



Sea Star

Curtailing Aquatic Introductions

Sea Grant Scientist Evaluates an Array of Ballast Water Treatment Options

By Jeff Bowman

Visit many locations within Puget Sound and you might notice numerous freighters, tankers and other large vessels from Asia, Alaska and other distant ports. These vessels deliver and receive the raw and manufactured goods that drive our region's economy. At the same time, they bring something else: millions of gallons of seawater from other ports, held in massive tanks as ballast. Each gallon of ballast water contains hundreds of small floating animals (zooplankton), thousands of plants (phytoplankton) and many times that number of bacteria and viruses.

When these vessels offload cargo, they pump seawater into their ballast tanks to offset the lost weight and maintain their trim and stability. When a vessel takes on new cargo, it must pump the water out of its ballast tanks into the surrounding harbor. The vast swarm of organisms held within the ballast water is pumped out with the water. Exotic copepods, other adult and larval invertebrates, larval fish, diatoms, protists, bacteria and viruses are among the organisms released into the surrounding environment.

The non-native crab *Tritodynamia horvathi*, taken from a ship in Puget Sound carrying ballast water from Korea (photo by Jeffery R. Cordell)

Ballast Water Treatment • continued on page 2



Such ballast water discharges have led to numerous harmful introductions of exotic species. Most notably, the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*D. rostriformis bugensis*) were introduced from Europe into the Great Lakes by shipping through the St. Lawrence Seaway. Like many other sessile aquatic organisms, these similar-looking mussels have a free-swimming stage in their life cycle, which allows them to be easily transported in ballast water.

Once an invasive species such as the zebra mussel is established in its new home, it is nearly impossible to eradicate. Between 1989 and 2002, efforts to control zebra mussels, which were rapidly clogging sewage treatment plant intakes, stormwater outfalls and other structures, cost the Great Lakes region a conservatively estimated \$1 billion. In October 2007, Washington's first citations for illegally transporting zebra mussels were issued to two out-of-state trucking companies hauling large boats to the Pacific coast. Live zebra mussels were found attached to boats being transported by a hauler from Ontario, Canada, and another from Iowa.

A Range of Treatment Alternatives

Washington Sea Grant has made the control of zebra mussels and other invasive species a priority. WSG researcher and University of Washington Associate Professor Russ Herwig works on the development and testing of systems for sterilizing ballast water on large vessels. He and Jeff Cordell, a research scientist, at the UW's School of Aquatic and Fishery Sciences, lead a group of scientists and students, formally known as the UW Ballast Water Research Team.

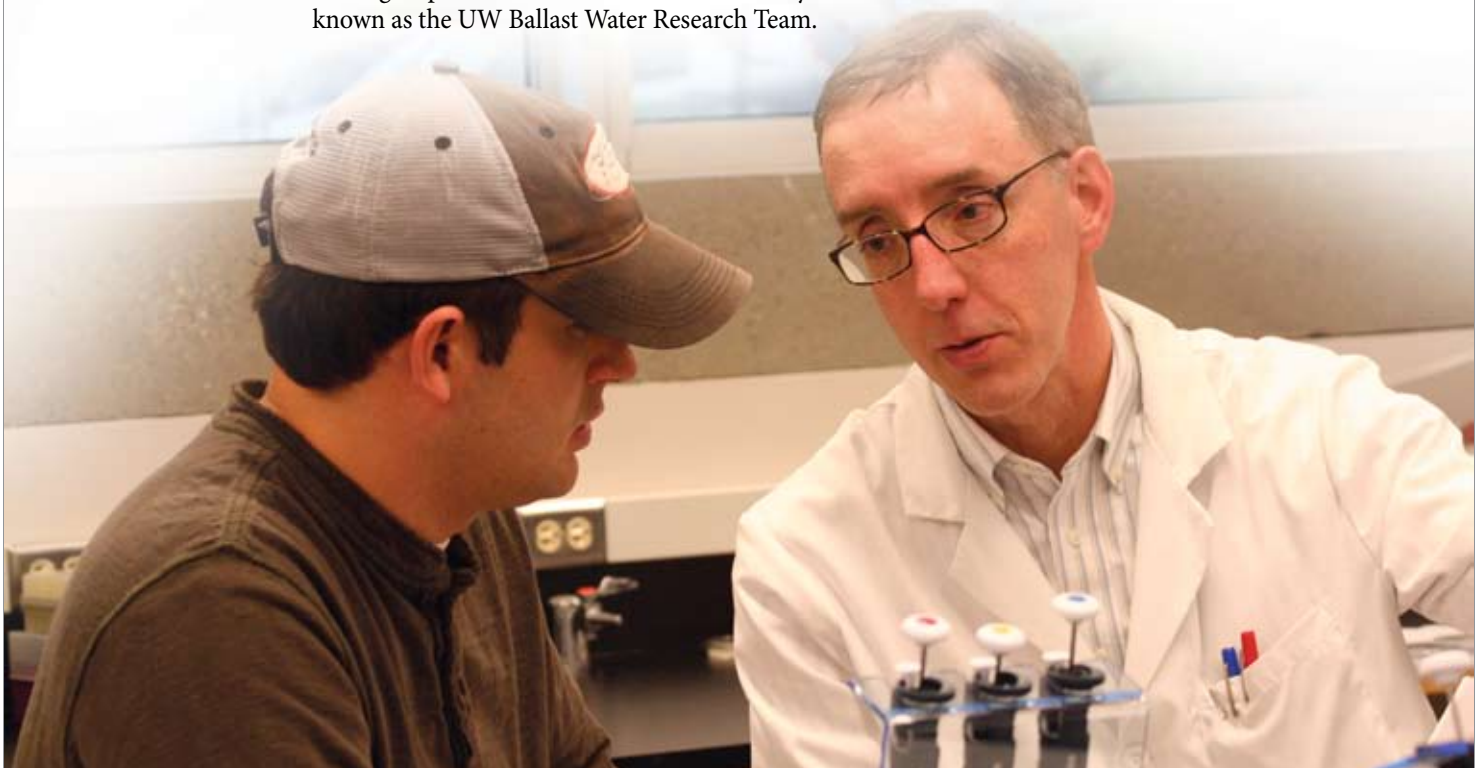
Disinfecting ballast water in a cost-effective and environmentally friendly manner is a daunting task. The most effective techniques often rely on chemicals (called biocides) to kill or inactivate the organisms and, as Herwig points out, biocide treatments need to be environmentally friendly — a challenge for any chemical.

Long-standing maritime record keeper Lloyd's of London lists 20 emerging technologies intended to solve this problem. These technologies employ a wide range of techniques for sterilizing ballast water. Because each technique produces slightly different results, the decision to adopt any particular technology will depend in large part on the ballast water standards set forth by various governing bodies.

Currently, standards for ballast water are set at state, federal and international levels. Within Puget Sound, the Washington Department of Fish and Wildlife inspects vessels for compliance with current regulations, requiring vessels to exchange ballast water off the coast before entering the state's waters. By having ships exchange ballast water offshore, it is hoped that any exotic species carried in ballast water will be diluted to levels that will prevent them from establishing new populations in Washington. The minimal level needed for establishment success is known as the "inoculation number" or the "propagule pressure." For most aquatic organisms, scientists do not know how many are required to create a successful invasion in a new environment.

Ballast Water Treatment • continued on page 4

In his Seattle laboratory, Russ Herwig consults with a UW student on matters planktonic.



Keeping Pace with Kitsap

By Jeff Adams, WSG Marine Water Quality Specialist, Kitsap County

This is the second in a series of essays, exploring the opportunities and issues addressed by Washington Sea Grant specialists in offices throughout western Washington.

Kitsap County has so much shoreline that if you were to stretch it out along Interstate 5, starting at the Columbia River, it would fall only a few miles short of needing a passport at the Canadian border. That's only one of the factors that make Kitsap County a great place to work on marine issues. Though often perceived as rural, Kitsap County is the second most densely populated county in Washington. Many residents are or have been associated with Naval Base Kitsap, the largest U.S. Navy organization in the Northwest, with installations in Bremerton, Bangor and Keyport. Many others are sailors of a different sort, arriving and departing regularly from one of the county's four Washington State Ferry terminals. Kitsap County has no large rivers but it does have a strong chum salmon population — and plenty of people interested in making a difference.

With one year under my belt as a member of Washington Sea Grant's Marine Advisory Services and a member of the Puget Sound Partnership-supported Water Quality Team, much of my effort has focused on marine shoreline landowner education. During the summer of 2007, Washington Sea Grant sponsored a day-long workshop in North Kitsap and co-sponsored several open houses with Kitsap County's Department of Community Development. These events provided shoreline landowners and users some of the resources and tools they need to be good stewards of Kitsap County's extensive shoreline. Responses from event participants and others who could not attend indicated a substantial interest in expanded outreach. I was also involved in the planning of the 14th annual Kitsap Water Festival, which in 2007 provided hands-on, water-related learning experiences to about 850 fourth graders. As it has for many prior years, Washington Sea Grant generously helped fund and staff the festival.

Aside from providing outreach opportunities in the community, I also work closely with the professionals in the county. I facilitate periodic meetings of the Kitsap Nearshore Coordination Group, allowing colleagues from agencies, tribes, non-profits and

other organizations to exchange information, coordinate projects and hear from regional experts. Many of the members of this group have also been participating in the formation of the West Sound Watersheds Council, a second regional coordinating body, which will be led by elected officials and will coordinate watershed and shoreline activities for the eastern half of Kitsap County and western part of Pierce County, south to Anderson Island. Contributing to this effort, Washington Sea Grant is helping organize a summit to explore the Council's relationship to the recently created Puget Sound Partnership and assist the Partnership's Action Agenda for restoring Puget Sound by 2020.

New opportunities also abound in Kitsap County. Interest continues to build for collaboration among Washington State University Kitsap Extension, Kitsap County Department of Community Development and Washington Sea Grant to create a county-wide beach watchers program, modeled on similar programs in north Puget Sound. A series of classes related to understanding, appreciating and caring for Puget Sound shorelines would be offered to potential beach watchers. Upon completion of the initial part of the program, full-fledged beach watchers would then volunteer for shoreline-related projects.

Also, thanks in large part to the leadership of the Home Builders Association of Kitsap County, the region has been a low-impact development leader, incorporating low-impact development into existing stormwater regulations to facilitate their broader use. Promoting the use of available tools and practices for reducing stormwater runoff is a great opportunity to reduce impacts of storms on water quality, public health and our pocketbooks.

Lastly, aquatic invasive species issues have been a recurring education and research theme that can be traced back to my high school days. I intend to use that experience and interest to expand efforts at raising public awareness and facilitating action related to the risks, challenges and solutions to aquatic invasive species issues within Kitsap County and the Puget Sound region.

For more information on these and related topics, please contact me at 360.337.4619 or jaws@u.washington.edu.



Jeff Adams



Field Notes

MAS Specialists Sarah Fiskén and Steve Harbell, MAS Program Leader Pete Granger and UW graduate student Mark Gleason are conducting a survey of meat cutters and seafood department managers in several local grocery chains to prioritize their retail seafood training needs. Coordinated by the Meat Business Apprenticeship Program of South Seattle Community College and the United Food and Commercial Workers International Union, the survey will help MAS staff design a seafood training program for apprentice meat cutters later this year.

Washington Sea Grant has renewed its role as a member of Clean Marina Washington. This program certifies marinas that comply with national environmental standards. Other participants include the Northwest Marine Trade Association, Puget Soundkeeper Alliance, Washington Department of Ecology and EnviroStars Cooperative. For information: **Eric Olsson, Oil Spill Prevention Education Specialist**, 360.221.4636 or olsson@u.washington.edu.

Natalie Graves is WSG's new Science Writing Fellow. She is a graduate student in the UW's School of Marine Affairs and a former Green Building intern with King County's Wastewater Treatment Division. "With my degree from the School of Marine Affairs, I hope to obtain a career that connects the greater public with their surrounding environment," says Graves, who has previously studied sustainable practices in Australia and Costa Rica.

An article by Education Specialist Nancy Reichley and Education Coordinator Julie Hahn will appear in the next issue of *Current: The Journal of Marine Education*. Published by the National Marine Educators Association, the article describes Washington Sea Grant's involvement with NOAA Science Camp. *Current* is a peer-reviewed publication that represents the work of its marine education membership across the nation.

Ballast Water Treatment • continued from page 1

"It is not clear whether an exchange alone removes enough organisms to push all species carried on a vessel to a number that will prevent an invasion," says Herwig. "Furthermore, the process is time-consuming and can be dangerous to vessels, particularly on stormy seas." Because of the ship's and crew's safety concerns, commercial vessels are sometimes permitted to bypass the open ocean exchange and discharge unexchanged water into their destination port's waters.

Recent treatment standards adopted but not yet enforced by the International Maritime Organization (IMO), an agency of the United Nations, will require near-complete eradication of all organisms in ballast water before it is discharged. A certain number of countries need to ratify the ballast water standards before they become "in force" by the international community. Meanwhile, California and Washington are moving ahead to adopt their own ballast water discharge standards since the United States does not have discharge standards. These strict requirements may favor the use of biocides. The use of biocides presents a huge challenge to developing an environmentally friendly ballast water treatment technique. "How do you kill the hardest organisms in ships' ballast without killing the most fragile organisms in the surrounding environment when the treated water is discharged?" asks Herwig.

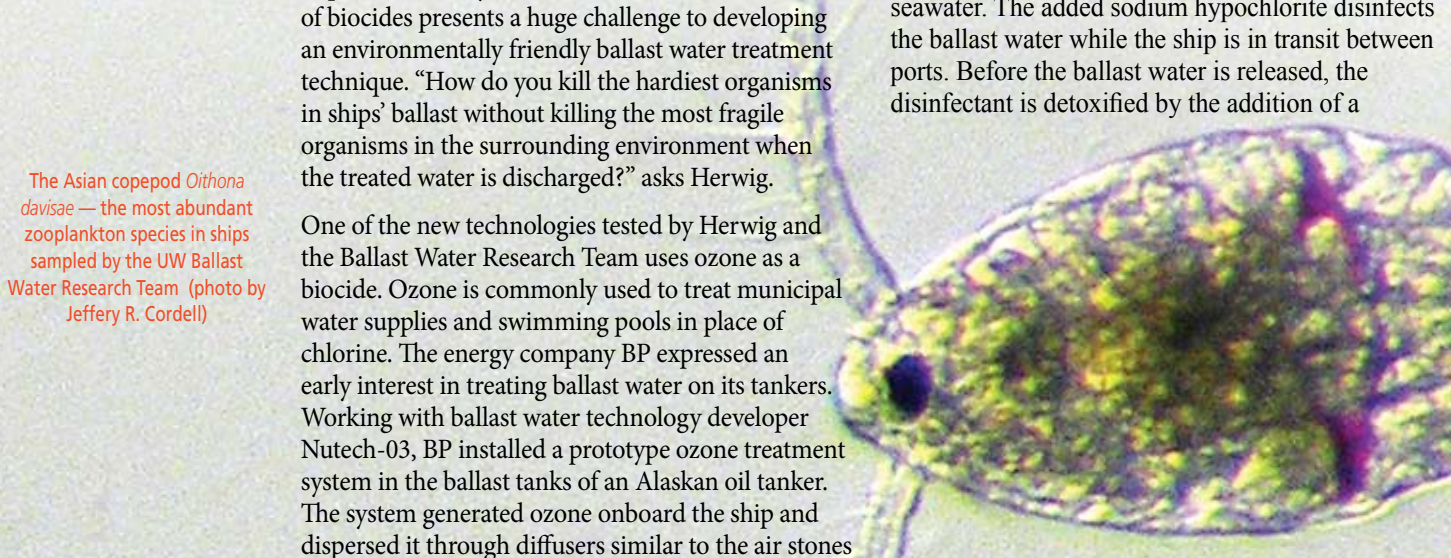
One of the new technologies tested by Herwig and the Ballast Water Research Team uses ozone as a biocide. Ozone is commonly used to treat municipal water supplies and swimming pools in place of chlorine. The energy company BP expressed an early interest in treating ballast water on its tankers. Working with ballast water technology developer Nutech-03, BP installed a prototype ozone treatment system in the ballast tanks of an Alaskan oil tanker. The system generated ozone onboard the ship and dispersed it through diffusers similar to the air stones

used in home aquariums. The team found that the effects of ozone throughout the treatment were not consistent. "Our results were very promising," recalls Herwig. "But the vendor and research team concluded that the use of diffusers in ballast tanks was not the best method for introducing ozone into ballast water."

Fortunately, the BP ship test did demonstrate the willingness of corporate partners to work with researchers toward solving the ballast water problem. So long as solutions are cost- and time-effective, ship owners and operators are generally willing to help.

Electrochlorination, UV Light and Vitamin K₃

Herwig's team is now testing additional technologies. One of the more promising is an electrochlorination system manufactured by Severn Trent De Nora of Sugarland, Texas. This technique takes advantage of a ship's ability to produce the biocide sodium hypochlorite, commonly known as bleach, by passing an electric current through seawater. The added sodium hypochlorite disinfects the ballast water while the ship is in transit between ports. Before the ballast water is released, the disinfectant is detoxified by the addition of a



The Asian copepod *Oithona davisae* — the most abundant zooplankton species in ships sampled by the UW Ballast Water Research Team (photo by Jeffery R. Cordell)

Marine Habitat Specialist Jim Brennan was recently named President of the Pacific Estuarine Research Society, a regional branch of the national Estuarine Research Federation. PERS is a non-profit organization intended to bring together persons actively engaged in estuarine and coastal research and management on the Pacific coast of North America to exchange ideas and knowledge for educational purposes.

A new updated electronic version of the crabber/towboat lane charts is now available. The charts delineate navigable tug and barge lanes through the crabbing grounds between Cape Flattery and San Francisco. The charts are available in three different formats — P-Sea Windplot, Maptech and Nobeltec — for compatibility with the specific types of onboard navigation equipment being used. For more information, contact **Steve Harbell, WSG Marine Field Agent**, at 360.875.9331 or sharbell@u.washington.edu.

WSG Communications helped edit, design and produce a series of 10 technical reports for the Puget Sound Nearshore Partnership, a cooperative effort among the U.S. Army Corps of Engineers and local sponsors, including state and federal government organizations, tribes, industries and environmental groups. The reports examine the status of orcas, nearshore birds, juvenile salmon, native shellfish and other valued ecosystem components of Puget Sound. They are available as downloadable PDFs on the PSNP Web site, pugetsoundnearshore.org/technical_reports.htm.

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neutralizing chemical. Although highly effective at reducing invasive species in ballast water, chlorination highlights the difficulties presented by several biocide agents. Even after the neutralizing treatment, some harmful disinfectant byproducts may be produced, albeit at very low concentrations that may not be of concern.

The Ballast Water Research Team has looked at other biocides that try to get around this problem by using chemicals with short half-lives — that is, degrade quickly in the environment. Vitamin K₃ or menadione, for example, has been developed for use as a ballast water biocide under the trade name SeaKleen® and manufactured by the firms Vitamar LLC and Garnett, Inc. It can be introduced at a toxic level and then allowed to degrade to a level safe for release while the ship is in transit. Unfortunately, the team found that SeaKleen® did not degrade quickly enough in the cold waters of the Pacific Northwest. In addition, while SeaKleen® was found to be effective on zooplankton and other large ballast water invaders, it may not be as effective on small ones such as bacteria and phytoplankton.

Some other technologies have proven effective at controlling ballast water invaders with little risk to the environment. Ultraviolet (UV) light is commonly used in hospitals and laboratories to kill

bacteria. Large flow-through systems that pump ballast water past super-sized UV lamps on ships have proven effective at sterilizing ballast water, especially when combined with a filter that removes larger organisms. The Ballast Water Research Team was surprised to find that, over time, this technique reduced the number of bacteria *and* large ballast water invaders.

The problem with UV light is the regrowth of bacteria, reports Herwig. “To achieve the best results using UV light, water must be pumped through the system as it is brought aboard and as it is expelled from the vessel,” he explains. Additional concerns have been raised about the durability of the large UV lamps used in these systems, which must endure constant vibration and be kept clean during long voyages. Despite these concerns, UV light treatment may emerge as the technology of choice for small- and medium-sized vessels if it is effective enough to pass strict IMO and other regulatory guidelines. As the current technologies continue to improve and new technologies emerge, Herwig and other members of the Ballast Water Research Team will continue to provide scientifically sound testing and development. “That’s what we do best and what’s put us ahead of programs in other states,” says Herwig. “I work with a great team of scientists who are working together to solve an environmental problem, thanks to the continued support from Washington Sea Grant.”



UW Ballast Water Research Team members collect samples aboard a vessel anchored in Puget Sound.

Editor’s note: As this issue of Sea Star goes to press, the Ballast Water Research Team stands ready to test the Severn Trent De Nora electrochlorination ballast water system on a petroleum tanker in the Gulf of Mexico in February.

New Cyber Classroom: Olsson Puts Oil Spill Training Online



Eric Olsson

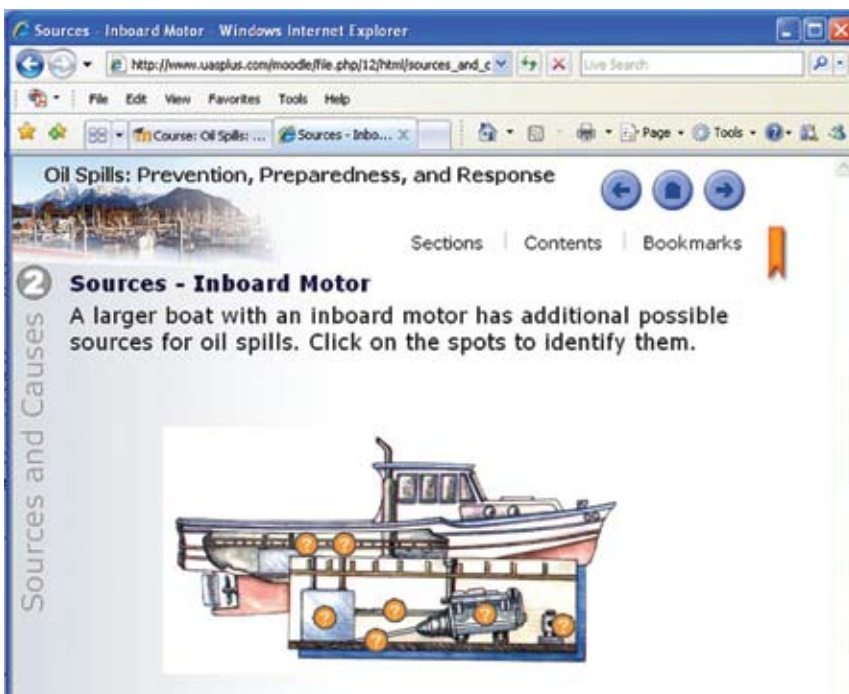
By Ben Larson, WSG Science Writing Fellow

A new distance-learning course, Oil Spills: Prevention, Preparedness and Response, is now available. It was developed by Eric Olsson, WSG's Oil Spill Prevention Education Specialist, with strong technical support from the University of Alaska Southeast (UAS), for inclusion in its Career Training for Ports and Marinas suite of online classes. Olsson serves as the course's online instructor.

"The course introduces students to some of the prevalent causes and toxic attributes of oil spills and increases their awareness of the environmental and economic consequences of polluting marina and boat operations and maintenance," says Olsson. "After completing the course, port and marina workers, in addition to students seeking entry-level employment in the industry, will be better prepared to deal with the small spills that contribute substantially to polluting our waters."

Funding for curriculum development and design of the fledgling course came from an Alaska Department of Education grant. According to Olsson, the Pacific Coast Congress of Harbormasters and Port Managers (PCC) is collaborating with UAS to provide this online training to marina and port employees throughout Alaska, British Columbia, Washington, Oregon and California. PCC plans to issue its own certificates acknowledging satisfactory completion of the UAS courses and other PCC certification requirements.

An interactive Web page from Olsson's online course invites students to pinpoint the sources of spills.



There are few available options for getting this type of marina-oriented training. Existing in-class training courses cater more to senior marina management and can cost \$2,500 or more for registration fees, travel and lodging. "Paying \$150 to \$200 for an online course is so much more cost-effective," says UAS program director Mary Purvis. This UAS career development program is also more convenient, reaching broader, more diverse audiences.

It took Olsson, Purvis and her team two years to develop the oil spill course and two other courses for port and marina workers. The three courses have only been available for a short while and, to date, enrollment has been sparse. That will soon change, Purvis notes. Harbormaster Ray Majekski of Sitka, Alaska, who was instrumental in the program's launch, is planning to have all of his employees participate in this Internet training. Eventually, UAS will offer 11 different courses, each dealing with an aspect of the maritime industry, including customer service.

Olsson's oil spill course consists of an interactive set of lectures on topics that range from oil toxicity to spill prevention. In one section, students can click on the components of recreational and commercial boats to learn more about the ways that oil slowly seeps into the marine environment. In another activity, they can investigate the sources of a hypothetical spill, using the Washington Department of Ecology's event form to record the details of its origins, which could range from a leaky hydraulic system to dripping gas pump nozzles at fueling stations.

"The class gets at the heart of what Washington Sea Grant's spill prevention program is all about: the recognition that small spills are a big problem and that the only sure way to protect our marine resources is through spill prevention," says Olsson.

Course material is supplemented by a "virtual textbook," with links to the best available online information. The course Web site also features online quizzes, writing assignments and bookmarking capability, so students can learn at their own pace.

Should online students need more guidance, there's a pre-recorded message from Olsson that encourages them to contact him by e-mail. "It's just like raising your hand in class," Olsson says in the recording.

In this case, the classroom is the entire West Coast.

For more information, contact Olsson at 360.221.4636 or olsson@u.washington.edu, or visit the UAS Web site: www.uasplus.com/moodle.

Be an Orca Bowl Booster!

Share the excitement as an Orca Bowl volunteer on Saturday, February 9, at the UW's Seattle campus. Hosted by WSG and the UW College of Ocean and Fishery Sciences, Orca Bowl is Washington's regional competition of the National Ocean Sciences Bowl program. This Jeopardy-style academic challenge attracts teams from across the state. In addition to regional prizes, the winner receives an all-expenses-paid trip to the national competition, to be held April 25 - 27 in Seward, Alaska.



For more information about Orca Bowl, visit wsg.washington.edu/education/events/orca.html. To volunteer, contact Veronique Robigou at 206.543.9282 or vero@ocean.washington.edu.

Marine Refrigeration Workshops

Saturday, March 15, and Saturday, April 12, at the Port of Port Townsend.

These one-day courses are for commercial vessel owners and operators and focus on general maintenance, controller programming, charging with Freon and thermal expansion valve adjustment. A 7 1/2-ton refrigeration unit will be used as a training aid during class.

The fee for the workshop is \$25. Space is limited, so pre-registration is advised.

To register or for more information, contact Sarah Fiskén, Continuing Education Coordinator, Washington Sea Grant, 206.543.1225 or sfisken@u.washington.edu.

Growers Gathering, March 3 and 4

Business and environmental considerations of growing, harvesting, marketing and distributing oysters, clams, mussels and scallops is the focus of the 16th Conference for Shellfish Growers, March 3 and 4 at the Little Creek Casino Resort in Shelton, Washington. Conference attendees will hear informative and practical presentations by experts from the shellfish industry, government and academia.

For more information or to register, contact Washington Sea Grant at 206.543.6600 or seagrant@u.washington.edu.



Fifth Annual Wild Seafood Exchange

For the fifth year in a row, Washington Sea Grant will co-sponsor the Wild Seafood Exchange, an all-day event organized by *Fishermen's News*. This educational and networking event is geared for commercial fishermen interested in or currently marketing their catch directly to retailers, restaurants and consumers. The all-day program will be held on February 21 at Seattle's South Lake Union Courtyard by Marriott. Some fishermen may qualify for registration subsidies through Washington Sea Grant.

"This is an excellent chance for fishermen, either already engaged in direct marketing or thinking about it, to network with others," says Pete Granger, WSG's Program Leader for Advisory Services. "It's also a great chance to meet buyers who want their products." For more information, contact Granger, 206.685.9261 or pgranger@u.washington.edu or visit the conference Web site, www.wildseafoodexchange.com/index.html.

Coming Soon

16TH CONFERENCE FOR
SHELLFISH
GROWERS

Deadlines Near for Four Sea Grant-Administered Fellowships

Washington Sea Grant is soliciting applicants for a variety of fellowships in 2008. "These fellowships offer exciting and valuable opportunities for graduate and postgraduate students to apply what they have learned in school to real-world marine research and policy, and to advance their own careers," says Nancy Reichley, WSG's Education Specialist.

The Dean John A. Knauss Marine Policy Fellowship provides eligible graduate students a one-year work experience on the staff of the U.S. Congress or with a federal agency addressing marine issues. The application deadline is February 29, 2008.

The Coastal Management Fellowship matches postgraduate students with state coastal zone programs to work on projects proposed by the state and selected by NOAA's Coastal Services Center. The application deadline is January 28.

The Sea Grant/NOAA Fisheries Fellowship offers two- and three-year research opportunities to Ph.D. candidates interested in either population dynamics and stock assessment or in marine resource economics. The application deadline is January 25.

The newly created **WSG Science Writing Fellowship** is for undergraduate and graduate students to assist in the development of a number of communication products about Sea Grant projects in marine research, education and outreach. One fellow is selected for each of three quarters during the academic year. Applications for the 2008 Spring Quarter fellowship are due on January 28.

For more information about these fellowships, visit the WSG Web site: wsg.washington.edu/education/fellowships/index.html or contact Nancy Reichley at 206.685.8302 or reichn@u.washington.edu.



Two distinguished former fellows: WSG Director and 1985 Knauss Fellow Penelope Dalton (left) and Education Specialist and 1984 Knauss Fellow Nancy Reichley (right).



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BALLAST WATER TREATMENT
OIL SPILLS ONLINE
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