2006-2316: NANOOS-PILOT: A COLLECTION OF OCEAN OBSERVING TOOLS FOR IMPROVING OCEAN SAFETY AND COASTAL DESIGN

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NANOOS-Pilot: a collection of ocean observing tools for improving ocean safety and coastal design

Abstract

The NANOOS-Pilot project (Northwest Association of Networked Ocean Observing Systems) is an ongoing effort to develop coastal ocean observing assets for the integrated observation of the estuaries and shorelines of the Pacific Northwest. The project is actively building nowcast and predictive capabilities for this environment, as well as interactive access to archival data, real-time data, and selected forecasts. In addition to the potential benefits accrued to the many sectors that depend upon the coastal waters of the Pacific Northwest, there are a number of education opportunities related to ocean observatories involving undergraduate and graduate institutions, K-12 schools and adult literacy programs. In this work, we describe some ocean technology applications of the NANOOS-Pilot and focus on the educational use of the system in a senior-level Civil Engineering course on Coastal Infrastructure.

Background

The development of NANOOS will benefit many sectors that depend upon the coastal waters of the Pacific Northwest, including marine shipping; transport/spill remediation; search and rescue; fisheries and aquaculture; marine recreation; coastal county planners; natural resource managers; homeland security; and research and education institutions. These stakeholders will have access to the information and real-time environmental data we generate through a number of mechanisms, such as web and ftp sites, newsletters, and public presentations.

There are enormous education opportunities related to ocean observatories involving undergraduate and graduate institutions, K-12 schools and adult literacy programs. These institutions are important users of data and knowledge generated within the NANOOS-Pilot project. For example, real-time regionally specific oceanographic data can be used for interactive educational exhibits at museums, and science centers and these efforts will contribute to building a constituency of educated citizenry. In addition, the development of the national Integrated Ocean Observing System will bring benefits to coastal engineering practice, because it will be a tremendous source of site-specific environmental data for use in coastal design projects.

Finally, within the NANOOS-Pilot project we are developing unique remote sensing capabilities for coastal ocean observing based on X-band marine radar technology. Remote sensing technology offers the ability to sample large areas synoptically and non-intrusively and shore-based remote sensors offer much longer dwell times, while avoiding the problems of deploying in-situ instruments in difficult and sometimes hazardous sampling environments. Furthermore, shore-based systems are inherently more mobile and easily deployable than offshore buoys. We will describe our initial application of this technology at the mouth of the Columbia River in the Pacific Northwest.

Summary of Ocean Observing Components

The leading partners in the NANOOS-Pilot project are:

- Oregon Department of Geology and Mineral Industries

- Oregon Health & Science University
- Oregon State University
- South Slough National Estuarine Research Reserve
- University of Washington
- US Geological Survey
- Washington Department of Ecology

The project objectives are to:

- Create a regional observation backbone for the estuaries and shores of Oregon and Washington
- Create a regional ocean & estuarine modeling backbone system
- Create a cross-site data and communications system
- Create cross-site quality metrics
- Develop cross-training mechanisms
- Proactively engage the regional community
- Proactively participate in the design of national Integrated Ocean Observing Systems

Our geographic focus is the coastal ocean and estuaries of Oregon (OR) and Washington (WA). Presently, observation efforts concentrate on five estuaries South Slough in Coos Bay, OR; Columbia River, OR-WA; Willapa Bay and Grays Harbor, WA; and Puget Sound, WA; and on three littoral cells Columbia River; Rockaway, and Netarts, OR. The NANOOS-Pilot effort is specifically focused on the role of climate change and anthropogenic activity on: (a) estuarine water quality; (b) estuarine ecosystem management and restoration; and (c) coastal storms and erosion, and objective scientific information on status, trends and susceptibility of estuaries and shorelines are essential to address each issue.

One example of a NANOOS component that has an impact on coastal engineering practice is the establishment of a shoreline observation network in the Rockaway littoral cell (Cape Meares to Tillamook Head). The Oregon Department of Geology and Mineral Industries is performing beach surveys across this cell approximately bimonthly and after major storm events. In addition, large-scale surface mapping is ongoing biannually at three locations along the Rockaway Cell. These highly detailed beach state-change data and their associated products are being disseminated among coastal managers, regulatory authorities, and the public. These types of data provide an essential basis for coastal engineering study and practice.

Columbia River Wave Observations

Another NANOOS component that will have an impact on coastal engineering practice is the development of a new wave observing system for the Columbia River entrance. The traditional engineering disciplines concern themselves with the study of forces, and engineering design/practice essentially involves how structures respond to forces generated within the Earth's interior, or by the movement of people and vehicles, or by the ocean and atmosphere. As far as the ocean is concerned, the primary force generators are surface waves and the Pacific Northwest is well known for its extreme wave conditions.

Oregon has eleven major ports and harbors. These facilities are essential pieces of the economic and transportation infrastructure in this state, and engineering clearly plays a role in maintaining these structures and supporting their related activities. Moreover, the navigational entrances to Oregon harbors are often quite hazardous. Entering the Port of Portland requires traversing the mouth of the mighty Columbia River, and the Columbia River bar is known as one of the most dangerous river bars in the world[1]. Not to be outdone, the anglers of Tillamook Bay (Port of Garibaldi) cite the Tillamook Bar as one of the most dangerous crossings on the Pacific Coast[2]. The recent tragedy of the capsizing of the *Taki-Tooo* at Garibaldi testifies to the seriousness of this claim.

The monitoring and prediction of energetic wave conditions at harbor entrances is not only an issue of practical interest for navigational safety but also presents several technical and scientific challenges. On the technical side, it is challenging to measure the wave conditions because not only are the waves highly energetic, which makes it a difficult place to maintain instrumentation, but the waves also show strong spatial variability. Hence, a single in-situ wave sensor can only crudely characterize the changes in the wave conditions across estuarine bars.

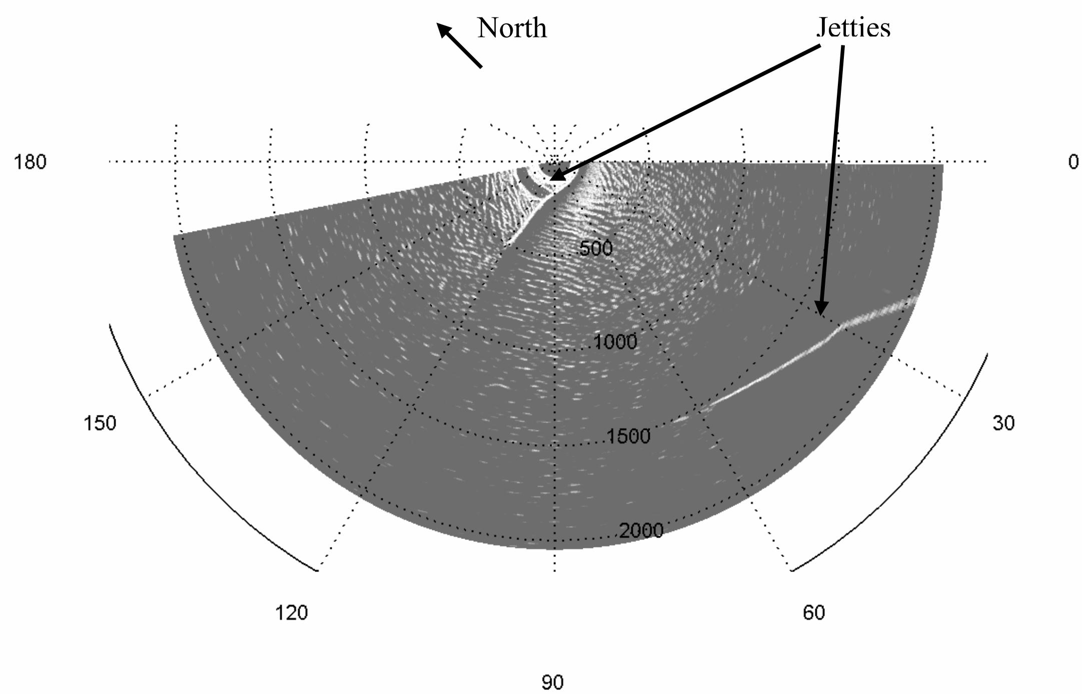

Figure 1: Snapshot radar image from the mouth of the Columbia River.

Marine radar systems (X-band imaging radars) were originally developed as a navigational aid for obstacle avoidance, and the signal they receive from the ocean surface (“sea-clutter”) is typically suppressed for navigation. However, with modifications to allow digitized recording of the signals, commercial marine radars can be used for observing ocean wave conditions[3]. The data collected by these systems consists of time series of radar backscatter intensity that describe the sea surface in space and time with imaging ranges of O(km) and resolutions of O(10 m). Presently, Oregon State University is developing an autonomous, remote-powered, marine radar wave imaging system to be deployed at the mouth of the

Columbia River in order to provide real-time wave observations through the NANOOS observatory. Figure 1 shows a single radar image that represents a plan view of the mouth of the Columbia River. The north and south jetties appear as the E-W trending, bright linear features. The radar was located at the center of the image and waves propagating into the river mouth are appear as bright linear features that are closely spaces and trending N-S.

Impact on Coastal Engineering Practice & Education

The main practical impact of this wave observing system is to provide wave information that can be used to improve the safety of marine operations. Improving marine safety at primary navigational entrances is a topic of interest to a wide variety of coastal user groups such as the commercial fishing industry, international shippers, and recreational boaters to name a few. It should be emphasized that, presently, no real-time wave observations from this area are available. This is due to the aforementioned difficulties in deploying in-situ instrumentation in environments such as this. Hence, at this stage, the best predictor of wave conditions at this entrance is a combination of the limited environmental data and the intuition of the experienced mariner. However, techniques for estimating wave directions and periods from these marine radar image sequences are well established. In addition, once the system is calibrated, we will utilize these data to provide estimates of wave height and to identify the presence of breaking waves.

Furthermore, the data obtained from this radar system will serve to inform engineering decisions regarding the Columbia River jetties. The U.S. Army Corps of Engineering is charged with maintaining navigational entrances and we are working with them in terms of planning our deployments and disseminating our results. These data can support their channel maintenance activities and help in locating dredge disposal sites.

These image sequences of the sea surface will also serve as a powerful teaching tool for both seasoned researchers and beginning students alike. For example, these images will allow concepts previously illustrated only by description and diagrams (e.g. wave refraction and diffraction) to be demonstrated to students using real data. The phrase 'A picture speaks a thousand words' is most applicable in this instance. In addition, these data will be actively incorporated into our senior civil engineering technical elective Coastal Infrastructure (CE 415/515). This course engages students in a coastal engineering design project based on a real-world problem from the Pacific Northwest. The last two years the topic has been the design and maintenance of the Columbia River jetties.

References

[1] *Columbia Bar Pilots Association*
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[3] Robinson, I.S., N.P. Ward, C.P. Gommenginger, and M.A. Tenorio-Gonzalez, Coastal oceanography applications of digital image data from marine radar, *J. Atmos. and Oceanic Tech., 17*, 721—735, 2000.