

Sea Star

Hiding from Hypoxia

How fish and invertebrates seek safety from lethal conditions in Hood Canal

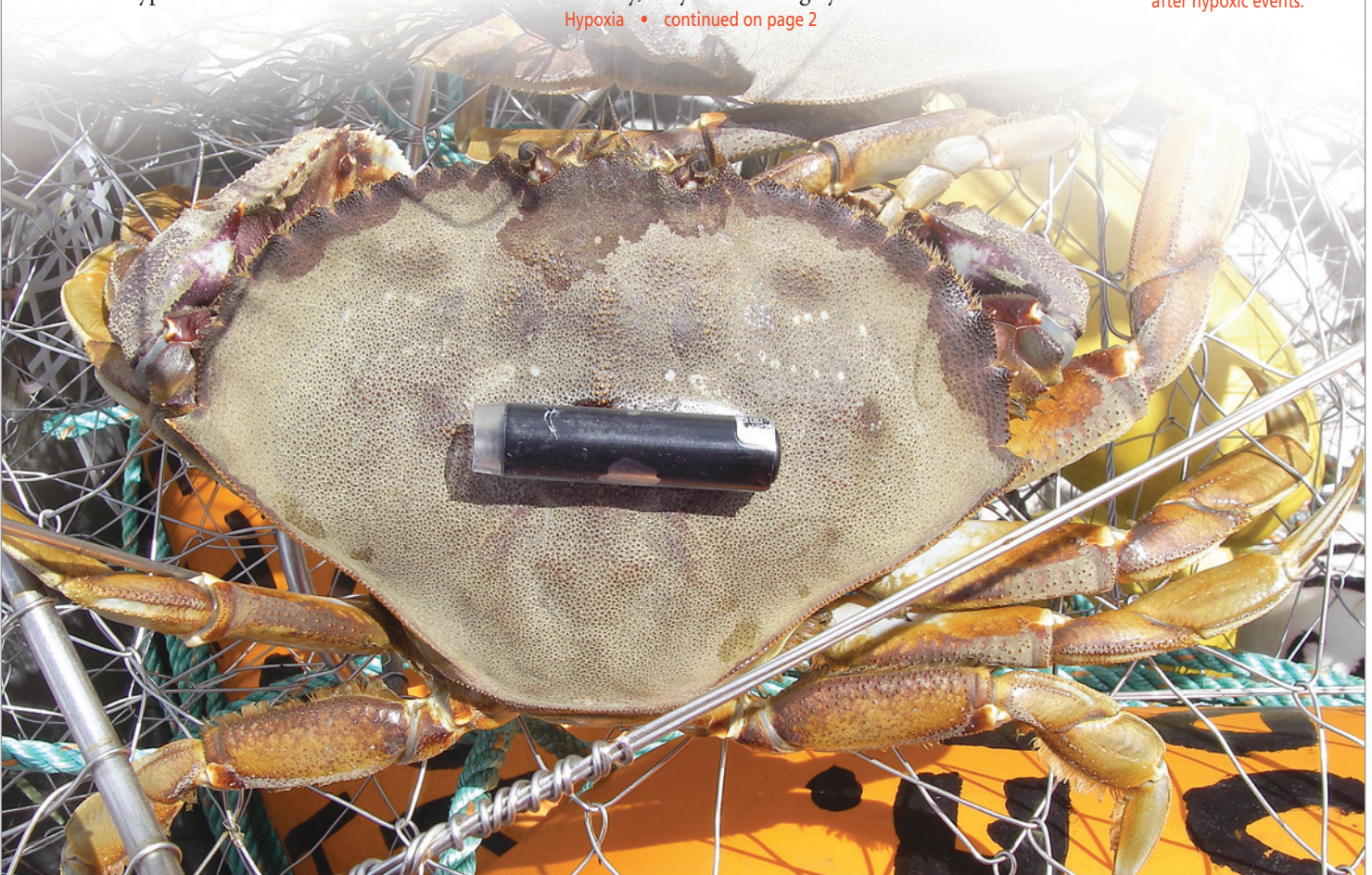
By Rachel Aronson, Autumn 2012 WSG Science Writing Fellow

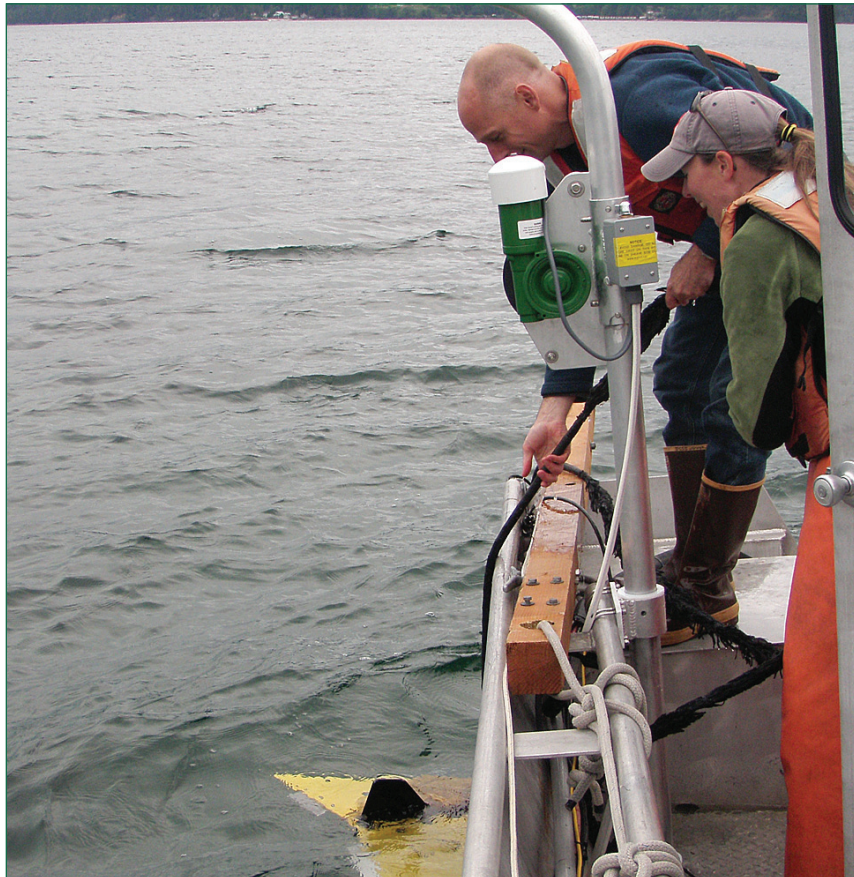
Hood Canal is best known for its salmon, shellfish and, increasingly, fish kills — those widely reported mass die-offs of sea life, traced to hypoxic, or low-oxygen, water conditions. Recent research funded by Washington Sea Grant is showing that before an actual fish kill occurs, there are mass migrations of certain sea creatures trying to escape the Canal's hypoxic conditions.

“Fish kills are devastating but, in the grand scheme of things, they’re relatively rare,” says Timothy Essington, an associate professor at the University of Washington’s School of Aquatic and Fishery Sciences. “Our research has indicated that, well before there’s any fish kill, there are widespread ecological changes going on. We just don’t see them happening so, until recently, they’ve been largely overlooked.”

Hypoxia • continued on page 2

Wearing battery-powered electronic transmitters, Dungeness crabs provide data about their movements before, during and after hypoxic events.





Essington oversees operation of a waterproof receiver as it gathers signals from the transmitters below.

Essington’s WSG-funded research in Hood Canal looked closely at the effects of hypoxia as animals try to avoid them. Are the fish, crabs and other animals all cramming into a few overcrowded hypoxia-free zones? Are they forced to move to subpar habitats? Can they still live, grow and reproduce like they did before hypoxic conditions became a frequent feature of Hood Canal?

Hypoxia mainly happens in southern Hood Canal in the summer. Warmer temperatures and fewer north-to-south winds combine with human-generated sources of nitrogen entering the water.

Nitrogen fuels algae blooms. The algae produce oxygen via photosynthesis during the day, but at night they respire, using up the oxygen. When the algae die and sink to the bottom, bacteria eat the remains — an activity that further consumes oxygen — robbing fish, crabs and the other marine animals of the oxygen they need. Under extreme conditions, a fish kill may ensue.

“The animals that don’t have an ability to get out of the way are the most impacted,” says Essington. “Those animals include the geoduck clam (*Panopea generosa*), which is by far the most valuable to shellfish harvesters. There is some pretty convincing evidence that they’ve suffered very large mortality rates due to the hypoxia that’s occurred over the past many years.”

Essington and his students wanted to find out if mobile organisms, such as English sole (*Parophrys vetulus*) and Dungeness crab (*Metacarcinus magister*), can avoid hypoxic conditions by moving northward to more oxygen-rich water. In a one-year blitz of field work, the researchers put an extensive array of 45 stationary hydrophone receivers at two sites — Bamban, in the south Canal near Hoodport, and Hamma Hamma, in the north Canal near Liliwaup.

Acoustic telemetry is a data-collecting technique that gives researchers a continuous map of animal movement underwater. Battery-powered VEMCO V9 transmitters, each a small cylinder about 30 mm long and 9 mm in diameter, are attached to study animals. The team surgically implanted them in English sole and glued them to Dungeness crabs.

Each transmitter sends out a unique transmission, or ping, to the network of receivers, which interprets the pings as the location of a specific animal at a specific time. Some transmitters are also pressure-sensitive and able to send information about an animal’s depth at the time of the ping. Over time, the ping data can be collected into a four-dimensional map of underwater animal movement over space, depth, and time. The receivers are even Bluetooth-equipped for easy data access in the field.

One more receiver was pulled around on a boat to fill in the gaps between the shore and the network of stationary receivers. For an additional source of data, the research team did visual surveys. They turned to an underwater video camera, which was fitted with bright lights and lasers and dragged behind a boat for a visual count of animals in the study sites.

Says Essington, “Our study sites have never been covered this thoroughly and probably will never be covered this thoroughly again. We can say with high confidence that one of our tagged organisms was in our study site or not in any given week. It’s really unusual to have that level of coverage.”

The next step for Essington and his partners is to find out what the seasonal shifts in animal distribution mean for “the ecological engine that we call food webs,” as he puts it. “My guess is that there are winners and losers.” Some animals might be exposed to predators (including humans) that they don’t normally see. Other animals, surprisingly, might actually gain from hypoxic conditions.

“Imagine you’re a polychaete worm,” explains Essington. “You’re stuck in the mud and hypoxia is coming in, so you need to extend your body and start flailing your gills around to get the oxygen you need, and that makes you really vulnerable to polychaete-eating English sole. So, if a predator can tolerate hypoxia, areas with low dissolved oxygen

could, in theory, be great places to forage.”

Halley Nelson, a student of Essington’s, is developing a test for proteins called hypoxia-inducible factors (HIFs). Animals that have recently been exposed to hypoxic conditions express HIFs to cope with low-oxygen conditions. A test for HIFs would help scientists learn if some animals are purposefully making forays into low-oxygen water.

Another hopeful result from the study is the distribution of Dungeness crabs, which are generally thought to be doing well in Hood Canal. Essington was initially concerned that what he calls “herds of crabs” were being forced out of deeper water by low-oxygen conditions, right into the waiting traps of eager humans. The team found that crab spatial distribution was relatively unchanged by hypoxia, and the animals were neither more nor less likely to be caught in crab pots.

Essington and his team plan to wrap up their analysis of their data by midwinter and then begin to present it at conferences.

This study is the best look to date at how hypoxia is changing the lives of animals in Hood Canal in ways previously invisible to us. “Hypoxia is one of the hot-button issues people talk about when they talk about the health of Hood Canal. Working on this project, it was very clear how understanding how animals move around has immediate importance and also feeds into the broad question of what we should be doing about hypoxia,” says Essington. This research will help provide policy makers and citizens with the best science for tough decisions about water treatment, stormwater collection, agricultural fertilization and the other ways we put nutrients into the Canal.

Hypoxia takes over more of Hood Canal’s waters for a longer period every summer. This research project gives us the clearest image to date of how animals are relocating themselves around hypoxic waters. As policymakers and citizens around Hood Canal debate ways of limiting human-produced nitrogen entering the water, work like this gives them the concrete knowledge that they need to produce policy based on the best available science.

For additional information on this project, contact Tim Essington at 206.616.3698 and essing@uw.edu.



UW associate professor Tim Essington contemplates a lion’s mane jelly, a common inhabitant of Hood Canal, during a recent cruise.

Sea Grant in Cyberspace

Follow Washington Sea Grant on Facebook (www.facebook.com/WaSeaGrant) and get the latest news about calls for proposals, upcoming workshops and other important program highlights online. While you’re there, visit WSG’s YouTube channel (www.youtube.com/user/WashingtonSeaGrant) for a growing collection of video clips offering visual introductions to beach walking, seabird bycatch avoidance and more.

Help shape WSG’s future — and enter a raffle for one of three \$50 Made In Washington gift cards. Complete the brief online survey at wsg.washington.edu/strategy.html.





In December 2011, WSG's Marine Education Coordinator Sarah Fiske, Marine Field Agent Steve Harbell and Oil Spill Prevention Education Specialist Eric Olsson held a 10-hour coldwater survival and safety training course for staff of the Cascadia Research Collective, a nonprofit organization addressing the protection and management of marine mammals. "Because Cascadia operates in a very different way than commercial fishermen, we modified our regular training schedule to focus on topics that were most relevant," explains Harbell. "Much of their work

is done on small inflatable boats, creating significant challenges in dealing with various emergencies while operating miles offshore." As such, the training was particularly valuable in helping them develop an effective plan to deal with emergency situations. "All of the participants improved their knowledge, skills and preparation for at-sea emergencies, including much needed equipment upgrades," says Harbell. For more information on upcoming training opportunities, visit WSG's online Calendar of Events, wsg.washington.edu/mas/calendar_of_events.html.

WSG extends a fond farewell to Katrina Hoffman, who accepted the position of president and CEO of Prince William Sound Science Center in Cordova, Alaska, this past December. Until her position as WSG Coastal Resource Specialist is filled, Hoffman's role as project coordinator for the Green Shores for Homes project (described in the Autumn 2011 *Sea Star*) will be taken over by WSG Citizen Science Specialist Kate Litle. WSG Marine Water Quality Specialist Teri King will help coordinate The Shoreline and Coastal Planners Group, a collaborative project of WSG and the Washington

State Department of Ecology, during the interim. Contact Litle or King at kalittle@uw.edu or 206.616.0151 and guatemala@uw.edu or 360.432.3054 respectively.

Welcome aboard to UW School of Marine Affairs graduate student Emily Davis, WSG's Winter 2012 Science Writing Fellow. For her 10-week fellowship, she will join Fall 2011 Fellow Rachel Aronson, a graduate student at the UW School of Marine and Environmental Affairs, who was asked to continue for a second quarter — a WSG Science Writing Fellowship first. Aronson shared her initial fellowship quarter

New WISE Program Targets Northwest

By Adrienne Sussman, WSG Communications Intern

A new program, headed locally by Washington Sea Grant's Jeff Adams, is helping K-12 teachers in Washington become stewards of their local waterways. The Watersheds and Invasive Species Education (WISE) program is designed to educate teachers about aquatic invasive species — the plants and animals that are accidentally spread beyond their native ranges by human activity and cause harm to our economy, health or environment. "The program will build a network

of teachers and foster and support their interest in invasive species education," says Adams. "A more specific goal is to stop teachers from adding to the problem whenever they release invasive animals from their classrooms."

Many Washington educators use crayfish in their classrooms to teach about behavior and morphology, according to a recent Sea Grant survey. Unfortunately, the most commonly used species, rusty crayfish (*Orconectes rusticus*) and red swamp crayfish (*Procambarus clarkii*), pose serious threats to the freshwater and brackish water environments in the Pacific Northwest and are prohibited under Washington law. For a limited time, the Washington Department of Fish and Wildlife is providing a special permit to allow schools to possess live specimens of red swamp crayfish until they can be replaced outright by the native signal crayfish (*Pacifastacus leniusculus*) or a different kind of organism. Rusty crayfish are simply not allowed in the state alive.

Teachers who order crayfish from biological supply stores might be unaware that they are breaking Washington state law.

Why such a fuss over a crayfish? Historically, after their science projects are over, some well-meaning teachers or students have released these animals into local waterways where the non-native crayfish can outcompete native animals for food, space and other resources. Even a single released crayfish can be dangerous to native ecosystems, as female crayfish are able to store sperm and, later, lay large numbers of fertilized eggs. When these eggs hatch, the offspring can rapidly establish permanent populations. Even if teachers use the signal crayfish, they should avoid releasing them. Specimens from other areas may introduce diseases to local populations. Because of this potential for damage from released crayfish, Adams, says, "the do-not-release ethic is something we need to consistently promote."

The WISE program extends beyond crayfish, however. Through talks and field trips, the program trains a small group of teachers about the full range of aquatic ecological issues in Washington. After the training, program coordinators brainstorm with participating teachers to design classroom activities and stewardship projects for the coming year. In Oregon, where the program was developed, WISE collaborations have resulted in projects that involve students and their communities. Oregon teachers have used the program and its resources to get involved with local media, form outreach campaigns and involve their students in restoration efforts.

with Laura Geggel, currently enrolled in the Science, Health and Environmental Reporting Program at New York University. For more information or to apply for the Spring 2012 fellowship, contact Dan Williams, WSG Communications Manager, 206.616.6353 and dw7@uw.edu.

Pete Granger, WSG Marine Advisory Services program leader, and Suzanna Stoike, WSG-sponsored West Coast Sea Grant Fellow, are helping to coordinate planning for the Working Waterways and Waterfronts symposium scheduled for March 2013 in Tacoma. Oregon Sea

Grant and other West Coast programs will also be assisting with this three-day event of nationwide scope. For more information, contact Granger at pgranger@uw.edu or 206.685.9261.

Three WSG-nominated 2012 Dean John A. Knauss Marine Policy Fellows have been assigned to offices in Washington, D.C. **Dan Crowther**, a graduate of Washington State University's School of Earth and Environmental Sciences, is now working with the Office of Marine Transportation Systems Management Directorate (U.S. Coast Guard). UW School of Marine and Environmental

Affairs (SMEA) graduates **Rebecca Jablonski-Diehl** and **Meghan Massaua** are fellows in the Office of U.S. Representative Madeleine Bordallo (Guam) and at the U.S. Department of Energy, respectively. All three assignments are for one year.

Closer to home, four 2012 Marc Hershman Marine Policy Fellows have been placed for one year in offices in Olympia and Tacoma: **Heather Gibbs** (SMEA) with the Department of Natural Resources, **Clara Hard** (SMEA) with the Department of Health, **Bridget Trosin** (SMEA) with the Washington Department of Ecology and

Allison Osterberg (Evergreen State College's Master of Environmental Studies Program) with the Puget Sound Partnership. For more information on these and other WSG-sponsored fellowships, contact WSG Education Specialist Nancy Reichley at sgfellow@uw.edu or 206.685.8302.

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Non-Native Crayfish

“Some of the projects that were done in Oregon are certainly inspiring, and we look forward to seeing what the teachers here come up with and supporting and promoting their projects,” says Adams.

Adams hopes that the reception to the WISE program in Washington will be similar to Oregon's, where it has produced ongoing relationships with individual teachers and school districts. The first Washington WISE session took place in Bremerton this past November and was run jointly by Sea Grant collaborators from Oregon, California and Washington. According to Adams, the collaborative planning process alone has proven enlightening, as outreach coordinators from all three states have been able to learn about the issues facing neighboring regions.

One of the WISE program's central messages is prevention. This is the most important line of defense against aquatic invasive species because control and eradication are costly and have limited success. Moreover, due to limited funding, eradication efforts tend to be temporary or periodic and are often no match against persistent invaders. The most effective programs prevent invasive organisms from being introduced in the first place. For invasive crayfish, this means banning importation of problem species, posting warning signs on some waterways and continuing education efforts by Washington Sea Grant.

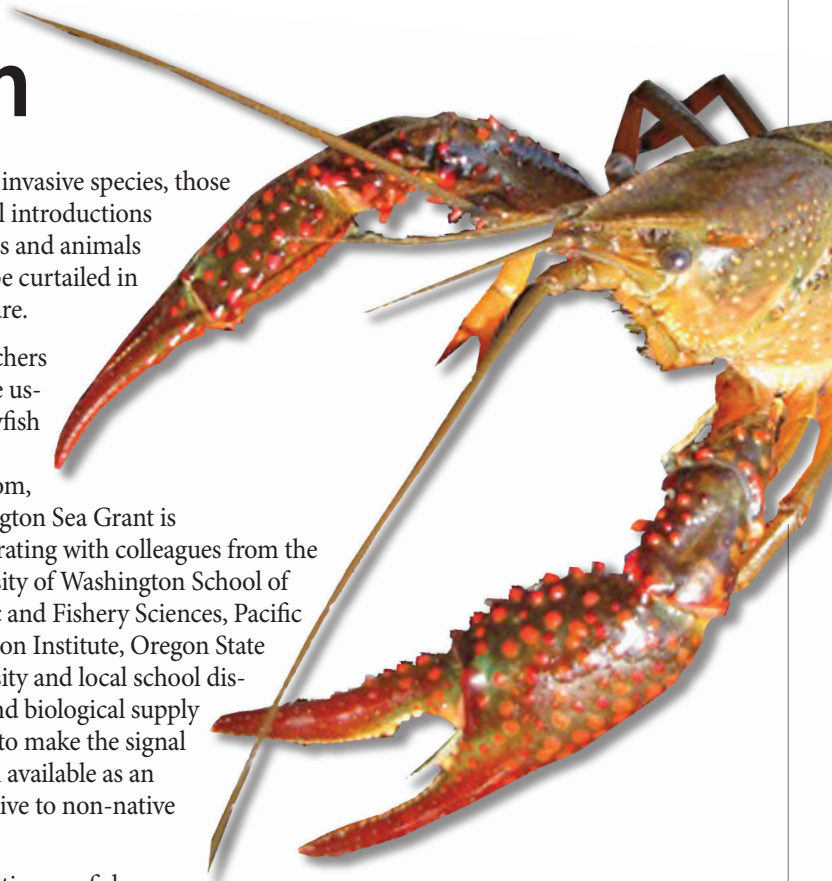
“Prevention delivers the biggest bang for the buck, but all too often we tend to react to whatever the current problem is,” said Adams. That's why outreach efforts that teach general stewardship practices are so crucial to protecting Washington aquatic systems from invaders: if more citizens understand the ecology of

aquatic invasive species, those harmful introductions of plants and animals might be curtailed in the future.

For teachers who are using crayfish in the classroom, Washington Sea Grant is collaborating with colleagues from the University of Washington School of Aquatic and Fishery Sciences, Pacific Education Institute, Oregon State University and local school districts and biological supply houses to make the signal crayfish available as an alternative to non-native species.

“The native crayfish poses some unique problems for classroom use, as it is not easily bred in captivity. We've focused on increasing survival rates during shipping and in the classrooms,” says Adams. “A lesson plan incorporating invasive species education and stewardship can allow teachers to meet their education requirements while reinforcing concepts of local ecology, stewardship and conservation of Washington waters.”

For more information, contact Jeff Adams, WSG Marine Water Quality Specialist, at 360.229.9398 or jaws@uw.edu.



Red swamp crayfish
(*Procambarus clarkii*)

New Marine Research Projects Selected for Funding

For additional information on these projects, contact Penny Dalton, Director, at pdalton@uw.edu or 206.543.6600 or Raechel Waters, Assistant Director for Research, at rlwaters@uw.edu or 206.685.8209.

Washington Sea Grant will fund 11 new research projects from 2012 to 2014, addressing a variety of issues and challenges facing the region's marine environment. In addition, WSG will continue to fund two ongoing projects and contribute to two new West-Coast-wide social science projects.

WSG selects, funds, oversees and manages marine-related projects carried out by academic and research institutions throughout Washington. For 2012-2014, WSG has about \$2.29 million for research. In January 2011, scientists submitted 66 preliminary proposals seeking more than \$13 million collectively over the biennium. The selected projects emerged after a rigorous 10-month review process by peer reviewers, two external scientific panels, the WSG Advisory Committee and organization staff.

The new projects are as follows:

- **Troubled Sediments: *Heterosigma* Cyst Formation and Longevity**
Rose Ann Cattolico, Professor, UW Biology Department
- **Acoustic Propagation Measurement and Modeling in Puget Sound to Support Noise Environmental Impact Efforts**
Peter Dahl, Principal Engineer, UW Applied Physics Laboratory
- **Governing Complex Environmental Commons: Stakeholder Partnerships in Salmon Recovery in Washington, Oregon and California**
Nives Dolsak, Associate Professor, UW School of Marine and Environmental Affairs
- **Effects of Early Exposure of Pacific Oysters to Ocean Acidification on Subsequent Performance**
Carolyn Friedman, Professor, UW School of Aquatic and Fishery Sciences
- **Using Zebrafish to Assess the Health Effects of Persistent Pollutants in Pacific Salmon**
Evan Gallagher, Associate Professor, UW Environmental and Occupational Health Sciences
- **Understanding Dormancy Requirements and Germination of *Alexandrium* Cysts and Evaluating Cyst Mapping as a Tool for Early Warning of Harmful Algal Blooms**
Cheryl Greengrove, Associate Professor, Interdisciplinary Arts and Sciences, UW Tacoma
- **Local Adaptation in Puget Sound Pacific Cod**
Lorenz Hauser, Associate Professor, UW School of Aquatic and Fishery Sciences
- **Effects of Ocean Acidification on Trophically Important Crustacean Zooplankton of Washington State**
Julie Keister, Assistant Professor, UW School of Oceanography
- **Using Microbiota for the Evaluation and Monitoring of Puget Sound Ecosystems**
Elizabeth Nesbitt, Curator, Burke Museum Invertebrate Paleontology Division, and Associate Professor, UW Earth and Space Sciences Department
- **Recovery of Elwha River Salmon and Trout after Dam Removal: Recolonization and the Awakening of Dormant Life-History Diversity**
Thomas Quinn, Professor, UW School of Aquatic and Fishery Sciences
- **Effects of Waterfront Stormwater Solution Prototypes on Water Quality Runoff in Penn Cove, Town of Coupeville**
Nancy Rottle, Associate Professor, UW Landscape Architecture

Continuing Projects

- **Impacts of Armoring on Puget Sound Beaches: Diverse Effects on Diverse Scales**
Megan Dethier, Research Professor, Biology, UW Friday Harbor Laboratories
- **Partitioning Multiple Pressures Impacting Southern Resident Killer Whales**
Sam Wasser, Research Professor and Director, Center for Conservation Biology, UW Biology Department

West Coast Social Science Projects

- **Social and Economic Effects of Individual Fishing Quotas on the West Coast Groundfish Fishery: Solving the Weak Stock/Bycatch Problem**
Christopher Costello, Professor, UC Santa Barbara (regional lead); Trevor Branch, Assistant Professor, UW School of Aquatic and Fishery Sciences (Washington lead)
- **Successful Adaptation: Identifying Effective Process and Outcome Characteristics and Practice-Relevant Metrics**
Pamela Matson, Professor, Stanford University (regional lead); Amy Snover, Research Scientist and Co-Director, UW Joint Institute for the Study of the Atmosphere and Ocean (Washington lead)

Washington's Far-Reaching Shellfish Initiative

In December, Governor Chris Gregoire and NOAA Administrator Dr. Jane Lubchenco unveiled the Washington Shellfish Initiative, an agreement among federal and state government, tribes and the shellfish industry to restore and expand Washington's shellfish resources to promote clean-water commerce and create family-wage jobs.

The new initiative calls for:

- Expanding, promoting and improving shellfish aquaculture in Washington
- Increasing opportunities for and improving access to public tidelands for recreational shellfish harvesting
- Restoring native shellfish habitat and populations such as the Olympia oyster and pinto abalone
- Improving and protecting water quality to help ensure healthy and safe shellfish for consumers.

Aquaculture Coordinator Teri King and several other WSG staff will assist in implementation of the initiative. WSG activities will include hosting a public symposium to share latest scientific research findings on the possible environmental effects of shellfish production, continuing an outreach program to encourage proper boat sewage discharge, and supporting new research to assess the risk of toxic algal blooms in Puget Sound.

WSG will also be involved in efforts to understand and counter the effects of ocean acidification, providing support for a blue-ribbon panel on the topic. Composed of scientific experts, government agencies, tribes, shellfish growers and others, the panel will provide recommendations to address the growing problem in Washington's marine waters. In addition, WSG is increasing its support for ocean acidification research and will fund an investigation of the effects of corrosive waters on the later life stages of larval Pacific oysters.

"The Washington Shellfish Initiative is the first regional implementation of a national effort to increase the commercial production of shellfish and restore native shellfish habitats and populations," says Lubchenco. "NOAA's contribution... supports an ambitious partnership to rebuild native Olympia oysters and to regain the important ecological, cultural and economic benefits from a viable, sustainable shellfish industry in the Pacific Northwest."

"We're enthusiastic about being a part of this federal and state partnership to support Washington's aquaculture industry," says WSG Director Penny Dalton. "The state's combined harvest of farmed clams, mussels and oysters is worth more than \$100 million annually. The industry employs more than 3,200 people and pumps more than \$270 million into the state economy each year."

For additional information on the shellfish initiative, contact Dan Williams at 206.616.6353 or dww7@uw.edu.



Orca Bowl teams and judges wear creative costumes, adding spice to the already colorful event.

Teens to Gather for Orca Bowl '12

On the morning of Saturday, March 3, 16 teams from 12 Washington high schools will gather on the University of Washington campus in Seattle for Orca Bowl '12, the regional competition of the National Ocean Sciences Bowl®. Newcomers to this annual event include Tacoma Science and Math Institute (one team) and Ellensburg High School (two teams).

All Orca Bowl teams receive prizes for participation, with top awards that include UW Oceanography scholarships and shipboard science experiences. The event also provides opportunities for students to meet university and ocean community scientists, faculty, staff and student volunteers. The winning team will travel, all expenses paid, to the National Ocean Sciences Bowl finals in Baltimore, Md., in April 2012.

Opportunities for sponsors and day-of-the-event volunteers are still available. For details, contact Maile Sullivan, WSG Education Specialist, at 206.543.2822 and mailesul@u.washington.edu.





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WINTER 2012

HOOD CANAL HYPOXIA
NON-NATIVE CRAYFISH
NEW RESEARCH PROJECTS

On the Horizon

The 19th Conference for Shellfish Growers

March 5-6 at Alderbrook Resort & Spa in Union, WA

This WSG-sponsored event brings together representatives from the shellfish industry, tribes, government and academia to discuss shellstock storage, weather monitoring, half-shell oysters, diarrhetic shellfish poisoning and numerous emerging issues. Check out the conference agenda and register online at www.wsg.washington.edu/shellfish_conf_12.html.

19TH CONFERENCE FOR SHELLFISH GROWERS

Beyond the Ivory Tower Seminar Series

Select Mondays through May, from 3:30 - 4:30, at Foege Auditorium, Foege Building (Genome Sciences) on the UW Seattle campus

Co-sponsored by Washington Sea Grant and the Centers for Ocean Science Education Excellence — Ocean Learning Communities, this series of presentations is focused on broadening the impacts of scientific research. Admission is free and refreshments follow each presentation.

March 5th

Best Practices for Translating Research for K-12 Audiences

March 26

Connecting with Stakeholders: Secrets of Success

April 16th

Research in Cyberspace: A Tale of Three Websites

May 7th

Informing and Influencing: Sharing Your Science with Decision Makers

For more information: wsg.washington.edu/communications/news_releases/notices/BroaderImpacts2012.pdf or contact Susan Bullerdick at coseeolc@uw.edu.

