Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS®:
NOAA Award: NA11NOS0120036 Reporting period: 12/01/2013 to 5/31/2014

1) Project Summary

Our overall project goal is to sustain the Northwest Association of Networked Ocean Observing Systems, NANOOS, as the Regional Coastal Ocean Observing System for the U.S. Pacific Northwest that serves regional stakeholders in alignment with the vision of U.S. Integrated Ocean Observing System (IOOS®). NANOOS, with its essential subcomponents (integrated in-water and land-based Observing Systems, Data Management and Communications, Modeling and Analysis, and Education and Outreach) that are closely integrated within the national IOOS® system, provides significant societal benefits across a wide spectrum of users including federal, tribal, state and local governments, marine industries, scientific researchers, Non-Governmental Organizations (NGOs), educators and the general public.

For this FY13 period (= Y3 of award; Y7 of NANOOS RCOOS operations) our specific objectives were to:
1) **Maintain NANOOS as the PNW IOOS Regional Association:** Sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement.
2) **Maintain surface current and wave mapping capability.** Maintain existing HF-radar foundational capability providing a portion of critical national capacity, and continue investment in wave mapping at a critical port.
3) **Sustain existing buoys and gliders (with reduced glider deployment in WA) in the PNW coastal ocean, in coordination with national programs.** Maintain these essential assets providing regional observations, with focus on hypoxia, HABs, ocean acidification, climate change detection and modeling input.
4) **Maintain observation capabilities in PNW estuaries, in coordination with local and regional programs.** Maintain these to aid sustainable resource management, water quality assessment and sub-regional climate change evaluation, with high priority new feeds.
5) **Maintain core elements of beach and shoreline observing programs.** Contribute to hazard mitigation by providing essential observations and decision support tools for coastal managers, planners and engineers, as resources allow.
6) **Maintain NANOOS' Data Management and Communications (DMAC) system for routine operational distribution of data and information.** Sustain the DMAC system NANOOS has built, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS.
7) **Contribute to a community of complementary numerical regional models.**
Contribute to the operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the EEZ in both OR and WA.
8) **Deliver existing user-defined products and services for PNW stakeholders.** Continue to provide meaningful and informative data products that will connect with user applications and serve society.
9) **Sustain NANOOS education and outreach efforts.** Foster ocean literacy and facilitate use of NANOOS products for IOOS objectives, the core task for which the entire NANOOS RCOOS is constructed, via existing approaches for engaging users.

Consistent with the new tasks outlined in our FY13 de-scope letter from the IOOS Program Office, NANOOS has the following additional tasks during FY13, with our progress/status noted in brackets:
10) Enhance our level of HF radar operation and maintenance for existing stations in Oregon, consistent with the IOOS Program Office and HF Radar Plan directives [ongoing, M. Kosro, OSU, see p. 12];
11) Support post IOOS Summit activities [met, J. Newton];
12) Continue IOOS DMAC support in data access services (SOS encoding templates), systems engineering (DMAC implementation guidance), and vocabularies, with the IOOS Program Office [ongoing, Mayorga];

13) Support the Eye on Earth project, with the IOOS Program Office [met, E. Mayorga];
14) Support collection of OA measurements on our La Push and NH-10 moorings, working with NOAA PMEL and the NOAA OA Program Office through the IOOS Program Office [ongoing, J. Newton, M. Alford, J. Mickett, UW, see p. 4];
15) Implement portions of the Marine Sensor Innovation project, with guidance from the IOOS Program Office [ongoing, B. Hales, J. Mickett, E. Mayorga, and J. Newton et al., see p. 13-18].

2) Progress and Accomplishments

During the project period, NANOOS accomplished or made substantial progress on all 15 of the objectives outlined above. NANOOS maintained the RCOOS subsystems it has developed, implemented, and integrated with NOAA IOOS funding and substantial external leverage. NANOOS remained focused on delivering data-based products and services that are easy to use to diverse stakeholders to address high-priority issues and aid decision-making. NANOOS continued its proactive interactions and regional coordination with a wide range of PNW stakeholders, to prioritize and refine our observations, products, and outreach efforts as funding allows.

NANOOS milestones for this award are provided in Table 1. Our assessment is that NANOOS has met these milestones for the reporting period. We report here progress for following: a) observing systems (shelf, estuaries, shorelines, and currents); b) modeling (estuaries and shelves); c) Data management and Communications (DMAC); d) User Products; e) Education and Outreach; and, f) Administrative.

Table 1. NANOOS Milestones for FY 13*:

Area	**Y3 Award = Y7 NANOOS**
Observations	
Shelf:	-Maintain La Push, Newport, and Columbia R. buoys and deliver NRT datastreams via the NANOOS Visualization System (NVS) (on-going) -Support collection of OA data from La Push buoy and NH-10 buoys (on-going) -Maintain WA and OR glider transects (except funds are insufficient for maintaining La Push, WA glider) and deliver these datastreams via the NVS (on-going) -Transition Newport, OR glider to Crescent City, CA, if the NSF-funded OOI Newport glider is on-line. (Depends on OOI schedule, *see p. 4 for update*)
Estuaries:	-Maintain Puget Sound, Columbia R., Willapa and South Slough moorings and deliver these datastreams via the NVS (on-going; Willapa terminated during this period, see p. 7)
Shorelines:	-Maintain shoreline observations in WA and OR and deliver these datastreams via the NVS (on-going)
Currents:	-Maintain OR HF radar sites and X-band radar site and deliver these datastreams via the NVS (on-going) -Maintain OR Priority-One HF surface current mapping radar sites to the national operations standard, deliver the data via NVS and the National HF Radar system (on-going)
Modeling	
OR/WA estuaries and coast models	-Maintain modeling & forecasting capabilities at OSU, OHSU, & UW at reduced level and make model output available via the NANOOS web (on-going) -Transition Salish Sea model to operations, *see p. 19 for update*
DMAC	
Web Site Improvement	-Enhance NANOOS help section (done) -Expand observational data searching and data downloading (done)

Tailored Product Development	-Focus on Ecosystems and Climate change (OA), as resources permit, to produce a new product for posting on a NANOOS web "theme page". (on-going and being coordinated with other RAs) -Work with IOOS DMAC to support data access services, systems engineering, and vocabularies (on-going) -Work with IOOS Office to support "Eye on Earth" Project (done)
Education and Outreach	
Networking	Maintain existing and build new relationships with NANOOS priority area users and the education community (on-going)
Product Development	Work with DMAC, User Products Committee on Tailored Product Development, as per above schedule, and in Tri-Committee meetings (on-going)
User Engagement	Conduct trainings to select user groups as resources permit (on-going)
Administration	
Meetings	Represent NANOOS at all NOAA IOOS, NFRA, and national meetings of significance (e.g., MTS/IEEE, Ocean Sciences) (met and on-going) -Support post IOOS Summit activities (done) -Support Marine Sensor Innovation (see Table 2)
Project oversight	Conduct regular PI meetings, annual Tri-Committee meeting, and assist with evaluations, as scheduled (met and on-going)
Coordination	Conduct annual Governing Council (GC) meeting (met and on-going) Conduct sub-regional, and user-group specific workshops (e.g., for CMSP; ocean acidification, etc) as resources allow (on-going) Coordinate with West Coast RAs and other RAs to optimize and leverage capabilities and assure consistencies, but with no travel and at reduced level (on-going)
Accountability	Submit required IOOS progress reports, assessments, and performance metrics and seek certification as a member of US IOOS once certification standards and processes are determined (met and on-going)

*Our work for the Marine Sensor Innovation (MSI) activities is reported in Table 2, later in the report.

a) NANOOS Observing Sub-system: Data from all assets reported here are served via NANOOS NVS. We note the National Science Foundation's (NSF's) Ocean Observing Initiative (OOI) plans for gliders and buoys within the NANOOS region. In this report, we mention these additions and how NANOOS's observing effort is adapting to design an optimal and integrated observing system for the region.

- ***Shelf***

Washington Shelf Buoy:

Led by M. Alford and J. Mickett, Applied Physics Laboratory, University of Washington (APL-UW), over this period NANOOS funding was used primarily for field operations and costs related to maintenance of the Cha'Ba surface and NEMO subsurface mooring components of this array. Both moorings were recovered in early May 2014 from a vessel of opportunity, the R/V Norseman II, which was en-route to Seattle from Long Beach. Having been deployed since October 2013, this was the first winter deployment of both moorings. Though this deployment prompted some minor modifications to the mooring design, in general the design showed that it could successfully withstand the harsh conditions of winter on the Washington Shelf. Data coverage for both moorings was relatively good despite power issues with Cha'Ba early in the deployment. Both moorings were serviced throughout May in preparation for a late-June planned deployment from APL's R/V Robertson.

In March J. Mickett and J. Newton attended the Puget Sound Ecosystem Monitoring Program (PSEMP) Marine Waters Workshop, with J. Mickett presenting observations from the Washington Shelf moorings for 2013, highlighting several low-dissolved oxygen events and anomalously warm near-surface water in late summer. Both Mickett and Newton submitted an article summarizing these observations to the 2013 Overview of Puget Sound Marine Waters publication.

In May, PIs Mickett and Newton received news that an IOOS proposal submitted to deploy a real-time Environmental Sample Processor (ESP) on the subsurface mooring was selected to be funded, with field-testing of the system in Puget Sound in 2014 and deployment offshore starting in the spring of 2015.

J. Newton (APL-UW) and this group have continued to work with NOAA PMEL scientists, Drs. Jeremy Mathis, Adrienne Sutton, Simone Alin, and Richard Feely, to maintain pCO_2 and pH datastreams and provide calibration samples, with C. Peacock of the PMEL OA Lab attending the September 2013 cruise. Sensor data have been transmitted to the NOAA OA and PMEL Carbon Programs and to NANOOS.

During this period we also collaborated with graduate student S. Bushinsky of UW Oceanography (advisor Dr. S. Emerson) through an NSF funded IGERT program to continue the deployment of a prototype self-calibrating DO measurement system on Cha'Ba. As extended offshore tests were critical to development of this system, Cha'Ba provided a perfect platform for this work.

Washington Shelf Glider: The Applied Physics Laboratory, University of Washington, Integrative Observational Platforms group led by C. Lee (APL-UW) operated Seaglider 108 from September 2013 through February 2014, completing 764 dives over a 5-month mission, for a total of 13 cross-shelf sections. NANOOS funds are insufficient for sustained glider operations off the Washington coast, but the team is working to execute one mission per year on the existing support. The next mission is scheduled for deployment in the second half of June, 2014.

Oregon Shelf Glider: During November 2013 to May 2014, the Oregon State University glider group led by J. Barth and K. Shearman conducted sampling using underwater gliders off Newport, Oregon. The Newport Hydrographic (NH) Line was sampled during March and April, 2014, using a 1000-m Seaglider on the offshore part of the line. We collected a total of 33 glider-days of measurements along 673 km of track. This included 438 vertical profiles and 2 cross-margin vertical sections. The central Oregon glider data are being shared with NANOOS modeler Alexander Kurapov to 1) investigate the influence of the Columbia River plume on upwelling off central Oregon (Kurapov et al., 2013) and 2) to incorporate glider data into the data-assimilative modeling forecast system for the NANOOS region.

The transition of glider operations on the Newport Line to being funded by NSF's Ocean Observatories Initiative (OOI) is anticipated to occur in summer 2014. Starting in March 2014, PI Barth began collaboration with Dr. Eric Bjorkstedt (NOAA Southwest Fisheries Science Center, Humboldt State University) to plan glider observations off Trinidad Head, CA (41° 3.5'N). We plan to deploy a 1000-m Seaglider off Trinidad Head, CA, starting in about July 2014 to complement Bjorkstedt's monthly hydrographic and zooplankton sampling, analogous to that being conducted by Bill Peterson's group along the NH line. This represents an excellent opportunity for collaboration between NANOOS and CeNCOOS and fills a gap in glider coverage along the U.S. west coast as identified in several California Current science plans. This transition is consistent with NANOOS' plan to expand the range once OOI assets were in.

NANOOS PI Barth co-organized and co-led a workshop on "Climate Variability and Change in the California Current Ecosystem 2," held during April 22-24, 2014, at the Scripps Institution of Oceanography and the NOAA Southwest Fisheries Science Center. The workshop's goal was to gather experts, including those involved in the three west coast regional IOOS associations, to help craft a long-term plan for research in the California Current Large Marine Ecosystem.

Oregon Shelf Mooring: Long led by M. Levine (OSU), and now by M. Kosro (OSU), a mooring about 10 miles off Newport, Oregon, in 80 m of water (site NH-10) has been maintained since mid-2006, primarily through support by NANOOS. Ship time to enable the mooring recoveries and deployments has been funded by the NSF CMOP Science & Technology Center. About every six months the mooring is recovered and a refurbished mooring is deployed.

In April 2014 on a cruise of the R/V Oceanus the wintertime mooring (subsurface only to improve reliability in harsh winter conditions) and attached instruments were recovered. The anchor had been rigged for recovery with a separate acoustic release, but the float did not surface during recovery or during subsequent visual checks, and the anchor and anchor release were lost. Ocean sensors measured temperature, salinity and water velocity at a number of depths. All data have been archived and are available.

On the same cruise, the summertime mooring(s) were deployed. Mooring locations were selected after consultation with NSF OOI, which will be deploying cabled moorings in the vicinity in September 2014. At 44° 38.59' N, 124° 18.17' W, the traditional physical oceanographic mooring was deployed with meteorological sensors at the surface and sensors for temperature, salinity, and velocity profiles, as well as dissolved oxygen and light transmission. A second mooring targeting CO_2 measurements was deployed nearby by Burke Hales' group, described in the MSI section of this report. Preparation is underway for the next deployment in late September 2014, with design aimed at a combined PO/CO_2 mooring.

Subsets of the data are available in real time via the NANOOS Visualization System and as buoy 46094 at the National Data Buoy Center (http://www.ndbc.noaa.gov/station_page.php?station=46094).

Northern Oregon to Central Washington shelf: Led by A. Baptista (OHSU), the Center for Coastal Margin Observation & Prediction (CMOP) maintains glider operations and two offshore buoys (SATURN-02 and OGI-01), with partial support from NANOOS. The operation and maintenance of the glider and SATURN-02 is also partially funded by the National Science Foundation.

Glider operations are seasonal (April-September) and are driven in part by collaboration with the Quinault Indian Nation, focused on characterizing shelf hypoxia for fisheries management. Since May 2009, we have had 425 days of glider operations. During the reporting period, no glider missions were conducted. The first mission for 2014 is planned for July/August).

SATURN-02 is a seasonal-configuration station, with its interdisciplinary configuration typically in May/Jun through Sep/Oct. For this reporting period, SATURN-02 was not deployed in interdisciplinary configuration, with the first deployment of the year anticipated in June. OGI-01 is deployed year-round in "winter configuration" (surface CT, no telemetry), as the deployment of an interdisciplinary suite of sensors–although highly desirable for modeling support–remains unfunded. Deployment of the buoy in minimal configuration satisfies USCG regulations.

Archival data from these 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[1].

- **Estuaries**

Puget Sound, ORCA Buoy program: Led by A. Devol, J. Newton, and J Mickett (UW), during this report period the ORCA (Oceanic Remote Chemical Analyzer) group had three buoys in operation in Hood Canal (Twanoh, Hoodsport, and Dabob Bay), one near Admiralty Inlet (Hansville), one in Puget Sound (Pt Wells), and one in south Puget Sound (Carr Inlet). There were periods of downtime at all the buoys at different times during the report period, mostly due to failure of aging components, worn winch parts, corroded cables and connectors, and sensor failure. Both the Pt. Wells and Hansville moorings were down for refurbishment during the report period. Despite the downtime, a total of 1541 profiles were collected from the buoy system during the report period. Significant progress was made towards redesign of the buoy system, as well as towards re-establishing the Pt. Wells and Hansville moorings and swapping out the aging hulls on 4 of the moorings. We anticipate profiles will resume at Pt. Wells and Hansville by the end of the summer.

We continued to make all buoy data available in real-time on the NANOOS website. Buoy maintenance is partially leveraged with Washington State Dept of Ecology and NSF funding. We continued to collaborate with NOAA PMEL (R. Feely) to support the deployment of the pCO2 systems operated on the Twanoh and Dabob Bay moorings through system maintenance and collection of water samples to aid system calibration. During spring the two moorings were upgraded with new hulls, via external federal funds (US IOOS at NOAA NOS grant to NANOOS), in order to facilitate mounting the pCO2 system into the hull, protecting and insulating the system to increase robustness and accuracy. The work for all the buoys has been leveraged by a grant to NANOOS; and in Dabob Bay a former grant from the State of Washington Puget Sound Partnership was leveraged to monitor surface water acidity and water column conditions as they might relate to hatchery failure.

Dissolved oxygen concentrations in southern Hood Canal were above normal for the first half of 2014, while temperature and salinity were lower than average. In contrast, dissolved oxygen concentrations, temperature and salinity were average at Carr Inlet in southern Puget Sound. We will again be closely monitoring dissolved oxygen conditions in southern Hood Canal through the growing season and into the fall bloom, a time when the potential for fill kills increases. These observations are important for State efforts to assess water quality and habitat.

During the report period we presented data to the Puget Sound Marine Waters Group at their synthesis meeting covering data from 2013; we also submitted data and analyses to their 2013 Year in Review document to be published later this year.

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 Unit supervisor) and led by C. Krembs (Senior Oceanographer). Due to budget cuts, Ecology continues to have only one mooring staff, a dedicated Field Technician (S. Pool), partially supported by NANOOS funds.

[1] http://www.stccmop.org/datamart/observation_network/dataexplorer

Ecology maintained its sole nearshore mooring station in Mukilteo (with near-surface and near-bottom sensors and daily telemetry of real-time data to Ecology's website and NANOOS NVS) in collaboration with Everett Community College and Port of Everett. In Puget Sound, we previously maintained moorings at Admiralty Reach, Mukilteo, Manchester, and Shannon Point with a focus on dissolved oxygen. The Admiralty Reach station remains suspended with plans to resume later in 2014. Budget cuts have required us to continue suspension of several stations with no immediate plans to resume: Manchester, Shannon Point, and Willapa Bay (however the USCG license to use the channel marker for the mooring was renewed for five years).

Ecology has begun a transition to using ferry vessels as an additional and cost-effective means of data collection. The advantage of the ferry en route monitoring approach is large surface spatial coverage that allows leveraging and calibrating of daily satellite products. Currently, Ecology has two sensors and a GPS on the Victoria Clipper IV ferry vessel that runs twice daily between Seattle and Victoria, BC. Variables are collected by sensors at 4 m depth and include temperature, salinity, in situ fluorescence, CDOM, and turbidity. The previous data collection system had been exposed to heat and fine oily dust since 2010, so frequently failed last year. During attempts to resurrect and upgrade the system, we were minimally successful in recording data from all sensors for only 12 days in this reporting period. The fluorometer was recently repaired and we are in the midst of upgrading data collection hardware with remote access. We are now leveraging some EPA NEP funds to resolve ongoing technical problems and restore data acquisition, data flow, and telemetry with help from APL UW.

The Mukilteo mooring observations from 1 Dec 13 to 31 May 14 began with a downward trend in temperature and salinity (Figure 1). In early spring, temperature and dissolved oxygen (DO) increased into April, after which DO declined. Skagit and Snohomish river flows in early March coincided with changes in salinity and DO. In latter half of March, a sensor issue or biofouling may have biased the salinity data, and thus, DO.

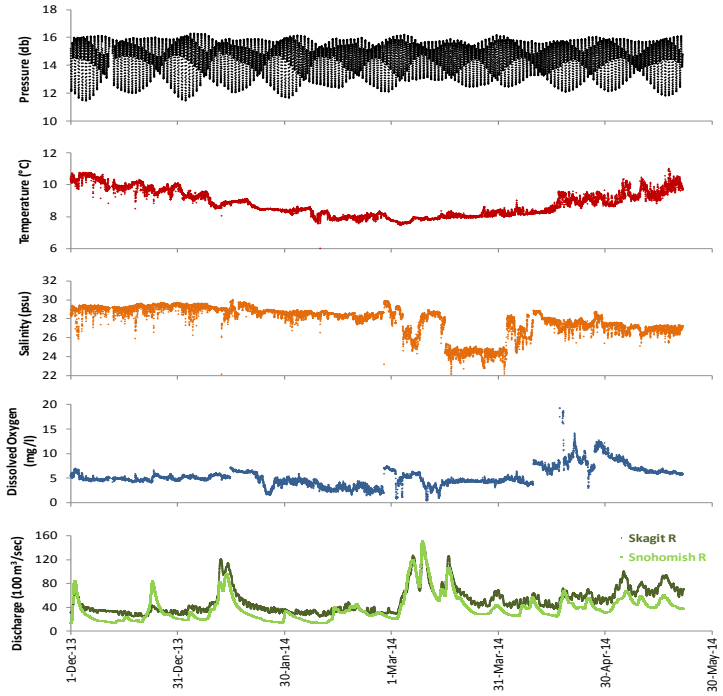


Figure 1
Time series of pressure, temperature, salinity, and dissolved oxygen from near-bottom mooring at the Mukilteo station (data are provisional). River discharge data are from USGS.

Columbia River estuarine monitoring: CMOP continued 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), which anchor CMOP's SATURN observation network. Also integral to SATURN, but not funded by NANOOS, are two freshwater stations: SATURN-06, maintained directly by the USGS, and SATURN-05, maintained by Dr. Joe Needoba with CMOP/NSF and regional stakeholder funding.

Of particular note during the reporting period, we continued to advance the characterization of ocean-induced estuarine hypoxia and acidification, and the role of local production in mitigating these deleterious ocean effects. Specifically:

• We now routinely observe dissolved oxygen (DO) from river to plume, and have since 2010 captured multiple events of severe estuarine hypoxia, some of which partially mitigated by local production (in the form of *M. rubrum* blooms). These and related findings on acidification (see below) are informing our thinking on the estuary as a bioreactor, including contemporary variability and change under the influence of global climate change. The findings have also informed regional recommendations to the State Department regarding the Columbia River Treaty Review.

• We are maintaining pH/pCO_2 sensors at three/two stations along the navigation channel of the estuary. These sensors are informing our characterization of estuarine hypoxia and acidification as coupled processes.

• We now maintain photosynthetically active radiation (PAR) sensors at SATURN-02 and (new this period) at Desdemona Sands, and an ACS (in situ spectrophotometer) sensor at SATURN-03 (new this period). The goal is to characterize local solar radiation and light attenuation, to provide context for observations of productivity in the lower estuary and to support an emerging suite of ecological models

• We maintain bottom nodes at three permanent stations (SATURN-01, SATURN-03 [new this year] and SATURN-04) and at a seasonal station in the North Channel (NCBN-1). Bottom nodes have Acoustic Doppler profilers and temperature/salinity, to better characterize (a) salt intrusion as a surrogate for the propagation of acidic/hypoxic ocean waters into the lower estuary, and (b) mechanisms of enhanced estuarine retention that might play a role in mitigating hypoxia/acidification through local production.

• We have now conducted several adaptive sampling experiments of microbial communities. The experiments involved the deployment of an Environmental Sampling Processor (for short periods) at SATURN-03, with automated sampling targeted by select aspects of the function of the estuarine bioreactor.

SATURN observations are used extensively in support (directly or via data-informed modeling) of regional management and decision making associated with Endangered Species Act (ESA) biological opinions, salmon restoration, navigation improvements and hydropower operations. These observations are also integral to the four signature CMOP science initiatives, which address estuarine hypoxia and acidification, plankton blooms, and the biogeochemistry of lateral bays and estuarine turbidity maxima.

Oregon South Slough: Participation by the Oregon Department of State Lands (ODSL) in NANOOS is led by A. Helms (Estuarine Monitoring Coordinator) and A. DeMarzo (Estuarine Monitoring Assistant) at the South Slough National Estuarine Research Reserve (SSNERR).

South Slough NERR continued operating a network of moored observing stations and a real-time weather station as part of the NERRS System-Wide Monitoring Program with additional support provided by NANOOS (Figure 2). The five water quality monitoring stations located along the estuarine salinity gradient provided continuous data over the period December 2013 – May 31, 2014. Four of the water stations and the weather station are equipped with telemetry systems.

In addition, we maintain one water quality station in partnership with one of our local tribes, the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). This station is located in Lower Coos Bay; the North Spit BLM (NESDID ID # 346F229A; sosnswq) and began transmitting data 6/6/13. The raw data is currently available through the Hydrometeorological Automated Data System (HADS), and should be available through NVS by late summer with help from Emilio Mayorga who is developing code to ingest this station from HADS. Working in partnership with the CTCLUSI tribes, we secured mounting infrastructure and the protective tube for the Boathouse station by diving at this site near the mouth of Coos Bay.

We have expanded the network of Coos Bay water quality stations to include four stations in Upper Coos Bay through the NERRS Science Collaborative Partnership for Coastal Watersheds project. These stations include North Point, Isthmus Slough, Catching Slough, and Coos River and were installed in the Fall 2013 (See station map below). With future funds, South Slough would prioritize adding real-time capability to the North Point station which is near commercial oyster cultivation areas in Mid Coos estuary and this station would also provide real-time water level data for Coos Bay Bar Pilots, who currently rely on staff tide gauges.

The water quality stations provide real-time data access for shellfish growers in South Slough and Coos Bay, including North Bend and Coos Bay Oyster Companies, Clausen Oysters, and Qualman Oyster Farms to monitor environmental conditions, and environmental data for eelgrass, fecal coliform monitoring and native oyster restoration projects. The weather station provides real-time data to assess the short-term effects of local weather on water quality within the estuary.

Figure 2. SSNERRS stations

- **Shorelines**

Washington Shorelines: NANOOS funds contribute to the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. In December 2013, CMAP conducted fall seasonal beach monitoring surveys in the Columbia River Littoral Cell (CRLC). In total, 46 profiles and two surface maps were collected. At the end of March through April 2014, CMAP completed winter CRLC seasonal monitoring surveys. During this survey, 46 seasonal profiles along with 11 additional profiles on the south side of the Columbia River East Jetty for the U.S. Army Corps of Engineers to augment the monitoring being done for the newly placed revetment. CMAP also collected 5 surface maps within the CRLC and 58 sediment samples from multiple cross-shore locations along 12 of the seasonal profiles. The wave bumpers and geotubes that protect condominiums along the primary dune at Ocean Shores are still a concern as they have continued to become increasingly exposed and several

photos were taken to document the change. Photos were also taken of profiles Worm and Spice in Grayland Plains where erosion is also of particular concern due to nearby development.

Also in April, CMAP worked with the USGS to collect 135 beach and nearshore profiles at the Elwha River mouth, with some additional nearshore profiles extending the routine survey area east toward Ediz Hook. A total of 150 km of nearshore bathymetric data and 130 km of topographic data were collected during the survey. Data compared to previous surveys show significant accumulation of sediment in the nearshore totaling 2.8 million m^3 of net deposition since the dam removals began in September 2011, including the development of multiple sand bars that have attached to the shore on the east side of the delta.

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). As part of DOGAMI's commitment to NANOOS, the OBSMAP network continues to be sustained, with surveys of beach observation sites having been undertaken in December 2013 and February 2014 (Rockaway cell (25 sites) and along the Clatsop Plains (6 sites)) and January and March 2014 (Neskowin cell (15 sites)). Data for the OBSMAP monitoring sites are available through the NANOOS Visualization System. Due to the current phase of mild weather conditions and a lack of significant storms in the past three years, many of the beach study sites exhibit a general trend toward accretion. Erosion issues that had plagued several sites in the past, are for now somewhat stable.

Over the past 6 months, PI Allan has moved to update the Neskowin beach profile database so that it is now fully standardized across all surveys (e.g. 2006 vs 2014 formats) and survey platforms (GPS vs lidar). Moving in this direction addresses some problems with our original Matlab processing code, with the updated version enabling the code to be simplified. The latter will also allow for easier extraction and exporting of the data to end users as needed. In addition to improvements in the database, we have continued to refine our Matlab code used to process the data and ultimately generate the plot outputs used in NVS. During this period, problems with aging infrastructure continued to occur. We continue to be plagued with ATV breakdowns (now 10 years old), often occurring in precarious locations out on the beach.

Data from the OBSMAP beach monitoring continues to be used by agencies such as the Oregon Parks and Recreation Department to help guide permitting for engineering structures, by local community groups in Neskowin and Rockaway to help guide their understanding of changes taking place along their beach. Finally, the combined beach observation dataset and bathymetric surveys of the nearshore in Lincoln, Tillamook and Clatsop Counties is being used to revise and field check recently complete FEMA coastal flood maps for the central to northern Oregon coast. In addition, beach morphology and shoreline change data from Tillamook County is being used to guide the development of new coastal erosion hazard maps that are being development for the entire length of the county coastline.

PI Allan helped run a Coastal Processes and Hazards Working Group meeting in Newport Oregon on May 7th at the Newport Community College. The purpose of this meeting is to bring a variety of folks together, such as from state agencies (e.g., ODOT, OPRD, ODFW, DLCD, and DSL), local Government (coastal planners), academia (OSU, Oregon Sea Grant), geotechnical consultants, and NGOs to discuss issues relating to coastal hazards along the Oregon coast. Finally, PI Allan presented to the Central Oregon Coast Board of Realtors as part of a Coastal Hazard Training Session for Realtors operating on the central Oregon coast. The material presented included information relating to a variety of NVS web

applications, including the Pacific Northwest Tsunami Evacuation Zones web app, and the Beach and Shoreline changes web app.

Nearshore Bathymetry: P. Ruggiero's group at Oregon State University completed processing nearshore bathymetry data along the four sub-cells of the Columbia River littoral cell (CRLC). Over 200 individual cross-shore profiles were collected during summer 2013 extending from the lower inter-tidal to ~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. These nearshore bathymetric data continue to provide a critical source of information for improving coastal hazard mitigation along the coastlines of the CRLC.

Ruggiero's group also completed the processing of nearshore bathymetric data within the Rockaway littoral cell in Oregon. Over 80 individual cross-shore beach profiles were processed from the lower intertidal to approximately 25 m of water depth (~1500 m from the shoreline). In addition, Ruggiero's group completed the processing of nearshore bathymetric data in Curry County in southern Oregon. Over 100 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. The combined beach/nearshore observation dataset now available for Curry County is being used to assess 1% (100-year) coastal flood and erosion risk along the county shorelines for the purposes of developing updated FEMA flood insurance rate maps.
These nearshore bathymetric data continue to provide a critical source of information for improving coastal hazard mitigation along the coastlines of the Pacific Northwest. During this reporting period, NANOOS funded nearshore bathymetric data has supported the US Army Corps' Regional Sediment Management at the Mouth of the Columbia River, FEMA flood mapping activities in Tillamook, Lincoln, and Curry Counties, Oregon, as well as basic research on coastal hazards, morphodynamics, and the impacts of climate change. In particular, NANOOS funded nearshore bathymetric data is being incorporated in a coastal hazards decision support tool supported by NOAA's Climate Program Office Coastal and Ocean Climate Applications (COCA) program.

- **Currents**

Coastal Currents: Surface current maps determined from an 11-site Seasonde array along the Pacific Northwest coast continue to be obtained hourly, and provided to the public through NANOOS NVS, and via the national network to NDBC, the USCG, and other agencies, led by M. Kosro (OSU).

We continue our collaboration with our modeling partners (Kurapov group) by providing data for assimilation, and by working together to understand results. Radial HF data were examined to verify earlier HF-informed model predictions of intensified diurnal tidal currents at the outer edge of Heceta Bank (Erofeeva et al., 2003), and to find additional and stronger intensified regions, notably in the vicinity of Cape Blanco (Osborne et. al, in press).

We are working with Kurapov, Shearman and collaborators to examine interannual variability in the winter circulation from high-resolution numerical models, in-situ glider and mooring data, and HF radar. We also continue our collaboration with Sung Yong Kim, and have a manuscript in revision for JGR.

Our AIS site at Cape Blanco was completed with installation of an antenna, and is providing vessel locations and identifications via Marine Traffic.com in this previously poorly sampled region of coast, to aid domain awareness.

Of concern is the program of offshore wind turbines for the Coos Bay area, which has recently seen accelerated progress toward funding, permitting and eventual leasing. Land-based wind turbines are known to interfere with measurements from land-based radars, and initial data from Europe and simulations from models indicate the likelihood of interference of offshore wind turbines with surface-current measurements by HF radar. We have alerted BOEM to our concerns regarding interference, via public comment, and they have recommended one mitigation study for their FY2015 Environmental Studies Plan. We have also alerted the Oregon Ocean Policy Advisory Counsel. Without mitigation, such interference could degrade our current measurements over regions of unknown extent, harming present use, which is particularly a concern in man-overboard scenarios.

The site at PSG (Crescent City) was brought back on-line in April 2014 after an extended outage due to multiple simultaneous hardware problems. LOO, the northernmost site, has been used as components to fill in at other sites during repairs. It requires an expensive repair for reinstallation, which will be possible with the coming supplemental funds for repairs and backups. We have augmented that supplement by successfully competing for $53K in equipment reserve funds from the OSU Research Office, using the IOOS supplement as leverage.

Port X-band Radar: The wave imaging radar at Newport South Jetty has continued to operate and provide imagery of the wave conditions and wave spectral information to the NANOOS Visualization System on an hourly basis. During the last period we have dealt with a few maintenance issues. We replaced motor brushes in December but lost a motor brush cap. We put in a temporary fix that occasionally had to be replaced until we acquired a replacement brush cap in April. In May the radar was taken offline due to vibration issues possibly caused by a bad rotor bearing. The vibration was causing problems for the co-located ODFW fishery cameras. As of June 1, we were awaiting arrival of a replacement part. The radar is expected to be back online by end of June. In the coming months we are also going to investigate whether moving the station to the Coast Guard tower (similar to our station at the MCR) would be feasible, as we believe it might be a much better spot.

We remain excited about the new radar installation at the Mouth of the Columbia River. We would like to consider adding that station as a regular NANOOS observational station, there is significant stakeholder interest in the Columbia River site. We have been working with the Columbia River Bar Pilots (Dan Jordan) to develop a “front-imaging” data product. These fronts indicate where there are sharp surface current gradients that can affect navigation. We are also sharing our data with a group (Donald Lyons et al.) in the Oregon Cooperative Fish and Wildlife Research Unit (Oregon State University) who are tracking cormorant behavior and their foraging around the fronts. An example of our front-imaging product can be viewed on YouTube at: https://www.youtube.com/watch?v=pblzkrqozUE&hd=1 and we have built our own webpage for the station at: http://research.engr.oregonstate.edu/haller/CapeD_radar.htm.

- ***NANOOS Marine Sensor Innovation project activity***

Table 2: Marine Sensor Innovation activities

Item	***Y3 Milestone***	***Partners***
Provide beta aragonite saturation state prototype monitoring equipment (pCO_2 and DIC) for testing at three shellfish hatchery locations (Alaska, Central CA, Southern CA)	Build equipment for use in three hatcheries	Work with AOOS, CeNCOOS, SCCOOS, and PMEL
Develop and apply state of art OA technologies in estuarine monitoring relevant to shellfish growers	Put surface pCO_2 on 2 buoys in Puget Sound (1 will likely be done via WA state funds) Put pH on profiler package at 1 of those buoys	UW to work with PMEL on QA/QC
Apply and test new OA technologies on deep water moorings	Put deep pH on La Push buoy Equip NH-10 buoy with PMEL surface OA sensors	UW to enhance La Push Cha'ba buoy in WA OSU to enhance Newport NH-10 buoy in OR
Provide data management for all OA data streams via an NVS-like product for West Coast	Accept data streams from all OA relevant assets here into new portal based on NVS technology	Work with AOOS, CeNCOOS, and SCCOOS

There are three NANOOS MSI project observing and one DMAC activities for FY13:
1. Testing of Beta aragonite saturation state prototype monitoring equipment currently being developed by Burke Hales at Oregon State University for use in shellfish operations.

B. Hales, OSU, lead: For this work, Hales and colleagues have been developing real-time full-suite carbonate measurement systems for deployment at facilities with flowing streams of seawater. To date, these systems have been built and deployed at OSU, OSU-HMSC, Whiskey Creek Shellfish Hatchery (WCSH; Netarts, OR), Taylor Shellfish Hatchery (Quilcene, WA), UC-Santa Barbara, USC Wrigley Marine Science Center. Funding for this project was targeted for deployment of these systems at three additional locations: Carlsbad Aquafarms (Carlsbad, CA); Hog Island Oyster Company (HIOC; Marshall, CA); and Alutiiq Pride Shellfish (Seward, AK). All three systems have been delivered. Systems for Carlsbad (23 June, 2014) and Alutiiq (12-15 August, 2014) will be installed by Hales with training for local personnel in coming weeks. The Hog Island system has been operational since late May, although operating in pCO_2-only mode as the local academic partners prepare the TCO_2 methodology and Hales resolves some valve-control communication issues.

A key part of the development was improvement of the operational software to provide real-time calibration and display of the full-suite of carbonate-chemistry parameters calculated from the primary pCO_2 and TCO_2 measurements. This was developed and tested at Whiskey Creek, and illustrated below (Figures MSI-1a and 1b). Note the extreme dynamic range in pCO_2 in this productive coastal estuary, with values ranging from < 60 µatm up to nearly 900 µatm over the course of a diel cycle (MSI-1a), driven by the large metabolically-driven changes in TCO_2. Of particular importance is the ability to calculate aragonite mineral saturation state (blue trace, Figure MSI-1b), which is not directly

measureable. This parameter varies by a factor of ~5 over the diel cycle. WCSH data is now being served live on the NANOOS data server.

Real-time data from HIOC is shown in Figure MSI-2. Although TCO_2 analyses are not currently operational, calculations are performed using real-time pCO_2 and a salinity-based alkalinity estimation. Note the relatively small dynamic range for this estuarine system, with little variability in T or S, and correspondingly lower dynamic range in pCO_2 and other calculated parameters.

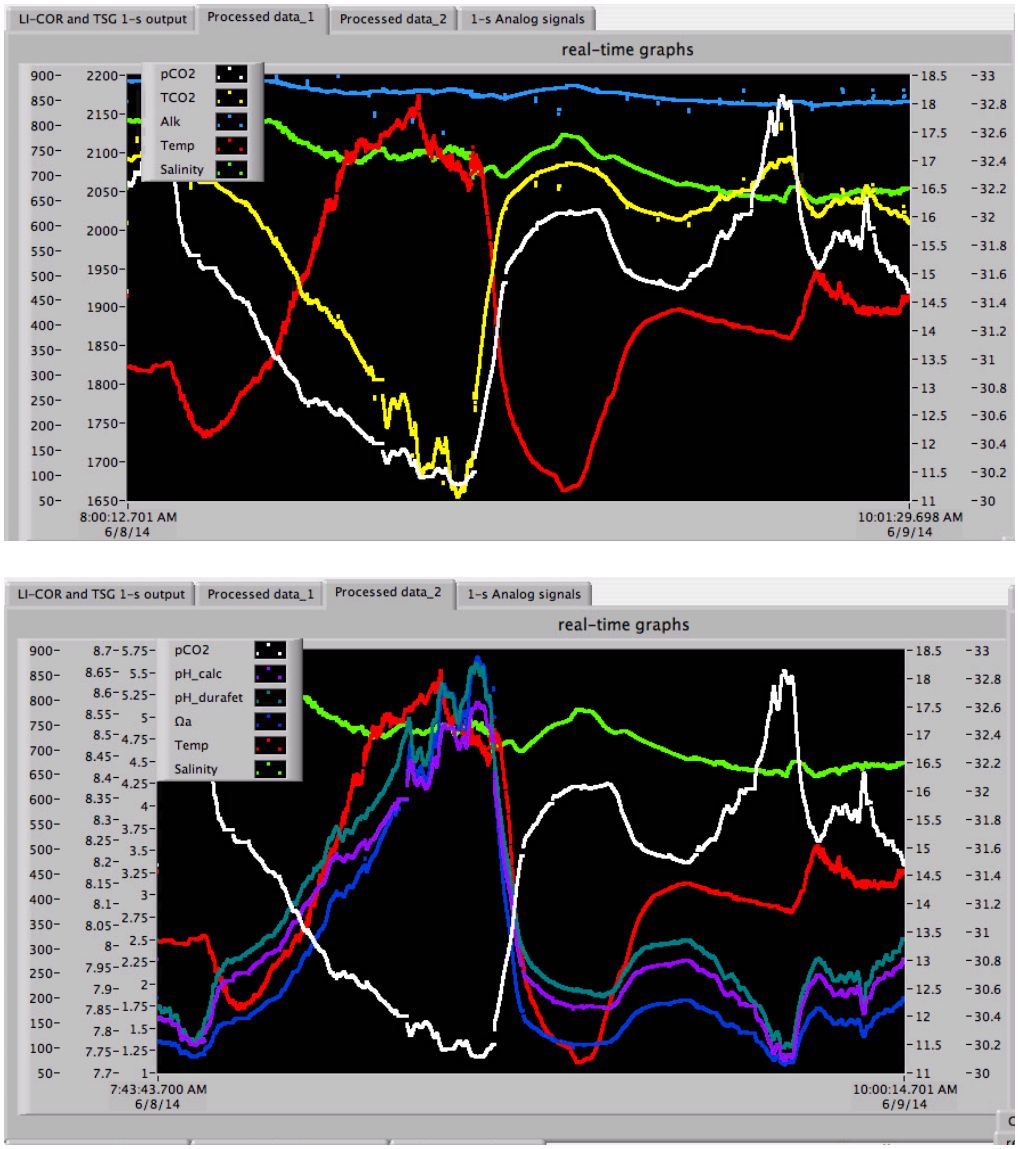


Figure MSI-1. Real-time carbonate system data from the WCSH (Netarts, OR) site, showing the functionality of the full combined pCO_2-TCO_2 system. A) Temperature (red) salinity (green), pCO_2 (white), TCO_2 (yellow) and alkalinity (light blue) for a ~24 hour period in early June. B) As in A, but including calculated pH (purple) and aragonite saturation (Ωa; dark blue), along with an independent measure of pH.

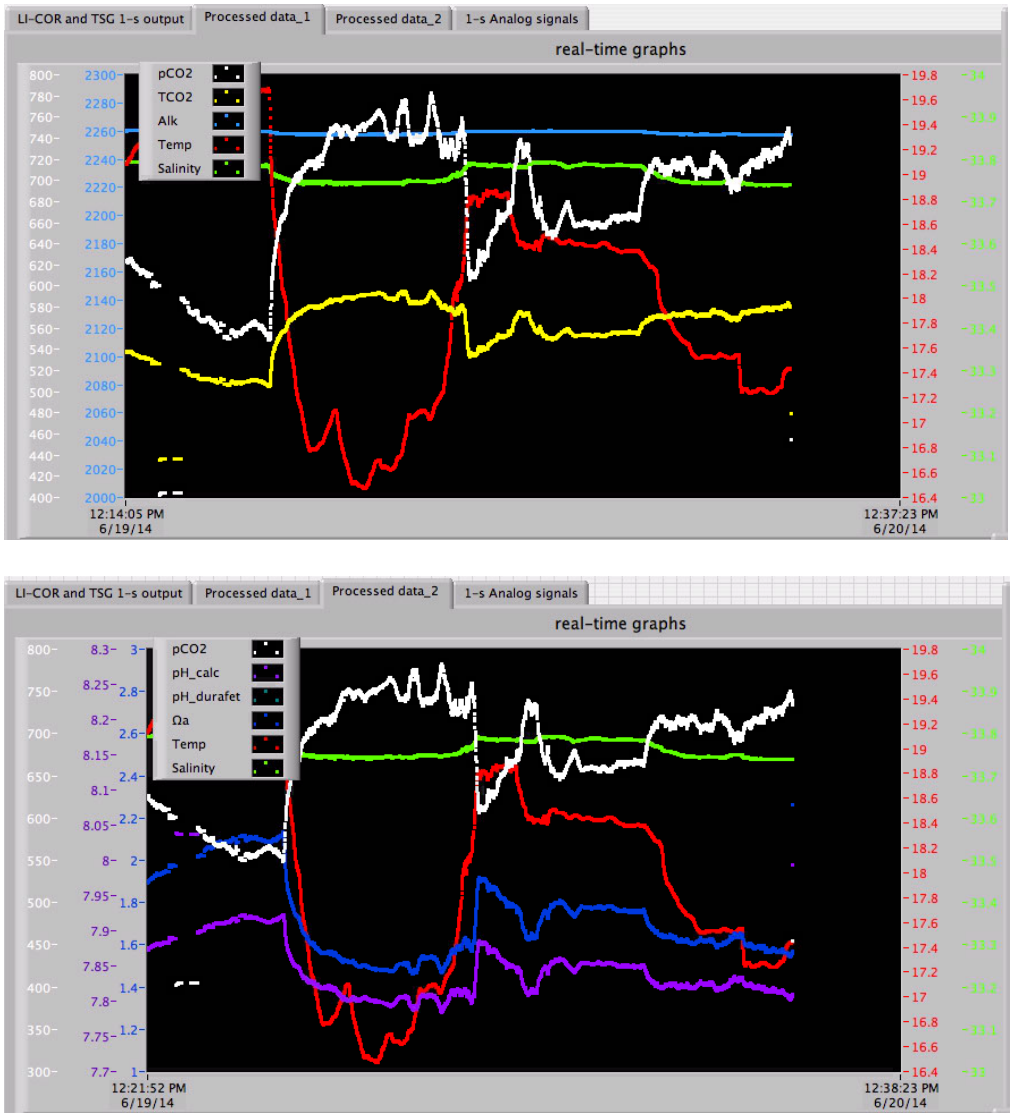


Figure MSI-2. Real-time carbonate system data from the HIOC (Marshall, CA) site, showing the functionality of the full combined pCO_2-TCO_2 system. A) Temperature (red) salinity (green), pCO_2 (white), TCO_2 (yellow) and alkalinity (light blue) for a ~24 hour period in early June. B) As in A, but including calculated pH (purple) and aragonite saturation (Ωa; dark blue), along with an independent measure of pH.

2. Development of open water, nearshore, moorings that measure relevant ocean acidification parameters throughout the water column and report in near real time, withstanding the temperature extremes which exist in nearshore, shallow water, temperate systems.

J. Mickett, UW, lead: During this period we upgraded two ORCA moorings (Dabob and Twanoh) with new hulls designed to allow easy integration of the Battelle pCO_2 system and to resolve data-quality issues related to large temperature fluctuations. The new hulls also provide improved stability and buoyancy and allow easy integration of additional peripheral systems including SST and ADCP measurements. This highly-successful fieldwork, which involved the recovery, servicing, upgrade and re-

deployment of both moorings, was carried out from APL's R/V Robertson during the second week of April. A third hull conversion of the Carr Inlet mooring is planned for early June.

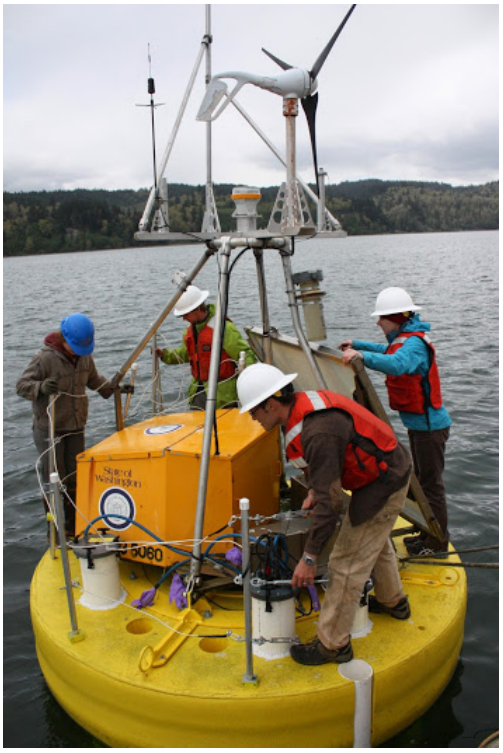


Figure MSI-3. Upgraded Dabob ORCA mooring with installed pCO_2 system. *Photo credit R. Vander Giessen, NANOOS*

During this period we also collaborated with SeaBird electronics to successfully develop a plan for integrating a SeaFET pH sensor with a SeaBird 19-plus profiling CTD, with SeaBird committing to competing the needed firmware changes on both the CTD and the SeaFET by the end of 2014. This integration is a very significant step forward for oceanic pH observations---enabling long-term, real-time profiles of pH at fine vertical resolution---and will likely benefit many other monitoring programs seeking water column pH measurements. The instruments were ordered from SeaBird/Satlantic and will be integrated with several ORCA moorings this fall, with a profiling pH system to go online next spring (2015).

3. Apply and test new OA technologies on deep water moorings
B. Hales, OSU, lead for NH10, OR, buoy: Work on this component has centered on continued deployment of the near-bottom moorings at NH10 and NH20 and continued algorithm development. Algorithm development (led by L. Juranek, OSU) has progressed to incorporate glider CTD+O_2 data, with encouraging results even as the finite response-time of the Aanderaa optodes limits precise resolution. Development of NH10 as an OA node has continued. Conflicts with the original NH10 physical mooring pushed the integration of the platforms into a single surface expression into the current summer season, but NOAA-PMEL contributed a PICO-style MapCO2-ready mooring for the spring deployment cruise. This data has been online since April (Figure MSI-4).

The close proximity of the mooring to OSU's home port has allowed ready access for collection of validation samples, which have shown remarkably good agreement with the in-water measurements. It has also allowed access for mooring service. Following one high-amplitude and exceptionally short-

period wind-wave event in late April, the equilibrator became stuck in the mooring pass-through above the waterline. A small-vessel platform of opportunity allowed Hales to access the mooring and manually free the equilibrator in mid-May, saving expensive recovery and redeployment options and the summer-season data.

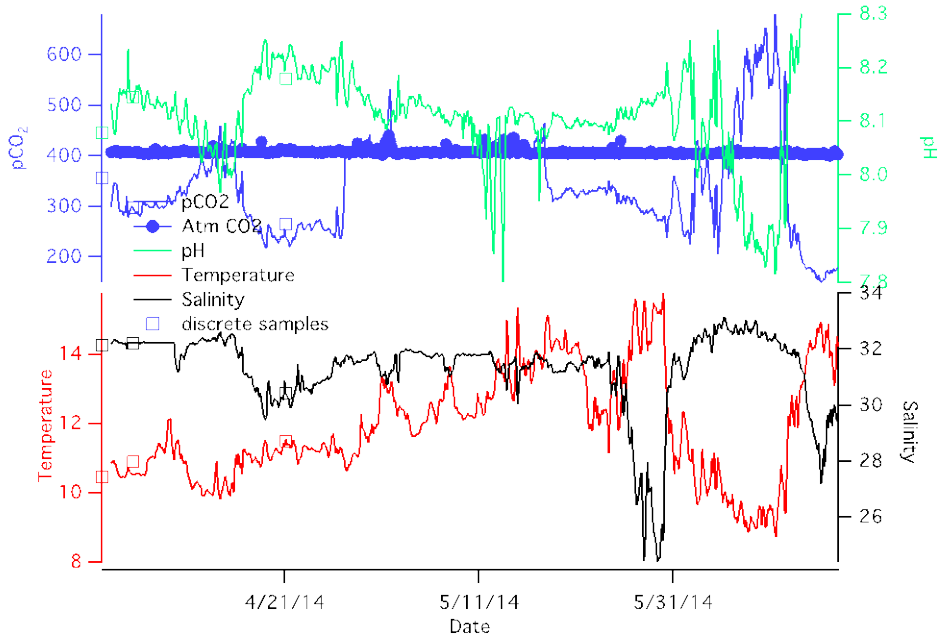
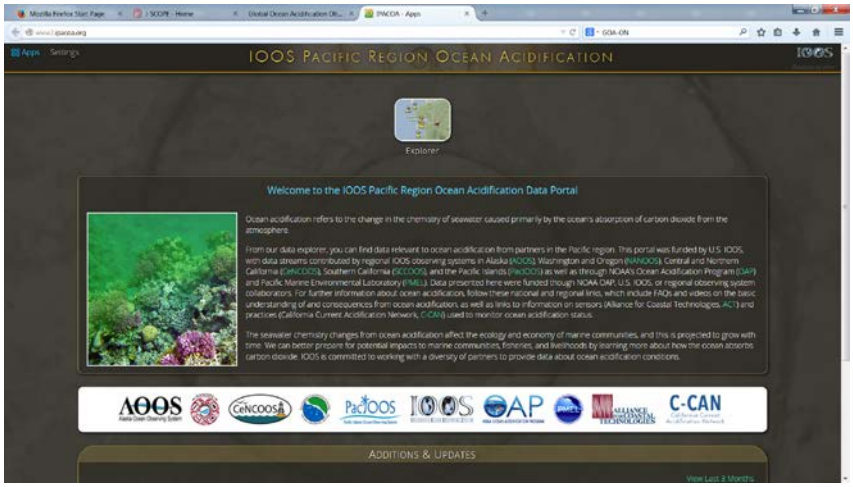


Figure MSI-4: Time-series from NH10 MAPCO2 mooring showing surface water and atmospheric pCO_2 (blue line and solid blue circles, respectively), pH (green line), Temperature (red) and salinity (black). Open squares are opportunistic validation samples (color matches line of in-water parameter) collected during close-pass-by ship opportunities, analyzed in Hales' lab at OSU. The interval from 4-27 through 5-17 corresponds to a time when the equilibrator became stuck in the buoy housing above the water line; Hales manually freed the equilibrator on an opportunistic vessel pass-by.

J. Mickett, UW, lead for La Push, WA, buoy: Activity during this period for the Cha'Ba and NEMO-subsurface shelf moorings was intertwined with discussions/collaboration with SeaBird Scientific to integrate a SeaFET with a SeaBird CTD. Due to complications with firmware, in the end SeaBird could not commit to integrating a SeaFET with an inductive SBE16 CTD, so instead the SeaFETs will be co-located at depth (50 m) with a DO-sampling CTD (SBE 37 ODO) and connected to an inductive modem to allow real-time data collection. Instruments were ordered and will be integrated into the Washington Shelf moorings starting in the spring of 2015, with measurements to be displayed in real-time on the NANOOS Visualization System (NVS) immediately upon deployment.

4. Provide data management for all OA data streams via an NVS-like product for West Coast
In May-June 2014 we deployed the first working test version of the new "IOOS Pacific Region Ocean Acidification" data visualization application, adapted from NVS (Figure MSI-5). A conference call was held with participation by all RAs, AOOS, NANOOS, CeNCOOS, SCCOOS, and PacIOOS. The first live version containing OA assets throughout the region will be released this summer.



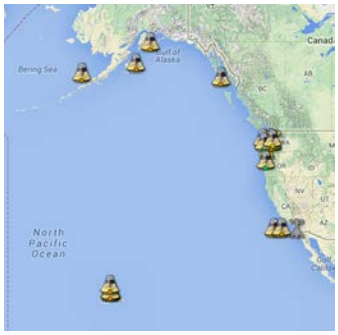


Figure MSI-5. Landing page for the new IOOS Pacific Region OA Portal, with inset of Pacific assets.

b) NANOOS Modeling Subsystem:

• **Shelf:** Computer circulation modeling of PNW coastal ocean shelf conditions has been conducted by A. Kurapov's group at OSU. The system utilizes the Regional Ocean Modeling System (ROMS) as the forecast model. Along-track altimetry observations from Jason-2, CryoSat, and Altika, hourly GOES SST, and surface currents from land-based high-frequency (HF) radars have been assimilated to improve initial conditions for the forecasts. The system produces daily updates of 3-day forecasts of ocean conditions, including currents, temperature and salinity through the water column (at 3-km horizontal resolution). Results are provided to fishermen and public via the NANOOS Visualization System. Via the OpenDAP server, forecast currents are also provided to the NOAA Office of Response and Restoration Lab in Seattle, where they can be used with the tools for oil spill mitigation. Routines for pre- and post-assimilation quality control have been established, along with new online tools (http://ingria.coas.oregonstate.edu/rtdav/, L. Erofeeva, OSU).
Currently, the forecast model is extended to 40.5-47N in the alongshore direction and is focused on the OR coast. We also developed and tested (without assimilation) a 2-km resolution model in an extended domain (40.5-50N), which includes both the WA and OR coasts. Forcing of this model includes tides and the Columbia River fresh water discharge. Solutions with and without the Columbia River have been compared. It has been found that the river plume, turning toward the Oregon coast in summer, influences the sea surface temperature. In the area of the plume, where atmospheric heat flux is attenuated in a shallower surface layer, waters are generally warmer. In response to upwelling-favorable southward winds, waters inshore of the river plume may be relatively colder than in the case without the Columbia River. Including the river discharge in the forecast model is planned, to potentially improve accuracy of forecasts.

Initial assimilation tests using this new configuration have been done, and the impact of the river plume on assimilation is being studied. Efforts have been made to improve the initial condition error covariance based on an ensemble of model runs with localization (ongoing study by I. Pasmans, an OSU PhD student).

• **Estuaries**

Puget Sound:

NANOOS PI P. MacCready (UW School of Oceanography), working with D. Jones (APL-UW) and N. Banas (UW Joint Institute for the Study of Atmosphere and Ocean) are creating a pre-operational forecast model of ocean circulation in Puget Sound and adjacent waters. In the past six months MacCready and

Banas used NANOOS support to develop parts of the forecast model system and a system for validation against observations. NANOOS also supported salary for Dr. MacCready's system administrator, David Darr, who oversees computer operations and assists with the gathering and archiving of model atmospheric fields from Dr. Cliff Mass. The forecast work is also be supported by a grant of state funds made through the Washington Ocean Acidification Center, greatly accelerating the work and leveraging the impact of NANOOS funds.

Columbia River: With a mix of NSF funding, regional stakeholder funding, and modest NANOOS funding, CMOP maintains an extensive modeling system for the Columbia River coastal margin, denoted *Virtual Columbia River* (VCR). The VCR is operated under the direction of A. Baptista, but it is a multi-institutional collaboration involving modelers and non-modelers, in academia and across regional, federal and tribal agencies.

On-going during this reporting period:

- We have continued to use the circulation modeling capabilities of the VCR to assist the region in the study of salmon life cycle, habitat and status under the Endangered Species Act and in relation to hydropower management and climate change. Of particular note were studies supporting the region on (a) the Columbia River Treaty Review, a collaboration with the USGS, Army Corps of Engineers, Bonneville Power Administration, Columbia River Inter-Tribal Fish Commission and others; and (b) the post-construction assessment of the ecological impact of the Columbia River Channel Improvement Project, a collaboration with the Army Corps of Engineers, NOAA, and a large number of state and federal agencies.
- The daily forecasts of the VCR form the foundation of the NOAA PORTS forecasting system for the Columbia River. We continue to collaborate with NOAA in improving the skill of those forecasts.
- Driven in part by the needs of the above-mentioned projects, we continued to assess and improve the skill of the circulation simulations. Peer-reviewed papers are in preparation to document the process, with the first submitted in June 2014.
- We are continuing to expand the disciplinary scope of the VCR, to be able to address CMOP science questions and emerging ecological issues in the estuary. Progress has been made developing models of estuarine hypoxia, sediment dynamics and nitrogen and carbon cycles. Peer-reviewed papers are in preparation to document the process, with the first submission anticipated in the last quarter of 2014
- Several presentations at regional and national forums were made on the Virtual Columbia River and its societal applications, including several to Native American forums or on issues of interest to Native American tribes.

c) Data Management And Communications (DMAC) Subsystem:

Co-chaired by E. Mayorga (APL-UW) and S. Uczekaj (Boeing), this committee is composed of members from Boeing, CMOP-OHSU, DOGAMI, OSU and UW. The DMAC and User Products (UPC) teams work in an integrated fashion on the prioritization, development and evaluation of data services and user products. NANOOS is an active collaborator in national IOOS DMAC efforts, including the SOS Reference Implementation efforts (Mayorga) and the IOOS DMAC Steering Team (Uczekaj). Meeting highlights for this period included: 1) IOOS DMAC Steering Team meetings, Uczekaj; 2) annual NANOOS DMAC & User Products meeting (Feb 13-14); 3) weekly NANOOS DMAC-UPC teleconferences; and 4) IOOS DMAC monthly webinars, where Mayorga was co-presenter for the Feb and May meetings – on Python tools for ocean data access (with Rich Signell, USGS), and CUAHSI HIS and the Water Data Center (with Rick Hooper, CUAHSI Director), respectively.

NANOOS Visualization System (NVS) enhancements encompass asset additions and continuous updates: new near-real-time in-situ monitoring assets (Penn Cove Shellfish, and NOAA PMEL CO_2 data stream at the Seattle Aquarium); a new 11-year chlorophyll-a and sea-surface-temperature monthly climatology and anomalies from the MODIS-Aqua satellite sensor covering the California Current System, created by OSU and also distributed via NOAA-SWFSC ERDDAP (see *osuChlaAnom* and *osuChlaClimate* datasets at http://coastwatch.pfeg.noaa.gov/erddap/griddap/); a UW-hosted XTide tide and currents forecast system; and many redeployments and upgrades. A large NVS framework and backend upgrade was released in April as NVS 3.2. It included a refactoring of the server environment, database and data harvesting system that will greatly enhance the scalability and portability of the NVS framework and underlying DMAC infrastructure.

NANOOS and IOOS DMAC system implementation. As part of its DMAC upgrades, NANOOS created the new subdomain http://data.nanoos.org to provide a consistent presentation of data web service access. In April we deployed an IOOS 52North SOS server (http://data.nanoos.org/52nsos/) and registered the SOS endpoint on the IOOS Registry. We also overhauled our GeoServer instance (now at http://data.nanoos.org/geoserver/) supporting OGC standard geospatial services. NANOOS worked with NGDC and IOOS to help advance IOOS capabilities to handle OGC WMS cataloging at the NGDC GeoPortal and IOOS Catalog; and to register and improve the presentation of web services from the OSU ROMS model via THREDDS and HYRAX. NANOOS also continued its participation in IOOS DMAC community implementation activities, including an active role in the IOOS Github repositories, and collaborative development and dissemination of Python tools for convenient IOOS data access. Mayorga worked with Dan Ramage from SECOORA to test, document, enhance and disseminate good practices for the IOOS-supported PyOOS package. Mayorga and Rich Signell (USGS) jointly developed best practices and accessible code examples using online IPython notebooks, and configurations for replicating IOOS-friendly Python environments.

West-Coast Coastal and Marine Geospatial Data. NANOOS collaborations with the West Coast Governors Alliance Ocean Data Network (WCODN), SCCOOS, CeNCOOS, and a WCODN SeaGrant fellow resulted in continued enhancements to the West Coast Ocean Data Portal and the development of initial oceanographic data products to meet stated needs of the marine debris and ocean acidification communities. This is described in more detail in the Supplemental text.

Ocean Acidification (OA) Data. NANOOS made great strides in OA data access. We added new OA data streams to NVS, and completed code development and testing for the new “Burkolator” OA sensors being deployed at shellfish growers' sites; these sensors include more sophisticated OA variables than have previously been available in near-real-time, including aragonite saturation ratio. Working with the joint WCODN & West Coast RA's SeaGrant fellow, we led the update and expansion of the West Coast OA monitoring inventory that will be released soon. Finally, as part of the NANOOS MSI activity, we deployed the first working test version of the new “IOOS Pacific Region Ocean Acidification” data visualization application, adapted from NVS; the first live version containing OA assets throughout the region will be released this summer.

d) User Products Committee (UPC):

The UPC operates in concert with and is informed by both the DMAC and Education & Outreach subsystems. The objective 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 guide the development of 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.

Chaired by J Allan (DOGAMI) 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 2013/2014 period included: 1) multiple weekly NANOOS DMAC and UPC teleconferences; 2) annual UPC/DMAC and E&O meeting on February 13-14, 2014; and 3) continued refinements to an 'ocean climatology' product for the Pacific Northwest (PNW) coast, focused on NDBC buoy measurements and MODIS satellite climatologies.

Website: Efforts during this period were largely directed at further improvements in the overall NANOOS web experience (http://www.nanoos.org/products/products.php).

NVS: The backbone of the NANOOS RCOOS is the NANOOS Visualization System (NVS) that currently distributes data from a myriad of regional and federal assets. On April 16th, NANOOS released NVS v3.2, which reflected a major update to the "back end" of the NVS platform. This update was necessitated by the need to substantially overhaul the NVS database structure, data harvesters and server-side codebase in order to address a number of legacy issues that affected how the NVS platform interacts as a whole. Additional enhancements included minor improvements to the Timeline function, as well as a comprehensive update to the NVS help content.

On April 28th, NANOOS released a new web app targeting the "boater community" (Figure 3, http://nvs2.nanoos.org/Boaters). The Boaters web app, designed expressly for boaters, provides access to two primary types of insitu assets (HF Radar (surface currents) and NOS Tide gauges (tide predictions)), along with a suite of forecast overlays (air temperature, pressure, humidity, waves and winds), and markers depicting the locations of marina's and their address details. Of particular significance is the inclusion of a new tide prediction tool for multiple stations throughout the PNW region; for the purposes of this web app, we use XTide for predicting the hourly tides.

Clicking on a particular tide prediction station, actives the timeline, which depicts a plot with the hourly predicted tide values. As the user navigates the timeline slider, the predicted values are updated automatically in the NVS map window. This last feature is especially powerful enabling the user to query the heights of the tides at any time of the day and for several days into the future. Additional enhancements to the XTide graphical user interface includes symbology that depicts whether the tide is rising or falling, and a change in color in the symbols to highlight those tide predictions that fall below Mean Lower Low Water (MLLW). Besides the XTide tide predictions, the Boaters app also includes the predicted ebb and flood tidal currents for selected sites along the coast (mostly within Puget Sound and up in the Columbia River where such predictions are available). Finally, the Boaters app also includes the digital nautical charts introduced originally in the Maritime Operations web app early in 2013.

Additional work to the NVS platform occurred in February 2014, which reflected an overhaul to the NOS/CO-OPS tides forecast harvester. This was necessary due to a problem with the measured and predicted tides derived from the NOS, which resulted in a major offset in the data streams. During the same period, DMAC member, Craig Risien, completed initial development of two climatology products: water temperature and Chlorophyll, which have been integrated into the NVS Data explorer. These data are derived from MODIS satellite imagery and remain experimental. UPC Chair Allan, continued to refine

an NDBC in situ climatology product developed initially for eight NDBC wave buoys located offshore the PNW coast. An example plot, Figure 4, shows the seasonal cycle, daily averages for the current year and previous year, along with various ranges (±1σ and +2σ) in water temperature measured at the Stonewall Bank buoy offshore from Newport, Oregon. Data that has been fully QCd are shown by the solid black line, while data subject to limited QC are depicted by the cyan line. The example plot includes a strong upwelling event that occurred offshore the central Oregon coast in early June 2014. Although not yet visible in NVS, Risien and Allan hope to have an NVS climatology product operational in the next reporting period.

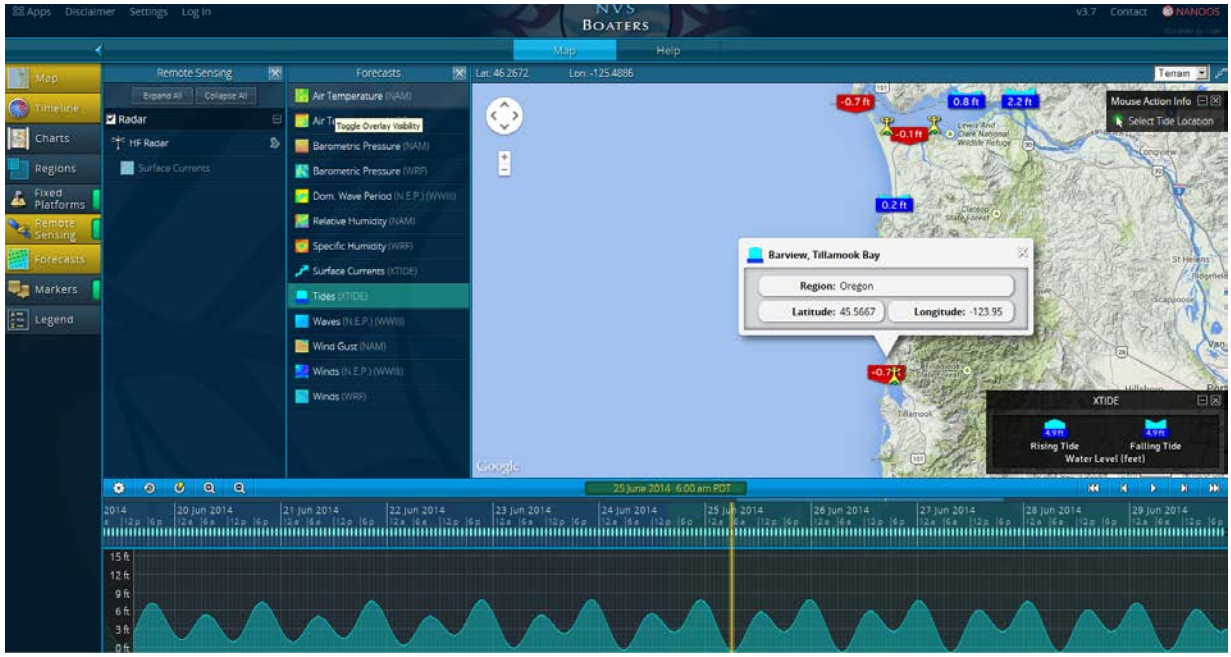


Figure 3. The new Boaster web app. showing the locations of in-situ XTide tide prediction stations.

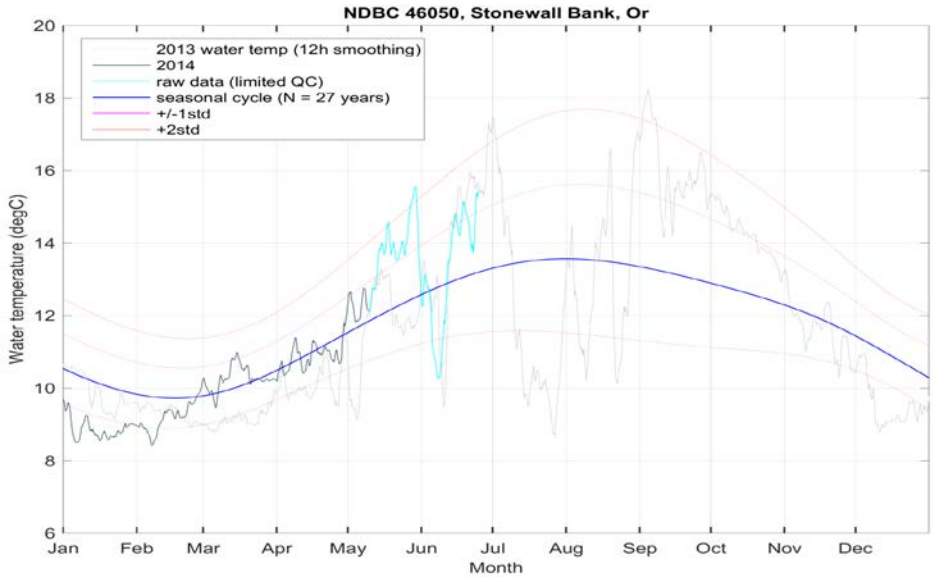


Figure 4. Water temperature climatology at buoy 46050, offshore the central Oregon coast.

Interest in NVS by NANOOS stakeholders continue to climb, evident in Figure 5, which shows numbers spiking at around 11,500 visits in August 2013, before falling again in December 2013. Since December 2013, the numbers of visits to the NANOOS website continues to fluctuate around 2000-3000 visits per month, while the long-term pattern remains one of gradual increase.

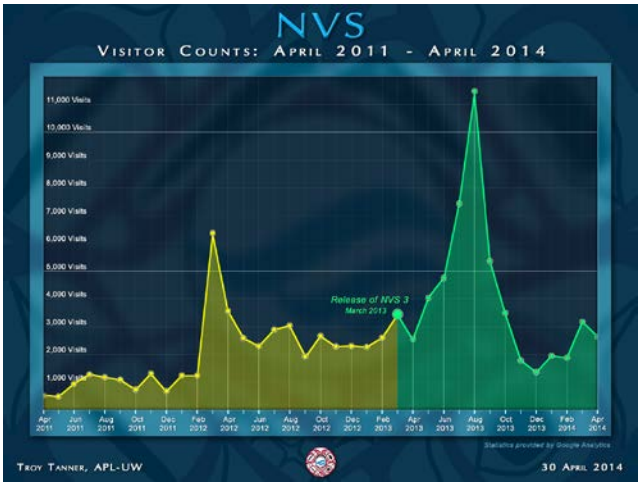


Figure 5. NVS visitor counts 2011 to 2014

Mobile Applications*[2]*: The NANOOS UPC/DMAC sub-working group is responsible for the release and maintenance of mobile applications that can access and display data from NANOOS data sources. Currently there are two such applications, ***NVS*** and ***Tsunami Warning NW*** that are available to the general public on both Android and iOS platforms. During this period, no significant enhancements were made to either of these applications.

Meetings: Members of the NANOOS UPC/DMAC sub-working group met at OHSU in Portland Oregon on February 13-14, 2014. The objective of this meeting was to review the status of existing DMAC/UPC/Web activities already underway and to explore new enhancements to the NVS framework and prioritize these new activities for the 2014-15 period. As a result, of this meeting we identified several new enhancements, including:

- Implement XTide to provide tide and current forecasts within NVS;
- Develop a situational awareness capability based around real-time reporting of values from multiple insitu assets for inclusion in NVS;
- Move initially towards the development of graphical plots that depict depth profiles and contour/fill plots. In time, implement development of a plotter function to internally handle this within NVS;
- Integrate AIS capability into the Maritime Operations web app.

e) NANOOS Education and Outreach Subsystem:

In February 2014 NANOOS hired a new staff member, Rachel Vander Giessen, to support NANOOS in both Outreach and Administrative roles. This increased NANOOS funded E&O staff from .5 FTE since June 2013 through Feb. 2014 to 1.25 FTE as of Feb., increasing NANOOS Education and Outreach capacity. Newton, Sprenger and Vander Giessen are all active members of the weekly DMAC/UPC tag-up conference calls. Sprenger continues participation with IOOS E&O monthly calls.

[2] http://www.nanoos.org/mobile_apps/index.php

Summary of Education Accomplishments: NANOOS education efforts have continued to focus on building and sustaining connections with Pacific Northwest educators and partnering with local and regional science and marine science education efforts.

- Sprenger continues to support ocean acidification education efforts, particularly in WA State, as recommended in the 2012 WA State Blue Ribbon Panel on Ocean Acidification. Serving on the Marine Resource Advisory Committee Education and Outreach sub-committee to compile recommendations to implement the Education and Outreach Action Agenda from the Blue Ribbon Panel.
- Sprenger continues to facilitate and promote education using student built buoys as a research project for K-12 students both in and out of school. For the third year this coming summer, Sprenger will be partnering with WA Sea Grant led NOAA Science Camp, to instruct the Junior Leadership Program, high school aged students in designing, building and deploying buoys near the NOAA campus on Lake Washington to answer student derived research questions. During this off-season for the camp Sprenger and WA Sea Grant staff have been working to improve and refine the program.
- Sprenger is partnering with NANOOS member Ocean Inquiry Project and education staff with NOAA's Northwest Fisheries Science Center to plan a teacher workshop this upcoming summer which will engage teachers in collecting and using ocean observing data related to the carbon cycle, hypoxia and ocean acidification.

Summary of Outreach Accomplishments: NANOOS outreach efforts have been focused on engaging with target user groups, including fishers and scientists, improving and updating the content on the NANOOS web portal, energizing social media outreach efforts.

- In March, NANOOS provided the "Great Build a Buoy Challenge" activity at the Pacific Science Center's Paws on Science Weekend. The buoy challenge was again wildly popular among attendees with non-stop buoying throughout the weekend and over 300 parents and kids working together to do the challenge.
- Also in March NANOOS Outreach staff R. Vander Giessen participated in the Saltwater Sportsmen's Show in Salem, OR. Vander Giessen demonstrated NVS, particularly the NVS Tuna Fishers App, and provided information to over 100 recreational fishers and charter guides.
- NANOOS updated the Ocean Acidification information page on the NANOOS web portal (http://www.nanoos.org/education/learning_tools/oa/ocean_acidification.php), supported the Aquaculture America 2014 meeting, and created a new information page on Harmful Algal Blooms (http://www.nanoos.org/education/learning_tools/habs/harmful_algal_blooms.php).
- NANOOS renewed efforts on social media, regularly posting on Facebook with news, pictures, and interesting data. Vander Giessen has reprised the NANOOS blog (http://www.nanoos.org/education/blog/blog.php) posting on field maintenance work and research cruises and is working to gather blog post contributions from NANOOS collaborators.
- At the Salish Sea Ecosystem Conference in Seattle on 30 April- 2 May, NANOOS E&O staff presented a poster and staffed an information booth to demonstrate NVS. Sprenger and Vander Giessen spoke with more than 200 people during the conference.
- Vander Giessen worked with APL-UW Publications Staff to produce a new NANOOS/ NVS business card which can be handed out at events and distributed to appropriate businesses and institutions.

f) NANOOS Administration:

D. Martin (NANOOS Board Chair) and J. Newton (NANOOS Executive Director) continued to provide leadership to NANOOS operations. They and M. Kosro (NANOOS Board Vice Chair) participate in regular IOOS and IOOS Association calls. Newton is a member of the IOOS Association Executive Committee and

participates in their teleconferences regularly. During 3-6 March, Martin and Newton participated in IOOS Association and IOOS Spring meetings in Washington covering a wide range of national and regional IOOS-related issues including visits to Congressional and Executive offices.

Throughout the reporting period, Martin and Newton remained deeply involved with a complimentary research ocean observing effort in the Pacific Northwest, the NSF-funded Science and Technology Center (STC) for Coastal Margin Observation and Prediction, which NANOOS leverages heavily in the areas of DMAC and Education and Outreach. Martin serves as Co-Director for the Center and Newton directs the UW Education efforts for this multi-institution project. Newton continued to develop education opportunities for at-sea training with the Northwest Indian College through CMOP.

Newton and Martin held annual NANOOS meetings for all PIs and the Governing Council in Vancouver, WA on 19-20 August 2013. Martin served as Chair of the NANOOS Board during the GC Meeting. Newton coordinated with. J. Allan, User Products Committee Chair, to organize the Tri-Comm meeting, held 13-14 February 2014 in Portland, OR, hosted by OHSU.

Over the period, Newton has coordinated with other West Coast RAs, following the intent of our mutual MOU, as well as several other RAs to optimize and leverage capabilities and assure consistencies. This includes: the Sea Grant post-doc, Laura Lilly's work on ocean acidification and marine debris; input the Leslie Rosenfeld's presentation to Marine Mammal Health Mapping workshop in Sausalito, CA (April 7th); participation in the workshop on "Climate Variability and Change in the California Current Ecosystem 2," held during April 22-24, 2014, at the Scripps Institution of Oceanography and the NOAA Southwest Fisheries Science Center, coordinating with CeNCOOS and SCCOOS to define an IOOS role in this proposed work.

NANOOS PI and GC member Barth and Newton continued to support the West Coast Ocean Acidification and Hypoxia Science Panel (http://calost.org/science-advising/?page=ocean-acidification-and-hypoxia-panel), working on scientific manuscripts and public interest documents on west coast OA.

Additional coordination:

From 21 – 25 April, Martin participated in Navy meetings at the Naval Undersea Warfare Center (NUWC) in Newport, RI which had a principal focus on the use of unmanned platforms for conducting METOC and other reconnaissance functions.

Newton continued coordination of ocean acidification observations on local through global scales, in cooperation with the Washington Ocean Acidification Center, regional (NANOOS & MSI-West coast activities) national (NOAA OAP & IOOS) and global (GOA-ON) efforts. She was invited to present the plan "Global Ocean Acidification Observing Network (GOA-ON): Basic Requirements and Governance" for the GOA-ON side event to the GEO-X Summit, on 16 January 2014 in Geneva, Switzerland. She is on the Steering Committee for GOA-ON, and helps to represent IOOS capabilities to this global effort. Newton was also invited to present perspectives from Washington state at the Science Assessment of Chesapeake Bay Acidification Workshop in Edgewater, MD, 11-12 March 2014. She provided a webinar on ocean acidification to the PNW Tribal Climate Change Webinar Series on 21 May, 2014. She attended the GOA-ON Executive Council meeting in Paris, France, at UNESCO 26-27 May, 2014, to ratify the GOA-ON Plan and develop priorities for next year. NANOOS facilitated the new non-governmental portal for GOA-ON, hosted at UW: http://www.goa-on.org/.

Newton was requested to participate in the Ocean Acidification Innovation Act Press Event for U.S. Congressman Kilmer in Tacoma, WA on 12 May to present research and observing needs. http://www.theolympian.com/2014/05/13/3129992/kilmer-calls-for-competition-to.html?sp=/99/101/

Newton was invited to be a member of the International Science Advisory Committee and attended its first meeting in Whistler, British Columbia on 6-7 February. Newton will provide advice and also work to find synergies between IOOS and MEOPAR.

Newton participated in several NOAA FATE meetings for J-SCOPE, the ecological forecasting model for seasonal coastal ocean prediction to which NANOOS provides the portal. See http://www.nanoos.org/products/j-scope/.

Newton participated in the workshop held by SCCWRP to assess the status and needs for modeling of OA and hypoxia on the US West Coast. She presented a summary of OA findings and facilitated two sessions for this workshop held in Costa Mesa, CA, on 10-11 December 2013.

Newton was interviewed regarding climate change observations in the coastal ocean for the radio show "Native America Calling" in December 2013.

Newton continued to fill the Research seat as a member of the Olympic Coast National Marine Sanctuary Advisory Council, attended their meetings in January, March, and May 2014. She presented an introduction to the WOAC activities on ocean acidification monitoring and research in response to the SAC recommendations.

Newton, a member of the Scientific Advisory Committee of the Joint European Research Infrastructure Network for Coastal Observatories (JERICO), reviewed proposals for the 3rd call for Trans National Access (TNA) and evaluated their suitability for funding.

During the reporting period Newton continued to represent NANOOS in regional efforts, e.g., C-CAN, Pacific Salmon Marine Survival, and West Coast Ocean Data Portal, and to be a regional resource. She was invited to deliver the Keynote Address to graduate students at their annual symposium at Western Washington University on 17 May, 2014, in Bellingham, WA.

3) Scope of Work

There were neither current nor anticipated changes in scope of work, aside from downtime for various observing assets detailed above, due to weather, aging infrastructure, lack of sufficient funding support or other matters beyond our control. NANOOS succeeded in meeting our milestones for this period.

4) Personnel and Organizational Structure

Rachel Vander Giessen was hired to assist with NANOOS Outreach. There were no other changes in key scientific or management personnel for this period.

6) Budget Analysis

At the end of this reporting period, the project period for the NANOOS Yr5-9 award was 75% complete and we have encumbered or spent 72% of the funds provided ($7,617,175.34). In this context, "encumbered" refers to funds that are dedicated to specific planned expenditures in the UW Financial Systems where they are treated as funds already spent though they are not invoiced until actually spent. For example, all of the sub-awards are encumbered and thus not available to be spent for any other purpose. Indirect costs are also encumbered. However, encumbered amounts are NOT listed as actual expenditures until sub-awardee invoices are actually paid and indirect costs are actually charged. These percentages (75% and 72%) match well, indicating that spending is commensurate with our plan.

The actual invoiced expenditures at the end of this reporting period are $6,756,319.93, or 64% of the funds provided. This difference (72% vs. 64%) reflects the inherent lags in the posting of expenditures in our institutional budget tracking systems and, in some cases, the nature of leveraging multiple funding sources so spending is not linear. In summary, we assess that the spend rate for this award are solid and appropriate for this point in the reporting period. The expenditures to date are suitable for maintaining robust execution of NANOOS plans to meet our objectives.

Presentations and Publications acknowledging NANOOS support: underline indicates NANOOS PI

Presentations:

Anderson, D., Ruggiero, P., Allan, J., 2013. Evolving shoreline change rates along the US Pacific Northwest coast, Abstract EP13A-0834 presented at 2013 Fall Meeting, AGU, San Francisco, Calif.

Baptista, A.M., C. Seaton, K. Fresh, D. Bottom, J. Miller, K. Jones, H. Moritz, C. Studebaker, R. Lothrop. 2014. Fast prediction of river influences on the Columbia River estuary and plume, and implications for policy, adaptive management and operation. 2014 Columbia River Estuary Workshop: Forging Links in the Columbia River Estuary. May 28, 2014. Liberty Theater, Astoria, Oregon

Baptista, A. 2014. CMOP report on activities relative to ATNI resolution #10-23. Affiliated Tribes of Northwest Indians (ATNI) Mid-Year Convention. May 6, 2014. Grand Mound, WA

Baptista, A.M. 2014. Of Salmon and People, of Environment and Health. American Indian/Alaskan natives Health Seminar. April 3, 2014. Portland, OR

Baptista, A.M., Karna, T., Seaton, C. 2014. River Influences On the Circulation, Ecosystem Services And Modeling Of A Large Eastern Boundary Current Estuary. Ocean Sciences Meeting. February 27, 2014. Honolulu, HI

Baptista, A.M. 2014. Of Salmon and People, of Environment and Health. American Indian/Alaskan natives Health Seminar. April 3, 2014. Portland, OR

Baptista, A.M., Karna, T., Seaton, C. 2014. River Influences On The Circulation, Ecosystem Services And Modeling Of A Large Eastern Boundary Current Estuary. Ocean Sciences Meeting. February 27, 2014. Honolulu, HI

Baptista, A.M., Green, V., Bueno Watt, N. 2014. Integrating Traditional Ways Of Knowing With Western Science, Through Collaborative Opportunities Fostered By The Network Of NSF Science And Technology Centers. Ocean Sciences Meeting. February 26, 2014. Honolulu, HI

Cohn, N., Ruggiero, P., and Walstra, D.J., 2013. Investigating storm-induced total water levels on complex barred beaches, Abstract EP13A-0836 presented at 2013 Fall Meeting, AGU, San Francisco, Calif.

Durski, S. M., A. Kurapov, J.S. Allen, G. Egbert, P.M. Kosro, "Modeling winter circulation off the Oregon coast: comparison of El Nino/La Nina years". Ocean Sciences Meeting, Session 003, Honolulu, HI, Feb 26, 2014.

Haller, M.C., D.A. Honegger, G. Diaz Mendez, and R. Pittman, Rip currents, tidal jets, and wild frontal features: Some recent observations with X-band marine radar, Abstract:17517, AGU Ocean Sciences Meeting, Honolulu, HI, 2014.

Haller, M.C., 2014. "Rip currents, tidal jets, and wild frontal features: Some recent observations with X-band marine radar", INVITED Ocean Engineering Seminar, Texas A&M University, College Station, TX, March 6, 2014.

Karna, T., Baptista, A.M., Lopez, J., McNeil, C., Sanford, T.B. 2014. Numerical Modeling Of A River-Dominated Estuary: Representing Sharp Density Gradients. Ocean Sciences Meeting. February 26, 2014. Honolulu, HI

Kim, S.Y., and P.M. Kosro, "Observations of near-inertial surface currents off oregon: decorrelation time and length scales". Ocean Sciences Meeting, Poster 1501, Honolulu, Hawaii, Feb 27, 2014.

Kosro, P.M., and S.Y. Kim, 2014. "Could use of measured patterns be degrading current retrievals?". Presented May 12, 2014 at the Radiowave Oceanography Workshop 2014 conference, Savannah, GA.

Kurapov, A. L., P. Yu, K. R. Shearman, and J. S. Allen: SST variability in the upwelling region off Oregon influenced by the Columbia River plume, Gordon Research Conference on Coastal Ocean Circulation, U. Maine, June 2013.

Kurapov, A. L., The NASA-SWOT wide-swath altimeter project work, Paris, France, June 2013

Kurapov A. L., The Workshop on Modeling in Support of Management of Coastal Hypoxia and Acidification in the California Current Ecosystem, Southern California Coastal Water Research Project (SCCWRP), Costa Mesa, CA, December 10-11, 2013.

Kurapov, A. L., Improvements in the Oregon coastal ocean forecast system: data assimilation in the presence of the Columbia River plume, GODAE COSS-TT Workshop, Puerto Rico, Jan 2014.

Lopez, J.E., Baptista, A.M., Karna, T.. 2014. Modeling ETM Dynamics In The Columbia River Estuary. Ocean Sciences Meeting. February 25, 2014. Honolulu, HI

Maloy, C.F., C. Krembs, S. Pool, J. Bos, L. Hermanson, S. Helgath, J. Thomson, W. Deppe, and B. Sackmann. 2014. Using Ferries for Marine Water Quality Monitoring in the Salish Sea. Poster presented at Pacific Estuarine Research Society Meeting, April 3-5, 2014. Ecology Publication No. 14-03-017.

Mickett, J., J. Newton and M. Alford, Moored Observations from the NW Washington Shelf: The NANOOS Cha'Ba Mooring, Puget Sound Ecosystem Monitoring Program (PSEMP) 2013 Puget Sound Marine Waters Overview Workshop, University of Washington, March 28, 2014.

Newton, J. Present State of Acidification on the US Pacific Coast. Workshop on Modeling in Support of Management of Coastal Hypoxia and Acidification in the California Current Ecosystem, Southern California Coastal Water Research Project (SCCWRP), Costa Mesa, CA, December 10-11, 2013.

Newton, J. The Global Ocean Acidification Observing Network, GEO-X Summit, 16 January, 2014.

Newton, J. Visualizing and Accessing Northwest Ocean Observations, Forecasts, Models, Data and More: NANOOS Visualization System Demonstration. Aquaculture America 2014, 11 February, 2014, Seattle, WA.

Newton, J., Z. Willis, L. Jewett, and R. Feely. Ocean acidification observing systems: local to global. Ocean Sciences Meeting. 24 February, 2014. Honolulu, HI.

Newton, J., Z. Willis, L. Jewett, and R. Feely. Ocean acidification observing systems: perspectives from WA state for the Chesapeake Bay, 10 March, 2014, Edgewater, MD.

Newton, J. Ocean Acidification. APL Board Meeting, 17 April, 2014, Seattle, WA.

Newton, J. Ocean Acidification. Seattle Aquarium Board Meeting, 21 April, 2014, Seattle, WA.

Newton, J. Ocean Acidification, Pacific Northwest Tribal Climate Change Webinar Series-Marine Issues, 21 May, 2014.

Ortiz, J., Cohn, N., and Ruggiero, P., 2013. Interannual sandbar variability within the Columbia River littoral cell, Abstract EP13A-0835 presented at 2013 Fall Meeting, AGU, San Francisco, Calif.

Publications:

Cohn, N., Ruggiero, P., Ortiz, J., and D.J. Walstra, 2014. Investigating the role of complex sandbar morphology on nearshore hydrodynamics. In: Green, A.N. and Cooper, J.A.G. (eds.), Proceedings 13th International Coastal Symposium (Durban, South Africa), Journal of Coastal Research, Special Issue No. 66, ISSN 0749-0208.

Erofeeva, S.Y., G.D. Egbert, and P.M. Kosro, 2003. Tidal currents on the central Oregon shelf: models, data and assimilation. Journal of Geophysical Research, 108(C5), doi:10.1029/2002JC001615.

Kim, S.Y., E.J. Terrill, B.D. Cornuelle, B. Jones, L. Washburn, M. Moline, J.D. Paduan, N. Garfield, J.L. Largier, G. Crawford, and P.M. Kosro, 2014. Poleward propagating subinertial alongshore surface currents off the U.S. West Coast. Journal of Geophysical Research, 118: 6791-6806, doi:10.1002/jgrc.20400.

Kurapov, G.D. Egbert, and P.M. Kosro, 2014. Intensified diurnal tides along the Oregon coast. Journal of Physical Oceanography, doi: 10.1175/JPO-D-13-0247.1 (in press).

Osborne, J.J., A.L. Kurapov, A.L., P. Yu, R.K. Shearman, and J.S. Allen, 2013: Sea surface temperature variability in the upwelling region off Oregon influenced by the Columbia River plume, J. Geophys. Res., in review.

Osborne J.J., A.L. Kurapov, G.D. Egbert, and P.M. Kosro, 2014: Energetic diurnal tides along the Oregon coast, J. Phys. Oceanogr., in press.

Ruggiero, P., Kratzmann, M.A., Himmelstoss, E.G., Reid, D., Allan, J., and Kaminsky, G., 2013, National assessment of shoreline change: Historical shoreline change along the Pacific Northwest Coast: U.S. Geological Survey Open-File Report 2012–1007, 62 p.

Washington State Department of Ecology. 2013. Eyes Over Puget Sound, Surface Condition Report, December 31, 2013. Ecology Publication No. 13-03-081. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2013_12_31.pdf

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Washington State Department of Ecology. 2014b. Eyes Over Puget Sound, Surface Condition Report, March 24, 2014. Ecology Publication No. 14-03-071. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2014_03_24.pdf

Washington State Department of Ecology. 2014c. Eyes Over Puget Sound, Surface Condition Report, April 21, 2014. Ecology Publication No. 14-03-072. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2014_04_21.pdf

Washington State Department of Ecology. 2014d. Eyes Over Puget Sound, Surface Condition Report, May 12, 2014. Ecology Publication No. 14-03-073. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2014_05_12.pdf

Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS®:
NOAA Award: NA11NOS0120036

June 2014 Progress Report Annual Supplemental

The reporting period for this annual supplemental is 6/1/2013-5/31/2014.

- **Regional Ocean Governance Organization activities**

1. NANOOS Collaboration with the West Coast Governors Alliance on Ocean Health (WCGA):

NANOOS continued and strengthened its close collaboration with the WCGA in partnership with the two other West Coast IOOS Regional Associations, SCCOOS and CeNCOOS. This collaboration focused particularly – but not exclusively – on the WCGGA Ocean Data Network (WCODN, formerly known as the WCGA RDF; http://www.westcoastoceans.org/index.cfm?content.display&pageID=153). NANOOS Director J. Newton is a member of the WCODN Action Coordination Team (ACT). With NANOOS technical support and guidance, including NANOOS DMAC Lead E. Mayorga serving as the WCODN IT Working Group lead, the West Coast Ocean Data Portal (WCODP, http://portal.westcoastoceans.org) was officially launched in January 2014 (see the WCGA press release, http://www.westcoastoceans.org/media/Press_Release/WCGA_Ocean_Data_Portal_Launch_Press_Release_-_Jan_21_2014.pdf). Its goal is to increase access and connectivity of West Coast ocean data and people to facilitate regional ocean management, policy development, and planning. In recognition of the WCODP's ground-breaking combination of regional collaboration, distributed data hosting, user-friendliness and sophisticated use of Esri technology, Esri awarded its Oceans Special Achievement in GIS (SAG) award to the WCGA in May 2014. As the award announcement states: *"The award is presented by Esri, a leading Geographic Information Systems (GIS) software company, in recognition of the WCGA's leadership, contribution and innovation in advancing ocean health and awareness [....] The Esri SAG Award is given to user sites around the world in recognition of outstanding work with GIS technology. The West Coast Ocean Data Portal was selected from over 100,000 nominations and will help showcase the WCGA's contributions in GIS to the global community. Representatives from the WCGA will receive the award at Esri's Annual User Conference in July."*

In addition to this work, NANOOS' E. Mayorga has served as the technical supervisor for Laura Lilly, the CA SeaGrant fellow hosted at SCCOOS and serving the collaboration between the WCODN and the three WC RA's. The fellow carried out user-needs surveys and strengthened partnerships among the West Coast Marine Debris and Ocean Acidification communities. She has made great strides in meeting these needs, including the creation of preliminary oceanographic data products from High-Frequency Radar surface currents; an update and substantial overhaul of the West Coast Ocean Acidification monitoring inventory; and additions to the WCODP catalog to enhance the discovery and access to oceanographic data made available by the West Coast RA's. All these products will be released summer 2014.

NANOOS is also actively working with the California Current Acidification Network (C-CAN) and their alignment with the WCGA efforts. Newton sits on the West Coast Ocean Acidification and Hypoxia Science Panel.

- **Efforts to leverage IOOS funding**

NANOOS is substantially leveraged in every aspect of its effort. None of NANOOS' assets or teams is supported by 100% IOOS funds. Maintaining the sources of the current leverage, in times of budget cuts and shrinking funding levels affecting all sectors of NANOOS, represents a major commitment of time. NANOOS leadership, Newton and Martin, as well as all of its PIs, actively engage to leverage and build

capacity for our existing systems. We can honestly say leveraging activities permeate daily practice throughout NANOOS. These include CMOP's NSF funding, UW's EPA-NEP funding, federal investments in NERRS, from NOAA's OAP, and state of Oregon and state of Washington funding.

Additional examples include:

The National Science Foundation Ocean Observing Initiative (OOI) project is progressing in the NANOOS region, as mentioned in the Progress Report, with gliders and buoys to be deployed. NANOOS has adapted its observing plan to take advantage of these additions, filling in gaps (e.g., see OR glider report in Progress Report) and assuring seamless data delivery of the OOI assets into the NANOOS data Visualization System service. This latter effort is not yet visible, but has received active attention to set up.

NANOOS led or participated in seven submissions to the FY14-15 FFO for Marine Sensor Innovation. NANOOS led two proposals, both of which were selected for funding. The HAB focused MSI proposal will include work with the NWFSC, tribes, and NANOOS' La Push mooring. The OA focused MSI proposal involving stakeholders was written in collaboration with three other RAs, AOOS, CeNCOOS, and SCCOOS, and involves leveraged shellfish grower and hatchery operations utilizing state directed OA monitoring funds in AK, WA, and OR.

NOAA Fisheries and the Ecosystem (FATE) program renewed funding for the JISAO-Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE) project, in which NANOOS is a partner, along with NOAA Northwest Fisheries Science Center and the UW-NOAA Joint Institute for the Study of Atmosphere and Oceans (JISAO). J-SCOPE produced a 6-9 month seasonal forecast of the ecosystem and ecosystem indicators identified by the California Current Integrated Ecosystem Assessment (IEA) on a regional scale, displayed through NANOOS' portal to present its results. Goals for this second period are to refine the skill of the model and to socialize the project with NANOOS fisheries management partners including WA and OR fisheries departments and tribes in both states. This ecosystem forecasting project links atmospheric and basin scale models with NANOOS PI MacCready's regional model as operated by JISAO researcher Dr. Samantha Siedlecki.

- **Update to NANOOS membership and Board of Directors**

NANOOS gained the following new members: VIU, Oak Harbor Middle School, plus ONC, Leidos. We are still working to get NOAA PMEL one year later

Our Board members have not changed during this period and they have stayed engaged. Per IOOS Supplemental Report guidance, we confirm that the NANOOS Governing Council Board affiliation types represented in the IOOS template is accurate and up to date: http://www.ioos.noaa.gov/regions/ra_membrshp_govern_template.xlsx.

- **Governance activities and accomplishments**

Newton and Martin held annual NANOOS meetings for all PIs and the Governing Council in Vancouver, WA on 19-20 August 2013. Newton coordinated with. J. Allan, User Products Committee Chair, to organize the Tri-Comm meeting, held 13-14 February 2014 in Portland, OR, hosted by OHSU. At these meetings, NANOOS reviews progress made to date, priorities for going forward, and tends to the business of NANOOS.

Newton has scheduled the all-PI and Governing Council meetings for 11-12 August in Vancouver, WA. The format will be PI discussion of issues on day 1; an overlapping meeting with PI and GC on morning of day 2 for NANOOS and IOOS updates; and a GC session on afternoon of day 3 for Council matters.

Our Governing Council Board members are completing the first year of their 3 year terms. We have one vacancy for NGO representative that we will seek to fill in our upcoming GC meeting in August 2014.

Academic:
David Martin, Governing Council Board Member for University of Washington
Mike Kosro, Governing Council Board Member for Oregon State University
Antonio Baptista, Governing Council Board Member for Oregon Health and Sciences University
State:
Carol Maloy, Governing Council Board Member for Washington State Agencies
Vicki McConnell, Governing Council Board Member for Oregon State Agencies
Tribes:
Paul McCollum, Governing Council Board Member for Tribes
Joe Schumacker, Governing Council Board Member for Tribes
Federal:
John Stein, Governing Council Board Member for Washington Federal Offices
Andy Lanier (acting), Governing Council Board Member for Oregon Federal Offices
Industry:
Casey Moore, Governing Council Board Member for Industry
Steve Uczekaj, Governing Council Board Member for Industry
NGO:
Fritz Stahr, Governing Council Board Member for Non-Governmental Organizations
Vacant, Governing Council Board Member for Non-Governmental Organizations
At Large:
Rich Chwaszczewski, SAIC, Governing Council Board Member At-Large
Chris Mooers, Portland State University Governing Council Board Member At-Large

Per our NANOOS MOA, the elected Board, plus the Chairs from the DMAC, User Products, Education and Outreach Standing Committees plus the Executive Director comprise the NANOOS EXCOM. Martin and Newton used the NANOOS EXCOM to obtain input and approval of the NANOOS budget for Y4 funds during 2014. Newton, using input from the Governing Council on priorities that had been established at the 2013 GC meeting, and having consulted by phone with all NANOOS PIs in early 2014, drafted a Y4 budget that was responsive to NANOOS priorities and reflected realistic operations. Martin, as Chair of the NANOOS Board, distributed this budget to the EXCOM, with the notation that near level precluded changes in the existing plan NANOOS chooses to sustain. Further, the modest increase, $50k, would be best invested in hardening DMAC, which serves all. The increase was distributed across the DMAC team to make investments in hardware and personnel to best serve NANOOS' needs. There was unanimous consent to adopt the budget.

- **Education and Outreach Activities & Training and Education Activities**

Per IOOS Supplemental Report guidance, we confirm that the NANOOS outreach and engagement activity information in the IOOS Education, Outreach and Training web tool is current and up-to-date and that the additional spreadsheet has been filled in and uploaded to the g-mail site.