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

As one of five IOOS Regional Associations awarded a competitive RCOOS grant in FY 07 (NA07NOS4730203 covering Y1-3 of the NANOOS RCOOS), NANOOS was requested to and submitted a successful proposal for a one-year bridge award (NA10NOS4730018 covering Y4 of the NANOOS RCOOS). This one-year duration was timed to permit NANOOS to compete for the omnibus IOOS RCOOS FFO in FY11. NANOOS requested and was granted a 1 year no-cost extension to our initial Y1-3 award in order to assure continuity in the RCOOS activities while the new Y4 award was being set up. Accordingly, NANOOS presently has two active RCOOS awards in place (both NA07NOS4730203 and NA10NOS4730018). As these RCOOS activities are necessarily blended during this transition phase, similar Progress Reports are submitted for each.

1) Award Information: Provided as a separate Cover Sheet.
Reporting period: 01 Oct 2010 – 31 Mar 2011

2) Project Summary
NANOOS is engaged, through this 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.
- **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.

We have delineated 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 the sections of our efforts for: a) observing systems (shelf, estuaries, shorelines, and currents); b) modeling (estuaries and shelves); c) Data management and Communications (DMAC); and, d) Education and Outreach. Administrative efforts orchestrating this RCOOS effort are reported separately in our NANOOS RA progress reports.

a) Observing System: NB: Data from all assets reported here are served via NANOOS NVS.

- Shelf

1. Washington Buoy and Glider observing network operations: Led by M. Alford, Applied Physics Laboratory, University of Washington (APL-UW), over this period NANOOS funding was used to recover the Cha'ba surface buoy and Seaglider previously deployed off the Washington Coast and to service, upgrade and repair these items in preparation for a planned re-deployment in mid-April, 2011. Additionally, these funds covered salary and supplies that allowed the completion of the subsurface mooring component to this observation system described in the last progress report. Equipment and instrumentation for this system was purchased primarily via a grant from the Murdock Charitable Trust to the University of Washington (Newton, Alford, Devol, PIs).

The Cha'ba surface mooring and Seaglider were recovered on October 17, 2011, after a successful three-month test deployment. The Seaglider performed flawlessly, transmitting data back to shore after each dive and completing 10 one-way transits of its 80-mile trackline and almost 700 dives during its deployment. Although real-time data transmission to shore failed shortly after deployment of the Cha'ba buoy in mid-July, most instruments continued to sample and record data autonomously, producing an unprecedented time series of full-depth profiles of velocity as well as temperature, salinity, and density at a number of fixed depths. The source of failure of the real-time data transmission was determined shortly after recovering the buoy and has since been corrected.

As of the end of the reporting period, the Cha'ba buoy, the Seaglider and the subsurface mooring are undergoing final preparations for a planned deployment on April 15th, 2011 aboard the R/V Thomas G. Thompson. With roughly a 4-month battery life given the planned trackline, Seaglider recovery will likely take place in mid-summer. Present plans are to field-service both moorings in October, again from the R/V Thomas G. Thompson. Ship time for mooring deployment and servicing has been generously donated through the University of Washington, School of Oceanography's state-funded underway days, which is a significant cost-savings for NANOOS.

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, using a combination of NANOOS, NSF, and private funding (Moore Foundation). The gliders measure 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. The October 2010 to March 2011 glider operations were particularly challenging due to a problem with a new version of the Webb glider altimeter and a faulty CTD on one of our gliders. In spite of the equipment challenges, we were able to maintain our one-week-per-month wintertime sampling off Newport, Oregon, from October 2010 to March 2011.

The glider data have documented colder and fresher than average water over the shelf in the latter part of 2010, consistent with La Nina conditions, and then a switch to warmer and fresher waters from January to March, 2011.

Presentations acknowledging NANOOS support:

Barth, J. A. "Observing Change in the Northeast Pacific: Past, Present and FUTURE," PICES 19th Annual Meeting Keynote Lecture, October 2010.

Barth, J. A., S. D. Pierce and F. Chan. "The Changing Coastal Ocean: Low-Oxygen Water off the Pacific Northwest." American Geophysical Union Fall Meeting, GC12A-04 (Invited), December 2010.

3. Oregon Buoy (mooring) operations: Led by M. Levine (OSU), a mooring about 10 miles off Newport, Oregon, in 80 m of water (site NH-10) has been in operation since mid-2006, partially supported by NANOOS. About twice a year the mooring is recovered and a refurbished mooring is deployed. A successful mooring turn-around was conducted in October 2010. The next turnaround is scheduled for April 2011.

As most sensors are borrowed from other projects, the number of sensors on a given deployment depends upon availability. The infrastructure is in place to increase the number of real-time sensors should funds become available. Some of the data are transmitted to shore through a cellular phone modem in near-real time and in addition to being available in the NANOOS Visualization System are also displayed by the NOAA National Data Buoy Center as station #46094.

Winter time deployments continue to be a challenge. The October 2010 deployment unfortunately broke free from its anchor in late December due to failure of a 1" diameter nylon line (10 m long) that was used as a shock absorber. We are rethinking the winter mooring design. Fortunately the buoy and most of the instruments were recovered without damage.

The mooring field work requires the use of a medium-sized UNOLS vessel or equivalent for a minimum of 1 day, twice per year. Funding for ship time is currently being provided by NSF through the Science and Technology Center for Coastal Margin Observation and Prediction (CMOP).

4. Northern Oregon to Central Washington shelf: Led by A. Baptista (OHSU), the Center for Coastal Margin Observation & Prediction (CMOP) continued to maintain a glider and two offshore buoys (SATURN-02 and OGI-01). Funding for the operation and maintenance of the glider and SATURN-02 was primarily through the National Science Foundation (OCE 0424602).

The CMOP glider operates spring through fall, in collaboration with the Quinault Indian Nation (QIN) Department of Fisheries, typically in a radiator pattern for 1-5 weeks, across the WA shelf from Grays Harbor to Quinault in support of fisheries management (QIN), science, and modeling; of particular interest is the characterization of upwelled water, for detection of hypoxia and biological blooms. The glider has flown 162 days since its first deployment on May 2009. During the reporting period, a mission was flown in October (last fall mission of 2010) and the glider was prepared for the first spring mission in 2011 (which will start mid-April). Also, a second glider was ordered, which will mirror the sensing capabilities of the existing glider; the primary goal of the second glider is to allow a deployment rotation that minimizes data gaps due to maintenance requirements.

The SATURN-02 buoy is installed in the northern OR shelf, at ~40m depth, within the region of influence of the Columbia River ebb tides. It is deployed year-round, in two settings: extensively equipped from spring to fall; and minimally equipped (single surface CT) in winter. During the reporting period, the spring-to-fall SATURN-02 buoy was recovered, and replaced by the winter buoy. The spring-to-fall buoy was refurbished, extended in sensing capabilities (as described above), and will be deployed in April 2011. Sub-sets of data are reported near real-time every hour (spring-to-fall only) via spread-spectrum radio. Data are collected in support of salmon ocean-survival biological opinions (with NOAA/NWFSC) as well as science and modeling.

The OGI01 buoy is installed in the northern OR shelf, at 100m depth. It is deployed year-round and has over time been instrumented (physical sensors only) in different configurations to support calibration and validation of circulation models covering the far-field of the Columbia River plume. During the reporting period the buoy was maintained in a minimalist winter sensor configuration (surface CTD), to meet the requirements of the US Coast Guard permit. A spring-to-fall deployment, with a more extensive set of instruments, is anticipated for April-May.

Data from all the above platforms, and those from the Columbia River estuary, below, are publicly available. NANOOS NVS functions as the PNW-integration portal, displaying real-time data and allowing downloads of recent data; it also contains links to the CMOP SATURN website, which offers access to both the near real-time data and since-inception archival data, besides allowing interactive analysis of data within and across stations.

Presentations acknowledging NANOOS support:

Baptista, A. M.; Spitz, Y. H.; Needoba, J. A.; Peterson, T. D.; Zuber, P.; Herfort, L. M.; Seaton, C. M.; Cho, K. H.; Welle, P.; Lopez, J. E.; Collaboratory-enabled ecological forecasts, ASLO, Puerto Rico, February 2011

Baptista, A.; Lothrop, R.; Schumacker, E.; Roger, P.; Hudson, C.; Heinith, B.; Green, V.; Wegner, K.; Peterson, T.; Bringing together tribal and quantitative oceanographic perspectives in a scientific framework for coastal margins, ASLO, Puerto Rico, February 2011

- **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 4 buoys in operation in Hood Canal (Twanoh, Hoodsport, Dabob Bay, North), one in Puget Sound (Pt Wells), and one in south Puget Sound (Carr Inlet). All buoy data are available in real-time on the NANOOS website. These buoys were built with and maintenance is partially leveraged with the Hood Canal Dissolved Oxygen Program, Navy, and NSF funding.

In October 2010 we added a sixth Puget Sound profiling buoy to the NANOOS assets. This Carr Inlet buoy was built using non-IOOS funds. It was deployed in an area of southern Puget Sound potentially at risk for human impacts, and the same location as the original UW ORCA mooring deployment from 2000-2003. This buoy will provide information about South Sound now as well as allow historical comparison of current conditions with water properties observed ten years ago.

During this fall-winter period when water quality conditions are generally homogenous, we took the opportunity to take several buoys offline for necessary maintenance and upgrades. Maintenance included rebuilding two winches (Twanoh and North buoys) where aging motor compartment seals had allowed the motor to corrode and seize. Buoy weather stations were replaced with ones measuring wind speed and direction through ultrasonic transducer, with no moving parts subject to fouling. Power system upgrades included adding wind generators and new solar chargers allowing query and logging of battery state to aid troubleshooting power issues. The power system upgrades allow increased profiling frequency: Shallow moorings now profile once an hour vs. previous maximum of once every two hours during summer with plentiful solar energy; Deeper moorings now maintain charge for increased profiling frequency due to wind generator installation.

While the Dabob Bay mooring was undergoing upgrade, we continued to provide support and power to the pCO_2 system operated in collaboration with NOAA PMEL (C. Sabine, R. Feely). The ORCA team provided field support for trouble-shooting the system and collected water samples to aid system calibration. The pCO_2 system was not taken offline during the buoy upgrade. This work was leveraged by a grant from the State of Washington to monitor surface water acidity and water column conditions as they might relate to shellfish hatchery failure.

The spring bloom at Twanoh again occurred before any other buoy registered increased surface chlorophyll concentrations. By the end of March 2011, the spring bloom in southern Hood Canal had surface chlorophyll concentrations of 20 mg/m^3 or greater, while in Puget Sound were still less than 10 mg/m^3. Both Puget Sound buoys showed less stratification and generally colder and fresher waters at depth than southern Hood Canal.

Presentations acknowledging NANOOS support:

Ruef, W., A. Devol, J. Newton, C. Bassin. Quantifying the Role of Marine Nutrient Loading to Upper Layer Production and Bottom Water Hypoxia in a Coastal Estuary. Aquatic Sciences Meeting, San Juan, Puerto Rico, February, 2011.

Newton, J. Current ocean acidification monitoring in Washington waters: How can citizens learn more? Ocean Acidification: An evening seminar with scientific experts, Northwest Maritime Center, Port Townsend, WA, November, 2010.

2. Washington State estuarine monitoring: Coordinated by C. Maloy, the WA State Department of Ecology (Ecology) continues to contribute to regional estuarine *in situ* observations by maintaining monthly-calibrated moorings in Willapa Bay and Puget Sound. This work is funded by WA State, augmented by NANOOS.

Ecology, with the help of collaborative partnerships, continued to maintain a network of moored sensor packages throughout Puget Sound and Willapa Bay. Ecology's deployment locations are primarily designed to capture interbasin exchange signals of temperature, salinity, and oxygen. Moorings maintained this period were located in Admiralty Reach, Shannon Point, Manchester (2 depths), Mukilteo (2 depths), Squaxin Passage, and Willapa Bay (2 depths). Data are available via

the NANOOS Visualization System as well as Ecology. Key collaborative partners include Everett Community College, Western Washington University, University of Washington APL, and NOAA.

We looked for, and found, evidence of the tragic Japanese earthquake in our bottom-mounted pressure sensor data from our station on the coast. The 11 March 2011 tsunami was clearly evident (Figures 1 and 2).

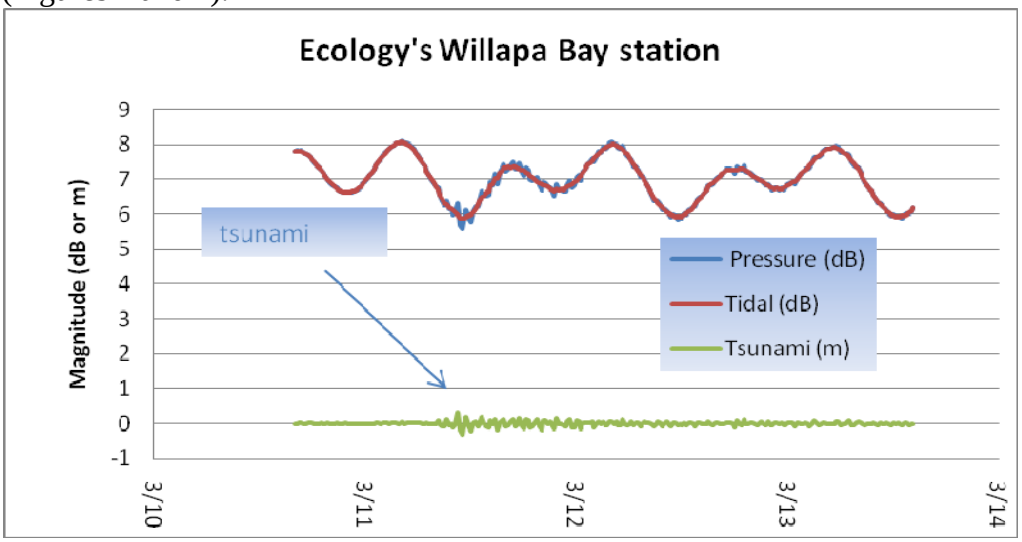

Figure 1. Water level measured at Ecology's Willapa Bay monitoring station following the Japan tsunami.

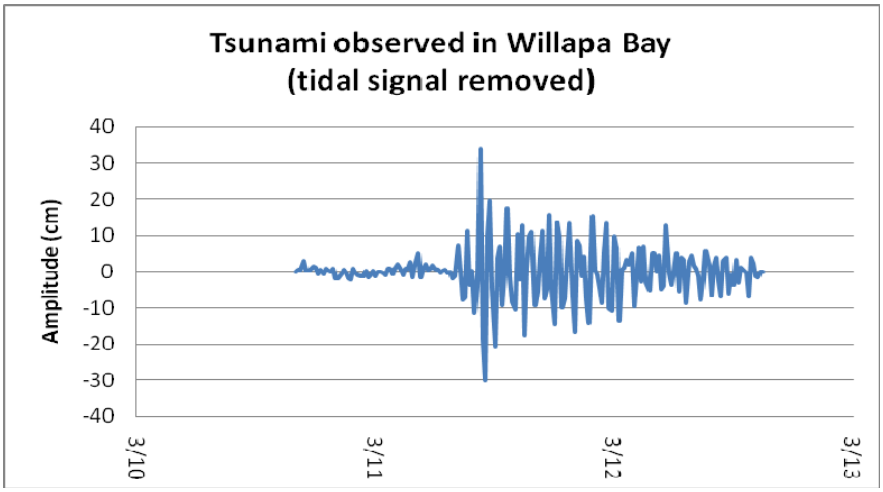

Figure 2. Amplitude of the tsunami measured at Ecology's Willapa Bay monitoring station in March, 2011.

Ecology continues to focus on timeliness of quality control data evaluations, usually within 30 days, and is using GOMOOS QAQC codes as a tool for describing data quality. Timely reviews of data have enabled Ecology to more rapidly analyze data, provide a statistical and historic context, and better communicate the message of what is happening on location. In particular Ecology is developing monthly condition reports that integrate continuous monitoring data from moorings with CTD profiler data from various stations.

Ecology has developed a set of data review tools where: 1) Data is automatically uploaded daily from instrument packages using cellular modems; 2) Incoming data receives an automated quality

code based on expected sample interval, ranges, and variance; and 3) Ecology data reviewers can readily update QAQC codes based on level of review.

3. Columbia River estuarine monitoring: CMOP continues to maintain 14 endurance stations in the Columbia River estuary (under the direction of A. Baptista, with a mix of NSF, NANOOS and regional-stakeholder funding), and two in the tidal freshwater (under the direction of J. Needoba, with a mix of NSF, NANOOS and regional-stakeholder funding). Eleven of those stations measure one of more physical parameters (temperature, salinity and/or water level), while five have an extensive array of biogeochemical sensors. All endurance stations operate year round, as a part of CMOP's SATURN observation network, a member of the NANOOS federation of systems. Data are collected in support of salmon ocean-survival biological opinions (with NOAA/NWFSC, BPA and others) related to hydropower management, estuarine management and restoration projects (with NOAA/NWFSC, LCREP and others), monitoring of impact of channel deepening (with USACE), scientific discovery, and modeling. Data are available as described in item "Northern OR to Central WA shelf", above.

During this reporting period, we have made substantial progress in data quality control procedures for a range of biogeochemical sensors. Quality control protocols were written, and will be published next quarter, after ongoing internal review.

4. Oregon South Slough: Participation by the Oregon Department of State Lands (ODSL) 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)).

Staff members from the ODSL / South Slough NERR continued ongoing operations for a series of moored observing stations within the South Slough estuary as part of the NERR/SWMP network of NANOOS anchor stations. The monitoring stations, equipped with a YSI-6600 multi-parameter datalogger located 50 cm above the bottom, are located at: 1) Oregon Institute of Marine Biology–Boat House, 2) Charleston Pier, 3) Valino Island, 4) Winchester Arm, and 5) Sengstacken Arm along the estuarine gradient, providing continuous near real-time data from marine (euhaline), marine-dominated (polyhaline), mixing (mesohaline), and riverine (oligohaline) hydrographic regions of the South Slough estuary. 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 NERR-SWMP / NANOOS water monitoring stations in the South Slough estuary were in continuous operation throughout the period of 30 October 2010 to 31 March 2011, and the dataloggers were retrieved, downloaded, recalibrated, reprogrammed, and redeployed on a monthly basis during the winter and spring seasons. Time-series measurements generated by four of the monitoring stations are available in near real-time from several websites including NANOOS, the NOAA / Hydro-Meteorological Automated Data System, and via the NOAA/NERRS data access website operated by the NERRS Centralized Data Management Office.

The network of SSNERR SWMP/NANOOS monitoring stations were operational within the South Slough estuary during the arrival of the diminished Honshu, Japan, tsunami that arrived along the Oregon coast during the morning of 11 March 2011. The tsunami was recorded with an initial amplitude of 1.1 m by the NOAA NWLON tide gauge located near the mouth of the estuary in Charleston, OR (Figure 3). The tsunami surge diminished to an amplitude of 0.8 m as it swept up the estuary past the NERR-SWMP/NANOOS station located at Valino Island (Figures 4 & 5, middle

estuary) and further diminished to an amplitude of 0.3 m at the Winchester Creek NERR-SWMP/NANOOS station (Figure 6, upper estuary). Localized disruptions in tidal amplitude persisted throughout the estuary for a period of about 60 hrs (Mar 11-14, 2011; Figure 5), and the period of water level disruptions encompassed three complete semi-diurnal tidal events. The diminished tsunami arrived near the time of Lower Low Water (0724 hrs on 11 March 2011) and was recorded as a series of multiple surges when the estuarine waters receded rapidly out of the tidal basin followed by a period of rapid flooding back into the tidal basin. The NERR-SWMP/NANOOS station at Valino Island recorded over 50 tsunami surges over the period of 11-14 March 2011, and a total of 19 distinct tsunami surges were observed over the first 17 hrs. The initial tsunami surges were also accompanied by an unanticipated elevation in dissolved oxygen concentrations at the Valino Island SWMP/NANOOS station, and the unusually elevated DO values occurred at Lower Low water and persisted for a period of about 5 hrs on 11 March and for about 4 hrs on 12 March, 2011 (Figure 4).

Figure 3. Tsunami surge flooding over the Charleston boat launch dock during initial arrival of the Honshu tsunami on the morning of 11 March 2011.

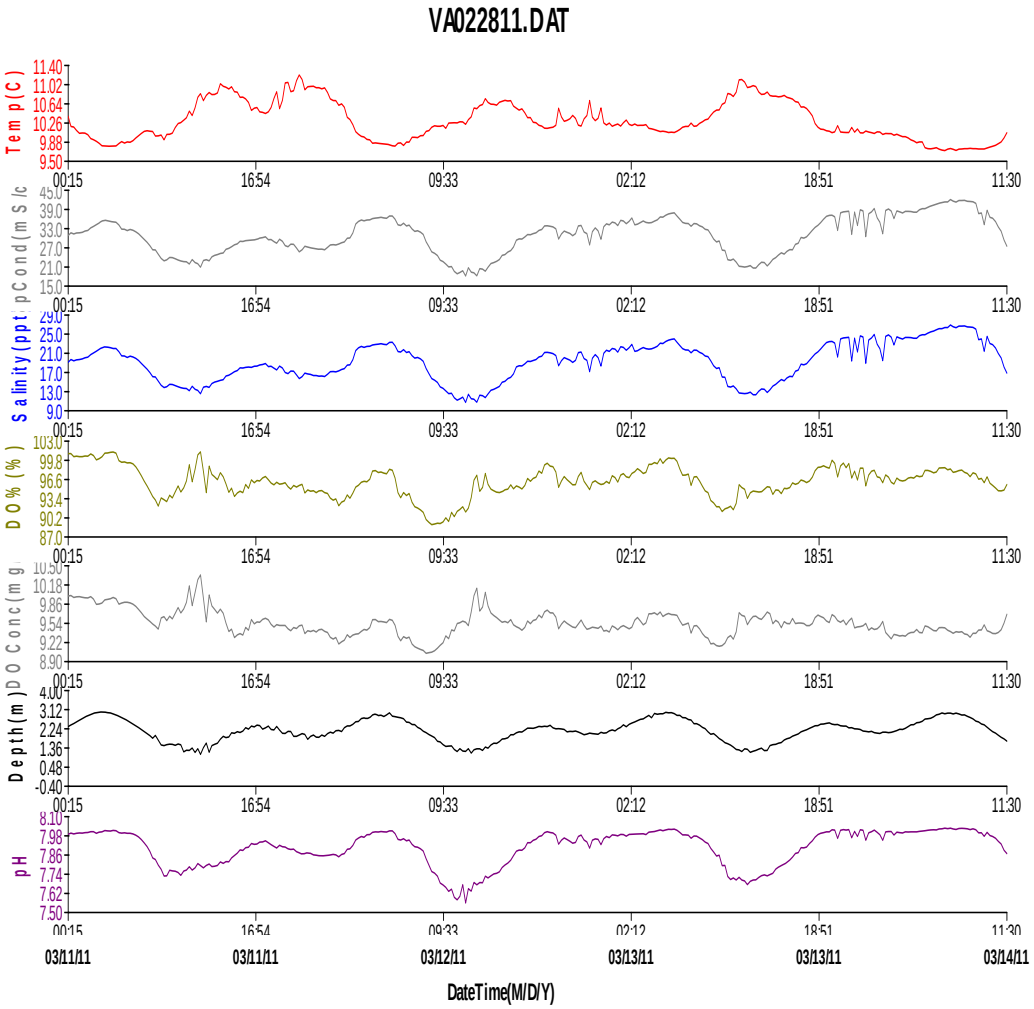

Figure 4. Time-series measurements of water parameters recorded by a YSI-6600 datalogger deployed at the Valino Island SWMP/NANOOS station. Note localized disruptions in water levels (row 6; Depth (m)) and elevated variability in dissolved oxygen concentrations over the period from 11-14 March 2011 in response to arrival of the diminished tsunami generated off the coast of Honshu / Sendai, Japan.

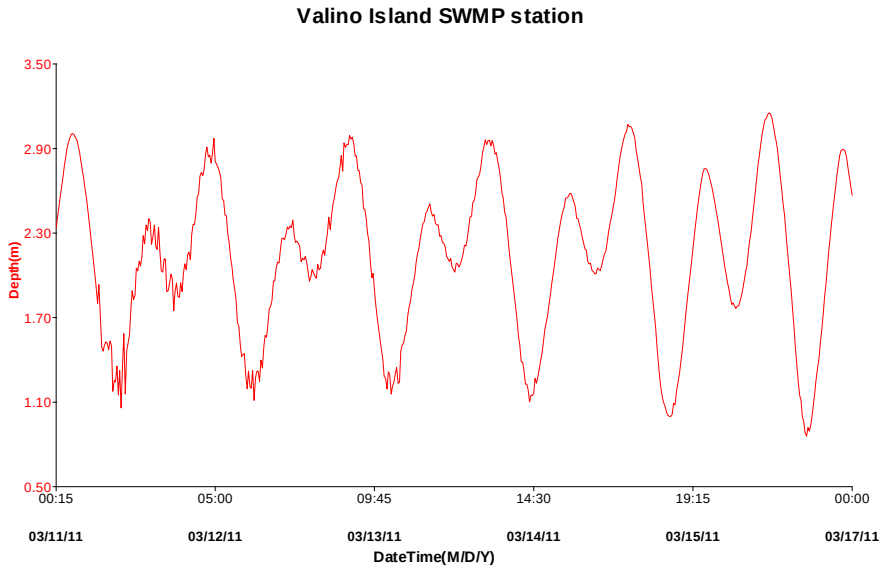

Figure 5. Localized disruption of water levels by tsunami surges at the Valino Island SWMP/ NANOOS monitoring station (mid region of the South Slough estuary, Charleston, OR) over the period of 11-14 March, 2011. Greatest tsunami surge amplitude was 0.8 m at the Valino Island station.

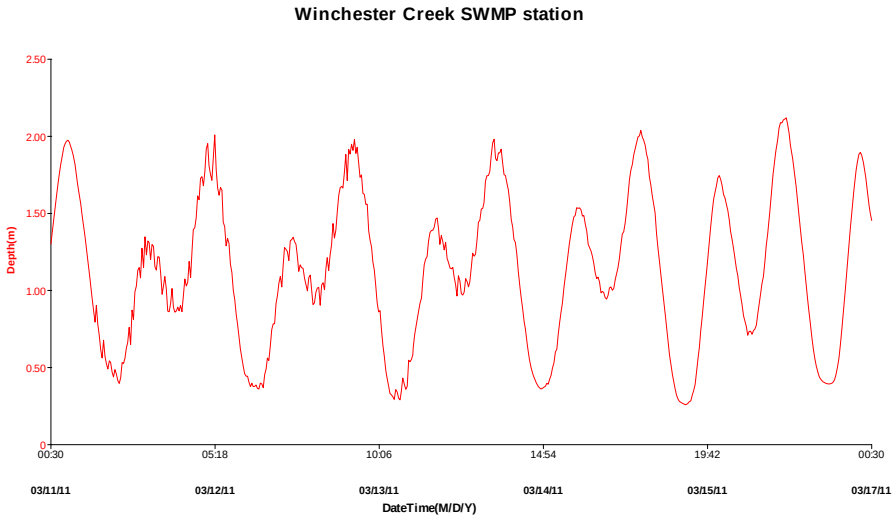

Figure 6. Localized disruption of water levels by tsunami surges at the Winchester Creek SWMP/NANOOS monitoring station (upper region of the South Slough estuary, Charleston, OR) over the period of 11-14 March, 2011. Greatest tsunami surge amplitude was 0.3 m at the Winchester Creek station.

Staff members from the South Slough NERR continued to interact directly with the commercial oyster growers in Coos Bay over the winter 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). The time-series measurements of temperature, salinity, DO, pH, and fluorescence are of primary interest to the local oyster shellfish growers because they provide the essential information to characterize estuary water quality conditions for shellfish mariculture and an indicator of the concentration of phytoplankton available in the estuarine water column as food for filter-feeding oysters.

Presentations acknowledging NANOOS support:

Rumrill, S. Ecology and natural history of Pacific Northwest estuaries. Seminar and field trip presented as curricula during the Oregon State University – Coastal Master Naturalist course, Charleston, OR. 6 November, 2010.

Rumrill, S. Recommendations for estuarine hydrodynamic monitoring in association with the Gulf of Mexico - Deepwater Horizon oil release: Lessons learned from the New Carissa oil spill event, Coos Bay, OR. OSPIRG Invited panel discussion, University of Oregon, Eugene, OR. 10 November, 2010.

Rumrill, S. Functional ecology of Pacific Northwest estuaries. Seminar presented as curricula during the technical training workshop for OR coastal resource managers, Oregon Department of State Lands; Salem, OR. 26 January, 2011.

Rumrill, S. The potential influence of estuarine vegetation and net ecosystem metabolism on pH values and acidified ocean waters in the South Slough estuary. Project update presented during NERRS research Coordinator – Annual Meeting, Hudson River, NY. 2 March, 2011.

Helms, A. Potential effects of net ecosystem metabolism on pH values in the South Slough estuary. Poster presented at the Pacific Estuarine Research Society – Annual Conference, Astoria, OR. 5 March, 2011.

Rumrill, S. Utility of long-term water-quality and meteorological datasets to address multiple manifestations of climate change within the South Slough estuary. Seminar presented to the NERR Coastal Training sector, Charleston, OR. 9 March, 2011.

Rumrill, S. Functional ecology of Pacific Northwest estuaries. Seminar presented during Aquatic Marine Educators / Coastwatch – Annual Conference; Newport, OR. 12 March, 2011.

- **Shorelines**

1. Washington Shorelines:

NANOOS funds contribute to the Washington State Department of Ecology's (Ecology) Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky continued to maintain a beach and shoreline monitoring effort in the Columbia River littoral cell (CRLC) during this semiannual period between October 1, 2010 and March 31, 2011. The monitoring program performs beach profile surveys on a quarterly basis and performs beach surface mapping on a semiannual basis. CMAP collected geospatial data on transects at 46 locations in the CRLC twice during this semiannual period. In addition, 14 surface maps were collected (7 during winter, and 7 at Benson Beach (monthly) in support of a beach nourishment experiment.

During this period CMAP also supported data collection using the Coastal Profiling System (i.e., nearshore bathymetry survey platform) in collaboration with Oregon State University (OSU) at Benson Beach on Oct. 6 and Dec. 5, representing the first late-fall/early-winter season nearshore surveys since beach morphology monitoring began in 1997. The high-resolution topographic surveys at Benson Beach collected ~30,000 data points over 64 km, while bathymetric surveys collected ~600,000 data points over 88 km of profile lines. Beach sediment samples were also collected each month from November to March. On Oct. 29, all principal investigators participating in the Southwest Washington Littoral Drift Restoration project participated in a one day workshop to share their respective efforts and to develop a framework by which to integrate activities.

Beach profile monitoring during this period revealed:

- Most of the Long Beach Peninsula showed only typical winter profile adjustment with lower beach steepening and minimal the upper beach adjustment. However, along the northern tip of the Peninsula at Leadbetter Point, the beachface between 2 and 3 m elevation contours retreated by over 20 m.
- The dunes along the northern entrance to Willapa Bay retreated roughly 11 m since summer 2010, while the beach along a 5-km reach to the north accreted as part of a shore-connected ebb-tidal shoal that continues to migrate northward over time. The 3-m contour (shoreline proxy) along this feature has shifted horizontally seaward by as much as 110 m since summer.
- The dune along the southern end of Ocean Shores adjacent to the emergency rock revetment placed in Nov. 1996 continued to retreat on the north end by 10 m, exposing more of the pre-

Figure 7. Dune erosion at Ocean Shores during winter 2010/2011 further exposed the rock revetment and geotubes that had been installed in 1996 and 1998 to protect condominiums and houses along this vulnerable shoreline reach.

During this period CMAP acquired a 28 x10' twin-hull vessel (beach-landing craft) specifically designed for shallow water hydrographic and topographic surveying in Puget Sound. The vessel is named after George Davidson (1825-1911), the pioneer west coast scientist who was responsible for producing the first U.S. Coast and Geodetic Survey charts of the U.S. Pacific coast beginning in the 1850s and who subsequently authored voluminous initial editions of the Coast Pilot of California, Oregon, and Washington. A shallow-water beach-landing craft is the only feasible way to access and survey the vast majority of Puget Sound shorelines because more than two-thirds (2,620 km) of the shoreline lacks public access and at least 27% (1,072 km) of the beaches are armored. Equipped with a drop-down bow door, the vessel enables all-terrain vehicle, personnel, and cargo loading and offloading at remote beaches. Initial efforts will focus on surveying a select number of beaches and bluffs that are vulnerable to coastal storms and on leveraging funds to sustain a Puget Sound beach monitoring program into the future.

CMAP staff collaborated with the USGS in surveying the beaches at Fay Bainbridge State Park and adjacent shorelines during October 19-21, 2010. CMAP surveyed locations of approximately 150 sediment samples that were collected to study the concentration and distribution of forage fish eggs relative to beach state parameters.

Presentations acknowledging NANOOS support:

Barnard, P.L., Kaminsky, G.M., Hansen, J.E., Allan, J., Ruggiero, P., and Hoover, D., The impact of the 2009-10 El Niño on West Coast beaches, AGU Fall 2010 Meeting, Session on Coastal Geomorphology and Morphodynamics, (EP21D-05).

2. Oregon Shorelines:
Leveraging NANOOS, 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 multiple occasions at a reduced scale during the first half of Year 3. Beach cross-section surveys were specifically carried out in October 2010 (late summer survey, Rockaway cell and Clatsop Plains: 31 sites), December 2010 (fall survey, Rockaway cell and Clatsop Plains: 31 sites), January 2011 (fall survey, Neskowin cell: 15 sites) and March 2011 (winter survey, Rockaway cell and Clatsop Plains: 31 sites). The beach surveys involved the conventional approach of re-measuring 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 to the new NVS – Beaches and Shorelines portal as part of a technology transfer between NANOOS and DOGAMI. These data are accessed by State resource managers (e.g. Oregon State Parks), Geotechnical consultants and the public for assessing coastal change, stability and erosion/flood hazard risk. For example:

- Beach surveys are being used in the community of Neskowin to assess ongoing problems relating to the loss of sand from the beach system and the increased incidence of damage to engineering structures, including overtopping by ocean waves and inundation of backshore properties.
- Beach survey data collected in the Rockaway cell are being used by Coastal engineers to assess the viability of placing wave energy devices either on the jetty or in the surf zone and the likely effects such devices might have to the beach sediment budget.
- Beach change data adjacent to the Columbia River south jetty is being used by the USACE to monitor the erosion of the dunes adjacent to the jetty, which exhibits signs that it may breach in the not too distant future.

Shoreline variability continues to be measured and 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 17 shorelines, along each of the littoral cells. These data are 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. Finally, outreach efforts in the form of public presentations were carried out at two recent forums including a National Research Council, US West Coast sea level rise meeting in Portland, Oregon in March 2011, and a Central Oregon Coast Watershed Council meeting in Florence, Oregon related to sea level rise, coastal change and climate change effects.

3. Nearshore Bathymetry: With partial support from NANOOS, P. Ruggiero's group at Oregon State University participated in The Southwest Washington Littoral Drift Restoration (SW LDR) project at the Mouth of the Columbia River (MCR). The aim of this project is to assess the long-term viability of placing dredged material from the MCR directly on Benson Beach to supplement the littoral sediment budget. Approximately 300,000 m^3 of dredged material from the MCR was placed along the intertidal area of Benson Beach during the summer of 2010. An extensive monitoring effort is underway to evaluate the effectiveness of the SW LDR project. One component of the monitoring program is to track the morphological response of the beach and nearshore areas during and after the SW LDR sand emplacement. Oregon State University, the Washington State Department of Ecology and the US Geological Survey are collaborating on collecting morphological

change data to address these questions and completed 5 nearshore survey of the region in 2010 (Figure 8, Andrew Stevens, personal communication).

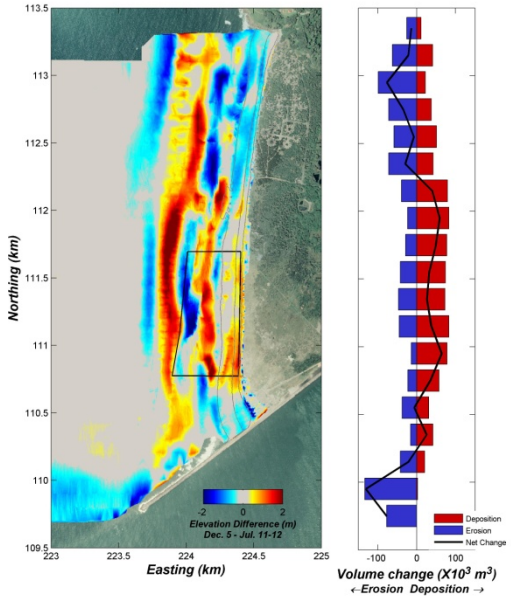

Figure 8. Map showing bathymetric and topographic differences of Benson Beach derived from data obtained between July 11-12, 2010 and December 5, 2010. Elevation measurements were interpolated using linear (triangular) interpolation. Grid resolution is 5 m. The black box indicates the Littoral Drift Restoration permit area. The right hand panel illustrates how volumetric changes vary alongshore.

- **Currents**

1. Coastal Currents: Partially supported by NANOOS, the HF surface current mapping program at Oregon State University (PI Mike Kosro, RAs Anne Dorkins and David Langner), has been providing near-real-time maps of ocean surface currents along the Oregon coast as part of NANOOS to the public via 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.

Kosro is a member of the HF Radar National Steering Team, and now serving on the focus team on Data Assimilation Modeling. He attended the regional meeting of the West Coast Governor's Agreement in response to the call for Marine Spatial Planning projects in Newport in November 2010. He is serving as an external member of a PhD committee for Phil Muscarella, University of Delaware, who in April will defend his dissertation on HF measurements in the MACOORA region.

This winter has been a tough one on the HF equipment, with four of the eleven systems requiring repair at the manufacturers. To deal with outages we have often shuffled equipment from one site to another, to maintain the most continuous array that we could. Data from our southernmost site, PSG, was compromised for an extended period by interference from the next site to the south. We have reprocessed the total velocity vectors from our array during this period, with the data from PSG removed, and revised our downloadable maps and data listings. We are trying new uninterruptible power supplies at some of our coastal locations.

Our group is collaborating with CODAR Ocean Sensors to begin beta-testing expanded capability for our systems by incorporating "bistatic" operation at three of our long-range sites (MAN, YHL, and WIN). Bistatic operation will allow velocity vectors to be estimated from radar returns not only from transmitters at the same site as the receiver (monostatic) but also from returns from adjacent sites (multi-static). This requires sharing the same operational frequency among multiple systems,

which requires sophisticated GPS-timing-based synchronized transmission; it also increases the requirements for data storage and transmission, and will require group effort for evaluation. We have installed upgraded GPS antennas at the three sites and increased disk storage there. If successful, this technique could significantly enhance the density of measurements available for mapping, leading to increased mapping area and greater reliability.

When the Japan earthquake was reported, we worked with CODAR to enable special high-density data collection at several sites to provide test data for tsunami detection algorithms being developed at CODAR.

Publications acknowledging NANOOS support:

Kim, S.Y., E. Terrill, B. Cornuelle, B. Jones, L. Washburn, M. Moline, J. Paduan, N. Garfield, J.L. Largier, G. Crawford, P.M. Kosro, 2011. Observations of high-resolution coastal surface circulation on the U.S. West Coast. *Journal of Geophysical Research*, 116, doi:10.1029/2010JC006669.

Publications in review acknowledging NANOOS support:

Osborne, J.J., A.L. Kurapov, G.D. Egbert and P.M. Kosro, Spatial and temporal variability of the M2 internal tide generation and propagation on the Oregon shelf. Submitted to *Journal of Physical Oceanography*, 2011.

2. Port X-band Radar: Led by M. Haller (OSU) the wave imaging marine radar (X-band) station at the Newport jetties continues to collect regular observations of hourly image sequences uploaded to our web database server on the OSU campus and made available in real-time through the NANOOS Visualization System. Also, in January 2011 we recovered our Datawell WaveRider buoy, which had been deployed off Newport (40 m depth) since Aug, 2010. Data analysis is ongoing.

An exciting recent investigative activity has been the deployment of a UHF radar (RiverSonde from CODAR) at the Newport jetties. This effort has been funded primarily through a CODAR student grant to one of our PhD students with partial funding through NANOOS. This system became operational at the site during Sept 2010 and has been operating, almost continuously, since then. The system produces continuous maps of the surface currents through the jetties (300m footprint, 5m resolution). This data is potentially available in real time, and part of effort is focused on that aspect, but the main effort is to correlate these data with our marine radar wave observations and to investigate the influence of the tidal currents on the occurrence of dangerous wave conditions near the Yaquina bar.

Also, using leveraged funds (USACE), we also performed a temporary deployment of our radar at the MCR in support of regional sediment management at the MCR. In this effort we generated high-resolution wave direction maps and bathymetry estimates using our radar observations and compared these data to outputs of local wave predictions from the SWAN model. In the near future we will be implementing these data products into our outputs for the Newport site.

Lastly, in support of broader IOOS efforts, M. Haller was an invited scientist to the *Alliance for Coastal Technologies*: Waves *Protocol Development Workshop* at the University of South Florida (Feb. 2011).

Presentations acknowledging NANOOS support:

Honegger, D.A., M.C. Haller, J.A. Lerczak, and P. McEnaney, Concurrent remote and in situ wave and current observations at a tidal inlet, *AGU Fall Meeting*, San Francisco, CA, December 2010.

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 through the NANOOS Visualization System.

The forecast model, forced with NOAA NAM atmospheric forecasts, uses the climatologic boundary conditions derived by the Navy regional NCOM-CCS model. We have added a data assimilation component to our real-time product to improve quality of the forecasts. Model ocean estimates are constrained by HF radar surface current observations (provided by our NANOOS partner P. M. Kosro) and hourly GOES SST (from NOAA Coastwatch, D. Foley).

In October 2010-March 2011, we continued to run the data assimilative forecast model without interruptions and accumulate some essential statistics, to guide future improvements in the model. In particular, we found that assimilation of GOES SST helps to improve accuracy of the SSH slope (hence the geostrophic component of surface currents), as verified against the RADS near-real time altimetry (this work is done in collaboration with L. Miller, NOAA STAR). Our preliminary model-data comparisons suggest that satellite SST assimilation improves accuracy of the SSH slope (and hence surface geostrophic currents) (Figure 9). To improve efficiency of the data assimilation algorithm and facilitate assimilation at a higher spatial resolution and/or larger computational domain in the near future, we have just completed the parallel version of the AVRORA tangent linear and adjoint codes (in the MPI regime). As the next steps, these new codes will be incorporated in the real-time assimilation system and the domain extended to cover both Washington and Oregon coasts.

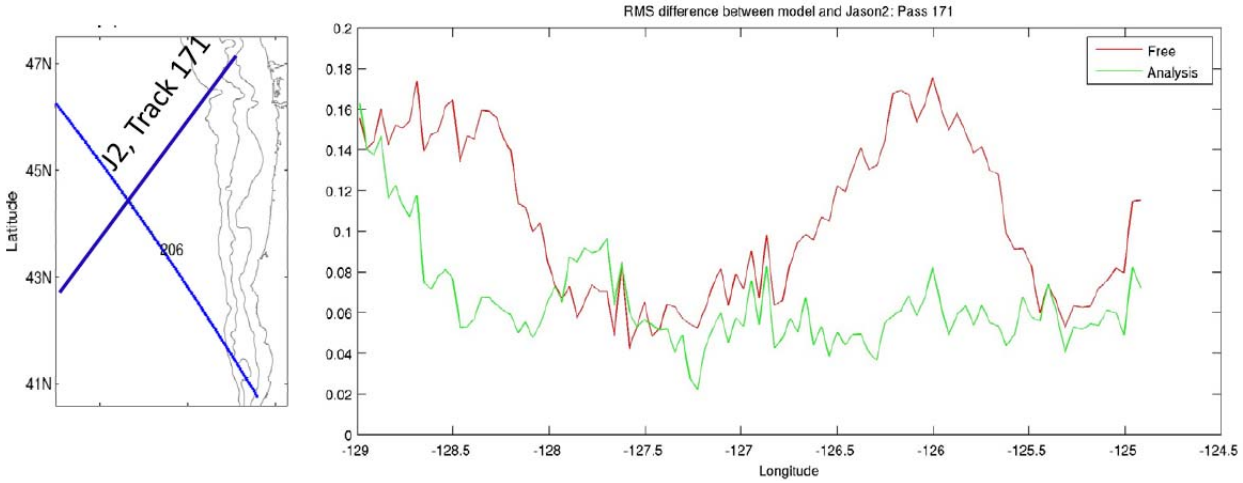

Figure 9. Assimilation of GOES SST in the real-time coastal ocean forecast system has helped to improve the SSH. Shown is the RMS model-data difference for SSH along Jason-2 track 171, for the free model, run without assimilation (red – larger error) and data assimilation analysis (green – error reduced). Alongtrack means have been removed from the data and model, track-by-track. The averaging period is September 2010 – January 2011.

Publications acknowledging NANOOS support:

Kurapov, A. L., D. Foley, P. T. Strub, G. D. Egbert, and J. S. Allen, 2011: Variational assimilation of satellite observations in a coastal ocean model off Oregon, J. Geophys. Res., in press.

Presentations acknowledging NANOOS support:

AGU Fall Meeting, San Francisco, 13-17 December 2010.

- **Estuaries**

1. Puget Sound: Overseen by D. Jones, in the last 6 months APL-UW has worked to develop a system using the General Estuarine Transport Model (GETM) to model synthetic oscillating/curving channels in an estuarine setting. These models are used to analyze the sensitivity of various estuarine features to changes in bathymetry. This work is motivated by an interesting feature in Willapa Bay, where there exists two regions in the bay that have vastly differing turnover time scales.

APL-UW has collaborated with Parker MacCready (UW School of Oceanography) to develop a version of the MoSSea model (see Figure 10 of the model domain) that runs using surface forcing that comes from a WRF climate model for the years 2045-2055. This work will eventually allow APL-UW to run ROMS locally in an operational mode. We have been developing the IT infrastructure required to port models and model tools developed by partners in the MacCready and Banas groups at UW to NVS and new operational applications.

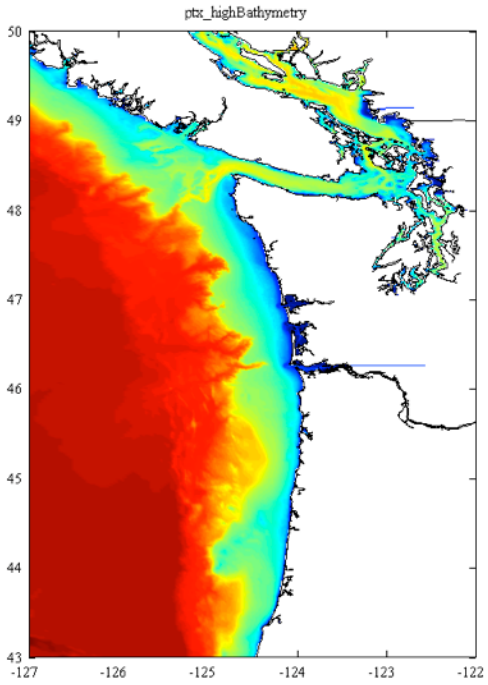

Figure 10. MoSSea model domain, showing bathymetry. Credits: Parker MacCready, Sarah Giddings, Kristen Davis, and Neil Banas (UW Oceanography and APL), supported by the NOAA/NSF PNWTOX (Pacific Northwest Toxins) program; more information at http://faculty.washington.edu/pmacc/MoSSea.

APL-UW is in the process of implementing an ocean particle-tracking tool that was initially developed by Neil Banas. When completed, the tool will be viewable via NVS and can use data from any ocean current gridded data supplied by a ROMS model.

APL-UW continues its research with the Navy's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS). The COAMPS model allows for predictions down to scales of less than one km. APL-UW has implemented a complete version of COAMPS and it allows the ability to manipulate the model parameters and model physics packages and thus tailor the prediction. The APL-UW system is being currently used in a statistically based model-tuning project. APL-UW can: 1) generate daily forecasts, 2) study new methods to compare model output with analysis fields. These include the use of optical flow, variogram, and clustering methods; and develop new methods for picking model parameters.

2. Columbia River: With a mix of regional stakeholder funding, NSF funding, and NANOOS funding, CMOP, under the direction of A. Baptista, maintains an extensive modeling system for the river-to-shelf circulation of the Columbia River. Regional stakeholders include the Bonneville Power Administration (BPA), NOAA, U.S. Army Corps of Engineers (USACE), Lower Columbia River Estuary Partnership (LCREP), and Columbia River Inter-Tribal Fish Commission (CRITFC).

The modeling system is integral to the SATURN collaboratory, and is informed by SATURN and other regional observation networks. It is envisioned as \a "virtual Columbia River," with an array of products readily available for the use by a broad community of scientists, educators, and managers. As described in the progress report for October 2009-March 2010, Virtual Columbia River products include daily circulation forecasts, decade-long hindcast simulation databases, and scenario simulations (forecasts available through NANOOS NVS).

We recently extended the modeling domain of the Virtual Columbia River upstream of Beaver Army, to include the tidal freshwater in the Columbia River through Bonneville Dam and in Willamette River through Willamette Falls (see October 2009-March 2010 progress report). The changes permit a more effective use of the simulations to support: climate impact studies; salmon and ecosystem restoration projects; flood protection studies; hydropower and navigation management; and search and rescue operations.

During this reporting period we continued the systematic enhancement of the modeling skill of circulation in the Virtual Columbia River, with emphasis on the extended domain. Activities included:

(a) extensive spatial refinement of the underlying (unstructured) numerical grid; \particular care was placed in incorporating regions and scales of interest for salmon recovery projects;
(b) incorporation in the grid of the revised version of the most recent bank-to-bank bathymetry for the Columbia River estuary and tidal freshwater (released by the Lower Columbia River Estuary Partnership in early 2011).
(c) sensitivity studies to various model parameters; including time step
(d) modification of the treatment of river boundary conditions, to better address the effects of Bonneville Dam and Willamette Falls on the upstream propagation of the tidal wave.

Informed by the above enhancements, we have created a new daily forecast of circulation and are developing the corresponding version of a new simulation database.

We have continued or initiated applications of the Virtual Columbia River to multiple issues of regional significance, typically in partnership:

(a) Studies associated with the revision of the Columbia River Treaty between the US and Canada; these studies have been conducted in partnership with CRITFC and with funding from NSF.
(b) Studies of the influence of the Columbia River plume on salmon survival; these studies have been conducted in partnership with NOAA and with funding from BPA.
(c) Studies of the variability and contemporary evolution of salmon habitat opportunity in the Columbia River estuary and tidal freshwater; these studies have been conducted in partnership with NOAA and with funding from USACE.
(d) Studies of habitat suitability in the Columbia River estuary and tidal freshwater, funded by LCREP and conducted in collaboration with the Pacific Northwest National Laboratory.

(e) Creation of maps of coastal storm inundation in the Columbia River estuary and Pacific County, funded by FEMA and conducted in collaboration with a consulting company (PBS&J).

c) Data Management And Communications (DMAC)

1. Managerial: Boeing is lead for managerial duties. S. Uczekaj (Boeing – DMAC lead) is the Chair of the NANOOS DMAC Committee. Technical implementers include R. Blair (Boeing – Infrastructure and Standards), A. Jaramillo (CMOP OHSU – Data Provider Services [DPS]), E. Mayorga (APL UW – DPS), C. Risien (OSU – DPS), T. Tanner (APL UW – Portal Services).

Activities for this period included: 1) weekly NANOOS DMAC and User Products Committee (UPC) telecon; IOOS Regional DMAC Implementation (RDI) bi-weekly telecon; 4) annual NANOOS DMAC-UPC Meeting (Nov) with the inclusion of regional Coastal and Marine Spatial Planning (CMSP) representatives; 3) IOOS DMAC Steering Committee weekly telecon; 4) Planning Committee for April 2011 IOOS DMAC Workshop, as one of 3 regions represented in creating the agenda and direction for the workshop. The NANOOS DMAC and UPC teams continue to work in an effective, integrated fashion towards the prioritization, development and evaluation of data services and user products.

2. Summary of Significant Technical Accomplishments: Significant progress was made in maturing the NANOOS DMAC architecture. The **NANOOS Visualization System (NVS)** was enhanced through two new releases (see UPC section for details) and continuous asset additions and updates, strengthening its role as a regional data aggregation, discovery and access tool. Mechanisms to support asset inventorying and reporting were greatly expanded to encompass asset list sorting, filtering, and downloading, and a status-update logging feature now integrated across the NVS asset database and user interface. 118 updates were logged including 40 new assets and 78 additional status updates reflecting platform, sensor and telemetry reconfigurations. New assets include three entities providing data to NANOOS for the first time (29 USGS river gages, CO_2 sensor data from NOAA PMEL leveraging 3 NANOOS buoys, and 1 new mooring from the Pacific Shellfish Institute), a NANOOS ocean model (OSU ROMS), and new deploy-ments and offerings from existing NVS providers (UW, King County, NOAA NERRS). NVS support for web-service-based asset data redistribution to external applications was enhanced, and is being used since Nov. by the Real-time Water Quality Application for Shellfish Growers – a NANOOS–NERRS partnership. Substantial progress was also made in the **implementation of IOOS DMAC data services** and standards, including THREDDS, SOS and WMS. Support for these services and NVS was strengthened via considerable **system hardware and software upgrades** that included deployment of new servers and disk arrays, and overhauled or updated operating systems and relational database management system software.

3. Task 1 Progress: DMAC Systems Architecture Definition and Development: The DMAC Team continued maturing the implementation of IOOS DMAC standards through regular participation in **IOOS RDI telecons** and software and system enhancements. CMOP upgraded **THREDDS** to vers. 4.2.5 and is now distributing historical in situ observations and irregular-grid model output for the Columbia Estuary, while OSU is using THREDDS to distribute regular-grid ROMS model output for the Oregon Shelf. The CMOP Python **IOOS-Profile SOS** server code in operation since May 2010 is being enhanced and adapted to provide SOS access to NVS asset data. **OGC WMS** access

is now available for CMOP models, while the NANOOS GeoServer was upgraded (vers. 2.1RC2) and its use expanded to provide better support for the Oregon tsunami evacuation zones layer and other GIS datasets relevant to regional CMSP partnerships. These enhancements were supported by **hardware and software upgrades**: 1) a new OSU server (Dell PowerEdge R310, Red Hat 6) hosting model image overlays and other NANOOS services; and 2) several APL server upgrades and standardization to Ubuntu LTS 10.04, PostgreSQL 8.4 and PostGIS 1.5. The **NVS system architecture** was improved via: 1) development of web and mobile services to monitor status of NVS hardware and applications; 2) strengthening NVS data-access web services for use by external applications; 3) enhancement to the backend handling of measurement metadata; 4) enhancements to the APL EIS tile server.

4. Task 2 Progress: DMAC Network Engineering Definition and Development: Work continued in the development of a NANOOS data aggregating service (**ERDDAP**, upgraded to vers. 1.2.8); dataset definitions are being developed to provide methods of data discovery and access that extend beyond NVS capabilities but are consistent with its asset inventory. Progress was made in **NVS** towards automatic detection and loading of new and updated assets from providers; and support for access to a greater range of data services, including the NSF-sponsored CUAHSI Hydrological Information System (HIS) cyberinfrastructure supported by USGS and EPA, relying on SOAP web services and WaterML encoding.

5. New DMAC Areas: The DMAC team pursued partnerships and laid out initial strategies for expansion into new areas of importance to both IOOS and regional stakeholders: 1) **CMSP**: led ongoing discussions with regional partners towards common DMAC approaches incorporating recommendations from IOOS and the Coastal Atlas community; and co-led the regional integration of DMAC efforts and goals between the West Coast IOOS RA's and the West Coast Coastal Atlas community in support of the West Coast Governors' Agreement on Ocean Health December response to NOAA's Regional Ocean Partnership funding program (Newton et al. 2011); 2) **Biological Data**: hosted a visit to Seattle by the OBIS-USA technical lead (P. Goldstein) in Jan. to identify areas of collaboration with NANOOS DMAC, and pursued continued discussions and biological data project delineations with several partners.

Presentations acknowledging NANOOS support:

Mayorga E. and D. Jones. Using IOOS to increase efficiencies in offshore fisheries: The NANOOS Pacific NW experience. First Energy Use in Fisheries Symposium: Improving Efficiency and Technological Innovations from a Global Perspective, Seattle, Nov 14-17, 2010. (Mayorga was a presenter and panelist in the Operating Strategies & Vessel Maintenance Workshop.)

Newton, J., E. Mayorga, J. Allan, S. Rumrill, A. Lanier, C. Bernthal, G. Galasso, E. Bowlby and J. Hennessey. IOOS' role in contributing to national and regional capability for Coastal Marine Spatial Planning: A view from the NANOOS Regional Association. ASLO Aquatic Sciences Meeting, San Juan, Puerto Rico, Feb 13-18, 2011.

d) <u>User Products Committee (UPC)</u>

1. Managerial: Chaired by Jonathan Allan (Oregon Department of Geology and Mineral Industries) this committee is composed of members from Boeing, OHSU, UW, OSU, NANOOS E&O, OR Sea Grant, and NOAA. NANOOS UPC chair Allan participates in weekly "tag-up" calls with a smaller sub-group comprised of members from DMAC, UPC, E&O, and Web development in order to facilitate consistent work efforts and improvements to product development and enhancements. Ac-

tivities for this period included: 1) weekly NANOOS DMAC and User Products Committee (UPC) teleconferences; 2) annual NANOOS DMAC-UPC-WEB Meeting (Nov 2010) with the inclusion of regional Coastal and Marine Spatial Planning (CMSP) representatives from the Oregon Department of Land Conservation and Development agency and from Oregon State University.

2. Summary of Significant Technical Accomplishments:

A core focus of the NANOOS DMAC-UPC-WEB sub-working group remains the provision of on-going technical support to the NANOOS Visualization System (NVS). In addition, to this important task, the sub-working group has initiated and completed several important enhancements to the NANOOS web portal and the Oregon Coast Tsunami evacuation portal.

NVS: Specific enhancements to the NVS platform have occurred on two separate occasions over this period: v2.0.5 was released on 8 Nov 2010, and most recently a major enhancement to v2.5 on 30 Mar 2011. Detailed documentation on the most recent changes and version history is available online: http://www.nanoos.org/nvs/information/version_history.php. In brief, these enhancements and changes include the following (see also the DMAC section, above)

- ***v2.05*** enabled compositing of image overlays (vectors and backdrop color image), implemented with NOAA Wavewatch III forecast model output; this version also significantly enhanced the Asset list, which became dynamic enabling assets to be simply filtered and sorted according to user interest and needs.
- ***v2.5*** reflected a major enhancement to the NVS platform with several new additions. These include:

- The creation of a Settings tab within NVS which provides specific controls to key NVS features;
- The creation of a "Units mode" that allows the user to define units of interest. These are distinguished between Common (US Customary System) and Scientific (International System) nomenclature;
- Introduction of a dynamic y-axis range that can be modified based on two settings: Global (data are plotted based on predefined y-axis ranges) and Local (the y-axis range is optimized for each asset variable based on statistics observed over the previous 2 weeks;
- The creation of a myNANOOS that allows users to login and predefine the look and feel of NVS according to their specific needs; and,
- Addition of new image overlays from forecast model assets: 1) NANOOS OSU ROMS model (SST and surface currents composite, and SST and surface currents composite optimized for commercial and recreational tuna fishermen needs); 2) NANOOS CMOP Columbia Estuary model (salinity and SST); 3) NOAA North American Mesoscale (NAM) model (surface barometric pressure, air temperature, wind speed, relative humidity); and 4) NOAA Wavewatch III NE Pacific (wind speed and direction, and wave height, period and direction wave)

Oregon Coast Tsunami Hazards portal: The portal was recently modified and updated in February 2011. Modifications to the portal included the addition of new evacuations maps developed for the southern Oregon coast (Bandon to the OR/CA border) and for Cannon Beach, modifications to the "map notes" and "legend" on the front page of the portal, and fixes to the print function that had broken. The portal continues to be used by the public (in lieu of paper maps that are accessible through DOGAMI), with a significant (400%) spike on March 11 in response to the Japan Tohoku earthquake and tsunami. Of this traffic, 76% visited directly, 6.5% came from Google, 4% from Facebook, and 3.25% from IOOS. The increased interest was so significant that it crashed the NA-

NOOS Geoserver that hosted the portal. We are particularly grateful to Nicholas Lederer (NANOOS web engineer) who was able to rapidly re-start the Tsunami portal on an alternate platform. Future enhancements include a complete reengineering of the existing portal, with the inclusion of evacuation information mapped for the Washington coast. To facilitate this process, NANOOS UPC chair Allan with input for UPC members and staff from the Oregon Department of Geology produced a working document that describes the conceptual look and feel of this new portal.

The NANOOS Data Access Program (N-DAP): Based on Environmental Research Division's Data Access Program (ERDDAP), N-DAP continues to evolve. N-DAP is a data server that aggregates oceanographic, meteorological, and remotely sensed data and model output from diverse sources, offering users the ability to visualize, browse and download available datasets, in many common file formats, via a relatively simple to use user- interface. Development on this new platform continues to proceed slowly, due to the complexity of the system. Recently, the server failed and had to be rebuilt and upgraded to the most current ERDDAP platform. Model data derived from CMOP and OSU ROMS are presently being compiled and added to the N-DAP platform as a test case. Future enhancements will include the development of a NANOOS GUI that will enable easy access to various capabilities offered by ERDDAP.

Website: The NANOOS website continues to undergo various enhancements and modifications. Most recently, NANOOS developed a webpage specific to the Honshu (Tohoku) Earthquake and Tsunami, which featured various news items about the effects of the tsunami observed along the PNW coast. Prior to this, the NANOOS web team and E&O staff (Sprenger and Mikulak) developed a series of Theme pages focused on the following topics: Maritime Operations; Ecosystem Assessment, Fisheries & Biodiversity, Coastal Hazards, and Climate. More detailed information pertaining to each of these subjects, including specific products developed or supported by the NANOOS RCOOS, can now be accessed directly on the NANOOS home page (www.nanoos.org).

e) Education and Outreach

1. Managerial: The Education and Outreach Committee, chaired by Dr. Nancee Hunter (Oregon Sea Grant), was sustained during the reporting period, with membership from University of Washington, Oregon State University, Ocean Inquiry Project, Hood Canal Salmon Enhancement Group, Oregon Sea Grant, CMOP, Padilla Bay National Estuarine Research Reserve, COSEE Pacific Partnerships, Washington Sea Grant, South Slough National Estuarine Research Reserve, and the Olympic Coast National Marine Sanctuary. NANOOS E&O staff, A. Sprenger and S. Mikulak, continued their participation in IOOS-NFRA E&O monthly calls and in the monthly NANOOS E&O committee conference calls, in collaboration with the E&O Committee Chair. Mikulak became a highly involved and active member of the User Products Committee. She attended the NANOOS DMAC/UPC Y4 kick-off meeting held Nov 18-19, 2010 in Corvallis, OR.

Education and outreach efforts in the past six months have focused on improvements to informational content on the NANOOS portal, continued work to connect with educators in the Pacific Northwest, outreach to users groups, partnering with informal education centers and supporting national IOOS efforts.

With help from the NANOOS E&O Committee and NANOOS web portal team, new introductory theme pages created for NANOOS's five areas of emphasis: Maritime Operations; Ecosystem Assessment; Fisheries & Biodiversity; Coastal Hazards; and Climate. They can be accessed via links

on our home page. Other improvements to the NANOOS web portal include a new People page and Calendar. The Winter 2011 edition of the NANOOS Observer, our newsletter, was published in February 2011: http://www.nanoos.org/documents/key/NANOOS_Observer_Winter_2011.pdf.

2. Summary of Education Accomplishments: Through a partnership with NANOOS member Ocean Inquiry Project, and NOAA BWET educational grant recipients, Edmonds Community College and the nonprofit Service, Education and Adventure, Amy Sprenger has presented at five professional development workshops for K-12 educators, reaching 100 educators. The NOAA BWET grant funded teacher workshops focus on helping teachers bring meaningful watershed educational experiences into their classrooms. The weekend trainings include a day-long cruise on marine waters. Throughout the day, Ocean Inquiry Project and NANOOS staff engage teachers in collecting and analyzing various types ocean observing data and demonstrating the NANOOS portal, products and lesson plans available for teachers to bring locally focused ocean data into their classrooms. Two more workshops with NANOOS participation are planned for this spring. Sprenger and Mikulak have also presented to more than 50 teachers in Oregon and Washington during other regional educational conferences listed below.

3. Summary of Outreach Accomplishments: Regionally, NANOOS outreach efforts to reach different user groups including fishers, coastal community residents, and scientists reached over 600 people in this 6 month period. Major events included: Saltwater Sportsmen's Show, Salem in OR; Heceta Head Conference in Florence, OR; and the UW College of the Environment/Washington Sea Grant/COSEE Ocean Learning Communities event in Seattle, WA. Mikulak and Sprenger created new outreach materials: a vertical banner, and one-page handouts that are tailored for targeted end-user groups and feature specific NANOOS data products relevant to that group.

In response to the Japanese earthquake and tsunami, Mikulak posted updates of NANOOS water level data on Facebook and compiled information from NANOOS PIs about their observations around the region: http://www.nanoos.org/features/honshu_earthquake_2011/overview.php.

NANOOS is partnering with informal learning centers in both Oregon and Washington. A coastal hypoxia animation created by Mikulak will be featured in a permanent exhibit at the Hatfield Marine Science Center, which is part of Oregon State University, a NANOOS member. The other group providing content to this exhibit is the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), who also provided input on this NANOOS created animation. Mikulak also continues to work with Port Townsend Marine Science Center to develop and field test a modular interactive computer exhibit focusing on helping visitors understand different parameters (salinity, temperature, dissolved oxygen and chlorophyll) coming from buoys in the NANOOS region.

On the national scale, Mikulak and Sprenger assisted in the IOOS effort to create one-pagers for each of the RAs by compiling and creating content for the NANOOS specific flyer. Mikulak was invited by Chris Simoniello of GCOOS to present her exhibit work at the annual GCOOS EOC meeting in June 2011.

Presentations acknowledging NANOOS support:

Sprenger, A. *Eyes on Washington Waters, Bringing Ocean Observing Data Into the Classroom*. Washington Watershed Education Teacher Training Program: Tacoma, WA November 6, 2010; Union, WA November 11, 2010; Everett, WA March 5, 2011; Seattle, WA March 26, 2010.

Hannafious, D. and A. Sprenger. *Bringing the Layers of Marine Water to the Classroom.* Storming the Sound South, Tacoma, WA October 1, 2010 *and* Storming the Sound West, Port Angeles, WA October 22, 2010

Mikulak, S. and A. Sprenger. *Habitat, Habitat, Have to Have a Habitat: An Oregon Ocean Habitat Game.* Science and Math Investigative Learning Experiences (SMILE) Teacher Workshop, Oregon State University, Corvallis, OR. January 28, 2011.

Sprenger, A. *What's in the Water? Puget Sound Marine Science Research for the Classroom.* Washington Science Teachers Association/Environmental Education Association of Washington joint Conference, Poulsbo, WA. March 19, 2011.

4) Issues (NONE)

5) Key Personnel Changes (NONE)

6) Budget Analysis

NA07NOS4730203: NANOOS RCOOS Y1-3
NANOOS requested and was granted a 1 year no-cost extension to this initial Y1-3 award in order to assure continuity in the RCOOS activities while the new Y4 award was being set up. The project period (including the extension) for the NANOOS RCOOS award is 88% completed and we have spent approximately 94% of the project funds. We are carefully monitoring burn rate and activities to assure the project closes cleanly. All required financial reports have been submitted.

NA10NOS4730018: NANOOS RCOOS Y4
The project period for the NANOOS RCOOS Y4 award is 52% completed and we have obligated 87% of the funds provided. Actual total expenditures, however, are less than 20%, as there was a several month delay in establishing contracts and hence, appropriately slow initial billing by our subcontractors. This situation will ease now that all financial instruments are in place. All required financial reports have been submitted.