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 Apr 2009 – 30 Sept 2009

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 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

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) <u>Observing System efforts</u>

- **Shelf**

1. Washington Buoy and glider observing network operations: Led by M. Alford (University of Washington (UW)), these efforts have focused on finalizing the surface mooring design for deployment off La Push, WA, and making equipment purchases to allow bench-top assembly of the instrumentation/communication framework by January 2010. To ensure both survivability and serviceability, extensive research has been conducted regarding various mooring components including the sub-surface instrument cage and the buoy hull design. The buoy controller is presently being assembled. Work is on target to deploy the surface mooring for tests within Puget Sound during the early spring 2010, and offshore for an initial ~4-month deployment during the summer 2010.

In August, 2009, we (Newton, Alford, Devol, Martin, UW) were informed that we were chosen as the recipients of the Murdock Charitable Trust Award, providing $450K for the purchase of equipment/instrumentation in support of this network. Additionally, in September we hired a field engineer who will commit half of his time to assisting with mooring fabrication and maintenance.

2. Oregon Glider operations: The Oregon State University (OSU) glider group led by J. Barth and K. Shearman deployed an autonomous underwater glider off Newport, Oregon, for the NANOOS-contracted two months during March-April 2009. These months were chosen to try and capture the spring transition when winds become predominantly upwelling favorable after the winter season. This strategy was successful because the spring transition occurred around mid May this year. 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 and before we can share quality-controlled, near real-time data. This is a goal for NANOOS Year 3. 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 Year 3, we plan to fly the glider for 3 months under NANOOS support. Our overall goal is to provide year-round glider data, but this must wait for additional IOOS/NANOOS support.

Presentations acknowledging NANOOS support:

Barth, J. A., R. K. Shearman, F. Chan, S. D. Pierce, A. Y. Erofeev, J. Brodersen, M. D. Levine, K. Page-Albins, C. Risien, L. Rubiano-Gomez, and B. W. Waldorf, 2009: An expanding observatory to monitor hypoxia in the Northern California Current System. Presented at the Ocean Obs'09 Conference, Sept. 2009, Venice, Italy.

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. The most recent mooring turnaround was in late August 2009; the next is scheduled for May 2010. The data time series has been recording nearly continuously for about 1.5 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 borrowed 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 summer 2009 the superstructure of one of the buoys was significantly rebuilt. We also added a new sonic anemometer to the sensor suite. Some instrumentation was damaged during the last deployment and is being 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 (CMOP).

4. Central Washington shelf: With NSF funding, OHSU through the Center for Coastal Margin Observation and Prediction (CMOP) under direction by A. Baptista established in 2009 glider operations in the Central Washington shelf, thus adding to NANOOS' regional glider efforts on the Oregon and Washington shelves. The operation is based on the use of a Slocum glider ("Phoebe"; http://www.stccmop.org/corie/observation_network/glider).

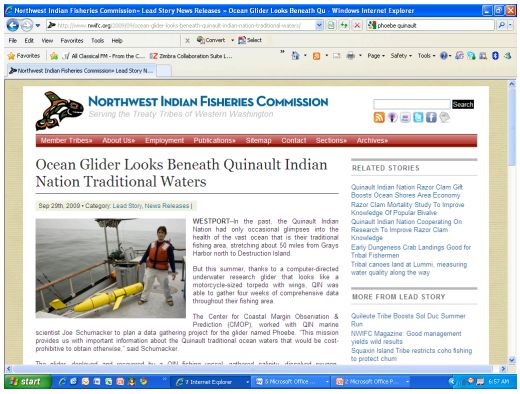

Fig. 1: Northwest Indian Fisheries Commission article on Phoebe. See more at http://www.nwifc.org/2009/09/ocean-glider-looks-beneath-quinault-indian-nation-traditional-waters

Operations are conducted by a three-person field team based in Astoria, OR. Route planning is coordinated from Portland, OR, by a technician that provides liaison between the field and cyber teams. The cyber team ensures that all data is available on the CMOP and NANOOS web portals, both real-time and in archival mode.

Operations are coordinated with the Quinault Indian Nation (QIN), which has input on the sampling pattern, and provides logistical support for deployment and recovery. As explained in the web site of the Northwest Indian Fisheries Commission (Fig. 1), "QIN is particularly interested in dissolved oxygen levels after an episode of low oxygen left hundreds of normally bottom-dwelling creatures on the nation's beaches in 2006. Tribal Dungeness crab fishermen were bringing up pots that were either empty or full of dead crab."

After experimentation, we have settled on a series of continental shelf transects in a radiator pattern between Grays Harbor and Quinault. The intent is to maintain sampling as close to year-round as logistically possible. However, weather windows for deployment and recovery are scarce in winter, suggesting that longer-life (e.g., lithium) batteries will be necessary at that time. We will not operate in the 2009-2010 winter. Purchase of a second glider is under consideration, and would allow a more continuous data record in spring-fall.

The sensor package permits measurements of salinity, temperature, dissolved oxygen, Colored Dissolved Organic Matter (CDOM), chlorophyll *a* and turbidity. Early deployments have already captured the occurrence of frequent hypoxic conditions in the proximity of submarine canyons. The glider also measured occasional

presence of low salinity waters that were not correlated with the riverine CDOM signature and therefore not consistent with a PNW freshwater source.

- **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 and Hoodsport buoys operated continuously throughout the period; the Duckabush and North buoys both had intermittent down time due to various winch problems. The North Buoy mooring is back up and profiling; we are working to resolve the Duckabush winch problems and get it up and profiling again as well. Sampling frequencies were increased throughout the spring as available solar power increased, and by summer the moorings were profiling 12 times per day. All buoy data was made available in near real time on the NANOOS website. These observations are leveraged against the Hood Canal Dissolved Oxygen Program and NSF. Average bottom water temperature was lower than 2008 by as much as 0.5 degrees C, and lower than previous years by as much as 1 degrees C. Salinity and oxygen concentrations were relatively high compared with the previous 3 years.

Through collaboration with NOAA (C. Sabine, R. Feely), we added a pCO2 sensor to the Twanoh mooring in July 2009 and it has been measuring atmospheric and surface water pCO2 since early August. We also collaborated with the NOAA IOOS-funded Alliance for Coastal Technologies during their demonstration project to field test several different pCO2 sensors for comparison by mounting them on the Twanoh mooring for 30 days and assisting with the intensive nearly-daily sampling regime during the project.

Also during the summer of 2009, a new profiling mooring was deployed in the main basin of Puget Sound near Point Wells, funded externally through a UW partnership with Intellicheck- Mobilisa, Inc. Similar to the ORCA moorings, the data are available on the web in near real time on the NANOOS website (http://www.nanoos.org/data/products/npb/npb-1/overview.php). It is equipped with sensors for temperature, salinity, dissolved oxygen, chlorophyll fluorescence, turbidity, currents, nitrate, PAR, transmittance, and meteorological data. We have been working on software to automatically process and calibrate the data files, posting profile data to the web.

We recently were officially notified that we (Newton, Alford, Devol, Martin, (UW)) have been awarded a Murdock Charitable Trust Grant to install an observing system on the Washington State continental shelf. These funds will augment NANOOS funding to establish a system that consists of a fixed mooring with a surface expression that will measure in the mixed layer, a subsurface mooring that will profile between about 20 m and the bottom, and a glider. We will measure temperature, salinity, dissolved oxygen, chlorophyll fluorescence, turbidity, currents, nitrate, and meteorological data on the fixed and profiling moorings and temperature, salinity, dissolved oxygen, chlorophyll fluorescence with the glider. The fixed and profiling moorings will provide relatively high frequency measurements at one location while the glider will provide spatial coverage over a section across about half of the shelf and somewhat out over the slope. All data will be transmitted back to UW via iridium satellite linkage and posted to the NANOOS web relatively quickly. These data are essential to understanding dynamics in Puget Sound, for instance, human eutrophication and coastal upwelling can have a similar nitrate/oxygen signature.

Over the next 6 months we plan to continue maintaining the ORCA moorings and data streams, and begin decreasing profiling frequency down to 1-2 profiles per day for the winter. 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.

Presentations acknowledging NANOOS support:

(1) Newton, et al. 2009. Sumary of findings from the Hood Canal Dissolved Oxygen Program Integrated Assessment and Modeling Study and Implications for Corrective Actions, presented to the Hood Canal Coordinating Council's Technical Advisory Committtee, 1 Sept 09, Bremerton, WA.

(2) Devol, A.H., Newton, J., Ruef, W. 2009. Sampling frequencies necessary for cloastal ocean observatories. Ocean Obs 09 confrence, Venice, Itlay. 21-25 Sept 09.

(3) Newton, J. and Martin, D. 2009. Development of a regional coastal ocean observing system for societal benefit through US IOOS: NANOOS. Ocean Obs 09 confrence, Venice, Itlay. 21-25 Sept 09.

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 observations by maintaining monthly-calibrated moorings in Willapa Bay and Puget Sound. To augment this effort Ecology recently hired a new moorings coordinator, D. Mora. The moorings continue to deliver indispensable information on environmental conditions, as evidenced by ongoing data requests from government, academic, tribal, and private entities for projects ranging from shellfish growing to fish migrations to hydrodynamic models.

In Puget Sound, Ecology now operates three near shore, fixed mooring stations located in Manchester/Clam Bay, Squaxin Passage, and the newly added station in Mukilteo (Boeing pier/Port of Everett). The moorings are maintained with assistance from volunteers from Ecology's Manchester Lab, NOAA, and most recently, Everett Community College and the Port of Everett. 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 Mukilteo station is a near-bottom deployment. The near-bottom devices are configured for telemetry, and data are available in real-time on the web at http://www.ccalmr.ogi.edu/nanoos/.

All Puget Sound mooring locations are situated to capture and describe net inter basin water mass and oxygen exchange. Exploratory mooring deployments have occurred at the Narrows, Admiralty Inlet, and Shannon Point and will continue contingent on future funding and data quality.

On the Washington coast, Ecology continues to monitor near surface water temperature, salinity, and fluorescence in Willapa Bay (Bay Center) and has maintained the effort to get these data available real-time. 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 impossible to attach a fixed telemetry cable. In an effort to meet requests for real-time data, Ecology explored the idea of installing a fixed near-bottom Hydrolab sensor package. Last spring, Ecology conducted a test of Hydrolab's sensor performance on the pier of Manchester Labs with the idea to capitalize on Hydrolab's reliable telemetry. The Hydrolab sensor package consistently recorded and transmitted temperature, salinity, pressure, chlorophyll fluorescence, turbidity, and dissolved oxygen data side by side with the existing Sea-Bird 16+ CTD mooring. The side by side analysis of Hydrolab and Sea-Bird sensor systems has not been completed. In the interim, Ecology received strong urging from UW to stay with the SeaBird sensor package and continue efforts to telemeter the surface-floating mooring. The UW NANOOS technicians offered to contribute their experience and expertise to solving our telemetry issues and have agreed to help set up a new acoustic telemetry system at this site.

Expected activity for next 6-month period includes that Ecology is committed to continuing measuring all variables at our moorings in WA estuaries with the help of collaborations between Ecology and stakeholders. This grant is partially supporting the time of our mooring technician, M. Jones. Through the efforts of Mora and Jones, we will continue to maintain and service the Manchester, Squaxin Passage, Mukilteo, and Willapa Bay sites. We anticipate bringing the Willapa Bay real-time mooring data to the web with assistance from UW.

We will also report on the success of our exploratory deployments in Puget Sound, aimed at better describing basin exchange.

3. Columbia River estuary and plume: With a mix of NANOOS funding, regional stakeholder funding, and NSF funding, OHSU through the Center for Coastal Margin Observation and Prediction (CMOP) under the direction of A. Baptista, maintains multiple endurance stations in the Columbia River river-to-shelf continuum. Those stations are part of CMOP's SATURN observation network (Fig. 2), a member of the NANOOS federation of systems. We describe below two sub-components of SATURN.

CORIE endurance stations were originally deployed as a part of an autonomous observation and prediction system, one of the pioneer estuarine observatories in the US, now subsumed within the SATURN collaboratory. They are still often referred to as 'CORIE' stations, for legacy reasons. This system is maintained through majority NANOOS funding, with partial support coming from regional stakeholders.

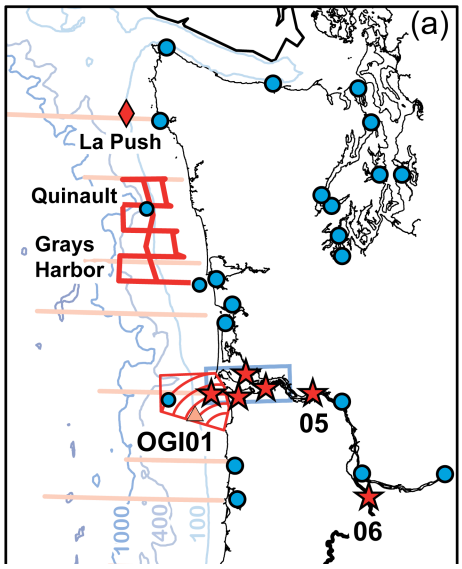

Fig. 2: SATURN assets in the Columbia River coastal margin: (a) river-to-shelf, (b) estuary, (c) estuary North Channel. Endurance stations include SATURN01-06 (★) and CORIE current (▲) and historical (▲) stations. These are shown against other regional in-situ stations in estuaries (●) and the shelf (◆). Also shown are the CMOP glider paths (—), CMOP-supported surface radars in the plume (■) and estuary (■), and CMOP campaign base-line sampling: (—) and (●).

Most CORIE stations are in the estuary (deployed year round, with radio-based real-time telemetry) and one is in the far-field plume (OGI01, deployed seasonally, with no telemetry)–see Fig. 2. In most stations, measurements are at single level. Variables are salinity, temperature, water levels, and velocity profiles. Two former CORIE stations have been upgraded to become biogeochemical stations (SATURN 02 and 04, described below).

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. Data is available on the CMOP and NANOOS web portals, both real-time and in archival mode.

Major operational challenges are posed by the large number of stations, the heavy currents at many of the station locations, and weather (partially year-round local winds, but especially winter weather). In this context, the set-up of CORIE stations continues to be progressively modified to reduce 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) is designed to minimize the need for operations during winter.

We are also examining–with the guidance of results from formal studies of network optimization (Frolov et al. 2008)–the possibility to reduce the number of stations with loss of overall information. If the number of stations can be decreased, we would the able to strategically increase the vertical resolution of salinity and temperature observations at a small number of stations. We would also be able to re-vamp observations of velocities. Both are needs identified through applications (including those referred below).

OGI01, located at 100 m depth, just south of the Columbia River in the OR shelf, offers a potential North-South complement to the NANOOS inter-disciplinary stations NH-10 (maintained by OSU at the Newport line, in central OR) and La Push (to be deployed within the next year in northern WA by UW). Pending funding, consideration will be given to adjust location (from 100m to 80m) and/or add interdisciplinary sensors.

Salinity, temperature and water level data are quality controlled on a monthly basis, using documented procedures. Data, quality control procedures, and performance metrics are available through the CMOP web site.

Because they have been in place for an extended time period (some since 1996), CORIE 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, Fig. 3) are often visible in the estuary time series.

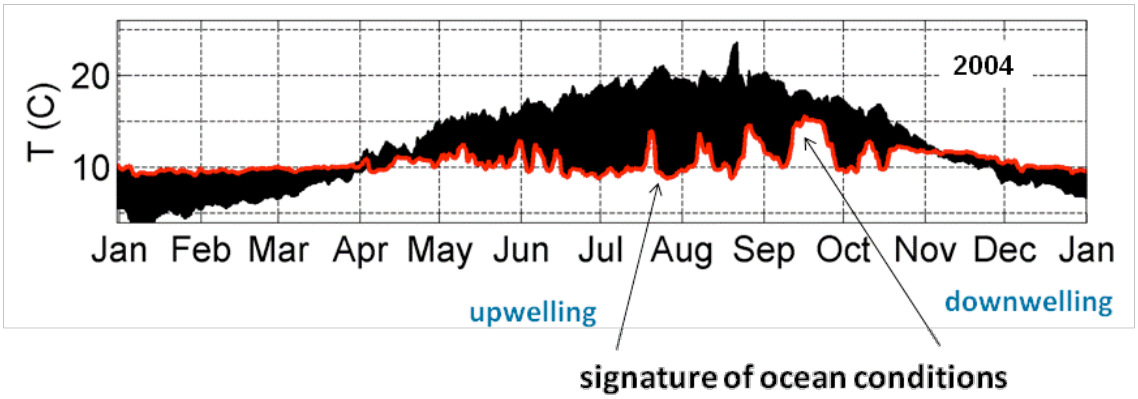

Fig. 3: In downwelling conditions during spring-to-fall, warmer surface shelf water constitutes the marine end member for the Columbia River. The lower envelop of the temperatures from all CORIE stations in the Columbia River estuary thus becomes a sentinel for downwelling events during this otherwise upwelling-dominated season.

Several CORIE stations are maintained under contract with the U.S. Army Corps of Engineers, in support of monitoring of potential effects of channel deepening, with particular consideration of impacts on salmon habitat. Context for that application can be found in (Bottom, et al. 2005) for salmon context and in (USACE 2001) for channel deepening context. A range of other restoration efforts and environmental impact studies in the Columbia River estuary resort to CORIE station data.

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, Baptista et al. in press).

Scientific use of data from CORIE physical stations include insights into biogeochemical processes (Bruland, et al. 2008) as well as direct characterization of physical processes (Chawla, et al. 2008).

Accessible via the NANOOS web portal, the database and web interfaces used to support sensor-to-user flow of information for CORIE is the same used across SATURN, and constitutes one of the three main NANOOS data centers. The same database supports NANOOS stations maintained by the Washington Department of Ecology.

Six SATURN biogeochemistry stations have been recently deployed to resolve the Columbia River river-to-shelf gradient (Fig. 2). These stations are all being developed under NSF funding. As the stations reach maturity and funding allows, they will be considered for maintenance support through NANOOS. SATURN-02 is in the near-field plume; SATURN-01, 03 and 04 are in the estuary (in two channels and a low-salinity lateral bay); SATURN-05 is in the main stem of the CR at river mile 53; and SATURN-06 is in the Willamette River (a major tributary that joins near Portland, OR). All stations experience tidal fluctuations.

Each SATURN biogeochemical station consists of a horizontally-fixed platform. River stations (05, 06) monitor near surface only, while estuary and plume stations are designed to capture the vertical structure of the water column (using either winch- and pump-based technologies). The goal is for each station to monitor at a minimum the following "baseline variables": conductivity/salinity, temperature, CDOM, turbidity, chlorophyll *a*, nitrate and dissolved oxygen. While not all stations are equipped with this spectrum of sensors yet, we expect that to occur over time.

SATURN-01, 02, 03 and 04 are maintained by the Astoria field team, under the direction of A. Baptista. SATURN-05 and 06 are maintained by J. Needoba in collaboration with WET Labs (a NANOOS member) and

USGS. An additional station (07) is expected to be deployed in an ocean-influenced lateral bay of the estuary; 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 CORIE stations. Data, 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. Sensor-to-user handling of information flow, including database and web interface, are the same as for CORIE data. SATURN-06 is also a USGS NAWQA water quality site, and reported as such via the USGS web site. SATURN-05 is also a Satlantic LOBO station (Land/Ocean Biogeochemical Observatory), and reported as such on a dedicated Satlantic website. The LOBO technology is emerging as an industry/stakeholder-led national biogeochemical network.

4. Oregon South Slough: Observations: 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)). Rumrill and technical staff members from the South Slough NERR (A. Helms and A. DeMarzo; NERR System-Wide Monitoring Program / SWMP) continued ongoing operations for the series of moored observing stations located within the South Slough estuary as part of the NERR/SWMP network of NANOOS anchor stations. The monitoring stations are located at: (1) Oregon Institute of Marine Biology – Boat House, (2) Charleston Pier, (3) Valino Island, (4) Winchester Arm, and (5) Sengstacken Arm. These moored monitoring stations have been established along the estuarine gradient of the South Slough estuary where they provide characterizations of the marine (euhaline), marine-dominated (polyhaline), mixing (mesohaline), and riverine (oligohaline) hydrographic regions of the estuary. Each of the water monitoring stations in the South Slough is equipped with a YSI-6600 multi-parameter datalogger with the array of electronic sensors located 50 cm above the bottom of the estuarine tidal channel, and a sub-set of the stations are equipped with Sutron SatLink2 data telemetry systems that transmit the digital datastreams via the Geostationary Operational Environmental Satellite (GOES) system. The monitoring stations in the South Slough were in continuous operation throughout the period of March to October 2009, and the dataloggers were retrieved, downloaded, recalibrated, reprogrammed, and redeployed on a monthly basis during the spring, summer, and fall 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 (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). Posting of the datasets generated by the South Slough NERR to the websites has been periodically interrupted due to a weak satellite signal strength, and many technical adjustments have been made to increase reliability of the transmissions of the near real-time datasets.

Data Synthesis and Application: Datasets generated by operation of the monitoring stations were used to construct an atlas of variability in ambient water parameters. The project (Estuary Atlas of the South Slough: Preliminary Draft) was constructed with Surfer (ver. 8) software and provides a graphical illustration of seasonal and spatial changes in temperature and salinity of the tidal waters of the estuary. Additional components of the atlas are planned for the future including transition of the spatial and temporal information to an ArcGIS framework, and to develop thematic maps to illustrate spatial and temporal changes in dissolved oxygen, pH, fluorescence, and dissolved inorganic nutrients, and fecal indicator bacteria.

Datasets generated by the NANOOS/SWMP observation stations were also used to help guide local decisions over the summer about the optimum location in the estuary for the placement of experimental out-plants of Olympia oysters (Ostrea lurida). In particular, time-series data from the Charleston and Valino Island monitor-

ing stations were used to describe variability in summer 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.

Recent observations of elevated pCO2 values in the nearshore ocean waters along the Pacific coast of North America provide an opportunity to investigate the relationship between ocean acidification and variability in pH values in Pacific coast estuaries. Staff members from the South Slough NERR examined time-series measurements of water column parameters recorded at the NANOOS/SWMP stations (YSI-6600 EDS multi-parameter dataloggers equipped with a YSI 605091 pH/ORP sealed gel probe (resolution 0.01 pH unit; accuracy $\pm$ 0.2 pH unit)). The dataloggers have been operated continuously over the period of 2002-2009, and recorded about 208,500 measurements of estuary pH values. Estuary pH values typically ranged between 7.7 and 8.3 throughout each day, and a strong tidal signal as well as a diurnal cycle was observed with lowest pH values in mid-morning and highest pH values in mid-afternoon. The daily pH cycle appears to be driven by photosynthesis and respiration of phytoplankton, macroalgae, and submerged aquatic vegetation within the estuary.

Outreach: Staff members from 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). In addition, the NERRS Centralized Data Management Office has assisted with identification of the programming changes required to allow near real-time measurements of fluorescence to be displayed on the NANNOS website. Along with measurements of water temperature and salinity, the time-series measurements of fluorescence are of primary interest to the local oyster shellfish growers because they provide an indicator of the concentration of phytoplankton available in the estuarine water column as food for the filter-feeding oysters.

- **Shorelines**

1. Washington Shorelines:

CMAP implements monitoring in accordance with NANOOS scope of work (WA Dept of 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 the second half of Year 2. This effort also supported 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, 14 surface maps were collected during summer 2009 each containing an average of 10,000 data points over a distance of 3 to 4 kilometers alongshore. 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. The text files are organized and cataloged into onsite network drives with accompanying FGDC metadata.

Monitoring data documents benefits of sand fence stabilization of beach berm (US Army Corps) - After the U.S. Army Corps placed 125,000 cubic yards of dredged material to create a sand berm on an eroded and washed-out dune area adjacent to the Columbia River North Jetty in August, 2008, CMAP installed sand fences on the sand berm in September 2008. Since then, CMAP's quarterly beach monitoring program has documented a net sand-volume increase on the beach berm due to the sand fences. The fences are trapping sand that would otherwise be blown into the Columbia River navigation channel. The accumulation of sand in the fenced area will reduce impacts of flooding and may reduce the rate of beach erosion. This summer, CMAP implemented Phase 2 of the sand fence project with the installation of 3,000 ft of sand fence and replacement of all metal posts with wood posts.

Beach change data shows relationship to razor clam abundance (WA Dept. Fish & Wildlife) - In collaboration with Washington Department of Fish and Wildlife, CMAP initiated a comparative assessment on beach profile

change and razor clam population density to explore possible relationships to beach dynamics. A cursory review shows higher clam populations where the beach is highly accretional, and low populations in where the beach has been eroding. This information will be important in siting and permiting dredged-material disposal sites along northwest Oregon and southwest Washington.

- Presented a poster entitled "Dune Face Erosion and the Winter Wave Climate in the Columbia River Littoral Cell" at the 2009 Pacific Estuarine Research Society Conference. The poster showed the results of continuing research on correlating wave climate to dune retreat.
- Provided input for a presentation to the West Coast Regional Coastal Managers Meeting on Washington's climate change adaptation activities.
- Provided input to the scope of work for the Climate Change Action Coordination Team of the West Coast Governor's Agreement on Ocean Health.
- Participated in a coastal experts workshop, a joint effort between the Province of British Columbia's Ministry of Environment, Climate Change Branch and Washington State's Department of Ecology to bring together experts on sea level changes along the Pacific coast.
- Provided input and planning support to a wave hazard and navigation safety workshop organized by the Lower Columbia Solutions Group. A key motivation for the workshop was to work out an agreement on how the relationship between navigational safety and dredged material management will be handled in the permitting of a new nearshore disposal site. The workshop was critical to developing information needed for designation of alternative nearshore disposal sites.

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 (DOGAMI). Monitoring was undertaken at 119 sites on several occasions between March 31, 2009 and September 30, 2009. Beach cross-section surveys were carried out in March to April 2009 (winter survey), May to June 2009 (spring survey), and July to September 2009 (summer survey) along the Neskowin and Rockaway littoral cells, Clatsop Plains, and along the Newport cell (Yachats to Otter Rock).

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 presented at several forums including Oregon Shores conservation coalition (September 09), Netarts community (May 09) and OSU researchers (April 09).

Summary information describing the state of the beach monitoring effort and results were published by the Oregon Department of Geology & Mineral Industries in an open-file-report earlier this year (Allan, J.C. and Hart, R., 2008). Oregon beach and shoreline mapping and analysis program: 2007-2008 beach monitoring report. Open file report O-08-15, Oregon Department of Geology and Mineral Industries, Portland.).

In addition, to the core beach and shoreline monitoring occurring on the central to northern Oregon coast, DOGAMI staff integrated other beach monitoring activities onto the OBSMAP website, expanding its scope to cover several south coast monitoring activities.

3. Nearshore Bathymetry: In summer 2009, P. Ruggiero's group at Oregon State University successfully completed the collection of nearshore bathymetry along the four sub-cells of the Columbia River littoral cell (CRLC) in close collaboration with the Washington State Department of Ecology and the US Geological Survey. Over 200 individual cross-shore profiles were collected in the cell extending from the lower inter-tidal to approximately 12 m of water depth (~2000 m from the shoreline). Approximately 400 kilometers of nearshore mapping took place within 13 days of field data collection. In all cases these nearshore bathymetry measurements are being combined with topographic measurement collected by Ecology to develop complete maps of the nearshore planform. These data are being processed from their raw format into deliverable text files and are passing a rigorous quality assurance process.

- Ruggiero's group, in close collaboration with DOGAMI, Ecology, and the USGS successfully executed the second annual nearshore bathymetric data collection effort within the Rockaway littoral cell in Oregon. Over 70 individual cross-shore beach profiles were collected from the lower intertidal to approximately 25 m of water depth (~1500 m from the shoreline). These data are being combined with topographic data collected synoptically by DOGAMI, and are being processed from their raw format into deliverable text files and are passing a rigorous quality assurance process.
- Ruggiero's group, with support from NANOOS, has successfully developed a 4th generation Coastal Profiling System (CPS), 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. In summer 2009 this tool was used for the first time along a rocky coastline (Cape Foulweather, OR) in support of OSU's PISCO group. The nearshore bathymetric data will be used in studies of nearshore larvae transport.
- Ruggiero gave an invited talk at the 'Wave amplification/safe navigation at the Mouth of the Columbia River workshop' in Ilwaco, WA in April 2009. The talk was titled: "Bathymetry survey assessment methodologies," and highlighted NANOOS efforts.
- In October 2009 Ruggiero and PI Allan led a field trip along the coasts of Oregon and Washington (25 participants from several countries) associated with the Geological Society of America's annual meeting. The focus of the field trip was coastal hazards and morphodynamics and NANOOS efforts were highlighted.
- Ruggiero and PI Kaminsky along with intern C. Guthrie gave a paper at the Pacific Estuarine Research 2009 meeting highlighting NANOOS efforts: Guthrie, C., Ruggiero, P., and Kaminsky, G., 2009. Wave climate and dune face erosion in the Columbia River littoral cell, Proceedings of the Pacific Estuarine Research 2009 Meeting, Bellingham, WA, April 2009.
- 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. Results of the monitoring program have been presented and discussed at several meetings hosted by the Lower Columbia Solutions Group (LCSG), convened by the Governors of Washington and Oregon, in their ongoing projects, including the Southwest Washington Littoral Drift Restoration (Benson Beach) Project, and the Oregon Nearshore Beneficial Use Project.
- Ruggiero uses NANOOS supported data and knowledge in his Coastal Geomorphology and Coastal Hazards classes taught at Oregon State University. NANOOS efforts are highlighted during guest lectures and in advising students.

- **Currents**

1. Coastal Currents: The HF surface current mapping program at OSU (PI M. Kosro, RAs A. Dorkins and W. 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 developed a new capability

for dual-processing at our Columbia River sites, to allow production of both standard and expanded first-order-limit output in real-time, with the goal of improving our resolution of the strong ebb-flow currents there.

To improve QA/QC and outage detection, we implemented a heads-up site status display for the web. A pamphlet was prepared for the visitor center at Cape Blanco for public outreach. Incidents of large ionospheric noise in July were investigated, and a report sent to the ROW-G mailing list (techs from other HF operators). Remote sites have been upgraded to MacOS 10.5.8; we plan to hold off on 10.6 until it stabilizes. We are rolling in CODAR updates to the data acquisition software (SS10R6), with about half of sites updated. Three new computers have been installed. In a major operation, we moved our two Columbia River sites STV and SEA to address issues of erosion and neighbor relations, respectively. In the former case, the move required construction of a new shelter, trenching of a new cable set and electric-power feed, and moving the electronics, computers, and communications equipment, as well as installing new security fences and alarms. The moves also required a major effort to collect new antenna pattern measurements over the water.

We have been conducting tests at Cape Blanco to diagnose low returns, solved false-alarm problems from our security system at Loomis Lake, WA, reduced interference by adjusting GPS timing delays at Point St. George, CA, and added an Internet-enabled power switch to our Winchester Bay site, to provide more reliable remote-on-off capability. We are also working with the NSF-sponsored Ocean Observing Initiative to allow them to test ocean-to-shore data transmission through our established wireless communications channels for HF radar data.

2. Port Radar: Led by M. Haller (OSU) the marine radar station at the Newport jetties began regular observations on May 1st 2009. An example radar image is shown below (Fig 4). The system has been collecting hourly image sequences and uploading them to our web database server on the OSU campus. Work is ongoing with C. Risien (OSU, NANOOS User Products/DMAC) to make this data available through the NANOOS portal in real-time. Very recently we have had some hardware failures and replacements are on order.

We are also leveraging other funds for a graduate student who is working on data product development for the radar site. He is developing algorithms to analyze the wave breaking conditions at the entrance to the jetties and investigating their correlation with the tides. Finally, another graduate student (on Fellowship) is establishing a wave model system (using the SWAN wave model) to model the Newport shelf region. The goal of this work will be to establish real-time wave predictions and to test these predictions against our radar observations. P. McEnaney has joined our group as a part-time Faculty Research Assistant and is maintaining the radar station.

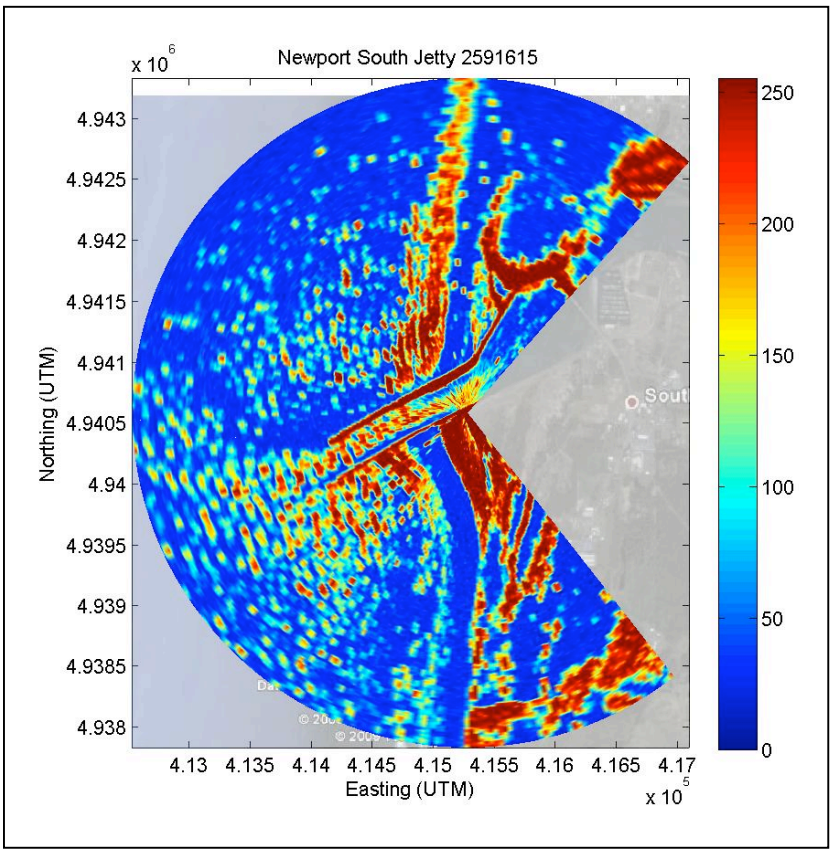

Fig. 4. Output of surface wave imagery from the radar station at the Newport, OR, south jetty.

b) <u>Modeling efforts</u>

 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. Boundary information has been obtained from the real-time NCOM model of the California Current System (I. Shulman, NRL). To enable forecasts without interruption during days when real-time boundary conditions are not available, in addition to our current first-choice model, we have also run the back-up model with the climatologic boundary conditions.

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 May 2010, in collaboration with the NANOOS partner M. Kosro and NOAA experts on satellite observations (L. Miller, D. Foley).

Publication arising from this work:

Kurapov, A. L., G. D. Egbert, J. S. Allen, and R. N. Miller, 2009: Representer-based analyses in the coastal upwelling system, Dyn. Atmos. Oceans, doi:10.1016/j. dynatmoce.2008.09.002, 48(1-3), 198-218.

Presentations by the PI acknowledging NANOOS support:

(1) EGU General Assembly, Vienna, Austria, 19-24 April 2009.
(2) Gordon Research Conference on Coastal Ocean Circulation, New London, NH, June 7-10, 2009
(3) ONR Review Meeting, Chicago, IL, June 11, 2009
(4) 3rd Coastal Altimetry Workshop, Frascati, Italy, 17-18 September, 2009.

- **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. During the last six month extensive code maintenance was necessary to allow the model to run beyond the short time frame that was initially specified when the model was developed at UW Oceanography. This maintenance should allow the model to continue running without interruption, contingent on atmospheric forcing fields from the UW Atmospherics department being available. Hardware assets were obtained to ensure smooth model execution, in light of localized power grid issues, ensuring the longevity and stability of computer that runs the PS-POM model.

Model output was used to experiment with new graphing architectures which have since been selected for use in NVS. Effort was expended to include model output from PS-POM in the NANOOS Visualization System (NVS). While none of the preliminary products are ready for public display, certain
graphical products should be available for public consumption in the near future.

Members of the APL-UW modeling group started working with P. MacCready's (UW) group to use the ROMs model of Puget Sound. This involvement will streamline the possible addition of the ROMs model as an operational model to be run by APL-UW. This will also assist the continued development of *Particulator*, a software package used to track particles in circulation models.

A new Puget Sound circulation model developed by M. Kawase (UW) based on the SUNTANS model has now been calibrated against tidal observations, and the results have been reported at the Eighth European Wave and Tidal Energy Conference, Uppsala, Sweden on September 9, 2009. This model will mainly be used by the Northwest National Marine Renewable Energy Center (NNMREC, http://depts.washington.edu/nnmrec/) for assessment of tidal energy extraction potential of and resultant environmental impact on Puget Sound, but will be available for operational running after baroclinic processes are incorporated, as planned for FY 2009 - 2010.

2. Columbia River and other Oregon estuaries: With a mix of regional stakeholder funding, NSF funding, and NANOOS funding, OHSU under the direction of A. Baptista, through the Center for Coastal Margin Observation and Prediction (CMOP) maintains an extensive modeling system for the river-to-shelf circulation of the Columbia River. Our goal is to create a "virtual Columbia River," available 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, 2008), and model-independent data assimilation capabilities (Frolov, 2009) are available when required (Frolov, 2008; Frolov, 2009). We are working with Rich Signell (NOAA IOOS) to make SELFE an integral member of the NANOOS-interoperable unstructured grid models.

- Operation of the modeling system is conducted through a coordinated effort of the CMOP modeling and cyber teams (both based in Portland, OR), under the guidance of Baptista.
- Daily forecasts routinely support field campaigns. Hindcast databases (Baptista, 2005;Burla, in press) provide insights into the response of E-GRs to ocean, atmospheric and river forcing, enabling characterization of processes and creation of climatology for, and detection of anomalies in, key variables and sentinels of system behavior. Comparison against multiple types of data (including SATURN observational assets and periodic CMOP cruises) allows continuous assessment and improvement of modeling skill.
- Daily forecasts: We maintain a factory of multiple daily circulation forecasts, 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. Applications include real-time support of oceanographic and fisheries cruises, multiple times a year and historically from multiple groups in the region (e.g., BPA/NOAA, EcoHAB, RISE, CMOP). These forecasts are being transferred to NOAA NOS, for assessment and official adoption by NOAA COOPS (targeted for 2010). We will maintain our forecast factory active after the transfer, and upgrades will be made available to NOAA on an annual basis.
- 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. 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 (e.g., Bottom, 2005; Burla, 2009). 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).
- 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.
- Open Columbia River modeling benchmark: The vision is a "plug-and-play" environment, inclusive of rigorous skill assessment cases, that allows multiple coastal margin models to be cross-tested in the SATURN data-rich environment, at a low cost-of-entry and regardless of developer affiliation. With NSF-funding, we have implemented components of this vision, with increasingly more comprehensive model-data comparisons that take advantage of the SATURN endurance stations and pioneer array and the CMOP campaign science.

In addition:

- Baptista has represented 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 assessment is highly variable and typically low compared to the more mature and skill-assessed forecasts for the Columbia River. "Extended PNW" forecasts would greatly benefit from a modest investment of the region in simple, local observation networks for model skill assessment. Local stakeholders' interest will dictate which of these forecasts will be maintained beyond this pilot phase.

c) Data Management and Communications (DMAC)

1. Managerial: Boeing is taking lead for managerial duties. S. Uczekaj (Boeing) is the Chair of the NANOOS DMAC Committee and represented NANOOS at the following meetings:

- Attended an April NANOOS Joint Committee meeting at UW.
- Attended a June NANOOS Governing Council Meeting at Washington State University, Vancouver campus, and presented progress on NANOOS DMAC.
- Presented NANOOS at a September PACOOS meeting held at University of Washington.
- Participated in NOAA Strategy meetings held at University of Washington in September.
- Participated in regular Regional DIF Implementation (RDI) team conference calls.
- Coordinated a NANOOS inter-committee working group to establish requirements and prioritize tasks for the Portal effort.
- Provided input for NANOOS Y4 Bridge funding proposal.
- Provided regional inputs on progress towards implementing DIF recommendations and provided inputs on NANOOS DMAC data-flows.

2. Summary of Significant DMAC Technical Accomplishments: Significant accomplishments were made in maturing the NANOOS DMAC architecture including addition of new data sources and addition of distributed sensor observation services. Recent progress includes:

- Extended the NANOOS data services to include a second SOS server for assets based in Washington State and Canada.
- Added an experimental open source ERDDAP server as a data aggregation service.
- Added an open source THREDDS data service for OSU model output.
- Added Web Coverage Service for Tsunami inundation model output.
- Created an asset database as the backend to the NANOOS Visualization System (NVS).
- Updated CMOP SOS server to be compliant with current DIF Standards.
- Added new data offerings to the NANOOS SOS service including the following:
  1. Fixed Moorings from Environment Canada.
  2. Water Quality from King County Marine Moorings.
  3. PRISM Cruises from University of Washington.
  4. Fixed platforms from National Estuarine Research Reserve System (NERRS)
  5. Tides and Currents data from Center for Operation Oceanographic Products (CO-OPS)

Also effort was directed to strengthen regional partnerships to support the redistribution of sub-regional assets through DIF services. Support may involve providing NANOOS expertise and assistance or assuming the role of direct re-distributor.

3. Task 1 Progress: DMAC Systems Architecture Definition and Development: The DMAC Team continued participation in IOOS standardization committees and gave input to national IOOS effort on definition and prioritization of 12 key areas of interest to the IOOS program office. These areas include security, alerts, archiving, standardization, registration, visualization, data integration, catalog, system monitoring, format conversion, metadata and quality control and assurance. Under this task, DMAC architecture design was modified to include an asset database and data cache for NVS.

The DMAC Team developed second NANOOS relational database for *in-situ* observations. By basing it on an adaptation of Xenia (the best-practice IOOS/RCOOS community data model), we leveraged existing IOOS cyber infrastructure investments while contributing to community software development. This new database complements the existing CMOP database, increasing regional capacity and NANOOS' ability to provide personalized support to local providers throughout the Pacific Northwest. New datasets and assets were ingested and are being made available to IOOS and to NANOOS applications

DMAC implemented new DIF services for data distribution and interoperability. The OOSTethys Perl SOS server was adapted to the new APL database, and this implementation will be validated and made operational in November 2009. We have contributed to the debugging and enhancement of this community SOS server. Also,

we implemented the open-source GeoServer software and are configuring it for distribution of NANOOS and regional data via OGC WMS.

The NANOOS DMAC team worked 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.

4. Task 2 Progress: DMAC Network Engineering Definition and Development: Work continued in investigating alternate approaches to aggregating observation data and determining impact on performance and scalability. An ERDDAP server was installed to aid in these investigations. A second SOS service was installed at UW to provide data from NANOOS assets in Washington and data assets in Canada.

5. Task 3 Progress: DMAC User Product Development: The NANOOS DMAC committee worked closely with the NANOOS User Products Committee, in particular Chair J. Allen (DOGAMI), to define the requirements for NVS. Interfaces were designed between NVS and an asset database to allow automated data harvesting. This approach allows NCS to automatically display new data sets as they are added to the asset database resulting in dynamic creation of real-time 24 hour, 7 day and 30 day plots and downloads.

APL led the development of NVS and its DMAC components in close collaboration with NANOOS DMAC and User-Product Committee partners at OSU, OHSU/CMOP, DOGAMI and Boeing. NVS is an online asset visualization application and framework currently ("version 1", or NVS-1) focused on *in-situ* observation assets for its initial public release (Oct. 28 at Oceans '09 Conference). Key NVS-1 characteristics include:

- Dynamic, responsive user interface based on Google Maps, AJAX schemes, and multiple data-caching mechanisms.
- Focus on user needs and user friendliness.
- Consistent asset metadata integrated in a light-weight database, providing all asset metadata used in NVS displays and tools.
- Asset filtering and discovery tool based on asset metadata and controlled vocabularies.
- Consistent presentation of latest and recent data (30-days) independent of asset source.
- Inclusion of component providing access to PRISM cruise data from APL database, later to be expanded to other cruise programs.

DMAC team members developed requirements for visualization of glider and cruise data.

A DMAC committee member, C. Risien (OSU), wrote a paper on NVS (NANOOS Visualization System – see E&O below) that was accepted to the Oceans 09 conference.

d) **Education and Outreach:** This section details NANOOS Education and Outreach activities. NANOOS has an Education and Outreach Coordinator (A. Sprenger) and an Education and Outreach Committee (M. Kosro, Chair). 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 developed a concept white paper describing the scope and components that would make up the NANOOS Visualization System (NVS – see E&O section below), a web-based portal that will form the main interface for accessing regional and federal assets in the PNW (NANOOS) region. In addition, Allan has continued to work closely with DMAC and UPC colleagues in the development of the NVS, including participating in weekly meetings and by leading discussions about its various components and levels of functionality.

User products developments include: The full UPC committee last met in April 2009 in a NANOOS tri-committee meeting (User Products, DMAC, Education & Outreach). A smaller sub-group of UPC and DMAC 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 the development of a 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.

As new maps are developed, these will be incorporated into the portal. In addition, we hope to eventually incorporate tsunami evacuation information derived for the Washington coast. Finally, the present configuration involves OSU resources to host the evacuation polygons using an ARCIMS server. However, we are planning to move the polygons over to a GISserver that will be hosted by NANOOS at University of Washington.

UPC chair Allan, with support from UPC/DMAC/E&O committee members, developed a white paper that would form the conceptual framework for developing the NANOOS visualization system (NVS), a web mapping portal that will aggregate, display and serve near real-time coastal, estuarine, oceanographic and meteorological data, derived from buoys, gliders, tide gauges, HF Radar, meteorological stations, satellites and shore based coastal stations, as well as model forecast information in such a way that it presents end users with a rich, informative and meaningful experience.

The core focus of the UPC/DMAC team over the past several months has been to oversee the development of the NVS, scheduled for public release on November 2nd, 2009.

UPC/DMAC members (Risien, Allan, Blair, Jaramillo, Jones, Kosro, Martin, Mayorga, Newton, Tanner, and Uczekaj) co-wrote a paper to be published as part of the Oceans'09 conference proceedings. The paper title is "The NANOOS Visualization System: Aggregating, Displaying and Serving Data".

2. Web-related Outreach: In E&O we achieved two major web-related milestones this reporting period:

(1) We have stood up the "NANOOS Visualization System" (aka "NVS"). This web-based system allows public users to investigate available NANOOS data bases, and to construct presentations or products to meet their own specific interests or needs. NVS will be expanded as resources permit.

(2) The NANOOS Newsletter "The NANOOS Observer" has been established and has made available Issue #1 – both on the web and in hard-copy. The newsletter will appear as seems reasonable given stakeholder response – initial plans are for either quarterly or semi-annual issues.

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 has held two quarterly meetings to discuss NANOOS E&O efforts as well as E&O activities of NANOOS members. Sea Grant, CMOP STC, and COSEE staff are part of this Committee and actively participate.

Sprenger and Kosro, along with five E&O committee members, participated in the first tricommittee (User Products, DMAC, Education & Outreach) meeting, 15-16 April 2009. The roles and responsibilities of the different committees were discussed, and goals and timelines were established in our strategic areas.

- Sprenger has participated in the monthly conference calls of the NFRA Education subcommittee. As of August 2009, S. Mikulak has begun to attend these calls as well.
- NANOOS continued to support an OSU graduate student, S. Mikulak, in the development of an interactive exhibit at the Newport Marine Science Center. The exhibit is focused on building understanding and appreciation for real-time measurements, using data from the LOBO (Land/Ocean

Biological Observatory) mooring in Yaquina Bay (http://yaquina.loboviz.com/), owned and operated by NANOOS member WetLabs of Philomath, Oregon.

- Mikulak graduated in June 2009 and has continued to work with NANOOS on developing educational material for the NANOOS web portal. The exhibit she developed is now available on the NANOOS web portal and lesson plans to accompany the exhibit are in progress.
- Lesson plans for teachers using RTD to determine sea conditions, have been adapted by Sprenger, and posted to the Education section of the NANOOS web page. Six additional lesson plans are in development.
- Lesson plans using marine water monitoring data from the WA State Department of Ecology and PRISM data have been completed and are in review by educators.
- Sprenger presented on NANOOS at the COSEE OLC Citizen Science workshop, April 10.
- Sprenger attended and presented on NANOOS at the CMOP Education all hands meeting, April 1.
- The NFRA Education subcommittee presented at the National Marine Educators Association annual conference in Monterey, CA, June 2009. Each RA's educational programs were presented, as well as NOAA IOOS material. A resource guide for educators on using real time data was adapted by the NFRA education committee and presented. NFRA Education committee members attended a meeting to discuss and develop plans for future across-region education initiatives.
- Sprenger and Mikulak presented on ocean observing, NANOOS and its educational products to approx 25 educators from the Pacific Northwest at the annual NW Aquatic and Marine Educators (NAME) conference in Vancouver BC, Canada, in August. http://www.pacname.org/conferencepics09.html
- A NANOOS display was exhibited by Sprenger along with other PNW marine education programs at the North American Environmental Education Conference held in Portland, OR, in Sept, reaching 25 to 30 educators
- NANOOS Ed &Outreach committee members Mikulak and Risien put up a NANOOS display at OSU's COAS 50th Anniversary celebration. Mikulak also presented her work on the development of the interactive date exhibit.
- NANOOS continues to support NERRS in maintaining the Real Time Water quality data website for Shellfish Growers.
- Sprenger is an active member of Econet, the Puget Sound Partnership's Education and Outreach Network
- Mikulak, Newton and Sprenger met with members of the Port Townsend Marine Science Center and Intellicheck Mobilisa to begin designs on an interactive display using RTD to be installed at the PTMSC. Mikulak and Sprenger continue to work on the development of this future exhibit

4) Issues (NONE)

5) Key Personnel Changes (NONE)

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Appendix 1. Milestone Schedule and Project Timeline.

Area	**Sub-element**	**Y1**	**Y2**	
				Progress toward Y2 milestones, as revised to NOAA funding level
Observations				
	Shelf	- Maintain buoy at Newport, OR, line for hypoxia/anoxia alerts	- Maintain OR buoy for HAB & hypoxia alerts	*Per above text – progress here is satisfactory.*
	Estuaries	- Maintain Puget Sound, Columbia River, Willapa Bay, Gray's Harbor, and South Slough moorings	- Maintain Puget Sound, Columbia River, Willapa Bay, Gray's Harbor, and South Slough moorings	*Per above text – progress is satisfactory.*
	Shorelines	- Maintain quarterly profiles at specified sites - Maintain 3-D mapping at specified sites - Maintain expanded NANOOS Pilot efforts	Maintain quarterly profiles at reduced number of sites - Maintain 3-D mapping at reduced number of sites	*Per above text – progress is satisfactory.*
	Currents	- Maintain OR radar sites	- Maintain OR sites. - Purchase and install one X-Band port radar system at high priority port	*Per above text – progress is satisfactory.*

Area	**Sub-element**	**Y1**	**Y2**	
				Progress toward Y2 milestones, as revised to NOAA funding level
Modeling				
	Oregon/Washington Estuaries	- Integrate and enhance existing forecasting capabilities at OSU, OHSU, & UW	- Integrate existing forecasting capabilities at OSU, OHSU, & UW	*Per above text – progress is satisfactory.*

Area	**Sub-element**	**Y1**	**Y2**	
				Progress toward Y2 milestones, as revised to NOAA funding level
Data Management and Communications				
	Task 1: DMAC Systems Architecture Definition and Development	- The Boeing Company lead with OHSU co-lead develop conceptual systems architecture design in compliance with IOOS standards and protocols	- Continue to refine and implement NANOOS DMAC systems architecture across NANOOS domain at a reduced level of effort	*Satisfactory- as noted above*
	Task 2: DMAC Network Engineering Definition and Development	- OHSU lead with The Boeing Company co-lead develop NANOOS DMAC network engineering design in compliance with IOOS standards and protocols	- Continue to refine and implement NANOOS DMAC network engineering across NANOOS domain at a reduced level of effort	*Satisfactory- as noted above*
	Task 3: DMAC User-product development	- UW lead with OSU co-lead define NANOOS DMAC/Web interface specifications in compliance with IOOS standards and protocols based on direct liaison with NANOOS stakeholders	- Continue to refine and implement NANOOS DMAC user products web interface design across NANOOS domain with initial nodes at UW, Boeing, OHSU, and OSU at a reduced level of effort	*Satisfactory- as noted above*

Area	**Sub-element**	**Y1**	**Y2**	
				Progress toward Y2 milestones, as revised to NOAA funding level
Education and Outreach				
	E&O infrastructure	- Fund the NANOOS Education and Outreach (E&O) Coordinator to work with the E&O SC Chair, the Executive Director, and the web development team Note: delayed start	- NANOOS E&O Specialist to work with NANOOS Administration, E&O Standing Committee, User Products Standing Committee and other stakeholders at a reduced level of effort	*Per above text – progress is satisfactory.*
	Ocean Literacy	- Focus on 7 basic principles of ocean literacy - Enhance collaboration with PNW COSEE efforts and NSF-funded CMOP STC ocean education efforts	- Initiate delivery of marine education material via web (Ed-Web) at a reduced level of effort Specifically focus on enhancing ongoing PNW marine education efforts including OIP, NAME, and WAML efforts	*Per above text – progress is satisfactory.*
	Focus area products	- Begin development of education materials for a NANOOS focus areas of: fisheries, maritime operations, coastal hazards, and ecosystem impacts - Focus on SAFE for fisheries - Focus on BIS for marine operations - Continue joint pilot with NERRS for ecosystem impacts	- Continue development of education materials for two NANOOS focus areas according to stakeholder prioritization between: fisheries, maritime operations, coastal hazards, and ecosystem impacts - Continue work with SAFE, BIS, and NERRS on educational products	*Per above text – progress is satisfactory.*