A National Oceanographic Partnership Program Award

Partnership for Modeling the Marine Environment of Puget Sound, Washington – Ocean Inquiry

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Long-Term Goals

Estuaries, fjords and sounds are important, major components of marine ecosystems worldwide. Because of this, and their generally poor treatment by humans, large estuaries should be the focus of large-scale, multidisciplinary, integrative modeling efforts. We need to both understand how these systems work, and be able to predict how they will respond to changes, whether natural or anthropogenic. Puget Sound, Washington State's largest inland sea, is both the largest fjord in the lower forty-eight states and closest to the substantial urban centers of Seattle, Tacoma, Everett and surrounding communities. Relative to other coastal systems, Pacific Northwest fjords have seasonally high annual phytoplankton standing stock and primary production, and they support several economically valuable fisheries. Our long-term goals are to develop quantitative understanding of the seasonal and longer time-scale variability of the Sound's circulation, roles of water column stratification, nutrients, and light (and their interactions) on phytoplankton and zooplankton dynamics, and the sensitivity of the physical and the biological system to natural and human perturbations. We will develop models of Puget Sound that can aid agencies with responsibilities for environmental management in making informed decisions and serve as marine science education tools.

Objectives

The Partnership for Modeling the Marine Environment of Puget Sound consists of five separate organizations: University of Washington (School of Oceanography and College of Education), King County Department of Natural Resources, Washington State Department of Ecology, Puget Sound Naval Shipyard, and Ocean Inquiry Project. The partnership will develop, maintain and operate a system of flexibly linked simulation models of Puget Sound's circulation and ecosystem, a data management system for archiving and exchanging oceanographic data and model results, and an effective delivery interface for the model results and observational data for research, education and policy formulation. The interface, model results and observational data will be accessible to all members of the partnership as well as to the regional and oceanographic community. The partnership engages in research activities aimed at developing fundamental understanding of the Sound's working, as well as addressing practical questions raised by the regional community concerning management of the Sound and its resources. The partnership will function as an estuarine research node within the NOPP Ocean Information Commons.

Approach

The Partnership is administered from the School of Oceanography, University of Washington (UW). The lead P.I., Mitsuhiro Kawase, is responsible for project oversight and coordination. Ocean Inquiry Project personnel include P.I. Stahr and Christian Sarason, Program Director.

They are involved with the Partnership's Education and Visualization team, consisting of themselves and investigators from the UW College of Education (W. Winn and R. Fruland) and UW Human Interface Technology Laboratory (P. Oppenheimer). This team's primary responsibility is developing a simple web interface and associated curriculum for the models and data collected by the Partnership. Stahr is coordinating OIP activities regarding curriculum development and Partnership interaction, and Sarason is focusing on the development of the web interface.

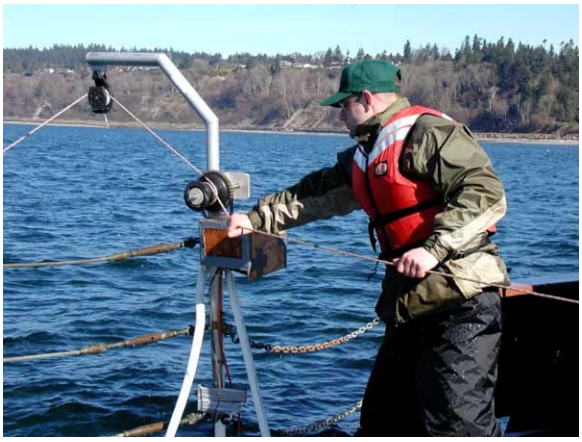

Figure 1: An OIP student participant helps gather CTD data on Puget Sound, WA. [Man uses winch to help pull CTD in from Puget Sound.]

Work Completed

The Education and Visualization Team has been meeting weekly to coordinate and work on various tasks. These fall into four broad categories: 1) moving the "Virtual Puget Sound" (VPS), a 3-D navigable learning environment based on Kawase's numerical model, from an SGI computer to a PC-based platform, 2) developing curricula using model output and VPS, as well as OIP's in-situ techniques, to educate students about circulation and oceanographic properties of Puget Sound, 3) developing assessment techniques that can measure learning in these environments, and 4) developing a browser-based interface for all (students and partners) to examine model and real data generated by the Partnership. A good start has been made on all of these, as well as working with other teams in the Partnership, such as the Aquatic Biogeochemistry (ABC) modeling team. OIP team members are primarily involved in the second and fourth activity, but are advising on all of them. The team will present a poster at the fall American Geophysical Union meeting showing past educational research results using the VPS learning environment as well as plans for its use in the present partnership.

OIP performed two cruises with an updated curriculum after funding became available in late FY02. This curriculum is a start at implementing ideas generated at the Education and Visualization team's weekly meetings; feedback from these cruises will help us to further improve the curriculum in FY03. In addition, OIP took delivery of a SeaBird 911+ CTD. This instrument will significantly improve our at-sea curriculum, and allow us to address more complicated questions; we are planning the first cruise with this instrument for October 12th, 2002. Data collected during two summer cruises (June 29th and August 19th, 2002) using an instrument from the UW Oceanography shared equipment pool has been shared with Kawase at

UW as a first effort at model verification. Higher quality data collected with our new CTD will be shared as soon as available.

Results

Results for FY02 center primarily around the creation of the Education and Visualization team, as well as design work on curriculum and evaluation techniques associated with the different types of models being created and linked by the Partnership. The most important feature of the curriculum is a design that will allow students to discover modeled phenomena for themselves, rather than just observing model runs and memorizing the significance of certain visualizations. Educational research performed using the VPS learning environment will be presented at the fall AGU meeting. The poster will highlight the importance of student discovery and exploration with the model in order to learn and retain oceanographic concepts. During FY03 OIP will develop simple web visualizations of model runs designed to facilitate this type of learning.

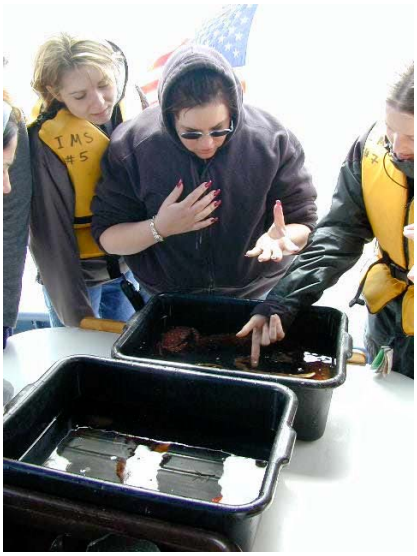

Figure 2: OIP students get up close and personal with benthic organisms from Puget Sound. [Woman viewing starfish in tub of water.]

Impact and Applications

National Security

The environmental security of the marine environment of Puget Sound (and by extension the people of the Pacific Northwest) is vulnerable to both natural hazards and acts of terrorism. Through our regional collaboration and partnership between academia and government institutions we will improve our ability to address the five major stages of Emergency Management – Planning, Preparedness, Response, Recovery, and Mitigation. An improved modeling capability of the circulation and marine ecosystem will help local and regional government devise procedures to deal with, for instance, chemical/biological attacks involving harmful agents that may be/need be flushed down into our marine waters, and with terrorism aimed at military and industrial installations that may result in environmental contamination.

Economic Development

From the coastal marine fisheries and aquaculture to shipping and municipal waste management, the Puget Sound economy depends upon its marine resources. Our modeling partnership is

designed to specifically address the temporal and spatial variability of these resources, understanding of which will aid businesses better plan their operation and improve productivity and efficiency. Prediction and early warnings will be a natural outcome of our work: For instance, forecasting of harmful algal blooms (HABs) in the Sound will help shellfish growers better deal with this threat to their livelihood. Detailed knowledge of currents and hydrography will help diving operators with their underwater work.

Quality of Life

A better understanding of the Sound's circulation and an ability to model it will have positive impact on all aspects of the maritime life in our region. The Puget Sound region has always enjoyed a quality of life directly related to the quality of it's environment. Yet our economic and social systems stress the resiliency of both the terrestrial and marine resources. Our project provides a major tool in understanding the trade-offs between regional scale actions and impacts to the ecological function of the marine environment. The sustainability of historical land use, recreational opportunities, shoreline development, and nearshore and marine economies, all characterize the Puget Sound quality of life. To sustain that quality we must understand the likely response of the marine environment to potential stressors. Oceanographic knowledge also has direct uses and benefits for those who work and live at sea. For instance, knowledge of currents will help Coast Guard and regional law-enforcement agencies with search and rescue operations and contaminant spill containment; it will also help recreational boaters make better decisions.

Science Education and Communication

The results of our model will allow us to contribute in important, innovative ways to emerging applications of information technology to formal and informal education. With the aid of suitable visualizations, support material, and curriculum modules, our model results will be a valuable tool for learning about Puget Sound's marine environment that can be used in classroom settings as well as by the public at large in museums and through the web. This work is making important contributions to educational technology generally. Also, the curriculum these technologies support is problem-based and student-centered. Research has shown that this kind of curriculum is the most effective. Our work therefore extends current "best practices" in science teaching to marine education. Finally, our materials allow students to work with real data, rather than "toy" datasets and learning systems so often used in schools. This puts us in the position of being able to help move science education towards studying the marine environment in its true complexity, which will reduce many common misunderstandings about how it works. Our work to date with museums and other forums for informal education will make it easier for us to deploy these materials where they will be accessible by the general public.

Transitions

National Security

We are developing a suite of models for Puget Sound's circulation, variously based on Princeton Ocean Model, EFDC and CH3D, as well as a marine biogeochemistry model of an original design. We are also developing an information infrastructure, based on Distributed Oceanographic Data System (DODS) and the NSF UNIDATA Internet Data Distribution (IDD) system, through which our modeling results and oceanographic data we hold are exchanged. A web-based access interface for users outside as well as inside the partnership will be created.

Municipalities and regional agencies needing to develop strategies to protect citizenry, properties and the environment in the event of an attack will be able to utilize our model results for their planning via the interface, and partnership members will assist them in use and interpretation of model results and oceanographic data.

Economic Development

The same interface to our information infrastructure will be available for the region's marine businesses as well as consultant working on their behalf. Again, partnership members will provide technical assistance with use and interpretation of model results and oceanographic data.

Quality of Life

Our informational interface and expertise will be available to all members of the Puget Sound maritime community, including municipalities, regional governments, tribes; environmental organizations; recreational boaters and divers; and others. In addition to the interface to the information infrastructure, which will primarily be aimed at technical audience, our web site will also feature visualizations of the models aimed at the general public, along the same line as web sites that feature outputs of numerical weather prediction models.

Science Education and Communication

We are developing technologies and techniques that will allow students to engage in relatively sophisticated online interactions with visual and textual material, built from the results of our model. Our more complex simulations of Puget Sound, currently stand-alone, allow students to interact with visualizations in hitherto unprecedented ways. This work extends earlier development of immersive and desktop virtual environments that allow students to interact with dynamic three-dimensional visualizations of Puget Sound in order to learn key concepts in environmental science. A prototype of this "Virtual Puget Sound" was demonstrated at American Geophysical Union Fall 2003 Meeting in San Francisco. We are also developing problem-based, student-centered curriculum that uses web-based and stand-alone visualizations and simulations, which will be used in an introductory oceanography course in a community college in the Spring Quarter of 2003. Over the course of the grant, we will build and test a variety of units of this kind in classes ranging from middle school to undergraduate level.