Progress Report for the Enhancement of the
Northwest Association of Networked Ocean Observing Systems (NANOOS)
Regional Coastal Ocean Observing System (RCOOS)

1) Award Information: Provided as a separate Cover Sheet.
Reporting period: 01 Oct 2009 – 31 Mar 2010

2) Project Summary

NANOOS is engaged, through NOAA funding, in an active process to develop, implement, and integrate various in-water and land-based systems that will constitute a fully robust and user-driven Regional Coastal Ocean Observing System (RCOOS) for the Pacific Northwest (PNW). This includes all necessary sub-systems to provide PNW, west coast, and national stakeholders with the ocean data, tools, and knowledge they need to make responsive and responsible decisions appropriate to their individual and collective societal roles. Our ongoing knowledge of prioritized issues and user needs is gained through proactive NANOOS interactions with a wide range of PNW stakeholders.

To attain the goals of this project, with adjustments for funding realities, we are:

- **Maintaining existing surface current mapping capabilities and evaluating the use of additional HF radar sites in the PNW.** This tool is a fundamental foundation block for building an observing system for the coastal ocean and serves a multitude of disparate users – regrettably, reductions in anticipated NOAA IOOS funding have to this point prohibited additional HF sensors throughout the NANOOS coastline (into WA).
- **Maintaining observation capabilities in PNW estuaries.** The NANOOS objective in this arena is a federated real-time observation network across Oregon and Washington estuaries to address PNW societal needs.
- **Strategically maintaining coverage and range of observations in the PNW shelf, in coordination with emerging national programs.** We have targeted the use of fixed (buoys) and mobile (glider) assets to provide advanced information on hypoxia/anoxia and Harmful Algal Blooms (HABs), which are major regional concerns affecting ecosystem and human health, fisheries, and coastal economies.
- **Maintaining core elements of existing beach and shoreline observing programs in Oregon and Washington.** This is improving coastal hazard mitigation by providing better decision support tools for coastal managers, planners, engineers, and coastal hazard mitigation decision makers.
- **Evaluating the creation of a federated system of numerical daily forecasts of PNW ocean circulation.** We are extending utility and availability of operational models from the head of tide of estuaries to the outer edges of the exclusive economic zone (EEZ).
- **Bolstering ongoing Data Management and Communications (DMAC) activities to support routine operational distribution of data and information.** Our DMAC design mandates a collaborative, dynamic distributed system of systems that provides a wide range of products, tools, and services to regional user communities while allowing unfettered access to the IOOS national backbone and national information infrastructure.
- **Building from and strengthening ongoing NANOOS education and outreach efforts.** We are conducting these in coordination with other regional efforts (e.g., NSF-funded STC and COSEE projects), to foster ocean literacy and facilitate use of NANOOS products in the PNW by stakeholders, decision makers, and the general public.

The above summation points delineate a specific NANOOS RCOOS focus on high-priority PNW user-driven applications of: **a) maritime operations; b) ecosystem impacts including hypoxia and harmful algal blooms; c) fisheries; and, d) mitigation of coastal hazards** as these issues represent applications having the greatest impact on PNW citizenry and ecosystems and, we believe, are amenable to being substantively improved with the development of a PNW RCOOS.

3) Progress and Accomplishments -- ***See also tabular milestone chart at end of this report.***
NANOOS reports in this section in the fashion it adopted in the original proposal; specifically, we divide our progress report into sections of our efforts in: a) observing systems (further divided because of our coastal environment into shelf, estuaries, shorelines, and currents); b) modeling (again divided further into estuaries and shelves; c) Data management and Communications (DMAC); and finally, d) Education and Outreach. We list specific accomplishments in bullet form in each of these areas below and follow in Appendix 1 with a tabular representation of progress to toward our milestones at this point. Administrative efforts orchestrating this RCOOS effort are reported separately in our NANOOS RA progress reports.

a) Observing System efforts

- **Shelf**

1. Washington Buoy and Glider observing network operations: Led by M. Alford Applied Physics Laboratory, University of Washington (APL-UW), efforts this period have focused on finalizing the surface mooring design for deployment off La Push, WA, and starting bench-top assembly of the instrumentation/communication framework by January 2010. The award to J. Newton, M. Alford, A. Devol, and D. Martin (all at UW) from the Murdock Charitable Trust for funding of an ocean sensor array (surface and profiling buoys and glider) totaling more than $600k including UW matching funds, is being used to augment the NANOOS Washington Coast real-time mooring network. With Murdock funds largely being applied to instrumentation that includes both a McLane Moored Profiler (MMP) and a Seaglider, this network offers the potential to provide near real-time, highly-sampled time and space measurements of a wide range of environmental variables on the Washington shelf.

As reported previously, this network will consist of a fixed surface mooring measuring both atmospheric and oceanic properties in time, a subsurface mooring that will profile regularly between about 20 m and the bottom providing finely-resolved vertical measurements, and a Seaglider which will provide the spatial context for the mooring measurements. We will measure temperature, salinity, dissolved oxygen, chlorophyll fluorescence, turbidity, currents, nitrate, pCO2 and meteorological data on the fixed and profiling moorings and temperature, salinity, pressure, dissolved oxygen, and chlorophyll fluorescence with the glider. These measurements are essential for an improved understanding of the complex physical and biological processes on the Washington Coast.

All data will be transmitted back to UW via Iridium satellite and/or Freewave VHF linkage and posted to the NANOOS web relatively quickly. The Freewave system will greatly increase the amount of data that will be sent to shore in near real-time while decreasing the cost of data transfer. Use of this system is possible because of our collaboration with the U.S. Coast Guard Station, Quillayute River.

We are making significant progress on the completion of surface mooring, which is the first phase of the network deployment. We intend to complete the construction of the surface mooring this May (2010), wet-test the fully-functioning surface mooring in Puget Sound in early June, and then deploy the mooring for 2-3 months off the Washington Coast this July. We plan to recover the surface buoy in early fall to address any problems and to check for mooring gear wear, then re-deploy along with the subsurface mooring in more of a permanent sense in the spring. The Seaglider will likely be deployed for a short (several weeks to a month) deployment this summer, then again on more of a long-term basis in the spring of 2011 subject to funding availability.

We have recently begun integrating individual peripherals/instruments with the surface buoy controller---which has been built and tested. All instruments and buoy components have been ordered with the exception of the nitrate sensors, McLane profiler, and the Seaglider. These will be ordered as soon as the remaining Murdock Charitable Trust funding becomes available. Design of the buoy hull, tower and base is complete, with the buoy to be delivered around the beginning of May. The lead engineer of the University of Maine group in charge of deploying/maintaining the highly-successful GOMOOS mooring system (J. Wallinga) designed the buoy and is presently conducting stability analyses. We're very pleased with the final design and believe that time spent researching various hulls, buoy configurations, etc. early on has paid off in a buoy that is appropriate for extended deployments in the rough conditions offshore. The buoy is designed to handle an extensive instrumentation payload, and will be able to be deployed from smaller vessels such as APL's R/V Robertson (a significant cost savings for maintenance).

2. Oregon Glider operations: The Oregon State University (OSU) glider group led by J. Barth and K. Shearman continued deployments of an autonomous underwater glider off Newport, Oregon, for the NANOOS-contracted four months beginning October 1 2009. The Fall-Winter-Spring deployments helped monitor the progress of the 2009-2010 El Niño and the March 2010 measurements will help define upwelling sourcewater properties for the 2010 summer season. The glider measured vertical profiles of temperature, salinity, dissolved oxygen, chlorophyll fluorescence, colored dissolved organic matter fluorescence and light backscatter from near the shore in about 20 m of water to out over the continental slope approximately 45 nautical miles offshore. Near real-time, the glider reports position and returns a subset of data to shore every 6 hours. Plots of all variables were linked to the NANOOS Data Products web page. We are working on delivering near real-time data, but need to improve our near real-time data processing before we can share quality-controlled, near real-time data. We are making progress toward correcting the temperature-conductivity lags present in an unpumped glider CTD. The glider data are useful for assessing changes in water column properties in support of studies of hypoxia, harmful algal blooms, coastal productivity, etc. In Fall 2009, we refurbished one of our two Webb gliders, at a cost of nearly $30,000 paid by a Moore Foundation grant, so that we can maintain operations on the Newport line. Our overall goal is to provide year-round glider data, but this must wait for additional IOOS/NANOOS support.

Presentations acknowledging NANOOS support:

Erofeev, A., J. A. Barth, R. K. Shearman, L. Rubiano-Gomez, and J. Brodersen, 2010: Seasonal and Interannual Variability of Hydrographic and Bio-Optical Fields off Central

Oregon from Glider Observations. Presented at the 2010 Ocean Sciences Meeting, Feb. 2010, Portland, OR.

3. Oregon Buoy (mooring) operations*:* Led by M. Levine (OSU), a mooring about 10 miles off Newport, Oregon, at a site known as NH-10 has been in operation since mid-2006. The mooring is recovered and a refurbished mooring is deployed about twice a year. We have two moorings and hence are able to repair and improve one system while the other one is in operation. The most recent mooring turnaround was in late August 2009; the next is scheduled for April 2010. The data time series has been recording nearly continuously for about 2 years. The mooring measures a combination of meteorological parameters and ocean temperature, salinity, velocity, chlorophyll fluorescence, light backscatter and dissolved oxygen. The specific number of sensors on a given deployment depends upon availability, as most sensors are leveraged from other projects. Some of the data is transmitted to shore through a cellular phone modem in near-real time and becomes part of the NANOOS data stream (http://agate.coas.oregonstate.edu/data/nh10.html). It is designated as station #46094 by the National Data Buoy Center and also appears on their website (http://www.ndbc.noaa.gov/station_page.php?station=46094).

In winter 2010 improvements to the mooring system were made, including: new sonic anemometer, new air temperature sensor, new buoy compass, new solar panel to charge batteries, software modifications to improve data acquisition and transmission. Some instrumentation that was damaged during the last deployment was repaired; sensors were recalibrated as appropriate.

This field work requires the use of a medium-sized UNOLS vessel for a minimum of 1 day twice a year. Funding for ship time is not included in this project; ship operations were funded by NSF through the Science and Technology Center for Coastal Margin Observation and Prediction.

4. Central Washington shelf: With NSF funding, OHSU through the Science and Technology Center for Coastal Margin Observation and Prediction (CMOP), under direction by A. Baptista, runs glider operations in the Central Washington shelf that add to other regional glider efforts on the Oregon and Washington shelves. The operation is based on the use of a Slocum glider.

Glider data and images (Fig. 1) are currently available both real time and in archival mode at http://www.stccmop.org/corie/observation_network/glider which can be linked to from the NANOOS website. Access via NANOOS NVS is planned for 2010/11.

In 2009, glider observations detected: (a) bottom hypoxic conditions, in particular near canyons (Fig 1); (b) low salinity waters which CDOM signature not consistent with a PNW freshwater source were detected.

Operations are interrupted during winter, because in winter weather glider recovery can not be guaranteed within time windows consistent with the lifetime of batteries.

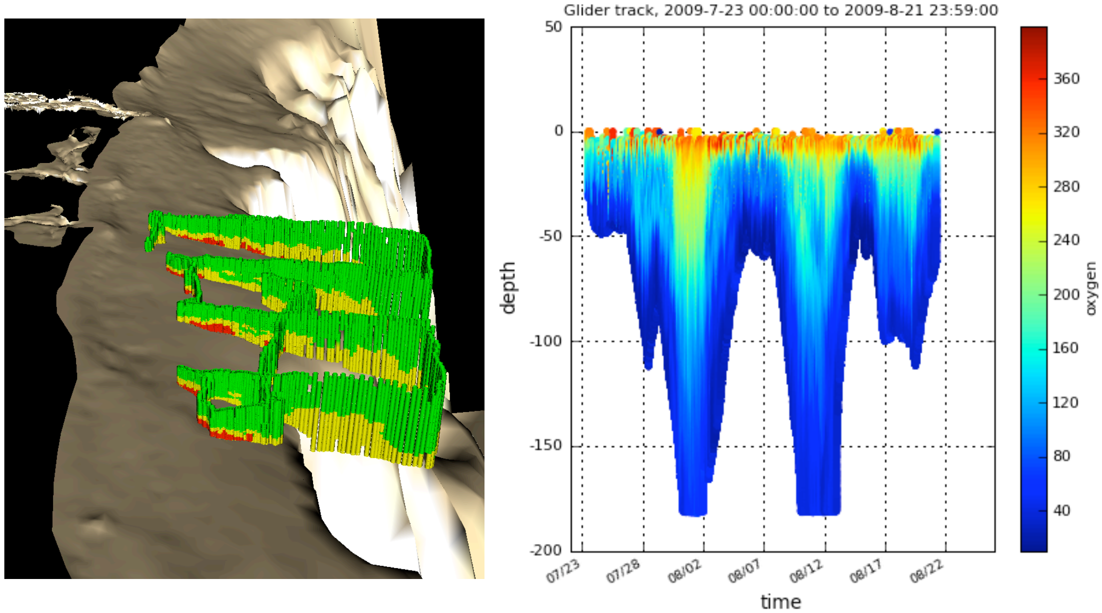


Figure 1: (left) Glider path off the central Washington coast (July 23-August 21 2009). Colors represent degree of hypoxia. Green represents well oxygenated waters. Yellow represents 'hypoxic waters', with oxygen levels lower than 1.4 ml/l (62.6 µM) but above 'severely hypoxic waters', which are represented in red and correspond to oxygen levels lower than 0.5 ml/l (22.3 µM).(right) Depth-time profile of oxygen concentrations along the path, in µM.

- **Estuaries**

1. Puget Sound, ORCA Buoy program: Led by A. Devol and J. Newton (UW), during this report period the ORCA (Oceanic Remote Chemical Analyzer) group had four buoys in operation in Hood Canal, Puget Sound (see http://orca.ocean.washington.edu via the NANOOS web portal for buoy locations). Each buoy measured vertical profiles of temperature, salinity, dissolved oxygen, chlorophyll fluorescence, and meteorological data. Additionally, some buoys also measured currents, nitrate, PAR (photosynthetically active radiation) and turbidity.

The Twanoh, Hoodsport and North buoys operated nearly continuously throughout the period; the Duckabush buoy was not operational and we are planning to move that buoy to a new location before making it operational again. The sampling frequencies were decreased to as low as one profile per day during February and we are now increasing them as solar radiation becomes available.

Of note are low oxygen concentrations at both the Twanoh and Hoodsport buoys. The fall re-oxygenation of Hood Canal happened about 1.5 months later than average and during the subsequent January and February low dissolved oxygen built back in in the deep waters at the southern end of Hood Canal. These are the lowest oxygen concentrations in bottom waters at this time of year that we have observed since the buoys have been in operation. All buoy data was made available in near real time on the NANOOS website. These observations are leveraged with the Hood Canal Dissolved Oxygen Program and NSF funding.

Through collaboration with NOAA (C. Sabine, R. Feely), we added a pCO_2 sensor to the Twanoh mooring in July 2009 and it has been measuring atmospheric and surface water pCO_2

since early August (Fig. 2). We now have a 7 month continuous record of pCO_2. The CO_2 drawdown due to photosynthesis is clearly evident during the fall. During winter the concentrations fluctuate between undersaturation due to small phytoplankton blooms and supersaturation due to mixing. There is a strong increase in pCO_2 supersaturation during large freshwater discharge events. The 2010 spring bloom resulted in very undersaturated water in the surface mixed layer. All in all the pCO_2 in this estuarine environment is highly variable and also shows extremes much further from equilibrium than typical coastal settings.

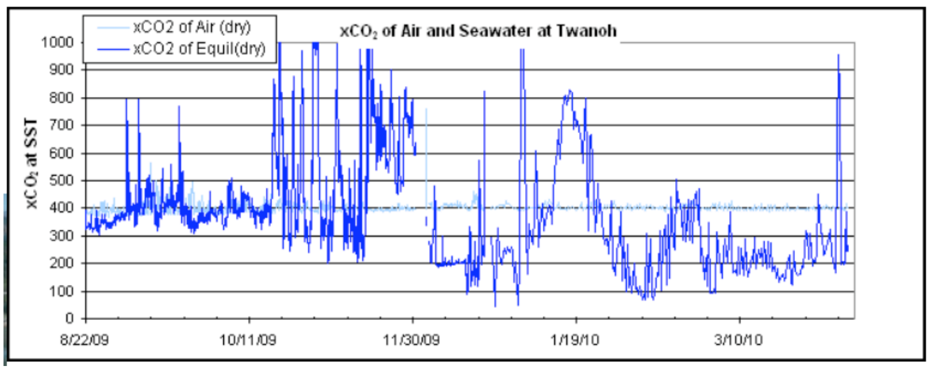


Figure 2 pCO2 concentration of the mixed layer (dark blue) and air (light blue) at the Twanoh mooring.

Finally, we recently completely rebuilt the operating system of the Point Wells water column profiling buoy that is deployed in the main basin of Puget Sound. This buoy was redeployed during the first week of April 2010. Data is again available on the NANOOS website. The buoy is equipped with sensors for temperature, salinity, dissolved oxygen, chlorophyll fluorescence, turbidity, currents, nitrate, PAR, transmittance, and meteorological data.

Over the next 6 months we plan to continue maintaining the ORCA moorings and data streams, and increasing the profiling frequency up to 12 profiles per day for the summer. We plan to conduct more spatial surveys to further characterize spatial variability in southern Hood Canal. We also plan to move the Duckabush mooring from its current location to a new location in Dabob Bay, Hood Canal, to study ocean acidification near shellfish beds and industry. This move will take place in early May.

Presentations acknowledging NANOOS support:

1) Devol, A.H., Ruef, W., and Newton, J., 2009, Determining Coastal water sampling frequencies using a profiling mooring. IEEE fall meeting, October, Biloxi, MS
2) Newton, J., Devol, A., and Ruef, W., 2009. Measuring nitrate fluxes to assess estuarine eutrophication. IEEE fall meeting, October, Biloxi, MS

3) Ruef, W., Devol, A., Bassin, C., and Newton, J., 2009. High-frequency variability in water properties in estuaries and the implications for monitoring programs. Coastal and Estuarine Research Federation meeting, November. Portland, OR.
4) Devol, A., Ruef, W., and Newton, J., 2009. Coastal Sampling frequencies determined using a profiling mooring. Coastal and Estuarine Research Federation meeting, November. Portland, OR.
5) Newton, J., Devol, A., and Ruef, W., 2009. Insights on Phytoplankton Dynamics from High-resolution Timeseries Observations. Coastal and Estuarine Research Federation meeting, November. Portland, OR
6) Newton, J., Devol, A., Richey, J. Kawase, M., Alford, M., Warner, M., Hannafious, D., Brewer, S., Fagergren, D., Josberger, E. 2010. Use of IOOS-NANOOS observing data for understanding causes of hypoxia in Hood Canal, Puget Sound, WA. *Eos Trans. AGU*, *91*(26), Ocean Sciences Meeting Suppl., Abstract IT25N-03. February 2010, Portland, OR.

2. Washington State estuarine monitoring: Coordinated by C. Maloy, the WA State Department of Ecology (Ecology) continues to demonstrate commitment and interest in contributing to regional estuarine *in situ* observations by maintaining monthly-calibrated moorings in Willapa Bay and Puget Sound. This work is funded by WA State and augmented by NANOOS. Ecology recently hired a new technician, Ashley Carle, while Marissa Jones works on a different project. The moorings continue to deliver indispensable real-time information on *in situ* environmental conditions, as evidenced by ongoing data users from government, academic, tribal, educational institutions, and private entities.

In order to effectively report our mooring data, Ecology is developing automated quality assurance procedures and statistical algorithms to automatically flag real-time data streams. Ecology is currently working towards moving the real time data stream in-house, to its own web site. The greater control over data postings allows us to quickly address communication errors and calibration factors to enhance the informational value of real time data. A current effort is to present real time information in a historical and statistical context to provide users with contextual information to evaluate environmental anomalies at the site.

In Puget Sound, Ecology now operates three fixed mooring stations located in Manchester/Clam Bay, Squaxin Passage, and near Mukilteo (Mount Baker Boeing pier/Port of Everett). The Mount Baker mooring is maintained with assistance from volunteers from Everett Community College and the Port of Everett. The Mount Baker station is bottom-mounted and located below the density discontinuity between river and marine water. This station in combination with Ecology's bottom mounted Admiralty Reach mooring is aimed at capturing low oxygen ocean water intrusions into Puget Sound and Whidbey Basin. The Manchester and Squaxin stations record data from the near-surface (water temperature, salinity, chlorophyll fluorescence, and turbidity) and near-bottom (water temperature, salinity, pressure, and dissolved oxygen). The dual approach allows us to draw inferences from water column stratification, which is of particular interest to our collaborator V. Trainer and the Marine Biotoxins Group at NOAA for investigating the development of harmful algal blooms. The near-bottom devices at all of these locations are configured for telemetry and data are available in real-time on the web at http://www.nanoos.org/nvs/ and http://www.stccmop.org/datamart/observation_network.

In addition to the three fixed stations above, Ecology has two additional moorings with the intent to capture the exchange of water masses between Puget Sound regions. In collaboration with the Applied Physics Laboratory/UW, Ecology provides a CTD and dissolved oxygen sensor for a bottom mounted mooring in Admiralty Reach (at 65m) to capture the dynamic of ocean-water intrusions into Puget Sound. An exploratory mooring has also been deployed at Western Washington University's Shannon Point Marine Center with the goal of capturing the exchange of water masses across Rosario Strait into Bellingham Canon and Padilla Bay. We have successfully retrieved data from this exploratory site and posted the data to a publicly accessible FTP site: ftp://www.ecy.wa.gov/eap/Mooring_Raw/ . This effort will continue contingent on future funding and data quality. Ecology will continue to evaluate the suitability of these sites toward explaining water mass behavior.

On the Washington coast, Ecology continues to monitor near-surface water temperature, salinity, and *in situ* fluorescence in Willapa Bay (Bay Center) and has maintained the effort to get these data available real-time despite inclement weather conditions. This site has unique challenges because the mooring is not fixed, but floats at the surface, moving up and down with the tides by traveling on a fixed track, making it challenging to attach a fixed telemetry cable. The UW's NANOOS technician, Mike Carpenter, is working with Ecology to tackle telemetry problems. Carpenter has been out to the Willapa site and is developing a system that is compatible with Ecology's new cellular modem devices.

During the next six-month period, Ecology is committed to measuring all variables at our moorings in WA inshore waters. In collaboration with stakeholders and NANOOS partners, Ecology will strive to improve online access and data presentation. This grant is partially supporting the time of our mooring technician, Ashley Carle. Through the efforts of our Mooring Coordinator and technicians, we will continue to maintain and service the Manchester, Squaxin Passage, Mount Baker Terminal, and Willapa Bay sites and to improve data quality assurance and control for posted data. We anticipate bringing the Willapa Bay mooring data to the web in real-time with assistance from UW. We will also continue to report on the success of our exploratory deployments in Rosario Strait, aimed at better describing inter-basin water exchange north of Puget Sound.

3. Columbia River estuary and plume: With a mix of NSF, NANOOS and regional-stakeholder funding, CMOP, under the direction of A. Baptista, continues to maintain multiple endurance stations in the Columbia River river-to-shelf continuum. Those stations are part of CMOP's SATURN observation network, which is a member of the NANOOS federation of systems (Fig 3).

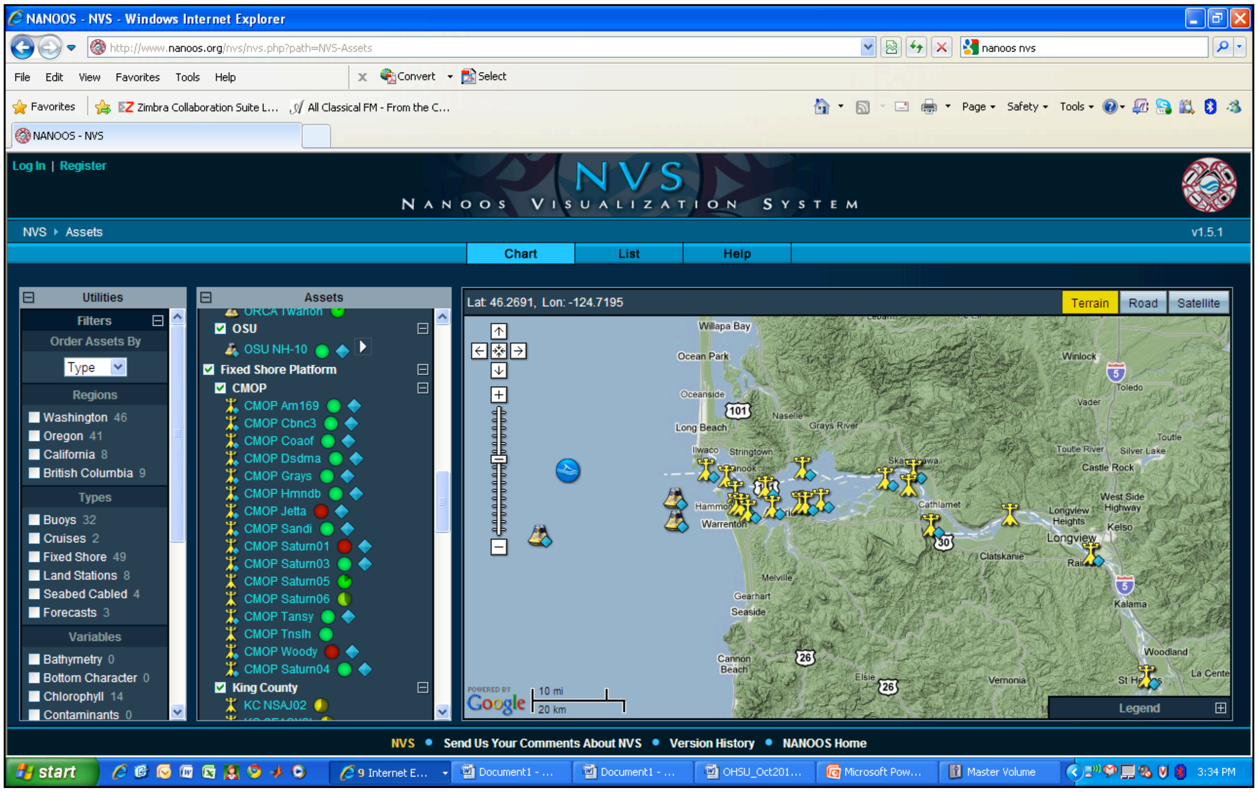
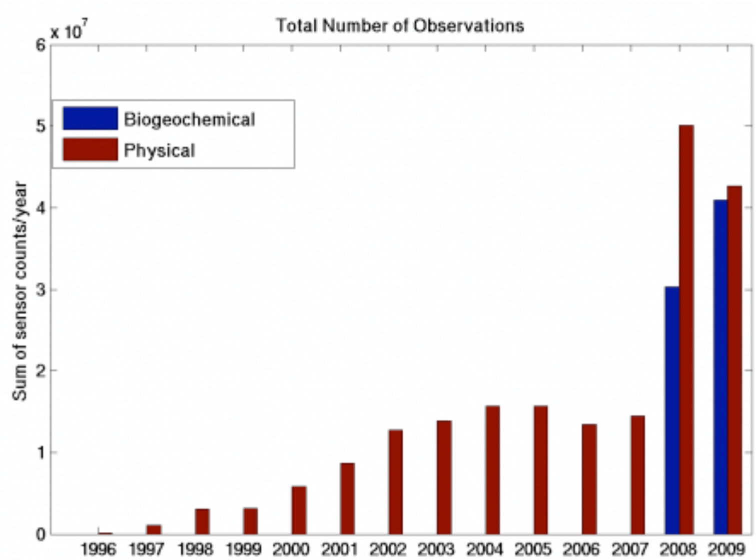


Figure 3: NVS view of NANOOS-affiliated stations for the Columbia River estuary and plume, most of which are SATURN endurance stations.

Of note is the growth of the total counts of raw physical and biogeochemical observations since the program's inception in 1996 (Fig. 4). The counts represent sums over all sensors, so observations from instruments with multiple sensors are counted per sensor rather than per instrument. These counts do not include data from gliders, drifters, AUVs, and observations gathered during CMOP cruises from ship based instrumentation. Also excluded are CODAR and high-resolution radar observations.

Figure 4: Total counts of raw physical and biogeochemical observations from SATURN endurance stations, from 1996 through 2009. The sums are over all sensors so observations from instruments with multiple sensors are counted per sensor rather than per instrument. These counts do not include data from gliders, drifters, AUVs, and observations gathered during CMOP cruises from ship based instrumentation. Also excluded are CODAR and high-resolution radar observations.



Physical endurance stations: These stations were originally deployed as a part of an autonomous observation and prediction system (CORIE), one of the pioneer estuarine observatories in the US, now subsumed within the SATURN collaboratory. This system is maintained for the most part by NANOOS funding, with partial support coming from regional stakeholders.

Operations are conducted by a field team based in Astoria, OR. A cyber team, based in Portland, OR, conducts data quality control on a monthly basis, and maintains the sensor-to-user flow of information.

Major operational challenges continue to be posed by the large number of stations, the heavy currents at many of the station locations, weather (partially year-round local winds, but especially winter weather), and regulations on protected species. We are progressively reducing dependency on diving operations, which are limiting in the complex environment of the Columbia River estuary. Maintenance during summer and fall (including additional seasonal staff) has also been re-designed to minimize the need for operations during winter. We continue to analyze gaps and redundancies of data, in light of identified regional needs and of improvements in modeling skill. In this context, and in part with the guidance of formal studies of network optimization (Frolov et al., 2008), we plan to add in 2010/2011 vertical resolution measurements (for salinity and temperature) to station AM169; we are also considering additional observations of velocity profiles (at stations AM169 and SATURN-03). Any additions may require reductions in the overall number of existing stations.

Salinity, temperature and water level data are quality controlled on a monthly basis, using documented procedures. Data are available through NANOOS NVS. In addition, user-customizable access and analysis of data, descriptions of quality control procedures, and station- and system-wide performance metrics are available through the CMOP web site.
Because they have been in place for an extended time period (some since 1996), physical endurance stations offer useful temporal context for the other, emerging, observational assets in the region. Ocean signatures (such as spring-to-fall upwelling and downwelling regimes) are often visible in the estuary time series. These time series are starting to be used as surrogates to understand the impact of shelf hypoxia and acidification in the estuary.

Several physical endurance stations are maintained under contract with the U.S. Army Corps of Engineers, in support of monitoring of potential effects of channel deepening (USACE, 2001), with particular consideration of impacts on salmon habitat (Bottom et al., 2008).

CORIE stations are routinely used for skill assessment of the SATURN modeling system, both near real-time (for daily forecasts) and retrospectively (for hindcast databases). Examples of the latter include: Baptista et al., 2005; Zhang and Baptista, 2008; Burla et al., in press.

SATURN biogeochemical stations. The six biogeochemistry stations deployed in 2008 and 2009 to resolve the Columbia River river-to-shelf gradient (Table 1) are all being developed under NSF funding. As the stations reach maturity and funding allows, they will be considered for maintenance support through NANOOS.

Table 1: Capabilities of SATURN biogeochemical stations

SATURN-01	Full-year. Autonomous profiling winch on bridge piling. Utility power. SWAP telemetry. Baseline sensors: conductivity, temperature, fluorescence, turbidity, CDOM, nitrate, DO. Other sensors: PhytoFlash.
SATURN-02	**Spring-fall buoy**. Multi-level mooring. Solar/battery power. Real-time telemetry. Baseline sensors: multi-level CT; near surface nitrate, fluorescence and turbidity. Other sensors: down-looking ADCP. **Winter season buoy**: surface temperature and conductivity
SATURN-03	Full-year. Multi-level pumped-through system, with most sensors dry (on dock). Utility power. SWAP telemetry. Baseline sensors: conductivity, temperature (measured underwater at intakes), CDOM, fluorescence, turbidity, DO, nitrate. Other sensors: remote seabed mounted up looking ADCP (planned). Specialty sensors: Fluid Imaging FlowCAM (short term deployments; planned), SubChem APNA, Turner PhytoFlash, and Sequoia LISST-100.
SATURN-04	Full-year. Multi-port pumping system on dock, with mostly above-water sensors. Solar/battery power. Real time telemetry. Baseline sensors: conductivity, temperature (measured at intake), fluorescence, turbidity, DO, CDOM, nitrate. Other sensors: pCO2
SATURN-05	Full-year. LOBO instrumentation on mid-channel fixed platform. Solar/battery power. Cell phone telemetry. Baseline sensors: conductivity, temperature, fluorescence, turbidity, DO, CDOM, nitrate.
SATURN-06	Full-year. YSI 6600 V.2 Sonde. Baseline sensors: conductivity, temperature, fluorescence, turbidity. Others: pH, DO

An additional station (07) is expected to be deployed in an ocean-influenced lateral bay of the estuary (tentatively in 2011/2012); responsibility is of the Astoria field team. SATURN-07 will monitor all baseline variables.

Salinity, temperature and water level data are quality controlled on a monthly basis, using documented procedures developed for physical endurance stations. Data are available through NANOOS NVS. Data, analyses tools, quality control procedures, and performance metrics are available through the CMOP web site. Quality control for biogeochemical data is under development.

All stations are supported by the CMOP cyber team and the NANOOS DMAC team (which have a synergistic overlap). Sensor-to-user handling of information flow, including database and web interface, are the same as for physical data. SATURN-06 is also a USGS station, and reported as such via the USGS web site. SATURN-05 is also a LOBO station, and reported as such by the web site of the LOBO network. LOBO is an industry-led national biogeochemical network.

4. Oregon South Slough: Participation by the Oregon Department of State Lands in NANOOS activities is led and coordinated by S. Rumrill (Chief Scientist and Research Program Coordinator for the ODSL / South Slough National Estuarine Research Reserve (NERR)).

Observations: Rumrill and technical staff members from the South Slough NERR (A. Helms and A. DeMarzo; NERR System-Wide Monitoring Program / SWMP) continued to operate four moored observing stations located within the South Slough estuary over the period of Oct 2009 to Mar 2010. The moored monitoring stations are operated jointly between the NERRS and NANOOS as contributors to the network of NANOOS estuarine anchor stations and to the federal backbone of ICOOS. The South Slough NANOOS monitoring stations are located at: (1) Charleston Pier, (2) Valino Island, (3) Winchester Arm, and (4) Sengstacken Arm. These moored monitoring stations have been established along the estuarine gradient of the South Slough where they provide characterizations of ambient water column conditions in the marine (euhaline), marine-dominated (polyhaline), mixing (mesohaline), and riverine (oligohaline) hydrographic regions of the estuary. Each monitoring station is equipped with a YSI-6600 Extended Deployment System (EDS) multi-parameter datalogger, and the array of electronic probes and sensors is located 50 cm above the bottom of the tidal channel. Three of the stations (Charleston, Valino, Winchester) are outfitted with Sutron SatLink2 data telemetry systems that transmit the digital datastreams to a receiver and internet service provider via the Geostationary Operational Environmental Satellite (GOES) system.

The monitoring stations in the South Slough were in continuous operation throughout the reporting period of Oct 2009 to Mar 2010, and the dataloggers were retrieved, downloaded, recalibrated, reprogrammed, and redeployed on a monthly basis during the fall and winter seasons. Each datalogger records measurements of the following parameters every 15 minutes: water level, temperature, conductivity, salinity, pH, dissolved oxygen, turbidity, and fluorescence. Time-series measurements generated by three of the monitoring stations are available in near real-time from several websites including NANOOS (NANOOS Visualization System (http://www.nanoos.org/nvs/nvs.php?path=NVS) and (http://www.nanoos-shellfish.org/ and http://www.ccalmr.ogi.edu/nanoos/), NOAA / Hydro-Meteorological Automated Data System (www.weather.gov/oh/hads), the NOAA/NERRS (http://www.nerrs.noaa.gov/monitoring/water.html), and via the website operated by the NERRS Centralized Data Management Office (http://cdmo.baruch.sc.edu/QueryPages/Stationmap.cfm Site ID=SOS). Staff members from the South Slough NERR (Alicia Helms and Adam DeMarzo) attended a technical training workshop hosted by the NERRS Centralized Data Management Office (University of South Carolina, Baruch Marine Laboratory, Myrtle Beach (SC) 8-12 Feb 2010). The workshop provided instruction on working with software and hardware upgrades to the YSI-6600 water-quality dataloggers and their electronic probes, and on troubleshooting problems with operation of the Sutron SatLink2 telemetry equipment that is used to relay digital datastreams via the GOES system.

Data Applications: Datasets generated by the NANOOS/SWMP observation stations were used to help guide decisions about the optimum location in the estuary for the placement of experimental out-plants of native Olympia oysters (*Ostrea lurida*) in the South Slough. In particular, time-series data from the Charleston and Valino Island monitoring stations were used to evaluate variability in fall and winter temperature and salinity regimes, and to identify the region of the tidal channel that will be most conducive to survival and growth of juvenile oysters.

Staff members from the South Slough NERR continued to examine time-series measurements of estuarine pH values and other water column parameters recorded at the NANOOS/SWMP anchor stations in an effort to better understand the potential influence of acidification of nearshore ocean waters on carbonate chemistry within the estuary. Estuary pH values recorded at the Charleston NANOOS anchor station typically ranged between 7.9 and 8.3 throughout each day (Fig. 5), and a strong diurnal cycle occurs with lowest pH values in the pre-dawn (pH 7.9 to 8.0) and highest pH values in early-afternoon (pH 8.2 to 8.3). The daily pH cycle appears to be driven by photosynthesis and respiration of phytoplankton, macroalgae, and submerged aquatic vegetation within the estuary.

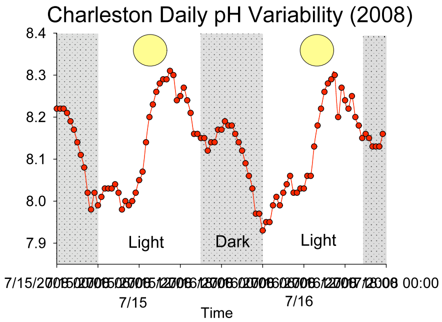


Figure 5. Diurnal variability in estuarine pH values measured by a YSI-6600 EDS datalogger deployed at the Charleston SWMP/NANOOS station; South Slough, OR.

<u>Outreach</u>: The South Slough NERR continued to interact directly with the commercial oyster growers in Coos Bay to provide technical assistance with access to water-quality data, and to further promote utility of the NANOOS Data Product (Real-Time Water Quality Data for Shellfish Growers in the Pacific Northwest). Time-series measurements of water temperature, salinity, dissolved oxygen, and *in situ* chlorophyll-a concentrations are of primary interest to the local oyster shellfish growers because they provide essential information about oyster growing conditions and an indicator of the concentration of phytoplankton available in the estuarine water column as food. The commercial oyster mariculture industry is also becoming concerned about ocean acidification, and they have expressed their desire to gain access to measurements of pH values in Pacific Northwest estuaries.

Presentations acknowledging NANOOS support:

1) Datasets generated by the SWMP/NANOOS anchor stations were incorporated into several presentations delivered during the recent Coastal and Estuarine Research Federation conference held in Portland, OR (1-5 Nov 2009):
   a. Alicia Helms presented a seminar titled "*The effects of seasonal and long-term ocean cycles on water quality dynamics within the South Slough estuary, Oregon*"
   b. Adam DeMarzo presented a poster titled "*Estuary Atlas: a visualization tool to illustrate spatial and temporal variability in water parameters along the estuarine gradient of the South Slough"*

2) Datasets generated by the South Slough NERR were also presented by Dr. Burke Hales (Oregon State University) during his Chautauqua seminar (*Ocean acidification: the other CO2 problem*).

3) South Slough NERR staff members also developed a poster titled *"Detection of a Long-term pH Shift within the South Slough Estuary, Oregon: Potential Relationships to Climate Change, Ocean Acidification, and Net Estuary Ecosystem Metabolism."* The poster was presented during the annual NERR SWMP Technical Training Workshop (8-12 Feb 2010; Myrtle Beach, SC).

4) In addition, Steve Rumrill delivered a lecture titled *"Nearshore Oceanography, Upwelling, and Ocean Acidification: Physical and Biotic Processes in the Nearshore Ocean Waters and Estuaries along the Oregon Coast"* during the seminar series hosted by Shoreline Education and Awareness.

- **Shorelines**

1. Washington Shorelines:

CMAP implements monitoring in accordance with NANOOS scope of work (Ecology): The Washington State Department of Ecology's (Ecology) Coastal Monitoring & Analysis Program (CMAP) led by George Kaminsky (Ecology) continued to maintain a beach and shoreline monitoring effort in the Columbia River littoral cell (CRLC) at a reduced scale during this semiannual period of October 1st to March 31st. This effort also supported further development of the Coastal Profiling System (i.e., nearshore bathymetry survey platform) in collaboration with Oregon State University. The monitoring program performs beach profile surveys on a quarterly basis and performs beach surface mapping on a semiannual basis. These field campaigns serve the ongoing monitoring project that is now in its 12th year of operation.

CMAP collected geospatial data on transects at 46 locations in the CRLC twice during this semiannual period. In addition, 10 surface maps were collected (5 in fall, 5 in winter) each containing an average of 10,000 data points over a distance of 3 to 4 kilometers alongshore. To track the alongshore extent of increased winter erosion, the field crew collected erosion scarp position data at 6 beach locations. These data have been processed from raw format into deliverable text files and have passed a rigorous quality assurance process that continues to be refined over time as new technology becomes available. The text files are organized and cataloged into onsite network drives with accompanying FGDC metadata.

Overview of CRLC beach monitoring results: Beaches immediately north of tidal inlets (entrances to the Columbia River, Willapa Bay, and Grays Harbor) in the Columbia River littoral cell eroded rapidly during this semiannual period. The erosion trend is comparable in magnitude and geographic area to that of the El Niño winter 1997/98. The frequency and length of CMAP's monitoring campaign has documented beach response to these decadal-scale events, which contrast with typical winter erosion cycles. Continuing this time series of morphology data will provide valuable perspective for coastal management decisions and improve the understanding of beach dynamics.

Monitoring data documents unusually severe coastal erosion (Pacific County): Quarterly monitoring of the coastline between the Grays Harbor and Willapa Bay entrances allowed CMAP to document extraordinarily large shoreline retreat along the entrance to Willapa Bay and southern Grayland Plains.

In the last six months approximately 195 m (640 ft) of road has been destroyed and fallen into the ocean. The seaward edge of the community is located inland along the road 295 m (968 ft) from the current erosion scarp line. Typical erosion rates in area have been on the order of 15 m per year over the past 2 decades.

Erosion destroyed infrastructure including a public beach-access road near North Cove, a geodetic survey monument, and a State Parks restroom facility. Future erosion may threaten the community inland of the State Parks facility.

In the last 100 years, more than 100 homes and a mile of beach have been lost to the south of Warrenton Cannery Road. In the last six months, 14 structures have been lost: seven houses, five sheds and two unidentifiable structures. Two residents of a home appeared in an interview on KING 5 TV news shortly before their house was lost.

Erosion is now reorienting the southern Grayland Plains shoreline to the southwest. The eroded sand is migrating north toward Westport, where condominiums and more homes are at risk. Immediately to the north of the erosion area is a dramatically widened beach that has temporarily enhanced snowy plover habitat.

CMAP would like to add more profile locations in this area to resolve alongshore variability and answer the questions:

a) Will the sand move north fast enough to prevent loss of development around Westport?
b) How is the northward rate of the sand mass changing?

Accurate answers to these questions are integral to Pacific and Grays Harbor Counties and landowners in making informed management decisions in the future.

Monitoring data documents benefits of sand fence stabilization of beach berm (US Army Corps of Engineers): CMAP's monitoring of the U.S. Army Corps of Engineers sand berm adjacent to the Columbia River North Jetty shows the sand fencing is stabilizing the area and protecting the jetty from wave inundation from the north. Quarterly beach monitoring program has documented a net sand-volume increase on the beach berm due to the sand fences even after two years of large winter storms. Seasonal monitoring allows inspection of damage to fences and timely scheduling of repairs to maximize the fence's performance in trapping sand that would otherwise be blown into the Columbia River navigation channel. The accumulation of sand in the fenced area is reducing the scour that is prevalent in nearby areas that have structures to the south, like the Seaview area and the north jetty to Grays Harbor in Ocean Shores.

CMAP also assisted the installation of a new high resolution ARGUS camera system that observes Benson Beach morphology on high frequency temporal scale (http://www.planetargus.com/north_head/). CMAP's field crew, in cooperation with Northwest Research Associates, helped to obtain precise ground control points to calibrate the cameras. The images and data products from this system provide information about beach dynamics in between CMAP's quarterly surveys.

CMAP's collection of historical data helps Shoreline Specialists convey shoreline change risks to city planners: After an El-Niño-like winter, Ocean Shores has experienced a significant amount of erosion similar to that experienced during the 1997/1998 El Niño. Homeowners along the stretch of land just north of the jetty became concerned and asked Ecology's shoreline specialist to do a site visit. The photos collected during this site visit were shared with CMAP, prompting the creation of a PowerPoint presentation that shows how precedent had already been set in this area for this type of erosion. Ecology staff found it very informative and useful in conveying the vulnerability of this area. The images presented show large changes in the dune that can occur within a short period. With the knowledge of the temporal variability of shoreline position, planners are grappling with the problem of basing building setbacks solely on the location of the vegetation line at the time construction is proposed. The owner of a condo that was built during the last 4 years believes that City of Ocean Shores staff should have disclosed that the vegetation line at the time his condo was built represented only a recent (and ephemeral) recovery of the dune. That recovery has been washed away with this winter's storms and the dune has eroded to within 10 m of a house north of the condo. The historical data and images that CMAP compiled illustrate the similar erosion that occurred eleven years ago. The risk of legal action against the City of Ocean Shores illustrates a real value of the beach monitoring data time series.

2. Oregon Shorelines: In Oregon, leveraging NANOOS funds, the Oregon Beach and Shoreline mapping Analysis Program (OBSMAP) efforts are led by J. Allan and V. McConnell of the Oregon Department of Geology and Mineral Industries (DOGAMI). Monitoring was undertaken at 119 sites on several occasions at a reduced scale during the first half of Year 3. Monitoring occurred between October 1, 2009 and March 31, 2010. Beach cross-section surveys were specifically carried out in October to November 2009 (summer survey), and December to February 2010 (fall survey) along the Neskowin and Rockaway littoral cells, Clatsop Plains, and along the Newport cell (Yachats to Otter Rock). Monitoring during the first half of Year 3 was compromised on several occasions during this period, and especially over a month long period between mid-December 2009 and late January 2010 due to repeated equipment failures, which resulted in the GPS equipment having to be sent away for servicing. This highlights the near tenuous state that now exists with the equipment (now coming up to six years old) and the expectation that unless the gear is replaced soon equipment down-times may begin to increase or more troubling the complete shut-down of the beach monitoring program.

The beach surveys involved the conventional approach of re-measuring the existing transect sites using RTK-DGPS surveying technology developed for PNW beaches. Results of the profile measurements and contour excursion plots (time stack plots that show contour changes near the dune toe (e.g. the 6.0 m and 5.0 m contour) and lower down the beach face near the Mean High Water mark (e.g. the 3.0 m contour)) have been disseminated via the OBSMAP website (http://www.oregongeology.org/sub/Nanoos1/index.htm) and linked through the NANOOS website. These data are now being actively used by State Agencies, Geotechnical consultants and the public for assessing coastal stability and hazard risk.

Shoreline variability continued to be measured as part of the OBSMAP beach monitoring effort. The approach used involves re-measuring the Mean High Higher Water (MHHW) contour located at an elevation of ~2.5 m above MLLW, a tidally-based proxy for the position of the shoreline, along each of the littoral cells. These data are now being used on an annual basis to assist the Oregon Parks and Recreation Department with identifying potential erosion "hotspot" sites prior to the ensuing winter.

Outreach efforts in the form of public presentations were carried out at several forums including a Neskowin community meeting in November 2009 (), to discuss ongoing concerns over the loss of the public beach, increased incidence of failure of engineering structures, and periodic flooding of coastal properties along the Neskowin shore. Presentations were also made to the Western Snowy Plover Range-wide Recovery Meeting on January 13th, and to Oregon's new Nearshore Research Task Force on January 21, 2010. The former meeting discussed the implications of results obtained from Oregon's beach monitoring program as they relate to loss of ecological habitat due to ongoing coastal erosion, while objectives of the last meeting was to provide an overview of NANOOS activities.

Publications acknowledging NANOOS support:
NANOOS beach observations were published as part of the Geological Society of America 2009 filed trip guide. The full publication is:

> Allan, J. C., Witter, R. C., and Ruggiero, P., (2009). Coastal geomorphology, hazards, and management issues along the Pacific Northwest coast of Oregon and Washington. Volcanoes to vineyards: Geologic field trips through the dynamic landscape of the Pacific Northwest: Geological Society of America Field Guide 15. J. E. O'Connor, R. J. Dorsey and I. P. Madin , The Geological Society of America: 495-519.

3. Nearshore Bathymetry: In autumn 2009, P. Ruggiero's group at Oregon State University completed the processing of nearshore bathymetry data collected along the four sub-cells of the Columbia River littoral cell (CRLC). Over 200 individual cross-shore profiles were collected in the cell during summer 2009 extending from the lower inter-tidal to approximately 12 m of water depth (~2000 m from the shoreline). These data have been processed from their raw format into deliverable text files and have passed a rigorous quality assurance process. In all cases these nearshore bathymetry measurements have been combined with topographic measurement collected by Ecology developing complete maps of the nearshore planform.

Ruggiero's group completed the processing of nearshore bathymetric data within the Rockaway littoral cell in Oregon. Over 70 individual cross-shore beach profiles were processed from the lower intertidal to approximately 25 m of water depth (~1500 m from the shoreline). These data have been combined with topographic data collected synoptically by DOGAMI, and have been processed from their raw format into deliverable text files and have passed a rigorous quality assurance process.

Ruggiero's group, with partial support from NANOOS, has successfully completed the development of the second vessel in our fleet of two 4th generation Coastal Profiling System (CPS) PWCs. The CPS is a platform for a physical/biological sampling system for the nearshore ocean. The platform essentially consists of a pair of personal watercrafts (PWCs) outfitted with fixed sampling equipment for high-resolution surveying of sea bottom topography and for physical and ecological sampling in the previously inaccessible surf zone. The Coastal Profiling

System is a unique asset that is supporting emerging research into nearshore ocean processes in the PNW.

The data and information obtained from the monitoring efforts supported by NANOOS continues to be a critical component to ongoing work on regional sediment management at the mouth of the Columbia River (MCR). During winter 2010 it was determined that approximately 300,000 cubic yards of dredged material will be placed as a beach nourishment effort just north of the river. Results of the NANOOS supported monitoring program have been used in the design of this largest ever beach nourishment project in the region. NANOOS supported nearshore morphology measurements are also being used to support wave energy conversion device siting investigations.

PI Ruggiero used NANOOS supported data and knowledge in his Coastal Hazards class taught at Oregon State University during winter 2010. NANOOS efforts were highlighted during guest lectures and in advising students.

Presentations acknowledging NANOOS support:

1) Ruggiero and colleagues presented results for the 'Shorelines' component of NANOOS at the 2010 Ocean Sciences meeting in Portland, OR.
2) Kaminsky, G.M., Allan, J.C., and Ruggiero, P., 2010, PNW coastal morphology monitoring and observation network, Eos Trans. AGU, 91(26), Ocean Sci. Meet. Suppl., Abstract IT25L-12.

As part of the latter presentation we examined, for the first time, the regional variability of nearshore morphology throughout the region (Fig. 6).

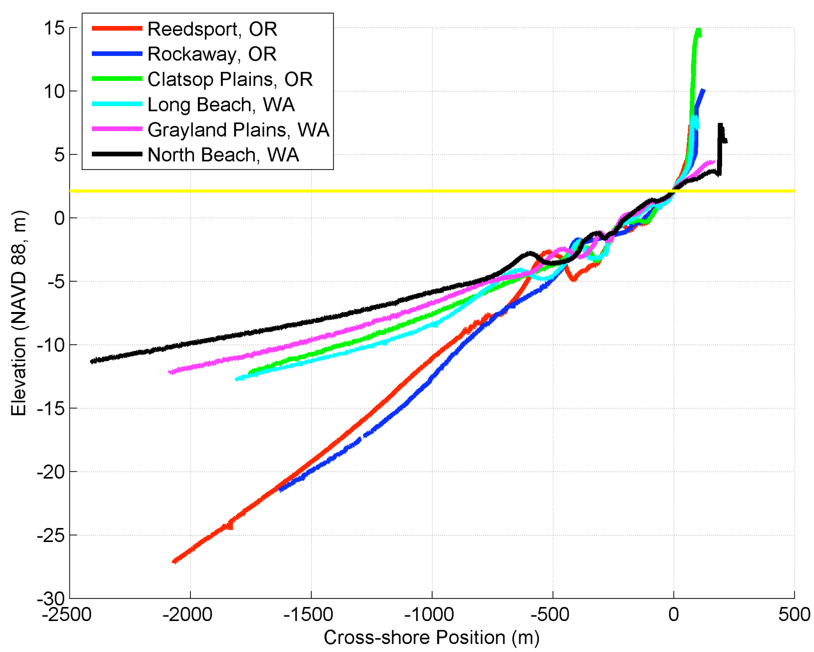


Figure 6. Regional variability in nearshore morphology along the coasts of Oregon and Washington.

- **Currents**

__1. Coastal Currents:__ The HF surface current mapping program at Oregon State University (PI Mike Kosro, RAs Anne Dorkins and Walt Waldorf), has been providing near-real-time maps of ocean surface currents along the Oregon coast to the public via the web (http://currents.coas.oregonstate.edu, plus links to this page from the NANOOS web site), as well as downloadable text files containing the data values. These data are also being provided to NOAA/NDBC via the national HFR-net, now in the newer RDL format.

We have upgraded our data retrieval system by completing our transition of all sites to internet-based data transfers. The last site to be converted, Cape Blanco early this year, is quite isolated, and doesn't have line-of-sight connection to an internet-enabled location; we have outfitted this site with a cell-phone modem.

In late October, our northernmost site at Loomis Lake, WA, stopped working. Onsite trouble-shooting indicated that the electronics needed factory repair, so the system was returned to CODAR Ocean Sensors; in December, CODAR provided a repair estimate of $4990 for essential repairs; the unit was returned in late February.

This winter we also experienced periods of reduced areal coverage at our oldest HF site, on Cape Blanco (CBL1). This has been an intermittent but recurring problem at this site, which is central to our chain and important. In mid-March, we repaired/upgraded CBL1 by replacing all exterior cables, at a cost of approx. $6K; at the same time, we moved the receive antenna electronics and the repaired transmitter/receiver from Loomis Lake to Cape Blanco. This was wildly successful, with CBL now extending reliably to its maximum range. On April 8, we installed the CBL electronics and receive antenna box at LOO; so far, this too appears to be working well, but it will take more time to fully evaluate. Electronics at our standard-range site at Washburn (WSH1) have failed, and we have sent the equipment to CODAR for analysis and repair estimate. It should be noted that, due to NOAA program cuts, budgeted funds for repairs had to be eliminated.

Presentations using the HF data from this system were made by numerous authors at the IEEE Oceans '09 Meeting in October 2009 (Barletto et al.; Risien et al.), the Coastal and Estuarine Research Foundation (CERF) meeting in Portland in November 2009 (Kosro et al.), and at the Ocean Sciences Meeting in Portland in February 2010 (Osborne, et al.; Kim et al.; Yu et al.; Levine et al.; Cho et al.). In addition, two invited talks at the Meeting of the Americas, scheduled for Aug 2010, have been solicited (Zelenke and Kosro; Kurapov et al.). The paper by Barletto, Kosro and Harlan (2009) at the Oceans '09 conference provided a vision for cooperation with the OOI to leverage their offshore technology and our onshore array, substantially extending the region of mapped HF coverage through the use of bistatic techniques with a transmitter mounted on the planned OOI surface infrastructure far offshore.

Presentations acknowledging NANOOS support:

1) Zelenke, B., and P.M. Kosro. "Short-term Current Forecasts from an Empirical Statistical Model". (Invited Presentation), Meeting of the Americas, Foz do Iguassu, Brazil, 8-13 Aug 2010, Session OS02.

2) Kurapov, A., P. Yu, G. Egbert, P. M. Kosro. "Variational assimilation of high-frequency (HF) radar surface current observations in the coastal ocean model off Oregon" (Invited Presentation), Meeting of the Americas, Foz do Iguassu, Brazil, 8-13 Aug 2010, Session OS02.
3) Osborne J., A. L. Kurapov, G. D. Egbert, M. Kosro. "Modeling Interactions of M_2 Internal Tide with Wind-Driven Circulation on the Oregon Shelf." Ocean Sciences Meeting, Portland, OR, Paper PO31A-02. Feb 24, 2010.
4) Kim C., S. Lee, H. Moon, M. Kosro. "Surface Current Response to Wind Force during winter in the Coastal Sea off the Keum River Estuary (South Korea)". Ocean Sciences Meeting, Portland, OR, Paper PO35E-15. Feb 24, 2010.
5) Yu P., A. L. Kurapov, G. D. Egbert, J. S. Allen, M. Kosro. "Variational Assimilation of HF Radar Surface Currents in the Coastal Ocean Circulation Model off Oregon". Ocean Sciences Meeting, Portland, OR, Paper PO41E-09. Feb 25, 2010.
6) Levine M. D., S. D. Pierce, L. F. Kilcher, M. Kosro, A. M. Baptista, B. C. Crump. "Challenges in Tracking Dye in the Columbia River Plume". Ocean Sciences Meeting, Portland, OR, Paper PO45J-10. Feb 25, 2010.
7) Cho K., A. M. Baptista, Y. J. Zhang, C. L. McNeil, M. P. Wilkin, K. Rathmel, M. Kosro, Y. H. Spitz, B. C. Crump, M. D. Levine, S. D. Pierce, T. D. Peterson, C. Wingard, "Subtidal circulation in the Columbia River estuary-plume-shelf system in spring and summer 2009". Ocean Sciences Meeting, Portland, OR, Paper IT25H-05. Feb 23, 2010.
8) Kosro, M., J. Newton, and D. Martin, "NANOOS: Building coastal ocean observing within a historical context". Coastal and Estuarine Research Foundation (CERF) Meeting, Portland, Oregon, Nov 2-6, 2009.
9) Barletto, P., P.M. Kosro, and J. Harlan, "Next Generation Use of High Power and Bandwidthin the NE Pacific - A Component of the NSF Ocean Observing Initiative". Oceans 2009 MTS/IEEE Meeting, Biloxi Mississippi, 26-29 Oct 2009.
10) Risien, C., J. Allan, R. Blair, A. Jaramillo, D. Jones, P.M. Kosro, D. Martin, E. Mayorga, J. Newton, T. Tanner, S. Uczekai, "The NANOOS Visualization System: Aggregating, Displaying and Serving Data". Oceans 2009 MTS/IEEE Meeting, Biloxi, MS, 26-29 Oct 2009.

2. Port Radar: Led by M. Haller (OSU) the marine radar station at the Newport jetties began regular observations on May 1st 2009. The system has collects hourly image sequences and uploads them to our web database server on the OSU campus. In early October 2009 the data acquisition suffered a motherboard failure and needed replacement. As of April 1, the data acq has been rebuilt and switched over to a Windows XP operating system. The wave radar system was temporally installed and tested using our mobile trailer and tower at the South Jetty of the Columbia River. This test was successful and these data also serve as a pilot study for a potential new permanent station at the MCR. Figure 7 below is an example image and demonstrates that good coverage of both the MCR navigational channel as well as Clatsop Spit can be achieved from a radar station installed at a relatively safe location in the South Jetty parking lot. We shall pursue an additional station at this site in future Fiscal Years if funding is available.

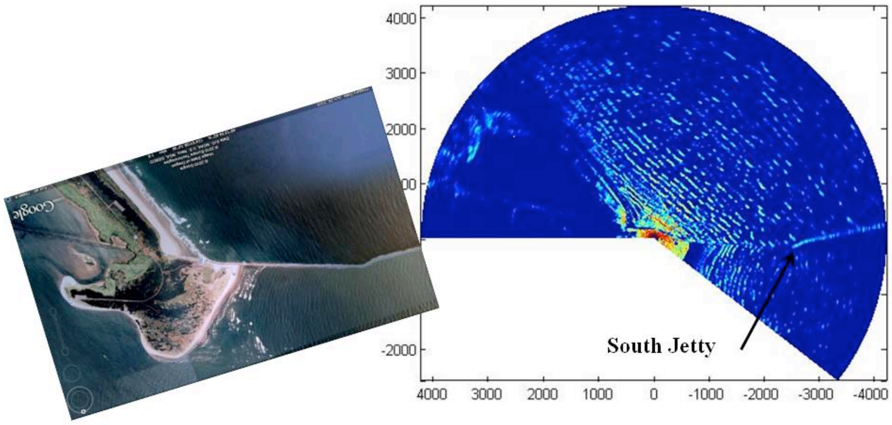


Figure 7: (left) Google Earth South Jetty, Columbia River, (right) wave radar image.

Shay Meskill was a Navy-funded graduate student who successfully completed his MS Project on analysis of our 2009 wave radar data from the Newport South Jetty site. His analyses demonstrated changes in the wind wave spectrum caused by strong winds between the offshore NDBC wave bouy (46050) and the shoreline as shown in Figure 8. The work also demonstrated a clear correlation between tide stage and wave breaking conditions in the navigational channel.

Another (PhD) student, David Honegger, who is funded through a Fellowship and leveraged funds from the Northwest National Marine Energy Center (DOE), has established a nearshore wave model system using the unstructured grid version of SWAN (un-SWAN) for the Newport region. His effort will compare model hindcasts to our wave radar collections in order to improve our understanding of wave breaking conditions and navigational hazards at this inlet.

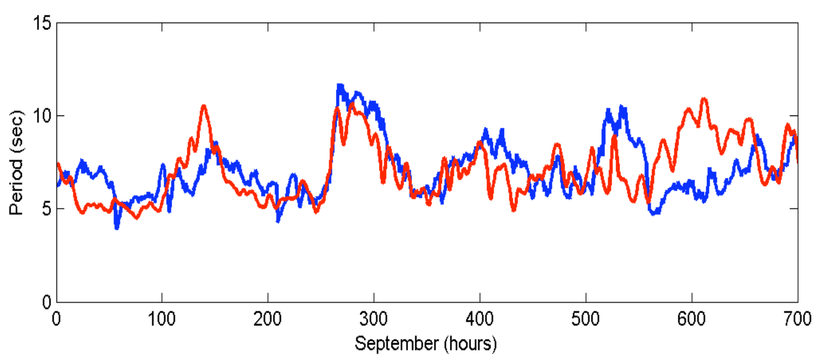


Figure 8: Wave period comparisons: radar-derived (red), NDBC 46050 (blue).

We are scheduled to reinstall the wave radar at the Newport South Jetty site on April 12th. Work is ongoing with C. Risien (OSU, NANOOS User Products/DMAC) to make this data available through the NANOOS portal in real-time.

Publication arising from this work:

Meskill, S., “Applications of Marine Radar Wave Observation Systems,” MS Project Report in partial fulfillment of the requirements for Masters of Science Degree, Oregon State University, Dec. 2009.

Presentations acknowledging NANOOS support:

1) Haller, M.C., “Wave observations and modeling at Newport, OR”, Hatfield Marine Science Center, Newport, OR, November 12, 2009.
2) Honegger, D.A., S. Meskill, and M.C. Haller, “X-band radar observations of waves near a tidal inlet and comparisons to the SWAN model”, *AGU Ocean Sciences Meeting*, Portland, OR, 2010.

b) Modeling efforts

- **Shelf:** Computer circulation modeling of PNW coastal ocean shelf conditions has been conducted by A. Kurapov's group at OSU, which produces daily updates of 3-day forecasts of ocean conditions, including currents, temperatures and salinities through the water column. Maps of the nowcasts and forecasts are posted daily to the web (http://agate.coas.oregonstate.edu/forecast_index.html), available through the NANOOS website.

The forecast model is forced with NOAA NAM atmospheric forecasts. Until August 2009, boundary information had been obtained from the real-time NCOM model of the California Current System (NCOM-CCS, I. Shulman, NRL). Since these became unavailable, we have used the climatologic boundary conditions derived from several years of NCOM-CCS.

Model outputs have been shared with our NANOOS collaborator C. Risien (OSU, NANOOS User Products and DMAC) who has worked to improve the interactive content of the presented model information. Regular users of our forecasts have included a group of local fishermen who obtain information on surface currents and SST to help plan fishing trips (our forecast web-pages registered up to 200 unique visits a week during summer). Requests for the surface velocity and SST have been obtained from the U.S. Environmental Protection Agency and NOAA Hazmat Team. Researcher H. Batchelder (OSU) has utilized our fields to develop a Lagrangian particle tracking tool, to help fisheries management.

We have continued to work toward inclusion of data assimilation in our forecast model. The PI on this project (Kurapov), using leveraging from the ONR grant, has developed a variational data assimilation system suitable for the coastal ocean. After initial idealized tests with this model (Kurapov et al. 2009), we have run hindcast tests for previous years assimilating along-track satellite SSH altimetry (AVISO), HF radar observations (Kosro, OSU), and multisatellite SST (D. Foley, NOAA) in our coastal model. Assimilation performed in a series of 3-6 day time windows shows promising results constraining circulation over the shelf and in the eddy dominated coastal transition zone, in particular, in 6 day forecasts. We are planning to include the variational assimilation system as a part of the real-time forecast model by June 2010, in collaboration with the NANOOS partner M. Kosro and NOAA experts on satellite observations (L. Miller, D. Foley).

Publications acknowledging NANOOS support:

Kurapov, A., D. Foley, P. T. Strub, J. S. Allen, G. D. Egbert, Variational assimilation of satellite observations in the coastal ocean model off Oregon, manuscript in preparation.

Presentations acknowledging NANOOS support:

Kurapov, A., G.D. Egbert, J. S. Allen, P. T. Strub, Variational Assimilation of Satellite Observations in a Coastal Ocean Circulation Model off Oregon. Ocean Sciences Meeting, Feb. 2009, Portland, OR

- **Estuaries**

1. Puget Sound: Overseen by D. Jones, APL-UW continues to maintain an operational hindcast model of the Puget Sound (PS-POM) based on the Princeton Ocean model, plus they are providing data sets and software engineering assistance to the Salish Sea ROMS model development team operated by Parker MacCready and Dave Sutherland of UW Oceanography and Neil Banas of APL-UW. In this reporting period, a passive-particle tracking model has been developed. The original code was developed for use with a ROMS model of the Chesapeake Bay. This code has been modified to work with the Salish Sea ROMS model. The particle tracking software was also parallelized to take advantage of multi-core/multi-cpu computing environments. Work related to this has recently started to investigate the effects of bathymetry geometry on flushing rates for estuarine environments.

APL-UW has also enhanced its model data access page, found through the NANOOS website. The main page can be found at: http://metoc1.apl.washington.edu/. The two models provided are:

Salish Sea ROMS Model: The Salish Sea ROMs Model is operated by Parker MacCready and Dave Sutherland in the School of Oceanography at UW (Fig. 9). APL-UW is developing a visualization system for the ROMS model written in Python called ROMPY. Source code with example images and movies made with ROMPY can be found: http://metoc1.apl.washington.edu/~lederer/rompy/.

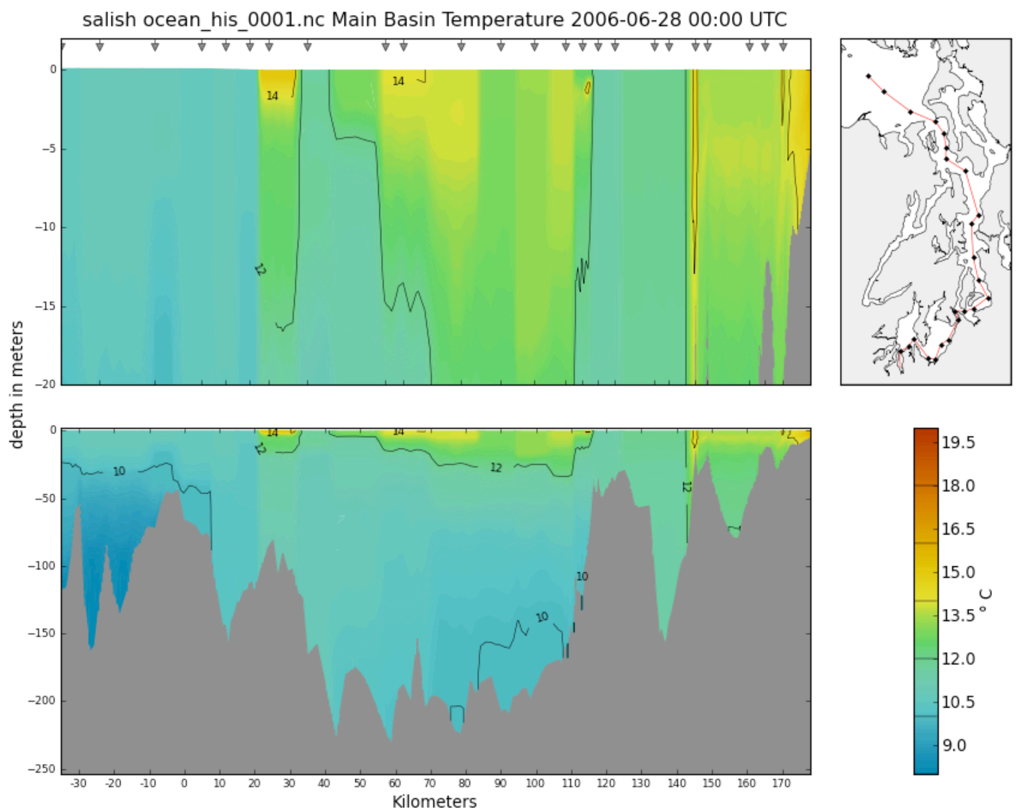


Figure 9. An example of the Salish Sea ROMS output for temperature on June 28, 2006 in Puget Sound.

Puget Sound POM: APL-UW continues to run the Puget Sound POM (PSPOM) daily and makes the data available via an OPeNDAP server, and as kml-formatted files viewable via Google Earth. PSPOM has a grid resolution of 295 grid points with 540 meter grid spacing in the North-South direction and 199 grid points with 360 meter grid spacing in the East-West direction. There are 14 sigma levels used to discretize the vertical axis. The model is run in a hindcast mode. The output for the previous day is made available daily at 4am PST. The output from one run is used as the initial conditions for the next day's hindcast.

The PSPOM files use the naming convention pom-YYYY-MM-DD.cdf.bz2. A user may use this to quickly retrieve information on a data set. For example, to view the netCDF header information on the PSPOM output file from the 1st of October, 2007 you can enter this line in a browser: http://metoc1.apl.washington.edu/cgi-bin/nph-dods.cgi/POM/pom-2007-10-01.cdf.bz2.info

APL-UW stores the POM output locally in a compressed format. It may take some time (a minute or two) for the machine to uncompress the file and display the desired output. Once the file has been uncompressed it is cached, so subsequent viewing/data retrievals should not take as long.

There has also been effort to establish verification of the model with observations taken in Puget Sound (Fig 10). Some rudimentary visualizations of this can be found http://metoc1.apl.washington.edu/Visualizations/tide_verification/. Data for these plots is taken from http://www.co-ops.nos.noaa.gov/.

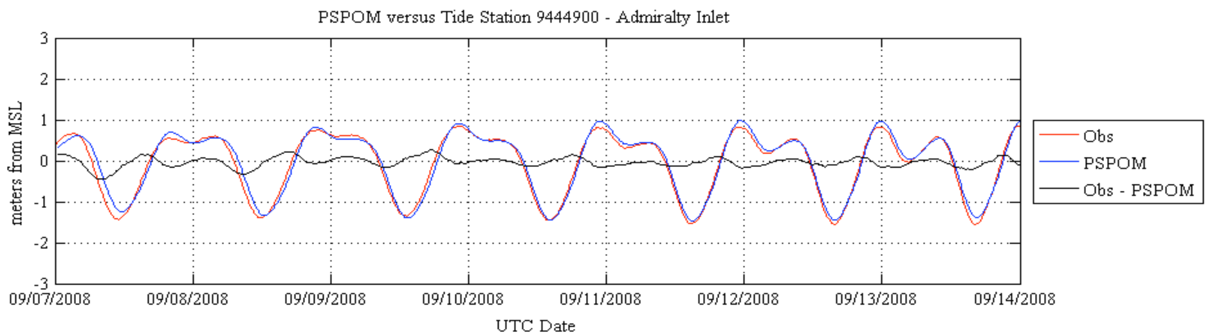


Figure 10. A comparison of the PS-POM tide prediction compared to the observation at Admiralty Inlet Tide Station 9444900.

2. Columbia River and other Oregon estuaries: With a mix of regional stakeholder funding (Bonneville Power Administration, NOAA Fisheries), NSF funding, and NANOOS funding, OHSU through the Center for Coastal Margin Observation and Prediction (CMOP), under the direction of A. Baptista, maintains an extensive modeling system for the river-to-shelf circulation of the Columbia River. The goal is to provide a “virtual Columbia River” to a broad community of scientists, educators, and managers.

The system, currently focused on 3D baroclinic circulation, includes daily forecasts, decade-long hindcast databases, and scenario simulations. The computational engine is the 3D baroclinic model SELFE (Zhang and Baptista, 2008), and model-independent data assimilation capabilities (Frolov, et al., 2009a) are available (Frolov, et al., 2008; Frolov, et al., 2009b). Operation of the modeling system is conducted through a coordinated effort of the CMOP operational modeling and cyber teams (both based in Portland, OR).

The virtual Columbia River is broadly available through the CMOP web site, via a newly developed interface: http://www.stccmop.org/datamart/virtualcolumbiariver. Forecasts of salinity and temperature at selected stations are also already available through NANOOS NVS, and additional products will become available through NANOOS NVS in 2010/2011. We will also continue to work with Rich Signell to make SELFE an integral member of the IOOS-interoperable unstructured grid models.

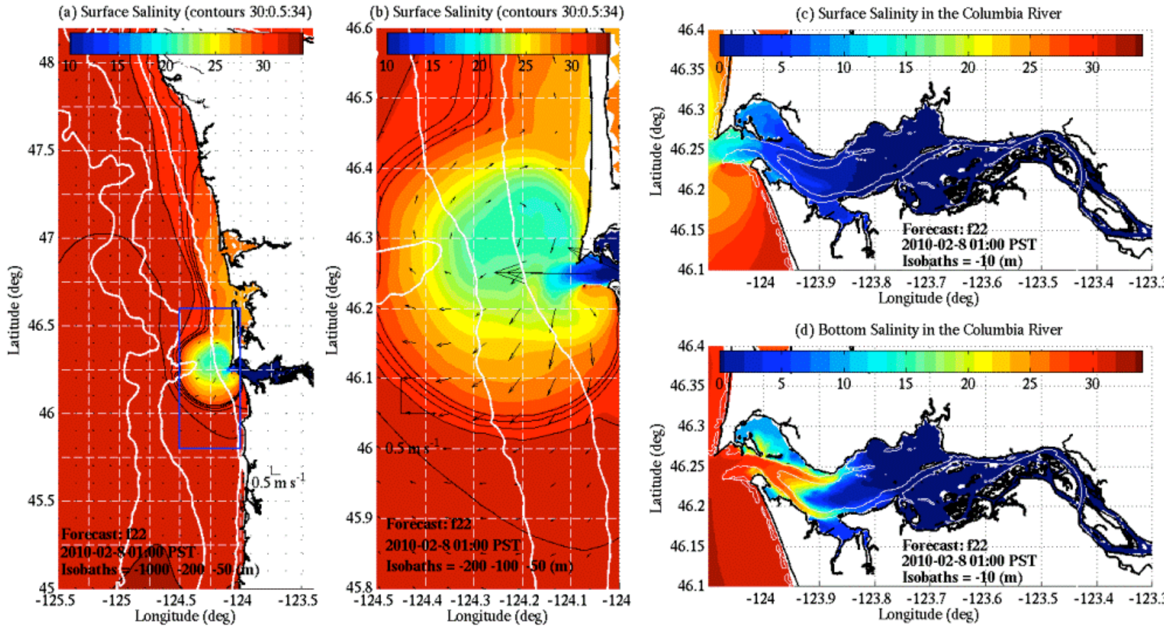


Figure 11: Sample daily forecast product (http://www.stccmop.org/datamart/virtualcolumbiariver/forecasts)

Additional details, per component of the virtual Columbia River:

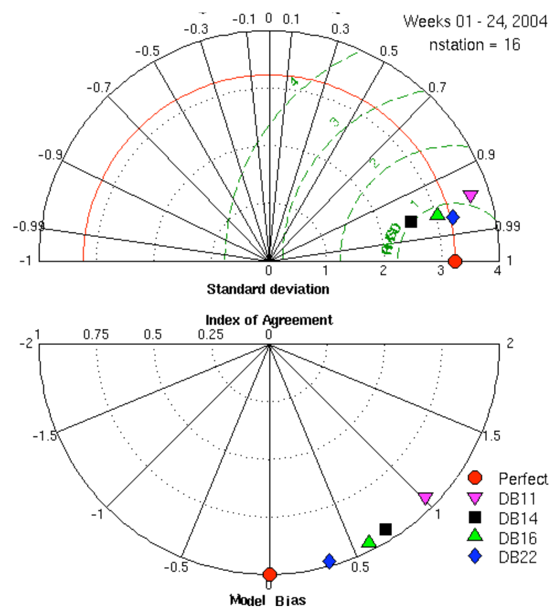


Figure 12: Modified Taylor diagram, illustrating improved skill of DB22 for simulation of temperatures. Top semi-circle refers to accuracy in representing temperature patterns, and bottom semi-circle refers to model bias and overall accuracy. Multi-directional proximity of a database relative to the red circle represents its level of accuracy.

<u>Daily forecasts</u>: We maintain a factory of multiple daily circulation forecasts (Fig. 11), which we upgrade periodically to reflect advances in modeling skill. Automated skill assessment is conducted near real-time against fixed SATURN, NANOOS and NOAA station data. When these assets are deployed, we also conduct semi-automated skill assessment against shipboard data, glider data, and AUV deployments. **As a service to the broad scientific community**, daily forecasts of circulation routinely support field campaigns in the Columbia River estuary, plume and shelf. Programs that have taken advantage of the resource include NAF RISE, NSF CMOP, NOAA/NSF ECOHAB, and NOAA/BPA salmon cruises. **As a service to the region**, daily forecasts of circulation: (a) are provided for inclusion in the NOAA-published Harmful Algal Bloom bulletin for the region; (b) are being integrated in the national emergency response system of the U.S. Coast Guard (work in progress); (c) are being integrated in NOAA PORTS (work in progress).

Hindcast databases. We keep up-to-date and periodically extend decade-long hindcast circulation databases. The databases are replaced every few years by newer and more skilled versions, as model capabilities improve. The most recent database (DB22, in progress) substantially improves the skill for simulation of water temperatures (Fig. 12). Databases are used by a range of regional stakeholders, in support of interdisciplinary science, management, and restoration/recovery efforts. A long-standing collaboration with NOAA Northwest Fisheries Science Center is a major driver, and focuses on salmon recovery efforts. Climatologies of a set of circulation model-based environmental indicators were developed and are serving as a basis for analysis of impacts of climate and human activities in the Columbia River (see "scenario simulations). A Climatological Atlas, including products such as Fig. 13, is available at http://www.stccmop.org/datamart/virtualcolumbiariver/simulationdatabases/climatologicalatlas.

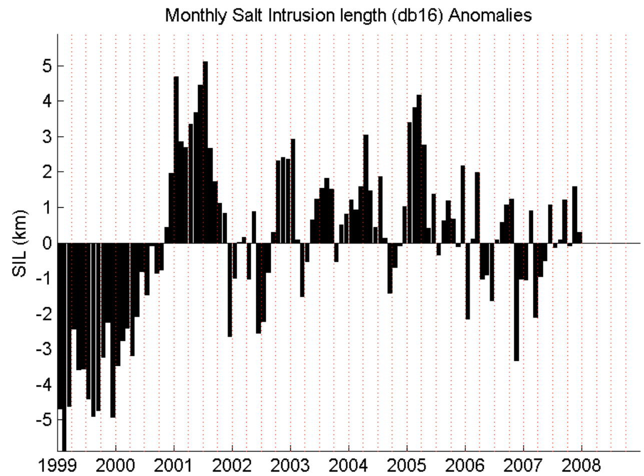


Figure 13: Among the products of the Columbia River Climatological Atlas are anomalies of salinity intrusion length (SIL)

Scenario simulations: Simulations of historical and future conditions of circulation are being conducted in support of NSF- and NOAA-funded studies to characterize change in the Columbia River estuary and plume for various scenarios of management and climate change. Issues being addressed include the effect of model error in assessments of climate and anthropogenic impact; distinguishing between "variability" and "change"; and exploring the feasibility of regionally-accepted protocols for assessing effects of anthropogenic actions in the context of environmental impact statements.

Other modeling activities within NANOOS:

- A. Baptista represents NANOOS in the NFRA Modeling Committee, which meets approximately monthly. In this role, he is participating in the definition of the role of regional associations in a national modeling system.
- We continue to maintain daily 3D circulation forecasts for the following "extended PNW" estuaries: Coos Bay; Fraser River; Grays Harbor; Humboldt Bay; Monterey Bay; Siletz and Depoe Bay; Tillamook, Nahalem and Netarts Bays; Willapa Bay; and Yaquina and Alsea Bays. Skill varies greatly but is typically low compared to the more mature and skill-assessed forecasts for the Columbia River. Continuation of these forecasts beyond 2010/2011 will depend on factors such as additional funding and availability of data for calibration/validation.

c) <u>Data Management and Communications (DMAC)</u>

1. Managerial: Boeing is lead for managerial duties. Steve Uczekaj (Boeing – DMAC lead) is the Chair of the NANOOS DMAC Committee. DMAC committee technical implementers include Rick Blair (Boeing – Infrastructure and Standards), Craig Risien (OSU – Data Provider Services), Emillio Mayorga (APL UW – Data Provider Services), Troy Tanner (APL UW – Portal Services). DMAC activities for this period include the following:

- NANOOS DMAC Weekly Tag-up telecon.
- IOOS Regional DMAC Implementation (RDI) bi-weekly telecon.
- DMAC Steering Committee weekly telecon.
- IOOS DMAC program workshop in Silver Springs, MD – March 2010.
- NANOOS Tri-Committee meeting in Portland, OR – April 2010
- Presented new NANOOS Visualization System (NVS) at Oceans '09 conference in Biloxi, MS, Oct. 2009.
- Provided information about NVS to IOOS Program at a site visit and conference call in Nov. 2009
- Responded to the IOOS RCV scoping request in Dec. 2009.
- Presented NANOOS-APL data management activities (including some NVS aspects) at Ocean Sciences meeting in Portland, OR, Feb. 2010.
- Met with Cyndy Chandler from the NSF-funded Biological and Chemical Oceanography Data Management Office (BCO-DMO) to discuss future coordination on issues of data quality assessment and QARTOD involvement.

2. Summary of Significant DMAC Technical Accomplishments: Significant accomplishments were made in maturing the NANOOS DMAC architecture including release of a NANOOS Visualization System (NVS) providing real-time web-based access to NANOOS region assets, data, and forecasts. Recent progress includes:

- **Released NVS 1.0 in Nov. 2009 and NVS 1.5 in Mar. 2010. NVS 1.0 integrates all known *in-situ*, near-real-time assets in the Pacific NW. NVS 1.5 features user-interface enhancements, model forecasts, and user-activity tracking in support of usage metrics.**
- Extended the NANOOS data services to include a second SOS server for assets based in Washington State and Canada.
- Added new model data sets to ERDDAP data aggregation server.
- Brought online an open-source GeoServer providing tsunami inundation hazard map via Web Mapping Service (WMS). Also available as KML for Google maps.
- Added experimental access to NVS assets metadata via WMS, GeoRSS and KML.
- Updated CMOP SOS server to be compliant with current DIF Standards.
- Instrumented CMOP SOS server and ERDDAP SOS client for performance measurements.
- Added new assets to NVS:
    1. Four VENUS seabed cabled observatories in British Columbia
    2. Three Puget Sound buoys from a private industry partner (ICM-Mobilisa)
- Created a mobile iPhone application to visualize NANOOS assets and data.
- Added an open source THREDDS data service for CMOP in-situ historical observations and glider data.

- Added new data offerings: SATURN-05 and SATURN-06

3. Task 1 Progress: DMAC Systems Architecture Definition and Development: The DMAC Team continued maturing implementation of IOOS DIF standards through participation in Regional DIF telecons. Specific contributions include investigation of alternate data encodings for SOS service and performance evaluation of SOS protocols. The team also made significant progress on an extensible framework for regional data visualization through the NVS, migration of in-situ observation database to a more robust server, and the extension of an OpenDAP server for CMOP observation and forecast data.

The NANOOS DMAC team continues to work closely with the development of the NANOOS Visualization System (NVS) to bring DMAC capabilities and best practices in support of NVS functionality and to exploit opportunities for re-purposing NVS-specific data flows and products to wider IOOS applications. This effort was expanded to include mobile devices for discovery, browsing, displaying and downloading of NANOOS *in-situ* data. In addition an open-source GeoServer was configured for distribution of NANOOS and regional data via OGC WMS.

The NANOOS-APL database was migrated to a more robust server to support higher loads. This database (adapted from Xenia) was discussed at the Feb. 2010 Ocean Sciences meeting in Portland, OR. Based on our experience with this database, we have made additional contributions to the Xenia community via the Xenia wiki portal and mailing list. The OOSTethys Perl SOS server attached to this database will be upgraded soon to the new version released in late 2009.

CMOP cyber-infrastructure team working in conjunction with NANOOS DMAC deployed an OpenDAP server to allow external users access to CMOP in-situ data archive. CMOP possesses a substantial data archive that extends for more than 10 years. This service has been thoroughly tested and is an integral part of CMOP data architecture and reassures CMOP's commitment to improve interoperability with other regional and/or national entities. The data is served following the DIF recommendations and standards. CMOP OpenDAP for in-situ observation will be extended to offer model data in the following months, which will offer a more complete picture of the state of the Columbia River and the Coast (Oregon and Washington) to scientists, policy makers, and interested public.

4. Task 2 Progress: DMAC Network Engineering Definition and Development: Work continued in development of an aggregating server using ERDDAP, re-factoring CMOP data for access through OpenDAP and presentation through NVS, and initiation of a multi-region collaboration with Alaska Ocean Observing Systems (AOOS).

NANOOS aggregation and transformation services are being developed on an ERDDAP server. The transformation services available in ERDDAP will be used to provide NANOOS data in a variety of formats from NVS. This requires additional work to expose ERDDAP transformation capabilities as network services. NVS asset data will also be made available for access from geospatial applications through the NANOOS GeoServer instance.

CMOP has made substantial progress towards sharing model data. This is not an easy task given that CMOP models use an irregular grid; however alternatives are being considered to side step some difficulties. Currently model data from points where in-situ observations are collected is available internally to CMOP and steps are being taken to make it available through NVS.

NANOOS DMAC started a new multi-region collaboration with AOOS to prototype cross region asset/data registration and visualization leveraging NVS implementation. Results will be shared with the IOOS national team. IOOS national team progress on a standard Registry /Catalog/ Viewer (RCV) service will be leveraged where possible.

5. Task 3 Progress: DMAC User Product Development: The NANOOS DMAC committee continued to work closely with the NANOOS User Products Committee to finalize the initial release of the NANOOS Visualization System (NVS), as described in the NANOOS September 2009 report. The NVS 1.0, launched on Nov. 2, 2009, has been running robustly and operationally since then and has received considerable attention and praise. The NVS technical design was outlined in a paper (Risen et al., 2009) and presented in a special IOOS track at the Oceans09 Conference in Biloxi, MS.

A major upgrade (NVS 1.5) was released in Mar. 2010, featuring:

- Significant upgrade and refactoring to the NVS asset database, user-interface framework, and data harvesters;
- User-interface enhancements (e.g., content sizes with browser, legend panel, new introduction page, updated help information);
- Addition of forecasts at *in-situ* asset locations, currently including WaveWatch III, NOAA CO-OPS tide, and NANOOS OHSU/CMOP Columbia estuary and plume forecast;
- User-activity tracking in support of usage metrics;
- New pages for NDBC Anomalies and availability of data downloads for the Hood Canal Dissolved Oxygen Program (HCDOP) dataset.

One of the more unique features to NVS 1.5 was the incorporation of forecast information at specific observing stations (Fig. 14). Additional enhancements for the next few months are under development and will include integrated HF Radar maps (NANOOS and UCSD CORDC) and satellite products from NOAA CoastWatch.

In the NANOOS-APL instance, substantial updates and quality checks were performed on the PRISM cruises and Hood Canal Dissolved Oxygen Program datasets, available via the NANOOS SOS. In addition, initial scoping and preparatory work has been performed for ingesting the Hood Canal ADCP time series and the marine environmental assessment datasets from the NNMREC (Northwest National Marine Renewable Energy Center) tidal energy pilot site at Admiralty Inlet in Puget Sound.

Presentations acknowledging NANOOS support:

Risen, C, J. Allan, R. Blair, A. Jaramillo, D. Jones, P, Kosro, D. Martin, E. Mayorga, J. Newton, T. Tanner, and S. Uczekaj. (2009). The NANOOS Visualization System: Aggregating, Displaying and Serving Data. *Proceedings of the MTS/IEEE Oceans 2009 Conference*, Biloxi, MS., October 26-29, 2009

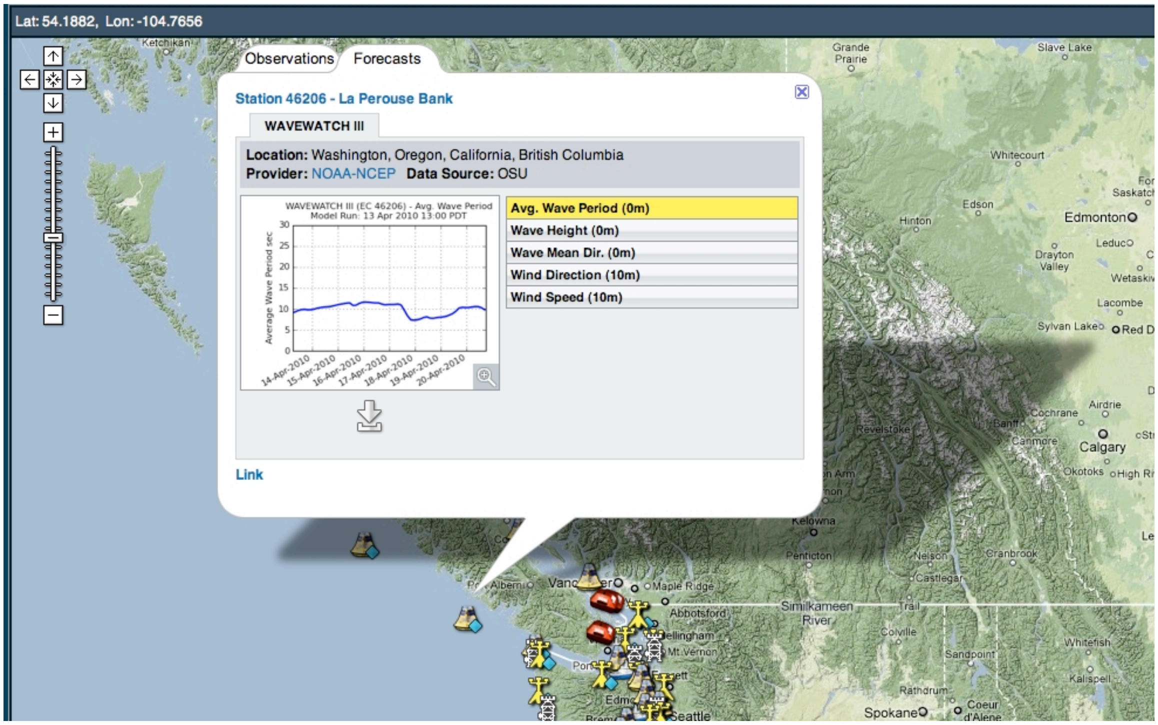


Figure 14. Screen shot from NVS. Displays the Wave Watch III forecast for the location at the La Perouse Bank buoy, Station 46206, between the dates April 14, 2010 and April 20, 2010.

d) <u>Education and Outreach</u>

This section details NANOOS Education and Outreach activities. NANOOS has an Education and Outreach Coordinator (A. Sprenger, APL-UW) and an Education and Outreach Committee (M. Kosro, Chair, OSU). The work of this committee is informed by NANOOS' User Products Committee and is partially executed via the NANOOS web. We thus divide this section into those three inter-related and interacting components.

1. User Products Committee: Chaired by J. Allan (DOGAMI), the NANOOS User Products Committee is comprised of fifteen members, including 6 members who are part of the DMAC committee and another 4 who are members of Education and Outreach (E&O). As User Products chair, Allan has continued to work closely with DMAC and UPC colleagues in the development of the NVS portal delivery system, including participating in weekly meetings and by leading discussions about its various components and levels of functionality. Since its public release in November 2009, Allan has continued to work with NANOOS DMAC and the Web Team to further refine NVS functionality. In its most recent upgrade (v1.5.1), NVS now boasts the inclusion of WaveWatch III derived wind and wave forecast information at all offshore buoy locations, and tidal forecasts at all National Ocean Service tide gauge stations. Forecasts are harvested by C. Risien (OSU) and transferred to E. Mayorga (UW) for inclusion in NVS.

The full UPC committee met recently on April 1-2 2010 in a NANOOS tri-committee meeting (User Products, DMAC, Education & Outreach). A smaller sub-group of UPC and DMAC has continued to meet weekly in order to monitor DMAC and User Product activities and product development.

NANOOS UPC and DMAC team assisted the Oregon Department of Geology and Mineral Industries in additional modifications to the online tsunami evacuation map web-portal. The portal currently displays evacuation maps developed for coastal communities on the Oregon coast and is being hosted by NANOOS. The URL link is http://www.nanoos.org/data/products/oregon_tsunami_evacuation_zones/index.php. In the most recent changes, a web-mapping server was established at the University of Washington's APL lab and the tsunami evacuation polygons were migrated to the new site to minimize down-times that had been occurring with the previous server configuration.

2. Web-related Outreach: With the goal of improving the NANOOS web portal, APL-UW began a pilot study (Jones and Olsonbaker, 2009) designed to investigate ways to measure how effectively IOOS RA web portals deliver data and information. Good measurement techniques can help the IOOS community improve its support to users through the development of best practices. In the APL-UW examination of 10 RA web portals, the main questions it investigated were: how easy is it to search, locate, and use IOOS data. The paper was presented at the Oceans09 conference in Biloxi. The presenter, Jones, was invited in November 2009 to provide a follow-on briefing at the IOOS program office.

Presentations acknowledging NANOOS support:

Jones, D and J. Olsonbaker (2009). Developing Best Practices for IOOS Web Portals. *Proceedings of the MTS/IEEE Oceans 2009 Conference*, Biloxi, MS., Oct 26-29, 2009.

3. Education & Outreach Committee: Under the leadership of A. Sprenger (NANOOS Education and Outreach Specialist) and M. Kosro (NANOOS Education and Outreach Committee Chair), the NANOOS Education and Outreach (E&O) Committee, of which OR Sea Grant, CMOP STC, and COSEE staff are part, engaged in the following activities:

- Sarah Mikulak was hired through the University of Washington Applied Physics Laboratory in Feb, 2010 to work on informal education projects.
- Sprenger represented NANOOS at the West Coast Marine Spatial Planning Workshop conference organized by the Nature Conservancy, held in Seattle, WA in October 2009.
- Sprenger had a display at two "Storming the Sound" conferences, one-day conferences on environmental and sustainability education. Storming the Sound North (29 January in La Connor) was attended by 100 educators from northern Puget Sound. Storming the Sound Central (26 March in Seattle) was attended by 170 educators.
- Sprenger had an informational exhibit on educational opportunities with NANOOS at COSEE OLC's Education and Public Outreach for research scientists workshop held at the University of Washington in January, 2010.
- Sprenger and Mikulak have participated in the monthly conference calls of the NFRA Education subcommittee. In February, 2010 the NFRA EOC submitted a letter of intent for a NOAA informal/nonformal environmental literacy grant. The LOI was favorably received and the NFRA committee has been working together on the full proposal to be submitted in early April, 2010.
- Sprenger submitted an LOI on behalf of NANOOS to this same NOAA funding opportunity. The NANOOS LOI, which proposes the development of capabilities and tools to integrate citizen science data into NANOOS, was also positively received. E. Mayorga, Newton, and Education committee member, N. Hunter of OR Sea Grant, along

with Risien, Sprenger, Mikulak and K. Litle from WA Sea Grant as senior staff pulled together a complete proposal for early April 2010 submission.

- The theme page about hypoxia in the PNW developed by Mikulak during the summer of 2009 was made on the NANOOS portal during the winter of 2010.
- NANOOS hosted an exhibit booth at the Coastal and Estuarine Research Federation (CERF) meeting in Nov 2009 at Portland, OR. Information given to attendees included resources on NANOOS, NOAA IOOS, NFRA and other regional associations. Mikulak and Sprenger had approximately 100 direct conversations with conference attendees over the 4 day conference, with many more attendees stopping by to pick up information.
- Sprenger and Mikulak participated in a three part COSEE NOW webinar about exhibit design and development that occurred from Dec 2009- Jan 2010.
- In March, 2010, Newton, Jones, Sprenger, and Mikulak attended a progress meeting with Intellicheck Mobilisa at UW APL about the on-going exhibit design project. Mikulak presented the to-date exhibit prototype.
- NANOOS Ed &Outreach committee member C. Risien put up a NANOOS display at the Oregon Coalition for Educating ANglers meeting, which was held on 6 March 2010, in Newport Or. Risien presented on NANOOS history, mission, goals and organizational structure. In addition, the presentation described in detail the products currently provided that are of interest to members of the recreational and commercial fishing communities. These include SST and surface current forecast information for Oregon, plots of satellite derived SST and CHLA and the NANOOS Visualization System. Approximately 70 people were present for this presentation.
- Sprenger presented and exhibited at the Washington Science Teachers Association annual conference in mid-March, 2010. 20 teachers attended her presentation on NANOOS resources for the classroom, about 50 more educators visited the NANOOS exhibit booth.
- NANOOS continues to support NERRS in maintaining the Real Time Water quality data website for Shellfish Growers, with a telecom in January 2010 about status/needs.
- Sprenger is an active member of ECONET, the Puget Sound Partnership's Education and Outreach Network.
- **NANOOS prints its first newsletter** - The first edition of the "NANOOS Observer" was released on the NANOOS web in late October. It is the NANOOS community's update for new products, news items, and ocean-related issues affecting the NANOOS region of the Integrated Ocean Observing System. Janet Olsonbaker, Amy Sprenger, and Eric Shulenberger contributed to this first edition. The second edition of the "N.O." will be released in April, 2010.

Presentations acknowledging NANOOS support:

1) Mikulak, S., C. Orrico, S. Rowe, and N. Hunter. 2009. A Partnership Model of How to Develop an Interactive Exhibit to Present Real-Time, Estuarine Water Quality Data to the Public in an Informal Education Setting. *Coastal and Estuarine Research Federation Conference,* Portland, OR, November 1-5, 2009.

2) Mikulak, S., S. Rowe, N. Hunter, and C. Orrico. 2010. Ocean Observing Data and Science Center Visitors: Creating Motivation and Relevance. *Eos Trans. AGU*, *91*(26), Ocean Sciences Meeting Suppl., Abstract ED45C-03. February 2010, Portland, OR.

4) Issues (NONE)

5) Key Personnel Changes (NONE)

6) Budget Analysis

The NANOOS RCOOS award is 83% completed and NANOOS has expended or obligated 88% of the funding. All required financial reports have been submitted.

References cited:

Baptista, A. M. et al., 2005. "A cross-scale model for 3D baroclinic circulation in estuary-plume-shelf systems: II. Application to the Columbia River," Continental Shelf Research, vol. 25, pp. 935-972.

Bottom D. L., et al., 2005. "Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon,"

Burla, M. et al., in press. "Seasonal and inter-annual variability of the Columbia River plume: A perspective enabled by multi-year simulation databases," Journal of Geophysical Research, vol. doi:10.1029/2008JC004964.

Frolov S., et al., 2008. "Optimizing Placement of Fixed Observational Sensors in a Coastal Observatory," Continental Shelf Research, vol. 28, pp. 2644-2658 November 15, 2008.

Frolov S., *et al.*, 2009. "Fast Data Assimilation Using a Nonlinear Kalman Filter and a Model Surrogate: an Application to the Columbia River Estuary," *Dynamics of Atmospheres and Oceans,* vol. 48, pp. 16-45, October 2009.

Frolov S., *et al.*, 2009. "Estimation of Ecologically Significant Circulation Features of the Columbia River Estuary and Plume Using a Reduced-Dimension Kalman Filter," *Continental Shelf Research,* vol. 29, pp. 456-466.

Jones, D and J. Olsonbaker (2009). Developing Best Practices for IOOS Web Portals. *Proceedings of the MTS/IEEE Oceans 2009 Conference*, Biloxi, MS., October 26-29, 2009.

Risen, C, J. Allan, R. Blair, A. Jaramillo, D. Jones, P, Kosro, D. Martin, E. Mayorga, J. Newton, T. Tanner, and S. Uczekaj. (2009). The NANOOS Visualization System: Aggregating, Displaying and Serving Data. *Proceedings of the MTS/IEEE Oceans 2009 Conference*, Biloxi, MS., October 26-29, 2009

USACE. 2001. Biological Assessment - Columbia River Channel Improvements Project: An internal report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. Available: https://www.nwp.usace.army.mil/issues/crcip/pubs.htm

Zhang Y. and A. Baptista, 2008. "SELFE: A semi-implicit Eulerian Lagrangian Finite-element model for cross-scale ocean circulation," Ocean Modeling, vol. 21, pp. 71-96.