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

NANOOS reports here on progress funded by a one-year "bridge" award (NA10NOS4730018), covering Y4 operations of the NANOOS RCOOS. This competitively-awarded one-year "bridge" award allowed continued NANOOS RCOOS operations until NOAA released the IOOS RCOOS FFO in FY11, to which NANOOS responded with a proposal which was successful. NANOOS requested and was granted a 1 year no-cost extension to our NA10NOS4730018 "bridge" award in order to assure continuity in the RCOOS activities while the new Y5 award (NA11NOS0120036) was being set up. Accordingly, NANOOS presently has two active RCOOS awards in place (both NA10NOS4730018 and NA11NOS0120036). At the close of this reporting period, some investigators used one or the other or both award funds to keep the NANOOS RCOOS sustained. We report here on work done using the NA10NOS4730018 funds, noting where an investigator has completed the use of those funds prior to this reporting period. Progress for those elements of the RCOOS effort will be reported in our NA11NOS0120036 report, which has a different submission timing and format.

1) Award Information: Provided as a separate Cover Sheet.
Reporting period: 01 Oct 2011 – 31 Mar 2012

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) <u>Observing System</u>: NB: Data from all assets reported here are served via NANOOS NVS.

- Shelf

1. Washington Moorings and Glider observing network operations:

M. Alford, Applied Physics Laboratory, University of Washington (APL-UW), is the lead for field operations and maintenance of: 1) the Cha Ba buoy, 2) the new NEMO subsurface mooring, and 3) the Seaglider, all run off of La Push, WA. The investigator had completed the use of NA10NOS4730018 funds prior to this reporting period. Progress for these elements of the sustained NANOOS RCOOS effort will be reported in our NA11NOS0120036 report.

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. Since Oct 2011, glider deployments have continued on the Oregon shelf, including through the stormy winter months. Glider observations have documented the coastal ocean

response to several large storms during this past winter, and a period of record precipitation in early 2012.

Presentations acknowledging NANOOS support:

Erofeev, A., Barth, J.A., Shearman, R.K., Kurokawa, Z., Adams, K., Ordonez, C., Mazzini, P., Welch, P., Sampling the Dynamic Oregon Coastal Ocean with Underwater Gliders, Ocean Sciences Meeting, Feb 2012.

3. Oregon 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. The investigator had completed the use of NA10NOS4730018 funds prior to this reporting period. Progress for these elements of the sustained NANOOS RCOOS effort will be reported in our NA11NOS0120036 report.

4. Northern Oregon to Central Washington shelf: Led by A. Baptista (OHSU), the Center for Coastal Margin Observation & Prediction (CMOP) maintains a glider and two offshore buoys (SATURN-02 and OGI-01). All these platforms are seasonal, with focus on April-September. During the reporting period, SATURN-02 and OGI-01 were deployed their winter configurations (surface CT only, no telemetry), and there were no glider deployments.

Glider deployments will re-start in late April/early May. For the first time, we will have two gliders to deploy along the same route, with each glider deployed when the other is recovered, which should minimize temporal data gaps. SATURN-02 will also be deployed in full interdisciplinary configuration in late April or early May. The deployment of OGI-01 is considered lower priority, and has not yet been scheduled.

Archival 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 through the SATURN Data Explorer (http://www.stccmop.org/datamart/observation_network/dataexplorer).

- **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 operated six buoys in the Puget Sound and Hood Canal. This included restoring the North Buoy near Admiralty Inlet to service in October, with both water column profiling and real-time weather streams. The Hoodsport mooring was in service until December 2011, when a flooded solar panel brought down the power system.

We continued to make all buoy data 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, Ecology, Navy, and NSF funding. The Dabob Bay 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. We also continued to provide support and power to the pCO_2 system operated at Dabob Bay and Twanoh in collaboration with NOAA PMEL

(C. Sabine, R. Feely) by supplying power to the system and collecting water samples to aid system calibration.

With 7 years of data in southern Hood Canal we are able to observe significant inter-annual variability. As in previous years, the spring bloom at Twanoh was observed in February 2012, weeks before spring blooms were observed at other buoys throughout the Puget Sound. At both Twanoh and Hoodsport dissolved oxygen concentrations at the end of 2011 were on the high side of the average of the previous 7 years. This trend continued through the first 3 months of 2012 at Twanoh, with dissolved oxygen concentrations higher than those observed in most of the previous 7 years, but similar to those observed in 2009. A further comparison between 2009 and 2012 at Twanoh revealed similarity between the two years in bottom water temperatures as well, where 2009 and 2012 trended significantly below the average. In terms of salinity, however, 2009 and 2012 were significantly different from each other; bottom water salinity in 2009 was solidly above average, whereas bottom water salinity in 2012 has thus far been average.

Presentations acknowledging NANOOS support:

Newton, J. and T. Klinger. Integrating ocean acidification research across the Salish Sea. *Salish Sea Ecosystem Conference 2011*, Vancouver, BC, Canada, October 25-27, 2011.

Feely, R.A., S.R. Alin, C.L. Sabine, J. Newton, M. Warner, and A. Devol. Ocean acidification in the Salish Sea. *Salish Sea Ecosystem Conference 2011*, Vancouver, BC, Canada, October 25-27, 2011.

Alin, S., B. Allen, A. Suhrbier, J. Davis, R. Feely, J. Newton, A. Devol, C. Sabine, B. Peabody, B. Hales. Water chemistry and larval oyster success in Puget Sound as impacted by ocean acidification. *Salish Sea Ecosystem Conference 2011,* Vancouver, BC, Canada, October 25-27, 2011.

Keister, J.E., J.A. Newton, J.K. Bos, and L.B. Tuttle. Zooplankton community variability in the Strait of Juan de Fuca and Puget Sound. *Salish Sea Ecosystem Conference 2011*, Vancouver, BC, Canada, October 25-27, 2011.

Newton, J., A. Devol, J. Richey, M. Kawase, M. Warner, S. Parker-Stetter, D. Hannafious. Hypoxia in Hood Canal: Lessons learned from HCDOP. *Salish Sea Ecosystem Conference 2011,* Vancouver, BC, Canada, October 25-27, 2011.

Newton, J., A. Devol, M. Alford, and J. Mickett. NANOOS contributions to understanding ocean acidification. *National Shellfisheries Association Meeting, 2012,* Seattle, WA, 26-29 March.

2. Washington State estuarine monitoring: Participation by the WA State Department of Ecology (Ecology)'s Marine Waters Monitoring Program is directed by C. Maloy (Marine Monitoring Manager), led by C. Krembs (Senior Oceanographer) and coordinated by D. Mora (Mooring Coordinator). Ecology, with the help of collaborative partnerships, operates a network of four mooring stations (six total sensor packages) in Puget Sound and two moorings in Willapa Bay. The deployment locations are primarily designed to capture inter-basin exchange of temperature, salinity, and oxygen. Ecology funded the establishment of the mooring stations and NANOOS funding partially supports technician time for maintenance. We contribute to regional estuarine *in situ* observations by maintaining our monthly-calibrated moorings, providing quality controlled data, compiling monthly reports, and reporting on anomalies.

Moorings maintained during this period were located in Admiralty Reach, Shannon Point, Manchester (two depths), Mukilteo (two depths), and Willapa Bay. Data are available via the NANOOS Visualization System as well as from Ecology's web page. Key collaborative partners include Everett Community College, Western Washington University, University of Washington APL, and NOAA.

In October 2011 our Mooring Technician, Ashley Carle, moved on to WSDOT. We hired a new Mooring Technician, Suzan Pool, in March 2012. Previously Suzan led Ecology's field work for the EPA's National Coastal Condition Assessment.

At our Willapa Bay station, with the help of EPA divers, we recovered our mid-depth CTD that had become lodged in the protective housing, PVC pipe. We are exploring an alternate deployment scheme so that we can reestablish telemetry broadcasts.

We decided to decommission the Carlyon Beach station (SQX01CF). We believe the data set collected from 2006-2012 is highly valuable toward helping improve our understanding of water quality dynamics in South Puget Sound. However, after careful consideration of the station's cost effectiveness in these increasingly difficult budget times, we decided it is better to place a higher focus on fewer stations.

At the 2011 Salish Sea Conference we reported on the timing and conditions of dissolved oxygen intrusions into Puget Sound, as detected by a moored sensor package deployed within Admiralty Reach. This deployment is a collaborative effort between Ecology and UW-APL. We found that Puget Sound dissolved oxygen minima coincide with oceanic source water, positive upwelling, and neap tides. Observations from this station are important for supporting Puget Sound modeling efforts.

Ecology is continuously developing monthly condition reports that include summarized observations from mooring stations. Reports can be downloaded from:
http://www.ecy.wa.gov/programs/eap/mar_wat/moorings.html

Presentations acknowledging NANOOS Support:

Mora, D., Carle, A., Krembs, C., Thomson, J., Albertson, S. Admiralty Reach as Conduit for Low Oxygen Water Intrusions Into Puget Sound. *2011 Salish Sea Ecosystem Conference,* Vancouver, British Columbia, Canada. October 25-27, 2011.

3. Columbia River estuarine monitoring: CMOP continues to maintain multiple SATURN endurance stations in the Columbia River estuary (under the direction of A. Baptista, with a mix of NANOOS, NSF and regional-stakeholder funding), and two in the tidal freshwater (under the direction of J. Needoba, with a mix of NSF and regional-stakeholder funding). Data are available as described in item "Northern OR to Central WA shelf", above.

During this reporting period, we continued to improve and maintain the SATURN network, with increasing emphasis on the biogeochemical stations, and associated data quality control. Progress has included:

- Increased robustness of the SATURN-01 profiler, an anchoring interdisciplinary station located in the North Channel
- Preparations for the extension of the capabilities of the stations 03 and 04 (which allow land access to instrumentation), in particular to (a) improve the characterization of the degree of acidity of waters intruded from the shelf into the estuary, and (b) to begin characterizing microbial communities. The deployment of the new capabilities will occur starting May 2012.

- Preparations for the deployment of an additional biogeochemical station (SATURN-07) in Baker Bay, with the goal to explain the formation of late-summer plankton blooms that appear to be incubated in this saline lateral bay of the estuary. The deployment is scheduled for early May 2012.

4. Oregon South Slough: Participation by the Oregon Department of State Lands (ODSL) in NANOOS activities is led by A. Helms (Acting Research Program Coordinator for the ODSL), and coordinated by A. DeMarzo (Estuarine Monitoring Assistant) at the South Slough National Estuarine Research Reserve (NERR).

South Slough NERR continued operating a network of moored observing stations and a real-time weather station within the South Slough estuary as part of the NERRS System-Wide Monitoring Program and NANOOS. The water monitoring stations 1) Charleston Bridge 2) Valino Island 3) Winchester Creek and 4) Sengstacken Arm/Elliot are located along the estuarine salinity gradient, providing continuous near real-time data from marine to riverine hydrographic regions. The weather station is located on the Oregon Institute of Marine Biology campus about 1.2 km northwest of the Charleston water quality and 20 meters from the inner boat marina at Charleston harbor. Three of the water stations and the weather station are equipped with telemetry systems, and the fourth water quality station will begin transmitting data by the end of May 2012. The fourth station involved a relocation from the historical site Sengstacken Arm to Elliot Creek to accommodate telemetry. A fifth water quality station will be installed near the mouth of Coos Bay (Boathouse) or at a site in upper Coos Bay with a goal to begin data transmission by the end of Sept 2012. We are working with the Coast Guard and Port of Coos Bay to determine which existing structures (range markers/pilings) are suitable for installing and maintaining equipment for the fifth station.

Time-series water quality measurements generated by the telemetered monitoring stations are available in from several websites including NANOOS, the NOAA Hydro-Meteorological Automated Data System, and the NERRS Centralized Data Management Office.

South Slough staff purchased two new YSI 6600 V2-4 dataloggers and converted an older instrument to the V2-4 configuration to replace aging equipment for measuring the suite of estuarine water quality parameters. In addition, bridge funds were used to replace weather station sensors, which provide real-time data to assess the short-term effects of local weather on measurements of water parameters within the estuary.

Presentations acknowledging NANOOS support:

Partnership for Coastal Watersheds Environmental Science Advisory Group Meeting, http://www.partnershipforcoastalwatersheds.org/, April 25, 2012, C. Cornu

Oregon Coast Education Program, Water quality webinar "Delving into the Murk of Water Quality," March 8, 2012, A. Helms

Olympia Oyster Recovery Advisory Committee, February 28, 2012, S. Rumrill

NERR Technician Training Workshop, Myrtle Beach, SC, Poster Presentation "Detection of Small Scale pH shifts using long-term water quality data in the South Slough estuary, OR: A relationship between pH variability, eelgrass habitat, and ecosystem metabolism," February 7-9, 2012, A. Helms

Partnership for Coastal Watersheds steering committee meeting, Estuary water quality data summary presentation, January 26, 2012, C. Cornu

Coastal Oregon Marine Experiment Station Advisory Board Meeting, Presentation on Native oyster restoration and estuary pH, November 3, 2011, A. Helms

- **Shorelines**

1. Washington Shorelines:

NANOOS funds contribute to the Washington State Department of Ecology's Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. CMAP continued beach and shoreline monitoring in the Columbia River littoral cell (CRLC) during this semiannual period between October 1, 2011 and March 31, 2012. The monitoring program in the CRLC 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 and surface maps at two locations in the CRLC during Fall 2011. At Benson Beach, two surface maps were collected in October and December including a survey of the sand fences and the collection of 14 sediment samples to complete monthly monitoring for the Southwest Washington Littoral Drift Restoration project. CMAP initiated Winter 2012 surveys during March, including 31 beach profiles and 42 sediment samples. No surface maps were collected during March due to mechanical problems with our beach survey vehicle. Winter surveys and surface map collection will continue in April. CMAP performed long GPS occupations of several monuments (17) in the CRLC geodetic control network to verify their positions, which were originally surveyed in 1997.

A series of sinkholes were observed along the Columbia River North Jetty on November 23, 2011 (see photos, below), possibly indicating subsurface leakage of sediment through the jetty into the inlet.

Finally, CMAP performed a survey at Cama Beach on Camano Island on March 25th in response to a coastal bluff landslide (see photo, below). CMAP will monitor the site over time to assess beach feeding and sediment transport.

2. Oregon Shorelines:

Leveraging NANOOS, the Oregon Beach and Shoreline mapping Analysis Program (OBSMAP) efforts continue to be led by J. Allan and V. McConnell of the Oregon Department of Geology and Mineral Industries (DOGAMI). As part of DOGAMI's commitment to NANOOS, the OBSMAP network was sustained for the study period (1 Oct 2010 to 30 Sep 2011) and in some cases enhanced with the addition of new observation sites.

Figure 1: Map showing the OBSMAP beach and shoreline monitoring network as well as other non-NANOOS beach observation programs.

PI Allan also provided equipment support for PI Ruggiero (OSU) in order to assist Ruggiero with the collection of nearshore bathymetry (Mean Higher High Water (MHHW) out to a depth of approximately 20 m (~65 ft)) using personal water crafts along the length of the Tillamook County coastline, totaling ~250 bathymetric transects. These latter surveys occurred in late summer at the same time as our regular beach monitoring to provide overlap and quality control checks of the land-based and bathymetry data.

Beach and shoreline monitoring continues to be maintained at 46 sites on the northern Oregon coast; 6 sites along the Clatsop Plains, 25 sites in the Rockaway cell, and 15 sites in the Neskowin cell (Figure 1). Periodic monitoring is also being undertaken at 73 sites in Lincoln County, Oregon (Newport/Beverly Beach cells). Monitoring occurs either on a seasonal[1] or biannual basis[2] and is able to be rapidly implemented due to its reliance on Real Time Kinematic Differential Global Positioning System (RTK-DGPS) surveying technology developed for beach monitoring (Barnard et al., 2011). RTK-DGPS has effectively become the standard for undertaking rapid and highly accurate surveys of coastal change on beaches, bluffs and in the surfzone, due to its high degree of accuracy (both horizontal and vertical positioning), ease of use, and because it enables large areas to be monitored at significantly lower costs (Figure 2). These data have been supplemented with the help of airborne Light Detection and Ranging topographic data (lidar)

[1] Summer (~August/September), Fall (~December/January), Winter (~March/April), Spring (~May/June).
[2] Summer (~August/September), Spring (~May/June).

collected by the USGS/NASA/NOAA in 1997 (summer), 1998 (winter, post El Niño), and 2002 (summer), enabling the measured time series to be extended over a ~15 year period. These data are providing important information on the state of Oregon's beaches, their response to storms, El Niños, and over the long term, effects associated with climate change and variability.

Figure 2: *Beach profile surveys being undertaken using a Trimble R8 GPS rover mounted on a backpack in the community of Neskowin, Tillamook County. Erosion at this site has resulted in the loss of over 50 m of dune since 1997, with homeowners having to resort to expensive engineering in order to safeguard their properties.*

Through technology transfers and by leveraging funding from other sources, similar observation networks have been established at an additional 180+ sites along the length of the Oregon coast. For example, in February/March 2011 DOGAMI staff expanded the OBSMAP network to include 24 new sites in the Netarts cell and another 35 sites on the southern Oregon coast (Gold Beach/Nesika Beach cells) in order to document erosion hazards and coastal changes in those areas. Of importance, however, these latter sites are presently not supported by NANOOS, and are thus observed on an *ad hoc* basis, or as and when funding becomes available.

The collection and processing of the GPS data is now routine (Figure 3). Data continue to be disseminated to interested parties through the OBSMAP and NANNOOS websites. These data are being used by State resource managers (e.g. the Oregon Parks and Recreation Department

(OPRD) who manages the public beach, and the Department of Land Conservation and Development Ocean Coastal Management Program (DLCD-OCMP)), Geotechnical consultants and the public for assessing coastal change, stability and erosion/flood hazard risk.

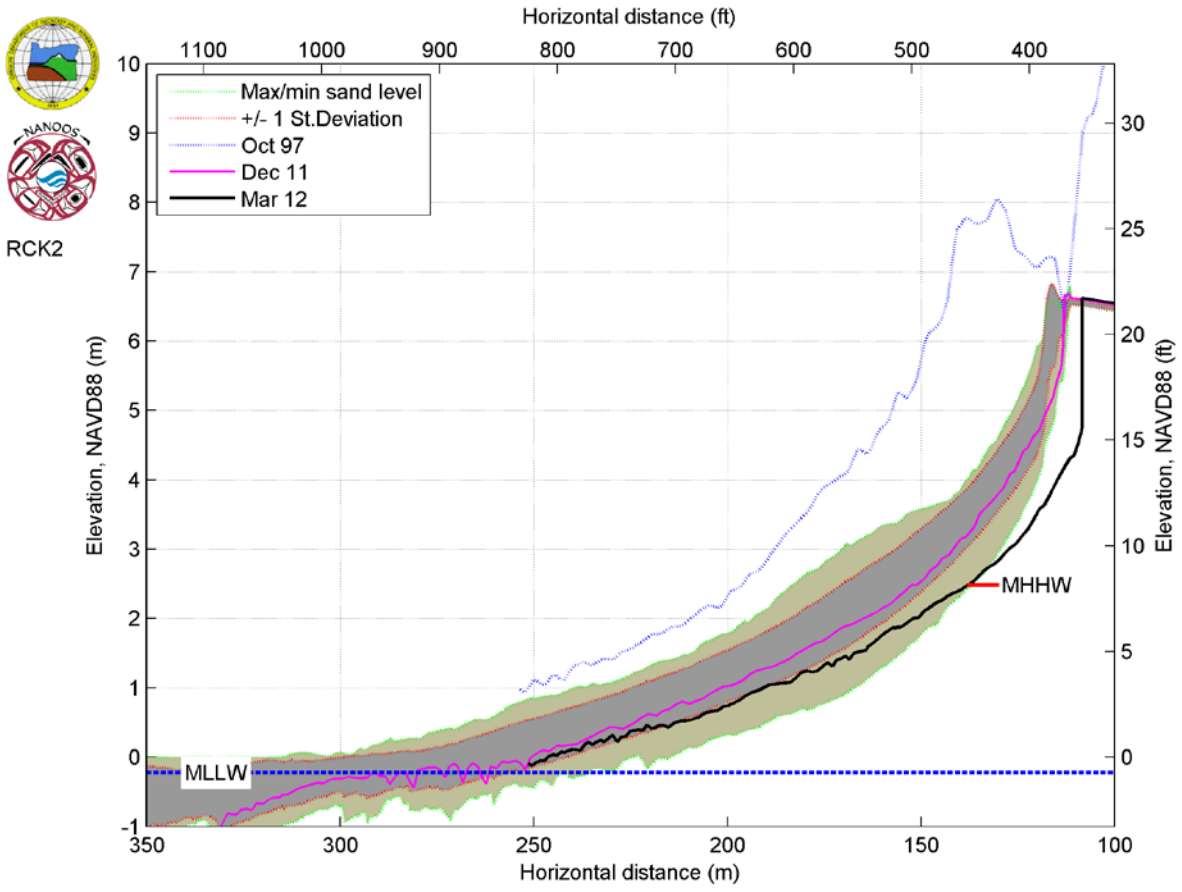

Figure 3: Beach profile plot example at the Rck2 site in the Rockaway littoral cell. Dark grey shading depicts the typical interannual fluctuations measured at this site. Light grey shading indicates the extreme high and low sand elevations and excludes the most recent survey. Recent measurements indicate ongoing erosion at this site, which has now retreated by some 40 m.

Figure 3 provides an example beach profile plot from the Rockaway (Rck2 site) littoral cell. The plot identifies the initial survey of the site derived from lidar in 1997 (blue line) and the most recent survey (black line). Importantly, the plot includes shading that defines the 'typical' range of variability (i.e. 1σ about the mean profile (dark shading) and the maximum/minimum beach elevation changes (light grey shading) determined for the period 2004 to 2011 (i.e. based only on the GPS surveys). This product is useful since coastal resource managers and other stakeholders can quickly assess the condition of the beach identified by the most recent survey, relative to some 'normal' range of expected responses.

In order to understand changes that may be occurring at the seasonal to interannual time scale, we have developed contour change plots. These latter plots provide a "time stack" of changes

occurring at four different elevations down the beach face (e.g. near the dune toe (6.0 m and 5.0 m contour) and lower down the beach face near the MHHW mark (3.0 m contour). The former describe changes that tend to be more event-based (i.e. the product of major storms), while the latter characterize the seasonal variability. Ultimately, these data are made available to NANOOS stakeholders via the OBSMAP[3] and NANOOS[4] websites.

Besides the transects, shoreline variability continued to be also measured, involving re-measurement of the Mean High Higher Water (MHHW) contour located at an elevation of ~2.3 m above MLLW, a tidally-based proxy for the position of shorelines along each of the littoral cells. These data are important since they provide greater insights and hence understanding of the spatial and temporal variability of the beaches, and in particular can be used to identify the locations of rip embayments, which may be used to define potential 'hotspots' of erosion.

Key findings:
Our GPS monitoring indicates erosion continues to dominate much of the Neskowin and Rockaway shorelines, which have eroded 20 - 50 m since the late 1990s, much of which can be attributed to major winter storms. In response, residents have spent several million dollars in expensive remediation in order to mitigate the hazard and safeguard their properties and infrastructure from further erosion (Figure 2). Due to the amount of beach and dune erosion having taken place in communities such as Neskowin, these sites are now even more vulnerable to storm damage and wave inundation due to the loss of significant buffering capacity provided by the beaches previously.

Stakeholders:

- Oregon State Parks and Recreation Department (OPRD) used the OBSMAP data to assist with beach management, including the permitting of engineering structures. This has included the development of "hotspot" hazard maps for selected communities preceding a winter season;
- Beach surveys have been used in the community of Rockaway 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 change data measured adjacent to the mouth of Tillamook Bay have been used to evaluate the potential effects of wave energy development offshore from Tillamook Bay.
- Beach surveys were and continue to be 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 change data adjacent to the Columbia River south jetty were 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;
- The combined beach observation dataset now available for Tillamook and Clatsop Counties are being used to assess 1% (100-year) coastal flood and erosion risk along the

[3] http://www.oregongeology.org/sub/Nanoos1/index.htm
[4] http://www.nanoos.org/nvs/nvs.php?section=NVS-Products-Beaches-Mapping

shorelines of both counties for the purposes of developing FEMA flood insurance rate maps;
- The data are being used to by state resource agencies to provide technical guidance on an erosion problem on the southern Oregon coast at Gold Beach.
- Other stakeholders include the Coastal Hazards Processes Working Group (an ad hoc group of planners, geotechs, engineers, agencies, and environmental groups that periodically met to discuss coastal hazard issues), practicing geotechnical consultants, planners, and the public at large.

3. Nearshore Bathymetry: In autumn/winter 2011/2012, P. Ruggiero's group at Oregon State University completed the processing of nearshore bathymetry data collected along the four sub-cells of the Columbia River littoral cell (CRLC). Over 200 individual cross-shore profiles were collected in the cell during summer 2011 extending from the lower inter-tidal to approximately 12 m of water depth (~2000 m from the shoreline). These data have been processed from their raw format into deliverable text files and have passed a rigorous quality assurance process. In all cases these nearshore bathymetry measurements have been combined with topographic measurement collected by Ecology developing complete maps of the nearshore planform.

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

With partial support from NANOOS, Ruggiero's group has hired a full time field technician, Jeffrey Wood, to assist with data processing, archiving, and field equipment maintenance. Jeff came on board in January of 2012 after working for Ruggiero's group as a student worker for over 1.5 years. Ruggiero's Graduate Research Assistant, Diana Di Leonardo, is using nearshore bathymetry data collected as part of this project for her Master's thesis work. In December, 2011, Diana presented her initial findings at the Fall AGU meeting.

Presentations acknowledging NANOOS support:

Di Leonardo, D. and Ruggiero, P., 2011. Applying a long-term data set to understand large scale coastal behavior, AGU Fall meeting, San Francisco, CA.

- **Currents**

1. Coastal Currents: With support from NANOOS, the HF surface current mapping program continues to provide near-real-time maps of ocean surface currents along the Oregon coast. Mike Kosro (PI), Anne Dorkins, and David Langner of OSU, and Jose Montoya of Humboldt State University, contribute to this program. These data are provided to the public through the NANOOS Visualization System (NVS) as maps over 3 regions, as well as downloadable text files. In addition, surface current data are simultaneously provided to the national distribution centers via HFR-net. They also are assimilated in regional ocean circulation model forecasts being done by Alexandre Kurapov's group, which in turn are made public via NANOOS.

We collaborated with Dr. Steve Anderson of Arete Associates in a test of their airborne high-resolution optical current sensing technique, by re-installing the SEA and STV sites and providing HF measurements as "ground truth" for their experiment of Oct 6, 2011. The assimilation of HF data in a model of coastal circulation is described in a paper by Yu and co-authors, in press for *Ocean Modeling*. The time- and space-variations in M2 tidal currents off Oregon have been studied, and regions of large energy flux identified, in a paper by Osborne and coauthors in Journal of Physical Oceanography during the reporting period. HF measurements were essential to, and Kosro was a co-author on, five talks presented at Ocean Sciences and EPOC during the reporting period.

Using funds from a successful OSU internal proposal, we have upgraded the last two long-range HF systems to use CODAR's GPS time-slicing software which allows multiple HF systems to operate on the same frequency without interference, a capability which will be essential under coming frequency rules. For this $30K upgrade, the proposal provided 80% of the cost, with the remaining $6K re-budgeted from NANOOS HF funds.

Our processing and mapping software were modernized to use Matlab HFR code published by Cook and Fernandez. This is a large change, since it involves use of a different format for the radial data, different plotting/mapping software, different automated scripts, and a reworking of our data flow. Site operational reliability has been bolstered by the completion of installation of Web Power switches at each of our sites, enabling power to be cycled to each outlet through a web interface. In addition, higher quality Uninterruptible Power Supplies (Back-UPS Pro 1500) were installed at 10 of our sites, completing this upgrade for all sites. Operating system software updates and virus checking have been done at all sites. Wireless internet access at WIN was repaired by configuring and installing new routers over the 2km jump to the internet drop.

This period has brought particularly difficult circumstances with aging equipment and infrastructure. The power company's buried lines to two of our sites are failing or have failed. We are working to find an affordable solution, but initial cost estimates are in the $50K range for each site. The poor-quality power has damaged some equipment, even though high-quality UPS systems were in place; these are being repaired at unexpected (and high) costs. Repairs to equipment include the sites LOO1, YHL1, YHS2, WLD2, WIN1 and CBL1. Most recently, extremely strong winds at YHL damaged the antenna box in a way unseen in 15 years of HF operation on the Oregon coast.

Papers acknowledging NANOOS support published during 10/1/2011-4/1/2012:

Osborne, J.J., A.L. Kurapov, G.D. Egbert, P.M. Kosro, 2011. Spatial and temporal variability of the M2 internal tide generation and propagation on the Oregon shelf. *Journal of Physical Oceanography*, 41(11), 2037-2062, doi: 10.1175/JPO-D-11-02.1.

Papers in press acknowledging NANOOS support during 10/1/2011-4/1/2012:

Yu, P., A.L. Kurapov, G.D. Egbert, J.S. Allen, P.M. Kosro, 2012. Variational assimilation of HF radar surface currents in a coastal ocean model off Oregon. Ocean Modeling, doi:10.1016/j.ocemod.2012.03.001. (In Press).

***Conference Presentations during 10/1/2011-4/1/2012*:**

Kurapov, A.L., P. Yu, S. Erofeeva, P.M. Kosro, "Effects of Assimilating GOES SST, alongtrack altimetry, and high-frequency radar surface currents on the coastal ocean surface topography", Ocean Sci-

ences Meeting, Salt Lake City, Feb 20, 2012.

Osborne, J., A.L. Kurapov, G.D. Egbert, P.M. Kosro, "Modeling slope-shelf interactions in the coastal ocean", Ocean Sciences Meeting, Salt Lake City, UT, Feb 21, 2012.

Terrill, E., et al., "Role of a Networked Ocean in Assessing Large Marine Ecosystems – Monitoring Ocean Currents at a Cascade of Scales with HF radar", Ocean Sciences Meeting, Salt Lake City, UT, Feb 20, 2012.

Osborne, J., A.L. Kurapov, G.D. Egbert, P.M. Kosro, "Modeling shelf, slope and river plume flow interactions in the coastal ocean", 58th Eastern Pacific Ocean Conference, Fallen Leaf Lake, CA, Oct 14, 2011.

2. Port X-band Radar: Led by M. Haller (OSU). During the reporting period our activities involved: 1) completing repairs on the X-band wave imaging system deployed at Newport, OR; 2) continuing development of real-time wave data products for the X-band system, and 3) quality control and analysis of the data from the demonstration deployment of the UHF-band inlet current radar system (RiverSonde).

Details:

1) Radar repairs were finally completed during March, 2012. Repairs involved the DAQ mother board originally and, later, both the Koden signal conditioning box and the marine radar transmitter. Unfortunately, as soon as the repairs were completed, our field site (Newport "blockhouse") developed a fault in its connection to the power grid. A number of different groups are using this site for field work (OSU, HMSC, ODF&W, etc.); presently, the consortium is discussing options, whether it's a move to solar, investing in (expensive) power line repairs, or moving to a different site. We shall see.
2) In the meantime, we have spent some effort developing additional data products for the wave imaging radar and laying the groundwork to make them available in real time. At this point, we now have a wave directional distribution product and we have started testing a bathymetric estimation product for the adjacent beaches. An example output of the directional distribution product is shown in Figure 4. The bathymetric estimation product also looks promising; we are presently testing whether the product can be improved by collecting longer data runs.

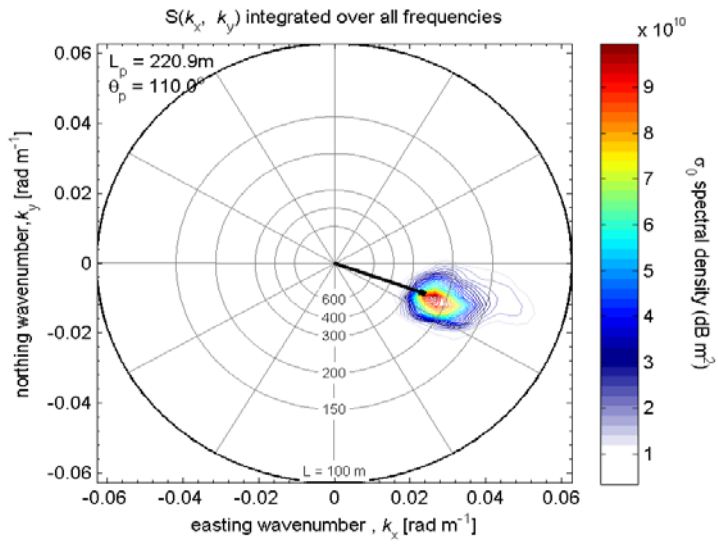

Figure 4. Mean wave directional distribution, as determined from marine radar image intensity data. Black line points in the direction waves are traveling, shore is to the right (east).

3) We also have an ongoing effort involving a test deployment of a UHF-radar system (RiverSonde by CODAR) for measuring inlet currents at the Newport field site. During this reporting period we have continued quality control of this data and made comparisons to co-located in-situ ADCP data (collected in collaboration with J. Lerczak, OSU). Initial comparisons with in-situ ADCP data look very promising. The system offers the capability to observe a cross-channel profile of inlet currents at half-hourly resolution, and, potentially, surface currents over an even larger footprint (300m x 300 m, 10 m resolution). Results presented at the 2012 Ocean Science Meeting are in Figure 5.

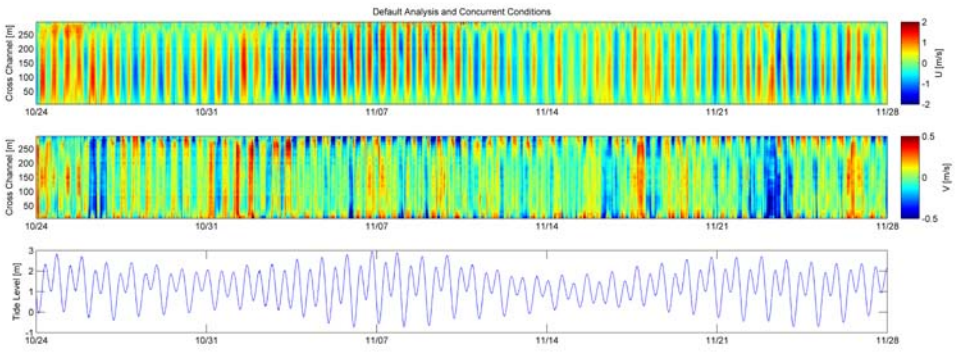

Figure 5. Top panel shows the along-channel surface current as a function of time, the middle panel the cross-channel currents. The lower panel is the corresponding tidal elevation. Tidal signals are clearly evident in the surface currents, interesting cross-channel structure is evident as well.

Presentations acknowledging NANOOS support:

Honegger, D.A., M.C. Haller, J.A. Lerczak, C. Teague, and H. Aguilar, Remote observations of surface current structure at an engineered tidal inlet mouth, *AGU Ocean Sciences Meeting*, Salt Lake City, UT, 2012.

Einolf, A.E., J.A. Lerczak, and M. Haller, Tidally-dependent stratification, shear and secondary currents in Yaquina Bay estuary, Oregon, *AGU Ocean Sciences Meeting*, Salt Lake City, UT, 2012.

b) Modeling efforts

- **Shelf:**

A. Kurapov's group at OSU has developed a real-time coastal ocean forecast model, which produces daily updates of 3-day forecasts of ocean conditions, including currents, temperatures and salinities through the water column (at 3-km horizontal resolution). Maps of the nowcasts and forecasts are posted daily through the NANOOS Visualization System (NVS) (Figure 6).

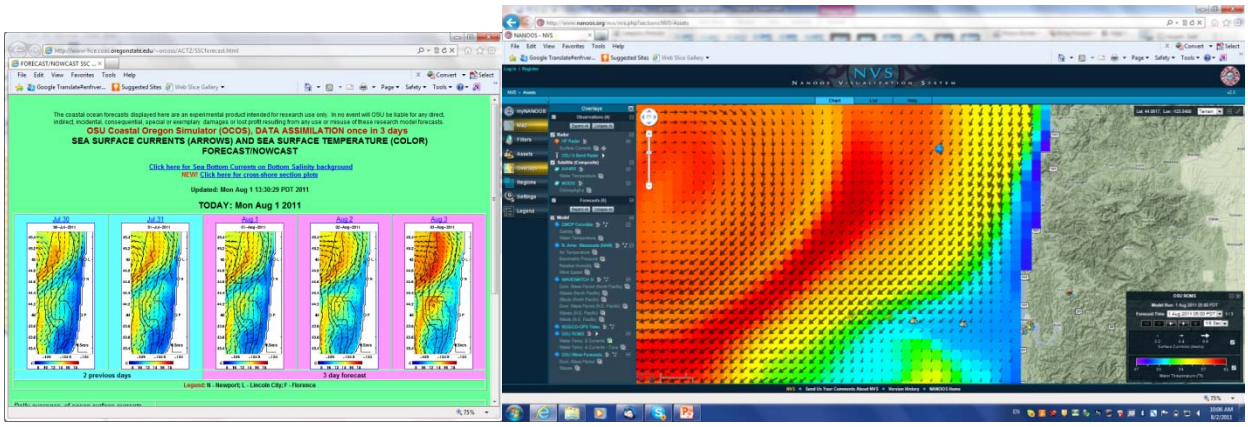

Figure 6. Maps of forecasts of SST and surface currents are provided to the public online via the OSU modeling group site (S. Erofeeva, www-hce.coas.oregonstate.edu/~orcoss/ACTZ/SSCforecast.html) (shown on the left), and the NANOOS visualization system (www.nanoos.org) (shown on the right).

In August 2011 we have started routine assimilation of observations in the real-time regime, which significantly improved accuracy of the sea surface temperature, currents, and SSH. Assimilated data have included daily maps of high-frequency (HF) radar currents (provided by P. M. Kosro, OSU), RADS alongtrack altimetry (provided by L. Miller, NOAA-STAR), and hourly GOES SST (provided by D. Foley, NOAA-Coastwatch). Assimilation proceeds using the advanced variational method (Kurapov et al. 2009, 2011, Yu et al., 2012) in a series of 3-day time windows, which allows synthesis of the sparse and noisy data from different platforms. This method may be viewed as space- and time-interpolation of sparse and noisy observations using dynamically based interpolation (covariance) functions implied by the model.

In 2012, we have begun developing a forecast model in an extended domain that will provide prediction of ocean conditions for both Oregon and Washington shelves (Figure 7). The forcing will include the Columbia River fresh water discharge and tides. First tests of this model (so far run in a hindcast regime and without data assimilation) have shown important effects of the Columbia River on summer and winter circulation off the Oregon and Washington shelves (Figure 8).

These forecasts have become a hot topic of fishermen's blogs (http://www.ifish.net/board/showthread.php?t=369346), indicating that the forecasts are useful. The owner of one of the boat charter companies has even made (and posted on their site) a tutorial video of how to use our forecasts via the NVS system (http://amigocharters.com/?page_id=58).

We have established collaboration with Dr. Amy MacFadyen (NOAA, the Office of Response and Restoration (ORR) lab, Seattle) who has run tests of their GNOME oil spill software using our surface velocity forecast fields. Dr. P. Yu, the research associate in charge of the real-time assimilation model, has set up an OpenDAP server that is used to provide fields to ORR immediately in case of emergency.

To better understand the impact of different data sources on the coastal ocean prediction, we have run and compared different hindcast cases (the free-run model and cases assimilating SST alone, HF radar currents alone, SST and currents, and SST, currents, and SSH in combination). These studies not only guide further development of this product, but also let us obtain new knowledge about regional ocean dynamics and identify challenging areas, for instance, enhanced diurnal tides around capes, the effect the Columbia River plume on SST, and interior-coastal ocean connectivity in winter.

Future plans include setting the data assimilation in a new, extended domain (see Figure XX) and adding new data streams to the pool of assimilated data (most importantly, glider sections of temperature and salinity, NANOOS mooring time series data, satellite microwave radiometry, etc.), to further improve quality of the forecasts and to extend the user base.

Publications acknowledging NANOOS support:

Koch, A. O., A. L. Kurapov, and J. S. Allen, 2010: Near-surface dynamics of a separated jet in the coastal transition zone off Oregon, J. Geophys. Res., 115, C08020, doi:10.1029/2009JC005704.

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., 116, C05006, doi:10.1029/2010JC006909

Osborne, J., A. Kurapov, G. Egbert, and P. M. Kosro, 2011: Modeling intermittency and energetics of the M2 internal tide on the Oregon shelf, J. Phys. Oceanogr., 41, 2037–2062.

Yu, P., A. L. Kurapov, G. D. Egbert, J. S. Allen, P. M. Kosro, 2012: Variational assimilation of HF radar surface currents in a coastal ocean model off Oregon, Oc. Mod., in press.

Presentations acknowledging NANOOS support:

4th Coastal Altimetry Workshop, San Diego, CA, Oct. 2011

INVITED: The PICES Annual Meeting, Khabarovsk, Russia, Oct. 2011

INVITED: International Workshop of the GODAE/OceanView Coastal and Shelf Seas Task Team, Miami, FL, Jan. 2012

Ocean Sciences Meeting, Salt Lake City, UT, February 2012

NOAA Satellite Science Week, Kansas City, MO, May 2012

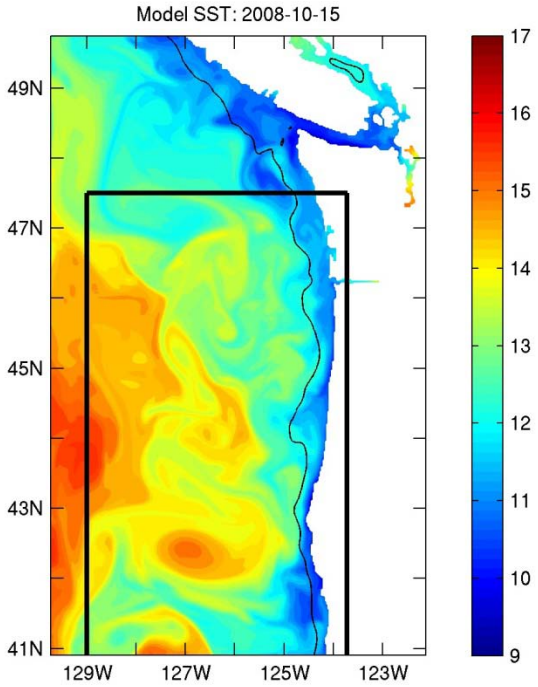

Figure 7. The extended model domain includes both Oregon and Washington coasts. Shown is model SST, October 15, 2008 (preliminary hindcast runs). The black contour is the 200-m isobath. The box shows the extent of the present real-time forecast model. [courtesy P. Yu]

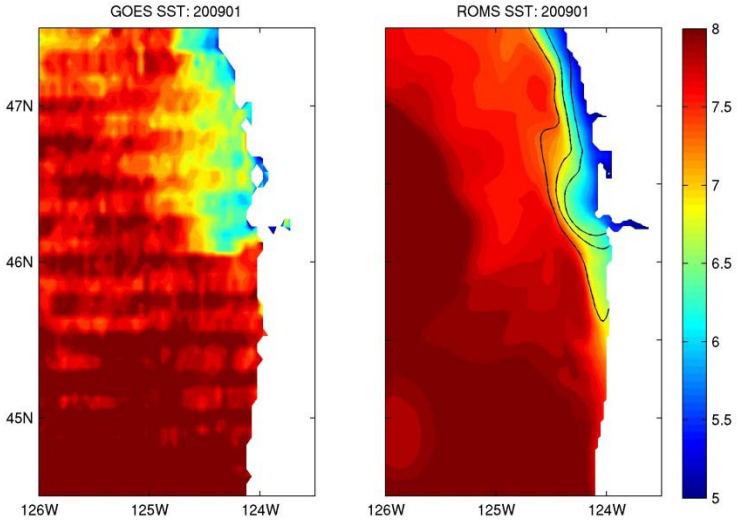

Figure 8. Temperature contrast associated with the Columbia River discharge in winter is seen in the monthly averaged SST (^{o}C), reproduced qualitatively in our new model: (left) GOES geostationary satellite composite, (right) model. SST is shown as color; black contours are model sea surface salinity (28, 30, and 32 psu) showing the location of the river plume. [courtesy P. Yu]

- **Estuaries**

1. Puget Sound: Overseen by D. Jones, APL-UW, the investigator had completed the use of NA10NOS4730018 funds prior to this reporting period. Progress for these elements of the sustained NANOOS RCOOS effort will be reported in our NA11NOS0120036 report.

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. Virtual Columbia River products include daily circulation forecasts, decade-long hindcast simulation databases, and scenario simulations (forecasts available through NANOOS NVS).

During the reporting period, we have continued 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 are being conducted in collaboration with the USGS and the Columbia River Intertribal Fish Commission, and in coordination with the CR Review Team (led by BPA and the Corps of Engineers).
(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 the Corps of Engineers.
(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) and DOGAMI

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

1. Managerial: Co-chaired by Steve Uczekaj (The Boeing Company) and Emilio Mayorga (APL-UW) this committee, composed of members from Boeing (R. Blair, S. Uczekaj), CMOP-OHSU (A. Jaramillo, C. Seaton), UW (E. Mayorga, T. Tanner), OSU (C. Risien), and DOGAMI (J. Allan), has weekly "tag-up" calls to achieve consistent work efforts for NANOOS DMAC. Activities for this period included: *1)* Weekly NANOOS DMAC and User Products Committee (UPC) joint telecon; *2)* Annual DMAC-UPC planning meeting (Dec.); *3)* IOOS Regional DMAC Implementation (RDI) monthly telecon; *4)* IOOS DMAC Steering Committee monthly telecon;

5) IOOS SOS Reference Implementation working group bi-weekly telecon and associated activities, including an IOOS-sponsored workshop (Feb.; Baltimore, MD); *6)* Project planning and launching of new IOOS-sponsored DMAC collaboration on animal acoustic tracking data with IOOS and the Pacific Ocean Shelf Tracking (POST) Project, including kick-off meeting (Mar.; Seattle, WA); *7)* Ocean Acidification Data Management Steering Committee participation, workshop (Mar.; Seattle, WA) and follow-up data-management discussions; *and 8)* West-coast collaboration with formation of new West-Coast Regional Data Framework, including initial planning workshop (Dec.; Oakland, CA). 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. The NANOOS Visualization System (NVS) was enhanced through an important new release (vers. 2.6, Nov. 2011) to the online platform, and the development of a new, customized application and mobile apps (iOS & Android) focused on tsunami hazards; see the UPC Section for details on user functionality and tsunami applications. NVS enhancements also encompass continuous asset additions and updates reflecting platform, sensor, telemetry and model reconfigurations, including: in-situ monitoring assets from a new near-real-time provider for NANOOS (Taylor Shellfish) and a new asset-inventory-mode provider (Whiskey Creek Shellfish Hatchery); and new deployments, new offerings and re-deployments from existing NVS providers (CMOP, OSU, UW, WADOE, King County, HCDOP, PSI, ICM-Mobilisa, LOBO/Wetlabs, VENUS, CDIP, NOAA NDBC, NERRS). NVS support for redistribution of information to external, regional applications – including mobile apps – continued to be enhanced. In particular, substantial progress was made in modifying the existing CMOP Data Explorer online application to consume NVS in-situ asset data in order to provide sophisticated Data Explorer functionality to users of NVS regional data; a working prototype is in operation and is undergoing testing. Finally, the NVS platform is poised to expand in capabilities and scope via a newly funded (National Science Foundation, NSF) collaboration between the APL-UW team and the NSF Critical Zones Observatories (CZO, http://criticalzone.org) Network's cyberinfrastructure program, focused on national integration of CZO site data.

3. Implementation of system architecture and IOOS DMAC data services and standards was advanced through regular participation in IOOS RDI telecons and software and system enhancements. NANOOS DMAC is a leading participant in the IOOS SOS Reference Implementation working-group and helped lead the IOOS-sponsored SOS Reference Implementation workshop in February (Feb.; Baltimore, MD), which resulted in substantial progress in the definition of important IOOS data services and metadata conventions. In coordination with the IOOS DMAC and IOOS Catalog teams, NANOOS released in mid November a new SOS service connected to the NVS data store and providing access to in-situ data from regional providers. This service has been fully integrated into the IOOS Catalog, seamlessly joining an existing NANOOS SOS service from CMOP that provided the original Python code base. Challenges uncovered in implementing and deploying this service provided valuable input to the IOOS SOS working group and helped move the IOOS DMAC community towards the adoption of several new service, asset and sensor metadata conventions.

4. Partnerships and efforts for DMAC expansion into relatively new areas: The DMAC team continued to advance efforts deemed of high priority to both IOOS and regional stakeholders:

1. *Biological Data*. NANOOS is co-leading a new IOOS-supported project addressing animal acoustic tracking data, in collaboration with IOOS and POST (http://postprogram.org); the project was launched on March 29 at a kick-off meeting in Seattle hosted by NANOOS, with local and remote attendance by partners from across the country and Canada. In addition, progress was made on a small-scale collaboration with OBIS-USA to publish on the OBIS-USA national node a NANOOS species occurrence dataset from the San Juan Islands.
2. *Ocean Acidification Data*. NANOOS DMAC played an important role in the ongoing, NOAA-led Ocean Acidification Data Management project, participating in its Steering Committee, a March workshop in Seattle (Mayorga, 2012), and follow-up data-management discussions; NANOOS DMAC has also supported the activities of the emerging California Current Acidification Network (C-CAN, http://c-can.msi.ucsb.edu), as well as related data dissemination and access needs of the regional shellfish aquaculture industry.
3. *West-Coast Coastal and Marine Geospatial Data*. In close partnership with the two other West Coast IOOS RA's (SCOOS and CeNCOOS), NANOOS has helped lead an West-coast-scale collaboration with the West Coast Governors Alliance (WCGA) and a partnership of federal, state, local, tribal, non-profit, academic and industry groups to enhance discovery, access, coordination and prioritization of important coastal and marine geospatial datasets. The RA's presented a common vision at the West-Coast Regional Data Framework (http://www.westcoastoceans.org/index.cfm?content.display&pageID=153) planning workshop in Dec. in Oakland, CA (Mayorga et al., 2011); NANOOS DMAC has supported follow-up activities, including coordination of the Information Technology working group.

Presentations acknowledging NANOOS support:

Mayorga, E. Ignite Talk: Complex Marine Data Visualization via GIS Web Services. *University of Washington GIS Day, Seattle, WA, Nov. 16, 2011.*

Mayorga, E., H. Kerkering and C. Cohen. IOOS West Coast Regional Experience and Capabilities. *West Coast Regional Data Framework Workshop, Oakland, CA, Dec. 13-14, 2011.*

Mayorga, E. IOOS National and Regional Components and Ocean Acidification Data. *Ocean Acidification Data Management Workshop, Seattle, WA, Mar. 13-15, 2012.*

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, synergy across the committees, and improvements to product development and enhancements. Activities for this Y4 period included: 1) multiple weekly NANOOS DMAC and UPC teleconferences; 2) annual meetings of a core subgroup of NANOOS DMAC-UPC-WEB staff; and, 3) annual meetings of the full NANOOS DMAC-UPC-WEB-E&O Tri-committee members.

2. Purpose of Committee:

The core focus of the NANOOS UPC is to guide the conceptual development of the data/analysis products (i.e. observations, time series, models, applications, etc.) identified by NANOOS stakeholders, and develop the appropriate graphical formats and lines of communications for product dissemination. Critical to this process has been the recognition that the UPC works closely with

other NANOOS committees, most importantly the DMAC and Education/Outreach teams to ensure product concepts are effectively developed and tested prior to their release.

3. Achievements:

Website: NANOOS continues to maintain, refine and update content on the web site. Currently, NANOOS provides links to 42 products, of which 21 are custom built to meet the needs of NANOOS stakeholders. Several of these products are discussed in more detail below. Figure 9 provides a time history of web traffic for the complete NANOOS web site. Of significance is the progressive increase in daily visits to the NANOOS web site over time, emphasizing the increasing use of NANOOS related data and products by Pacific Northwest stakeholders.

NVS: The backbone of the NANOOS RCOOS is the NANOOS Visualization System[5] (NVS) that currently distributes data from a myriad of regional and federal assets. While, it is recognized that a single visualization tool is unable to meet all user needs throughout the NANOOS region, such a tool can still provide the necessary framework on which additional applications[6] are based and subsequently developed that meet specific user needs. It is this latter approach, which now forms the basis for future enhancements to application development within the NVS platform.

During Y4, NVS underwent two minor updates and one major enhancement. Version 2.01 (released 23 September, 2010) and version 2.05 (8 November, 2010) reflected relatively minor improvements while version 2.5 released on March 30, 2011 was more substantial. Version 2.01 included a new products section, which highlights several web applications developed for specific stakeholder groups. In addition, NANOOS purchased a new tile server to provide greater functionality and stability for the dissemination of overlays within NVS. Version 2.05 provided additional overlay capabilities.

Version 2.5 added several new functions including the ability to establish a myNANOOS account, allowing users to both customize and save various NVS settings. These specifications included the ability to switch between common (U.S.) and scientific (metric) units. In addition, users are now able to toggle figure plot ranges, which may vary between global (default; all plots use the same range) and local (optimized for each asset) y-axis ranges.

[5] http://www.nanoos.org/nvs/nvs.php?section=NVS-Assets

[6] NVS Web Applications

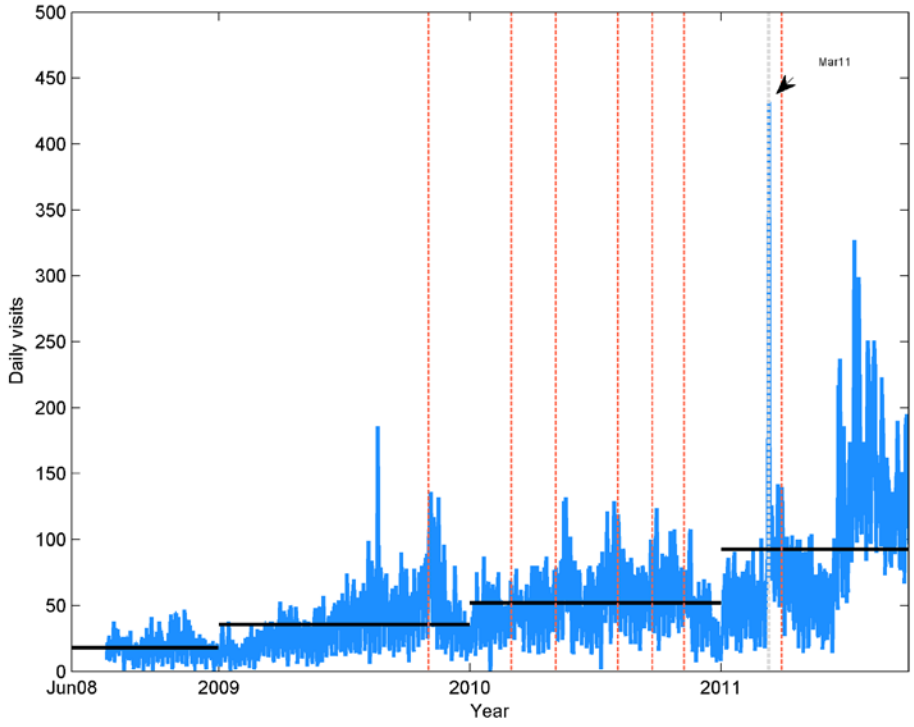

Figure 9: *Time history of NANOOS web traffic (daily visits) for the period June 2008 to September 2011.Solid black lines denote the annual mean daily visits while the red dashed lines indicate periods when web enhancements were introduced. Note the spike in web traffic on March 11, 2011 due to occurrence of the magnitude 9 earthquake in Japan, which initiated a tsunami warning the NANOOS region.*

Oregon Coast Tsunami Hazards portal: Many communities located in exposed, low-lying areas along the PNW coasts of Oregon, Washington, and northern California face the risk of tsunami inundation. The hazard originates from two main sources: distant tsunamis (e.g., Tōhoku, Japan, on March 11, 2011) that cross the expanse of the Pacific Ocean, and local tsunamis spawned by a great subduction earthquake on the CSZ and accompanying giant tsunamis. Of these, local Cascadia tsunamis pose the greatest hazard to people living along the PNW coast. To reduce the risk associated with such events, the Oregon Department of Geology and Mineral Industries (DOGAMI) and the Washington Department of Natural Resources (WADNR) began developing tsunami evacuation zones for their respective coastlines. These first generation maps were completed in the mid 1990s. Considerable outreach was performed at the time, and continues to this day, involving the provision of tsunami evacuation maps, community presentations, tsunami evacuation drills, and local community efforts.

In June 2009, NANOOS released its first generation tsunami evacuation portal, which contained overlay information documenting inundation zones for the Oregon coast. An updated version of the tsunami inundation zones were later released in February 2011, the product of new mapping that is being carried out by DOGAMI. This particular release occurred on February 23, 2011 and now included two evacuation zones for selected portions of the Oregon coast, while the bulk of

the coast still contained only one inundation zone. For example, from Bandon to OR/CA border and Cannon Beach on the northern Oregon coast, two inundation zones are depicted that reflect the estimated maximum extent of inundation for a LOCAL Cascadia tsunami (yellow zone) and a DISTANT tsunami (orange zone). These enhancements reflected the inclusion of new model results that were being performed by DOGAMI, in partnership with researchers from CMOP, OSU, and the Canadian Geological Survey. It is of interest that with the occurrence of the March 11 Japan earthquake and tsunami, NANOOS witnessed a significant spike in web traffic as people sought critical information on the likely impact that such a tsunami might have (Figure 9).

Mobile Applications: Work commenced in Y4 on the development of a brand new Pacific Northwest Tsunami Evacuation web-based and mobile application[7]. The purpose of this effort was to enhance the existing web portal bringing it more in line with the NVS platform, enhancing it with overlay data from Washington State, and providing links to the West Coast Alaska Tsunami Warning Center. This work was completed early in NANOOS Y5.

Presentations acknowledging NANOOS support:

Martin, D. L., Allan, J. C., Newton, J., Jones, D. W., Mikulak, S., Mayorga, E., Tanner, T., Lederer, N., Sprenger, A., Blair, R., and Uczekaj, S. A., Using Web-based and social networking technologies to disseminate coastal hazard mitigation information within the Pacific Northwest component of the Integrated Ocean Observing System (IOOS), in Proceedings Oceans'11, Oceans of Opportunity: International cooperation and partnership across the Pacific, Kona, Hawaii, 2011, p. 10.

e) Education and Outreach

1. Managerial: The Education and Outreach Committee, chaired by Nancee Hunter (Oregon Sea Grant), was sustained during the reporting period, with membership unchanged since previously reported. The NANOOS E&O committee continued monthly conference calls through 2011, but in 2012 changed the frequency to every other month.

NANOOS E&O staff, A. Sprenger, returned from maternity leave in late October 2011, to work at 0.5 FTE on NANOOS E&O efforts. NANOOS staff S. Mikulak is continuing to work at 1.0 FTE on NANOOS efforts. Mikulak is an active member of the NANOOS User Products Committee (UPC) and, along with Sprenger and Newton, participates in weekly DMAC/UPC conference calls.

A. Sprenger and S. Mikulak continued their participation in IOOS-NFRA E&O monthly calls. Mikulak is a member of the sub-committee for the IOOS video project and has been providing input and guidance in the development process.

2. Summary of Education Accomplishments:

Education and outreach efforts in the past six months have focused on supporting the continued development of the NANOOS Visualization System, NANOOS mobile apps and the redesign of the NANOOS tsunami web 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.

[7] http://www.nanoos.org/nvs/nvs.php?section=NVS-Products-Tsunamis-Evacuation

In December 2011 NANOOS partnered with Washington Sea Grant, Northwest Aquatic and Marine Educators and COSEE Ocean Learning Communities to exhibit "Marine Education Opportunities in the Pacific Northwest" at the joint WA Science Teachers Association/regional National Science Teachers Association (NSTA) conference held in Seattle. The conference was attended by over 500 educators, with over 150 educators visiting our exhibit.

Mikulak's Hatfield Marine Science Center (HMSC) exhibit that was partially funded by NANOOS is now included in a supplemental DVD for Ocean Gazing podcasts. The podcast producer, Ari Daniel Shapiro, had previously created a podcast about WET Labs, Inc., a NANOOS member organization, and was creating a DVD of supplemental information for educators to use in their classrooms. Since the HMSC exhibit showcases data collected using WET Labs equipment, it is included in the DVD to supplement the podcast about WET Labs (http://coseenow.net/podcast/2012/04/free-ocean-gazing-dvd/).

Mikulak also assisted with the development of a Master's project that will expand on the previous work NANOOS has done with recreational tuna fishers. Ted Strub, a non-NANOOS funded scientist, works with NANOOS PI Alexander Kurapov at Oregon State University to provide and enhance regional ocean forecasts. These forecasts have been tailored specifically for the recreational tuna fishing community in Oregon, and Strub is interested in providing similar tailored products for other recreational and commercial fishing communities. Because of Mikulak's involvement with the tuna fishing community, she was involved in developing a project for a Master's student in OSU's Marine Resource Management program to complete this work.

In March 2012 Sprenger was invited to present on NANOOS, focusing on efforts in Puget Sound, at the Puget Sound Education Summit, a one-day professional development workshop for formal K12 educators organized by the Puget Sound Partnership. Sprenger's session was attended by 30 educators.

Newton and Sprenger were invited to discuss NANOOS during the March 2012 monthly conference call of the Ocean Awareness and Literacy Action Coordination Team for the West Coast Governors Alliance on Ocean Health.

3. Summary of Outreach Accomplishments:

Regionally, NANOOS outreach efforts to reach different user groups including fishers, coastal community residents, scientists, and shellfish growers. Major events included: the Salish Sea Ecosystem Conference in Vancouver, B.C., Canada; the Heceta Head Conference in Florence, OR; the National Shellfish Association Conference in Seattle, WA, Pacific Science Center's Paws on Science Weekend in Seattle, WA and the Saltwater Sportsmen's Show in Salem, OR.

At the Salish Sea Ecosystem Conference, along with science talks by Newton, Mikulak and Sprenger staffed a booth at the conference's "Data Fair of Web-based Ecosystem Tools" on Oct 26, 2011. The Data Fair was a special opportunity for conference attendees to view, test, and explore resources related to data collection, handling and sharing, mapping, and modeling from governmental, academic, and nonprofit organizations in the Salish Sea area. Since this was an international conference, we were able to highlight the partnerships and data streams that NANOOS has with Environment Canada and the VENUS program at the University of Victoria.

Sprenger also presented the poster “Ocean observing data and products for informal and formal education and outreach” in the education session of the conference.

Mikulak hosted a table at the 2012 Heceta Head Conference on Oct 29, 2011. This small, local conference is largely attended by Oregon coastal community members and local and state officials and policy-makers. This is the second year Mikulak has attended and tabled at this event, and several speakers at the event mentioned the value of NANOOS and other ocean observing efforts.

Newton was appointed to the Olympic Coast National Marine Sanctuary Advisory Council in the Research Chair in January 2012, and to the Washington Governor’s Blue Ribbon Panel on Ocean Acidification in February, 2012.

NANOOS held a major workshop "Pacific Northwest Waters: Gateway to our Future" on 2-3 February, 2012, hosted at Microsoft Research. This workshop was part of a national series conducted regionally through assistance of the IOOC (Interagency Ocean Observation Committee), established by Congress in 2009 as part of the Integrated Coastal Ocean Observing Act. This workshop was a huge success, with an attendance of ~150 on day 1 and ~45 on day 2 and a high degree of participant interaction. Its success was hailed on the IOOS website: http://www.ioos.gov/ioos_in_action/stories/industry_workshop_feb2012.html which includes more details, video links to major presentations, and the workshop agenda and materials. Sprenger tabled for the workshop, supplying NANOOS MOAs, brochures, and newsletters.

NANOOS continued outreach efforts with recreational tuna fishers at the annual Saltwater Sportsmen’s Show Mar 31-Apr 1, 2012. There were 600 people in attendance, and Mikulak interacted with over 250 attendees. The additions to the tailored product page from last year, including a point-and-click function to get lat/long coordinates on the data plots and an FAQ list, were well received and many fishers who used our page during the last fishing season indicated the value of the product we provide. Fishers were also excited about using the NVS mobile app on their iPhones to access the data and forecast plots we provide on the web.

NANOOS partnered with AOOS, CeNCOOS, and SCCOOS to host a table at the National Shellfish Association Conference held in Seattle, WA, March 24-28, 2012. Each RA contributed outreach materials and informational sheets tailored to shellfish growers and resource managers in their respective regions. Newton and Sprenger staffed the table and fielded inquiries, and demonstrated RA websites. We held longer conversations with over 25 attendees.

The Pacific Science Center hosted “Paws on Science”- a weekend focused on research efforts at the University of Washington March 31-April 1 2012. Sprenger, Newton, D. Hannafious, and C. Bassin with the help of Alison Fundis and Liza Ray from UW’s OOI program offered a booth “Ocean observing in the Pacific Northwest” during the three-day event. Visitors built model observing buoys, gathered temperature and salinity data from a model Puget Sound, constructed water column profiles and had the opportunity to look at the NANOOS Visualization System and OOI videos. Over 400 people visited the Pacific Science Center each day, and it seemed most visited our booth as it was very busy the entire time.

New NANOOS outreach materials created this reporting session include the Winter 2012 NANOOS Observer (http://nanoos.org/documents/key/NANOOS_Observer_Winter_2012.pdf) and one-page handouts that are tailored for targeted end-user groups and feature specific NANOOS data products relevant to that group.

NANOOS was invited to contribute two articles that were published in the Council of American Master Mariners' magazine "Sidelights." The first was on IOOS and NANOOS; the second on tsunami hazard information via IOOS (http://www.mastermariner.org/sidelights/archives.html).

In addition to printed outreach materials, Mikulak created a video series providing a tour of the newly updated NANOOS Tsunami Evacuation Zone Portal (http://www.youtube.com/playlist?list=PL324845DBA5FBBFC8). These four videos provide a quick orientation to the features and functions of the portal, as well as how to interpret the map and data.

Presentations acknowledging NANOOS support:

Mikulak, S. et al. Data and data products available via the NANOOS Visualization System (NVS). *Salish Sea Ecosystem Conference 2011*, Vancouver, BC, Canada, October 25-27, 2011.

Sprenger, A. Ocean observing data and products for informal and formal education and outreach. *Salish Sea Ecosystem Conference 2011*, Vancouver, BC, Canada, October 25-27, 2011.

Johnston, R., J. Newton, J. Gaydos, B. Labiosa, P. Levin, S. Redman, J. Becker, N. Hamel, K. Dzinbal, R. Duff. Indicators, targets, and monitoring: Developing a dashboard of vital signs for ecosystem recovery. *Salish Sea Ecosystem Conference 2011*, Vancouver, BC, Canada, October 25-27, 2011.

Newton, J. West coast ocean acidification information and data needs and an inventory of observing assets. *California Current Acidification Network Workshop*, Palo Alto, CA, December 13-14, 2012.

Martin, D. Why We Are Here. *Pacific Northwest Waters: Gateway to our Future Workshop*, Redmond, WA, February 2-3, 2012.

Newton, J. Delivering Observations in the Northwest Region. *Pacific Northwest Waters: Gateway to our Future Workshop*, Redmond, WA, February 2-3, 2012.

Allan, J. Communication through the NANOOS Visualization System. *Pacific Northwest Waters: Gateway to our Future Workshop*, Redmond, WA, February 2-3, 2012.

Newton, J. A. and D.L. Martin. NANOOS: Serving the Pacific Northwest. *Ocean Sciences Meeting*, Salt Lake City, UT, February 21, 2012.

Newton, J. and E. Mayorga. The Northwest Association of Networked Ocean Observing Systems (NANOOS): Exploring contributions to weather services. *Pacific Northwest Weather Workshop 2012*, March 2-3, 2012.

Sprenger, A. Ocean observing data and resources for Puget Sound educators. *Puget Sound Education Summit*, March 15, 2012 Coupeville, WA.

Newton, J. The Northwest Association of Networked Ocean Observing Systems (NANOOS): Exploring contributions to Public Health. *Chesapeake Bay and Puget Sound Health Workshop*, March 21-22, 2012.

Publications acknowledging NANOOS support:

Newton, J. 2011. News from the U.S. Integrated Ocean Observing System (U.S. IOOS®) and Northwest Association of Networked Ocean Observing Systems (NANOOS). *Sidelights*, The Council of American Master Mariners, Inc., December, 2011.

Newton, J. and D. Martin. 2011. Tsunami Hazard Information through the Integrated Ocean Observing System (IOOS): How NANOOS is employing web-based, social networking and mobile application technologies in the Pacific Northwest. *Sidelights*, The Council of American Master Mariners, Inc., February, 2011.

4) Issues (NONE)

5) Key Personnel Changes (NONE)

6) Budget Analysis

NA10NOS4730018: NANOOS RCOOS Y4
This effort had an initial completion date of 9/30/2011 but we requested and obtained a no-cost extension through 9/30/2012 to ensure prudent expenditure of funds as we were conservative in our expenditure plan to minimize the possibility of needing to cease effort or remove assets from service if federal budget processes were delayed. Accordingly, we have effectively committed or obligated effectively 100% or our authorized funding and are modifying subcontracts and monitoring efforts to ensure necessary NANOOS activities (including subcontractors) and associated burn rates. We anticipate this will allow completion of this effort by approximately 6/30/2012, well ahead of the 9/30/2012 end date.