed since 1996 and has continuously recorded earthquakes from the East Pacific Rise and Central and South American subduction zones. We are currently using earthquake data to look for possible correlations between seafloor seismicity and variations in sea surface height. The weight of the column of seawater above the seafloor will cause it to flex under the load. The height of this column of water will vary during both daily tidal cycles and month-to-year seasonal oceanographic phenomena (i.e., El Nino). Thus changes in the water column height will cause corresponding variation in the load applied to the seafloor, resulting increase and decrease in seafloor seismicity depending on the orientation of the fault. This work is particularly interesting because it presents a potential link between ocean climate conditions and the rate of seafloor earthquakes. We have also combined this work with our analysis of ambient ocean noise levels recorded on the SOSUS hydrophones arrays for the past 13 years. It is our hypothesis that ocean noise levels fluctuate in response to changes in wave height along the coast of the Pacific Northwest. Variation in wave height has been shown to be linked to climatic changes, thus ocean noise could similarly reflect this climate variability.

We have developed a new type of autonomous hydrophone instrument: a “Quasi-Eulerian hydrophone”, or QUEphone. Unlike our autonomous moored hydrophones, the Quephone is a tether-free hydrophone float capable of ascending and descending in the water column by its own buoyancy controller, an oil-filled bladder. In contrast to the Lagrangian floats, the QUEphone stays in the same area on the seafloor by maintaining negative buoyancy for most of its life span. While on the seafloor it runs an intelligent event detection algorithm. Upon detection of a significant event, or at regular intervals if no events occur, it surfaces to transmit a small data file to shore. This instrument allows near-real-time monitoring of a selected study area, and can be modified to use various types of chemical or oceanographic sensors.

Support was provided this year to Barbara Zennarro, a Marine Resource Management Masters degree graduate student and her project on relating seafloor earthquakes to variations in sea-surface height. We also support a high school intern, Kirol Chang-Gilhooly, who provides assistance on a variety of scientific and technical aspects of our project.

Researchers in our group have given instructional presentations on our work to various civic, middle and high school teacher groups. In addition, Dziak was the instructor for the undergraduate course Geology 380, “Earthquake in the Pacific Northwest”, in the winter and spring 2006 terms. This course provides background on the basics of geological and seismological setting of the northwest and also satisfies the baccalaureate core science requirement.

We have also developed several websites to inform the public and ocean research community on the design of the hydrophones we use in the experiment:http://www.pmel.noaa.gov/vents/acoustics/haru_system.html.

Marine Mammal Acoustics

David Mellinger Assist. Prof., Sr. Res.; Sharon Nieukirk, Sr. Faculty Research Asst.; Sara Heimlich, Faculty Research Assistant; Hisham Qayum, Research Associate

In order to acoustically monitor areas of the world ocean not covered by existing fixed hydrophone arrays, CIMRS and PMEL scientists have developed autonomous moored hydrophone instruments to record acoustic energy from both underwater seismic activity as well as that from whale calls. These instruments are capable of recording frequencies from 1 - 1000 Hz, and can record data for over a year before servicing is required. The hydrophones are designed to be deployed as an array of independent instruments whose geometry can be determined by the needs of the experimenter in order to localize acoustic

sources of interest.

In summer of 2004, five autonomous hydrophone instruments were deployed on the Scotia Shelf in eastern Canada. These were configured for collecting sounds of North Atlantic right whales, the most highly endangered large whale species. Two of these instruments were recovered in August 2005, and three other ones deployed. The instruments revealed that the period of peak occurrence in right whale calling in this area is August through October, and that right whales are present in small numbers as early as the end of June and as late as the end of December. The remaining six instruments were recovered in June 2006, with analysis of the data just beginning. These data may be very useful for conservation and management of this species: Information on seasonal occurrence of right whales in the Bay of Fundy has been used to change shipping lanes there, in an effort to prevent fatal ship strikes -- one of the two principal causes of mortality in North Atlantic right whales. It is hoped that the information on seasonal occurrence on the Scotia Shelf can be applied similarly.

In a similar project, beginning this year, we are deploying autonomous hydrophones at three sites in the Bering Sea to listen for whales there. The principal subject of this study is again right whales, but we will also look for evidence of blue whales, fin whales, sperm whales, and other large whale species.

Automatic signal detection methods were developed to identify whale calls in large data sets. Dr. Mellinger’s automatic detection program, Ishmael, includes the ability to detect calls by use of matched filters, spectrogram correlation, or energy detection. It also contains a specialized method for detecting tonal sounds, such as dolphin whistles and whale moans. This software program has been used to detect calls of blue and minke whales from Atlantic Ocean hydrophones, of right and sperm whales from the Gulf of Alaska hydrophones, of right whales on the Scotia Shelf hydrophones, of blue whales in the Indian Ocean, and over other species elsewhere. Analyses of these data continue with the goal of assessing seasonal distribution of species.

Finally, we are currently investigating the characteristics of blue whale sounds. Blue whale researchers elsewhere noticed that the frequency of blue whale calls appears to be changing downwards slowly over time. At CIMRS, we have a dataset that is ideal for studying this phenomenon: recordings made continuously since 1991 at sites in the Pacific Ocean. Because the geographic location of the recordings hasn’t changed, and because we can examine the frequency at the same time of year for all sites, the data we

get from these recordings will be invaluable for elucidating this frequency change.

Geophysical Monitoring

William W. Chadwick, Jr. Assoc. Prof., Sr. Res.; Andra Bobbitt, Susan Merle, Sr. Faculty Research Assistants

The goal of this program is to better understand how submarine volcanoes work. Our efforts continue to be divided between projects focused on volcano monitoring in the NE Pacific and seafloor mapping and exploration in the W Pacific. In addition, an on-going project in the Galapagos islands provides the opportunity to compare volcanic activity on land and underwater.

NeMO (New Millennium Observatory) is a long-term multidisciplinary project at Axial Volcano in the NE Pacific that is in its eighth year. This project involves arrays of seafloor and water-column instruments, and sample collection systems for documenting chemical, biological, hydrographic and geologic changes in and around Axial caldera. Axial volcano last erupted in 1998 and monitoring data have shown that it is already building up to its next eruption. One of the goals at NeMO is to document a complete volcanic cycle at a submarine volcano. Precise pressure measurements in 2000-2004 showed that the caldera floor at Axial is being uplifted at a rate of about 20 cm/yr, and has probably risen by more than 1.5 m since the 1998 eruption. We will be repeating these measurements this summer to see if this trend is continuing. This is the first time that volcanic inflation has been documented at an active submarine volcano.

We also continue to participate in the Submarine Ring of Fire program, a multidisciplinary international project that has included seafloor mapping and submersible dives on active volcanoes in the Mariana and Kermadec volcanic arcs in the W Pacific. We participated this year in an expedition that included ROV dives at several submarine volcanoes in the Mariana arc. This year we witnessed spectacular eruptive activity at NW Rota-1 volcano, which generated international press coverage after the cruise, in part because it coincided with the publication of a paper in *Nature* presenting the results from two previous visits to the site. Other highlights of the cruise included the discovery of ponds of molten sulfur and new insights into the chemosynthetic ecosystems at Mariana submarine volcanoes.

Both NeMO and the Submarine Ring of Fire programs present opportunities for public outreach through the NeMO and the NOAA Ocean Exploration web sites:

<http://www.pmel.noaa.gov/vents/nemo/>

<http://oceanexplorer.noaa.gov/explorations/06fire/>

In both these projects, when CIMRS scientists are at sea periodic updates are posted on the web and these are often featured in public lectures at the Hatfield Marine Science Visitor Center during the expeditions.

In addition to this oceanographic research, Chadwick continues to stay active in fieldwork related to volcano monitoring on land. This effort is focused on GPS monitoring networks on two active volcanoes in the Galapagos islands: Sierra Negra and Fernandina. This research, funded by several NSF grants has been very rewarding this year because both volcanoes erupted in 2005 and fieldwork in 2006 is expected to reveal exciting new changes as a result of the eruptions. This project provides a valuable comparison to the results from observations at submarine volcanoes.

Hydrothermal Emissions

Leigh Evans and Ron Greene, Faculty Research Assistants

CIMRS researchers collect, measure, and analyze trace elemental gases in hydrothermal fluids, particularly Helium-3, using ultra-high vacuum mass spectrometry. The objective of this research is to assess the locations, mechanisms, chemical flux rates and ages of active hydrothermal systems along sea floor spreading centers with the eventual end result of quantifying and predicting large-scale spatial and temporal effects of venting on ocean chemical and thermal budgets. Water-column samples have narrowed down the possible vent locations of many plumes along the Mariana Arc during previous years. Improvements were made to the sampling device used to collect vent fluid samples at the Mariana Arc. The unusual vent fluids from that part of the world produce so much gas that a new collection instrument was made combining an optional smaller sampling device and a much larger volume for expansion of gas. In fact, liquid carbon dioxide still oozes from NW Eifuku volcano. Follow-up expeditions with the remotely operated vehicles, Jason II and Hyperdolphin, collected samples directly from the vents of the undersea volcanoes that had been characterized by water-column analyses. Analyses of samples from expeditions this year and previous years contributed to interpretation of the both the Kermadec Arc and Mariana Arc, showing trends that will be useful in discovering the magma source for the ridge volcanoes. A review of analysis of water-column samples previously collected in 1999 from Bransfield Strait by other OSU researchers showed two specific sites of vent fields. Samples collected during the 2005 Ocean Exploration cruise to the area were analyzed with results that support earlier findings. Additionally, the source of the deeper plume at Hook Ridge may have been discovered from these samples.

Oregon Sea Grant

Bob Malouf, Director

Jay Rasmussen, Extension Program Leader

For nearly 35 years, since Oregon Sea Grant's origins as one of the original four Sea Grant programs, Oregon Sea Grant has been an active component of OSU's Hatfield Marine Science Center.

In this and other areas within this report, Oregon Sea Grant's roles are evident in funding research, promoting student experiences, providing public outreach through extension and communication activities and products, managing the Visitor Center, and delivering quality education programs to K-12 audiences, home school, and other audiences. In recent years our attention has turned to making the university and the HMSC a center for excellence in free-choice learning (where people have a choice in what, how, and when they learn) and in national and international ornamental fish health.

Sea Grant's charge is to "increase the understanding, assessment, development, utilization and conservation of the nation's ocean and coastal resources."

—U.S. Congress, National Sea Grant College and Program Act of 1966

First established at Oregon State University (OSU) in 1967, Oregon Sea Grant had become one of the first four Sea Grant Colleges in the nation by 1971. With federal, state, local, and private funding totaling about \$5 million annually, it remains one of the largest and most productive of the 30 programs currently in the National Sea Grant network. Oregon Sea Grant is a part of OSU, but our research, education, and outreach programs are open to all Oregon institutions of higher education. We believe all of the people of the state, the region, and the nation are our stakeholders.

Oregon Sea Grant works to further knowledge of the marine and coastal environments of the Pacific Northwest and the forces—natural and human—that shape their destiny. Although the principal offices of the Sea Grant Program are on the main campus in Corvallis, it has a large presence at the Hatfield Marine Science Center. The central office for the Marine Extension Program is located at the HMSC, as is the major portion of Oregon Sea Grant's Marine Education Program. In 1997, Oregon Sea Grant also took over responsibility for managing the HMSC Visitor Center.

Different components of the Sea Grant program—research,

outreach, and education—are described in appropriate parts of this report. Examples of youth education, public programming and exhibitry, ornamental fish health, and other focus areas of Oregon Sea Grant are contained in other sections of this report, with linkages to the Coastal Oregon Marine Experiment Station and the Colleges of Agricultural Sciences, Science, Oceanic and Atmospheric Sciences, Veterinary Medicine, the Oregon Coast Community College, and the Oregon Coast Aquarium.

Oregon Sea Grant is the conduit for National Oceanic and Atmospheric Administration research and outreach grants, awarded competitively by the National Sea Grant College Program. Additional funding comes from the Oregon legislature and occasional collaborative efforts with public and private sources.

Oregon Sea Grant provides competitive, peer-reviewed grants that allow top ocean and coastal researchers to apply their skills to issues of critical importance to the state, the region, and the nation. Over the years, the program's funding emphasis has changed to meet and anticipate the region's changing needs. Urgent issues—the decline of once-abundant fisheries, the challenges posed by coastal population growth, the heightened awareness of invasive species—help propel Sea Grant's research priorities as the program strives to put limited resources where they can do the most good. Many research projects have outreach components, ensuring that the results of cutting-edge science will be put to work on the ground and at sea. Researchers come from the leading ranks of academic science in Oregon. In some cases, Oregon researchers partner with others from the Pacific Northwest and beyond to explore questions of broader regional, national, or international scope.

Over \$315,000 of Oregon Sea Grant-funded competitive projects took place at the Hatfield Marine Science Center during the 2005–2006 grant cycle. Research and projects included developing methods for reducing the mortality in oyster production, retaining native oysters, teaching new audiences about aquatic invasions through an innovative aquarium exhibit, developing an ocean wave power source, applying regionally the results of the Salmon River study on the use of restored estuarine wetlands by salmon, understanding mortality of wild-caught marine ornamental fish, tracking juvenile chinook salmon, promoting bibliographic information into geographic information systems, supporting fisheries student projects, and collaborating in a lingcod/rockfish predator-prey interaction study.

Research Programs by Academic Unit

College of Agricultural Sciences

Department of Fisheries & Wildlife

Marine Fisheries Genetics

Michael Banks, Assistant Professor

New projects, graduation and transition to new students and staff capture the spirit of current activities in the Marine Fisheries Genetics Program. Significant involvement in coordinating and performing real-time stock ID in ProjectCROOS has been a delight. This project, in response to the Chinook fisheries crisis owing to low Klamath escapement, uses state-of-the-art DNA ID and GSI techniques to map the distribution of Klamath and other stocks encountered by the fishery. Primary goals are to research the feasibility of graduating from the year delayed coded-wire data (limited to only hatchery fish) currently used in management to real-time genetic ID/GSI results more in key with changing oceanic conditions and also addressing both hatchery and wild stocks. Pilot results were very promising, with good prospects to extend this project to California and Washington next year. We thus celebrate application of the molecular and statistical tools we have developed over the last 12 years to real-life issues in stock harvest and conservation along with significant human dimension considerations (see www.ProjectCROOS.net). Power analysis for stock assignment of the coast-wide DNA baseline used to identify Klamath Chinook currently underway results from timely foresight of the Pacific Salmon Commission's Chinook Technical Committee.

Students Daniel Gomez-Uchida, and Jeremiah Bernier both graduated to great new opportunities, a post doctorate with the Canada Research Chair in Marine Conservation, Dalhousie, Halifax for Daniel and a PhD program for Jeremiah at the University of Lausanne, Switzerland. Post docs Greg Moyer and Isabelle Meusnier also graduated to new positions, Greg to a research position the US Fish & Wildlife Service in Georgia and Isabelle to the Canadian Centre for DNA Bar-coding, Biodiversity Institute of Ontario. We celebrate our time with these excellent students, all we have learned together and especially, these great new opportunities. Although we'll miss them, graduation to good futures is how things should be!

Coho research in the genetics and life history of the Oregon Coastal ESU has culminated in a paper under review for publication in *Molecular Ecology*. Likewise findings from our study of hatchery/wild fitness comparisons for Umpqua River coho are in review for publication in the *Canadian Journal of Fisheries and Aquatic Sciences*. Seven other

manuscripts in review or press cover findings from research in life history discrimination among Chinook, effective population size and population structure among rockfish.

In response to the student exodus mentioned above, we have welcomed two new PhD students to the program. Our webpage has been rebuilt and updated, see <http://marineresearch.oregonstate.edu/genetics/index.html>. We are also pleased to be currently recruiting both a post doctorate and an assistant professor position to nurture academic and program development.

Invasive Species Ecology

John Chapman, Assistant Professor

Major accomplishments 2005-2006:

Volunteer presentations, lectures, labs and/or led field trips, on estuary ecology and aquatic biological invasions for: Spring Marine Ecology - Zool. 451/551, Fall - Coastal Ecology and Research Management, the Oregon Coast Aquarium and Oregon Coast Community College Aquarium Science Program, the HMSC summer intern and adult volunteer program and Special topics in marine biology Corvallis High School honors class 2006
Formal teaching: 2006 Aquatic Biological Invasions BI 421 FW 421/521, 4 credits.

A reanalysis of the origins of the introduced periwinkle *Littorina littorea*, performed in cooperation with the Michael Banks lab, Maritime Studies Program; Williams College – Mystic Seaport, CT; and University of New Hampshire, Durham, NH, and completion of a MS that is in review for publication in the journal "Biological Invasions" and that was also presented at the April 2005 Benthic Ecology Meeting. This earliest record of a marine introduction to North America (via the Vikings) is accepted for publication in *Biological Invasions* and should appear in 2006.

Additional notes on a 2003 publication on seafood as a source of introduced species appeared in *Conservation Biology* (2005) 19(2).

Completed a survey of the nonindigenous peracaridan Crustacea of San Francisco Bay buoys in collaboration with the San Francisco Bay Estuary Institute in November 2005. These data allow a 60 year review of introductions in San Francisco Bay since the previous 1940 buoy survey and were entirely relevant for assessment of a controversial proposal to break ships from San Francisco Bay in Yaquina Bay.

John is completing his 6th (and last) year of participation on the executive committee of the Western Regional

Panel, (of the National Invasive Species Panel) with duties that included – organization of a special session on Nonindigenous Species for the international Desert Fishes Council, held in November 2005 Cuatro Ciénegas, Coahuila, México, November 19-20, 2005 and, contributing authorship on the national “Management and Control Plan for the New Zealand Mudsail (*Potamopyrgus antipodarum*)” produced through the University of Montana, Bozeman, MT. Completed December 2005.

The first comprehensive synthesis of eastern Pacific marine gammaridean amphipod taxonomy was completed, a ten-year project in April 2006 that will appear in Smith and Light’s Manual: Intertidal Invertebrates of Central California, University of California Press. The published chapter of approximately 120 pages, will include 900 + illustrations of approximately 330 species. It is the only comprehensive treatment of all known species of marine gammaridean amphipods of any eastern Pacific region ever to appear and it is the culmination of 10 years of work.

Work continues on the biology of native and introduced parasitic isopods that castrate burrowing shrimp. This work is funded to control mud shrimp for oyster growers in Washington and Oregon and began with the discovery that, *Orthonie griffenis*, one of former parasitic isopods is introduced. A paper describing that introduction is underway. John trained, organized and provided logistics for a crew of Lincoln County “Summer Natural Resources” (SNR) students to survey the *Orthonie* infestation in *Upogebia* in Yaquina Bay permitting an assessment of the impact of *Orthonie* on native mud shrimp populations. This crew also performed the majority of labor required to isolate the settling life stages and critical experiments that demonstrate induced chemical signaling by these parasites to attract mates.

Sponsored 2006 summer Research Education for Undergraduates student, Lauren Woods, in cooperation with Brett Dumbauld, on the feminization of *Upogebia* by its bopyrid parasite. This work is being prepared for publication. The work of last year’s REU that he sponsored is ready to submit for publication in the Journal of Crustacean Biology.

Serves on the committee of Ph.D. student, Michael, Chi-Chang Liu, Dept Fisheries and Wildlife. Michael’s thesis topic is the New Zealand Mudsail.

Other accomplishments: Organized Newport Sprint Triathlon – Newport Swim Team and Newport High School National honors society. Isopod research featured in local, state and national news. Lectured at Concepcion University, Concepcion Chile, December 2005.

Posters and presentations

- Chapman, J. W., J.T. Carlton, M. R. Bellinger, and A.M.H. Blakeslee* Premature refutation of a human mediated invasion: The case history of the marine snail *Littorina littorea* in the northwestern Atlantic, Poster, Benthic Ecology Meeting, 6-10 April, 2005 Williamsburg, VA
- Chapman, J. W. Invasive species of the Oregon Shore, Oregon Shores Symposium, Hatfield Marine Science Center, Newport, Oregon 23 Oct 2005.
- Chapman, J. W. Invasive species of the Oregon Shore, Invited Speaker, Oregon Coast Community College Biology, Hatfield Marine Science Center, Newport, Oregon 9 November 2005.
- Chapman, J. W. Greenland, Rapa Nui, Natural Resources and Nonindigenous Species, Desert Fishes Council and Western Regional Panel Biological Invasions symposium, Cuatro Cienegas, Mexico 19 November 2005
- Chapman, J. W. Chi-Chang Liu, Hang-Kwang Luh, Selina Heppell Finding the New Zealand mud snail (*Potomopyrgus antipodarum*, NZMS) and its vectors in North America, Desert Fishes Council and Western Regional Panel Biological Invasions symposium, Cuatro Cienegas, Mexico 19 November 2005.
- Dumbauld, B., J. Chapman, A. Kuris, E. Ashley, S. Heehartz, J. Markham and M. Torchin 2005. Augmentative biological control of burrowing shrimp in estuarine oyster aquaculture, Pacific Estuarine Research Society / 2005 Annual Meeting
- Dumbauld, B. R., J Chapman, and A. Smith. 2005 A preliminary look at the potential for using a parasitic isopod for augmentative biological control of its burrowing shrimp host. Pacific Coast Shellfish Growers Association/ National Shellfisheries Association Meeting, Hood River Oregon, September 2005.

Marine Fish Ecology

Selina Heppell, Assistant Professor
Scott Heppell, Assistant Professor
Jessica Miller, Assistant Professor

The Heppell Lab continues working across a diverse array of marine fish ecology projects. We hosted two interns during the summer of 2005 Raquel Sosa (HMSC REU) studied habitat use of juvenile rockfish in Yaquina Bay. Megan Baker (Saturday Academy ASE) conducted a mark-recapture study of juvenile Dungeness crab in the Bay. Marine Team continues to collect monthly data on fishes and invertebrates in Yaquina Bay and continues to receive funding through CIMRS and Oregon Sea Grant.

Professional activities included serving as co-hosts for the 14th Western Groundfish Conference and so-convening a conference on environmental sampling in Yaquina Bay. The Cooperative Fisheries Internship Program (Fisheries Experience) is continuing. This program is designed to provide opportunities for students to gain hands-on experience with the fishing industry and resource managers. Funding has been provided for this program by Oregon Sea Grant, the Coastal Oregon Marine Experiment Station, and the Department of Fisheries and Wildlife.

On-going student projects based at HMSC include:

- Field work and experiments on the spread and impact of the invasive New Zealand mud snail by Markham award-winner Michael Liu, who is also an Aquarist for the Visitor's Center
- Diet analysis and surveys of lingcod on the central and southern Oregon Coasts by Markham award-winner Craig Tinus, who is working with the Port Liaison Project and local fishermen in a cooperative research project to investigate the potential impacts of recovering lingcod populations on local rockfish populations.
- Analysis of dispersal patterns of juvenile Steller sea lions by Crebbin award-winner Jon Scordino, who is conducting a controlled study of the impacts of scientific branding on sea lion pup survival and behavior with ODFW biologist Robin Brown,
- Nearshore and estuary sampling of juvenile rockfish by Brett Gallagher, who will compare the growth rates and genetic composition of fish that settle in Yaquina Bay with those of fish that settle on nearshore reefs over years of strong and weak upwelling conditions.:
- Analysis of oceanographic parameters and sea turtle bycatch and satellite tracks in the North Atlantic by Abby McCarthy, who will use the data to define pelagic habitat for these threatened species. Abby was a recipient of the Reynolds award in 2004, a Mastin award in 2005, and a Marine Technology Fellowship in 2005
- Investigation of the impact of maternal age on offspring quality in Pacific Ocean perch in the Gulf of Alaska and Aleutian Islands by new graduate student Emily Waschak.:
- Lab experiments in the AFSC lab on behavior of juvenile flatfish in response to predation risk and light intensity by Kate Boersma, a new student working with Cliff Ryer and Tom Hurst and our lab.:
- Analysis of distribution, diet and reproduction of Northern anchovy by Marisa Litz, a new student working with Robert Emmett in the NWFSC lab:
- Nursing behavior and maternal attendance

patterns in Steller sea lions by undergraduate Emily Hamblen, who has obtained a fellowship from Oregon Sea Grant to support her research

In January 2006, Jessica Miller joined OSU, the Department of Fisheries and Wildlife, and COMES as Assistant Professor in the position of Marine Fisheries Ecologist. Jessica is interested in the ecology and evolution of life history variation in fishes and the development and maintenance of that diversity. Her research has focused on larval dispersal and transport, population connectivity and structure, and the use of estuaries by larval and juvenile marine and anadromous fishes. She has combined techniques, including otolith microchemistry, genetic, and time-series analyses, to address these topics. At HMSC, she plans to continue to use diverse methods to address basic questions in fish ecology while also providing information critical for management and conservation efforts.

Since arriving to HMSC, Jessica has worked to develop the marine fisheries ecology program within COMES. The construction and equipping of the dry laboratory was completed in May! Jessica has worked to complete existing projects, initiate new efforts, and incorporate students into the program. She has a project, funded by Oregon Sea Grant, using otolith chemistry of juvenile and adult black and canary rockfish (*Sebastes melanops* and *S. pinniger*) to infer patterns of mixing and migration along the coast. She has also initiated research using otolith chemistry to reconstruct migratory history in salmon and steelhead. A research assistant, Abby Nickels, who will become a MS student in OSU's Department of Fisheries and Wildlife this fall, and Stefanie Gera, an undergraduate at the College of William and Mary and a participant in HMSC's National Science Foundation's Research Experience for Undergraduate program, worked in the lab over the summer learning and applying otolith microstructural and chemical techniques. Abby worked on the preparation of both salmon and rockfish otoliths while Stefanie completed a project on the migratory history of juvenile steelhead along the Oregon coast. Pam Archer, an OSU Marine Resource Management graduate student, will join the lab this fall to work on an ecological restoration effort in Netarts Bay, Oregon. The project, funded by NOAA and The Nature Conservancy, aims to re-establish the native oyster, *Ostrea conchaphila*, to the estuary. Although native inhabitants of Oregon estuaries, little is known of the ecological role these native oyster reefs played in estuarine systems. Future research will examine the growth and survival of the oysters, impact of the restoration efforts on native eelgrass, *Zostera marina*, meadows, and potential changes in associated fish communities.

Jessica has also served on the steering committee for the

7th Larval Biology Symposium to be held August 27 to September 1 at the Oregon Institute of Marine Biology. She is a co-organizer for the session, Dispersal and Connectivity in Marine Populations, in honor of Dr. Rudi Scheltema's 80th birthday.

Molluscan Aquaculture

Christopher Langdon, Professor

A major focus of the OSU-COMES Aquaculture program at HMSC is the USDA-funded Molluscan Broodstock Program (MBP). This purpose of this program is to develop superior Pacific oyster (*Crassostrea gigas*) broodstock for the West Coast shellfish industry through selection. About 1000 families of Pacific oysters have been produced since the inception of MBP in 1995. These families have been planted at commercial test sites along the West Coast, from Prince William Sound, Alaska, to Tomales Bay, California. Yields of families from MBP selected broodstock after two generations of selection are on average 42% greater than those from unselected broodstock, with a realized heritability of 0.57 for yield. We are currently transferring some outstanding broodstock families to commercial hatcheries that should improve yields of offspring by up to 75%, compared with those from non-selected broodstock.

Joint research conducted with the USDA-ARS shellfish genetics program, under Dr. Mark Camara, will result in improvements in the effectiveness of the breeding program for Pacific oysters. This research currently focuses on 1) identification of genetic markers for a range of desirable traits, 2) identification of molecular and physiological responses of juvenile oysters to heat stress that can be used to predict the response of adults to summer mortality at grow-out sites and 3) evaluation of mixed-family versus single-family plantings in determining family performance at grow-out sites.

In addition, we have received funding from the NOAA Restoration Program to support identification of appropriate broodstock for restocking depleted populations of native oysters (*Ostrea lurida*) on the West coast. We are currently developing microsatellite markers to identify genetically distinct populations. This information will be useful to various native oyster restoration projects in Puget Sound, Netarts and Yaquina Bays as well as in San Francisco Bay, California.

The aquaculture program at HMSC also focuses on marine fish larval nutrition. On the West Coast, aquaculture of commercially important fish species, such as sablefish, lingcod and rockfish, will become increasingly important in meeting our food demands as natural fish stocks decline and fishing becomes more limited. In addition, the ornamental

fish industry is also expanding globally and there is a need to develop culture techniques to reduce fishing impacts on sensitive habitats, such as coral reefs. The major bottleneck in rearing marine food and ornamental fish species is successful rearing of their larval stages. In response to this need, we have received funding from Oregon Sea Grant to continue work on the development of microparticulate diets for marine fish larvae. In addition, Chris Langdon spent 5 months on sabbatical in Norway working on developing lipid spray beads for delivering micronutrients to enrich rotifers and other prey species used in rearing cod larvae. It is anticipated that there will be further collaboration with Norwegian aquaculture nutritionists in the future.

Marine Mammal Program

Bruce Mate, Professor

The Marine Mammal Program wrapped up a busy research season last summer and fall, studying Gulf of Mexico sperm whales and Eastern North Pacific blue and humpback whales in the summer, and working with Mediterranean fin whales in the fall. Data from the 36 satellite-monitored tags applied in June–October 2005 (12 on sperm whales, 15 on blue whales, seven on humpbacks and two on fin whales) continued to stream into the laboratory through the first quarter of 2006. Analysis of these data continues into the second quarter. While these analyses are conducted and initial conclusions drawn, program staff have also been busy writing papers from earlier research seasons, including four sperm whale papers, one on Chilean blue whales, and one on Gabon humpbacks. In addition, a paper by Etnoyer et. al., co-authored by Bruce Mate, has been accepted but not yet published.

Gray whales tagged in March 2005 in Baja transmitted for up to 321 days and resulted in more than 86,000 km of track lines. This was the first time the entire spring migration and feeding range of gray whales has been documented and identified. The feeding data reveal much more intense use of the high Arctic (Chukchi Sea) than previously known, and is probably associated with a recent warming trend/regime shift in the Bering Sea. These data were presented to the International Whaling Commission meetings in May 2006. In April 2006, the group hosted a four-day synthesis workshop for collaborators on four years of MMS-sponsored sperm whale work in the Gulf of Mexico. Work conducted on seismic effects in proximity to sperm whales was presented at an IWC-sponsored workshop.

Our photo ID specialist has been busy cataloguing approximately 3,000 whale photographs taken during the 2005 field seasons, as well as adding photographs of whales and our new research vessels to our website. Other

improvements have also been made to the website, including updating the publications page and adding a page highlighting our new curriculum for grades 6–9, titled “The Great Whales.” The site itself is scheduled for a complete revision in fall 2006 to bring it in line with existing OSU styles and to take advantage of audio, video and slideshow software.

We have completed the hiring of two new professors, a cetacean ecologist and a pinniped ecologist, and are currently in the process of bringing aboard their support staff. Program staff have undergone a reshuffling of offices to make room for the new arrivals, and we are looking forward very much to the new dynamics resulting from these changes and additions.

Population Dynamics

David Sampson, Professor

Research

As in past years Dr. Sampson’s research activities during 2005/06 focused on stock assessment and fisheries management issues. As part of his duties for the Oregon Department of Fish and Wildlife, which funds half his position, David continued to serve as Oregon’s representative on the Scientific and Statistical Committees (SSC) for the North Pacific Fishery Management Council (through Dec. 2005) and the Pacific Fishery Management Council, attending seven regular SSC meetings and several sub-committee meetings, including a formal review of the 2006 assessment update of Pacific mackerel.

During the year David continued to serve as the External Coordinator for the University of Miami’s Center for Independent Experts, which provides independent peer reviews of fishery stock assessments and other forms of marine science to NOAA Fisheries. As the CIE External Coordinator David helps administer all science 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.

David continued his involvement in a collaborative research project that is attempting to develop survey methods for canary rockfish, with the aim of supplementing the information provided by the standard bottom trawl surveys. During 2005/06 the Canary Rockfish project, funded by the Pacific Groundfish Conservation Trust, focused most of its activities on a study of the puzzling change with age in the sex ratio of canary rockfish, which has been consistently observed in the trawl survey and commercial fishery. After canary rockfish reach the age of maturity (7-8 years) males are much more prevalent in the trawl catches, with males outnumbering females

by as much as 3:1 or more. Recent stock assessments have modeled this data feature by assuming that older females have elevated rates of natural mortality, and the mature female portion of the canary rockfish stock has been assessed as being at extremely low levels as a result. The Pacific Council’s attempts to control catches of canary rockfish have been seriously constraining many commercial and recreational fisheries. The project’s field collections of canary rockfish, which started in spring 2005, use rods and reels and other forms of hook and line gear to catch canary rockfish from deepwater rocky reefs off Washington, Oregon and northern California. The study has found an overall 3:2 female to male sex ratio, lending support to the hypothesis that old female canary rockfish are alive and well and living in rough, untrawlable areas along the West Coast. Results from the study were presented at the Western Groundfish Conference in February 2006.

During spring 2006 the Canary Rockfish project completed its hook-and-line sampling to measure age-specific sex ratios and began work on a different aspect of surveying canary rockfish, field-testing a video-trawl system, with the aim of providing a non-lethal quantitative method for counting canary rockfish and other large bottom dwelling fish species. A non-lethal method for conducting a rockfish survey is needed so that survey coverage can be increased to provide more precise estimates of rockfish biomass without competing for fish with the commercial and recreational fisheries. The video-trawl device consists of a lighted backward-facing color video camera that monitors fish as they are forced up and out of the trawl by a rigid fish-excluder grate. Field trials during May and June 2005, using chartered commercial trawlers from Newport and Astoria, captured almost a dozen hours’ worth of video footage of fish passing through an open-ended commercial bottom trawl, apparently unharmed. Although additional work with the gear is required to determine optimal placement of the camera and lights, in most of the video images it is possible to count fish passing across the grate and identify to the species level the larger fish (canary rockfish, yellowtail rockfish, widow rockfish, bocaccio rockfish, yelloweye rockfish, lingcod, and Pacific halibut).

Teaching

During autumn 2005 David taught his course “*Fishery Stock Assessment Methods*”. As in past years, lectures for the course were given in the HMSC studio classroom and televised to the main campus, with about half the students at either location.

In March 2006 David’s graduate student Bob Emmett successfully defended his PhD thesis, entitled “The relationships between fluctuations in oceanographic

conditions, forage fishes, predatory fishes, predator food habits, and juvenile salmonid marine survival off the Columbia River". For many years Bob has been at the HMSC as a NOAA Fisheries scientist, studying juvenile fish, particularly salmonids, in the Columbia River estuary and plume. Bill Peterson, also of NOAA Fisheries and based at the HMSC, also served with David on Bob's graduate committee.

Department of Agricultural and Resource Economics
Marine Fisheries Management and Policy
Susan Hanna, Professor

This is an active time for fishery management and policy in Oregon and the Pacific Northwest, nationally and internationally. The pending reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act and the recommendations of the U.S. Commission on Ocean Policy are shaping changes in federal and regional fishery management. Dr. Hanna is involved in a number of emerging issues related to management trends, fishery allocation, incentive-based tools, management performance, fishing communities and ecosystems.

Management Trends

- *Extension Education*: Gave the opening presentation to the Sea Grant workshop "Pacific Coast Marine Fisheries Extension: Integrating Human Dimensions Into Our Work" on the changing landscape of Pacific fisheries." (June)
- *Oregon Ocean Policy*: briefing to the newly reformed Oregon Ocean Policy Advisory Council (OPAC) on reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act, covering content of various bills, the national issues likely to be included, and their implications for Oregon. Hanna was appointed to the newly formed Scientific and Technical Advisory Committee (STAC) of OPAC.
- *Coastal Oregon Decisionmakers*: Served on the Steering Committee of the OCZMA Economic Demographic Study and gave advice on project design and data needs.
- *Regional Investment in Social Science*: Continued to work with NOAA Fisheries Northwest Fisheries Science Center (NWFSC) leadership to advise on the Social Science Research Plan and on development of a fishery economics internship and research program.
- *National Policy*: Continued to serve on the NOAA Science Advisory Board (SAB), providing general scientific advice to NOAA and specific social science advice to the NOAA Research Council on implementation of the report of the

Social Science Review Panel (SSRP) "Social Science Research Within NOAA: Review and Recommendations." The Board has formed a panel of external experts to do a "check-in" on progress toward implementing recommendations of the SSRP report. Hanna will chair the panel.

- *National Policy*: Hanna was named a science advisor to the Joint Ocean Commission Initiative (JOCI), the combined implementation effort of the US Commission on Ocean Policy and the Pew Ocean Commission.
- *International Policy*: Continued to serve on the Board of Directors of the Institute of Fishery Management and Coastal Community Development, North Sea Centre, Hirtshals, Denmark.

Fishery Allocation:

- *Columbia River*: At the request of ODFW to the OSU Institute for Natural Resources (INR), Hanna and Sylvia, with Gail Acterman (INR) and Michael Harte (COAS) reviewed the economic literature related to the allocation of Columbia River spring Chinook among commercial and recreational fisheries. In January Hanna presented a summary of the report "Review of the Economic Literature on the Allocation of Columbia River Chinook Salmon" to the Oregon Fish and Wildlife Commission.
- *International Practice*: Presented an invited keynote address summarizing the conference discussion of the issues surrounding allocation of fish to the International Conference "Sharing the Fish," Perth Australia, in February.

Incentive Based Tools:

- *Oregon Ports*: Presented a seminar to the Astoria Port Commissioners at their July meeting on individual fishing quotas (IFQs) for groundfish and sardines and how they might function under different designs.
- *Oregon Sardines*: Presented a talk to the Consumer Seafood Initiative 3rd Annual Sardine Symposium "Individual Fishing Quotas: Would They Work for the Oregon Sardine Fishery?"
- *Pacific Fishery Management Council*: Continued to chair the Independent Experts Panel for the development of the trawl individual quota program of the Pacific Fishery Management Council.
- *National Policy*: Briefed congressional staff at the U.S. Congress Ocean Caucus IFQ Briefing, Washington, DC, on effective design of ITQs. The briefing focused on the Fishing Quota Standards Act of 2005.

- *General Education*: Through Sea Grant Extension, with Chris Dewees, U.C. Davis, developing an outreach education program for West Coast fisheries on fishery management tools and policy. Also developing a series of Sea Grant outreach education briefs on fishery management tools.
- *Graduate Student Supervision*: Ph.D. student Branka Turcin is modeling spatial distribution of Oregon groundfish effort as part of a project to develop incentives-based approaches to best management practices in fisheries. Branka has accepted a faculty position at the University of Alaska Fairbanks and is nearing completion of her dissertation.
- *Graduate Student Education*: Gave a graduate seminar to Marine Resource Management Program, Oregon State University “Making Fishery Management Work: What’s the Answer?”

Fishing Communities:

- *West Coast Ports*: With Gil Sylvia and others, met with West Coast port managers regarding community interests in ITQs.
- *International Issues*: Gave an invited presentation to the workshop “Community Fishing Rights”, sponsored by the Centre for Fisheries and Aquaculture Management and Economics at the University of Southern Denmark. “Community Fisheries Rights and Management: Origins, Structure, Benefits, Costs and Incentives” (August).
- *International Issues*: Organized and chaired a special session and presented an overview paper at the 2006 Conference of the International Institute of Fishery Economics and Trade (IIFET), Portsmouth, England (July.) “Fishing Communities and Fishery Management: Economics and Property Rights.” Also at the conference, chaired the plenary “Policy Day” session and presented a review paper on an EU stock recovery project “UNCOVER.”

Ecosystems:

- *Ecosystem-Based Fishery Management*: Gave an invited talk to the Workshop on Social Science for Ecosystem Management, Western Pacific Fishery Management Council, “Economics of Organization and Ecosystem Management.” (January) The workshop was held to identify the social science components and research needs of fishery ecosystem management plans.
- *Regional Ocean Governance*: Gave a presentation on the pros and cons of regional ocean governance as recommended by the US

Commission on Ocean Policy at the 2005 Duke Environmental Law and Policy Forum “Regional Ocean Councils: Solution of Superfluous?” The talk was titled “Implementing Effective Regional Ocean Governance: Perspectives from Economics” and used Pacific Salmon as an example of some of the design issues to be taken into consideration for regional governance. (October)

- *Salmon Ecosystem Resilience*: Serving on the steering committee of the Oregon Sea Grant 2007 conference on resilience in salmon ecosystems. “Pathways to Resilience: Preserving Pacific Salmon in a Changing World”

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, Oregon Department of Fish and Wildlife, the Cooperative Institute of Marine Resource Studies, and economists and biologists of the National Marine Fisheries Service.

Research projects include: 1) bioeconomic modeling of the pink shrimp fishery; 2) developing a user friendly scallop bioeconomic simulation model; 3) developing optimal traceability and accountability systems for handling, marketing, and sustaining albacore tuna and salmon; 4) developing education programs for fishery managers; 5) conducting consumer surveys to determine perspectives and values for developing seafood traceability systems; 6) developing market-based approaches for managing the environmental impacts of fishing; 7) developing case studies for improving education in stock assessment and international seafood trade; and, 8) forming 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.

We are publishing work from a Sea Grant sponsored cooperative project with the Oregon Department of Fish and Wildlife and the Astoria Seafood Laboratory focusing on the economics of the Pacific pink shrimp industry. This research focuses on development of a bioeconomic model that shows the relationships of alternative

economic objectives and the management, biological, and oceanographic characteristics of the fishery. We also produced a recent study on the Management of Oregon's Estuarine Clam Resources which Polly Endreny presented as part of her MRM Master's defense. We continued to work closely on numerous ventures with the Community Seafood Initiative. A key project is developing handling and traceability strategies for supporting coastal production and marketing of albacore tuna and troll caught Chinook salmon. We also worked with CSI and the Oregon Dungeness Crab Commission in developing information to support MSC certification of the Oregon Dungeness Crab Fishery. We have initiated four new research projects including two funded by Sea Grant, and projects funded by USDA and the Oregon Watershed Enhancement Board (OWEB). The OWEB project is a major new initiative and a collaborative project (ProjectCROOS.com) involving five 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 use digital technology systems for developing information tracking systems for management and marketing. The project is the largest collaborative research program ever undertaken by the Oregon salmon industry and involves over 100 fishermen and vessels. We hope to develop a larger and more comprehensive three year project that can collaborate with other West Coast agencies and industries.

These research projects have generated over \$1.1 million in extramural funding and are supporting six graduate students (Six Masters' candidates) from the Departments of Agricultural and Resource Economics and Marine Resource Management.

Department of Food Science and Technology

Astoria Seafood Lab

Jae Park, Professor

During the fiscal year 2005-2006, Dr. Jae Park, Professor of Food Science and Technology, has been conducting three primary research projects like in the previous year. They are: 1) dealing with protein recovery from sardine using a pH shift; 2) enzyme inhibition by egg white; and, 3) thermostability of fish protein in the presence of special starches. Multidisciplinary approach for early quality determination has also been studied.

Dr. Park has brought over \$100,000 in research project funding, including gifts and donations from the Surimi and

Surimi Seafood Industries around the world.

Dr. Park and his staff/students presented 8 papers at various professional meetings and published 9 refereed journal articles and 2 book chapters. He gave four invited lectures, which included the PacifiChem Society (Honolulu, HI) in December 2005 and the ACS color symposium (Atlanta, GA) in April 2006.

He offered three OSU Surimi Schools at three different locations (Paris, France; Astoria, OR; Bangkok, Thailand) and trained over 250 people around the world. He invited his OSU colleagues (Dr. Michael Morrissey, Dr. Yi-Cheng Su, Dr. Mark Daeschel) to participate as speakers.

In the last year, Dr. Park has funded and trained four graduate students and two staffs/visiting scientists at his lab.

He has also served on the Peer Review Communication Committee (PRCC) of IFT, which is the largest professional society for food science and technology in the world. He became a chair-designate in 2006-2007.

College of Oceanic and Atmospheric Sciences *College of Science*

Marine Geochemistry
Clare Reimers, Professor

Areas of Strategic Plan: Research and Teaching

Research in the Clare Reimers' lab focuses on investigations of how the chemistry of sediments in marine environments is shaped by physical and biological processes with a specific focus on oxidation and reduction reactions, where the oxidant and/or the reductant may be organic or inorganic compounds. For many projects, lab members construct and employ electrochemical microsensors as tools for measuring chemical distributions and fluxes.

During 2005-2006 two projects focused on developing and evaluating prototypes for revolutionary "bio"fuel cells designed as self-refueling power sources for both fixed seafloor sensors (the seafloor biofuel cell) and mobile Autonomous Underwater Vehicle Gliders that operate within the water column of the ocean (the plankton biofuel cell). A NSF grant sponsored the initiation of a year-long laboratory experiment that was set up in a refrigerated lab at HMSC and designed to evaluate the impacts of seafloor biofuel cell reactions on sedimentary organic matter. An ONR grant sponsored field experiments with chambered seafloor biofuel cells in Yaquina Bay. These latter studies are being led by Oceanography graduate student, Mark Nielsen, who completed OSU's Research SCUBA Diving course.

In the spring of 2006, C. Reimers coordinated a graduate course in field and laboratory methods in Chemical Oceanography that included sampling and analyses of Yaquina Bay waters. C. Reimers also was invited to Evergreen College by 2005 REU intern Katie Shultz to speak on experiences of women in science.

Department of Botany and Plant Pathology
Gayle Hansen, Associate Professor

During the 2005-2006 academic year, Gayle Hansen, our marine botanist, moved her lab from HMSC to the Newport EPA building where she is an OSU guestworker. In this partially retired capacity, she continues to be involved in research and outreach projects related to the seaweeds of the North Pacific.

Research: Her research projects still mostly target the seaweeds of Oregon and Alaska, and she continues to develop her databases on the historical collections of seaweeds from these two areas. However, she is now also looking at the taxonomy and distribution of North Pacific seaweed genera worldwide with colleagues from other countries. This year, she examined 3 well-known brown algal genera: *Fucus* (rockweed), *Laminaria* (kombu or oarweed), and *Alaria* (wing kelp). (1) *Fucus*. With collaborators from Portugal and Ireland, she examined the molecular identity of salt-marsh species of *Fucus* that occur throughout the North Atlantic and North Pacific. Although the morphology of these species is very similar in both oceans, the molecular identity of the species is not always the same. *Fucus spiralis*, found to be common here in the North Pacific, is identical to *F. spiralis* in the North Atlantic. *Fucus "cottonii"*, newly found in the North Pacific, differs dramatically from the North Atlantic species in that it is simply an ecological variant of *Fucus gardneri*, the most common North Pacific *Fucus* species. (2) *Laminaria*. With collaborators from Kamchatka in Russia, she has also been comparing the taxonomy & morphology of Russian vs. American *Laminaria* species. With 17 species of this genus known from Russia, 13 species from Japan, and 12 from western North America, the North Pacific appears to be the center of speciation for this genus. We are in the process of elucidating the genetic features and confirming the validity and relationships of these species in the North Pacific. (3) *Alaria*. With a collaborator from Alaska, Gayle has recently summarized the morphological taxonomy of the species of *Alaria* found in Alaska and has begun to work on the description of a new species found only in the Juneau area. Although species in this genus are difficult to distinguish with current molecular methods, she is now working with scientists from Korea who are searching for a new gene that will help them to confirm the species and determine the phylogeny of this important genus.

Outreach: Gayle's interest in marine conservation has led her to several outreach activities. (1) She has joined CoastWatch, a volunteer group that monitors the coastal

changes that occur along each mile of Oregon's coast. In addition to adopting her own mile, she has given lectures and led field trips for volunteers in both central and southern Oregon in order to familiarize this group with Oregon's seaweeds and their importance in the marine environment. (2) With the transfer of seaweed conservation responsibilities to Oregon Department of Parks and Recreation, Gayle has been recruited as scientific advisor on seaweeds to several committees within this Department including the Rocky Shores II Technical Advisory Committee and the Committee on Macroalgal Harvesting.

In addition to these volunteer services, Gayle continues to identify algae for the public herbaria in various universities and museums and for local authors & photographers who are writing books for the public on Oregon's intertidal areas.

Her specimen databases that continue to be updated are: Hansen, G. I. Oregon's Seaweeds and Seagrasses: Herbarium Records of Occurrence & Distribution (An Ongoing Survey). <http://ocid.nacse.org/research/orseaweeds>.

Hansen, G. I., and S. C. Lindstrom. A Flora of the Benthic Marine Algae of Alaska: An Ongoing Inventory of the Existing Collections. <http://ocid.nacse.org/research/alaskanalgae>

2005-2006 presentations at meetings:

Stekoll, M. S., & Hansen, G. I. 2006. The Alaskan *Alaria* species, including an unusual fat *Alaria* from Southeast Alaska. Abstract #124. Phycological Society of America Annual Meeting. Juneau, Alaska. (Poster)

Selivanova, O., Zhigadlova, G., & Hansen, G. I. 2006. Species and genera of the order Laminariales from Russian Pacific Coasts that are unfamiliar to western phycologists. Abstract #125. Phycological Society of America Annual Meeting. Juneau, Alaska. (Poster)

Serrao, E., Vliet, M., Hansen, G. I., Perrin, C., Maggs, C., and Pearson, G. 2006. Molecular characterization of the "cottonii" form of *Fucus* in the Northeast Pacific versus the Atlantic. Abstract #126. Phycological Society of America Annual Meeting. Juneau, Alaska. (Poster)

Hansen, G. I. 2005. The Nature Conservancy's Preliminary Target List for the Northwest Ecoregion's Rare and Endangered Marine Algal Species. Northwest Algal Symposium Annual Meeting. Rosario Beach, Washington (Poster)

Department of Microbiology

Fish Disease Research

Paul Reno, Professor (COMES)

The Laboratory for Fish Disease Research has continued to pursue its goal of understanding and minimizing the impacts of diseases on marine and anadromous animals. We have become more involved in the question of how pathogens can become distributed among populations of aquatic animals. One focus of our efforts is whirling disease of salmonids caused by the microscopic parasite *Myxobolus cerebralis*. This parasite has severely reduced populations of trout in the intermountain states and infects anadromous salmon in some Western states, including Oregon. The parasite has a complex life cycle that involves alternating hosts: a salmonid fish, usually trout or Pacific salmon, which release the parasite from the cartilage of the skull and gills when they die, and an oligochaete worm, *Tubifex tubifex*, which releases an alternate form of the parasite (called a triactinomyxon, or TAM for short) in its feces. With funding from the USFWS, we have been able to establish a long term laboratory model of the complex dual host life cycle of the organism, the first time this has been done in the lab. We have been able to maintain an infection in the worm hosts for at least 3 years after a single exposure to the parasite—essentially the entire lifespan of the host. In another study funded by USFWS, we have been able to establish that a single infected trout can transfer the parasite to more than 50% of susceptible worms held downstream of the dead fish and that, similarly, a single infected worm can transmit the pathogen to more than 75% of susceptible trout over a period of one month. We have also found that infected worms held in sand substrate can release parasite spores which then, due to their density, can infiltrate gravel substrate and infect trout fry (>75%) that are below the gravel in simulated redds. This suggests that trout and salmon are most susceptible to infection during the time they spend in the redd between hatching & emerging—two months or more. These results help explain how the parasite can become established for long periods of time after a single exposure of a susceptible host to the parasite. This has broad implications for the management of the disease in wild fish. Work on this project has been performed by research assistants Harriet Lorz and Lidia Sandoval.

We are also working on a project to assess the potential of birds and anglers to inadvertently transfer the parasite from watershed to watershed, since transfer with the movement of fish from hatcheries is not thought to be responsible for the spread of disease in Montana, Colorado, and possibly Eastern Oregon. Graduate research assistant Dave Latremouille has found that the parasite form found in the worm can be carried on waders and transferred, though at low efficiency, to susceptible trout fry, thus establishing

the possibility that the parasite can be transmitted this way in wild fish. The converse also appears to occur; that is, the parasite in infected trout car-casses was also transferred by waders to susceptible worms. Further work on this project determined that when the felt-soled waders were allowed to dry, the TAM form of the parasite, which could be readily transferred to trout via waders, was inactivated within 8 hours, but that the more resistant spore form from the fish was not inactivated for at least 24 hours. A similar project on the possibility of piscivorous and omnivorous birds (mergansers and crows) transferring the parasite into the water from feces after ingestion of infected fish has thus far failed to demonstrate that this is a method by which the parasite is transmitted. Likewise, herbivorous birds (mallards) were fed plant material imbued with infected worms and no evidence has indicated that the parasite was transmitted after passage through the intestinal tract of the birds.

A second area of emphasis has been the effort to inactivate potential foodborne viruses contained in contaminated oysters by the use of high hydrostatic pressure (HHP). This USDA-funded project has found that viruses closely related to the Norwalk-like viruses (noroviruses) that cause severe gastrointestinal illness in those who consume contaminated shellfish is readily inactivated at relatively low pressures. We have found that pressures of 40,000 psi for 2 minutes, caused a 1,000,000-fold decline in the concentration of live virus in artificially exposed oysters. Some virus was inactivated even at pressures as low as 25,000 psi. This finding will have a significant impact on the oyster industry because this postharvest treatment is already being used to help shuck oysters as well as ridding the oysters of the human pathogen *Vibrio parahaemolyticus*. The commercial utilization of this process is timely, considering the serious outbreak of *Vibrio parahaemolyticus*-associated seafood illness in the Pacific Northwest & New York. Thus, the use of high pressure processing is a beneficial postharvest method for eliminating multiple pathogens from shellfish and reducing the human health hazard of consuming raw shellfish. Other experiments in this study have indicated that the virus is only taken up transiently in the oyster after a 3 hour exposure (virus was not detected 24 hours postexposure) and that the virus is likely to be present only interior surface of the oyster tissues, because little virus was detected within the hemolymph or the adductor muscle, where it would be present if it were disseminated throughout the tissues. This indicates that oysters must be near the source of contamination and that they will purge themselves of contaminating virus rapidly, thereby reducing their potential for causing human disease. However, it was found that the virus remained viable for at least 2 weeks in seawater.

We also did a series of experiments to determine if the reduction in virus that we observed could have been a result of aggregation of virus particles during the processing, rather than true inactivation of infectivity. This could be problematic, since aggregates often disperse after suspension or dilution, thereby apparently "reactivating" the virus. We showed by experiments that filtered out all virus aggregates, that aggregation was not the mechanism by which the virus count was reduced, but rather that the virus was completely inactivated. We also became interested in whether virus that survived the longest under relatively low pressure (usually <1-10% of the original virus) was genetically programmed to survive better under the high pressure conditions. Genetic analysis by polymerase chain reaction (PCR) indicated that the genes responsible for producing the major virus protein were identical in clones of virus collected before or after high pressure treatment. This indicates there is no subpopulation of virus resistant to pressure treatment.

The work on this project was carried out by research assistants Prudy Caswell-Reno and Nichole Rudel.

**Department of Science and Mathematics Education
Shawn Rowe, Associate Professor (Sea Grant Extension)**

Shawn Rowe, Ph.D., represents the College of Science's Department of Science and Mathematics Education at the HMSC. In addition to his own research focusing on how people learn science in informal settings like museums, Rowe oversaw or coordinated research and evaluation work by students from the College of Science involving HMSC visitors. The HMSC's Visitor Center is a prime laboratory for this research, and Rowe and/or students presented research findings from work at the HMSC, at the National Marine Educators' Conference, the Environmental Educators Association Annual Meeting, the National Association of Research in Science Teaching and the NSF-funded Bay Area Institute from July 2005 to June 2006.

Studies underway now at the HMSC's Visitor Center look at tools for evaluating learning activities and programs, how individuals learn science, and how groups learn together. In addition to current work being undertaken by Rowe and Bill Hanshumaker of Sea Grant and Alicia Christensen of the College of Oceanic and Atmospheric Sciences, Science and Mathematics Education doctoral student Molly Phipps began work in 2005 -- partially funded by the Cooperative Institute of Oceanographic Satellite Studies -- that will lead to her dissertation. Other Science and Mathematics Education students participated in workshops and teaching marine education for K-12 classes in the spring of 2006.

This year, a search was mounted for a Professor of Free-Choice Learning in the Department of Science and Mathematics Education to work closely with Rowe and the Visitor Center. Two top researchers in the field of Free-Choice Learning, Lynn Dierking and John Falk, were hired to share the new position and will be on campus and at the HMSC beginning in the fall of 2006. Their international profile will further extend the ability to use the Visitor Center and Marine Education at the HMSC as world-class facilities for research into the learning that occurs by choice in leisure time. The free-choice learning graduate programs in Science and Math Education continues to expand.

Department of Zoology

Marine Ecology

Bruce Menge, Professor and Jane Lubchenco, Distinguished Professor

Drs Menge and Lubchenco are lead PIs for PISCO, the Partnership for Interdisciplinary Studies of Coastal Oceans, a long-term, large-scale ecological research consortium. This research program relies heavily on the HMSC for access to facilities, sea water tanks, the library and housing. PISCO also uses the COAS ship operation facilities at HMCS for access to the RV Elakha. Their research group consists of 9 graduate students, 4 technicians, 3 postdocs, 5 support and management personnel and, in summer, up to 22 interns.

Graduate Students and Postdoc Activities

Beginning in the summer of 2002, HMSC has served as the launching point for research on the causes and consequences of hypoxia off the Oregon coast. In collaboration with the COAS GLOBEC group and David Fox and Hal Weeks of the Oregon Department of Fish and Wildlife, researchers from the PISCO lab (Francis Chan, Jack Barth, Anthony Kirinich Bruce Menge and Jane Lubchenco) have been able to link the novel emergence of hypoxia and extensive marine life die-offs along the Oregon coast to large, regional-scale changes in ocean climate. With funding support from NSF in 2003, the PISCO group were able to conduct over 30 cruises out of HMSC onboard the R/V Elakha in order to elucidate the mechanisms by which hypoxia develop and deploy inner-shelf moorings that continuously monitor oxygen conditions along the coast. Hypoxia recurred in 2004 and our research was able to identify and evaluate key linkages between coastal upwelling circulation, shelf production and hypoxia formation. On-going monitoring has taken place during the 2006 summer field season. Understanding and forecasting the conditions that promote the recurrence of hypoxia remains an important research focus in the PISCO lab.

John Howieson recently completed a master's degree in the Menge/Lubchenco lab. He used the Hatfield facility to support mussel predation experiments in Puget Sound, WA. Outdoor tanks at HMSC are used to attach mussels to a substratum that is then placed in experimental and control conditions in the field. Laboratory experiments affording controlled trials on the same subject were completed during 2005/2006.

Sarah Dudas, a post-doctoral fellow, Joe Tyburezy, a doctoral student, and Gil Rilov, the PISCO science coordinator, used HMSC as a base for field research. In August 2005 they conducted an intensive field sampling project to study the fine-scale spatio-temporal linkage between nearshore larval supply and onshore arrival and settlement, and the influence of ephemeral oceanographic features (fronts) and tidal effects on larvae transport. They used indoor facilities for field preparations and processing plankton samples. Sarah Dudas used HMSC as a base for a field research project, investigating diel vertical migration of marine invertebrate zooplankton, for one week in August. Gil Rilov also conducted a feeding preference experiment in the laboratory to determine mussel size preference of seastars.

Anne Guerry, a recent doctoral graduate from PISCO, used the HMSC both as a base for field experiments and for conducting laboratory experiments on the drivers of biological diversity in intertidal communities. Specifically, her recent work examined how gradients of available nutrients and grazing pressure by limpets interact to alter the development of algal communities. She tested whether intermediate levels of these ecologically important factors do, in fact, lead to the highest levels of biodiversity, as predicted by some influential ecological theory.

PISCO activities

The PISCO onshore team uses water tables at HMSC for the purpose of storing mussels and barnacles for short periods of time as part of mussel growth experiments. The animals are collected from a common site, then stored in sea water at the Hatfield lab until they can be transplanted to nine intertidal sites along the Oregon coast, ranging from Cape Meares in the north to Cape Blanco in the south. After a year, the animals are collected and processed in the laboratory to determine differences in growth along the geographic range.

In September 2005, PISCO taught a graduate level intensive 10 day course called Marine Conservation Science and Policy. The course was held at HMSC, using the library facilities extensively as well as the housing. This course will be taught every other year at HMSC.

College of Veterinary Medicine

Tim Miller-Morgan, Extension Vet Aqua Specialist

Tim Miller-Morgan's academic home is in the College of Veterinary Medicine, Department of Biomedical Sciences (BMS) and is the first College of Veterinary Medicine faculty to be permanently based at the HMSC. He is currently working with Jerry Heidel, Director of the Veterinary Diagnostic Laboratory; Luiz Bermudez, Chair BMS; and Michael Kent, Director Laboratory for Fish Disease Research to develop a fish health program within the veterinary college.

Miller-Morgan, and Heidel are also involved in an Oregon Sea Grant funded project to model shipping stress in wild-caught marine ornamental fish in order to decrease shipment and post-shipment morbidity and mortality. Through a partnership with a marine ornamental importer in Los Angeles, they plan to use their results to develop recommendations for best management practices for marine ornamental importers. Additional funding was secured to work with suppliers and collectors in Indonesia to characterize the health and husbandry status of these fish as they arrive at collecting stations and export facilities. Miller-Morgan participated in a 2005 research trip to Indonesia. Information on courses taught is contained elsewhere in this report.

B. Federal and State Agencies

US Department of Agriculture

Agricultural Research Service (ARS)

Mark Camara, Research Geneticist

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 growing 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 seek alternatives to chemical methods to control pests in shellfish farms. The USDA supports two research programs at HMSC. Mark Camara's laboratory studies shellfish genetics. Brett Dumbauld's laboratory addresses the ecological aspects of shellfish farming in west coast estuaries.

The objective of the shellfish genetics project is to combine quantitative and molecular genetics techniques to develop improved breeding stocks for Pacific Northwest shellfish aquaculture. This program works in close collaboration with the Molluscan Broodstock Program to address economically important factors such as growth rate/efficiency, reproduction, survival, disease resistance, and product quality.

This past year, the shellfish genetics program has focused on four areas:

- 1) Using microsatellite DNA markers to determine the parents of oysters from plantings of mixed families. The ability to reconstruct pedigree information provides a powerful tool for conducting high intensity selective breeding while minimizing the deleterious effects of inbreeding depression.
- 2) Analyzing quantitative genetic variation and covariation in economically important characters in Pacific oysters to develop better selection procedures.
- 3) Identifying patterns of gene expression in selected oyster strains that are associated with enhanced tolerance to heat stress using DNA microarray technology. At present, summer mortality causes substantial and sometimes catastrophic losses on oyster farms. By determining which genes are important for responding to heat stress, it will eventually be possible to directly select for genotypes that are more likely to survive.
- 4) Obtaining genetically novel breeding stock of Kumamoto oysters from Japan in the hopes of correcting problems due to inbreeding depression and unintentional hybridization with Pacific oysters in commercial hatcheries.

The long-term goal of the shellfish ecology program is to

investigate the ecological role that shellfish aquaculture plays in west coast estuaries and to use the knowledge gained to design shellfish grow out, harvest and pest/predator control practices that are economically and environmentally sustainable.

This past year the shellfish ecology program has focused on two areas:

- 1) Examining the life history and ecology of two species of burrowing shrimp (*Neotrypaea californiensis* and *Upogebia pugettensis*) that cause substantial damage to oyster crops in Oregon and Washington. The intent is to develop integrated pest management strategies that combine physical, chemical, and augmentative biological control mechanisms for these shrimp. Shrimp population monitoring efforts were continued in three coastal estuaries and results suggest that ghost shrimp recruitment continues to be relatively low while mud shrimp recruited extensively to Oregon but not Washington coastal estuaries in 2006. Shrimp life history is being examined for vulnerable periods such as recruitment of juveniles to the benthos and mating and molting during larger juvenile and adult life stages. A collaborative project with Dr. John Chapman at HMSC also indicates that a parasitic bopyrid isopod is influencing mud shrimp populations .
- 2) Studying the effects of shellfish aquaculture on estuarine habitats utilized by juvenile salmonids and other important species in order to develop farming practices and farm plans that are compatible with the habitat requirements of these species. Willapa Bay, Washington is being targeted in this effort due to the extensive aquaculture operations there. An extensive mapping effort was initiated in Willapa Bay this year to map burrowing shrimp populations and ground- truth eelgrass cover from aerial photography taken in 2005.

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service

Alaska Fisheries Science Center

Allan W. Stoner, Program Manager

The Fisheries Behavioral Ecology Program conducts experimental research directed toward understanding the role that behavior plays in regulating distribution, abundance growth and survival of fish species and their interactions with fishing methods and fishing gear. The goal of the Program is to provide the critical information needed to improve survey techniques, to improve predictions of population abundance and survival, 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. 1) The Behavior Program continues to evaluate the key principles which control mortality in fish when they are discarded from fishing operations (bycatch mortality). Simple behavioral indices (e.g., reflex responses) were developed to predict capture-related delayed mortality, and the new predictors are being incorporated into field experiments in the United States and Canada. 2) Experiments on the effects of environmental conditions on the feeding and growth of fish were conducted. Laboratory studies were designed to test the thermal sensitivity of growth in northern rock sole and the effects of light level on foraging patterns for several fish species. Also, with the support of a new grant from the North Pacific Research Board (2006-08), new experiments were initiated to determine the effects of temperature on egg and larval development in Pacific cod. This project, representing collaboration between AFSC and the OSU Departments of Oceanography and Botany, is designed to project the effects of climate change on cod recruitment in the Bering Sea. 3) The habitat requirements of Alaska flatfishes are a continued emphasis for the Program. Spatially-explicit habitat models, based upon four years of towed camera surveys in Kodiak, Alaska, are being developed for juvenile northern rock sole. Laboratory experiments were focused on habitat-mediated predator-prey relationships, and both field and laboratory data are being used to assess the role of density-dependent behavior in flatfish distribution. 4) Behavioral observations were made on halibut and Pacific cod to assist in the improvement of fishing gear efficiencies and fish stock assessments. Experiments were conducted to explore how water temperature affects Pacific halibut and the associated relationship between catch-per-unit-effort on longlines and fish abundance, and a drop camera was used in Kodiak to determine how current velocity influences catch rates for halibut and Pacific cod.

Program staff & students

Benjamin Laurel joined the Fisheries Behavioral Ecology Program as a post-doctoral researcher in July 2005, to conduct experimental research related to density dependent behavior in flatfishes and to initiate early life history studies with Pacific cod.

Jena Lemke completed her MS degree in August 2005, with a thesis entitled "Evaluation of differing anti-predator strategies of three juvenile North Pacific flatfish species". The research was supervised by Cliff Ryer (AFSC)

Northwest Fisheries Science Center

NOAA Fisheries' Northwest Fisheries Science Center (NWFSC) is headquartered in Seattle and has five research stations in Washington and Oregon. The NWFSC's Newport Research Station, the Center's only ocean-port facility, is located on Oregon State University's Hatfield Marine Science Center campus and conducts critical research on groundfish and salmon and their ecosystems throughout the West Coast.

Administration :

Hollis Lundeen, Newport Research Station Facilities Manager

NWFSC staff conduct critical West Coast salmon and groundfish research in the Captain R. Barry Fisher building (BFB), Newport Aquaculture Lab (NAL), and Research Support Facility (RSF) building.

Center staff continued to make improvements in the areas of environmental compliance and safety. Recent additions to the facility included developing outside corridor and driveway lighting and improving building access using credential key cards with increased security requirements. Center staff conducted a series of inspections resulting in modifications to research fume hoods, lab reconfigurations, asbestos removal, and a HAZMAT shower and eyewash installation. Staff also participated in onsite training and tsunami drill coordination as part of the facility's Emergency Response Plan. In addition, Hollis Lundeen hosted several site tours for Foreign National visitors, local Job Corps graduation students, and visiting research vessel crew.

Environmental Conservation Division (EC):

Dr. Mary Arkoosh, Supervisor, Immunology and Disease

Dr. Mary Arkoosh and Bernadita Anulacion represent the Environmental Conservation Division (EC) in Newport. Their research continues to focus on interrelationships between salmonid's resistance to a pathogen, environmental stressors (e.g. pollution and the hydropower system), and infectious pathogens. Previous research, by EC 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. Little is currently known, however, as to the extent and relative significance of an altered immune function or delayed-disease induced mortalities associated with stressors and the subsequent impact 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 during out-migration; (2) dose-response assessment or laboratory studies to determine if immune dysfunction is observed in salmon after exposure to the stressor; and (3) risk characterization or determination of the extra risk to salmon populations exposed to the stressor.

Staff and collaborators from many disciplines are involved with these studies and they include: Dr. Frank Loge, Dr. Joseph Dietrich, Dr. Claudia Bravo, Erik Loboschefskey, and Don Thompson, University California Davis; Deborah Boylen, Dina Spangenberg, Nancy Raskauskas, and Amber Roegner, Frank Orth; and Dr. Tracy Collier, Lyndal Johnson, Dr. Nat Scholz, Gina Ylitalo and Bernadita Anulacion from the EC Division in Seattle.

LABORATORY STUDIES

Disease challenge after dietary exposure to contaminants EC scientists conducted a number of studies to characterize how a contaminated diet may influence disease susceptibility. They found that disease challenged fish (rainbow trout exposed to *Aeromonas salmonicida*) treated with an environmentally relevant contaminant mixture of PAHs, suffered about 40% cumulative mortality compared to 29% for controls. EC scientists also conducted diet studies on juvenile Chinook salmon and found that fish exposed to either a mixture of persistent organic pollutants, PAHs, PCBs, and DDTs, or to the flame retardant, PBDE, were more susceptible to the pathogen (*Listonella anguillarum*) than those that were fed the control diet.

Regulation of immune genes after dietary exposure to contaminants

EC scientists also performed microarray analysis on kidney tissues from rainbow trout exposed to PAHs and found that various immunologically relevant genes are influenced by contaminant exposure. Roughly 50 immunologically relevant genes were differentially expressed under pathogen challenge and PAH exposure. The genes were identified by comparing fish challenged with *A. salmonicida* and fed either the control or PAH treated diet. A sample of five immune genes that were differentially expressed under pathogen challenge when the fish were exposed to PAHs was selected to measure transcripts number with real time PCR. These five genes were not differentially expressed with just PAH exposure (no pathogen challenge). This comprehensive profile of transcriptional response in rainbow trout after exposure to PAHs and *A. salmonicida* can be used to identify potential biomarkers of exposure and to explore mechanistically PAH-induced immunosuppression.

FIELD STUDIES

Survey of pathogen prevalence and contaminant exposure To understand the potential impact of pathogens and contaminants on salmon populations from various Pacific Northwest estuaries, EC scientists have evaluated the prevalence

of pathogens and the concentration of contaminants, such as PCBs, DDTs and PAHs, in various populations of juvenile salmonids. Studies of juvenile fall Chinook and coho salmon from several Oregon and Washington coastal estuaries revealed that selected bacterial, protozoan, and viral agents are integral components of watersheds, although their intensity and prevalence varied. Contaminants were also found in tissues and stomach contents of Chinook and coho salmon sampled from all estuaries. Chinook salmon had a greater whole body contaminant concentration than coho.

Lower Columbia River Ecosystem Monitoring Program (LCREP) To better understand the spatial extent of contaminant uptake in outmigrating juvenile salmon, EC scientists initiated a pilot study, in conjunction with the Army Corps of Engineers, to measure contaminant concentrations in outmigrating juvenile salmon in the Columbia River Basin. Chemical analyses were completed on stomach contents and whole body samples of Chinook salmon from the Willamette/Columbia Confluence, Kalama/Longview, and West Sand Island. DDTs, PCBs, and PAHs were found in the stomach contents of fish from all sites, with high concentrations in fish from the Willamette/Columbia confluence. In some cases, the average concentrations of PCBs in whole body composites exceeded NOAA Fisheries' estimated threshold for adverse health effects. EC scientists are currently developing a method to determine the ability of salmon collected from the three sites to generate an immune response, which will allow scientists to monitor the plasma antibody response of individual fish to indigenous bacteria. In addition, EC scientists are currently developing a conceptual model, based on existing toxicological information, to identify contaminant sources and describe likely models and routes of transport, potential exposure and uptake of toxicant by listed salmon stocks, possible effects on survival and productivity, and regulatory or management issues to be addressed. These studies on salmon from the Columbia River Basin have been expanded to include monitoring outmigrant juvenile salmon from the lower Columbia River and estuary, and reconstructing historical growth rates for returning adults. The growth analysis involved measuring the inter-annuli distance on individual scales collected from Chinook salmon returning to the Columbia River from 1960 to 2000. The annual growth rates were then compared to measures of ocean productivity (e.g., Pacific Decadal Oscillation (PDO)), fishing harvest, and chemical production practices, to identify the impact of ecosystem variables on size.

Anadromous Fish Evaluation Passage (AFEP)

EC scientists recently expanded research into host-environment interactions to address the impact of in-river stressors (e.g., dams) on host susceptibility in the Columbia River Basin. Roughly 129,000 fish were PIT (Passive Integrated Transponder)-tagged at the Rapid River Hatchery located 40 miles upstream of Lower Granite Dam on the Snake River. Approximately 5,000 fish were collected at Lower Granite, the first dam encountered during outmigration, and barged around the next seven consecutive dams to Bonneville dam. EC scientists challenged both PIT-tagged in-river and barged fish that were collected at Bonneville dam with *L. anguillarum* to provide an aggregate measure of immune status. They found that fish that traveled in-river had

a substantially higher incidence of disease-induced mortality relative to barged-fish. This study was performed in conjunction with the Army Corps of Engineers and other NWFSC scientists and will be published in the *Journal of Aquatic Animal Health* in September. This study is currently being expanded upon to include PIT-tagged salmon from the Dworshak Hatchery located 73 miles upstream of Lower Granite Dam.

ECOLOGICAL RISK CHARACTERIZATION

From the laboratory studies conducted to date, infectious disease within outmigrant juvenile salmon in the Columbia River Basin appears to be strongly modulated by chemical and non-chemical (dams and predation) stressors that influence host-susceptibility. Through the application of a dose (stressor)-structured population dynamic model, EC scientists have shown that chemical and in-river stressors influence host-susceptibility, increasing the mean force of infection by a factor of 2.2 and 1.6, respectively. Using *L. anguillarum* as a model pathogen, they have shown that non-chemical in-river and chemical stressors contribute equally to the cumulative incidence of delayed disease-induced mortalities in Chinook salmon that range from 3 to 18% for estuary residence times of 30 to 120 days, respectively. Within this context, mitigation of the incidence of delayed disease-induced mortality represents a significant component in future management strategies to recover listed salmon stocks, strategies that must focus not only on controlling pathogen numbers, reservoirs, and virulence, but chemical and non-chemical in-stream stressors that influence host-susceptibility.

WEST COAST CENTER FOR OCEANS AND HUMAN HEALTH

Fish as Sentinels

EC scientists are actively involved in the NWFSC's new West Coast Center for Oceans and Human Health (OHH). This is one of three NOAA Centers established in 2004 to investigate critical linkages between oceans and human health. The Center is a multi-institutional partnership, including representatives from California, Oregon, and Washington. West Coast Center scientists are investigating three main agents that threaten human health—pathogens, marine biotoxins, and toxic chemicals—to assist resource and human health managers in making sound decisions that reduce or eliminate human health risks. Our research focuses on water quality and sentinel species. Fish, as sentinel species, are useful for examining disease transmission as related to modulation of host susceptibility because fish share a number of structural and functional characteristics of the mammalian immune system, and can be studied both in the laboratory as well as in their natural ecosystems. Our research focuses for OHH, in part, on examining the sequence of mRNA that produces the heavy chain of the antibody protein to determine if the antibody diversity has been altered due to contaminant exposure.

Fish Ecology Division (FE):

Dr. Ric Brodeur, Team Leader, Ocean Ecology

Dr. Dan Bottom, Supervisor, Estuarine Ecology

Dr. Bill Peterson, Supervisor, Climate Change and Ocean

Productivity

Drs. Ric Brodeur, William Peterson, Kym Jacobson, Dan Bottom, and Tom Wainwright and Robert Emmett represent the Fish Ecology Division (FE) in Newport and are all members of the NWFSC's Estuarine and Ocean Ecology Program (EOEP). Research programs involve extensive collaboration with scientists from Oregon State University, Oregon Graduate Institute, Department of Fisheries and Oceans/Canada, NOAA/Northwest Fisheries Science Center/Seattle, NOAA/Alaska Fisheries Science Center, NOAA/Southwest Fisheries Science Center, the University of Washington, the University of California at Santa Cruz, Troy State University (Alabama) and Centro Interdisciplinario de Ciencias Marinas, Departamento de Plancton y Ecología Marina. Current collaborators include: CIMRS: Cheryl Morgan, Leah Feinberg, Greg Krutzikowsky, Susan Pool, Elizabeth Daly, Toby Auth, Jen Menkel, Carrie Johnson, Jason Phillips, Paul Peterson, Heather Soulen, Tracy Shaw, Jesse Lamb, Rian Hooff, Mary Bhuthimethee; Post Doctoral Associates: Drs. Hongsheng Bi, Cynthia Suchman, Jay Peterson, Jim Ruzicka, Doug Reese, and Vlada Gertseva; Graduate Students: Todd Miller, Julie Keister, Todd Sandell, and Rebecca Baldwin.

Columbia River Plume Study: Ocean conditions and juvenile salmonids

FE scientists study 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. This project includes study of salmon feeding and relationships between feeding preferences and prey, and of the potential impact of salmonid predators on salmon survival. FE scientists also study interrelationships between zooplankton and salmon, sardines, anchovy, and herring. In conducting these studies, scientists use an ecosystem-based approach to investigate the biotic and abiotic factors that control growth, distribution, health and survival of important fish species and on the processes driving population fluctuations. Ultimately, this ecosystem-based research will be applied to management of fish stocks off the Oregon coast.

FE scientists study predator/prey relationships among hake, mackerel and juvenile salmon off the Oregon and Washington coasts as part of a project funded by the Bonneville Power Administration. This project is led by Robert Emmett with field assistance from Carrie Johnson and Paul Peterson. Cruises are conducted every 10 days off Willapa Bay and the Columbia River. Predators and prey are sampled with a pelagic trawl at night to determine if hake and mackerel are significant predators on juvenile salmonids. Information is also gathered on the abundance and distribution of forage fishes, which may act as alternative prey for these predators. This study is testing the hypothesis that recent increases in abundances of predators may explain the recent declines in juvenile salmonid abundances.

Another major FE investigation involves examining the correlation between salmon growth and survival and the unique physical and biological characteristics of the Columbia River

plume. This work is also funded by the Bonneville Power Administration and is being performed in collaboration with scientists from the Oregon Graduate Institute. 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 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, and prey fields and relating them to ocean conditions in and around the plume. There are many scientists involved with salmon growth and survival studies in the plume, including Drs. Peterson, Brodeur, and Jacobson, and Cheryl Morgan, Jesse Lamb, and Elizabeth Daly. The ultimate goal of these studies is to determine whether the plume represents a favorable feeding location for juvenile salmon.

In another project funded by the Bonneville Power Administration, Dr. Peterson, Dr. Bi, Cheryl Morgan, and Joe Fisher are studying habitat requirements of juvenile salmonids in the Washington and Oregon upwelling zones. After years of sampling, they established that coho and Chinook salmon juveniles are restricted entirely to coastal waters, chiefly off the coast of Washington State. Chinook were found at stations with shallower water depths than coho. In fact, through analysis of their data, along with historical data collected by Dr. Bill Pearcy (OSU), they found that the two species maintain a constant depth separation. To further study the habitat requirements of juvenile salmon, Rachel Ruppel used GIS to map salmon distributions along with oceanographic variables. Hongsheng has been using logistic regression, poisson regression and quantile regression to determine which oceanographic variables best describe salmon habitats. At this point, the best predictors of habitat size are water depth, chlorophyll and copepod biomass. Rachel established that chlorophyll, as measured by NASA satellites, is a good predictor of the size of available habitat for juvenile salmon in continental shelf waters.

The RISE Program (Riverine Influences on Shelf Ecosystems) This research program is funded by the National Science Foundation to investigate the influence of the Columbia River plume on productivity of the coastal ecosystems off Washington and Oregon. The program is led by Dr. Barbara Hickey (University of Washington) and involves principal investigators Drs. Ken Bruland and Rafel Kudela (University of Santa Cruz), Evelyn Lessard and Parker MacCready (University of Washington), Jonathan Nash, Jim Mourn, Mike Kosro and Ed Dever (Oregon State University), David Jay and Antonio Baptista (Oregon Health Sciences Institute) and Dr. Peterson. The program is investigating the reasons for high productivity within the Columbia River plume and is testing the hypothesis that phytoplankton growth and zooplankton production are higher in waters associated with the plume and in shelf waters off Washington due to the influence of iron and silicate on phytoplankton growth. Jay Peterson (HMSC/CIMRS) is using a Laser Optical Plankton Counter to look at fine scale distributions of zooplankton. Jay has established that high concentrations of zooplankton-sized particles are found at the base of the plume-generated pycnocline and within fronts along the northern edge of the plume. Tracy Shaw and Bill Peterson have been measuring

spatial variations in egg production by euphausiids and copepods and molting rates of euphausiids in order to determine if secondary production is higher off Washington than Oregon and whether there are any productivity “hotspots” off Washington. This program will improve understanding of why salmon are much more abundant off Washington than Oregon.

Long Term Coastal Monitoring

This research program involves euphausiid, copepod, and ichthyoplankton studies, as well as ecological indices.

Euphausiid Studies. A research program, under the leadership of Dr. Peterson, continued this past year and involves at-sea sampling 2-3 times per month at stations from 1 to 25 miles west of Newport. The year 2006 marks the beginning of the 11th year of these efforts. At each station, Leah Feinberg, Tracy Shaw and Jen Menkel measured temperature and salinity profiles and collected samples for later analysis of nutrients, phytoplankton, zooplankton and ichthyoplankton. Leah Feinberg is analyzing data from the ten-year 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.

Over the years, the coastal monitoring research program has provided valuable information. Through this program, FE scientists found that from 1996-1998 zooplankton biomass was low and there was a high incidence of subtropical species in coastal waters. Euphausiids, a key forage item for rockfish, salmon, Pacific whiting, seabirds, and whales were in low numbers and spawned only once per year, in late summer. Beginning in 1999, commensurate with cool ocean conditions, zooplankton biomass began to increase and the euphausiid spawning season was expanded to include April through September. Since late 2002, the ocean has been warming, productivity has declined and copepod biodiversity has increased to levels near those observed during the 1983 and 1997/1998 El Niño events. The summer of 2005 was unusual in the northern California Current, being characterized by a “warm water event” which resulted in a collapse of the food chain and high death rates of many fishes (including salmon) and seabirds. The effects strongly resembled a major El Niño, however the equatorial waters were in a neutral El Niño state. A perturbation of the normal climate forcing resulted in a delayed start of the coastal upwelling season from the usual April to late July. Bill Peterson, along with Nick Bond and Ed Casillas, convened a workshop in Seattle in January 2006 to discuss the causes and effects of this warm event. Papers discussing the physical forcing and biological response will soon be published in a Special Issue of *Geophysical Research Letters*.

Laboratory measurements have been a key focus of the euphausiid research, including measurements of euphausiid brood size, molting rates and feeding rates, using live animals that are collected during each cruise. These studies support estimates of krill biomass in the northern California Current and the potential

for a krill fishery in this area. Tracy Shaw recently finished writing a handbook that describes protocols for carrying out laboratory measurements of egg production and molting rates of euphausiids. This handbook is the first installment of activities devoted towards standardization of methods for carrying out experimental work and field sampling of these animals, and is part of a larger North Pacific Marine Science Organization (PICES) program, “The Year of the Euphausiid”. Jen Menkel is enumerating euphausiids in plankton net samples at a furious pace so as to produce some of the first estimates of euphausiid biomass in the northern California Current. She is finding that there is often a maximum in euphausiid biomass on Heceta Bank and off southern Oregon. Leah Feinberg is summarizing a massive laboratory experiment whereby she, Tracy Shaw and Jaime Gómez monitored daily egg production by nearly 30 female euphausiids, each day, for nine months, during which females from Santa Barbara were compared to females from Heceta Bank. They found that Santa Barbara produced a brood of eggs every four days whereas Heceta females were producing eggs every five days on average. Both had similar brood sizes.

Copepod Studies. Dr. Peterson and Rian Hooff worked to coordinate the analysis of historic data sets collected off Newport to describe long-term changes in hydrographic conditions and zooplankton abundance off the Oregon coast. Recent analysis of these zooplankton data show high correlation between coho salmon survival and zooplankton species 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. They also have shown that changes in sign of the Pacific Decadal Oscillation (PDO) clearly manifest themselves in Oregon waters, but with varying time lags. That is, water temperatures lag the PDO by several months, changes in copepod biodiversity lag the PDO by four to six months, but changes in copepod biomass lag the PDO by two years. Similarly, the response of baitfish abundances and juvenile salmon abundance lags a change in PDO by one to two years.

Ichthyoplankton Studies. Dr. Brodeur, Dr. Peterson, Dr. Emmett, Toby Auth, and Heather Soulen examined ichthyoplankton samples from fixed stations off the Columbia River and 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. From the 1970s to present, they have found major changes in the ichthyoplankton composition related to shifts in ocean conditions. In particular, sardines, anchovies, Pacific hake and jack mackerel have been spawning regularly off the Oregon Coast in contrast to some earlier periods, whereas some cold-water species such as smelts are in relatively low abundance.

Dr. Robert Emmett and Dr. Brodeur initiated a new study in summer 2004 to examine seasonal variation in abundances of juvenile fishes, including rockfish. This project was funded by NOAA's Stock Assessment Improvement Program and will examine 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. Jason Phillips and Toby Auth conduct the sampling and process the biological and physical data. Surveys in 2004 and 2005 (five each year) found high numbers of juvenile rockfishes, but also found many juvenile hake and jack mackerel, species not known to spawn off Oregon.

Modeling and Ecological Indices. As part of the NOAA Fisheries and the Environment (FATE) program, Drs. Peterson, Wainwright, and Ruzicka are developing a biophysical model of zooplankton production. This model will be used to reconstruct a time series of plankton production as an index of food supply for juvenile salmonids and other small pelagic fishes. This new ecological index will help improve fish harvest management. Bill Peterson recently completed a lengthy 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," which will soon be published to the web. This report includes nearly a dozen of ecological indicators of ocean conditions in the northern California Current and shows how some can be used to predict returns of coho and Chinook salmon one year in advance. Further development of biophysical models for the northern California current is being conducted by Drs. Wainwright and Ruzicka in collaboration with PICES and funding from the NOAA Office of High Performance Computing and Communications, with an aim to better understand the relationship of biological production to physical forcing and climate change.

GLOBEC Investigations

Zooplankton studies transitioned from the data acquisition to data synthesis phase. The GLOBEC Long-Term Observation Program sampling was completed in September 2003 and the GLOBEC-funded studies of euphausiid population dynamics were completed at the end of 2004. Synthesis activities began in 2005 and include 1) synthesis of salmonid studies, including distribution and abundance, trophodynamics and diseases and parasite studies along with determination of habitat requirements of juvenile salmon, and 2) population dynamics of euphausiids. Dr. Hongsheng Bi is developing statistical models of habitat requirements of juvenile salmonids, and together with Dr. Bill Peterson and Cheryl Morgan is developing statistical models that predict coho survival based on measurements of water temperature, chlorophyll, and zooplankton biomass and species composition.

Companion GLOBEC studies by Drs. Brodeur, Jacobson, and Wainwright and Emmett continued to investigate the distribution, abundance, growth, food habitats, and condition of juvenile salmon off Southern Oregon and Northern California. A number of scientists are contributing to these studies, including Suzan Pool (distribution and habitat associations of nekton and neuston), Todd Miller (feeding relationships among salmon and other nekton), Rebecca Baldwin (parasite fauna of these nekton), Todd Sandell (pathogens of salmonids), and Dr. Jim Ruzicka (ecosystem model). Determination of associated pelagic nekton, including potential competitors and predators, will provide clues

regarding the relationship between oceanographic conditions and the abundance and health of salmon during their first summer at sea.

Dr. Jacobson and Todd Sandell evaluated the ecology of disease and the importance of disease processes that affect salmon populations in the estuary and ocean environments. The potential contribution of salmon pathogens (viruses, bacteria and macroparasites) to growth and survival of salmon is being examined in ocean juveniles along the coast. The results will be related to results of growth, condition and bioenergetics being conducted by Joe Fisher (OSU) and FE scientists at the NWFSC in Seattle. Pathogen prevalences will also be compared to the results of studies conducted in Oregon and Washington estuaries by scientists within the EC Division. These later studies are aimed at gaining a better understanding of the contribution of infectious agents to salmonid mortality. Funding for this research comes from both U.S. GLOBEC and the Bonneville Power Administration.

As part of a large-scale GLOBEC synthesis study of salmon in the Northeast Pacific, Dr. Brodeur co-organized a session at the American Fisheries Society Meeting that will look at regional comparisons of salmon distribution and ecology. Studies were made on regional comparisons in distribution (Fisher, Brodeur), condition (Fisher), feeding (Brodeur, Daly, Miller), parasites (Jacobson, Baldwin) and associated nekton (Brodeur, Emmett). These papers will be published in a special volume of the American Fisheries Society.

In May 2005 and 2006, Dr. Peterson led a coastwide hydrographic and plankton survey between central California and central Washington. This study, funded by the Stock Assessment Improvement Program, was specifically designed to provide estimates of euphausiid biomass in the northern California current and to examine broadscale ichthyoplankton distributions.

Harmful Algal Blooms

Dr. Bill Peterson was recently funded to begin work on Harmful Algal Blooms in Oregon's coastal waters. A post-doc, Dr. Linda O'Higgins from the National University of Ireland, Galway, Ireland, will join Bill's group this fall when she will begin to enumerate phytoplankton species in plankton samples that Bill's group has been collecting since the year 2000. Bill and Linda will work closely with members of the ECOHAB and ORHAB groups at the University of Washington and the NOAA Fisheries NWFSC in Seattle.

Pelagic Migratory Species

Drs. Jacobson and Emmett began a program in 2005 to investigate the migration and stock distribution of pelagic baitfish initially focusing on Pacific sardines off the coast of Oregon and Washington. This program, conducted by Rebecca Baldwin, includes the use of parasites as potential biological markers.

Drs. Richard Brodeur and Doug Reese are collaboration on a project to use LIDAR (laser) technology to survey pelagic schools from airplanes and comparing abundance estimates to shipboard and moored acoustic arrays. Preliminary results from

August 2005 surveys indicate very patchy distribution of schools related to oceanographic features such as fronts and the Columbia River Plume. Researchers from NOAA's Environmental Technology Lab and University of Alaska, University of Washington, and Oregon State University are also involved in the project.

Columbia River Estuary Studies

FE scientists have been regularly sampling the Columbia River estuary for baitfish and juvenile salmon, as part of a Bonneville Power Administration-funded study. This program is led by Drs. Emmett and Jacobson, with assistance from Todd Sandell and Carrie Johnson. Information generated from this research includes relative abundance of different baitfish species, length/age-frequency distributions, and comparisons to offshore catches of baitfishes. Ultimately this study should identify if estuaries provide a "critical" habitat for a resource (baitfish), which strongly influences salmonid marine survival.

In collaboration with NWFSC scientists at other laboratories, Dr. Emmett has been involved with a Salmon Time of Release Study funded by the Army Corps of Engineers. This study examines the relationship among time of juvenile salmon ocean entry, physical and biological characteristics of the estuary and nearshore ocean plume environment, and smolt-to-adult return rates (SARs) for spring chinook salmon reared by the Clatsop Economic Development Committee Fisheries Project (CEDC) in the lower Columbia River. By enhancing our understanding of the linkages between ocean entry and the physical and biological estuarine and ocean conditions smolts encounter, we can optimize SARs by manipulating transportation tactics and hatchery release dates.

A team of researchers lead by Dan Bottom and supported by funds from the U.S. Army Corps of Engineers and Bonneville Power Administration evaluated the effects of flow management and historic habitat change on juvenile salmon in the Columbia River estuary. The study evaluates fish and prey assemblages within selected tidal wetlands; analyzes historic 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. Dr. Jacobson and Mary Bhuthimethee are also examining parasite communities of juvenile salmon to provide independent indices of juvenile salmon diet, habitat use, and habitat health within the Columbia River Estuary. Scientists will 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.

Coastal Estuary Investigations

FE scientists, in collaboration with Oregon and Washington Departments of Fish and Wildlife, Oregon State University, and the University of Washington continued a project, funded by Oregon Sea Grant, to investigate Salmon River marshes in various stages of recovery following the removal of dikes and tidegates. The project included several phases that examined various aspects of restoration. The final phase of the project is testing whether the results from Salmon River apply to tidal

marshes in other Northwest estuaries and the relative contribution of various juvenile life history types to the returning adult population in Salmon River and other coastal estuaries. Field studies for the Salmon River project will be completed in 2006. Project completion will culminate in an April 2007 conference to discuss the concept of resilience and applications for managing salmon ecosystems.

Fishery Resource Analysis and Monitoring Division

(FRAM):

LCDR Brian Parker, Newport Program Manager

Dr. Michael Schirripa, Supervisor, Assessment and Aging

Dr. Waldo Wakefield, Supervisor, Habitat Conservation and Engineering

FRAM Division science team members, many of whom are located at the HMSC in Newport, conduct studies providing the scientific information used as the basis to manage West Coast Groundfish stocks and their ecosystems. The studies involve comprehensive analysis of data from fishery monitoring, fishery-independent resource surveys, and biological investigations. The results provide estimates of the current status and future trends in abundance and productivity of marine fishery resources, evaluations of the potential effects of fishery management alternatives on abundance and yield of living marine resources, and better information on fishery bycatch and other multi-species issues. LCDR Brian Parker (NOAA CORPS) and Drs. Michael Schirripa, Waldo Wakefield, Patrick Ressler, and Jean Rogers, and Keith Bosley, Erica Fruh, Dan Kamikawa, John Buchanan, Julia Clemons, Mary Craig, Jim Miller, and seasonal technicians Keri York, Justin Ainsworth, and Melanie Johnson represent FRAM in Newport. Cooperating staff include:

- 1) Cooperative Institute for Marine Resources Studies (CIMRS) fellows Drs. Vladlena Gertseva and Jim Colbert and graduate students Josie Thompson, Natalie Strom, Maria Jose Juan Jorda, and Andy Lanier;
- 2) Oregon Coast Community College (OCCC) undergraduate students Jessica Trantham, Nick Russo, and Miranda Petersen;
- 3) Pacific States Marine Fisheries Commission (PSMFC) staff Patrick McDonald, Nikki Atkins, Omar Rodriguez, Betty Kamikawa, Susan Coccetti, Lisa Lysak and Jennifer Cramer;
- 4) IAP World Services, Inc. staff Allen Cramer;
- 5) Archipelago Marine Research, LTD staff Steve Ward and Andrea Crumpacker; and
- 6) Mechanical Engineering Systems (MES) staff Carol Kscynski.

This season a number of the Newport staff as well as FRAM Division Director Dr. M. Elizabeth Clarke, participated along with a number of university and other agency groundfish researchers in planning and organizing the 2006 Western Groundfish Conference held in Newport January 30 – February 3, 2006. Attended by researchers from all along the U.S. and Canadian Pacific coast, the conference provides a unique, biennial opportunity to review current research on groundfish

science and management on the west coast of the United States and Canada. Topics included stock assessment, survey methodology, fishery monitoring, ecosystem analysis, conservation, marine protected areas, habitat classification and general fishery biology.

Stock Assessments and Stock Assessment Research

In 2005 the FRAM Stock Assessment team members produced two full assessments, one on sablefish (*Anoplopoma fimbria*) prepared by Dr. Michael Schirripa, and one on darkblotched rockfish (*Sebastes crameri*), prepared by Dr. Jean Rodgers. Details on these assessments (and other west coast groundfish assessments conducted in 2005) can be obtained from the Pacific Fisheries Management Council's web site (www.pcouncil.org). The sablefish and darkblotched assessments form the basis for Council recommendations for Allowable Biological Catches and Optimum Yields for these species for 2007-08, which will be finalized at the June 2006 Council meeting.

Michael Schirripa obtained funding from the NOAA Fisheries And The Environment (FATE) program. Part of this money has been used to continue funding Dr. Jim Colbert (CIMRS), who is working with Dr. Schirripa on incorporating environmental indices in the stock assessments. Previous work within this project identified key oceanographic variables that were correlated with annual variations in sablefish recruitment success. This work was formally incorporated into the 2005 sablefish stock assessment. Since the completion of that assessment, FATE-sponsored work has focused on two issues:

- 1) Testing and improving the capability of assessment software to utilize available ecological indicators and correctly estimate pertinent fishery parameters and;
- 2) Determining data requirements for future FATE studies.

The Stock Synthesis Assessment Program (SS-II, Methot 2005) is the primary modeling software used in assessing west coast groundfish. The research examines the ability of this software to estimate the effect of environmental leading indicators on fish population recruitment dynamics. By producing data inputs to SS-II that originate from designed simulations with known parameter values using an independent fishery simulation model (FSIM Goodyear 2005), we are testing the ability of SS-II to recover the true underlying effects of the leading indicators on the simulated population, as well as the ability to differentiate between environmental drivers and other potentially confounding effects, such as random variations. Through simulating population and fisheries dynamics from pre-determined parameters, the ability of SS-II to correctly estimate unknown environmental influences in a typical assessment setting can be better understood. Results from this work will be of use to the stock assessment community, through identification of potential improvements to the manner in which SS-II models environmental influences on historic and projected fish populations. These results should also prove useful to FATE by determining the data requirements involved in producing leading indicators and consequently helping to design future FATE studies. This simulation project also has the potential to improve

our understanding of number of important assessment modeling questions, including estimating selectivity, survey catchability, and growth.

Dr. Vladlena Gertseva, a CIMRS cooperator, and Dr. Schirripa have begun work on the first skate assessment for the U.S. west coast. Although focusing on longnose skate (*Raja rhina*), other important species of skates such as big skate (*Raja binoculata*) and sandpaper skate (*Bathyraja kincaidii*) will also be considered.

In September 2005, Dr. Schirripa chaired a scientific session of the North Pacific Marine Science Organization (PICES), an inter-governmental scientific organization that was established in 1992 to promote and coordinate marine research in the northern North Pacific. The session, entitled "Evidence of distributional shifts in demersal fish and invertebrates in relation to short and long term changes in oceanographic conditions", included seventeen oral presentations given by scientists from Canada, China, Japan, Korea, Russia, and the United States. Details of these presentations can be found at the PICES web site (www.pices.int). Dr. Schirripa continues his role as one of the three U.S. representatives and members of the PICES Fishery Science Committee.

Through a cooperative agreement between NOAA Fisheries and the Pacific States Marine Fisheries Commission, the assessment program continues to collaborate with the cooperative Ageing Lab based at HMSC. The Ageing Lab produced ages to support assessments on Pacific hake, Pacific Ocean perch, sablefish, Dover sole, canary rockfish, darkblotched rockfish and English sole. Quality control is provided through regular training and double reads. In addition to production aging, the Ageing Lab also cooperates with NWFSC stock assessors on research projects that enhance future stock assessments. One project compared English sole age estimates from interopercles to otoliths, providing NWFSC scientists the ability to incorporate more fishery independent data into English sole stock assessments.

Habitat Investigations

The FRAM Habitat and Conservation Engineering Team members, Dr. Wakefield, Keith Bosley, and Julia Clemons, are located at the HMSC. The HCE Team is responsible for conducting fish habitat studies and for working with agency and academic scientists, and the fishing industry to develop and evaluate modifications to fishing gear to reduce fishing impacts on bycatch species and marine habitats. Along the West Coast, a number of regional interdisciplinary groups have come together to apply innovative approaches to the study of fish habitat. In general, these groups have linked the fields of marine geology and fisheries to identify habitat associations in commercially important groundfish species. For Oregon and Washington, FRAM has formed an interdisciplinary team with geologists from Oregon State University and the NOAA Pacific Marine Environmental Laboratory and invertebrate ecologists from Washington State University Vancouver. Examples of other recent and ongoing research projects involving the HCE Team include work on fish behavior during interactions with bottom trawls, and stable isotope and dietary studies of demersal fishes.

West Coast Essential Fish Habitat: Geologic and Geophysical Bottom Character Database and GIS for U.S. West Coast Groundfish - The database and GIS project for West Coast Essential Fish Habitat is a joint effort between Dr. Chris Goldfinger's Active Tectonics and Seafloor Mapping Laboratory at Oregon State University and Dr. Wakefield. Initiated in 2001, the goal of this program is to create and use a comprehensive, helpful and easily accessible, multi-layered GIS database and associated CD-ROM-based products for groundfish habitat assessment in the Pacific Northwest. The database for Oregon and Washington has been linked to an integrated habitat database for California (Dr. Gary Greene at Moss Landing Marine Laboratories and Mary Yoklavich at Southwest Fisheries Science Center). For the first time, marine researchers working along the U.S. West Coast have an integrated map of structural habitat for the entire region (San Diego, CA to Cape Flattery, WA). In addition, the combined GIS database for California, Oregon and Washington is being used in the current Essential Fish Habitat Environmental Impact Statement for West Coast groundfish.

Version 1.0 of the maps for Oregon and Washington was completed in 2003. Since delivery of the interim maps, work has continued in 2005 and 2006 on updates of the habitat maps. Information from this project feeds directly into the development of a new "West Coast Marine Habitat Server" which will be an interactive mapping tool providing access to various marine habitat data through an online mapping service (ArcIMS map server). The development of this website is being led by Dr. Elizabeth Clarke (NWFSC FRAM Division), is a collaboration between the Northwest Fisheries Science Center, Oregon State University's ATSMML, Pacific States Marine Fisheries Commission and Alsea Geospatial Inc. and PaCOOS (Pacific Ocean Observation System) and is funded by the Integrated Ocean Observation Program of NOAA,

Bycatch Reduction: Fish behavior during interactions with bottom trawls - Initiated in 2004, this project utilizes a state-of-the-art ultrasonic camera (DIDSON or dual frequency identification sonar) in conjunction with conventional in situ video to document and categorize fish behavior during the sequence of capture in bottom trawls with an emphasis on a selective flatfish trawl – an experimental net being used in West Coast groundfish fisheries. The selective flatfish trawl has been shown to maintain the catch rate of flatfish while allowing larger and more mobile species (e.g., rockfishes, shortspine thornyhead, and hake) to escape by swimming above the headrope. Complementary biochemical studies are being conducted to evaluate swimming capabilities in selected groundfish species. This project represents the first successful application of a DIDSON sonar in bottom-tending mobile fishing gear. A novel set of mounting frames provided a stable platform for sonically imaging all areas in front of and in the mouth of the trawl (e.g., footrope, headrope, wings, and form of the footropes mud cloud). Investigators acquired an extensive set of paired observations with video and DIDSON imaging of the same areas/fish targets, providing the first documentation of the efficacy of using a DIDSON sonar in mobile fishing gear. Pacific halibut, lingcod, Pacific hake, skates, and other flatfish were imaged routinely

with the DIDSON. This initial phase of the project provided information on the performance of the selective flatfish trawl: the speed and direction of movement of fishes, herding behavior, wing interactions, and footrope and headrope effects. These preliminary observations will be the basis for the second phase of study to be conducted during summer 2006. This work is collaborative between the NWFSC, Alaska Fisheries Science Center and Oregon Department of Fish and Wildlife.

Stable Isotope and Dietary Studies of Demersal Fishes Off of Oregon and Washington - The combination of stable isotope studies with the analysis of feeding habits presents an effective tool for characterizing some of the dynamics of exploited marine ecosystems on both a species and a trophodynamic basis. As part of an ongoing study of groundfish trophodynamics, Keith Bosley has continued to add to and expand his collections of tissue samples from several rockfish species during the NWFSC's bottom trawl surveys of the continental shelf waters along the U.S. west coast to examine trophic relationships. During the upcoming 2006 field season, the study will expand to include flatfishes as well. Most recently, Mr. Bosley was awarded funding from NWFSC to extend the use of stable isotopes to examine the feeding ecology of late larval and young-of-the-year rockfish (genus *Sebastes*) off Oregon and southern Washington. The new project involves collaborations with Drs. Ric Brodeur (NWFSC-FE Division) and Chris Harvey (NWFSC-FRAM Division).

Resource Surveys

The FRAM survey team, with biologists Keith Bosley, John Buchanan, Erica Fruh, and Dan Kamikawa and biological technicians Keri York and Melanie Johnson stationed at the HMSC, is responsible for conducting the annual coast wide groundfish trawl surveys. These surveys are designed to provide information needed to determine the relative abundance and distribution of groundfish species along the continental shelf and slope off the Washington, Oregon, and California coasts.

The 2005 survey season began with the annual "At Sea Safety" training and survey orientation session for team members, participating students, and volunteers at HMSC. From May through October the team worked aboard the chartered fishing vessels Ms. Julie, Noah's Ark, Excalibur and Raven conducting the West Coast Bottom Trawl Groundfish Survey. The survey targets trawlable areas along the U.S. western continental shelf between the Canadian and Mexican borders, in depths ranging from 30 to 700 fathoms. In addition to collecting catch data, team members collect biological samples such as otoliths for fish aging data and stomach samples for prey analysis. Survey team members also collect biological samples and conduct cooperative research projects with and for other agency and university researchers around the country.

The ninth annual groundfish survey began in May 2006 with the annual "At Sea Safety" training and Survey Orientation sessions at HMSC. The contracted fishing vessels Noah's Ark and Ms Julie embarked upon the actual survey in late May. The second pass will be aboard the fishing vessels Excalibur and Raven and is expected to conclude in late October.

Acoustics

In addition to coast-wide bottom trawl surveys for groundfish, FRAM scientists conduct surveys and fisheries research employing underwater acoustics. Dr. Ressler, the Newport-based member of the FRAM Acoustics Team, and seasoned biologists contributed to both survey and analysis efforts involving acoustic fisheries surveys, research on environmental factors driving the distribution of groundfish species, and the application of acoustic technology to fisheries problems. Major efforts of the FRAM Acoustics Team during 2005-2006 included:

The completion of another of a series of an established joint Canadian and U.S. coast-wide Pacific hake acoustic survey. Science teams, which included the NOAA Fisheries scientists stationed at Newport and OSU Oceanographer, Steve Pierce, conducted the survey from 20 June to 19 August aboard the NOAA vessel Miller Freeman. The survey spanned the continental slope and shelf areas the length of the West Coast from south of Monterey California (35.7o N) to the Dixon Entrance area (54.8o N). Aggregations of coastal Pacific hake were detected from approximately 37o N (Monterey Bay) and extending nearly continuously to the furthest area to the north surveyed at Dixon Entrance. Areas of prominent concentrations of hake included the waters off Point Arena (ca. 39o N) and north of Cape Mendocino, California (ca. 41o N), in the area south of Heceta Bank, Oregon (ca. 44o N), the waters spanning the US-Canadian border off Cape Flattery and La Perouse Bank (ca. 48.5E N), and local concentrations within Queen Charlotte Sound (ca. 51o N). Mid-water and bottom trawls, deployed to verify size, species composition and collect biological information (i.e., age composition, sex), found that smaller individuals - age-2 fish - were prevalent in the southern portion of the range, but the coastal Pacific hake stock continued to be dominated by representatives of the 1999 year-class (age 6) throughout most of their range, with the expected occurrence of older Pacific hake most predominant in the north.

Based on the acoustic survey, the coast-wide estimates of Pacific hake abundance totaled 2.5 billion fish weighing 1.26 million metric tons. As expected from the age and length distribution, the population was dominated by age-6 fish. These fish, the 1999 year class, contributed about 48% of the total coast-wide number and 55% of the total coast-wide biomass. Age-2 hake contributed 24% of the coast-wide number and 13% of the coast-wide biomass. The 2005 biomass estimate of 1.26 million metric tons represents a 0.58 million metric ton, or 68% decrease over the biomass estimate made for 2003. Though reduced and representing the eighth largest estimated biomass over the entire history of the survey, the 2005 estimate is at a level commensurate with recent levels. Our expectation of the level of abundance of Pacific hake was confirmed by this survey with the 2005 estimate representing declining trend in coastal hake biomass. Clearly, the increase seen in 2001 and subsequent decline in 2005 coast wide biomass can be attributed almost entirely to the 1999 year class.

In a related item, the onset of the 2005 upwelling season was about five weeks later than usual, and well-established upwelling

with a cold surface temperature signature did not occur until about seven weeks after this. As part of the joint US-Canada Pacific hake survey, we surveyed the Newport Hydrographic section at 44.65°N, ranging from the Oregon coast to 83 km offshore during 14-16 July 2005. Instead of the cold surface layer expected in July, we observed anomalously warm water. We also noted an intriguing preliminary result regarding the effect of the unusual evolution of the 2005 upwelling season on hake. On 12 July 2005, prior to the onset of well-established upwelling, Pacific hake were observed in a tight aggregation just seaward of the shelf break at 43.44°N, at a mean depth of 61 m. When this same transect was repeated on 20 August 2005, in the midst of the stronger-than-average upwelling that was by then well-established, Pacific hake aggregations were found to have moved to a shallower mean depth of 231 m, in a mesopelagic layer which extended several kilometers offshore. This shift of mean hake depth off the Oregon coast, likely driven by their response to changes in thermal and other related hydrographic conditions, is the topic of intense analyses to be presented at several upcoming scientific conferences.

West Coast Groundfish Observer Program

Initiated in the summer of 2001, the West Coast Groundfish Observer Program continues to successfully deploy observers aboard commercial fishing vessels along the West Coast. Through a cooperative agreement between NOAA Fisheries and the Pacific States Marine Fisheries Commission, the observer program maintains an observer coordinator, Allen Cramer, and a data debriefer, Jennifer Cramer at the HMSC. Through a similar agreement with the Canadian-based Archipelago Marine Research, LTD, the observer program maintains two electronic monitoring technicians for three months a year at the HMSC facility who provide support for the inshore hake video monitoring program. The Observer Program conducts observer training (sampling, species identification, and safety) twice annually at Hatfield. Observers are responsible for collecting catch and discard estimates, species composition data, and biological specimens in West Coast groundfish fisheries. This year witnessed an increased effort on collecting biological specimens to aid in stock recruitment, composition and assessment estimates. Specimens were also provided to a number of scientific and educational organizations. Increasingly, the program has becoming more involved in cooperative training classes hosted at Hatfield, providing cold water survival, 'At Sea Safety', and fish identification training for the Survey Team and ODFW recreational port sampling group.

Conservation Biology Division (CB):

Dr. Peter Lawson

Drs. Peter Lawson and 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 population dynamics of Oregon natural coho salmon. Dr. Weitkamp's primary research interests include the marine ecology of Pacific salmon, salmon bioenergetics, life history variation, and conservation. Heather Stout's interests focus on the role of wetlands and estuary habitat as a limiting factor for Oregon Coast coho salmon, and in rapid

wetland assessment for use in restoration prioritizations and wetland permitting issues. Work is done in collaboration with Oregon Department of State Lands, Oregon Department of Fish and Wildlife, Coos Bay Watershed Council, tribal agencies, and Oregon State University Sea Grant.

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, 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.

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 the U.S. Forest Service PNW Research Lab's Coastal Landscape Analysis and Modeling Study, 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 instream habitat change on coho salmon populations. Integration with climate models will further enhance understanding of coho salmon population dynamics.

Salmon Harvest Management

Dr. Lawson continued to provide technical advice to fishery management agencies through the Scientific and Statistical Committee of the Pacific Fishery Management Council. He and Dr. Weitkamp also continued to serve on the Coho Technical Committee of the Pacific Salmon Commission.

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 plans for all listed salmon in several broad geographic areas (for more information about the process, see <http://www.nwfsc.noaa.gov/cbd/trt/>). The first step in this process is developing biological goals for the recovery of salmonid species, a task that is assigned to "Technical Recovery Teams" (TRTs). Dr. Lawson (co-chair), Dr. Weitkamp, Heather Stout, and Dr. Tom Wainwright (FE Division) continued to work with the Oregon and Northern California Coast TRT, which considers listed coho salmon along the coast from the Columbia River to Punta Gorda in California. This work involves identifying independent coho salmon populations in the region using genetic, habitat, and behavior information and assessing conditions for viability of the identified populations. This work is done in collaboration with 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.

Alaskan Salmon Marine Ecology

Dr. Weitkamp continued to work with scientists at the NOAA Fisheries Auke Bay Lab in Juneau to document the early ocean

ecology of juvenile Chinook and coho salmon in southeast Alaska. This research is part of the Southeast Coastal Monitoring Program, which focuses on the marine ecology of juvenile pink and chum salmon, the dominant salmon species. The study provides a unique opportunity to compare the ecology of Chinook and coho salmon from southeast Alaska with those captured off the Washington and Oregon coasts as part of an FE Division study to understand how salmon respond to diverse marine environments.

United States Fish and Wildlife Service

Oregon Coastal Field Office

Roy W. Lowe, Project Leader

The Oregon Coastal Field Office supports U.S. Fish and Wildlife Service (Service) 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's) 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 2005-06, the Oregon Coast National Wildlife Refuge Complex had seven permanent employees, and 2 AmeriCorps members located at the HMSC. A south coast unit office was established at Bandon Marsh NWR in June 2003 and one permanent employee and one AmeriCorps member are stationed there. 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 Siletz Bay, Nestucca Bay, and Bandon Marsh refuges. At the Neskowin Marsh unit of Nestucca Bay NWR a 5.5-acre parcel consisting of shrub swamp and forested wetlands was purchased from a private owner providing further permanent protection to this unique coastal bog system. Acquisition of two parcels of land at Siletz Bay NWR is under negotiation. We have been attempting to acquire one of these parcels for the past 13 years.

Post restoration monitoring of anadromous fish use continues on the Millport Slough Unit of Siletz Bay NWR where a 100-acre tidal marsh restoration project was constructed in October 2003. The monitoring is being done in cooperation with the Confederated Tribes of the Siletz Indians. Advanced planning for an 82-acre tidal marsh restoration project on the Little Nestucca Unit of Nestucca Bay NWR occurred throughout the year. This project will be constructed in the summer of 2007. In 2009, the refuge complex and various partners will be constructing a 400-acre tidal marsh restoration project within Bandon Marsh NWR. Because the Bandon Marsh restoration area and surrounding lands contain numerous cultural resource sites, locating and mapping all of the cultural resources is a critical first step in the marsh restoration process. In the summer of 2005, the refuge worked in cooperation with five universities and two tribes to deploy ground-penetrating radar (GPR) on the refuge. The GPR was used to allow researchers to "see" underground without disturbing the soil, to locate, characterize, and map buried archaeological, physical and geological features, including cultural resources, historic tidal and creek channels, buried woody debris and related stratigraphy. To ground-truth the GPR, a series of core samples were collected with a geoprobe and are currently being analyzed on the OSU main campus.

Annual wildlife surveys included the monitoring of nesting

seabirds (e.g. common murre, Brandt's cormorant and pelagic cormorant), peregrine falcons, bald eagles, Aleutian cackling and dusky Canada geese, black brant, wintering waterfowl, and brown pelicans. In addition, baseline data continues to be collected on plant communities and amphibians on refuge lands.

Research and monitoring of Steller sea lions continued in summer 2005 at Rogue Reef, in cooperation with NOAA-Fisheries and the Oregon Department of Fish and Wildlife's Marine Mammal Program. Research on Leach's Storm-Petrels initiated in 2004 continued this year as well. The storm-petrel work is being done on Saddle Rock within Oregon Islands NWR in cooperation with the University of Oregon.

The Environmental Education program continues to reach out to new schools and more students. Over 500 Oregon students from across Oregon submitted artwork for the annual Junior Duck Stamp Art Competition. The 2006 Oregon "Best of Show" winner was a senior from Chiloquin High School with a rendition of a preening hen Mallard. Thanks to a grant from the National Fish and Wildlife Foundation and talented work by AmeriCorps volunteers the Shorebird Sister Schools Program was expanded to include two additional counties, Clatsop and Tillamook. In total, over 700 4th and 5th grade students from Astoria to Bandon participated and learned about estuaries, bird behavior, adaptations, migration, and conservation. Students from the Jane Goodall Environmental Middle School in Salem conducted an owl pellet study at Nestucca Bay Refuge, surveyed for amphibian egg masses at Neskowin Marsh, and monitored movement of large woody debris at Siletz Bay Refuge as part of the Nature of Learning Program. Refuge staff and AmeriCorps volunteers gave multiple community presentations and docent training on coastal wildlife resources up and down the coast. Construction of the parking lot and viewing deck on the Ni-les'tun Unit of Bandon Marsh NWR was completed this year. The area overlooks the future +400-acre tidal marsh restoration marsh project on the lower Coquille River. Interpretive panels will be added at this site in 2007.

Newport Field Office

Laura Todd, Field Supervisor

The Newport Field Office (NFO) of Ecological Services 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 three permanent employees. 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 the purpose of providing funding 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 2005-2006, the Newport Field Office celebrated a number of accomplishments:

- Completed 11 restoration or education projects under the Coastal Program which enhanced or restored 400 wetland acres and 131 upland acres, restored or opened passage on 17.5 miles of stream, and provided a number of other benefits to coastal ecosystems and local communities. Anticipate funding six projects in FY06.
- Contributed to Western snowy plover recovery efforts throughout the state including predator control, nest protection and monitoring, habitat restoration, law enforcement, and public education.
- Assisted the Oregon Coast Aquarium in the development of the Western snowy plover exhibit, scheduled for public opening in July 2006.
- Coordinated volunteers and biologists for the Western snowy plover and Black oystercatcher surveys along the Oregon Coast and presented survey data on Black oystercatchers at the meeting for "Shorebird Science in the Western Hemisphere" in Boulder, Colorado.
- Supported a number of recovery projects and habitat restoration for the Oregon silverspot butterfly and western lily.

II. FACILITIES

Ship Operations

Peter Zerr- Marine Superintendent

Oregon State University's (OSU) College of Oceanic and Atmospheric Sciences (COAS) operates the 185-foot Research Vessel (R/V) *Wecoma* and the 54-foot R/V *Elakha*. OSU is one of 21 vessel-operating institutions in the University-National Oceanographic Laboratory System. The COAS Ship Operations office and pier facility are located at the Hatfield Marine Science Center in Newport, Oregon.

The R/V *Wecoma* is owned by the National Science Foundation (NSF) and operated by OSU under a cooperative agreement. She carries a crew of 12 and a science complement of up to 18. In 2006 her 125 days of scheduled operations are funded by the National Science Foundation, NOAA and the Office of Naval Research. Science missions are being led by researchers from Oregon State University, University of Washington, Scripps Institution of Oceanography, Harbor Branch Oceanographic Institution, the Naval Postgraduate School and NOAA. Major projects this year include the CoOP RISE Program (River Influences on Shelf Ecosystems) off the Columbia River, DART (Deep ocean Assessment and Reporting of Tsunamis), AESOP (Assessing the Effects of Submesoscale Ocean Parameterizations), and a variety of work off the coasts of Oregon & California.

R/V *Elakha* is owned by OSU and funded by user charges. The 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 including those of COAS, Zoology, Microbiology, and the OSU/NOAA Cooperative Institute for Marine Resource Studies (CIMRS). The vessel also supports educational activities for various OSU colleges and departments and Linfield College.

OSU Ship Operations also manages the West Coast NSF/UNOLS scientific van pool. There are currently three science vans in the pool including an isotope van, a general purpose van and a "cold laboratory" van. The vans are based in Newport at the Ship Operations facility but may be shipped anywhere in the Pacific region to support NSF-funded research.

The COAS Ship Operations pier in Newport serves a variety of visiting oceanographic research ships and U.S. government vessels. We have had several visits so far this year, and will be hosting many more during the summer months.

Additional information on OSU's Research Vessels can be found at the College of Oceanic & Atmospheric Sciences website www.coas.oregonstate.edu under the Facilities Section.

III. EDUCATION

Oregon State University offers courses at HMSC in Fisheries and Wildlife (fall term) and Marine Biology (spring term). The courses are open to upper division undergraduate students and graduate students, and generally attract 20-25 students per term.

Fall 2005 Fisheries and Wildlife Courses

FW 407/507.SEMINAR (1 credit).

See list of seminar series speakers.

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

This field, lab, and lecture course broadly covers the physical, biological, and sociological processes that affect Oregon's coastline, estuaries, and coastal communities. Led by faculty and agency scientists, this course introduces students to the Oregon coast and its natural resources first-hand in a one week, intensive class format, followed by weekly field trips and lectures. A "capstone experience".....

Winter 2006 Term Zoology Course

Z 465 SELECTED TOPICS IN ZOOLOGY (1-16)

Selected Topic: Marine Conservation Science & Policy.

Topics and credits vary. Grading mode TBA.

Spring 2006 Term Marine Biology Courses

BI 450. Marine Biology (8).

A comprehensive introduction to the flora and fauna of the marine environment approached from the level of the cell to the whole organism. Ecological patterns and processes characteristic of marine communities will be emphasized. PREREQ: A one-year course in biology or equivalent courses in introductory botany or zoology. Departmental approval required.

Guin Library

Janet Webster, Librarian

The Marilyn Potts Guin Library continues to be one of the best marine and estuarine libraries in North America. While not having the size or longevity of the Scripps Institute of Oceanography or the Fish and Oceans Library at University of Washington, we definitely hold our own in the world of field stations and marine laboratories in terms of the depth and focus of our collection and the expertise of our staff. The collection is shifting to more electronic journals and other digital material. As it does, the library staff focuses on collecting as well as digitizing material that is unique to our setting and the northeast Pacific Ocean. Our staffing remains stable with a full-time librarian, a full-time library technician and a part-time library technician. Student workers including local high school students and community college students in the Aquarium Science program assist us in getting our work done.

Many of our projects and resulting accomplishments address the OSU Libraries Strategic Plan. This Plan focuses on improving access to library resources through better searching tools and more digital materials as well as tailoring services to different user groups including undergraduates, graduate students and faculty.

- Faster delivery of articles and books to the desktops of HMSC researchers and students – We implemented RAPID which is a material requesting and delivery system used by a consortium of research libraries to guarantee 48 hour delivery of material.
- Easier discovery of library resources – We work with the Valley Library to develop a useful federated search system. This allows a user to enter a term in the search box and search across many of the library’s databases and digital collections. For more on the project: <http://dllab.library.oregonstate.edu>
- Better documentation of the research output of HMSC – The library staff maintains a station bibliography and is working towards adding digital version of some of the publications to the ScholarsArchive@OSU site.
- More recognition of the needs of graduate students at HMSC - We are now tracking the progress of graduate students so we can provide better orientation when new, assistance when doing literature review and publishing advice when completing their research. Additionally, we upgraded the Library Seminar Room so it is easier to give presentations using current technology.
- Increased digitization of unique materials – Collections for material on Oregon’s estuaries were created in ScholarsArchives@OSU. As part of the development process, the library staff learned more about copyright issues and now help maintain a copyright resources site available to all at OSU and HMSC.
- Focusing the physical collection: Given the transition of journals to digital format, we identified titles that were available electronically and not core to the Guin Library mission. This resulted in a major weeding project that freed up room to grow out physical collection of more unique material.

We work towards mounting three to four exhibits annually. This year, we presented three.

- In celebration of Banned Books Week, we installed a new display discussing intelligent design, evolution and science. The August New York Times series on the subject serves as the base for the display.
- Birds in Winter highlighted the many birds around us during this season. Bird watching tips and sites were included. A new subject guide to bird information was posted in conjunction with the display and is available at <http://osulibrary.oregonstate.edu/research/srg/Birds.html>
- Fighters on the Farm Front described Oregon’s reaction to the Farm Labor Supply Appropriation Act which established the Emergency Farm Labor Service. The exhibit included photographs from a collection of more than 600 taken by Extension Service staff between 1943 and 1947, and housed at the OSU Archives, Valley Library.

Staff activities

Janet Webster was appointed chair of Oregon Library Association’s Legislation and Development Committee for 2005/2007. She also serves on the Conference, Membership and Nominations committees of the International Association of Aquatic and Marine Science Libraries and Information Centers. She moderated a day-long session on responsible fisheries and information at IAMSLIC’s annual conference held in Rome, Italy. Ms Webster attended the annual Cyamus Regional Group workshop in early March held in La Paz, Mexico. She is also serves on the Search Committee for the Serials Cataloguer/Electronic Resources Librarian.

Susan Gilmont attended the annual Oregon Library Association Support Staff conference in Newport. She serves on the HMSC Space Usage Committee. She organized an HMSC chapter of the OSU Diversity Book Club.

Judy Mullen attended the annual Oregon Library Association Support Staff conference in Newport.

| Guin Library General Statistics | 2004-2005 | 2005- 2006 |
|--|------------------|-------------------|
| Number of items checked out & renewed | 4088 | 3505 |
| Number of items loaned to other libraries | 1742 | 1522 |
| Number of items borrowed from other libraries | 251 | N/A |
| Number of books, etc. added to the collection | 611 | 962 |
| Journal issues physically checked in | 1421 | 610 |
| Number of copies on photocopiers and printers | 138095 | 135,935 |

Library Displays

Ornamental Fish Health Programs

Tim Miller-Morgan, Oregon Sea Grant Ornamental Fish Health Specialist, College of Veterinary Medicine

The Ornamental Fish Health Program, part of Oregon Sea Grant Extension and the College of Veterinary Medicine, was created to provide educational programming and service to the ornamental fish industry in Oregon and is designed to assist wholesalers, retailers, and hobbyists to succeed in the rearing, husbandry, and health care of ornamental aquatic animals in the aquarium or pond environment.

It continues to have a strong collaborative relationship with the Oregon Coast Community College Aquarium Science Program (AQS), <http://www.occc.cc.or.us/aquarium/index.html> and the Oregon Coast Aquarium, <http://www.aquarium.org/>.

Tim Miller-Morgan was one of the co-principal investigators on the National Science Foundation implementation grant and works very closely with Bruce Koike, AQS Program Director and Instructor, on course development and the refinement of existing coursework. Miller-Morgan initiated and currently leads the biweekly Grand Rounds at the Oregon Coast Aquarium and the Hatfield Marine Science Center, which are required for all students participating in the second practicum. Students present and discuss active medical cases and common health problems at each facility from the standpoint of husbandry and health management. And in 2006, Dennis Glaze, an AQS student and then graduate became Miller-Morgan's Aquatic Animal Health & Husbandry Specialist.

Miller-Morgan teaches AQS 270, Fish and Invertebrate Health Management. This course, which is offered every winter quarter, introduces students to the basic principles and practices of health management in re-circulating aquarium systems. In addition, Miller-Morgan lectures in VM 709, Introduction to Veterinary Medicine, where he presents an overview of the subspecialty of aquatic medicine. He also teaches a section of VM 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 and is a co-instructor for VM 738, Animal Handling and Husbandry and Introduction to Fish Husbandry and Handling. He also teaches VM 790, Ornamental Fish Medicine, a 35-hour course that teaches senior veterinary students the basic skills they need to begin practicing fish medicine.

Aquarium Science Degree Program Oregon Coast Community College

The Aquarium Science Program Completes It's First Year of Instruction

Bruce Koike - Director, Aquarium Science Program

As the Aquarium Science Program at Oregon Coast Community College continues to prepare individuals for careers in the aquatic animal husbandry profession, we have some incredible partners to thank. Since the initial planning stages, Aquarium Science Program stakeholders identified student access to real workplace experiences as an essential element for the program's long-term success. In response to this need, various agencies and organizations stationed at Oregon State University's Hatfield Marine Science Center (HMSC) opened their doors to our students. Students have gained valuable experience working alongside staff members from Oregon Sea Grant, the Molluscan Broodstock Program, the Fish Behavior Laboratory and Oregon Coast Aquarium. This year Aquarium Science students served approximately 1,100 hours of workplace experience through three courses; Practicum 1, Practicum 2 and Aquarium Science Internship. The program will need to increase the capacity to provide these hands-on experiences as the program grows in size.

The Ornamental Fish Program through Oregon Extension Sea Grant became the first HMSC organization to host both a Practicum and an Internship student. Second year Aquarium Science student Dennis Glaze completed his internship under the guidance of Dr. Tim Miller-Morgan, Extension Veterinarian. The required internship course is a 40 hours, 11 week work experience that enables students to apply their knowledge to new environments while developing additional skills and knowledge sets.

Such learning experiences, not only prepares students for the workplace but also provides them with a competitive edge in the hiring process. The first five graduates of the program (2005) have each secured productive jobs. Graduates and students who were hired before the completion of their degree now work at the Henry Doorly Zoo and Aquarium (Omaha, NE), New York Aquarium (Brooklyn, NY), Georgia Aquarium (Atlanta, GA), Coral World (St. Thomas, Virgin Island), Riverbanks Zoo and Aquarium, and Oregon Coast Aquarium. Each of these individuals participated in a Practicum class at the HMSC.

Such an active partnership between HMSC and the Aquarium Science Program benefits the individual student who in time, will impact the aquatic animal husbandry industry. We appreciate that so many HMSC staff members have guided students through specific courses. To each person, we express our gratitude for their efforts to deliver real workplace learning experiences. Thank you!

STUDENT AWARDS and SCHOLARSHIPS

Scholarships and awards given by HMSC through the generosity of various donors represent an important source of financial support for graduate student research in marine science. The 2006 Markham Symposium (named for the Mamie L. Markham Endowment, which annually awards two years of financial support for eight students pursuing research at HMSC) was held on June 14. Students who had made significant progress towards completion of their research gave brief presentations. Those students being awarded new monies for 2006-07 year displayed posters explaining their proposed research. Their awards are listed below:

| Award | Recipient |
|--|--|
| <p><u>Mamie L. Markham First Year Student Award</u> - provides financial assistance to an incoming, first year graduate student who plans to be resident at the HMSC after completing first academic year in Corvallis.</p> | Abby Nickels Fisheries & Wildlife (\$10,000) |
| <p><u>Lillian Brucefield Reynolds Scholarship Fund</u> - for graduate students engaged in study of marine science at Hatfield Marine Science Center.</p> | Chi-Chang Liu Fisheries & Wildlife (\$1,000) |
| <p><u>Curtis and Isabella Holt Education Fund</u> - intended to foster education in the marine sciences by providing financial support to undergraduate or graduate students pursuing marine science studies.</p> | Heidi Schmoock, Environmental Sciences (\$5,996) |
| <p><u>Walter G. Jones Fisheries Development Memorial</u> - intended to encourage graduate work in subjects which contribute to fisheries development.</p> | Joodong Park, Food Science and Technology (\$1,300) |
| <p><u>William Q. Wick Marine Fisheries Award</u> - intended to encourage graduate student research in the area of marine fisheries ecology and ocean related research.</p> | Sureerat Phuvasate, Food Science and Technology (\$4,000) |
| <p><u>MacGregor Award</u> - intended to cover housing expenses for undergraduate and graduate student(s) in residence at the HMSC during summer 2006.</p> | Jessica Bishop, PSU-Biology (*) Laura Linn, Zoology (*) Haley Van Noord, HMSC Summer Session (*) (*) Up to \$250 to cover housing expenses. |
| <p><u>Anja Robinson Fellowship</u> - intended to support graduate student research in shellfish aquaculture.</p> | Sean Matson, Animal Science (\$800) |
| <p><u>Mamie L. Markham Endowment Award</u> - intended to assist graduate or postdoctoral level researchers and research utilizing OSU's Hatfield Marine Science Center.</p> | Rebecca Baldwin Fisheries & Wildlife (\$10,000) Karen Fischer, Fisheries & Wildlife (\$10,000) Mattias Johansson, Fisheries & Wildlife (\$10,000) Margot Hessing-Lewis, Zoology (\$10,000) Chi-Chang Liu Fisheries & Wildlife (\$7,900) Sean Matson, Animal Science (\$10,000) Mark Nielsen, COAS-PhD candidate (\$5,132) Todd Sandell, CIMRS-Microbiology (\$10,000) |

IV. PUBLIC OUTREACH AND EXTENSION

Visitor Center

William Hanshumaker, Public Marine Education Specialist, Oregon Sea Grant

Visitor Center Highlights

The OSU Hatfield Marine Science Visitor Center offers adults and children a unique, dynamic environment in which to discover and enjoy a lifelong exploration of marine science.

Managed by Oregon Sea Grant since 1997, the Visitor Center's exhibits and programming use the theme of "Patterns" to highlight the process and products of research conducted by OSU and associated governmental agencies. Using patterns, scientists test predictions and make educated guesses to build conceptual models. These models for understanding are often changed to reconcile new discoveries with previous knowledge.

Everyone makes predictions based on patterns and the recognition of patterns provides understanding that helps us live in the real world. These models change as our understanding grows. This dynamic is a fundamental attribute of science and is the underlying fabric that connects our exhibits and programming. The Visitor Center also provides opportunities for conducting research on devices, methods and concepts for informal science education that will advance the art of public education.

Exhibit Development

The large sablefish aquarium was renovated utilizing Sea Grant funding. The computer program was redesigned for increased reliability and a new scanner and transceiver were purchased to replace the older and less effective models. Research indicated that the overhead monitor was mostly ignored, so it was removed and replaced with two new flat screens mounted at visitor eye-level. Visitors successfully scanned the embedded tag on a graphic image of a sablefish to begin videos on fisheries research. After six months of successful activity, the scanner was removed, leaving the sablefish video looping passively. The effects of these changes on visitor learning are being investigated.

Twelve interactive exhibits titled "Pattern Puzzles" were featured between March 15 and May 15, 2006. These durable, self-standing exhibits challenge the visitor to solve visual patterns by manipulating blocks, pegs, ropes, or images. Situated in the Pattern Garden, these exhibits have broad appeal across all age groups and provide excellent group problem-solving opportunities.

Specimens and photomicrographs of invasive species for the Invasion of the Habitat Snatchers were updated. A new PowerPoint program was created with copy and photos for the ballast water exhibit titled High Sea Stowaways.

An exhibit on BioFuel Cells based on research conducted by the

Cooperative Institute for Marine Resources Studies (CIMRS) was renovated. This exhibit is scheduled for additional development to reflect the most current research efforts.

Public Programming

Special events for public education are scheduled monthly and are promoted at OSU Hatfield Marine Science Visitor Center's web site: <http://hmsc.oregonstate.edu/visitor/current.html>

Dissection of the Giants, January 21, 2006, was a side-by-side external and internal comparison of a Giant Pacific Octopus to a 20-pound Humboldt squid.

The eighth annual Fossil Fest on February 11, 2006, was a resounding success. More than 1250 people took advantage of this opportunity to learn more about Oregon fossils and fossil collecting. Thanks to a timely article in the Oregonian, visitors from the valley flocked to the coast to hear Dr. William Orr (University of Oregon emeritus professor of paleontology) speak on large animal fossilization, and to have their fossils identified by this expert. Guy DiTorrace's auditorium program provided "hands-on" experience, with each participating group receiving a bag of fossils. Children were provided the opportunity by North America Research Group (NARG) to cast and take home their own model fossils. As always, numerous displays and tables were set up for educational displays and "fossil swaps".

Winter and spring Whale Watch week special activities included public marine mammal classes, Whale Tales/Storytelling, daily updates on migrating gray whales posted on the Information Board, Marine Mammal videos shown in the auditorium and special marine mammal displays and exhibits featured throughout the Center. A public demonstration on the articulation of the gray whale skull from the calf that was stranded in Lincoln County was also conducted. Over 7300 people visited the public wing during spring Whale Watch Week.

Earth Day Programming on April 23, 2005 featured Guardians of the Forest by Jessica Cardinal. Scheduled events included Clueless and Lark: The Sea Otter Connection – the long-term impacts of the Lewis and Clark expedition on the peoples and ecosystems of Oregon, presented by Dave Hatch, and Hotel Deep, a children's event and book-signing presented by Kurt Cyrus. Featured videos were Marine Bioluminescence: Secret Lights of the Sea and World of the Sea Otter. Temporary displays included a sea otter skull, sea urchin test, 40' bull kelp specimen, and sea otter pelt under a magnifier. Public demonstrations were conducted and featured a sea urchin dissection and uni extraction -- cross-promoted with the Oregon Coast Aquarium's sea otter feedings.

The first annual International Migratory Bird Day was held May 14, 2005, at the HMSC Visitor Center. Auditorium programs included The Mystery of the Marbled Murrelet, presented by Kim Nelson of OSU. Roy Lowe of the U.S. Fish and Wildlife spoke about bird research on the Oregon Coast Refuges, and Rob Suryan presented an interesting program on natural history, conservation efforts, and his current research on the Short-Tailed Albatrosses. Other demonstrations and family activities included

a public dissection of a Great Blue Heron by me, a bird walk on the Yaquina Estuary conducted by Laimons Osis, and a special family program titled Birds' Beaks and Behavior by Fawn Custer.

As part of our OceanQuest 2005 summer programming, the interns, volunteers, and staff delivered over 67 guided estuary tours, engaging at least 547 visitors. During this same time period, over 1300 visitors attended the auditorium program Ring of Fire: Marianas, learning of deep-sea research conducted by HMSC faculty.

The HMSC's educational programming for National Estuary Day, September 24, 2005, included guided walks of the Yaquina Bay Estuary, demonstrations that explained the life of estuary plants and animals, a stream table that showed erosion patterns caused by flowing water, videos highlighting Oregon's estuaries, and exhibits about current research on estuaries. Estuary Live, an Internet-based tour of selected national estuaries, was set up to show in the Hennings Auditorium. Sponsored by the National Estuarine Research Reserves, this program enabled real-time interaction during which viewers could email questions to a naturalist and the questions could be answered during the live broadcast.

The seventh annual Salmon Saturday on October 15, 2005, included exhibits of live young salmon, videos, and hands-on activities that included Life History of Salmon, How Old is this Salmon?, Children's Coloring Station and the Stream Table from the Lincoln County Soil and Water Conservation District. Oregon's Ocean Salmon was presented by Eric Schindler, Oregon Department of Fish and Wildlife.

For the third annual Shark Day, November 19, 2005, a comparative dissection of three sharks (salmon, leopard, and blue) for approximately 80 members of the general public was performed. Oregon Coast Aquarium collaborated with other activities and publicity.

Bookstore.

Lynne Wright, Bookstore and Visitor Services Manager Oregon Sea Grant's Bookstore provides the visiting public, students, and staff with quality books, clothing, and other items. The bookstore is managed by Oregon Sea Grant's Lynne Wright, and is presently staffed by one full-time temporary staff member, Sara Johnson, and one part-time high school student, Jayme Ott. Four volunteers also work each week in the store to assist the staff. After more than four years as cashiers in the bookstore, the two original permanent part-time staff members elected to leave the position to pursue other interests. One permanent part-time position will be hired in the fall to replace these cashiers.

Wright continued in her additional duties as Visitor Services Manager, teaming up with Bill Hanshumaker, public marine education specialist, and Kath Fuller, volunteer coordinator, to work out scheduling, events, and other challenges that come up in the daily operations of the Visitor Center (VC). This team approach has worked well over the past year, with student interns, volunteers, and staff also benefiting because there is always one member of the team present during all open hours in

the Visitor Center to address issues as they arise. The VC team meets monthly to plan events, strategize for issues that have emerged, and problem-solve as needed. Wright also accepted the responsibility to oversee the budgets on site for the Visitor Center, and works with Sea Grant Extension in this area.

The Bookstore had an outstanding book event April 8 with photographer and author Bill Curtsinger. He is known throughout the world for his stunning photography published in such periodicals as Smithsonian and National Geographic. Curtsinger's recent retrospective of his work, Extreme Nature, received excellent coverage in the local newspapers and more than 175 people attended his presentation at the Hatfield Marine Science Center and the book-signing event that followed.

Another successful Bookstore event was the annual Lincoln County Glass Float Drawing and promotion, which is held each year between November 1 and January 31. The HMSC Visitor Center and Bookstore represented one of 75 locations where visitors could sign up to win one of two glass floats. This event helps attract the public to the HMSC Visitor Center because each visitor who wants to enter the drawing must visit each participating location to do so. This year's winners were both from the Portland area. This event has become quite a popular attraction over the few years that the Chamber of Commerce has been promoting it.

In addition, Wright was invited to set up a table of local interest and science titles at the Librarian Support Staff annual conference held July 15 in Newport at the Best Western Agate Beach Inn. Wright provided information on the HMSC, Oregon State University, and the Oregon Sea Grant programs, and offered two tables of book- and science-related inventory from the bookstore for purchase. Sales from the full-day event were excellent, and it was also a great opportunity to promote the Visitor Center and the many educational programs at the university to an audience of librarian support staff from throughout the state of Oregon.

Besides attending to Visitor Center and Bookstore business, Wright is also active in the local Chamber of Commerce meetings once a month, attends bookstore workshops and conventions to gather new products and ideas from the publishing industry, and locates authors who might be able to visit and do a presentation and book-signing during the year. Wright also has been one of two Sea Grant staff, along with Julie Howard, to attend the year-long Leadership Lincoln Program offered in Lincoln County. This program, created and co-administered by both Oregon Coast Community College and the Newport Chamber of Commerce, meets one day each month throughout the year. Participants learn about leadership throughout the county and are provided with an excellent opportunity to see and learn about what Lincoln County has to offer in the way of services and attractions to visitors and residents.

Wright chaired the search committee for the Sea Grant Extension's part-time education assistant position vacancy in the Visitor Center, which resulted in the selection, in early 2006, of Eileen Flory to fill the position.

SeaGrant Youth and Family Marine Education

Fawn Custer, Lead Youth Educator, Oregon Sea Grant

The mission of Oregon Sea Grant's Youth Marine Education Program at the HMSC is to educate and inspire students of all ages about marine life and the ocean itself in a fun and positive learning environment. This year we accomplished this mission and experienced an exceptional year for reaching new audiences through a variety of education programs and experiences, including summer camps, field trip programs, online education, workshops, and more.

Our education programs are led by an education staff who help make all of these activities not only possible, but extraordinary. They are Maureen Collson, Fawn Custer, Athena Crichton, Melina Moyer, and our newest educators Cait Goodwin, Marla Ranelletti, and Christine Smith. Additional volunteers like Vicki Osis (re-retired), Molly Phipps and Bill's intern Betsy were great helps in educating the additional 2000 students this year, bringing the numbers to well over 13000. We were able to show Maureen how much she meant to us by nominating her for an award as outstanding administrative assistant which she received in March.

Last summer concluded with the ever popular summer camps, Marine Biology I and Marine Biology II, geared toward our upper level students, where they have the opportunity to get experience in the field, work with scientists, carry out their own projects, and participate in hands-on experiences.

"I thought I learned much of camp last year but WOW I learned so much this year!"
--Summer Camper

Fall marked the beginning of our school group programs. With Jessica Haxel leaving for school, Vicki Osis was hired temporarily and helped to develop some new programs, such as the Tidepool Lab and Sandy Beach Exploration. Both classes are one hour and indoors -- great for the irregular inclement weather. Fawn Custer is now the lead youth educator for these programs.

"The instructors are great teachers. We like the dissections, we don't get the opportunity to do those at home." -- Home School Parent

The winter Career Day event for high school juniors and seniors was another success. Students were able to hear presentations from scientists, take an interactive tour and learn about careers in marine science.

This year we coordinated our Spring Home School Day with those of the Oregon Coast Aquarium, expanding our program from one to two days. We plan to do the same in the fall of 2006.

We again served approximately, 250 scouts from around the state and Washington.

Crichton facilitated the aquatic invasive species workshop for teachers and both she and Custer participated in various teacher workshops as presenters, including an all expense paid trip to Florida. This program was training for working cooperatively with public schools. We were able to meet educators and museum directors from around the US.

Las OLAS (Ocean Learning Activities in Spanish) program, continues to be a success. Anamarie Esparza-Smith has done a wonderful job translating curriculum and interpreting in classes, expanding our programs to even more students by reaching Spanish-speaking students, English as a Second Language (ESL) teachers and their students, and members of the local community.

"What a fantastic afternoon we had exploring the estuary, slurping shrimp and discovering sea creature adaptations! Thank you, thank you for all you do for my students and for Oregon's youth. Our trip was vastly enhanced by the Science Center's educational offerings. Thank you again for making this such a fabulous and educational day!" -- Third Grade Teacher

Marine Extension

Jay L. Rasmussen, Oregon Sea Grant Associate Director and Sea Grant Extension Program Leader

The mission of Oregon Sea Grant Extension's program is to educate Oregonians by delivering research-based, objective information to help them solve problems, develop leadership, and manage resources wisely. Sea Grant Extension is one of five Extension areas at Oregon State University. The others are Agriculture, Forestry, 4-H, and Family and Community Development.

Extension education is a discipline (some would even call it a science) that is awarded advanced degrees at some universities. But it is also an art. Sea Grant Extension programs appear in many forms. Typically they are university-based educational programs that seek to apply knowledge and understanding gained through research to aid individuals and groups. Programs that extend university knowledge require a dedicated group of individuals whose advanced education, training, and expertise may involve many segments of biology, sociology, economics, public policy, engineering, and a host of related fields.

A Sea Grant Extension professional is known by many names-- specialist, educator, marine adviser, and agent. Each professional works directly with people in coastal-related communities and at informal education venues, like the Hatfield Marine Science Center. Extension professionals are also schooled in approaches that can be used to facilitate information transfer.

Extension work might be defined as designing activities that effect behavior change through constituent-driven programs focused on outcome-based objectives using a variety of educational processes and techniques over a continuum of time.
-- Fundamentals of a Sea Grant Extension Program, 2000

Oregon Sea Grant's Extension program includes 22 field- and campus-based faculty members with approximately 17 FTE funded by Oregon Sea Grant, OSU Extension Service, or other sources. In addition, Oregon Sea Grant's Marine Education and Extension programs are seamlessly linked. Faculty members from both programs make up a single Marine Education team. Our Extension faculty are located in 10 counties, at the Hatfield Marine Science Center, and at OSU campuses in Astoria, Corvallis, and Portland. We have a long-standing and successful cooperative sharing arrangement with California Sea Grant for their north coast Marine Advisor to provide programming across state boundaries. And in 2006 we collaborated with the OSU Seafood Laboratory and the Community Seafood Initiative to hire a seafood product specialist, Mark Whitham, who works out of Astoria.

The Oregon Sea Grant Extension program leader is also the associate director of Oregon Sea Grant. As one of five program areas within the OSU Extension Service, Sea Grant Extension is an integral part of Extension and OSU Extension Service, in turn, provides a broad geographic presence, programmatic assistance, and significant funding support to Sea Grant Extension. A strong, cooperative relationship exists formally and informally with the Extension dean and director and with the program leaders of Sea Grant, Agriculture, Forestry, Family and Community Development, and 4-H. In fact, Sea Grant shares program responsibilities with the Forestry and Agricultural Extension programs—particularly in the watershed team area; new programs are being developed with 4-H Extension as well. Sea Grant Extension's plan relates to the NOAA plan and serves regional and national needs, often around our major theme areas of fisheries and seafood, ecosystems and watersheds, and marine education.

Sea Grant Extension faculty are part of the university's academic structure. Faculty members have academic homes in colleges and departments, with all the privileges and responsibilities of other university faculty. Oregon Sea Grant Extension faculty members are in seven colleges and many departments, reflecting the diversity and capacity of the program. Colleges include agricultural science, food science, forestry, liberal arts, oceanic and atmospheric sciences, science, and veterinary medicine. Among the departments are agriculture and resource economics, bioresource engineering, biomedical sciences, fisheries and wildlife, food science and technology, forest resources, math and science education, oceanic and atmospheric science, political science, and sociology.

In mid-2006, the following HMSC faculty members have appointments, ranging from full time to quarter time, with Oregon State University: Fawn Custer, Kath Fuller, Dennis Glaze, Bill Hanshumaker, Jon Luke, Tim Miller-Morgan, Shawn Rowe, Jay Rasmussen, and Lynne Wright. Fuller covers Visitor Center volunteer and interpretative duties, with assistance from Eileen Flory, and a number of marine educators – on contract -- provide youth education experiences. Dennis Glaze has been a lead in ornamental husbandry efforts along with our aquarists. Julie Howard and Maureen Collson provide outstanding support to our programs. And we have had a growing number of interns and graduate students over the past year. More information on

activities of those mentioned above is contained in college or other sections of this report.

Oregon Sea Grant, recognizing the special value and opportunities around informal education at the HMSC, has established a new position of Assistant Director for Education, to be located at the HMSC. A search for candidates began in the late spring of 2006.

Ornamental Fish Health Program

Tim Miller-Morgan, Oregon Sea Grant Ornamental Fish Health Specialist, College of Veterinary Medicine

The Ornamental Fish Health Program (OFHP), supported by Oregon Sea Grant and the College of Veterinary Medicine, has completed a busy fourth year solidifying existing programs and expanding into new areas. Tim Miller-Morgan is the extension veterinarian overseeing this program.

The purpose of the Ornamental Fish Health Program (OFHP) is to provide educational programming and service to the ornamental fish industry in Oregon and is 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 Ornamental Fish Health E-Newsletter and web site, <http://seagrant.oregonstate.edu/extension/miller-morgan.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 Indonesia, Australia, Guatemala, and Christmas Island have begun to give an international flavor to the program. Miller-Morgan also serves on the American Veterinary Medical Association (AVMA) Aquatic Veterinary Medicine Committee (AVMC). This committee, consisting of 12 specialists in fish medicine and aquaculture health advises the AVMA executive board as well as federal and international agencies on policy matters pertaining to aquatic animal health. In addition, Miller-Morgan works with local koi, goldfish, and aquarium clubs.

The program continues its relationship with the Associated Koi Clubs of America (AKCA) Koi Health Advisor (KHA) Program, <http://www.akca.org>. This program is in its fifth year of training selected koi hobbyists to become health and husbandry advisors to their fellow hobbyists. The program has trained approximately 180 Koi Health Advisors throughout the country (27% of these graduates living in Oregon, Washington, and Idaho). Miller-Morgan serves as a national advisor to this program, an instructor in the wet labs, and provides continuing education opportunities for Koi Health Advisors in the Pacific Northwest. He has published numerous articles in KOI USA (the AKCA magazine) and was invited to speak at the 2006 AKCA annual seminar in

Niagra, NY.

Miller-Morgan co-instructed two courses for pond professionals, one sponsored by a local pond distributor in Molalla, OR, and another sponsored by the University of Georgia's College of Veterinary Medicine. Both two-day courses focused on basic principles of fish health management for the pond fish retailer and pond contractor.

Miller-Morgan also serves as the curator of husbandry and staff veterinarian for the Visitor Center and Education Wing animal collections at the Hatfield Marine Science Center (HMSC). He has also been actively involved in the remodel of the HMSVC Hospital/Quarantine facility. This completely redesigned facility provides for state-of-the art care for our increasingly diverse fish and invertebrate collection as well as a wonderful hands-on teaching space for our veterinary and aquarium science students. Further, Miller-Morgan has been involved in the ongoing redesign of the West Wing animal holding area and the development and implementation of new animal exhibits. Dennis Glaze, an Aquarium Science Program student and recent graduate – who has worked with Miller-Morgan on special projects over the past two years – was hired in early 2006 as the program's Aquatic Animal Health & Husbandry Specialist. Glaze and the two graduate teaching Assistants (GTA) also have picked up duties from our curator of animal husbandry, Peter Noah, who left in late 2005 to assume directorship of an aquarium in the Caribbean.

Free-Choice Learning

Shawn Rowe, Marine Education Learning Specialist, Oregon Sea Grant

More people visit science museums, zoos, and aquaria in the United States in any year than attend all professional sports combined. They do this in their leisure time, making conscious choices about what they want to learn, where they want to learn, and how they want to learn. Such free-choice learning makes up the majority of learning we engage in throughout our lives, and most people's knowledge about marine and ocean sciences comes from these informal channels people choose in their leisure time. Yet, the learning that occurs and the way people use these informal science learning sites as well as science media for learning about science, technology, and culture is not well understood. To better understand how this learning occurs, Oregon Sea Grant has established a Free-Choice Learning Initiative to carry out research and education on lifelong, free-choice learning. Through its ongoing partnership with the Institute for Learning Innovation (ILI) in Annapolis, MD and the Ph.D. program in Free-Choice Learning in the College of Science's Department of Science and Mathematics Education, Oregon Sea Grant is using the Hatfield Marine Science Visitor Center and Marine Education programming to carry out a program of research, evaluation, and design in free-choice learning.

Perhaps the most exciting development in Free-Choice Learning for the 2005-2006 year was the hiring of John Falk and Lynn Dierking as Free-Choice Learning professors in the Department of Science and Mathematics Education. Falk and Dierking are credited with coining and championing the term "free-choice."

Falk holds a joint doctorate in Ecology and Science Education from the University of California, Berkeley, while Dierking's doctorate in Science Education is from the University of Florida. Both have written books. Falk's newest is *Thriving in the Knowledge Age: New Business Models for Museums and Other Cultural Institutions*, and Dierking is working on a new book focused on family learning due out in 2007.

Between them, the couple has more than 55 years of diverse experience in conducting free-choice science learning research. Both of them bring expertise in successful grant writing and project implementation; both currently have grants from the National Science Foundation; and both serve on the editorial boards of several academic journals. From 2000-2002 they co-chaired a task force of the National Association for Research in Science Teaching identifying key issues in this arena of science learning research.

The Free-Choice Learning Initiative also supports students carrying out research projects in learning in out-of-school environments. This year, the initiative continued financial and academic support for Alicia Christensen, an M.S. student in the Marine Resource Management Program. Christensen is working with the Oregon State Parks and Recreation Department to research evaluation tools that can be used effectively with their long-running Whale Watching Spoken Here program. Christensen was awarded a Holt Marine Education Fund Award to continue this work in the following year. Molly Phipps, a doctoral student in Science and Mathematics Education, was also supported by the Free-Choice Learning Initiative and the Cooperative Institute for Oceanographic Satellite Studies to carry out research on how the satellite images scientists regularly produce and use can be used in meaningful ways for general public understanding of ocean sciences. Heidi Schmook, an MS student in Environmental Sciences, was also awarded a Holt Marine Education Fund award to research Spanish-speaking families' science learning through the Oregon Sea Grant Las OLAS bilingual marine education program. Schmook's work began in March and will continue through the fall of 2006.

Additionally, through Rowe's work in the Department of Science and Mathematics Education, our website (<http://seagrant.oregonstate.edu/freechoice/index.html>), conference presentations, and professional development offerings, the Free-Choice Learning Initiative disseminated information about HMSC and OSU program offerings, activities, and project findings to students and professionals in formal and informal sciences around the region and country.

Seminars at HMSC

Seminars presented at HMSC from July 2005 to June 2006

| <u>DATE</u> | <u>NAME</u> | <u>AFFILIATION</u> | <u>TITLE</u> |
|-----------------|--|--|--|
| July 1, 2005 | Rob Suryan | grad student in Fisheries & Wildlife | Seabird studies in Japan, Alaska and the Columbia River |
| July 7, 2005 | Barbara Bond | Department of Forest Science, OSU | Using Stable Isotopes to Study Terrestrial Ecosystem Processes |
| July 14, 2005 | Jim Carlton | Director, Williams Maritime Studies Program and Mystic SeaPort Museum | Biological invasions and marine environments |
| July 21, 2005 | Abby McCarthy | Masters Candidate, Fisheries & Wildlife | Marine Turtles in the 21st Century- Technology and Conservation |
| July 28, 2005 | David Stein | Senior Marine Biologist, NOAA | Snailfishes: why? |
| August 4, 2005 | Round table discussion | Kelly Benoit Bird & Ken Hall | Managing a career in science - balancing personal & professional goals |
| August 4, 2005 | Mattias Johansen | PhD Candidate, Fisheries & Wildlife | Larval dispersal, design of marine protected areas, and investigation of Cape Blanco as a barrier to gene flow in Oregon copper rockfish |
| August 11, 2005 | Anne Sigleo | Research Environmental Scientist, EPA, Pacific Coast Ecology Branch | Nutrients in the Yaquina watershed: alder vs salmon |
| August 18, 2005 | Research Experience for Undergraduates | Mini Symposium - Results of research REU's did during 10 week internship at HMSC | REU interns: Matthew Campbell, Heather Hunsperber, Clara Lampi, Stephen Levas, Natalie Roman, Katie Schultz, Christie Singbusch, Andy Smith, Joy Smith and Raquel Sosa |
| | | | More seminars were presented in 2005-2006. |

IV. DEVELOPMENT AND PUBLICATIONS

Donor Honor Roll

Animal Medical Care of Newport
Laurance and Alma Beaumont
George and Susan Boehlert
Richard Bohn
John Bolen
Eugene and Susan Bureson
Paul and Anna Wiancko Chasman
Clayton and Margaret Elder Creech
Irene and Philip Crosby
Charlotte Dinolt
Gerald Michael Donahue
Melissa Ellen and Claude Elmore
John Evans and Theresa Griffith-Evans
Charles and Hollis Fishelson-Holstine
Kay Floyd
Martyn and Maret Frye
Doug Gilbert
Shirley and William Golden
Kenneth M Hatch
John P Hennessey, Jr
Margaret and Joel Hernandez
Gary and Jodell Hilberg
Janet and Warren Hopson
Anne Kapuscinski
Daniel and Sarah McKichan Kiefel
Ruth and John Kistler
David Koller
Stacy and Andrzej Korolewicz
Andy Tai-Kwan Lau
Peter Lawson
Don and L J Lindly
James and Marian Livers
James and Nicola Fredrickson Maxwell
Caroline and John F Murphy
Dominic Nicandri
Alan and Wendy Adams Niem
Robert and Jerryann Olson
OSU Anonymous Friends
Jodie Chun Mui Pang
Arthur and Jane St Ledger Partridge
Alan and Charlotte Paulsen
Cindy and Tom Picciano
Erica and Brian Pifer
Richard and Linda Raspolich Pratt
Arminne Rautio
Jean Roth
Nikki Rouget
Edward Schaefer
Donald and Darleen Searcy
John Sherman
Jean Shimp
Harriette Small
Anne Southcott
Frances Spigai
Stephen Stehman
James and Cathy Swanek
Andrea Thompson
Zachary and Amy Toledo
Bruce and Barbara Bechmann Trent
Carol and Roger Unser
Laura Urness
Lavern Weber and Pat Lewis

Donor Honor Roll Continued

Tim and Lisa Cardamon Weber
Janet and Stephen Webster
John and Lori White
Gail and J L Willeke
Donald and Marlene Winn
Susan and Jerry Zimmerman

HMSC Visitor Center Volunteers

Kath Fuller, Volunteer Coordinator

During FY05/06, the HMSC had 85 volunteers in the database with 66 of these actively contributing time and energy to the Visitor Center. In late October, over 40 individuals attended a Volunteer Recruitment Reception. The reception, as well as word-of-mouth from current volunteers and staff, helped us add 18 volunteers to the ranks this year.

Our 66 active volunteers contributed over 5,000 hours of service this fiscal year and drove almost 30,000 miles to contribute those hours. Volunteers are critical to the success of the visitor center. They greet most of the 150,000 annual visitors, orient them to the center and provide educational information related to species on exhibit, and marine science in general. Their enthusiasm for learning and desire to share information makes many memorable experiences for visitors of all ages.

In addition to providing service to visitors in the Center, volunteers also helped with a number of special events and programs. Some of these included providing training for, and leading estuary walks; assisting with public dissections and marine mammal articulations; and assisting with the annual Sea Fest in many ways.

Monthly meetings and training sessions are held regularly to enhance communication between individual volunteers and between volunteers and staff members. Training topics this fiscal year included (among others): tides and currents, invasive species, long-nose skates, ornamental fish health, and scientific chaos.

Volunteers' efforts are recognized on a daily basis and were also celebrated at a picnic in July and at a banquet in March.

PUBLICATIONS

KEY: * = Student, **Bold** = at HMSC

¹ 1 = OSU, ² 2 = NMFS, ³ 3 = PMEL

⁴ 4 = EPA, ⁵ 5 = ODFW

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BUDGETS

State and Federal Agency Budgets at Hatfield Marine Science Center

| | <u>\$ Amount</u> | <u>Total</u> | <u>% of Total</u> |
|---|------------------|---------------------|-------------------|
| Environmental Protection Agency | 3,500,000 | | 19% |
| Oregon Department of Fish & Wildlife | 5,100,000 | | 28% |
| Vents Program - Federal | 991,650 | | 5% |
| Nat'l Marine Fisheries Service - NWFSC | 5,072,480 | | 27% |
| Nat'l Marine Fisheries Service - AFSC | 1,187,000 | | 6% |
| US Department of Agriculture - ARS | 532,383 | | 3% |
| US Fish & Wildlife Service | 2,065,013 | | 11% |
| Total State & Federal Agency Budgets | | \$18,448,526 | 100% |

FUNDING SOURCES

Direct State Funding

| | | | |
|-----------------------------------|-----------|------------------|------------|
| HMSC | 1,260,972 | | |
| COMES | 1,700,833 | | |
| CIMRS | 143,931 | | |
| Guin Library | 289,300 | | |
| Extension Sea Grant | 569,781 | | |
| Ship Ops | 29,003 | | |
| Total Direct State Funding | | 3,993,820 | 11% |

Other State Funding

| | | | |
|----------------------------------|---------|----------------|-----------|
| Matching Funds (Endowments) | 227,877 | | |
| Student Fees (TRF) | 29,671 | | |
| Total Other State Funding | | 257,548 | 1% |

Sponsored Research and Education Programs

| | | | |
|---|-----------|-------------------|------------|
| Nat'l Oceanic & Atmospheric Admin. (NOAA) | 4,842,901 | | |
| Nat'l Science Foundation (NSF) | 2,950,901 | | |
| U.S. Dept. of Agriculture (USDA) | 727,233 | | |
| Office of Naval Research (ONR) | 504,710 | | |
| Department of Defense | -8,003 | | |
| Department of Energy (DOE) | 649,166 | | |
| Department of the Interior (DI) | 83,935 | | |
| Oregon Dept. of Fish & Wildlife (ODFW) | 106,573 | | |
| Other Oregon Agencies | 135,027 | | |
| California Dept of Water Resources | 459,436 | | |
| Foundations & Other Organizations | 1,019,505 | | |
| Sub-Contracts from other Universities | 520,931 | | |
| Total Sponsored Research | | 11,992,315 | 34% |

Other Funding

| | | | |
|--------------------------------|------------|-------------------|------------|
| Self-Funding Units | 837,461 | | |
| State & Federal Agency Budgets | 18,448,526 | | |
| Total Other Funding | | 19,285,987 | 54% |

| | | | |
|----------------------|--|-------------------|-------------|
| TOTAL FUNDING | | 35,529,670 | 100% |
|----------------------|--|-------------------|-------------|

BUDGETS

OSU at Hatfield Marine Science Center

| <u>Research Administration</u> | <u>\$ Amount</u> | <u>Unit Sub-Total</u> | <u>Total</u> | <u>% of Total</u> |
|--|------------------|-----------------------|---------------------|-------------------|
| Administration | 480,870 | | | |
| Visitor Center Support | 115,048 | | | |
| Non-Sponsored Research | 0 | | | |
| Non-Sponsored Education | 130,884 | | | |
| Sponsored Education | 72,446 | | | |
| Sponsored Research | 224,249 | | | |
| Total Research Administration | | \$1,023,497 | | 6% |
| <u>Physical Plant</u> | | | | |
| State Support | 578,756 | | | |
| Federal Support | 489,431 | | | |
| Other Sponsored Activity | 0 | | | |
| Total Physical Plant | | \$1,068,187 | | 6% |
| <u>Coastal Oregon Marine Experiment Station (COMES)</u> | | | | |
| Administration | 772,110 | | | |
| Non-Sponsored Research | 689,713 | | | |
| Cost Shared to Sponsored Research | 210,084 | | | |
| Self-Funded Programs | 337,603 | | | |
| Extension | 32,014 | | | |
| Endowment | 258,169 | | | |
| Sponsored Research | 3,300,506 | | | |
| Total COMES | | \$5,600,199 | | 33% |
| <u>Cooperate Institute for Marine Resource Studies (CIMRS)</u> | | | | |
| Administration | 143,931 | | | |
| Sponsored Research | 4,197,059 | | | |
| Total CIMRS | | \$4,340,990 | | 25% |
| <u>College of Oceanic & Atmospheric Sciences</u> | | | | |
| Ship Support/Operations | 2,551,430 | | | |
| Ship Support & Communications | 37,228 | | | |
| Ship Scientific Equipment | 390,211 | | | |
| Total Ship Operations | | \$2,978,869 | | 17% |
| Sponsored Research | 284,643 | 284,643 | | 2% |
| <u>Education Programs</u> | | | | |
| Extension | 288,953 | | | |
| Sea Grant | 337,286 | | | |
| Visitors Center (self-funded) | 271,370 | | | |
| Sponsored Programs | 50,508 | | | |
| Self-Funded Programs | 49,032 | | | |
| Total Education Programs | | \$997,149 | | 6% |
| <u>Housing</u> | | | | |
| Self-Funded Operations | 88,910 | \$88,910 | | 1% |
| <u>Bookshop</u> | | | | |
| Self-Funded Operations | 174,252 | \$174,252 | | 1% |
| <u>Other</u> | | | | |
| Guin Library | 289,300 | | | |
| OSU Foundation & Gifts | 44,221 | | | |
| Network Service | 163,966 | | | |
| Federal Agencies (through OSU) | 26,961 | | | |
| Total Other | | \$524,448 | | 3% |
| Total Hatfield Marine Science Center | | | \$17,081,144 | 100% |