

# Oregon State University Hatfield Marine Science Center

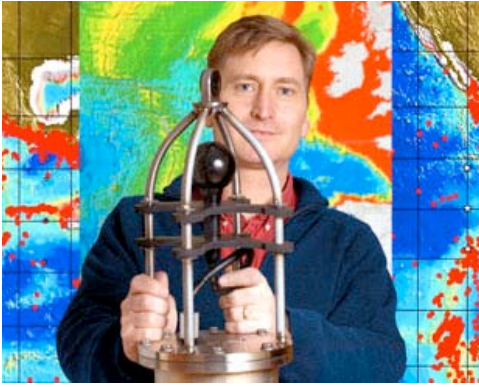
*Newport, OR*

2004

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2005

## Annual Report



Hatfield  
MARINE SCIENCE CENTER  
**OSU**  
Oregon State  
UNIVERSITY

**Table of Contents**

DIRECTOR'S MESSAGE..... 2

**I. RESEARCH..... 3**

**A. OREGON STATE UNIVERSITY ..... 3**

*Programs by Station and Institutes ..... 3*

    Coastal Oregon Marine Experiment Station ..... 3

    Cooperative Institute for Marine Resources Studies ..... 5

    Oregon Sea Grant..... 9

*Research Programs by Academic Unit ..... 10*

College of Agricultural Sciences ..... 10

    Department of Fisheries & Wildlife ..... 10

        Marine Fisheries Genetics ..... 10

        Invasive Species Ecology ..... 10

        Marine Fish Ecology ..... 11

        Fisheries Oceanography..... 12

        Molluscan Aquaculture ..... 12

        Marine Mammal Program..... 13

        Population Dynamics ..... 14

    Department of Agricultural and Resource Economics 15

        Marine Fisheries Management and Policy..... 15

        Marine Resource Economics & Marketing ..... 17

College of Oceanic and Atmospheric Sciences ..... 17

    Marine Geochemistry..... 17

College of Science ..... 18

    Department of Botany and Plant Pathology ..... 18

    Department of Microbiology ..... 19

        Fish Disease Research..... 19

    Department of Science and Mathematics Education... 20

    Department of Zoology ..... 20

        Marine Ecology ..... 20

College of Veterinary Medicine ..... 21

**B. FEDERAL AND STATE AGENCIES ..... 22**

US DEPARTMENT OF AGRICULTURE ..... 22

    Agricultural Research Service (ARS)..... 22

ENVIRONMENTAL PROTECTION AGENCY ..... 23

*Pacific Coastal Ecology Branch*

*Western Ecology Division* ..... 23

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)..... 24

*National Marine Fisheries Service*..... 24

        Alaska Fisheries Science Center..... 24

        Northwest Fisheries Science Center..... 25

            Environmental Conservation Division (EC):..... 26

            Fish Ecology Division (FE):..... 27

            Fishery Resource Analysis and Monitoring Division (FRAM): ..... 30

            Conservation Biology Division (CB):..... 34

*Oceanic and Atmospheric Research Division*..... 35

        Pacific Marine Environmental Laboratory (PMEL): ...35

        Vents Program ..... 35

U. S. FISH AND WILDLIFE SERVICE..... 36

*Oregon Coastal Field Office*..... 36

OREGON DEPARTMENT OF FISH AND WILDLIFE ..... 39

*Marine Resources Program* ..... 39

**II. FACILITIES ..... 42**

    HMSC Facilities ..... 42

    Ship Operations..... 42

**III. EDUCATION ..... 44**

Fisheries and Wildlife and Marine Biology Courses ... 44

Student Enrollment Statistics ..... 45

Internships at HMSC ..... 46

Guin Library..... 47

Ornamental Fish Health Programs..... 47

Aquarium Science Degree Program (OCCC)..... 48

STUDENT AWARDS and SCHOLARSHIPS..... 49

**IV. PUBLIC OUTREACH AND EXTENSION ..... 50**

Visitor Center ..... 50

    Visitor Center Highlights ..... 50

    HMSC Visitor Center Volunteers..... 55

    Sea Grant Marine Education ..... 56

Oregon Sea Grant Extension..... 56

    Free-Choice Learning Initiative..... 58

SeaFest..... 59

Coastal Ecosystem Learning Center Activities ..... 60

Civic Activities ..... 60

Friends of HMSC..... 61

Donor Honor Roll ..... 61

Meetings at Hatfield Marine Science Center ..... 63

Seminars at HMSC ..... 64

**V. PUBLICATIONS..... 67**

**VI. BUDGETS ..... 76**

## Director's Message

### Dr. George W. Boehlert, Director

Since its birth in 1965 as Oregon State University's marine research station and public aquarium, the Hatfield Marine Science Center has grown to become a world-class hub of marine science research, education and outreach. As we celebrate HMSC's 40<sup>th</sup> anniversary, we look back not only on this year's accomplishments, but also the legacy of four decades, highlighted throughout this report.

Many advances were made during 2004-5, including a start on implementing of our strategic plan. Partnerships, which represent a fundamental theme across the many agency and academic programs of the HMSC, were particularly fruitful this year. A memorandum of understanding was signed with the Oregon Coast Aquarium to strengthen collaboration on research and education activities, and our designation as a Coastal Ecosystem Learning Center was expanded to include the Aquarium as a co-equal partner.

HMSC's education programs have benefited from strengthened relationships with various OSU colleges, departments, the Oregon Coast Community College and our agency partners onsite. Donor-supported internships and the new NSF-funded "Research Experience for Undergraduates" program also flourished during 2004-05, with two of our interns being selected to present their research at the national meeting of the American Society of Limnology and Oceanography. With our recruitment of an Academic Programs Coordinator this past year, we are laying the foundation for expansion and enhancement of HMSC's educational enterprise, including a reinvigorated a summer program.

So too, is HMSC's research enterprise growing and receiving national recognition in several areas, including fisheries and climate variability, chemical and geological oceanography, introduced species, marine mammals, and aquaculture. Oregon Sea Grant's new research focus on free choice education has added a new dimension to the Visitor Center. Recruitment of three new COMES faculty and an ambitious program of growth for the Marine Mammal Program makes us examine space and to begin master planning for buildout of the HMSC campus.

Finally, a somewhat introspective look at vulnerability of marine labs was brought to the fore by the disaster associated with the Indian Ocean tsunami. HMSC, located in the inundation zone, had instituted its first tsunami evacuation drill several months prior to that event, and a real evacuation in June following a northern California earthquake. We continue to work with public safety organizations in this arena to assure the safety of employees at the HMSC.

Overall, it has been a productive year for the diverse staff of the HMSC. I hope you enjoy this report, which provides an excellent overview of the year's progress.

## 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 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 11 tenure-track faculty, 30 staff and research associates, 40 graduate students, and over \$3 million annually in external grants and funds.

The research programs of COMES encompass seven primary areas: *Aquaculture* (Chris Langdon, *Fish Disease* (Paul Reno), *Fisheries Science* (David Sampson), *Fishery Management* (Susan Hanna), *Marine Mammals* (Bruce Mate), *Marine Economics and Marketing* (Gilbert Sylvia), *Salmon and Marine Fisheries Ecology/Genetics* (Michael Banks), and *Seafood Science and Engineering* (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. COMES research, teaching and outreach contribution are extensive, and further information is provided on the specific programs within academic department writeups. 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 is now hiring three tenured-track faculty in Fisheries Ecology, Cetacean Biology, and Pinniped Biology which is expected to substantially boost the growth of COMES over the next five years.

The year 2004-2005 was highly successful and marked continued growth of the Station. Based on the *Oregon Invests* database, in 2004-2005 COMES programs generated over \$10 million in economic impacts and produced 30 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 78 manuscripts and reports including 45 in refereed journals and books. COMES graduated 18 students including 12 MS and 6 Ph.D's. COMES faculty also gave over 100 presentations and organized 16 workshops and conferences. For 2004-2005 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 2004-2005 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 fishery by volume 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, and the Seafood Consumer Center. CSI supports coastal businesses and value-added seafood production. Since 2002 CSI has assisted 35 fishermen and seafood processors in business and market planning, provided over \$1.5 million in investments and loans to coastal seafood companies, developed five new value added seafood products, delivered 50 seafood demonstrations, and is now 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 \$6 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.

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 140 international and domestic students in 2004-2005 and the Astoria school generated \$100,000 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. This is the fastest growing COMES program.

### **OSU-COMES Seafood Research Laboratory**

The OSU Seafood Research Laboratory (SRL) is part of the Coastal Oregon Marine Experiment Station (COMES) and represents a major research component of "OSU on the Coast" spearheaded by the Hatfield Marine Science Center. The Laboratory is involved in seafood research, graduate student training at the M.S. and Ph.D. level and is charged with transferring information to the seafood industry through publications, workshops and meetings. There are currently four faculty and nine graduate students at the Seafood Laboratory along with four staff supporting active research program.

Research activities over the past year have included:

Value-added products. Research continues in the area of value-added products from albacore tuna and shellfish. The SRL has teamed with the Seafood Consumer Center to develop a "Stage-gate Process" for developing new products through the Community Seafood Initiative (CSI). Currently there are six new products in the

pipeline working directly with small and mid-size seafood companies in the Pacific Northwest.

Seafood Safety. The use of electrolyzed water was studied for the reduction of *Vibrio parahaemolyticus* in Pacific oysters has shown the efficacy of this process in reducing Vp by 2 log no. Investigation on the levels of mercury in albacore tuna have shown that local troll-caught tuna has lower levels that reported for albacore by the FDA due to their smaller size. A research grant was awarded to the SRL to study the levels of cadmium in oysters and is ongoing.

Seafood Processing/Quality. New processing methods for the recovery and utilization of fish proteins through manipulation of pH have shown the potential of this method.

This method also proved valuable for the extraction of high omega-3 fatty acids from sardines. Lipase was used to further concentrate the omega-3 fatty acids.

Surimi Research. Various researches covering surimi and surimi seafood have been conducted. As a part of Sea Grant projects, sarcoplasmic proteins from sardine have been isolated at various pH conditions. Their interaction with myofibrillar proteins from Alaska Pollock has been studied. To find out a way to assess the quality of surimi quickly, a multidisciplinary approach was used: Ca<sup>2+</sup> ATPase activities and storage modulus showed a great correlation with breaking force and deformation of surimi gels. Ingredient studies were also conducted to determine the interaction between egg whites and fish proteins. Various modified starches were also reviewed for possible stabilization at higher temperature.

Outreach. The 13th Annual Surimi School was held April 12-14. It was co-sponsored by 25 companies and had over 100 attendees from all over the world. The 5th annual Surimi Forum was held the day before on April 11. The first annual Micro-canners Workshop was held January 19<sup>th</sup> and attended by 40 custom canners throughout the West Coast. The 3<sup>rd</sup> annual Sardine workshop was held on May 4<sup>th</sup> and was attended by 35 persons affiliated with the sardine industry. The SRL also hosted 140 attendees of the OSU Council of Regents in May as they toured the lab and the Seafood Consumer Center and feasted on grilled tuna in the courtyard. There was also a visit to the Seafood Lab by Governor Kulongoski in June who visited Astoria to find out more about seafood research and its ties to economic development in the area.

### Special News

We have a new faculty member at the Seafood Lab as Michael Thompson joined us in February of this year. He is a Sea Grant Extension agent specializing in the interactions of fisheries management and seafood technology through special topics such as traceability. Dr. Michael Morrissey received the Briskey Award for faculty Excellence awarded by the OSU College of Agricultural Sciences. Dr. Jae Park left on sabbatical at Korea University in Seoul, Korea in October where he is spending a year working with students and other professors.

## **Cooperative Institute for Marine Resources Studies**

### **Clare Reimers, Director**

Now in its twenty-second 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 28 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.

**2005 Continuing Fellows and Projects**

- Cara Fritz            Towards Establishing a Natural Disturbance Mosaic on the Pacific Northwest Margin; Major Professor: Rob Wheatcroft, COAS
- 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: Multiscale 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.

Detree	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>
Ph.D.	Haixia Lin	Agricultural and Resource Economics	Spatial Statistical Analysis of Marine Resource Economic/GIS data
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.	Vicki Wedell	Marine Resource Management	Participatory GIS for Local Fisheries management in the Community of Port Orford, OR
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 *	Marine Resource Management	Life history of the Longnose Skate ( <i>Raja rhina</i> ) from the U.S. West Coast and Vulnerability to Fishery Impacts
M.S.	Lance Campbell *	Fisheries and Wildlife	Life History of Columbia River Salmon
* = Degrees Completed			

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

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

Two notable results occurred last year from our ongoing project using U.S. Navy hydrophone arrays (SOSUS) in monitoring earthquakes along the Juan de Fuca Ridge. Our analysis of a JdFR earthquake swarm that occurred in 2001 was published in the journal *Nature* in July 2004. It was found that this earthquake swarm was the result of a seafloor spreading event that entrained, rather than expelled, seawater and hydrothermal fluid. This discovery was listed in *Discover* magazine's year end issue as one of the top (#72) science stories of 2004. In February 2005, a massive earthquake swarm was detected along the northern JdFR and a research cruise was mobilized to the site to investigate the seafloor and water-column for evidence of volcanic activity. Although no evidence was found of an eruption, this event was the impetus for development of a new seismic criteria that should make evaluation of the likelihood of volcanic eruptions more certain during future earthquake swarms.

In 2004 and 2005, the Ocean Exploration program supported deployment of four Ocean-Bottom Hydrophones (OBH) at the Brothers submarine volcano along the Kermadec Islands north of New Zealand. The OBHs were deployed in September 2004 during a cruise aboard the New Zealand vessel *Tangaroa* and were recovered in March 2005. We just received the hydrophones back in our lab, but preliminary scan of the data indicates the OBH recorded thousands of earthquakes and hundreds of hours of volcanic tremor from this volcano. This should give us an unprecedented view of the dynamics of magma movement and its relationship to hydrothermal venting at the Brothers volcano.

This was the fourth year of the OSU-NOAA-WHOI cooperative hydrophone monitoring experiment of Mid-Atlantic Ridge (MAR) seismicity between 15°N and 35°N. We continued our collaboration with French colleagues at the University of Brest and have re-configured our hydrophone array to focus on a hydrothermal area called Lucky Strike which is located just south of Azores. 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, and these results were published in the Journal of Geophysical Research in 2004. 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, 14,881 earthquakes have been located from throughout the Atlantic Ocean basin as compared to 6,182 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. This year the project's hydrophone/acoustics monitoring website was highlighted in "*Discover*" magazine in their March 2004 issue as a "what's hot" website.

We have produced websites that present our recent discoveries of seafloor volcanic activity along the MAR and in the Caribbean sea:  
<http://www.pmel.noaa.gov/vents/acoustics/seismicity/mar/LuckyStrike2001.html>  
<http://www.pmel.noaa.gov/vents/acoustics/seismicity/mar/kej-2001.html>

*Marine Mammal Acoustics* (David Mellinger, Assistant Prof., Sr. Res.; Sara Heimlich, Sharon Nieukirk, Faculty Research Assistants)

In summer of 2004, five autonomous hydrophones were deployed on the Scotian Shelf in eastern Canada. These were configured for collecting sounds of North Atlantic right whales, probably the most highly endangered whale species. The data, after collection in August 2005 and summer 2006, will be used to assess critical habitat needs for this species.



CIMRS scientists, led by Sara Heimlich, have also analyzed data from the eastern tropical Pacific (ETP) to study the Bryde's whale, a tropical species of baleen whale. The distribution and seasonality of this species are still poorly understood, and this effort has yielded significant new insights. Five types of calls were found in the ETP, most with distinct seasonal occurrence. Call types also had distinct geographic ranges, with some occurring principally at the easternmost sites, some at the more southerly sites, and one occurring only at the northwest site. These distributions are being studied in light of other recent results on the taxonomy of Bryde's whales, which have suggested that the species should be split into two or perhaps three different species.

Automatic signal detection methods were developed to identify whale calls in large data sets. Dr. David 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 these Atlantic Ocean hydrophones, of right and sperm whales from the Gulf of Alaska hydrophones, and (in collaboration with Scripps Institution of Oceanography) of dolphins off California. Analysis of these data continue, with the goal of assessing seasonal distribution of these species.

Dr. Mellinger's research on call detection of minke whales was highlighted in National Geographic's Pulse of the Planet in March 2005  
[http://news.nationalgeographic.com/news/2005/03/0330\\_050330\\_minkewhale.html](http://news.nationalgeographic.com/news/2005/03/0330_050330_minkewhale.html)

*Geophysical Monitoring* (William Chadwick, Associate Prof., Sr. Res.; Andra Bobbitt and Susan Merle, Sr. Faculty Research Assistants)

The overall 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.

NeMO (New Millennium Observatory) is a long-term multidisciplinary project at Axial Volcano in the NE Pacific that is in its seventh 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 the Axial caldera. A focus of the observatory is NeMO Net, a two-way communication system that allows data and commands to be sent between instruments on the seafloor and desktop computers on shore. The data from NeMO Net are posted on the internet. Axial volcano erupted in 1998 and the latest monitoring data show that it is already building up to its next eruption. Precise pressure measurements show that the caldera floor at Axial is being uplifted at a rate of about 20 cm/yr, and has probably risen by about 1.5 m since the 1998 eruption. This is the first time that volcanic inflation has been documented at an active submarine volcano. One of the goals at NeMO is to document a full volcanic cycle at a submarine volcano.

We also continue to participate in the Submarine Ring of Fire, 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 dives with the manned submersible PISCES in the Kermadec Arc northeast of New Zealand. New chemosynthetic ecosystems were discovered on the summits of five submarine volcanoes that had never been explored before.

Both NeMO and the Submarine Ring of Fire present excellent 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/05fire/>

In both these projects, when CIMRS scientists are at sea daily updates are posted on the web and these updates are usually featured in public lectures at the Hatfield Marine Science Visitor Center during the summer months. This year we also adapted the multimedia ROPOS exhibit in the HMSC Visitor Center to make it available on the internet at the NeMO web site:

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

*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 Kermadec Arc over the last year. Follow-up expeditions with the submersible vehicles, Shinkai and Pisces, collected samples directly from the vents on nine of the undersea volcanoes from New Zealand to Tonga that were characterized by water-column analyses. Results from the lab are still pending but the gas concentrations that were measured at sea indicate that some of the trends, e.g., elevated ratios of CO<sub>2</sub> to Helium-3, seen on the Marianas Arc in 2004 will likely be seen on the Kermadec Arc.

Pictures and daily journals of the Ocean Exploration Ring of Fire cruises are available at <http://www.pmel.noaa.gov/vents/ring-of-fire.html>.

## Oregon Sea Grant

**Bob Malouf, Director**

**Jay Rasmussen, Extension Program Leader**

*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, and Veterinary Medicine. 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.

Research and other projects competitively funded by Oregon Sea Grant at the HMSC include developing methods for production of effective microparticulate feeds for marine fish larvae, teaching new audiences about aquatic invasions through an innovative exhibit, developing a seafloor 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. Over \$454,000 of Oregon Sea Grant-funded competitive projects took place at the Hatfield Marine Science Center during the 2004–2006 grant cycle.

In May 2005, a national panel of experts spent four days reviewing the Oregon Sea Grant Program and rated it “excellent throughout.”

## ***Research Programs by Academic Unit***

### **College of Agricultural Sciences**

#### **Department of Fisheries & Wildlife**

##### ***Marine Fisheries Genetics***

**Michael Banks, Assistant Professor (COMES)**

Four new scientists, a top of the line capillary DNA sequencer, pipetting robotics and new laboratory space comprise our main achievements this past year. Primary staff now includes 5 graduate students, 2 post docs and 3 professional staff who enjoy access to state-of-the-science facilities for their studies. We graduated our first 3 students and they all now have fine jobs to boot! Two years of research on the genetic basis of run timing allows exciting discrimination between spring and fall Chinook returns to the same watershed - this was not possible with microsatellites. On a broader scale microsatellite characterization of Chinook stocks from California through Alaska and on to Russia provides unprecedented resolution for mixed stock analysis. This poses tremendous potential for learning about ocean life-phase migration and better management of high-seas harvest. Our study on the relative fitness of hatchery and wild coho stocks should reveal first findings in the next few months along with those from another coho study evaluating genetic and life history variance for Oregon's central coast Evolutionary Significant Unit. Our groundfish program now involves studies on canary, darkblotched, copper and china rockfish. Publications include a book chapter on stock identification, two manuscripts on Chinook, one on coastal cutthroat trout, two on rockfish, and a Marine Biology paper on harbor seals/salmon predator-prey dynamics in Alsea Bay. Overall despite unforeseen equipment failure and losses approaching half a million, our fortitude continues with funding, excellent facilities and staff and exciting discoveries.

##### ***Invasive Species Ecology***

**John Chapman, Assistant Professor**

This has been a busy year of teaching, supervision of students, collaborative research and participation in local, national and international efforts to manage nonindigenous aquatic species.

Ongoing activities and projects include:

Submission of a 3-year benthic invertebrate analyses for the Nonindigenous Aquatic Species of the Lower Columbia River in cooperation with Portland State

University and University of Washington, that was published by the Portland State University Center for Lakes and Rivers and presented at the American Fisheries Society meeting;

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;

Survey of the nonindigenous peracaridan Crustacea of San Francisco Bay in collaboration with the San Francisco Bay Estuary Institute in which the ballast water introduction of the Japanese mysid *Neomysis japonica* was discovered;

International and coast-wide collaboration in the discovery of the first introduced marine parasitic bopyrid isopod - *Orthione griffenis*, which may be the most extensive and ecologically important ballast water introduction ever discovered in the eastern Pacific;

Collaboration with Brett Dumbauld's lab and HMSC in a science display on parasitic isopods "Suck their blood and eat our friends" presented in "SeaFest";

A 4<sup>th</sup> year of participation on the executive committee of the Western Regional Panel, (of the National Invasive Species Panel) with duties that include – organization of a special session on Nonindigenous Species for the international Desert Fishes Council, to be held in 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. Completion of the plan is anticipated by December 2005;

Organization and logistics of three crews of Lincoln County "Summer Natural Resources" (SNR) students to survey the *Orthione* infestation in *Upogebia* in Lincoln County, estuaries (Salmon, Siletz, Yaquina, Alsea) to permit an assessment of the impact of *Orthione* on native mudshrimp populations;

Sponsoring 2005 summer Research Education for Undergraduates student, Andrew Smith, in cooperation with Brett Dumbauld, on the energetics of *Orthonoe* on its host is being prepared for publication in the Journal of Crustacean Biology;

And the lab sponsorship includes committee membership on Ph.D. student, Michael Chi-Chang Liu, Dept Fisheries and Wildlife thesis topic, the New Zealand Mudsnaill.

### ***Marine Fish Ecology***

**Selina Heppell, Assistant Professor and Scott Heppell, Assistant Professor**

Three students in our lab finished up their Master's work this year. Marine Resource Management student Tad Schwager determined through radio tracking and surveys that lingcod in Yaquina Bay are residents with strong site fidelity. Brooke Martin developed a biochemical assay to detect maturation in female black rockfish and characterized the annual reproductive cycle of old and young females; she will be defending in September. Josie Thompson, another MRM student, is completing her analysis of age and length relationships and mortality estimates for longnose skate, a bycatch species off our coast.

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; and

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.

Our undergraduate research and seminar program, Marine Team, continues to collect monthly data on fishes and invertebrates in Yaquina Bay. Team members also conducted a study of rockfish barotrauma this year and found that a surprisingly large percentage of fish caught on recreational fishing gear were able to recompress without assistance. A new student group is undertaking a project to examine the effects of disease on growth and mortality of English sole juveniles in the estuary. This program continues to receive funding through CIMRS and Sea Grant.

During the summer of 2005, we are hosting two interns: Raquel Sosa, an undergraduate from Monterey California who is part of the Research Experience for Undergraduates Program, and Megan Baker, a high school intern from the Apprenticeships in Science and Engineering program. Raquel is studying habitat use of juvenile rockfish in Yaquina Bay and conducting a laboratory study on trap efficiency for capturing these fish. Megan is conducting a mark-recapture study of juvenile Dungeness crab in the Bay and nearby reefs, utilizing a volunteer call-in tag return system with the help of local marinas and marine supply stores.

The Cooperative Fisheries Internship Program has received funding from Sea Grant, the Department of Fisheries and Wildlife, CIMRS and COMES to continue and expand opportunities for students to gain hands-on experience with industry and resource managers. Students are allowed to enroll in any term to participate in this opportunity.

***Fisheries Oceanography*****George Boehlert, Professor**

We are continuing to develop long-term growth chronologies for long-lived rockfish using ring widths of otolith growth increments. The lead in developing this technique has been CIMRS Postdoc Bryan Black, a specialist in dendrochronology. Chronologies are derived using two different approaches. The first of these approaches applies techniques from dendrochronology (tree-ring analysis) to build highly accurate and precise rockfish growth chronologies. We have successfully adapted the tree-ring dating procedure called crossdating as a means by which to validate that the correct calendar year is assigned to each growth increment. Crossdating is a process of matching among all samples the synchronous growth patterns induced by the physical environment. Time series of otolith ring width measurements should correlate with one another if they have been properly aged and measured. Unusually low correlation between a time series and the other series in a sample indicates an ageing or measurement error, and the given time series should be reexamined. Prior to September 2004, we successfully crossdated 50 *Sebastes diploproa* otoliths collected during rockfish surveys conducted by the Alaska Fisheries Science Center, NOAA Fisheries in 1989 and 1995. Otolith growth patterns correlate with one another at level considered fully acceptable by dendrochronologists working with tree-ring data sets, indicating a high level of accuracy in the data. A publication on the research developing this new technique is now in press.

Current research is using dendrochronological techniques to develop chronologies that reflect long-term ocean variability and reveal the effects of the physical environment on fish growth. By standardizing growth across age groups, we can evaluate growth patterns induced by environmental variability. Splitnose rockfish show strong correlation with environmental indices that indicated upwelling and cool water temperatures, especially in the winter months; long-term trends that vary on a decadal timescale inversely mirror the Pacific Decadal Oscillation, showing strong influence of this longer-term process on rockfish growth. Thus the rockfish growth increments contain short and long-term variations in growth that closely correspond with variations in the physical environment. Additional research is being developed in examining marine-terrestrial linkages through examination of the relationship of rockfish growth chronologies with those of trees, and examination of the spatial scale of growth

chronologies in the widely distributed yelloweye rockfish. Bryan Black is developing collaborations in the OSU College of Forestry that may bring more coastal forestry activities to HMSC, similar to activities of over a decade ago.

***Molluscan Aquaculture*****Christopher Langdon, Professor (COMES)**

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 900 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 42% greater than those from unselected broodstock, with a realized heritability of 0.57 for yield. Selected MBP families are now used in commercial hatcheries to produce billions of seed for large-scale production.

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 joint research currently focuses on 1) identification of genetic markers and determination of co-variance 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 in the field and 3) usefulness of mixed-family versus single-family plantings in the evaluation of family performance in the field.

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 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 culture. 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. Several novel microparticle types have been developed and we are presently evaluating them in larval feeding experiments. We are also working closely with the Oregon Coast Aquarium in developing methods for rearing larvae of various rockfish species, including the protected yellow-eye rockfish. If successful, it will be possible to produce large numbers of juveniles for stocking aquaria and natural marine habitats.

### ***Marine Mammal Program***

**Bruce Mate, Professor (COMES)**

This year the OSU Marine Mammal Program, headed by Dr. Bruce Mate, conducted research on four different whale species: sperm whales in the Gulf of Mexico, blue and humpback whales in the Pacific Ocean off central California, and gray whales in Bahía Ojo de Liebres in Baja California Sur, Mexico. Each of these species were tagged with satellite-monitored radio tags, then tracked by satellite and computer. The data transmitted by their tags revealed feeding and migratory movements, some of which were quite surprising.

### **Sperm whales—Gulf of Mexico, July 2004 and June 2005**

Poor weather conditions and unexpected distribution of sperm whales combined to make the 2004 Sperm Whale Seismic Survey (SWSS) cruise less successful than previous years; however, the dedication of the research teams allowed us to place a total of eight tags. Data from the 2004 tags supported the data collected in 2002 and 2003. We compiled the data from the complete three-year project and added it to the SWSS synthesis report, which was then submitted to Minerals Management Service, the sponsoring agency. We also presented our findings at an Informational Transfer Meeting in January 2005, attended by representatives of Minerals Management Service, the Office of Naval Research, oil and gas interests, Texas A&M University, Woods Hole

Oceanographic Institution, and other scientists who had participated in one or more of the cruises.

Among other findings, we learned that Gulf of Mexico sperm whales do not limit their range to the Gulf—a very exciting discovery! One of our tagged animals traveled out into the Atlantic Ocean, venturing as far as Charleston, South Carolina before turning back as it ran into the edges of Hurricane Isabel. We also saw two very different types of movements among tagged whales: some stayed relatively close to the shelf, while others ventured into deeper water and ranged over much of the Gulf.

The SWSS project was successful enough to warrant a two-year extension of funding, and a second cruise took place in June 2005. During this cruise we used a new generation of tags, which send not only location data and the number of dives the whale has made, but also depth data—how deep is the whale going during its dives? We are still receiving data from these tags, and have not yet completed our analysis.

### **Blue and humpback whales—California, August 2004**

Our final field season in 2004 was part of the TOPP program (Tagging of Pacific Pelagics), co-funded by the Sloan, Packard and Gordon Moore Foundations. We used our new research boat, the *Pacific Storm* (a former commercial fishing vessel donated to our program), to travel from Oregon to the waters off central California in search of blue and humpback whales. This season was extremely successful: in four weeks we tagged 29 animals, eight of them with the new depth tags. Within two months of tagging, the blue whales were ranging from the north end of Vancouver Island, Canada, to Magdalena Bay, Mexico—a range of over 2,000 miles. Of the 12 blue whales carrying location tags, four were briefly clustered in a five-mile area of water off Coos Bay, Oregon. Overall, the blue whales showed a strong affinity for the outer edge of cold, upwelled water (also known as salmon water), where they feed on krill. We'll be repeating this work in the summer of 2005, once again using both depth and location tags.

### **New faculty**

We're very excited about the addition of two new tenure-track faculty to our program: as this report goes to press, we are in the process of hiring a cetacean ecologist and a pinniped ecologist. These new positions will greatly expand the scope of our program, not only to

different species (adding research on seals and sea lions to our existing whale research) but also into different disciplines. As a program, we are looking forward very much to expanding our capabilities and building new collaborations with other researchers, taking advantage of the wealth of skills and experience right here at HMSC, as well as elsewhere in the world.

### ***Population Dynamics***

**David Sampson, Professor (COMES)**

#### Research

Dr. Sampson's research activities during 2004/05 focused on stock assessment and fisheries management issues. As part of his duties for the Oregon Department of Fish and Wildlife, which partially fund his position, David continued to serve as Oregon's representative on the Scientific and Statistical Committees (SSC) for the North Pacific Fishery Management Council and the Pacific Fishery Management Council. During the year David attended nine SSC meetings, at locations ranging from San Diego, CA to Anchorage, AK, and he was involved in providing recommendations on numerous fishery management issues. As part of his Pacific SSC responsibilities, David served as the chair of the stock assessment review (STAR) panel that reviewed three flatfish stock assessments in April. During the first six months of 2005 a significant portion of David's time and energy was focused on preparing a new coast wide stock assessment for Dover sole, which passed its STAR panel review in June.

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 is responsible for all science review panels pertaining to Atlantic and Gulf of Mexico resources.

In July David began a new collaborative research project that is attempting to develop survey methods for canary rockfish that will supplement the information provided by the standard bottom trawl surveys. The West Coast stock of canary rockfish has been assessed as being at extremely low abundance; the Pacific Council's attempts to control catches of canary rockfish are seriously constraining many commercial and recreational fisheries. The canary rockfish project, which is funded

by the Pacific Groundfish Conservation Trust, is initially focusing on the preponderance of male canary rockfish found 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. Field collections of canary rockfish, using rods and reels on rocky deepwater reefs off Washington and Oregon, have 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 untrawlable areas along the West Coast.

In March David accepted an invitation to join the editorial board of the journal *Fisheries Research*. During the spring David was kept very busy by his activities as chair of the search committee for the COMES Pinniped Ecologist position.

#### Teaching

During the autumn David taught his course "Dynamics of Marine Biological Resources". As in past years, lectures for the course were given in the HMSC studio classroom and televised to the main campus, where about half the students attended these broadcast lectures.

In December 2005 graduate student Jennifer Katalinich defended her MS thesis, entitled "Seasonal Abundance and Behavior of Steller Sea Lions in Oregon". Jennifer's major professor was Selina Heppell, but David supervised Jennifer during her first year at OSU, before he left to go to England. In May graduate student Megan Petrie, successfully defended her MS thesis, entitled "Habitat Associations and Determinants of Refuge Use in Post-Settlement Lingcod (*Ophiodon elongatus*)". David served with Cliff Ryer as co-chairs of Megan's graduate committee.

## Department of Agricultural and Resource Economics

### *Marine Fisheries Management and Policy*

Susan Hanna, Professor (COMES)

Activities in the past year have emphasized two areas: research on improving fishery management and scientific and policy outreach.

#### Research on Improving Fishery Management

- Research on improving fishery management concentrated on questions of institutional design for new approaches to ocean and fishery governance, developing knowledge about incentive-based fishery management tools, and developing new approaches to integrating economic and biological performance indicators for fishery management.
- A Sea Grant funded project to develop best management practices for fishery management supported graduate student Branka Valcic, who passed her oral prelims, entered into Ph.D. candidacy, and is now engaged in her dissertation research. She is using GIS data to model the incentive basis of spatial management tools such as marine protected areas. Branka was awarded the 2004 Bill Wick Marine Fisheries Student Award for Research. In June 2005 she presented her thesis research at the Markham Symposium for graduate student award winners at the Hatfield Marine Science Center.
- Another Sea Grant research project begun in March 05 will extend current research on best management practices for marine ecosystems to regulatory design for marine protected areas.
- A NMFS funded research-outreach project to apply incentive-based tools to the reduction of fishery bycatch in West Coast groundfish is supporting Ph.D. student Haixia Lin in the development of a model of the economics of compliance with bycatch regulations.
- The U.S. Commission on Ocean Policy (USCOP) issued its final report in September 2004. The report contains numerous recommendations for changes in ocean governance and fishery management. Several research activities have centered on institutional design implications of the USCOP recommendations. Two papers and an Op-Ed piece were co-authored with J. Sanchirico of Resources for the Future comparing the recommendations of the U.S. Commission on Ocean Policy (USCOP) with those of the Pew Oceans Commission (POC) (publications listed below). An invited presentation “Will Structural Reform Help the Regional Fishery Management Councils?” to the Florida State University Fifth Mote International Symposium in Fisheries Ecology: “The Good, the Bad and the Ugly: Integrating Marine and Human Ecology into Fisheries Management” (Nov 9-11, Sarasota, Florida) has been developed into a manuscript (listed below) now in its final revision. The manuscript discusses the USCOP recommendations for regional fishery management council reform in the context of boundaries in U.S. fishery management. It describes how boundaries have evolved over time, identifying incentives as a key contributor to management failure. It addresses the extent to which recommended structural reforms will resolve the fundamental problem of incentives in fishery management, concluding that problems in U.S. fishery governance have biophysical and economic symptoms but are institutional in their cause. Their resolution requires greater economic and ecological integration into sustainable ecosystem-based management.
- Another recommendation of the USCOP is to implement formal training of members of regional fishery management councils. This led to an invitation to give a talk to the Workshop for Members of the Regional Fishery Management Councils “Current Issues in Implementing the Magnuson-Stevens Fishery Conservation and Management Act” (18-20 October, Baltimore, Maryland.) The talk, titled “Training Regional Fishery Management Council Members: Development of a National Strategy,” described the recommendation of the US Commission on Ocean Policy for Council member training and presented a proposed approach for implementing the recommendation.
- Further research in design of ocean governance was presented at an invited keynote speech at the conference of the International Society for Ecological Economics (12-14 July, Montreal, Canada). The presentation, “Boundary Shifts in Marine Governance: The Challenge of Integration,” discussed the need for greater economic and ecological integration of ecosystem-based management and the institutional challenges of achieving this integration.



- A draft book manuscript summarizing social science research related to fisheries is near completion. The manuscript highlights research and outreach conducted under the Oregon Sea Grant “Adapting to Change” project. The book title is *Sustaining Fishing Communities in an Environment of Change*. The book is targeted at fishery managers, summarizing the “so what?” of the human dimensions of fisheries management.

### Scientific and Policy Outreach

General scientific advice was provided to regional and federal agencies primarily through service on two advisory committees: the Science Advisory Panel of the U.S. Commission on Ocean Policy and the Science Advisory Board of the National Oceanic and Atmospheric Administration. Additional advisory activities were also conducted.

- As a member of the U.S. Commission on Ocean Policy’s Science Advisory Panel, provided text review and scientific advice on the state of marine research, problems with fishery management, and options for improving fishery management in developing the Commission’s report. The Commission’s Final Report was released in September 2004.
- In response to the USCOP recommendations that dedicated access privileges be allowed as fishery management tool (individual transferable quotas are one example of these share-based allocation tools) and in anticipation of the upcoming reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) in 2005, addressed several educational opportunities related to these management tools. Continued to chair the Independent Experts Panel (a multidisciplinary group of economists and biologists) advising the process of developing a trawl individual quota program through the Pacific Fishery Management Council. Served as a resource person in a meeting with West Coast Port Managers regarding community interests in ITQs. Presented a talk to the Consumer Seafood Initiative (CSI) 3<sup>rd</sup> Annual Sardine Symposium in Astoria on Individual Fishing Quotas and how they might function for the Oregon sardine fishery. The audience for this talk was harvesters, processors, technologists, managers, and congressional staff. Accepted an invitation to brief the Astoria Port Commissioners at their July meeting on individual fishing quotas for groundfish and sardines and how they might function under different designs.
- Gave a presentation to the newly reconstituted Oregon Ocean Policy Council (OPAC) on MSFCMA reauthorization issues for 2005 and its implications for Oregon.
- As a member of the NOAA Science Advisory Board, provided general scientific advice to NOAA leadership and specific social science advice to the NOAA Research Council on implementation of the report of the Social Science Review Panel “Social Science. Research within NOAA: Review and Recommendations.”
- Related to improving communication between marine ecologists and economists, accepted an invitation to introduce and moderate the “great debate” between Daniel Pauley (ecologist) and Jim Wilen (economist) at the North American Association of Fishery Economists, Vancouver, Canada, 26 May 2005. Debate topic: sustaining fishery benefits for all generations.
- Continued to advise NOAA Fisheries Northwest Fisheries Science Center leadership on the development of a fishery economics research program. Reviewed and commented on the NWFSC social science research plan, and continued to work with NWFSC leadership on the development of a fishery economics internship program.
- Participated in the design and development of a West Coast Sea Grant Fisheries Extension Workshop “Pacific Coast Marine Fisheries Extension: Integrating Human Dimensions into our Work” to be held in Astoria in July 2005. Prepared an opening overview talk on “Emerging Marine Fisheries Issues and their Human Dimensions” for this workshop.
- Participated in the Sea Grant Extension Seafood and Fisheries and Community Development team.
- Prepared a research poster and participated in the meeting of the Oregon sea Grant Program assessment Team (PAT).
- Organized and chaired a second meeting of Oregon fishing industry and management interests to continue discussions of economic information needed to inform decisionmaking to assist economic recovery in West Coast groundfish. This is linked to economic data collection efforts of the Pacific States Marine Fisheries Commission.

- Continued to serve on the Board of Trustees of the Institute for Fishery Management, North Sea Centre, Hirtshals, Denmark
- Gave a lecture to FW499/599, class “The West Coast Groundfish Crisis” (taught by Dr. Steve Parker (ODFW) and Dr. Scott Heppell (OSU)) at the HMSC on October 12. Title: “US Regional Fishery Management: Structure, Function and Challenges.

### ***Marine Resource Economics & Marketing*** **Gil Sylvia, Associate Professor (COMES)**

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, 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) designing an optimization bioeconomic model for a loligo squid fishery; 4) developing optimal traceability and accountability systems for handling, marketing, and sustaining albacore tuna; 5) designing a simulation model for designing and managing seafood cold storage; and 6) developing education programs for fishery managers.

We are completing and 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 and shows the relationships of economic benefits and the management, biological, and oceanographic characteristics of the fishery. This work served as the primary research for Charmaine Gallagher who successfully defended her PhD in 2005. Charmaine is now working for the New Zealand Ministry of Fisheries in management of their offshore fisheries. The second project is titled the Community Seafood Initiative and is being conducted in

cooperation with the Astoria Seafood Laboratory and Shorebank Enterprises. The project was initially funded by USDA and the Kellogg Foundation and is designed to develop new value-added seafood products and coastal community business opportunities for albacore tuna, oysters, and other finfish and shellfish. A key part of the research focus is developing handling and traceability strategies for supporting coastal production and marketing of albacore tuna. This research formed the core work for Michael Thompson who successfully defended his Master’s Thesis in late 2004 and is now a Sea Grant Extension Agent in Astoria, Oregon working in close collaboration with CSI and the Astoria Seafood Laboratory. We have recently completed a user-friendly simulation model which can evaluate the costs, benefits, and risks associated with developing cold storage along the Oregon coast. We also completed two projects with the New Zealand Seafood Industry focusing on developing bioeconomic management models for the Challenger scallop fishery, and developing economic based environmental standards for the Ministry of Fisheries. Finally, we recently completed a project which developed a bioeconomic management model for the Falkland Islands loligo squid fishery.

These research projects have generated over \$1 million in extramural funding and are supporting four graduate students (1 Ph.D. and 3 Masters' candidates) from the Departments of Agricultural and Resource Economics, Marine Resource Management, and Fisheries and Wildlife.

## **College of Oceanic and Atmospheric Sciences**

### ***Marine Geochemistry*** **Clare Reimers, Professor**

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 2004-2005 two major 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 fuel cell)

and mobile Autonomous Underwater Vehicle Gliders that operate within the water column of the ocean (the plankton fuel cell). A NSF grant sponsored two research cruises on the *R/V Wecoma* during which prototype sea floor fuel cells were deployed for up to 9 months, and muddy areas of the Oregon shelf studied by making in situ microsensor measurements and by collecting sediment cores, water samples and bottom photographs.

In the spring of 2005 C. Reimers taught a new graduate course in "Sediment Biogeochemistry" that included a weekend coastal field trip and lab studies at HMSC. Student involvement in Reimers lab research is also increasing, with the addition of summer interns, Leslie Soule (in 2004), Katie Shultz (in 2005), and a new oceanography graduate student, Mark Nielsen.

## College of Science

### Department of Botany and Plant Pathology

#### Gayle Hansen, Associate Professor

During the 2004-2005 academic year, Gayle Hansen, our marine botanist, was involved in teaching and research and in efforts related to the conservation of Oregon's seaweeds.

In Oregon, she taught two intensive field courses: (1) Marine Algae (OSU/HMSC, a section of the Marine Biology Program, 23 students). Concentrating on the identification and biology of the local seaweed species, Gayle's course was the first in the Marine Biology series and helped to prepare students for the later courses in Marine and Estuarine Ecology. (2) Marine Animals and Plants of Oregon (UO/OIMB, Summer Program, 10 students). Co-instructed with Stewart Schultz, author of *The Northwest Coast*, this course provided undergraduate students with an introduction to the biology and ecology of Oregon's common marine fauna and flora.

Gayle's interest in public education and in marine conservation led her to several volunteer activities. To improve the public's knowledge of seaweeds, she led intertidal seaweed walks for: (1) the HMSC Visitor's Center Volunteers, and (2) Coast Watch of the Oregon Shores Conservation Coalition, a group of volunteers that monitor the Oregon coast for environmental change. To assist groups promoting marine conservation, she served as a committee member and seaweed specialist for: (1) Oregon's Rocky Shores II Technical Advisory Council, and (2) The Nature Conservancy's Northwest

Coast Ecoregional Assessment. Both groups were interested in obtaining and synthesizing data that would help them to assess and more adequately protect the northwest coast marine flora and fauna. As a part of her Nature Conservancy work, Gayle presented a poster for the 2005 Northwest Algal Symposium entitled "The Nature Conservancy's Preliminary Target List for Northwest Rare and Endangered Marine Algal Species". This poster discussed the difficulties of determining rare and endangered species in marine ecosystems and was successful in urging other specialists to investigate rare marine species in their areas.

Due to her taxonomic expertise, she was asked to identify marine algae for the authors of several upcoming books in marine biology and for the public herbaria at the University of British Columbia, the University of California at Berkeley, Oregon State University, and the University of Alaska. The University of Alaska contract included more than 800 subtidal specimens for the Census of Marine Life study in that area, including many rare and beautiful forms.

Gayle's personal research continues to focus on the taxonomy, distribution, and biodiversity of seaweeds in Oregon and Alaska. Since these plants are an essential food source for many near-shore marine animals, their conservation is crucial to the health of the marine ecosystem. In order to detect changes in species diversity over time, Gayle has been documenting the occurrence and distribution of seaweed species using historical to present-day specimens of Oregon and Alaskan marine algae deposited in herbaria around the world. By first correcting and updating the identification of each specimen and then databasing the label information, she has produced a digital catalog of species occurrences that includes not only the specimen names, but also their dates and location of collection. Since herbarium specimens are the only existing records we have of the historical occurrence of algal species along our coast, this catalog is providing an important baseline for our knowledge of algal biodiversity in Oregon and Alaska. From her studies, Gayle has found that collections from these areas began in the early 1800's. In Oregon, Lewis and Clarke collected and pressed a specimen of kelp from the mouth of the Columbia River in 1805. In Alaska, Russian scientists on the Luetke Expedition pressed material from Sitka, Unalaska and St. Matthew Island in 1827 and 1828. These collections and tens of thousands of later specimens collected up to present time have already been examined and cataloged for these projects. The

final databases along with full-color scanned images of many of the species are being presented on the Web with the assistance of the Northwest Alliance for Computational Science and Engineering located at OSU in Corvallis. Although these databases continue to expand, they have already provided important information on the first occurrences of introduced algal species and on the sporadic occurrence and decline of others. In the future, as the databases become more complete, they will provide valuable historical data for studies of environmental change along our coast.

In addition to the databases, Gayle has developed and curated a reference herbarium of her own collections over the years. These collections, also catalogued in her database, include specimens from Alaska to Mexico along the American west coast, Maine to Florida along the east coast, eastern Russia, southern Japan, and Australia. These specimens and her 30-years experience in marine algal taxonomy have given her the opportunity to work with both molecular biologists and ecologists on these algae. This year she has identified and/or supplied algae to scientists working in Alaska, British Columbia, Washington, Oregon, California, New Hampshire, North Carolina, England, and Ireland.

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>

Hansen, G. I. Problematic Subtidal Seaweed Taxa from South-Central Alaska. (for the NaGISA section of the Census of Marine Life).

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## 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, especially concentrating on whirling disease caused by the parasite *Myxobolus cerebralis*. This parasite, which has severely reduced populations of trout and salmon in some Western states, including Oregon, has a complex life cycle that involves

alternating hosts: a salmonid fish, usually trout or Pacific salmon, which release the parasite from its location within the cartilage of the skull and gills when they die, and an oligochaete worm, *Tubifex tubifex*. 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 2.5 years after a single exposure to the parasite. This confirms what often happens in rivers and lakes, that 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 from the worm can be carried on waders and transferred to susceptible trout fry, thus establishing the possibility that the parasite can be transmitted this way in wild fish. The converse does not appear to occur; that is, the parasite in trout was not transferred by waders to susceptible worms. 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. Another "missing link" in our understanding of the transmission of the whirling disease parasite is the minimum dose necessary to transmit the parasite from host to 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 -about a month or more- between

hatching and emergence from the gravel. Thus, those stocks of wild fish that are within the redds during the most prolific release of spores from infected worms (late spring) are most likely to become infected with the parasite; those that hatch and emerge earlier or later are less likely to become infected. We will be following up and completing these studies in the coming year.

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. 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*. 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. The work on this project was carried out by research assistant Prudy Caswell-Reno.

## **Department of Science and Mathematics Education**

### **Shawn Rowe, Assistant Professor (Sea Grant Extension)**

In June of 2004, Shawn Rowe, Ph.D., joined the faculty of the Department of Science and Mathematics Education in the College of Science. Dr. Rowe heads up Oregon Sea Grant's Free-Choice Learning Initiative and works with the Department's new Ph.D. program in Free-Choice Science Learning. Dr. Rowe's research focuses on how people learn science in informal settings like museums. The HMSC's Visitor Center is a prime laboratory for this research and, in early summer 2005, Dr. Rowe presented initial findings from research begun in 2004 at both the National Marine Educators' Conference and the 14<sup>th</sup> World Congress of Applied Linguistics.

Having a world-class marine science learning facility as part of the university means that OSU is able to attract faculty and graduate students from around the country who work on learning in informal settings or learning that occurs in leisure time. Studies underway now at 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 Dr. Rowe, Bill Hanshumaker, and Jessica Cardinal of Sea Grant and Alicia Christensen of the College of Oceanic and Atmospheric Sciences, doctoral students in Science and Mathematics Education will begin work in 2005 that will lead to dissertation research in free-choice science and math learning.

## **Department of Zoology**

### ***Marine Ecology***

#### **Bruce Menge, Professor and Jane Lubchenco, Distinguished Professor**

An important part of their research is PISCO, the Partnership for Interdisciplinary Studies of Coastal Oceans, a long-term, large-scale ecological 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, 6 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 of the Oregon Department of Fish and Wildlife, researchers from the PISCO lab (Francis Chan, Karina Nielsen, Brian Grantham, 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 2005 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, a master's candidate in the Menge/Lubchenco lab uses 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 are planned during 2005/2006.

Sarah Dudas, a post-doctoral fellow, Joe Tyburczy, 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.

Anne Guerry, a PISCO Scholar and NSF Fellow, currently uses 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 examines how gradients of available nutrients and grazing pressure by limpets interact to alter the development of algal communities. She is testing to see 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.

Maria Kavanaugh, a Markham Fellowship awardee, and Master's student, investigated the effects of phytoplankton shading on kelps. Differential levels of phytoplankton abundance and retention along the nearshore Oregon coast may affect benthic algal abundance and changes in overall community production. Her field experiment, begun in 2004 at sites both north and south of Newport, is designed to test the efficacy of artificial shades in the low intertidal zone and their effects on kelp growth and overall benthic diversity. She used HMSC facilities to conduct an experiment to study the mechanistic effect of different light levels on the growth and susceptibility to herbivory of *Hedophyllum sessile*, an intertidal kelp, using fluorometry, pigment extraction, and phlorotannin induction.

### *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.

## College of Veterinary Medicine

### **Tim Miller-Morgan, Assistant Professor (Sea Grant Extension)**

Dr. 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 Dr. Jerry Heidel, Director of the Veterinary Diagnostic Laboratory; Dr. 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, Heidel, and Dr. Rob Hildreth, a private fish veterinarian in Los Angeles, are also involved in an Oregon Sea Grant funded project to examine factors predisposing wild-caught marine ornamental fish to

post-shipment morbidity and mortality. Through partnerships with two marine ornamental importers in Portland and Los Angeles, they are able to examine fish as they arrive in the U.S. and characterize their health status. They plan to use their results to develop recommendations for best management practices for marine ornamental importers. Additional funding was recently secured to begin working with suppliers and collectors in Indonesia. As with their work in the U.S., the goals in Indonesia will be to characterize the health and husbandry status of these fish as they arrive at collecting stations and export facilities.

## **B. Federal and State Agencies**

### **US Department of Agriculture**

#### **Agricultural Research Service (ARS)**

**Mark Camara, Research Geneticist**

**Brett Dumbauld, Ecologist**

The Agricultural Research Service is the federal scientific research agency responsible for solving agricultural problems of national importance and developing solutions to a wide range of problems related to food and agriculture. ARS generally makes long-term commitments of resources to problems unlikely to have solutions with the quick commercial payoffs that would attract private funding. Since 2003, the ARS mission at HMSC has been to work with the 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 addressed the ecological aspects of shellfish farming in west coast estuaries. Both collaborate extensively with students and faculty at OSU as well as other agency scientists.

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. Determining the degree to which heavy metals accumulation in oysters is genetically determined and

amenable to modification through artificial selection. Heavy metals are known to have adverse health effects on humans, so developing oyster strains with reduced bioaccumulation could reduce these effects with little impact on the way oysters are farmed.

3. Analyzing quantitative genetic variation and covariation in economically important characters in Pacific oysters to develop better selection procedures.
4. 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.

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 established a presence at HMSC, including recruitment of a field technician and a graduate student through the Fisheries and Wildlife Department and laboratory set-up within the EPA Coastal Ecology Branch facility. A 5-year Research Plan was submitted and approved by the Office of Scientific Quality Review and research has been initiated on two issues:

1. Examining the 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 established in three coastal estuaries. 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. Tagging experiments, mating experiments and some trials with electrofishing as a control measure were initiated this year.
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. Aerial photography and ground- truthing for eelgrass maps was completed this year and extensive on-ground shrimp mapping efforts will be conducted next year.

## **Environmental Protection Agency**

### ***Pacific Coastal Ecology Branch, Western Ecology Division***

#### **National Health and Environmental Effects Laboratory**

**Office of Research and Development  
Walt Nelson, Director**

The Newport EPA research laboratory is part of the Western Ecology Division, located in Corvallis, Oregon. The research mission of the Pacific Coastal Ecology Branch is to develop procedures to assess the cumulative and interactive effects of human activities on the ecological resources of estuaries of the Pacific Northwest.

The high rate of human population growth in the Pacific Northwest is subjecting estuaries and coastal watersheds to many anthropogenic stresses. The amount of this stress will continue to increase as population growth continues and the Northwest further develops economically. Stressors which jeopardize the ecological sustainability of estuarine and coastal watershed resources include watershed alterations (e.g., urbanization, land use alteration, road construction, agriculture and forestry practices) such as increased nutrient and sedimentation loads, habitat loss and alteration (e.g., landfill and dredging), planned and unplanned biotic introductions, pollution, anthropogenic-caused algal blooms, and extreme natural events such as floods, droughts, and disease outbreaks. Determining the effect of stressors is complicated by the fact that they have different ecological effects and act at various, often overlapping, spatial and temporal scales.

The specific research focus for the Coastal Ecology Branch is to define ecological processes and to develop and evaluate models to predict stress-response relationships for Pacific Northwest estuaries at a range of spatial and temporal scales. The research seeks to evaluate how specific estuarine habitats, and particularly seagrasses and burrowing shrimp, respond to a range of potential stressors, which may lead to habitat alteration. Additionally, the research effort seeks to understand the



influences of these stress factors at spatial scales from local to regional, and seeks to develop indicators of ecological condition, which may be used to evaluate estuarine status across multiple spatial scales. Current projects include research on:

- Estuarine biota-habitat relationships
- Responses of estuarine ecological engineering species (seagrasses, burrowing shrimp) to multiple abiotic stressors
- Factors controlling distribution of native and exotic seagrass species
- Range expansion and reproductive ecology of *Zostera japonica*, a non-native eelgrass in Yaquina bay
- Evaluation of watershed versus oceanic nutrient inputs to Pacific Northwest estuaries
- Assessment of distribution of non-indigenous species in west coast estuaries
- Conducting assessments of west coast estuarine resources

Research activities include large-scale (within and among estuaries) field studies and laboratory investigations of relationships between stressors and effects. PCEB administers the Western Coastal Environmental Monitoring and Assessment Program, which is part of the National Coastal Assessment being conducted by EPA. The program is designed to determine the condition of estuarine and near coastal resources of Washington, Oregon and California, with additional efforts in Alaska, Hawaii, and the Pacific Island territories. In 2004, Western Coastal EMAP carried out an assessment of coastal ecological condition for the estuaries of Washington, Oregon, California, Guam and the southeastern region of Alaska.

EPA research staff at HMSC currently consists of 13 federal employees, 2 EPA postdoctoral fellows, and 20 technical and clerical contract support staff. Scientists from the U.S. Geological Survey and the U.S. Dept. of Agriculture, Agricultural Research Service are co-located with EPA scientists. PCEB interacts with the HMSC and wider university community both in research and educational programs. A number of PCEB staff scientists hold courtesy faculty appointments with OSU academic departments, and participate in teaching and serve on graduate student committees. The Branch typically has several undergraduate summer interns from OSU.

## 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.

Investigation of the key principles which control mortality in fish when they are discarded from fishing operations (bycatch) continues to be a primary research focus for Michael Davis in collaboration with Carl Schreck (USFWS, OSU), Sarah Lupes (OSU), Ed Noga (North Carolina State University) and Michael Schirripa (NOAA/NWFSC). During the last year emphasis was placed on susceptibility to stress and mortality in walleye pollock, sablefish, Pacific halibut and rock sole exposed to net towing and air exposure. New indices for stress and delayed mortality have been developed using behavior deficits, immune deficiency and physical injury caused by capture-related stressors. These measures can be used to estimate discard mortality in various fisheries.

The effects of environmental conditions on the feeding and growth of fishes continues to receive attention within the program. A laboratory study by Thomas Hurst determined the thermal sensitivity of growth in northern rock sole, leading to a demonstration that growth variation among nursery areas around Kodiak Island, AK is due only in part to temperature variation. Additional spatial and temporal variation in growth may be due to prey availability and other environmental factors. Laboratory experiments on the visual foraging ability of flatfishes indicated strong similarity across species, with northern rock sole, Pacific halibut and English sole all requiring  $10^{-5} \mu\text{mole photons m}^{-2} \text{s}^{-1}$  for effective foraging. Analyses currently underway will relate the visual abilities determined in the lab to diel foraging patterns observed in the wild for these three

species. Other experiments examined the energy budgeting of juvenile sablefish and walleye pollock following a period of interrupted feeding.

Investigation of habitat requirements and habitat-mediated predator-prey relationships relevant to fishing gear impacts is an important theme in the Behavior Program. Cliff Ryer is exploring how sediments, sponges, shell and other emergent structures in the benthos affect habitat choices and survival of juvenile rock sole, Pacific halibut, English sole and other species. Under his guidance, OSU graduate student Jena Lemke completed her MS thesis research on comparative anti-predator behavior in North Pacific juvenile flatfish. Another graduate student, Megan Petrie, completed her master's work, studying habitat preference and utilization by young-of-year lingcod. Detailed analysis of habitat associations for age-0 flatfishes was initiated in Kodiak in 2002, with support from the North Pacific Research Board. Using a towed camera sled to survey flatfishes and demersal habitat, Allan Stoner and Mara Spencer are using video records for both statistical and landscape interpretations of essential fish habitat for northern rock sole and Pacific halibut. All of these projects have the common goal of providing a clearer understanding of function of essential fish habitat for commercially important Northwest species, and providing for more informed management.

Performance of baited fishing gear is another important line of research in the Program. Allan Stoner, Tom Hurst and Michele Ottmar conducted experiments to explore how water temperature affects feeding rates in Pacific halibut and the associated relationship between catch-per-unit-effort on longlines and fish abundance. Allan Stoner and Rich Titgen conducted new experiments with a drop camera in Kodiak, Alaska, to determine how current velocity influences catch rates for halibut and Pacific cod. Cliff Ryer's laboratory studies demonstrate that light and temperature have a major impact on how flatfishes react to the ground-gear of a bottom trawl. New field studies with Craig Rose (AFSC-Seattle) have been initiated with high-frequency imaging sonar to explore flatfish responses to trawl sweeps in dark and light conditions. These investigations aid in understanding variation in catch rates, with the goal of improving fishing efficiencies and stock assessments.

#### Education

Megan Petrie completed her MS degree in June 2005, with a thesis entitled "Determinant of refuge use in post-settlement lingcod". The research was supervised by

Cliff Ryer (NOAA-AFSC) and David Sampson (OSU-COMES). Kate Boersma joined the HMSC community in June 2005 to begin research toward her MS thesis with Cliff Ryer (NOAA-AFSC) and Selina Heppell (OSU-FW). The HMSC-based program of the Alaska Fisheries Science Center supported two undergraduate interns during the last year including Jessica Ramsey (Salem College, NC -- NSF-REU funding) and Kelly Glaesemann (Texas A& M Univ).

## 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 is located on Oregon State University's Hatfield Marine Science Center campus and conducts critical research on groundfish and salmon, and the ecosystems in which they live.

### *Administration:*

#### **Hollis Lundeen, Newport Research Station Facilities Manager**

NWFSC staff working in the Captain R. Barry Fisher building (BFB), Newport Aquaculture Lab (NAL), and Research Support Facility (RSF) building continued to conduct critical West Coast groundfish and salmon research. In addition, Center staff enhanced interdisciplinary science, community partnerships, and educational linkages. Many Center scientists participated in the 4th annual SeaFest which occurred in conjunction with the 40th Anniversary celebration of the Hatfield Marine Science Center. As part of the marine festival and open house activities, the Captain R. Barry Fisher building housed SeaFest's "Science Zone" which included educational exhibits such as a 3-D tour of the ocean using GLOBEC data, Fish Otoliths: Tree Rings of the Sea, Albatross Tracking, and Seabird/Fishery Interactions.

Center staff continued to make improvements in the areas of environmental compliance and safety. Maintenance staff replaced the existing Hazardous Materials shed with a new metal structure that increases ventilation and improves user safety. In addition, Center staff updated the building's Emergency Response Plan to include earthquake and tsunami response procedures and continued working towards renewable resource management by implementing a recycling program and encouraging use of recycled goods in construction projects.

***Environmental Conservation Division (EC):***  
**Mary Arkoosh, Team Leader Immunology and Disease**

Dr. Mary Arkoosh and Bernadita Anulacion represent the Environmental Conservation Division (EC) in Newport. Their research continues to focus on interrelationships among host resistance, 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 delayed-disease induced mortalities associated with stressors and the subsequent impact on the structure and fitness of host populations and communities. Staff and collaborators involved with these studies include: Drs. Philip Rossignol and Larry Curtis, Oregon State University; Dr. Frank Loge, University California Davis; Joseph Detrick and Deborah Boylen; Frank Orth; Greg Kurtzikowsky and Claudia Bravo, CIMRS; and Dr. Tracy Collier, Lyndal Johnson, Dr. Nat Scholz, and Gina Ylitalo from the EC Division in Seattle.

To understand the impact of disease in salmon populations, EC scientists have evaluated the prevalence of pathogens 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 intensities and prevalences varied. EC scientists are currently evaluating risk factors, such as contaminants and the Federal Columbia River Power System (FCRPS), on salmonid bacterial infections and delayed disease-induced mortalities.

To better understand the spatial extent of contaminant uptake, 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 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 the NMFS' 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.

EC scientists expanded the Columbia River Basin study to include monitoring of juvenile salmon from the lower Columbia River and estuary to determine concentrations of contaminants in whole bodies of outmigrant Chinook salmon and their prey. This will enable scientists to characterize patterns of uptake and to assess exposure to contaminants. EC scientists are also developing a conceptual model, based on existing toxicological information, to identify contaminant sources and describe likely modes 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.

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 performed microarray analysis on fish kidney tissues and found that various immunologically relevant genes are influenced by contaminant exposure. They also conducted diet studies on juvenile Chinook salmon and found that fish exposed to environmentally relevant doses of PAHs, PCBs, and DDTs were more susceptible to the pathogen (*Listonella anguillarum*) than those that were fed the control diet. EC scientists are currently conducting microarray analyses on kidney tissues from the juvenile Chinook salmon.

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.

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.

EC scientists are actively involved in the NWFSC's new West Coast Center for Oceans and Human Health. This is one of three NOAA Centers established in 2004 to investigate critical linkages between oceans and human health. The Center is a multiinstitutional 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. Research is focused on seafood and water quality and sentinel species. EC scientists are using fish as biomedical models to investigate infectious disease transmission dynamics in marine systems, as well as to understand how multiple stressors alter disease ecology.

### ***Fish Ecology Division (FE):***

**Ric Brodeur, Team Leader Ocean Ecology**

**Dan Bottom, Team Leader Estuarine Ecology**

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, the University of Washington, the University of California at Santa Cruz, Troy State University (Alabama) and the University of Maryland. Current collaborators include: CIMRS: Cheryl Morgan, Leah Feinberg, Greg Krutzikowsky, Susan Pool, Elizabeth Daly, Toby Auth, Jen Menkel, Carrie Johnson, Jason Phillips, Paul Peterson, Maria Parnel, Tracy Shaw, Mitch Vance, Jesse Lamb, Rian Hooff, Rebecca Baldwin, Todd Sandell, Mary Bhuthimethee; Post Doctoral Associates: Drs. Hongsheng Bi, Jay Peterson, Jim Ruzicka, Cynthia Suchman, and Vlada Gertseva; Graduate Students: Todd Miller, Julie Keister, and Jaime Gomez; and undergraduate interns and REU Students: Rachel Ruppel, Lynn Goodman, and Ashley Emerson.

### **Columbia River Plume Study: Ocean conditions and juvenile salmonids**

FE scientists study the interactions and ecological linkages within and between the California Current and Columbia River plume to investigate the effects of the plume and ocean conditions on 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 salmon and 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. Greg Krutzikowsky helped analyze the stomach contents of the predatory fishes as part of this study.

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, Elizabeth Daly, and Lynn Goodman. 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, Cheryl Morgan, and Joe Fisher studied juvenile salmonids in the Washington/Oregon coastal zone. 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 Percy (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. Rachel and Dr. Bi are continuing this work.

### **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. 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. At each station, Leah Feinberg and Tracy Shaw measured temperature and salinity profiles and collected samples for later analysis of nutrients, phytoplankton, zooplankton and ichthyoplankton.

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.

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. Drs. Stephen Landers (Troy State University) and Dr. Peterson initiated a study of the biology and systematics of several ectoparasitic ciliates that affect euphausiids. In addition, Dr. Peterson and Rian Hooff are analyzing historic data sets in conjunction with recent data to describe long-term changes in hydrographic conditions and zooplankton abundance off the Oregon coast.

**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.

**Ichthyoplankton Studies.** Dr. Brodeur, Toby Auth, Maria Parnel, and Ashley Emerson examined ichthyoplankton samples from fixed stations off the Columbia River to investigate seasonal and interannual variability in fish recruitment. These data have been added to a newly-created 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, and jack mackerels have been spawning regularly off the Oregon Coast in contrast to some earlier periods.

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, and the Columbia River. Jason Phillips and Toby Auth conduct the sampling and process the biological and physical data. 2004 surveys found high numbers of juvenile rockfishes, but also found many juvenile hake, a species not regularly known to spawn off Oregon.

**Ecological Indices.** As part of the NOAA Fisheries and the Environment 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.

### **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.

Companion GLOBEC studies by Drs. Brodeur, Jacobson, and Wainwright and Robert 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), Dr. Vlada Gertseva (salmon growth and survival model), and Dr. Cynthia Suchman (spatial distribution of gelatinous zooplankton and their diet). 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.

In May 2004, Dr. Peterson led a coastwide hydrography and plankton survey between central California and central Washington. This study, funded by the Stock Assessment Improvement Program, was specifically designed to investigate potential transport mechanisms that may be responsible for increased abundances of euphausiid populations off the northern Oregon coast and to examine broadscale ichthyoplankton distributions.

#### **COAST Investigations**

Dr. Peterson (co-principal investigator) and Jesse Lamb continued work on the COAST project, a NSF-funded study led by Jack Barth (OSU). The field component of this project is completed. Current activities are focused on data analysis and synthesis.

#### **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 Dr. Jacobson and Robert Emmett, with assistance from Todd Sandell and Greg Krutzikowsky. 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, Robert 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 Dr. Bottom and supported by funds from the U.S. Army Corps of Engineers 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. The study is scheduled for completion early in 2006.

#### ***Fishery Resource Analysis and Monitoring Division (FRAM):***

**LCDR Brian Parker, Newport Program Manager**  
**Michael Schirippa, Team Leader Assessment and Aging**  
**Waldo Wakefield, Team Leader Habitat Conservation Engineering**

FRAM Division science team members, many of whom are located at the HMSC in Newport, conduct studies to

provide the scientific information used as the basis to manage West Coast Groundfish stocks and their ecosystems, involving 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 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 Suzanne Romain, 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, Ted Hart, Natalie Strom, Maria Jose Juan Jorda, and Andy Lanier;
2. Oregon Coast Community College (OCCC) undergraduate students Jessica Trantham and Nick Russo;
3. Pacific States Marine Fisheries Commission (PSMFC) staff Patrick McDonald, Nikki Atkins, Omar Rodriguez, Betty Kamikawa, Susan Coccetti, Jennifer Menkel, Lisa Lysak and Jennifer Cramer;
4. Johnson Controls (JC) staff Allen Cramer and;
5. Mechanical Engineering Systems (MES) staff Carol Ksycinski.

### Stock Assessments

This past year, research focused on improving stock assessment methodology, examining environmental effects on marine fish population dynamics, and evaluating fish age data.

Dr. Schirripa, stock assessment team leader, worked with Jim Colbert on incorporating environmental indices in the stock assessment of sablefish (*Anoplopoma fimbria*). Various sources of oceanographic data were used to develop an index of sablefish recruitment which was ultimately used within the statistical catch-at-age assessment model. Using oceanographic variables enabled recruitment estimates to be extended back in time an additional 50 years, as well enabling a forecast of recruitment strength the year of the assessment (year 2005). Dr. Schirripa worked with Dr. Michael Davis (HMSC) to incorporate results from Dr. Davis'

laboratory work on sablefish discard mortality into the stock assessment of sablefish. Estimates of discard mortality were used along with the discard estimates from the FRAM West Coast Groundfish Observer Program to arrive at estimates of mortal discards. Also this year, Dr. Schirripa was appointed to the Fishery Science Committee, an advisory committee to the North Pacific Marine Science Organization (PICES), an intergovernmental scientific organization that was established in 1992 to promote and coordinate marine research in the northern North Pacific and adjacent seas.

Dr. Rogers completed a full stock assessment and rebuilding update for darkblotched rockfish (*Sebastes cramerii*). There were substantial changes to the 2003 model structure and data (Rogers 2005).

### Cooperative Ageing Unit

The NWFSC continued its collaborative efforts with the Pacific States Marine Fisheries Commission to maintain a laboratory dedicated to the ageing of West Coast groundfish. The ageing information supplied by this lab is a critical element of many stock assessments. The lab generally focuses on ageing the following species: Pacific hake (*Merluccius productus*), darkblotched rockfish (*Sebastes cramerii*), sablefish (*Anoplopoma fimbria*), Dover sole (*Microstomus pacificus*), Pacific Ocean perch (*S. alutus*), and Canary rockfish (*S. pinniger*).

The Ageing Unit participates in many activities to compare ageing techniques and results between laboratories. This year, FRAM scientists completed an otolith exchange with the ageing lab in Nanaimo Canada for Pacific hake and Pacific ocean perch to compare ageing techniques and results. In addition, the ageing unit participated in an interlab reading workshop at the 2004 Committee of Age Reading Experts conference to further examine any ageing bias between labs.

### 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, stable isotope and dietary studies of demersal fishes, and the use of in situ observations to measure the size selectivity and catching efficiency of a survey bottom trawl.

*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. This release is entitled "Active Tectonics and Seafloor Mapping Laboratory Publication 02-01: Interim Seafloor Lithology Maps for Oregon and Washington Version 1.0". The interim habitat maps are now in use at the Northwest Fisheries Science Center. Investigators there are beginning to integrate fisheries data and benthic habitat data to look for associations, and to assess the state of existing benthic habitat data in terms of future needs.

Since delivery of the interim maps, work has continued in 2004 and 2005 on a second iteration of the habitat maps (Version 2) that will include detailed grain size

mapping, fully cross-checked and ground-truthed rock prediction mapping, similar cross-checking, ground-truthing of lithologic data to resolve conflicts between datasets, and removal of artifacts. Version 2 will also include additional oil industry core samples from archives of the Minerals Management Service, as well as much more comprehensive interpretation of the sidescan datasets, quantitative classifications of bathymetry data, and will include significant new multibeam sonar datasets collected in 2002, 2003 and 2004. Another significant task underway at present is the use of extensive human-occupied submersible and ROV video data for ground-truthing the maps. These data are being used to verify and or modify the existing layers, and are particularly useful for calibrating the interpretation of sidescan datasets.

*Bycatch Reduction: Fish behavior during interactions with bottom trawls* - This project, initiated in 2004, will use 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 work is collaborative between the Northwest Fisheries Science Center, Oregon Department of Fish and Wildlife, Alaska Fisheries Science Center, and University of South Florida. The at-sea tests of the ultrasonic camera were recently completed during spring 2005.

*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. This area of research began in earnest during the a NOAA funded Ocean Exploration cruise to Astoria Canyon in 2001, when tissue samples from several species of rockfish were collected along with a suite of potential prey items to look at trophic relationships in and around the Canyon (Bosley et al. 2004). This study specifically looked at several commercially-important rockfish species, and the findings indicated a significant amount of direct

predation on other rockfish species was occurring. With this information, FRAM scientists expanded the research to include much of Washington and Oregon. During the summers of 2003 and 2004, NOAA Fisheries conducted trawl surveys of demersal species inhabiting the continental shelf waters along the U.S. west coast. Samples were collected from several rockfish species to try to assess the degree of competition between species and trophic relationships. With yearly changes in harvest limits, for instance, it is possible that we may be able to track changes in trophodynamics through continued, long-term studies such as these. The new information from 2003 and 2004 is currently being analyzed and preliminary information was presented in 2004 at the Quantitative Ecosystems Indicators in Fisheries Management meeting in Paris, France. This research has included collaborators Keri York and Todd Miller, as well as scientists from the Northeast Fisheries Science Center Sandy Hook Laboratory, Southwest Fisheries Science Center, and the United States Coast Guard Academy (e.g., Witting et al. 2004).

*Fishery-independent estimates of density, and size selectivity and catch efficiency of a survey bottom trawl for thornyheads* - Through a collaboration between the Northwest and Alaska Fisheries Science Centers a pair of papers were recently published estimating the size selectivity and catching efficiency of a survey bottom trawl for commercially important thornyheads, *Sebastes* spp., as well as providing a fishery-independent estimate of their density based on direct counts from a towed video camera sled (Lauth et al. 2004a and 2004b). Data from a video camera sled and research survey trawl were used to estimate size-specific trawl selectivity for *Sebastes* spp.

### Resource Surveys

The FRAM survey team, with members Keith Bosley, Erica Fruh, Dan Kamikawa, and John Buchanan 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 to characterize the distributions of groundfish inhabiting the shelf and slope zone of the Washington, Oregon, and California coasts. The team uses chartered commercial fishing vessels to conduct bottom trawl surveys. Through summer 2004, the fishing vessels *Vesteraalen* and *Morning Star* conducted the triennial groundfish survey while the fishing vessels *Ms Julie*, *Excalibur*, and *BJ Thomas* conducted the annual groundfish bottom trawl survey. In spring 2005, the survey team initiated their season by conducting their annual sea safety and survey training

for team members, students, and volunteers at HMSC. In May 2005, the annual groundfish bottom trawl survey began aboard the contracted fishing vessels *Noah's Ark* and *Ms. Julie*.

In October 2004, members of all of the FRAM teams participated in a research survey to test and integrate a variety of mapping and survey techniques to assess groundfish and their habitat, particularly in rocky areas. An integrated map of geology, water column physics, plankton distributions and rockfish distributions on Cherry Bank in the Southern California Bight is being produced from data collected from multi-beam acoustics, video plankton recorders, ADCPs, and a remotely operated vehicle (ROV) during this survey.

### 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, contributes to 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 2004-2005 included:

- 1) A joint US-Canadian research cruise in September 2004 to study the target strength of Pacific hake (*Merluccius productus*);
- 2) Participation in the October 2004 field study testing the use of integrated technologies to map fish and their habitats;
- 3) Completion in August 2005 of an acoustics-trawl survey of Pacific hake, the latest addition to the biennial U.S.-Canadian survey time series for this species; and
- 4) March 2005 pilot work in Oregon waters to develop an acoustic survey for widow rockfish (*Sebastes entomelas*). Widow rockfish are currently designated as overfished and more data are required for proper management. This cooperative field study capped more than a year of meetings between commercial fishermen and scientists from NWFSC/FRAM, Pacific Whiting Conservation Cooperative (PWCC), and Pacific States Marine Fisheries Commission (PSMFC). The pilot work was conducted aboard a chartered commercial vessel, the F/V *Excalibur*, and involved an acoustic and underwater camera study of several sites off the Oregon coast identified by local fishermen as widow rockfish habitat. The Oregon State University Port Liaison Project partly funded the participation of the West Coast fisherman. The knowledge and participation of these fishermen in the development of the new survey as well

as in the planning and execution of associated fieldwork is crucial to developing a survey methodology appropriate for sampling widow rockfish from commercial vessels on a coast wide scale. Analysis of the March 2005 data is ongoing, and additional fieldwork is planned for spring 2006.

#### **West Coast Groundfish Observer Program**

Initiated in the summer of 2001, the West Coast Groundfish Observer Program continues to successfully deploy observers across the entire West Coast aboard commercial groundfish vessels. In addition to collecting catch and discard data for West Coast Groundfish, the program was expanded last season to include shrimp and near shore fisheries in Oregon. The observer program, a cooperative agreement between NOAA Fisheries and the Portland-based Pacific State Marine Fisheries Commission, maintains an observer coordinator, Allen Cramer, and data debriefer Jennifer Cramer, with FRAM at the HMSC. Annual observer training is conducted each spring at HMSC. Observers' duties include collecting estimates of total catch and discarded catch, species composition, fishing related data, and obtaining biological samples

#### ***Conservation Biology Division (CB):***

**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 NMFS' 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. NMFS 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 NMFS 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

NMFS 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.

## ***Oceanic and Atmospheric Research Division***

### **Pacific Marine Environmental Laboratory (PMEL):**

#### ***Vents Program***

**John Lupton, Acting Program Manager**

The Vents Program, which is part of NOAA's Pacific Marine Environmental Laboratory, is an interdisciplinary research effort focused on discovering and quantifying the effects of submarine volcanic and hydrothermal activity on the ocean. The Programs team of Principal Investigators, which includes federal employees and also scientists and technical support staff working through OSU's Cooperative Institute for Marine Resources Studies (CIMRS), collaborate with colleagues from other government agencies and at several universities both in the U.S. and abroad. With these broad collaborations, the Vents Program has created a diverse team with expertise in chemical, physical, geological, and biological oceanography.

Although a great deal of research has been devoted to studying hydrothermal systems on the global mid-ocean ridge system, very little is known about hydrothermal activity associated with subduction zone systems. Recently the Vents Program has begun studying the hydrothermal activity along Pacific Ocean volcanic arcs. During April and May of 2005, Vents Program scientists, in close collaboration with scientists from New Zealand, completed a series of submersible dives on the Tonga-Kermadec volcanic arc, which is situated between Samoa and New Zealand. These dives, which were conducted using the Pisces submersible deployed from its mother ship the *R/V Ka'imikai-o-Kanaloa* (KoK) of the Hawaii Undersea Research Laboratory, were co-funded by NOAA's Ocean Exploration Program on the U.S. side, and by the Institute of Geological and Nuclear Sciences (IGNS) and the National Institute of Water and Atmospheric Research (NIWA) on the New

Zealand side. Our principal New Zealand collaborators were Cornel de Ronde, Gary Massoth, and Alex Malahoff (all at IGNS, Lower Hutt, NZ), and Ian Wright (NIWA, Wellington, NZ). From the HMSC, Robert Embley, Bill Chadwick, John Lupton, Leigh Evans, and Ron Greene participated in the Pisces/KoK expedition.

The Pisces dives were a logical follow-up to several previous surface ship expeditions (aboard the NZ ship *R/V Tangaroa*) which mapped the hydrothermal plumes emanating from the volcanoes along the Kermadec arc using traditional hydrographic surveys. Although Pisces has a 2000-m depth limitation that puts most of the ocean's spreading ridges out of reach, all of the Kermadec arc volcanoes were shallow enough to be accessible with Pisces. A total of about 20 Pisces dives were completed along the Kermadec arc, focusing on 9 volcanoes that were known to be active based on the previous plume surveys. Pisces was able to directly collect fluid, sulfide, and biological samples from hydrothermal vents using a variety of sampling bottles and suction samplers. At Monowai, the first volcano studied, Pisces discovered a broad area within the caldera venting 50°C hydrothermal fluid. However, the previous plume surveys aboard the *Tangaroa* had shown that the most intense venting was located on the summit of Monowai cone, much shallower than the caldera site. Because earthquake swarms were recently detected on Monowai together with reports of gas bubbles observed at the ocean surface over the cone, it was decided that it was too dangerous to dive on Monowai cone because of the possibility of an eruption. Farther south at ~200 m depth on the summit of Giggenbach volcano, an unusual hydrothermal site was found venting gas bubbles mixed with gas-rich 200°C vent fluid. At Brothers volcano, the Pisces dives were culmination of a more comprehensive study of this volcano designed to quantify the flux of volcanic material (heat, gases, particles, and chemicals) coming into the ocean. As part of this Brothers flux study, current meters and also ocean bottom hydrophones (OBHs) were deployed on moorings in September 2004 from the *R/V Tangaroa*. Then in May 2005 the *R/V KoK* recovered both the current meters and hydrophones and conducted further water column plume mapping over the volcano. The concept behind the flux study was that the plume maps measured at the beginning and end of the 8 month experiment period combined with continuous current meter records should allow the quantification of the flux from the volcano. Independent of the flux study, Pisces collected samples of 290°C vent fluid at Brothers.

The analysis of samples and data collected during the Pisces/KoK expedition to the Kermadec arc is still underway at the Vents Program laboratories in Newport and Seattle, and also at IGNS and NIWA in New Zealand. It will be particularly interesting to compare the results from the Pisces/KoK expedition with the results from the study the Vents Program conducted along the Marianas Arc in 2004-2005. Both of these studies will add to our knowledge of activity along volcanic arcs and how it affects the physical, chemical and biological state of the oceans.

## **U. S. 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 very diverse National Wildlife Refuges (NWR's) spanning the Oregon coastline. These 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 2004-05, the Oregon Coast National Wildlife Refuge Complex had seven permanent employees, 1 temporary employee and 2 AmeriCorps members. 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 biological program for the Oregon Coast NWR Complex encompasses all six refuges, ranging from offshore rocks and islands to estuaries, uplands and an old-growth forest. 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 geese, dusky Canada geese, black brant, wintering waterfowl, endangered brown pelicans, neotropical migratory songbirds, and Steller sea lions. In cooperation with the Confederated Tribes of Siletz Indians, studies continued on juvenile fish use of intertidal and subtidal wetlands of Siletz Bay and Nestucca Bay. The Siletz Tribe is particularly interested in pre- and post-habitat restoration monitoring and in characterizing the importance of large woody debris to juvenile fish species. Pre- and post-restoration botanical surveys are also underway at Bandon Marsh, Siletz Bay and Nestucca Bay under the guidance of Green Point Consulting. Recent and upcoming estuarine restoration projects include Millport Slough (completed 2003), Little Nestucca River (scheduled for 2006) and Bandon Marsh (scheduled for 2007-2008).

Research continued on Leach's Storm-Petrels at one large breeding colony within Oregon Islands National

Wildlife Refuge. This project represents the only research on Leach's Storm-Petrels currently occurring on the U.S. west coast. Biologists are collecting data on diet, population size and structure and are developing means to monitor trends over time. In addition, basic life history information will be collected on this secretive species, which nests underground in burrows and is completely nocturnal in coming and going from breeding colonies. While Leach's Storm-Petrels are numerous in Oregon, little is known about the breeding ecology, life history, population trends and dynamics, and the effects of humans and predators on this species. In early 2004, Oregon Coast NWR Complex Biologist Dave Pitkin and South Coast Unit Refuge Manager Dave Ledig made several visits to the Saddle Rock colony to design and construct temporary boardwalks to allow research within the fragile study area. Because of the sandy substrate and high burrow densities, boardwalks are necessary to prevent researchers from crushing burrows and impacting vegetation as they carry out their work on the rock. The current research has been aided by a 19-year banding program on the rock that occurred from 1979-1997, when 8,863 birds, including adults and chicks, were banded. The research has been conducted in cooperation with the Point Reyes Bird Observatory (2004) and the University of Oregon, Oregon Institute of Marine Biology (2004, 2005) with partial funding provided by the National Fish and Wildlife Foundation. The coastal refuge complex was recently awarded a Challenge Cost Share Grant to characterize historic channel morphology, geologic stratigraphy and map cultural resources on the Ni-les'tun Unit of Bandon Marsh NWR using ground-penetrating radar. The project is scheduled to begin in late August 2005 and will involve a diverse group of cooperators, including eminent researchers and archaeologists from six universities and two Indian Tribes. Information gathered using this novel technology will provide information critical to designing and implementing a 400-acre marsh restoration project on the highly-impacted and culturally-rich Ni-les'tun Unit in 2007-2008. Since 2000, the biological programs for the six refuges within the coastal refuge complex have been designed and implemented by one biologist with occasional assistance from one or two seasonal employees. (From 1994 - 2000, the refuge complex employed two full-time biologists.) In September 2004, Michael Taft was hired as a term biologist to assist with program implementation. Unfortunately, due to unforeseen and unprecedented budget cuts, Michael's position will have to be terminated at the end of FY 2005. We'll miss Michael, and wish him all the best!

Environmental education through the refuge continues to expand. A total of 616 Oregon students participated in the Junior Duck Stamp curriculum and art contest, which links science with art. The program is coordinated by the Oregon Coast NWR Complex. The Shorebird Sister Schools program was expanded to include four coastal schools and over 200 students, combining classwork and field trips to introduce 4<sup>th</sup> and 5<sup>th</sup> graders to shorebird habitat requirements and migration. In addition, refuge staff presented training on coastal wildlife resources and laws to volunteer interpretive groups from Cannon Beach to Gold Beach, and slide shows featuring coastal wildlife and the Oregon coast refuges were given to many different interest groups.

The refuge's volunteer program expanded in 2005 to cover four areas of high visitor use, Cape Meares, Yaquina Head, Coquille Point and Simpson Reef. Volunteers were solicited from all over the country and response was quite enthusiastic. From April to August the volunteers were charged with personally meeting and greeting visitors on site to share with them the life history of some of the wildlife using our wildlife refuges. In all the volunteers spoke with more than 10,000 visitors and logged over 700 hours.

Projects that have been recently accomplished or will be initiated in 2004 to improve public use, or to improve habitat and facilities, include:

1. A final education project under the Oregon Education Project, funded under the auspices of the Tenyo Maru Oil Spill Restoration Plan, was completed. The project included the design, production and installation of large interpretive panels at eleven ports along the Oregon coast. The panels provided information to boaters about the sensitivity of coastal wildlife to disturbance and asked boaters to stay more than 500 feet away from rocks, islands and cliffs. The same interpretive message was reproduced on posters for distribution. The final component of the Oregon Education Project was for production of a poster to warn pilots not to conduct low-level flights over seabird use areas along the Oregon coast. The colorful poster asks pilots to remain 2,000' AGL over or 1/2 mile lateral distance from all refuge rocks, reefs, islands and headlands along the Oregon coast to protect nesting seabirds from disturbance.

2. A restoration project in the final planning stages and planned for fall 2006 will fully restore the Little Nestuca River Unit to intertidal marsh. In 2004, the Complex received two substantial monetary donations, enabling

the purchase of the last remaining tracts of land within the Little Nestucca River tidal marsh restoration area. The completed project will benefit juvenile anadromous salmonids, shorebirds, waterfowl and improve overall estuarine health.

3. Summer 2005 brought good news from Congress as it moved to fund the Bandon Marsh National Wildlife Refuge project with \$4.2 million from the Safe, Affordable, Flexible and Efficient Transportation Equity Act: A Legacy for Users. The Bandon Marsh project will rebuild and upgrade a section of county road that crosses and accesses the refuge and open up more than 400 acres of tidal wetlands for restoration to provide essential habitats for threatened coho salmon, waterfowl and shorebirds. According to estimates of federal highway officials, a \$4.2 million road improvement project can be expected to generate about 150 jobs: 85 direct jobs in the construction and materials fields and 65 indirect jobs, with actual construction estimated to begin within two years.

4. Coastal visitors and residents will soon be rewarded with sweeping views of the Coast Range, Oregon Islands NWR, the Little Nestucca River and the Pacific Coast Scenic Byway thanks to a grant of \$559,100 from the Transportation Enhancement Act and \$235,000 from Refuge Roads. The project will benefit coastal tourists and casual travelers along the Pacific Coast Scenic Byway, local communities, school groups and wildlife enthusiasts. Project funds will construct a viewing deck on Cannery Hill, a pedestrian trail from a parking lot to the deck, two parking lots, an accessible restroom, and it will install two electronic gates and design, fabricate and install interpretive panels.

5. Shoreline Education for Awareness (SEA) is an all volunteer non-profit that provides on-site education and interpretation for the public at two sites on the south Oregon coast, Coquille Point in Bandon and Simpson Reef at Cape Arago. Both of these sites are part of Oregon Islands National Wildlife Refuge, and for over 10 years the Oregon Coast NWR Complex has worked closely with SEA to bring awareness to the visiting public about the wildlife using the refuge. Increasing and solidifying community support for the refuge has long been a priority, so when SEA expressed an interest in expanding its education and volunteer program and coordinating more closely with the refuge the obvious solution was to formalize the relationship and have SEA become a friends group. Once finalized the relationship will bring more support for the refuge's interpretation,

education, and biology programs through the use of SEA volunteers. SEA will also expand their programs to cover more of the shore and to offer volunteers a wider variety of fun and challenging tasks.

Ecological Services division: Two biologists assigned to the Ecological Services staff in the office are charged with advancing conservation objectives throughout coastal watersheds. Ecological Services' responsibilities include implementing the protection and recovery mandates of the Endangered Species Act; administering the Oregon Coastal Program; and providing technical assistance to Federal, State, and local conservation and restoration efforts. Ongoing activities include western snowy plover recovery, restoring water quality and habitat function in coastal watersheds, and conservation and restoration of sensitive habitats such as estuaries, coastal strand, and wetlands.

## Oregon Department of Fish and Wildlife

### *Marine Resources Program*

Patricia M. Burke, Program Manager

#### **Program Overview**

The Marine Resources Program (MRP) is within the Oregon Department of Fish and Wildlife (ODFW) and has responsibility for assessment, management, and sustainability of Oregon's marine habitat, biological resources and fisheries. MRP is headquartered at Newport in the Hatfield Marine Science Center with field stations at Astoria, Tillamook, Charleston, Gold Beach, Brookings, and Corvallis.

In addition to direct responsibilities in state waters (from shore to three miles seaward), MRP provides technical support and policy recommendations to state, federal, regional, and international decision-makers who develop management strategies that affect Oregon fish and shellfish stocks, fisheries, and coastal communities.

Staffing consists of about 60 permanent and more than 70 seasonal or temporary positions. The program budget is approximately \$5 million yearly, with about 50 percent of funding from federal sources and the remainder from various state sources.

The program's work consists of three major elements:

- fisheries monitoring
- research on marine organisms and habitats
- marine resource policy and management.

#### **MONITORING**

##### **Fisheries Sampling**

The MRP runs large sampling programs that monitor commercial and sport fisheries along the Oregon coast. Information gathered includes amounts and kinds of fish landed, area of catch, various information about the execution of the fishery, and biological information from the landed catch – lengths, weights, age samples, and so on. The information is used both on an in-season basis to track fish landings with respect to catch quotas and other regulatory controls of fisheries, and on a long-term basis to provide managers with data needed for assessing stocks and managing fisheries. The data collected become part of a West Coast data system to inform Oregon, Washington, and California regional fisheries management.

#### **POORT**

The MRP conducted a cooperative research project with the Port Orford Ocean Resource Team (POORT), a non-profit community based organization made up of members from the recreational and commercial fishing industry as well as members of the community in Port Orford, Oregon. The extended sampling project collected and sampled nearshore species of concern, china rockfish, cabezon, and greenling. The MRP managed the project, staff trained POORT members to take biological samples and to record data. Commercial nearshore fishers were hired by POORT to collect nearshore species. POORT collected biological samples including otoliths for aging, gonads for histology, fin clips for genetics, as well as recording length and weight.

#### **RESEARCH**

##### **Nearshore Research**

Several research projects at the Marine Resources Program study the nearshore environment and its inhabitants. Two projects look at survival of rockfish species caught and released by anglers because they are undersized or are prohibited under fishing regulations. These fish suffer from expansion of gases in their swim bladders when they are brought up from depth and often die as a result. The projects examine the effects of being brought up from depth and explore methods to increase survivability of the fish. MRP staff are also working in the fourth year of black rockfish mark-and-recapture project that uses PIT (Passive Integrated Transponder) tags to determine recreational fishery exploitation rate of this species. Black Rockfish are also the subject of a continuing acoustic telemetry study to determine fish movement patterns. Ongoing nearshore habitat surveys and gear research is enhancing our understanding of these species complexes.

##### **Bycatch Reduction in Commercial Fisheries**

ODFW's Marine Resources Program worked on a number of projects this past year directed at reducing bycatch in West Coast commercial fisheries. Several years of collaborative research came to fruition this year with the implementation of federal rules requiring the use of selective flatfish trawls for all trawl-fishing inside 100 fathoms off Oregon, Washington and northern California. ODFW-funded research on the selective trawls conducted in 2000-2003 showed that these low-rise nets with cut-back headropes maintained flatfish catches while reducing the catch of most rockfish species by 50 to 90 percent. The study also defined how and where they would be most useful in reducing



bycatch. In combination with recent requirements for full-time permanent use of bycatch reduction devices in state-managed fisheries for pink shrimp, implementation of the selective flatfish trawl has vaulted the West Coast into the lead nationally in the implementation of bycatch-reducing trawl gear.

Monitoring of Oregon's shrimp trawl fishery has shown that vessel operators are switching to more efficient bycatch-reduction devices. MRP staff continued to work with the fishing industry this year to better define and further reduce the residual bycatch. Projects that went to sea in October 2004 and June 2005 sampled this residual bycatch, with a focus on better defining the amount and species of juvenile rockfish that continue to be caught.

### **Maturity and Ageing Studies**

Work continues on maturity studies to develop improved length/age at maturity for species for which little information exists, such as china, vermillion, tiger, and copper rockfish, as well as kelp greenling and cabezon. Because these species are not abundant in fishery landings, it will take several years of sampling to accumulate enough samples for an accurate description of maturity parameters.

### **Testing Imaging Sonar in Trawl Nets**

This project evaluates the utility of imaging sonar to observe fish behavior in and around trawl nets in the absence of artificial light. We can use this tool to evaluate how fish respond in an approaching trawl in areas with little or no visible light, and design bycatch reduction methods for those species that show different behaviors.

## **MANAGEMENT and POLICY**

### **Sport Groundfish**

The MRP has the primary responsibility of monitoring and regulating marine sport and commercial fisheries in Oregon coastal waters. The importance of comprehensive marine fisheries and resource management planning received heightened public interest recently when the Oregon marine sport groundfish season closed September 3, 2004 due to early attainment of a black rockfish harvest cap. This was the first time that season did not last the full year.

Eight species of groundfish are managed under harvest caps (six federally imposed and two state imposed). Mixed stocks and complex and unpredictable patterns in the ocean fisheries have created new challenges for the West Coast groundfish management programs.

Following public meetings in October 2004, more restrictive 2005 sport harvest regulations were adopted. Further restrictions were implemented in July 2005. The MRP continues to monitor sport groundfish catch closely and is managing the fishery for a year-round season.

### **Working With Fisheries Councils**

Recent developments point out the importance of representing Oregon's groundfish fishery interests at the Pacific Fishery Management Council (PFMC), which regulates marine fisheries on the West Coast. Implementation of new two-year management cycle began in January, 2005, and includes a special framework for regional management of key species in sport fisheries. Regional management of these key species means that high harvest levels in one state will not close fisheries in other states.

During 2005, PFMC will complete stock assessments for 22 species – more than twice the number considered in past years. Many of these species will be assessed for the first time. The completion of many assessments, as well as incorporating the outcomes into an already complex set of management measures, will present significant challenges in 2005-2006. MRP staff are involved in preparing and reviewing some of these assessments.

A federal plan for designating groundfish Essential Fish Habitat (EFH) and measures to minimize the adverse effects of fishing on EFH is due in early in 2006. The intent of this effort is to provide adequate protection for groundfish habitat while minimizing social and economic impacts. The MRP has been contributing to the dedicated data support, policy analysis, and public outreach necessary for the success of this federal effort.

### **Sardines: A Developing Fishery**

The commercial sardine fishery is jointly managed under the PFMC process (overall harvest guideline and allocation) and, in Oregon, under the Developmental Fisheries Program (permits and gear regulations). The PFMC process has been addressing development of a new fishery allocation system to take into account the new fishery off Oregon and Washington since 2000. A major focus of the Developmental Fisheries Program has been to move the sardine and the commercial bay clam dive fisheries out of Developmental Fisheries and creation of their own separate limited entry systems.

**Crab Fishery**

For the second year in a row the commercial Dungeness crab fishery had a record-breaking harvest year. By the eighth week of the season landings broke the previous year's record of 23 million pounds and by the end of July total landings in Oregon were more than 33 million pounds. Although this season was notable for its economic success, concerns about sustaining a healthy fishery in the long-term were also heightened. The MRP plays an active role in managing the Dungeness crab fishery on the West Coast through the Tri-State Commercial Crab Committee. MRP is working with the fishing industry in Oregon, partner state agencies, and other states to address several major policy, management and enforcement issues including state jurisdiction, enforcement, safety, domoic acid, limiting the amount of gear that can be fished, and pre-season testing. This year the MRP and the Crab Commission co-sponsored the first ever Crab Summit for Oregon commercial crabbers. Crab pot limit systems and state limited entry authority out to 200 miles was discussed for action in 2005-2006.

**Nearshore Planning**

The Marine Resources Program is nearing completion of the planning phase of the Nearshore Marine Resource Management Strategy. This effort, undertaken in collaboration with management partners, user groups, and the general public, is part of ODFW's development of a statewide Comprehensive Wildlife Conservation Strategy. The Nearshore Strategy will identify a set of priority needs and opportunities for the sustainable management of nearshore marine fish and wildlife. The Marine Resources Program anticipates beginning implementation of the recommendations in late 2005, which will include research and monitoring, public outreach, and increased coordination with other agencies that have management responsibilities in or affecting the nearshore marine environment.

**Marine Mammal Surveys**

In recent years, questions of how growing seal and sea lion populations affect fishery resources received increased attention. The MRP worked cooperatively with the National Marine Fisheries Service to assess and monitor pinniped populations and to conduct studies to evaluate their potential impact on recovering threatened and endangered salmonid stocks. An example of this concern is the escalating problem of California sea lions in the lower Columbia River and their negative interactions with sport fisheries, and the increasing levels of predation on adult salmonids at fish ladders at Willamette Falls and Bonneville Dam.

**Recreational Shellfish License**

Oregon began requiring a license for recreational shellfish harvest in 2004. Revenue from the license will fund shellfish monitoring, research, and management work within MRP, as well as State Police enforcement of shellfish harvest regulations, and Dept. of Agriculture testing for shellfish toxins. MRP hired a new shellfish biologist and began developing a new recreational shellfish program.

## II. FACILITIES

### HMSC Facilities

**Randy Walker, Facilities Manager**

This year has brought a flurry of activity to the HMSC Facilities Department. We have made extensive repairs to the Guin House. A few of the repairs include replacing the floor in the bathroom, stripping the insulation, and implementation of an aggressive pest elimination plan. Facilities is still keeping an aggressive approach to all housing needs, and as a result has heard few complaints this year.

The department has helped several research programs meet their expansion goals this year. Laboratory building and renovation activity has been strong in the East Wing. We have remodeled two general-purpose laboratories, one cold laboratory and a laboratory support room. In addition, facilities has completed the construction of an outdoors tank space and is currently building the tank supports. A storage remodel has been completed between the Education Wing and the Main Building. This will allow for the central storage of support equipment for meetings and public events.

Facilities has helped the Molluscan Broodstock Program achieve independence from the main seawater filtering system. It was felt this program needed to be separated because of MBP's need for higher quality water than HMSC's system currently supplies.

In addition, Facilities has accomplished many smaller projects, small construction jobs and kept current with its other obligations. The custodians have done an excellent job of keeping the place looking nice and even managed to get the Visitor's Center stripped, buffed and waxed this year. Great gains have been realized in our invasive species eradication both by our gardener and help by the USF&WS. We hope to continue to make positive strides in invasive species removal at HMSC in the coming years.

The Facilities Department has made much progress toward making sure that HMSC complies with proper environmental permitting and compliance. Gains have been made ensuring that land held for HMSC/OSU has the correct leasing and is on target with the goals for Oregon Division of State Lands, Army Corps of Engineers and Oregon Department of Land and Conservation. Parametrix Engineering completed a

study of the erosion problem impacting the HMSC Nature Trail and the coming year looks to be a busy one around the erosion issue on the trail.

### Ship Operations

**Fred Jones, 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 2005 her 236 days of scheduled operations are funded primarily by the National Science Foundation, but also by NOAA and the Naval Research Lab. Science missions are being led by researchers from Oregon State University, University of Washington, University of Hawaii, University of California-Santa Barbara, University of South Carolina, University of Alaska-Fairbanks, the Naval Research Lab and NOAA. Major projects this year include the CoOP RISE Program (River Influences on Shelf Ecosystems) off the Columbia River, a project to study the biogeochemistry of eddies that form in the lee of the Hawaiian Islands, a project to collect iron binding ligands around the Equator due south of the Hawaiian Islands, and a variety of work off the coast of Oregon.

Throughout 2004-2005 the *Wecoma* received several significant upgrades. These upgrades included the installation of a 55 kW emergency diesel generator and new distribution system with an Automatic Transfer Switch, a new S-band radar system, an Automatic Identification System to comply with IMO regulations, and a Fleet 77 satellite system to augment existing shipboard communications. In addition, a Vessel Security Plan was drafted and approved by the U.S. Coast Guard.

*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 *Elakha* has conducted a variety of research programs including

those of COAS, Zoology, Microbiology, the OSU/NOAA Cooperative Institute for Marine Resource Studies (CIMRS) and the Oregon Department of Fish & Wildlife at HMSC. 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.

The year 2005 brought about a change in command at Ship Operations. After being at the helm for 10-1/2 years, Fred Jones retired as Marine Superintendent at the end of May. We would like to express our sincere gratitude for his many years of excellent service and wish him well in his retirement.

Additional information on OSU’s Research Vessels can be found at the College of Oceanic & Atmospheric Sciences website [www.coas.oregonstate.edu](http://www.coas.oregonstate.edu) under the Facilities Section.

### III. EDUCATION

#### Fisheries and Wildlife and Marine Biology Courses

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 2004 Fisheries and Wildlife Courses

FW 407/507.SEMINAR (1 credit).

*See list of seminar series speakers. Pages 59-61.*

FW 420X.ECOLOGY AND MANAGEMENT OF MARINE FISHES (3).

A lecture and lab course that covers the ecology of marine fishes and important ecological principles that guide conservation and management. Life history, behavior, habitat, community dynamics and ecosystem processes are emphasized, along with alternative management strategies. REC: FW 320 or equivalent population dynamics class, ichthyology.

FW 426.COASTAL ECOLOGY AND RESOURCE MANAGEMENT (5).

Study of the ecology and management of coastal marine and freshwater ecosystems as well as natural resources, emphasizing experimental (participatory) learning in a field station setting. Lec/lab.

FW 431.DYNAMICS OF MARINE BIOLOGICAL RESOURCES (4).

Strategies of marine fishery management. A synthesis of the principles of population dynamics for single- and multi-species systems from the viewpoint of a marine resource manager. PREREQ: BI 370 or BI 371. Offered alternate years.

FW 442.PROBLEM DEFINITION AND ANALYSIS IN FISHERIES AND WILDLIFE (2).

Student groups working with mentors will define the problem selected in FW 441, collect and review relevant information, and develop a problem analysis plan on a fisheries and/or wildlife topic. Finalized plans will be presented at an open forum at the end of the term. PREREQ: FW 441.

FW 452X.APPLIED FRESHWATER FISH BIOLOGY (3).

Examines ecological principles for understanding the distribution and abundance of freshwater fishes and their management. The course focuses on freshwater and anadromous fishes, especially salmonids. Taught at the Hatfield Marine Science Center in Newport, OR. PREREQ: FW 320 and FW 321.

FW 455.SAMPLING AND ANALYSIS OF MARINE FISH STOCKS (3).

Field sampling of economically relevant marine fish stocks. Laboratory analysis of biological samples and computer modeling of data using general stock assessment techniques. This course will be offered at the Hatfield Marine Science Center in Newport. REC: FM 315 and FW 316. Lec/lab.

FW 494.DISEASES AND PARASITES OF MARINE AND ANADROMOUS FISHES (3).

Emphasis on interactions between marine/anadromous fishes, disease-causing agents, and ecological conditions under which disease agents may limit populations in the marine environment. PREREQ: 6 credits of upper-division biology.

FW 497.AQUACULTURE (3).

Principles and practices for the aquaculture of fish, shellfish, and algae. PREREQ: 9 credits of upper-division biology. (Writing Intensive Course.)

FW 498.AQUACULTURE LABORATORY (3).

Biology and culture requirements of fish, shellfish, and algae. Emphasis on laboratory culture techniques and practical experience in handling organisms. PREREQ: 9 credits of upper-division biology.

FW 499. WEST COAST GROUND FISH CRISIS (2).

A lecture and discussion course that covers the history of the current crisis and the effects of over fishing on fish and fishermen. Highlights for discussion include plans for rebuilding stocks and future management.

##### Spring 2005 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. COREQ: BI 451/BI 551. Admission to BI 450/BI 451 and BI 550/BI 551 is by application only.

## Student Enrollment Statistics

<b><u>Fall</u></b>	<b><u>Class</u></b>	<b><u>2003</u></b>	<b><u>2004</u></b>
FW 407/507	Marine Science Seminar	9	24
FW 420x/520x	Ecology and Management of Marine Fishes	25	21
FW 426x/526x	Coastal Ecology and Resource Management	24	21
FW 431/531	Dynamics of Marine Biological Resources	--	7
FW 442 & 499/599	Marine Team	1	6
FW 452	Applied Freshwater Fish Biology	20	16
FW 455x/555x	Sampling & Analysis of Marine Fish Stocks	--	7
FW 494/594	Diseases and Parasites of Marine and Anadromous Fishes	5	5
FW497/597	Aquaculture	4	8
FW 498/598	Aquaculture lab	1	8
FW 499	Ecology of marine Birds and Mammals	11	--
FW 499	West Coast Groundfish Crisis	8	12
FW 442	Group problem solving	--	6
<b><u>Winter</u></b>		<b><u>2004</u></b>	<b><u>2005</u></b>
AqS 100 (OCCC)	Intro to Aquarium Science	9	10
<b><u>Spring</u></b>		<b><u>2004</u></b>	<b><u>2005</u></b>
Bi 450/451	Marine Biology	21	23
AqS 100 (OCCC)	Intro to Aquarium Science	--	6
<b><u>Summer</u></b>		<b><u>2004</u></b>	<b><u>2005</u></b>
FW 421/521	Aquatic Biological Invasions	--	4
FW 499/599	Biology of Marine Mammals	--	5
Z 465/565	Marine and Estuarine Invertebrates	--	4

## Internships at HMSC

Internships are recognized as one of the best learning experiences a young person can have in preparing for almost any profession. For those contemplating careers in marine science education, research, or resource management, the HMSC is an ideal place for an internship experience. Beyond the practical hands-on experience offered, interns at HMSC uniquely benefit from the many opportunities for interaction with scientists, educators, and resource managers representing a wide range of expertise.

In 2004-05, over a dozen students took advantage of internship opportunities offered by OSU and partner agencies at HMSC, including EPA, NOAA Fisheries, NOAA's Pacific Marine Environmental Lab, and Oregon Sea Grant. Students secured positions by applying directly to the researcher or agency hosting the internship, or by applying to the NSF-funded "Research Experience for Undergraduates" (REU) program. Eight students were selected (through a competitive application process) to participate in the REU program, which paired each student intern with a faculty mentor to work on a defined research project over a 10-week period during the summer of 2004.

While all of the interns demonstrated a significant level of accomplishment with their research projects, several of the students developed projects that have a life beyond the 10-week summer program. Two of the students selected to present their research during the poster session at the February 2005 ASLO Aquatic Sciences meeting in Salt Lake City continued to work on their projects.

Katri Laukkanen worked on a research project examining population density and burrowing activities of ghost shrimp (*Neotrypaea californiensis*), and their effect on other organisms found in the same habitat, including shrimp, other macrofauna, meiofauna, and the microbial community. She conducted experiments in the Yaquina Bay estuary to quantify the relationship between *N. californiensis* burrow density and total oxygen uptake (TOU), the measurement selected to represent the metabolism of the sediment community. Katri's experiments produced evidence showing that the burrowing ghost shrimp exert strong control over oxygen uptake by tideflat sediments, even at low densities. Her discussion of the results of her field experiments showed a sophisticated level of interpretation of the data, explaining the stimulative

REU Intern	Home Institution	Faculty Mentor	Project Title
Nancy Lynn Goodman	Shawnee State University, Portsmouth, OH	Ric Brodeur	Abundance, Distribution, and Diet of Juvenile Coho Salmon in the Juan de Fuca Eddy
Walter Hannah	Ithaca College, Ithaca, NY	Robert Dziak	The Quasi-Eulerian Hydrophone: A New Method for Ocean Acoustics
Katri Laukkanen	Pacific University, Forest Grove, OR	Tony D'Andrea Ted DeWitt	Effect of Ghost Shrimp ( <i>Neotrypaea californiensis</i> ) Population Density on Oxygen Flux Across the Sediment-Water Interface
Kalin Lee	Oregon State University, Corvallis, OR	George Boehlert Bryan Black	Interannual Growth Variation in Marine Fish and Tree Rings: Examining Marine-Terrestrial Linkages
Jessica Ramsey	Salem College, Winston-Salem, NC	Clifford Ryer	Light Affects the Visual Foraging Ability of Northern Rock Sole
Rachel Ruppel	State University of New York, College of Environmental Science & Forestry, Syracuse, NY	William Peterson	Qualitative patterns of the distributions of juvenile Chinook and Coho salmon, zooplankton, and ocean conditions off Washington and Oregon
Leslie Soule	Willamette University, Salem, OR	Clare Reimers	Plankton Bio-fuel Cells: the roles of sulfide production in the anode chambers and of a bio-film in the cathode chambers
Brian Yellen	Brown University, Providence, RI	Chris Langdon	Methods in Culture of Hawaiian Bluespotted Goby ( <i>Asterropteryx semipunctatus</i> ) Larvae

effect of ghost shrimp's bioturbation and bioirrigation processes on microbial growth, and the overall exponential relationship to the benthic community's respiration rates. This research provides new evidence of the importance of burrowing shrimp to organic matter decomposition and nutrient cycling processes in Pacific tideflats.

Leslie Soule worked on a research project examining the potential of organic matter from anoxic seawater sediments as a source of power for underwater fuel cells used in oceanographic research. She participated in a laboratory experiment utilizing seven fuel cells powered by organic carbon from decaying plankton collected offshore to determine the function of sulfate-reducing bacteria. By examining sulfide concentrations and sulfate consumption rates in the fuel cells, Leslie and the other members of the research team sought to determine whether the bacteria could be shuttling electrons onto the anode surface of the fuel cell, thereby producing enough of an electrical charge to power the fuel cell.

## Guin Library

### Janet Webster, Librarian

The Guin Library, a branch of the OSU Libraries, houses the university's marine science collection. While much of the deep water oceanographic collection remains in Corvallis at the Valley Library, the collection at HMSC contains over 36,000 volumes with a strong focus on the biological and management issues of the marine and estuarine environment. In fiscal year 2003/2004, the book budget was \$11,000 with a heavy reliance on gift fund. The periodical budget is difficult to track as we have converted many of our journals to digital format. This trend will continue posing challenges to budgets as well as new opportunities to train library patrons to efficiently find material in the maze of electronic and print information. The library staffing remains stable with Janet Webster as the head librarian, Susan Gilmont as the Library Technician 3, and Judy Mullen as the .75 Library Technician 1. Physical highlights of the year include the thorough termite treatment of the building and the addition of poster rails in the Library Seminar Room.

For years, the Library staff has wanted to do a more thorough job of tracking the publications of those working at HMSC. This complex mix of university, state and federal researchers and managers produce between 100 and 200 publications annually. While captured in the HMSC Annual report, the Library staff

has completed stage one of the HMSC Station Bibliography by entering in publications from the early 1980s through 2004 into a ProCite database and then posting the contents on a web site. <http://osulibrary.oregonstate.edu/guin/StationBibliography.html> We anticipate beginning to capture the full text of current publications to incorporate into a section of the OSU Institutional Repository, a project that Ms Webster directs.

We have also been inundated with gifts from retiring faculty members. Retirements provide an opportunity to acquire unique material from the collections of long-term faculty members as well as encourage those faculty to give relevant papers to the University Archives. Too often, we lose part of the history of the institution to the recycling bin. Rescued from the bin this year are interesting materials on seafood science, coastal management and Oregon's fishing industry.

For years, we have collected award-winning children's marine books and integrated them into the collection. This spring, we established a children's book shelf to highlight this collection as well as make it more accessible to its users. Included in the collection are those marine and estuarine books that are favorably reviewed in the annual March issue of *Science and Children* and titles that Ms Webster finds through other sources. Recommendations are always welcome.

The year included several staff highlights. After four years of distant classes, Ms Gilmont was awarded her Bachelor of Arts degree from OSU in Liberal Studies on September 3. Ms Webster presented papers at the annual conference of the International Association of Aquatic and Marine Science Libraries and Information Centers in Hobart, Tasmania and at the 6<sup>th</sup> International Grey Literature Conference in New York. Her successful sabbatical ended in September and the work documented in *FAO Fisheries Circular No.1006*.

## Ornamental Fish Health Programs

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

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



Our first cadre of students graduated in June after completing 10-week internships in Alaska, Oregon, Washington, and Spain and our next cadre of 11 students are slated to graduate in June 2006. Dr. Miller-Morgan is one of the co-principal investigators on the National Science Foundation implementation grant and works very closely with Bruce Koike, AQS Program Director, and Dave Beran, Student Coordinator/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.

Miller-Morgan and Koike recently received funding to develop a Master Aquarist Pilot program, a collaborative program between the OFHP, the AQS program and the Greater Portland Aquarium Society, designed to train experienced aquarium hobbyists to be husbandry resources to beginning aquarium hobbyists and to work with local science teachers in the Portland Metro area who are interested in incorporating aquariums into their classrooms. Finally, Miller-Morgan began teaching AQS 270, Fish and Invertebrate Health Management. This course, which will now be 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. In addition, he teaches VM 790-29, Ornamental Fish Medicine, a 35-hour course that teaches senior veterinary students the basic skills they need to begin practicing fish medicine.

The completion of the World of Wet Pets Gallery in the HMSC Visitor Center provides a unique addition to not only the Visitor Center, but to the Ornamental Fish Health Program and the Aquarium Science Program as well. This new gallery was designed to promote and encourage ornamental fish-keeping, including high quality health and husbandry, and to educate the public

about this diverse industry that spans the globe. Further, it serves as an area of quiet relaxation and contemplation for visitors -- it's our "living room." Finally, it serves as a demonstration and teaching laboratory for our undergraduate students, aquarium science students, veterinary students, and veterinary practitioners.

## **Aquarium Science Degree Program**

### **Bruce Koike, Director, Aquarium**

Developing Enhanced Technicians: A Collaborative Effort Between the Hatfield Marine Science Center and Oregon Coast Community College's Aquarium Science Program

During this past year, various units and agencies at the HMSC continued their long-term commitment and association with the Oregon Coast Community College's Aquarium Science Program. These organizations provided students who are enrolled in Practicum 1 and 2 courses with work environment learning opportunities. OCCC students in this 2-year technical degree program reap the benefits of contributing to real projects within NOAA Fisheries, Fish Behavior Laboratory, Molluscan Broodstock Program, Oregon Sea Grant and the HMSC Visitor Center. These opportunities and real lessons are a crucial element of developing individuals who will have an impact nationally as aquatic animal care specialist. This "work environment" venue is further enhanced through the willingness of staff members within each organization to engage and guide the student's development. These interactions frequently provide the rationale behind the specific activity.

Accomplishments this past year include:

- The five Aquarium Science Program graduates in the inaugural class, each of whom was enriched through interactions with HMSC-associated personnel,
- 500 hours of workplace experience at the HMSC were gained by 9 students,
- Three internships with NOAA Fisheries were filled by OCCC students,
- Classes were taught by representatives from Oregon Sea Grant and Fish Behavior Laboratory,
- Student involvement at Sea Fest 2005,
- Hospital and Quarantine Aquarist position filled by an Aquarium Science student.

## 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 2005 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 2005-06 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>	Kate Boersma, Fisheries & Wildlife (\$10,000)
<p><u>Joan Crebbin Memorial Fellowship</u>                      - To foster education in the marine sciences by providing financial support to undergraduate or graduate students pursuing marine science related fields at OSU.</p>	Tricia Ratliff, Fisheries & Wildlife (\$2,200) Jonathan Scordino, Fisheries & Wildlife (\$1,000)
<p><u>Lillian Brucefield Reynolds Scholarship Fund</u>                      - for graduate students engaged in study of marine science at Hatfield Marine Science Center.</p>	Kathleen O'Malley, Fisheries & Wildlife (\$1,000)
<p><u>Anja Robinson Fellowship</u>                      - for graduate students doing shellfish aquaculture research at the Hatfield Marine Science Center.</p>	Paul Lang, Fisheries & Wildlife (\$400) Sean Matson, Animal Science (\$400)
<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>	Alicia Christensen, COAS (\$6,000)
<p><u>HMSC Housing Scholarship Fund</u>                      - to provide free or reduced-rate housing on-site graduate students taking summer courses at the Hatfield Marine Science Center.</p>	Barbara Zennaro, Marine Resource Mgmt (\$165) Matt Bullock, Fisheries & Wildlife (\$250)
<p><u>William O. Wick Marine Fisheries Award</u>                      - intended to encourage graduate student research in the area of marine fisheries ecology and ocean related research.</p>	Sarah Walters, Microbiology (\$4,000)
<p><u>Mamie L. Markham Endowment Award</u>                      - intended to assist graduate or student research utilizing OSU's Hatfield Marine Science Center.</p>	Markus Boin, Microbiology (\$8,000) Thom Gilbert, Fisheries & Wildlife (\$6,100) Marc Johnson, Fisheries & Wildlife (\$7,200) Sean Matson, Animal Science (\$8,560) Alena Pribyl, Fisheries & Wildlife (\$10,000) Ephraim Temple, Fisheries & Wildlife (\$1,500) Craig Tinus, Fisheries & Wildlife (\$6,610) Barbara Zennaro, COAS (\$4,140)

## IV. PUBLIC OUTREACH AND EXTENSION

### *Visitor Center*

#### 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, Visitor Center activities, exhibits and programs explain how scientific research helps us interpret the natural patterns that shape our world and enables us to better appreciate, manage, and sustain coastal and marine resources. 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.

More than 10 million people have visited exhibits developed and staffed with the help of Oregon Sea Grant since the opening of the HMSC, with the annual number of visitors averaging around 150,000 since the year 2000. Approximately 100,000 people have participated in the Visitor Center's public programs, which provide an opportunity for high-quality contact, feature lectures, demonstrations, videos, and guided nature walks. Admission to this public facility is free, although donations are encouraged; approximately \$384,000 in donations have been received since 2000.

SeaFest was established by Oregon Sea Grant in June 2002 and attracted over 12,000 visitors in its first three years. The annual event offers a rare opportunity for the public to get a free behind-the-scenes look at the marine research facility. Tours, demonstrations, lectures, exhibits, and displays by leading scientists from Oregon State University and five federal and state agencies are part of the activities.

In 2003 and 2004, football fans attending OSU home games were shown an up-tempo, 60-second video spot on the stadium Jumbotron which featured education programs at HMSC. Approximately 36,000 fans attended each game, so the total number of "exposures" during the two seasons was about 400,000 people (11 home games). This spot, produced by Oregon Sea Grant, continues to be shown as part of OSU programming on the Research Channel network and on

the Oregon Public Affairs Network (OPAN). The Jumbotron video spot about educational opportunities at HMSC received the Bronze award from the Council for the Advancement and Support of Education. The HMSC Visitor Center website ([hmsc.oregonstate.edu/visitor](http://hmsc.oregonstate.edu/visitor)) averages 14,300 page hits per month.

In another strategy to broaden awareness and use of the Visitor Center and its educational resources, Jon Luke, Marine Education Program Associate, and Joe Cone, of Sea Grant Communications, worked together to establish an informal Network of Oregon Science and Nature Centers. In 2003, Communications launched a Web portal by which visitors to any of the Web sites of the seven participating institutions immediate access to the Web sites—and thus the visitation and educational information—of the others. The standard basic measure of Web use—"hits"—shows that considerable traffic is coming to each of the sites via the portal.

Far more than just a public aquarium or a tourist destination, the Visitor Center, under Sea Grant's leadership, has been reconceived as a laboratory in which to study how people learn in informal settings. In 2004 we hired Dr. Shawn Rowe as the new marine education and learning specialist with Sea Grant Extension to lead our free-choice research and education. And we are currently establishing a new tenure-track Sea Grant professor position, devoted to free-choice learning, in the OSU College of Science. Although it is too early in the evolution of our free-choice learning program to present major outcomes, one key element merits mention. Under the guidance of Dr. Rowe, the notion of the Visitor Center as a learning laboratory is taking on new depth, as evaluations of exhibits and programming are being more systematically and professionally conducted, before, during, and after development.

**Exhibits.** Several new and exciting exhibits and displays were installed in the Visitor Center this year.

*The Adventures of Totally Turtle*, a conservation-based exhibit that was created in-house, featured 10 species of turtles from every continent except Antarctica. This popular exhibit ran from June to December and generated significant media attention.

Also created in-house, *The World of Wet Pets* opened in November. A new and permanent gallery exhibit, *The World of Wet Pets*, is devoted to the hobby and industry of ornamental fish-keeping, with the goal of educating the public about the value of aquatic pets and the

importance of the proper husbandry and health care for their aquatic pets. It also features a wide range of aquariums, from simple home units to complex reef systems.

In early 2005, the much-anticipated Invasion of the Habitat Snatchers! exhibit about aquatic nuisance species opened. This grant-funded exhibit was developed by Oregon Sea Grant and the exhibit design firm 1+ 2 to create a family-friendly way to make the difficult subject of invasive species more understandable to the general public. Combining interactive, audio-visual, and live animal components, Invasion of the Habitat Snatchers! not only brings current information about Oregon aquatic invasive species to HMSC visitors, but also explores, through evaluation, best practices for communicating about invasive species in informal settings. To that end, a process of using formative evaluation to test exhibit elements during the design phase was carried out by Sea Grant staff and students from OSU's Marine Resource Management program. The formative evaluation resulted in significant changes to some exhibit elements, creating conditions for more effective interactions around exhibit content. This formative evaluation was the first step in a more complete evaluation to be done later in 2005.

Currently under development in the Visitor Center is the new Guardians of the Forest exhibit, a project by Jessica Cardinal, who received her M.S in Marine Resource Management from OSU and joined the Oregon Sea Grant staff in 2004. As part of the new Free-Choice Learning Initiative project to work with community groups in the planning, development, and installation of marine science and cultural exhibits at the HMSC Visitor Center, Cardinal is working with an advisory board from the Confederated Tribes of Siletz to develop an exhibit on the history of the Tribes in Oregon, the extinction of sea otter on the Oregon Coast, and Tribal efforts at conservation and the reintroduction of sea otter. The exhibit combines Tribal history, information about the role of sea otter in kelp forest health, and efforts by the Elakha Alliance toward eventual reintroduction of sea otter in Oregon. The three-year project will culminate in a traveling version of the exhibit, and is part of the Initiative's commitment to seek to involve local communities in developing and using free-choice science learning activities.

**Programming.** We instituted the first annual *Shark Day* at the HMSC. Necropsies were conducted on an eight-foot, 400+ lb. salmon shark and a smaller soupfin shark for comparison. This was an extremely popular program, more than doubling our typical Saturday attendance.

Special activities for *Whale Watch Week* included: public marine mammal classes, whale tales/storytelling, and daily updates on migrating gray whales posted on the information board. Marine mammal videos were shown in the auditorium and special marine mammal displays and exhibits were featured throughout the Center.

January's special public programming event was titled *Dissection of the Giants*. This was a side-by-side external and internal comparison between a Giant Pacific Octopus and a 20-pound Humboldt Squid. We conducted this dissection in the auditorium with over 120 people in attendance.

The eighth annual *Fossil Fest*, held February 12, 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.

Twelve interactive exhibits titled *Pattern Puzzles* were installed in March and on display until May 15. These durable, self-standing exhibits challenged the visitor to solve visual patterns by manipulating blocks, pegs, ropes, or images. Situated in the *Pattern Garden*, these exhibits had broad appeal across all age groups and provided excellent group problem-solving opportunities.

The first annual *International Migratory Bird Day* was held on Saturday, May 14, 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. This educational and fun-filled event will be repeated next year on May 13, 2006.

**Animal Husbandry.** Headed up by Curator Peter Noah, the animal husbandry team consists of two outstanding graduate students, Michael Liu, working on his Ph.D. program, and Brendan Clack, working on his Masters Degree. Both Brendan and Michael are responsible for maintaining the aquarium systems in the Visitor Center and Sea Grant Education program areas. New to the animal care program is Dennis Glaze, a student in the Oregon Coast Community College (OCCC) Aquarium Science Program and part-time Sea Grant Extension employee. Glaze is currently responsible for the new hospital/quarantine area. Dr. Tim Miller-Morgan continues to serve as staff veterinarian as well as a critical guide for the entire husbandry program.

The animal husbandry team continues to be responsible for the care and feeding of approximately 75 species and 1000 plus specimens contained in the Visitor Center Education Program. Ongoing renovation of the west wing area has created a multiple use environment that supports exhibit development, provides space for student and faculty research, and serves as a holding area for all new incoming animals.

On the public side of our animal husbandry efforts, three new exhibits opened in the Visitor Center this year. Strong media attention to these new exhibits, combined with effective ongoing programming, resulted in the highest level of attendance at the Visitor Center since it reopened in 1997.

While all three exhibits have their own success stories, *The World of Wet Pets* project demonstrates the cooperative efforts the animal husbandry team strives to develop. Working with Dr. Tim Miller-Morgan, Dennis Glaze was instrumental in putting together *The World of Wet Pets* exhibit for the November grand opening. Using resources from the OCCC Aquarium Science Program, Sea Grant staff, HMSC physical plant staff, and many others, “Dr. Tim” and Dennis turned a previously underutilized space into one of the most exciting and educational exhibits in Visitor Center history. Great public response can be heard everyday as children lead their parents into the *Wet Pets* exhibit to see “Dory” and “Nemo” and then stay to learn more about these wonderful animals.

On a more practical note, several significant physical improvements have occurred over the year to improve infrastructure for our animals in the Visitor Center. Physical plant personnel, combined with animal husbandry staff, revamped the entire main seawater supply system to the Visitor Center and resolved several design problems with our major exhibits. The result is a safer, healthier environment for the animals in the Visitor Center for many years to come.

Behind the scenes was very busy as well. In addition to carrying out major renovations in the west wing, the animal husbandry staff hosted seven Oregon Coast Community College classes there this year: an introduction to the aquarium sciences class, a life support class, practicum I and II classes, a fish and invert health management class, an ornamental fish medicine class and last, but not least, an aquatic animal reproduction and nutrition class. In all, nearly 30 students used HMSC facilities to further their Aquarium Sciences Program education this year.

A major component of the Aquarium Sciences Program is the practicum experience. This hands-on program teaches real world skills and responsibilities. Practicum I students are tasked with basic animal husbandry and maintaining a series of exhibits in the Visitor Center under the watchful eye of the Curator and Aquarists. Practicum II students are given the opportunity to build and maintain systems of their own design. A highlight of the spring practicum II class was the opportunity for four aquarium science students to design in a “real world environment” a state-of-the-art hospital/quarantine facility. Once again, with the help of HMSC physical plant personnel, and Sea Grant and OCCC support, a new facility has been created that will not only benefit overall animal husbandry, but will also serve as a teaching area and support short-term research projects.

Speaking of research projects, Emily Cornwell, an intern from Kalamazoo College in Michigan, is one of the current student researchers. Last summer, she conducted a dominance study with clownfish and she’s back again this summer, studying transport stress on fish with Dr. Miller-Morgan. The new hospital/quarantine area has provided a foundation for her work, including monitoring baseline water quality issues and setting up areas for her individual experiments.

Finally, a major new effort to create a “life support” teaching area to facilitate OCCC’s Aquarium Science Program as well as new exhibit development for the

Visitor Center is in the development process. This revamped area will also support Dr. Tim Miller-Morgan's continued advancement in aquatic pet husbandry by providing advanced teaching space for ornamental fish retailers and wholesalers.

**Bookstore.** Oregon Sea Grant's Bookstore employees include Lynne Wright, Manager, regular cashiers Kim Gomez and Maxine Moodie, and a 25-hour/week temp employee during the four summer months.

This year Wright took on additional responsibilities beyond the bookstore to help better manage visitor services. Part of a new self-managed team plan, she works with Bill Hanshumaker, public marine education specialist, and Kath Fuller, the new volunteer coordinator, to work out scheduling, events, and other challenges as they come up in the Visitor Center. This arrangement has helped improve student intern training and performance issues. In addition, it has provided volunteers and staff persons of the day (SPODs) with a collection point for any input, observations, and suggestions with regard to the student interns and other Visitor Center floor issues.

There were six author events and book signings this year. On July 3, Eric Tamm, author of *Beyond the Outer Shores* spoke to approximately 60 people and signed copies of his book. Half the people in attendance purchased Tamm's book, which is an extremely large percentage compared to a typical book event.

The "Pirate Guy's" event took place August 21, with approximately 145 people attending and joining in with the "pirate song, romp, and shout." The bookstore sold over 40 copies of former Sea Grant employee John Bauer's book, *Well, Blow Me Down – Guys Guide to Talking Like a Pirate*. Quite a few kids books on pirates were sold too and Maxine joined "Terrible Terry the Pirate" in dressing up as a pirate for the occasion.

On October 23 -- just in time for Halloween -- author Jefferson Davis presented history and tales of Pacific Northwest ghosts and hauntings from his books, *Haunted Tour Guide of the Pacific Northwest* and *Ghosts, Critters and Sacred Places of Washington and Oregon*. Approximately 55 people were in attendance at this event.

Kathleen Dean Moore was the featured author at a March 4 event that was co-sponsored by the Oregon Council for the Humanities and Friends of the HMSC. The bookstore opened in the evening to serve the 190

people who attended. Rachel Carson was the main focus of Moore's presentation. Besides the author's books, two books by Carson were also featured.

"Hotel Deep -- Light Verses from Deep Waters," by author and illustrator Kurt Cyrus, was the featured children's book event April 23. A good-sized audience of children enjoyed the narration and slideshow of Cyrus's colorful verses.

On May 21, Frank Parchman, author of "Echoes of Fury: The 1980 Eruption of Mount St. Helens and Its Aftermath," held a slide-show presentation in the Hennings Auditorium in the HMSC Visitor Center, followed by a book signing. This event was well-attended by many of the local residents, volunteers of HMSC and visitors who happened into the Center.

Other successful bookstore events included the annual Lincoln County Glass Float Drawing and promotion. Held each year between November 1 and January 31, the HMSC Visitor Center and Bookstore represent one of 50 locations that that hold a drawing to give away two glass floats. All are eligible to participate. This year's drawing tapped two volunteers from the HMSC Visitor Center to take home the prized glass floats.

Some of the bookstore's busiest periods this year occurred during whale-watching weeks in December and March, on New Year's Day, and during February's Fossil Fest. Sales increased by 18% in November and were up 28% in February, or double the previous year's sales during this month. March sales were up 5% over the previous year, which had already seen an increase of 18%. Of course, the busiest period each year is during the summer months of June, July, and August. Business was brisk, with sales up 4% over this period the previous year.

Besides managing the Oregon Sea Grant Bookstore at the HMSC, Wright is also active as Sea Grant's representative to the Newport Chamber of Commerce and as Sea Grant's representative on the SeaFest planning committee. She regularly attends bookseller conventions and museum store conferences to gather insight and new ideas from workshops, authors, and other like-minded individuals. For Wright, these events are rich with opportunities to share stories and offer ideas or solutions for various challenges that come up. This year Wright also chaired the search committee for Sea Grant Extension's volunteer coordinator position, which resulted in the selection of Katherine Fuller to fill the position.

**Volunteer Program.** Without the support of dedicated volunteers, the Visitor Center would be very difficult to operate. During FY 04/05, 48 active volunteers contributed 5,761 hours of service. At \$10 per hour, (a bargain rate as the majority have at least a four-year degree) these volunteers saved HMSC \$57,610. Most of these volunteers greet visitors and provide information as the visitors enter the Center. They also provide interpretation and “touching” guidance for visitors at the popular touch tanks. Having a volunteer at the touch tanks helps eliminate many improper visitor behaviors and helps maintain the health of these animals.

Volunteers were honored for their contributions and dedication at a banquet in February. They were also recognized during National Volunteer Appreciation Week in April. Short volunteer training and enrichment sessions were offered on a monthly basis during the past year.

HMSC’s previous volunteer coordinator, Craig Toll resigned in February of 2005 when he became the owner of a small business. Katherine Fuller was hired in June to fill the vacated position.

**HMSC Visitor Center Volunteers**

**Katherine Fuller, Oregon Sea Grant Volunteer Coordinator**

The Hatfield Marine Science Center’s Visitor Center would not exist as it does without the contributions of time, energy, passion and knowledge given by its volunteer crew. Over the past year this crew contributed almost 6,000 hours of service to the Center and drove over 37,000 miles to deliver those services. These volunteers are truly committed to the mission of HMSC and contribute to its success. They include:

Larry Addison	Donald Kennedy	Anne Southcott
Myra Austin	Linda Kirkpatrick	Chet Stark
Kathy Bates	Ruth Kistler	Judy Stefl
Jennifer Berger	Ireen Lapham	Nadine Stilwell
Nancy Besse	Kary Mathis	Keith Stratton
Susan Boehlert	Curt McCann	Edwin Swartz
Gerald Boyd	Patricia McChesney	Christine Tomsik
Patricia Brown	Ed McCoy	Larry Tyler
Joyce Browning	Mary McLinn	Van Vanderbeck
Philip Carbone	Josh Mies	Robert Wallace
Gert Carey	Elizabeth Montgomery	Sharry Washburn
Harry Caylor	Melina Moyer	Helen Wellman
Ray Clark	Robin Nelson	Marlene Williams
Linda Coburn	Kennith Nevar	Sue Wilson
Matteo Costamagna	Kennith Parks	Lisa Wood
Stuart Diddel	Sylvia Pauly	Jack Woods
Terry Dillman	Walt Pazdalski	Judith Wright
Charlotte Dinolt	Suzanna Peterson	Trish Young
Nancy Edwards	Tom Peterson	
Gerald Engleman	Isabella Potter	
Bill Evans	Kathy Ramsey	
Jennifer Ferschweiler	Dolores Reed	
Elizabeth Gates	Clayton Richman	
Shirley George	Suzy Roberts	
Kathleen Halleron	Talia Sanfilippo	
Kathleen Holt	Mell Schierholtz	
Ralph Irvin	Gerti Schramm	
Paula Jones	Sandra Siler	
Jennifer Josef	Judy Sims	
Clyde Kellay	Margo Sloan	



## Sea Grant Marine Education

### Jesica Haxel, Oregon Sea Grant Education Specialist

The mission of the Youth Marine Education program 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 lead by an education staff who help make all of these activities not only possible, but extraordinary. They are Maureen Collson, Fawn Custer, Athena Crichton, Jesica Haxel, and our newest educators Melina Moyer and Christine Carlson.

Last summer concluded with the ever popular summer camps, Marine Biology I and Marine Biology II, geared towards our upper level students, where they have the opportunity to get experience in the field, 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 and our 7<sup>th</sup> Home School event, which was a huge success thanks to the hard work of our educators, Fawn and Athena, who took part in developing their own curriculum to bring new activities to the event, such as Wetland Wonders and a new Ichthyology Lab.

“Each year gets better. The instructors are great teachers. We like the dissections, we don’t get the opportunity to do those at home.”  
 – Home School parent

The Youth Education Program also got a taste of online education when educator Fawn Custer joined the OSU K12 Online staff and began teaching online marine biology courses beginning with winter quarter.

Another focus this winter was bringing back the annual Career Day event for high school juniors and seniors. Students were able to hear presentations from scientists, take an interactive tour and learn about careers in marine science. One student, Kiril Chang-Gilhooly, went on from our Career Day to work as an intern for the NOAA Vents Program.

This year, Youth Education Coordinator, Jesica Haxel was fortunate enough to coach Newport High School’s National Ocean Science Bowl (NOSB) team. The five students, Megan Baker, Dyllynn Crichton, Yuanbo Liu, Colin McNamara, and Ben Waite have been participants in our Youth Education Programs -- either on field trips or summer camps -- and went on to place second in the state in this year’s Salmon Bowl Regional competition.

As spring loomed around the corner our education staff remained busy with our Spring Home School Day, Whale Watch Week presentations, and collaborating activities with the Oregon Coast Aquarium. We participated in the Aquarium’s Home School program, Earth Day/Ocean Day Event and also co-taught the Estuary Sandy Beach Ecology Workshop for K-8 teachers. This spring also marked the teaching debuts for Melina and Christine and the beginning of Christine’s Sea Grant Fellowship with Youth Education. Christine will not only be teaching but developing new Oceanography curriculum with hands-on activities for both middle and high school students. This new endeavor will become a regular part of our school group programs.

The school year came to a close with a record 12, 000+ students taking part in our programs. We were also very grateful to receive an Oregon Community Foundation grant to begin the Las OLAS (Ocean Learning Activities in Spanish) program, which will expand our programs to even more students by reaching Spanish-speaking students, 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

## *Oregon Sea Grant 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 23 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. One of our faculty members has been active with members of Alaska Sea Grant's Marine Advisory Program, an arrangement that was called a best management practice by Alaska's most recent PAT. We also 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.

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. As a member of the cabinet of the dean and director of Extension, the Sea Grant Extension program leader helps set OSU Extension policy. 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. 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, business, 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 2004, the following faculty members have appointments, ranging from full time to quarter time, with Oregon State University: Jessica Cardinal, Susan Hanna (whose main office is on campus), Bill Hanshumaker, Jon Luke, Tim Miller-Morgan, Jesica Haxel, Shawn Rowe, Peter Noah, Vicki Osis (postretirement), Jay Rasmussen, and Lynne Wright. Katherine Fuller has joined us in a new volunteer manager position, Nadine Stillwell covers Visitor Center interpretative duties, and a number of marine educators provide youth education experiences. Dennis Glaze has been a lead in ornamental husbandry efforts along with our aquarists. 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.

## Ornamental Fish Health Program

**Dr. 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 Extension and the College of Veterinary Medicine, has completed a busy third year, solidifying existing programs and expanding into new areas.

Dr. 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 that 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://seagrants.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, and Guatemala have begun to give an international flavor to the program. Miller-Morgan also sits 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 continues to speak at 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 fourth year of training selected koi hobbyists to become health and husbandry advisors to their fellow hobbyists. The program has trained approximately 160 Koi Health Advisors throughout the

country, with 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. Together with Spike Cover, Director of the KHA Program and Dr. Sandy Yosha, a private fish practitioner from Lakeland, Florida, Miller-Morgan co-instructed three KHA wet labs in Texas, California, and North Carolina. He has published numerous articles in KOI USA (the AKCA magazine) and was invited to speak at the 2004 AKCA annual seminar in Honolulu, Hawaii, where he was recognized by the AKCA for his involvement in and support of the KHA Program.

Miller-Morgan also serves as the staff veterinarian for the Visitor Center and education wing animal collections at the Hatfield Marine Science Center (HMSC). He has been actively involved with Peter Noah, Curator of Animal Husbandry and Exhibitory, 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 two new exhibits that opened this year in the Visitor Center with extremely favorable public reviews. *The Adventures of Totally Turtle* was a conservation-based exhibit that featured 10 species of turtles representing every continent except Antarctica and the new ornamental fish exhibit, *The World of Wet Pets*, is a new and permanent exhibit gallery devoted to the hobby and industry of ornamental fish-keeping. The goal of this exhibit is to educate the public about the value of aquatic pets and the importance of proper husbandry and health care for their aquatic pets.

## Free-Choice Learning Initiative

**Shawn Rowe, Oregon Sea Grant Extension Learning Specialist**

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 Visitors Center and Marine Education programming at HMSC to carry out a program of research, evaluation, and design in free-choice learning.

In its first year, faculty and students associated with the Initiative have undertaken a variety of projects. Evaluations provide an opportunity not only to test content and exhibit ideas, but also to develop new tools for doing evaluation that may be exported to interested parties within the university, region, and nation. Three evaluations of Visitors Center exhibits top the list. Evaluations of the Invasion of the Habitat Snatchers!, The Adventures of Totally Turtle, and The World of Wet Pets were planned and carried out this year. In addition, an evaluation of the Alien Invaders exhibit at the Point Defiance Zoo and Aquarium in Tacoma, WA, helped to establish a comparative evaluation and research agenda with a regional scope.

The Free-Choice Learning Initiative also supports students carrying out research projects in learning in out-of-school environments. This year, the initiative provided financial and academic support for Alicia Christensen, an M.S. student in OSU's Marine Resource Management Program. Christensen is working with the Oregon State Parks Department to research evaluation tools that can be used effectively with their long-running Whale Watching Spoken Here program. In its 27th year, the program reaches about 30,000 visitors to the Oregon coast annually during three peak whale migration periods. Christensen was awarded a Holt Marine Education Fund Award to continue this work in the following year.

Another recent innovation in this area offered professional development for community college adult education instructors through the Ocean Sciences and Math Collaborative. Sixteen adult education instructors from 10 community colleges attended three Adult Education Instructors Institutes in a yearlong

professional development project. The instructors received background information from researchers and marine science educators and adapted curriculum materials to link ocean sciences, math, technology, critical thinking, and communication skills. To our knowledge, this project is the first of its kind in linking adult educational instruction and free-choice learning centers, such as the HMSC, and will benefit both groups. Informal learning centers will learn how to adapt their programs for adult education learners, and adult ed instructors will gain new learning perspective and experiences.

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

### *SeaFest*

Thousands of visitors helped celebrate the Hatfield Marine Science Center's 40th anniversary by taking part in the fourth annual SeaFest on June 24-25. This year's open house and festival was expanded to include a kick-off event on Friday night, featuring a lecture by famed undersea explorer Don Walsh, who captivated the full house audience with his personal accounts of record-setting dives to the deepest known points in the world's oceans.

NOAA Fisheries scientist Ric Brodeur introduced Friday evening's featured speaker, noting the numerous expeditions that Don Walsh has led over the past half century, to the poles of the earth and to the ocean's greatest depths, earning him international recognition as one of the world's great explorers. Following the talk, guests mingled over coffee and a ceremonial cake-cutting in honor of the HMSC 40th anniversary.

At the SeaFest opening ceremonies the following day, HMSC Director George Boehlert welcomed the crowd assembled outside the Visitor Center main entrance and introduced former HMSC Director Lavern Weber and OSU President Ed Ray, who both offered welcoming remarks. Kameran Onley, from the White House Council on Environmental Quality, also spoke to the crowd, commending the Hatfield center's leadership in forging partnerships that advanced the goal of increasing

“ocean literacy”, which is one of the principal recommendations of the report issued by the U.S. Commission on Ocean Policy last year.

Onley presented a Coastal America “Sprit Award” to the organizers of SeaFest 2004, in recognition of the successful partnerships that come together around SeaFest to educate the public about marine and coastal ecosystems. She also announced that the Oregon Coast Aquarium would be joining HMSC as an officially designated Coastal Ecosystem Learning Center, helping advance Coastal America’s goal of involving the public in protecting the nation’s coastal resources.

Following the opening ceremony, SeaFest visitors fanned out across the HMSC campus to check out the many activities, special tours, and exhibits on display. At the OSU dock overlooking Yaquina Bay, members of Dr. Clare Reimers’ marine geochemistry lab and other researchers from the College of Oceanic and Atmospheric Sciences hosted tours aboard the 187 foot research vessel *Wecoma*. OSU’s 54-foot research vessel *Elakha* was also on display. Visitors waiting in line for vessel tours had a great view from the dock of the afternoon demonstration by the U.S. Coast Guard of at-sea rescue drills, which involved their 47-foot motor life boats and HH-65 “Dolphin” helicopters.

The NOAA-Northwest Fisheries Science Center’s Captain R. Barry Fisher Building served as SeaFest’s “Science Zone,” housing numerous science booths and interactive activities. Visitors saw examples of NOAA’s research activity in the Pacific, including ocean modeling, habitat mapping, 3-D visualization of oceanographic data sets, fish ageing, studies of fish ecology and behavior, and recent ocean explorations of hydrothermal vent systems and undersea volcanoes in the western Pacific. Exhibits in the Science Zone also showcased the work of ODFW, EPA, and USDA scientists based at the Center, highlighting the diversity of their research programs and the applications to current challenges in marine resource management.

SeaFest 2005 featured an expanded area for exhibitors from the local community and OSU main campus, helping increase public awareness of research and educational activities complimentary to HMSC’s own mission. Hands-on learning activities were featured in all exhibit areas, providing opportunities for children to interact with scientists and educators and ask questions about what was on display. Special topic lectures were scheduled throughout the day in the visitor Center

auditorium, featuring guest speakers from the Astoria Seafood Lab (Michael Morrissey), COAS (Kelly Benoit-Bird), and OSU’s Hinsdale Wave Laboratory (Harry Yeh).

### ***Coastal Ecosystem Learning Center Activities***

As one of 17 officially designated Coastal Ecosystem Learning Centers (CELCs) across the United States, the Hatfield Marine Science Center is part of the Coastal America partnership’s national network of aquaria and science centers dedicated to increasing public awareness and understanding of coastal and marine issues. With over 150,000 people coming through the Visitor Center each year, there are many opportunities to promote learning about marine and coastal ecosystems, while highlighting the research contributions of HMSC scientists.

CELC activities center around special programs and exhibits such as the summer 2004 *Ocean Quest*, a daily 1-hour program held in the Hennings Auditorium, featuring video footage, images, and data reports from NOAA research cruises, moderated on site by marine education specialist Bill Hanshumaker. HMSC joined other CELCs around the country on September 24-25 to celebrate *National Estuary Day* with special presentations and activities, including guided walks along the Yaquina Bay estuary trail.

In June of 2005, Coastal America representatives at the SeaFest opening ceremonies announced an expansion of the network to include the Oregon Coast Aquarium as a co-designated Coastal Ecosystem Learning Center with HMSC.

### ***Civic Activities***

The Hatfield Marine Science Center’s contributions to the community go beyond the educational programs and activities offered on site. The people who work at HMSC are active volunteers and leaders in the community, serving on advisory boards and lending their support to local schools, arts organizations, civic and charitable groups across Lincoln County. Their philanthropic spirit is demonstrated through participation in OSU’s annual charitable fund drive and numerous local fundraising events held throughout the year.

HMSC personnel collected new toys, clothing, food, and gift certificates during the month of December to be donated to six local families over the holidays, in

coordination with the Salvation Army and My Sister's Place. Weeks later, an emergency aid appeal coordinated by an HMSC graduate student raised thousands of dollars for tsunami relief assistance in a remote area of Sri Lanka that had not yet received substantial international disaster aid. HMSC staff and students also participated in blood drives for the American Red Cross and sponsored a weekly soup kitchen during the month of March to raise money for the Lincoln County Food Share.



In August 2004, a team of walkers and runners representing HMSC raised \$1,287 for the American Cancer Society during the 24-hour Lincoln County Relay for Life event held at Newport High School.

### *Friends of HMSC*

The worth of HMSC's education and outreach mission is recognized by hundreds of private individuals and families who, as "official" members of the *Friends of the Hatfield Marine Science Center*, support programs and activities that help educate the public about the importance of ocean and coastal sciences, and how these inform resource management. As financial contributors and volunteers, the *Friends of HMSC* serve as liaisons to the public-at-large, helping communicate the value of the Center's research and education activities, ultimately promoting responsible stewardship of our marine environment.

The *Friends of HMSC* co-sponsor events such as weekend and evening lectures, guided tours of research vessels and labs, and special programs for members and guests. Events this past year included: the August 18<sup>th</sup> "Beachcombing for Science" lecture by oceanographer Curtis Ebbesmeyer, who has tracked cargo ship spills of Nike sneakers and other flotsam carried by ocean currents around the world; and the March 4<sup>th</sup> lecture by

Kathleen Dean Moore, "The Truth of the Barnacles", co-sponsored by the Oregon Council for the Humanities in commemoration of the 50<sup>th</sup> anniversary of Rachel Caron's book *The Edge of the Sea*.



Friends of HMSC Shirley and William Golden of Fresno, California, with HMSC Director George Boehlert at "Beachcombing for Science" lecture.

*Donor Honor Roll*

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H R & Lois Heeter	William Percy & Amy Schoener	Tim Weber	

## *Meetings at Hatfield Marine Science Center*

The Hatfield Marine Science Center hosts numerous lectures, conferences, workshops, training institutes, and a variety of public meetings throughout the year. The Friends of HMSC, a membership group supporting the research and education mission of the Center, sponsors guest lectures and special events that help promote greater public awareness and understanding of the marine environment. As a focal point for the public on a broad array of marine and coastal resource management issues, the HMSC is also a popular location for gatherings that address policy issues and explore many of the scientific questions of interest to coastal residents and marine resource dependent communities.

With facilities to accommodate large and small groups, the HMSC this past year also welcomed thousands of visitors attending a wide variety of public forums, meetings, and workshops sponsored by community and government partners and other organizations, including:

- Developmental Fisheries Board meeting
- NOAA Observers training workshop
- Ocean Sciences Instruction Institute
- Oregon Coast Crab Commission meeting
- Oregon Coastal Zone Management Association conference
- Oregon Council for the Humanities annual board meeting and public lecture
- Oregon Dept. of Environmental Quality / Yaquina
- Environmental Solutions meetings
- Oregon Dept. of Geologic and Mineral Industries meeting
- Oregon Dept. of State Lands meeting
- Oregon Dept. of Transportation meeting
- Oregon Policy Advisory Council meeting
- Oregon Shores Conservation Coalition's Annual Coast Conference
- Oregon Trawl Commission meeting
- OSU Alumni Association meeting
- OSU Department of Geosciences alumni
- OSU Science and Math Investigative Learning Experiences meeting
- Oregon University System Deans of Distance Education meeting
- Pacific Fisheries Management Council Star Panel meeting
- Pacific States Marine Fisheries Commission meeting
- Scientists and Fisherman's Exchange meeting
- U.S. Congressional representatives' town hall meetings
- U.S. Forest Service meeting
- Western State Lands Commissioners meeting
- Whale Watching Spoken Here training



Flip Nicklin (bottom), undersea photographer for the National Geographic Society for 17 years, led a digital photography workshop at HMSC in November 2004, organized by the Marine Mammal Program.



OSU Biology Grad Student Symposium – Elisha Wood-Charlson (Feb 20)



HMSC is a popular venue for public forums and town hall meetings, like this one hosted by U.S. Representative Darlene Hooley in January 2005.



***Seminars at HMSC*****Seminars presented at HMSC from July 2004 to June 2005**

<b>DATE</b>	<b>NAME</b>	<b>AFFILIATION</b>	<b>TITLE</b>
July 7, 2004	Abigail McCarthy	Department of Fisheries and Wildlife, OSU	Pelagic habitat of marine turtles in the Atlantic Ocean
July 14, 2004	Judi Li	Department of Fisheries and Wildlife, OSU	A Tangle of Riparian Foodwebs
July 21, 2004	Robert T. Lackey	Senior Fisheries Biologist, EPA Research Lab	Normative Science: A Corrupting Influence in Ecological Policy
July 28, 2004	Courtney S. Campbell	Professor of Philosophy & Director of the Program for Ethics, Science and the Environment, OSU	Scientific Research: Value-Free or Ethical Vocation?
Aug 4, 2004	Michael Liu	Ph.D. Candidate, Fisheries and Wildlife, OSU	Unwanted alien: introduced species in aquatic ecosystems
Aug 5, 2004	Miguel Goni	University of South Carolina (Candidate for COAS position)	Transport and Fate of Organic Matter in River-Dominated Continental Margins
Aug 12, 2004	Jay Brandes	University of Texas Marine Science Institute (candidate for COAS position)	New frontiers in nanoscale marine chemistry
Sept 28, 2004	John Goodlad	President of the Assoc. of European Fish Producers Organizations	Community Investment in Tradable Fish Quotas: The Shetland Islands' Experience
Sept 30, 2004	Mark Hixon	Professor of Zoology, OSU	Mechanisms of Density-Dependent Mortality in Coral-Reef Fishes
Oct 7, 2004	Janet Webster	Librarian at Guin Library, HMSC, OSU	Responsible Fisheries Information
Oct 14, 2004	Marta Torres	COAS, OSU	Methane-ice in marine sediments: Where, how and why we study these deposits
Oct 21, 2004	Shawn Rowe	Oregon Sea Grant, OSU	But are they really learning? Studying cognition and communication in interactive science museums
Oct 25, 2004	Lynn A Joens	Department of Veterinary Science & Microbiology, University of Arizona	Salmonella prevalence in market oysters
Oct 26, 2004	Bernd Schoene	Institute for Geology & Paleontology, JW Goethe University, Germany	Reconstruction past climates – Can bivalve mollusks help?
Oct 27, 2004	Elliott Norse	Marine Conservation Biology Institute	What's wrong with fishing? A marine conservation biologist's look at how we manage fisheries
Nov 4, 2004	Claudia Halsband-Lenk	School of Oceanography, University of Washington	Do diatoms kill copepod eggs?
Nov 10, 2004	Richard Feeley	Pacific Marine Environmental lab, Seattle, WA	The impact of anthropogenic CO <sub>2</sub> on the calcium carbonate system in the global ocean: Present and future
Nov 16, 2004	Shinsuke Tanabe	Laboratory of Environmental Chemistry and Exotoxicology Center for Marine Environmental Studies, Ehime University, Matsuyama, Japan	Present Status of Persistent Organic Pollutants (POPs) in Asia-Pacific Regions
Nov 16, 2004	Hisato Iwata	Laboratory of Environmental Chemistry and Exotoxicology Center for Marine Environmental Studies, Ehime University, Matsuyama, Japan	Species Differences in Toxicokinetics of POPs and the CYP Expression System
Nov 18, 2004	Martin Fisk	COAS, OSU	Microbes in deep sea lavas and the possibility of extraterrestrial life

***Seminars at HMSC - Continued***

Seminars presented at HMSC from July 2004 to June 2005

<b>DATE</b>	<b>NAME</b>	<b>AFFILIATION</b>	<b>TITLE</b>
Dec 2 2004	Peter Lawson	Northwest Fisheries Science Center, NOAA-NMFS	Climate impacts on OPI area coho salmon production: insights from a species sensitive to habitat change at daily to centennial time scales
Dec 9, 2004	Alan Trimble	Biology Department, University of Washington	Alternative Stable States in Marine Communities
Jan. 6, 2005	Laurie Weitkamp	NMFS – Northwest Fisheries Science Center, Newport, OR	Ocean conditions, marine survival, and performance of juvenile chinook and coho salmon in SE Alaska
Jan 13, 2005	Glenn Aguilar	University of the Philippines	Philippine capture fisheries: FADs and transitions in a tropical multi-species fishery
Jan 20, 2005	Walter Pearson	Batelle Marine Science Laboratory, Sequim, WA	Passage of salmon smolts through culverts or stranding of salmon in the Columbia
Jan 27, 2005	Kelly Benoit-Bird	COAS, OSU	Dynamics of midwater micronekton around the Hawaiian Islands
Feb 3, 2005	Benjamin Laurel	Environmental and Ecosystem Sciences Section, DFO-Canada, St. John's	Linkages in recruitment variability between three species of gadids: Atlantic cod, Greenland cod and white hake
Feb 10, 2005	Jim Colbert	CIMRS, OSU	Annual growth of Pacific hake: Age-group specific response to oceanographic conditions
Feb 18-19, 2005	Amatzia Genin	<a href="#">Distinguished Lecturer</a> Department of Evolution, Systematics and Ecology, The Hebrew University of Jerusalem, and The H. Steinitz Marine Biology Laboratory of The Interuniversity Institution, Eilat, Israel	Supply and Sink of Zooplankton in Coral Reefs: the role of currents and behavior (Friday) The Red Sea coral reefs: unique beauty in unusual settings (Saturday)
Feb 22-26		COAS Fisheries Oceanography Faculty Candidate presentations	
Mar 3, 2005	Don Lyons	Department of Fisheries and Wildlife, OSU	Avian Predation of Juvenile Salmonids in the Columbia River
Mar 10, 2005	Jody Stecher	COAS, OSU	Electricity from Sediments
Mar 30, 2005	Green Fire Productions	Screening and discussion of the film	Common Ground: Oregon's Ocean Are Marine reserves in Oregon's future?
Mar 31, 2005	Bill Sydeman	Point Reyes Bird Observatory	Seabird Indicators, Productivity Controls and Fisheries: Ecosystem Approaches to management of the California Current
Apr 7, 2005	Katie Dugger	Department Fisheries and Wildlife, OSU	Effects of Flipper-bands on Survival and Foraging Ecology of Adelie Penguins
Apr 14, 2005	Kate Field	Department of Microbiology, OSU	Who's Responsible? Identifying the Source of Fecal Contamination in Water with Molecular Markers
Apr 21, 2005	Barbara Bond	Department of Forest Science, OSU	Using Stable Isotopes to Study Terrestrial Ecosystem Processes
Apr 28, 2005	Mike Behrenfeld	Department of Botany & Plant Pathology, OSU	Rates and Stocks in the Ocean Productivity Business

***Seminars at HMSC - continued***

Seminars presented at HMSC from July 2004 to June 2005

<b>DATE</b>	<b>NAME</b>	<b>AFFILIATION</b>	<b>TITLE</b>
May 5, 2005	Monida Winder	School of Aquatic & Fishery Sciences University of Washington	Climatic Effects on Copepod Population Dynamics
May 11, 2005	John Annala	Chief Scientific Officer, Gulf of Maine Research Institute, Portland, ME	Fishery Ecosystem Research at the Gulf of Maine Research Institute
May 19, 2005	Dawn Wright	Department of Geosciences, OSU	Spatial Reasoning at Sea and Ashore: Progress and Challenges of Ocean Informatics
May 26, 2005	Steve Ferraro	Coastal Ecology Branch of EPA	Four Investigations in Quantitative Marine and Estuarine Ecology
June 2, 2005	Denise Parker	Joint Institute of Marine and Atmospheric Research, Newport	Living On the Edge: Following Pacific loggerheads, a study of the movement, oceanic habitat, and feeding ecology – implications for conservation and management.
June 3 & 4, 2005	Verena Tunnicliffe	<u>Distinguished Lecturer</u> Professor & Canada Research Chair in Deep Oceans, School of Earth & Ocean Sciences, University of Victoria, BC	Death and Life on Axial Volcano (Friday) Fast Living in the Deep Sea (Saturday)
June 15, 2005	Rita Horner	Department of Oceanography, University of Washington	Harmful Algal Blooms: Causes and Impacts
June 23, 2005	Hal Weeks	Oregon Department of Fish and Wildlife, Newport, OR	Fish Density and Diversity on a Nearshore Rocky Reef Complex: Influences of Time & Space

## V. Publications

### 2004/2005 HMSC Publications

Key: \* = is or was a graduate student based at HMSC, **Bold** = at HMSC, 1 = OSU, 2 = NMFS, 3 = PMEL, 4 = EPA, 5 = ODFW, 6 = USDA/ARS, 7 = USFW, 8 = Visiting Scientist

**Arkoosh, Mary R.**<sup>2</sup>; Boylen, D.; **Stafford, Coral L.**<sup>2</sup>; Johnson, L.L. and Collier, T. K. Use of disease challenge assay to assess immunotoxicity of xenobiotics in Fish. In: Ostrander, G.K. Eds. Techniques in Aquatic Toxicology. 2005; pp. 19-37.

**Arkoosh, Mary R.**<sup>2</sup>; Johnson, L. L.; Rossignol, P.A. and Collier, T.K. Predicting the impact of perturbations on salmon communities: implications for monitoring. Canadian Journal of Fisheries and Aquatic Sciences. 2004; 61:1166-1175.

**Arkoosh, Mary R.**<sup>2</sup>; **Clemons, Ethan R.**<sup>2</sup>; **Kagley, Anna N.**<sup>2</sup>; **Stafford, Coral L.**<sup>2</sup>; **Glass, Adam C.**<sup>2</sup>; **Jacobson, Kym C.**<sup>2</sup>; **Reno, Paul W.**<sup>1</sup>; Myers, M. S.; Casillas, E.; **Loge, Frank**<sup>2</sup>; Johnson, L. L. and Collier, T. K.. Survey of pathogens in juvenile salmon *Onchorhynchus* spp. Migrating through Pacific Northwest estuaries. Journal of Aquatic Animal Health 2004; 16:186-196.

Baker, E. T.; Lowell, R. P.; Resing, J. A.; Feely, R. A.; **Embley, Robert W.**<sup>3</sup>; Massoth, G. J., and Walker, S. L. Decay of hydrothermal output following the 1998 seafloor eruption at axial volcano: observations and models. Journal of Geophysical Research. 2004; Pt. B, 109(B1):B01205.

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**Black, Bryan A.**<sup>1</sup> and Abrams, M. D. Development and application of boundary-line release criteria. Dendrochronologia. 2004; 22:31-42.

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**Bobko, Stephen J.**\* and **Berkeley, Steven A.**<sup>1</sup> Maturity, ovarian cycle, fecundity, and age-specific parturition of black rockfish (*Sebastes melanops*). Fishery Bulletin, U.S. 2004; 102(3):418-429.

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## VI. 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	506,200			
Visitor Center Support	97,722			
Non-Sponsored Research	22,708			
Non-Sponsored Education	53,514			
Sponsored Education	47,158			
Sponsored Research	157,536			
Total Research Administration		\$ 884,838		5%
<u>Physical Plant</u>				
State Support	625,529			
Federal Support	437,753			
Other Sponsored Activity	14,000			
Total Physical Plant		\$1,077,282		6%
<u>Coastal Oregon Marine Experiment Station (COMES)</u>				
Administration	664,394			
Non-Sponsored Research	829,301			
Cost Shared to Sponsored Research	136,788			
Self-Funded Programs	183,252			
Extension	28,447			
Endowment	429,711			
Sponsored Research	3,265,070			
Total COMES		\$5,536,962		31%
<u>Cooperative Institute for Marine Resource Studies (CIMRS)</u>				
Administration	149,303			
Sponsored Research	3,838,920			
Total CIMRS		\$3,988,223		22%
<u>College of Oceanic &amp; Atmospheric Sciences</u>				
Ship Support/Operations	3,399,234			
Ship Support & Communications	29,697			
Ship Scientific Equipment	282,557			
Total Ship Operations		\$3,711,488		21%
Sponsored Research	1,000,241	\$1,000,241		6%
<u>Education Programs</u>				
Extension	483,892			
Sea Grant	302,596			
Visitors Center (self-funded)	55,151			
Sponsored Programs	39,557			
Self-Funded Programs	57,228			
Total Education Programs		\$938,424		5%
<u>Housing</u>				
Self-Funded Operations	88,117	\$ 88,117		0%
<u>Bookshop</u>				
Self-Funded Operations	183,946	\$ 183,946		1%
<u>Other</u>				
Guin Library	306,000			
OSU Foundation & Gifts	62,798			
Network Service/Computer Support	214,501			
Federal Agencies ( <i>through OSU</i> )	31,549			
Total Other		\$614,848		3%
<b>Total Hatfield Marine Science Center</b>			<b>\$ 18,024,370</b>	<b>100%</b>

***Budgets - continued***

**State & Federal Agency Budgets at**

**Hatfield Marine Science Center**

	<b><u>\$ Amount</u></b>	<b><u>Total</u></b>	<b><u>% of Total</u></b>
Environmental Protection Agency	3,000,000		16%
Oregon Department of Fish & Wildlife	4,856,887		26%
Vents Program - Federal	1,272,000		7%
Nat'l Marine Fisheries Service - NWFSC	5,612,090		31%
Nat'l Marine Fisheries Service - AFSC	1,106,000		6%
US Department of Agriculture - ARS	654,092		4%
US Fish & Wildlife Service	1,883,243		10%
<b>Total State &amp; Federal Agency Budgets</b>		<b>\$18,384,312</b>	<b>100%</b>

**FUNDING SOURCES**

**Direct State Funding**

HMSC	1,274,131		
COMES	1,658,929		
CIMRS	149,303		
Guin Library	306,000		
Extension Sea Grant	674,559		
Ship Ops	19,250		
Total Direct State Funding		4,082,172	11%

**Other State Funding**

Matching Funds (Endowments)	224,938		
Student Fees (TRF)	60,667		
Total Other State Funding		285,605	1%

**Sponsored Research and Education Programs**

Nat'l Oceanic & Atmospheric Admin. (NOAA)	4,526,523		
Nat'l Science Foundation (NSF)	4,072,722		
U.S. Dept. of Agriculture (USDA)	712,805		
Office of Naval Research (ONR)	262,337		
Department of Defense	815,068		
Department of Energy (DOE)	302,666		
Department of the Interior (DI)	16,287		
Oregon Dept. of Fish & Wildlife (ODFW)	96,433		
Other Oregon Agencies	304,434		
California Dept of Water Resources	338,765		
Foundations & Other Organizations	1,193,362		
Sub-Contracts from other Universities	312,774		
Total Sponsored Research		12,954,176	36%

**Other Funding**

Self-Funding Units	702,417		
State & Federal Agency Budgets	18,384,312		
Total Other Funding		19,086,729	52%

**Total Funding**

**36,408,682**      100%