Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS®:
NOAA Award: NA11NOS0120036 Reporting period: 6/01/2013 to 11/30/2013

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. 11];
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, E. Mayorga];
13) Support the Eye on Earth project, with the IOOS Program Office [ongoing, 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 and M. Alford, 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. 12-13, 15, and 20].

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 12:

Area	**Y2 Award = Y6 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 (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) -Work with the IOOS Program Office to begin development of a national glider plan and glider asset map (done) -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)

DMAC	
Web Site Improvement	-Enhance NANOOS help section (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 POST to improve access to animal telemetry observations (done) -Work with IOOS Office, EEA, and SECOORA re suitability of "Eye on Earth" for Citizen Science data in IOOS (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., CERF 2013) (met and on-going) -Support the SOS Reference Implementation workshop (on-going) -Support the Animal Telemetry Network Steering Committee Workshop (done)
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)

a) NANOOS Observing Sub-system: Data from all assets reported here are served via NANOOS NVS.

- ***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 upgrading and maintenance of the Cha'Ba surface and NEMO subsurface mooring components of this array. In late September, after a very successful 5-month deployment, Cha'Ba was recovered aboard the R/V Thomas G. Thompson (TGT) as part of a UW student cruise (J. Newton, Chief Sci.) on 22-25 Sept. The mooring was quicky re-furbished and re-deployed along with the upgraded subsurface profiling mooring on a short cruise from Oct 2-4th, also aboard the TGT. Both moorings remain deployed, though the real-time system on Cha' Ba ceased operation in mid-October due to an inexplicable loss of power, with planned recovery and re-deployment of both in early-to-late spring 2014.

A significant success during period is the new telemetry system of the subsurface mooring, which is now using a cell vs. VHF radio modem and has an improved surface expression. More than 95% of hourly

transmissions have been successful since deployment on October 3rd, sending profiler, CTD, and ADCP data.

The incredibly rich data set of the summer 2013 Cha'Ba deployment includes 3-second temperature measurements from more than 40 SeaBird temperature sensors, which were leveraged from a previous project and added to the mooring at vertical spacing of only 2 meters. This rich record of measurements resulted in an unprecedented set of observations for the Washington shelf, highlighting fine details of the vigorous and likely important non-linear internal wave field. Both Alford and graduate student S. Zhang attended the Gordon Conf. in Maine in August to present the findings on these waves from the 2010—2012 deployments. These waves have implications for the nearshore expression of hypoxia and ocean acidification.

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 cruise. Sensor data have been transmitted to the NOAA OA and PMEL Carbon Programs and to NANOOS.

During this period we collaborated with graduate student S. Bushinsky of UW Oceanography (advisor S. Emerson) through an NSF funded IGERT program to deploy 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, Seaglider group led by Dr. Craig Lee (APL-UW) operated Seaglider 187 from September 2012 through April 2014, completing 879 dived over an 8-month mission. Seaglider 108 was deployed on 24 September, 2013. The glider continues to operate flawlessly, completing nearly 500 successful dives along the 180km–long cross-shelf transect as of 20 December, 2013. NANOOS funds are insufficient for sustained glider operations off the Washington coast, but the team is working to execute one mission / year on the existing support.

Oregon Shelf Glider: The Oregon State University (OSU) glider group led by J. Barth and K. Shearman continued deployments of autonomous underwater gliders off Newport, Oregon. The Newport Hydrographic Line was sampled from about the 20-m isobaths out to 300 km offshore using a combination of a Slocum 200-m glider on the inshore part of the line and a 1000-m Seaglider on the offshore part. In contrast to previous years, the majority of sampling (80% of days and 66% of distance) was carried out over the outer shelf, slope and adjacent deep waters using a Seaglider rather than over the continental shelf using a Slocum glider. This resulted because the PIs' non-IOOS funded shelf work was discontinued in 2013. During Jun-Nov 2013, we collected a total of 185 glider-days of measurements along 2665 km of track. This included 5,819 vertical profiles and 19 cross-margin vertical sections. Oceanographic conditions off central Oregon were affected by unusually strong wind-driven downwelling during the month of September, which resulted in an early transition to fall-winter conditions when shelf waters are warm, fresh, and high in oxygen. The transition to glider operations on the Newport Line funded by NSF's Ocean Observatories Initiative (OOI) is anticipated to occur in early 2014.

Glider measurements are being used to monitor the dissolved oxygen content of upwelling source waters, that is the dissolved oxygen content of waters over the continental shelf that are subsequently upwelled onto the continental shelf by wind forcing. These source water values can be compared with measurements of near-bottom dissolved oxygen over the continental shelf to assess the degree of oxygen consumption by respiration as documented by Adams et al. (2013).

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.

Oregon Shelf Mooring: Led by M. Levine (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. During the summer of 2013, the winter mooring was re-designed to survive the harsh winter wave conditions. The main change was replacement of the surface flotation with a subsurface float, sacrificing real-time data delivery for mooring survivability.

In September 2013 on a cruise of the RV Oceanus the summertime mooring was recovered. The mooring measured a combination of atmospheric and ocean parameters. Ocean sensors measured temperature, salinity and water velocity at a number of depths. A few sensors measuring dissolved oxygen, turbidity and chlorophyll fluorescence were also attached. A meteorological package measured wind velocity, air temperature, atmospheric pressure, and incoming solar radiation. Some of these data were transmitted in near real time by a cell modem and delivered online through the NANOOS NVS—all data have been archived and are available. On the same cruise the wintertime mooring was deployed. Preparation is underway for the next deployment in April 2014.

On September 29, our friend and colleague Murray Levine, the lead PI for the NANOOS NH10 mooring, passed away, leaving a stunned group at NANOOS, OSU, and the wider ocean community. He will be sorely missed. Mike Kosro, who initiated the long-term NH10 program under GLOBEC, will take up the NANOOS lead.

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 402 days of glider operations. During the reporting period, we conducted two glider missions (May/June and August). Both missions were conducted with a new glider, replacing the one lost in April 2012.

SATURN-02 is a seasonal-configuration station. For this reporting period, it was deployed in its full interdisciplinary configuration in July 16 and returned to its winter configuration (surface CT only; no real-time data transmission) in October 4. 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 3832 profiles were collected from the buoy system during the report period. Significant progress was made towards redesign of the entire buoy system, which will increase robustness and reliability in the future; many upgrades will be implemented in the first half of 2014.

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. The Dabob Bay work was leveraged by a grant from the State of Washington to monitor surface water acidity and water column conditions as they might relate to shellfish hatchery failure. We also continued to provide support to the pCO_2 system operated at Dabob Bay and Twanoh in collaboration with NOAA PMEL (J. Mathis, R. Feely) by supplying a mounting system and collecting water samples to aid system calibration.

Moderate conditions for bottom water dissolved oxygen concentrations in southern Hood Canal continued through the 2013. During the fall oxygen concentrations were low at Hoodsport and Twanoh, but followed the average for the previous 5 years and no fish kill was observed. As observed in the previous report period, salinity and temperature trended with the average in southern Hood Canal, while at Carr Inlet both temperature and salinity were higher than the previous two years. These observations are important for State efforts to assess water quality and habitat.

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 had to eliminate the Mooring Coordinator position, a significant loss to the mooring program. We have been able to retain a dedicated Field Technician (S. Pool), partially supported by NANOOS funds.

Ecology maintained nearshore moorings in collaboration with research partners, including UW Applied Physics Lab, Everett Community College, and Western Washington University. Stations were strategically located to examine tidal, seasonal, and interannual patterns in temperature, salinity, fluorescence, and dissolved oxygen. In Puget Sound, we maintained moorings at Admiralty Reach, Mukilteo, Manchester, and Shannon Point stations with a focus on dissolved oxygen. The Admiralty Reach station was suspended in October with plans to resume in 2014. The Mukilteo station remains active with near-surface and near-bottom sensors and daily telemetry of real-time data to Ecology's website and NANOOS NVS. Budget cuts have required us to suspend several stations with no immediate plans to resume: the Manchester station with daily telemetry was suspended in July, the Shannon Point station was removed in August, and in Willapa Bay, one station was maintained until August 2013 when

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

it was suspended (however the USCG license to use the channel marker for the mooring was renewed for five years).

Ecology began 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 on the *Victoria Clipper IV* ferry vessel that runs twice daily between Seattle and Victoria, BC. Variables collected by sensors at 4-m depth include temperature, salinity, fluorescence, CDOM, and turbidity.

Observations in 2013 began with lower than expected oxygen conditions in Puget Sound that lasted well into July. During this period, massive and lasting *Noctiluca* blooms were observed in Central Sound (Washington State Department of Ecology, 2013). In previous years, *Victoria Clipper IV* en route ferry monitoring and ORCA buoy observations showed a strong decline in fluorescence in association with *Noctiluca* blooms, suggesting a large scale grazing impact of this species on phytoplankton biomass in Puget Sound (PSEMP Marine Waters Workgroup, 2013); this concept is being evaluated further to understand water quality and food web effects.

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 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 PAR sensors at SATURN-02 and (new this period) at Desdemona Sands, and an ACS 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 CT, 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 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 and NANOOS. The five water quality monitoring stations located along the estuarine salinity gradient provided continuous data over the period June 2013 - November 2013. Four of the water stations and the weather station are now equipped with telemetry systems.

This year we began partnering with one of our local tribes, the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians, which maintain two water quality stations in Lower Coos Bay. In April, we worked with NOAA and the NERRS Centralized Data Management Office to obtain permission and a GOES ID (NESDID ID # 346F229A; sosnswq) for this collaborative station. Equipment and site preparation occurred at the end of April and May with site visits made on 6/5/13 and 6/6/13 to install telemetry equipment and assess station performance. Data began transmitting on 6/6/13 and is available through the Hydrometerological Automated Data System (HADS). We are working with Emilio Mayorga to write program code to ingest the new collaborative North Spit station into NANOOS NVS.

Coos Estuary Water Quality Network and activities

Working in partnership with the U.S. Coast Guard (USCG), we began installation of telemetry equipment for the real-time Boathouse station at the mouth of Coos Bay. We are currently waiting on our licensing agreement with the Shore Infrastructure Logistics Center to continue installation of equipment. The protective casing for equipment was installed previously.

We are expanding the network of water quality stations to upper Coos Bay through the NERRS Science Collaborative Partnership for Coastal Watersheds project; we added four new stations this summer but

they are not real-time stations. The stations include North Point, Isthmus Slough, Catching Slough, and Coos River.

The water quality stations provide real-time data access for shellfish growers (North Bend and Coos Bay Oyster Companies, 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.

- **Shorelines**

Washington Shorelines: NANOOS funds contribute to the Washington State Department of Ecology's Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. In the beginning of June 2013, CMAP continued beach surveys for the Olympic Peninsula using funds leveraged from WDNR. CMAP partnered with Oregon State University (OSU) to complete beach profiles and nearshore bathymetry transects for Rialto Beach (45 profiles collected) and First Beach (16 profiles collected) to the north and south of the Quillayute River, La Push. Nearshore bathymetry data was also collected at Second Beach to be paired with the 32 beach profiles collected a few weeks prior in May. In addition, CMAP collected 18 beach profiles at Ruby Beach.

CMAP completed seasonal monitoring in the Columbia River Littoral Cell (CRLC) during spring and summer. The spring surveys were completed in June and included 47 beach profiles and two surface maps (North Head and Benson Beach). Between July and October, CMAP collected 49 beach profiles and 13 surface maps along with ~200 additional profiles to coincide with nearshore bathymetry transects collected by USGS and OSU. CMAP also collected 58 sediment samples from multiple cross-shore locations along 12 profiles. In July 2013, it was measured that the condos at profiles "Worm" in Grayland Plains were 50.6 m away from the scarp edge. The wave bumpers at Ocean Shores have become increasingly exposed which has raised concern over the erosion in the area. CMAP conducted a volume change analysis using 17 years of surface map data at Ocean Shores. Results show there was a large erosion event between summer 2010 and winter 2011 where the beach near the wave bumpers south to the jetty lost ~93,000 m^3 of sediment (41,000 m^3 more than the average). As of summer 2013, the beach has rebounded slightly (net accumulation ~40,000 m^3).

In mid September, CMAP worked with the USGS to collect 137 beach and nearshore profiles at the Elwha River mouth. This survey marked the first time ever that the river delta could be surveyed entirely by foot. There was no longer one main channel, but rather three small channels that could be easily crossed at low tide to get from one side of the river to the other. In October 2013, CMAP collected 12 large sediment samples from Benson Beach for the Army Corps of Engineers to be analyzed for tracer from the 2011 beach nourishment effort.

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 September (Rockaway cell (25 sites) and along the Clatsop Plains (6 sites)) and October (Neskowin cell (15 sites)) 2013. Furthermore, PIs Allan and Ruggiero collaborated in the September survey to collect updated nearshore bathymetric data in the Rockaway littoral cell. Data for the OBSMAP monitoring sites

are available through the NANOOS Visualization System[2]. 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.

During this period, problems with aging infrastructure continued to occur. For example, we continue to be plagued with ATV breakdowns (now 9 years old), often occurring in precarious locations out on the beach. Leveraging state agency funds, we replaced one of our GPS base radios with a newer version due to changes in FCC rules regarding narrow-banded radio frequencies (now illegal). 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 recent bathymetric surveys of the nearshore in Lincoln County is being used to assess the nearshore geomorphology for the purposes of determining where to safely land underwater cables as part of the establishment of a wave energy test site facility offshore from Newport, Oregon.

Nearshore Bathymetry: During summer 2013, P. Ruggiero's group at OSU collected nearshore bathymetry data along the four sub-cells of the Columbia River littoral cell (CRLC). Over 220 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). Approximately 400 kilometers of nearshore mapping took place within 10 days of field data collection. 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 PI Kaminsky's group at 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.

Also during summer 2013, Ruggiero's group collected nearshore bathymetric data along much of Curry County in southern Oregon. Over 100 individual cross-shore beach profiles were processed from the lower intertidal to ~25 m of water depth (~1500 m from the shoreline). These data have been combined with topographic data collected synoptically by PI Allan's group at 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.

Finally, in summer 2013 Ruggiero's group also collected 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). 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. This 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.

[2] http://nvs.nanoos.org/BeachMapping

The PWC based nearshore surveying system used by Ruggiero's group is now over 6 years old and the equipment is starting to show some wear and tear. In particular, the PWCs themselves have been driven for hundreds of hours in very demanding conditions and may only have one to two years left of being able to safely collect this data before needing to be replaced or extensively serviced.

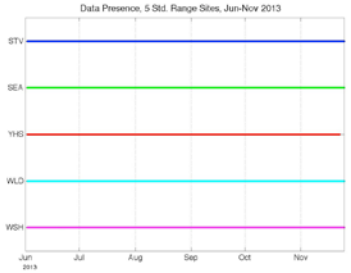
- **Currents**

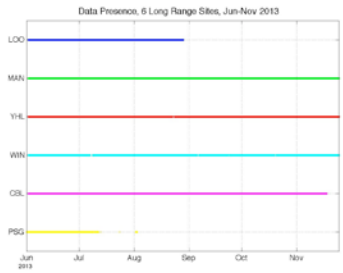
Coastal Currents: Surface current maps determined from an 11-site array along the Pacific Northwest coast continued to be obtained hourly, and provided to the public through NANOOS NVS, and via the national network to NDBC, the USCG, and other agencies. As project lead, Kosro (OSU) has continued the collaboration with our modeling partners (Kurapov group) by providing data for assimilation, and by working together to examine results.

Shelf HF currents were used to map a harmful-algal-bloom trajectory, explaining the presence and timing of an otherwise unsourced bloom off southern Washington, assuming it originated weeks earlier in a bloom imaged off Heceta Bank, in Oregon (Hickey et al., 2013). Also, we collaborated with Sung Yong Kim (Korea Advanced Institute of Science and Technology) to use HF measurements and a transfer function model to estimate length and time scales for the wind-forced near-inertial oscillations off Oregon (Kim and Kosro, 2013).

We are testing multi-static data collection and processing, as a test region for CODAR. To help in this effort, we initiated a campaign to update our measured antenna patterns, a logistically intensive task. We obtained measurements at 8 of the 10 sites which are accessible by small craft, have installed many patterns and are continuing to evaluate others. We confirmed the excellent repeatability of same-day-remeasured patterns with high signal-to-noise, and the larger changes in patterns over time. We also experimented with allowing more range cells at our standard range sites. This had the surprising effect of reducing the range for 3 of the 5 sites. We have scaled back to previous numbers of range cells. WIN1 needs a new amplifier for the transmitter, at a cost from CODAR of $10,400. We have moved the transmitter from a Priority 2 site temporarily, until later in the fiscal year.

We installed an AIS receiver at Cape Blanco, on loan from Marine Traffic.com, to provide vessel information via them and NVS. We are awaiting placement of the external antenna on site.
Two sites experienced extended outages during the reporting period: PSG (multiple simultaneous hardware problems, cables, connectors, GPS, antenna box, and modem), and LOO (used to fill in at other sites during repairs). LOO is due to be reinstalled in the next week, and the hardware for PSG is at CODAR for diagnosis and repair.





HF-R statistics for the reporting period

Port X-band Radar: The wave imaging radar at Newport South Jetty led by M Haller (OSU) has continued to operate and provide imagery of the wave conditions and wave spectral information to the NANOOS Visualization System on an hourly basis. In the last six months there have been sporadic, but brief, equipment-related outages. Thankfully, none of them have required major repairs.

Currently we are able to calculate 3D wavenumber-frequency spectra in the Nye Beach, Yaquina Inlet, and South Beach regions from hourly 256-rotation (~7 min) recordings. From these spectra and the estimated water depth in each region we derive peak wavelength, peak wave period, and peak wave direction. Work is in progress to calculate wave height and quantitatively report multi-peaked spectra.

We are also excited to report on our new radar installation at the Mouth of the Columbia River that is funded through a separate ONR project. This system is installed in the Coast Guard observation tower on Cape Disappointment. The much higher antenna elevation allows for a substantial increase in our observational footprint and an increase in the signal to noise ratio of the backscattered returns. We are typically configured to record a 6 km radius, which allows full coverage of the inlet, Benson Beach, and Clatsop Spit. We have arrangements to keep this station in place through June 2014 but are not funded beyond that.

We have received significant stakeholder interest in the Columbia River site. Specifically, we have been working with the Columbia River Bar Pilots (Dan Jordan) to develop a "front-imaging" data product. Our data has shown that current fronts are ubiquitous at the MCR and the Bar Pilots are directly interested in the front locations as they directly impact navigation, since they create sharp gradients in the surface currents. An example sequence of our front-imaging product has been stitched together into a movie and can be viewed on YouTube at: https://www.youtube.com/watch?v=pblzkrqozUE&hd=1.

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

There are three MSI project observing activities for FY13 that NANOOS is involved with:
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: After receiving funding in late August, Hales' efforts during the September-November time period were to initiate the fabrication of the shellfish-hatchery pCO2/TCO2 monitoring systems. Most of the major components have been purchased for all three systems, and fabrication of the first system, targeted for delivery to the Carlsbad Shellfish location in early February, has begun. The Hogg Island system will be developed in parallel and delivered in late February or early March. The Seward system will be constructed after that, and delivered in May.

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 completed the design of and began construction of a new version of the ORCA buoy hull, which will replace the fiberglass torroids presently deployed. The new hulls, which will be deployed in the spring and summer of 2014 at the Dabob, Twanoh and Carr Inlet locations, will allow easy integration of the Battelle pCO_2 system into the insulated foam hull, resolving present data-quality issues. The new, larger hull design also incorporates many design elements for added instrumentation capability, supporting collaboration and increased capabilities of the moorings. We will enhance one of the ORCA moorings to allow measurement of pH profiles, by integrating a SeaFET pH sensor with a profiling Seabird CTD.

3. Application and testing of new observing technologies for ocean acidification observing on deep water moorings off Oregon and Washington (the NH10 and La Push buoys) with an emphasis on high-quality data return and testing of water column sampling technologies.

B. Hales, OSU, lead for NH10 buoy: After receiving funding in late August, Hales' efforts during the September-November time period were to maintain and improve the moored observations of the carbonate-system chemistry of Oregon coastal waters. The two bottom-boundary-layer moorings were recovered in August, and all sensors have been recalibrated and re-installed, with a target re-deployment date of January 6th. The surface expression for the new MAPCO2-capable NH10 mooring is under design, with a planned deployment of April 2014.

J. Mickett, UW, lead for La Push buoy: We plan to add the capability to measure deep pH (70-80 m depth) to the Cha'Ba mooring and provide realtime data access for these new measurements.
In addition to allowing the integration of a pH sensor, with the purchase of the Seabird CTD we will be enabling year-round deep dissolved oxygen, temperature, salinity and pressure measurements, which is presently not possible on Cha'Ba because of limited instruments and the need for regular calibration and servicing. The new instruments are to be deployed with data available via the NANOOS Visualization System (NVS) in mid-spring following a Cha'Ba servicing cruise.

b) NANOOS Modeling Subsystem:

- **Shelf:** Computer circulation modeling of PNW coastal ocean shelf conditions has been conducted by A. Kurapov's group at OSU, which produces daily updates of 3-day forecasts of ocean conditions, including currents, temperatures and salinities through the water column (at 3-km horizontal resolution). The system has assimilated along-track altimetry from Jason-2 and CryoSat, hourly GOES SST, and surface currents from land-based high-frequency (HF) radars. Assimilation of Altika alongtrack altimetry was added during this period. 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.

Currently, the forecast model has a 3-km horizontal resolution. It is extended to 40.5-47N in the alongshore direction and is focused on the OR coast. We have continued testing 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. Initial assimilation tests using this system were performed.

- **Estuaries**

Puget Sound:
New NANOOS Co-PI, Dr. Parker MacCready (UW School of Oceanography), working with D. Jones (APL-UW) and Dr. Neil Banas (UW Joint Institute for the Study of Atmosphere and Ocean) are working toward the creation of 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 purchase a portion of a new 144-core linux cluster for the necessary dedicated parallel computation. 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 will also be supported by a new 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:

a. 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 are on-going 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.
b. 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.
c. 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, for submission in 2014.
d. 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 cycle. Peer-reviewed papers are in preparation to document the process, for submission in 2014

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). Team meeting activities for this period included: 1) IOOS DMAC Steering Team meeting (Nov 19-20), Uczekaj; 2) annual IOOS Regional DMAC meeting (Sep 10-12), Mayorga; 3) IOOS DMAC Joint Planning for FY2014 effort (Jun-Jul), Mayorga; 4) weekly NANOOS DMAC-UPC teleconferences, all team members.

NANOOS Visualization System (NVS) enhancements encompass asset additions and continuous updates: new near-real-time in-situ monitoring assets (NOAA-NWFSC Environmental Sample Processor data, NOAA PMEL CO2 sensor data from NDBC Cape Elizabeth buoy, Stillaguamish Tribe buoy, Vancouver Island University [Canada] shellfish research station), new forecast model ingests (UW NW WRF model and NCEP HYCOM), and many redeployments and upgrades. The NVS backend database and harvesting refactoring was nearly completed during this period; a new database schema is in place, and most of the data harvesting, asset monitoring and NVS access code have been updated. These upgrades will greatly enhance the scalability and portability of the NVS framework and underlying NANOOS DMAC infrastructure. In July we completed the "situational awareness" collaborative project with the Encyclopedia of Puget Sound and the NOAA ERMA team, delivering up-to-date, user-friendly map layers showing consistently aggregated in-situ data, such as daily near-surface water temperature and salinity averages; the layers are served to ERMA Pacific NW via OGC WMS[3], are accessible as standards-based services, and will be ingested by NVS in 2014.

[3] http://www.eopugetsound.org/blogs/new-geospatial-and-monitoring-features-eops

NANOOS and IOOS DMAC system implementation. NANOOS operationalized a new virtual machine (VM) scheme for deploying application environments that can be managed more flexibly. VM's were deployed for web-service software and NVS data harvesters and monitors. NANOOS also continued its participation in IOOS DMAC community implementation activities, including the completion of the Controlled Vocabularies wiki page, help with the new IOOS Github presence, a collaboration with Rich Signell (USGS) and others developing a cloud-based Python environment for ready access to and experimentation with IOOS data services, and an extension (with SECOORA) of the previous "EyeOnEarth" Python code base to harvest data from any data service compliant with IOOS SOS Milestone 1.

Biological Data (including animal telemetry). NANOOS, IOOS, the Ocean Tracking Network (OTN) and their regional, national and international partners presented the outcomes of this IOOS-supported project addressing animal acoustic tracking data at a workshop hosted by NANOOS on June 13, attended in person by NOAA, state agency and OTN staff, and remotely by a broad audience that included the Australian IMOS program. The ERDDAP and GeoServer pilot web services were presented and demonstrated live through access from different client software. The meeting was a great success, and project results are being operationalized by OTN.

West-Coast Coastal and Marine Geospatial Data. NANOOS collaborations with the West Coast Governors Alliance Regional Data Framework (WCGA RDF) initiative, SCCOOS and CeNCOOS strongly supported: the delivery of the first live version of the West Coast Ocean Data Portal catalog[4]; a new SeaGrant fellow funded by the WCGA, hosted by SCCOOS and supervised by NANOOS, who will focus on the application of oceanographic data to meet Ocean Acidification and Marine Debris information needs; and the 2nd RDF network meeting, Nov 19-20 in Costa Mesa, CA (Mayorga, 2013a & 2013b). Mayorga also participated in the Marine Portal Planning Network Meeting in Portland, OR, Aug 27.

Ocean Acidification (OA) Data. We continued to support OA data management activities (Mayorga et al. 2013). We overhauled NVS data harvesters from shellfish growers' assets and increased the number of OA-relevant assets ingested. NANOOS is also directly supporting the development of a greatly updated West Coast OA monitoring inventory, in collaboration with the new WCGA-WC RA's SeaGrant fellow. This activity seeds the work NANOOS will do on the MSI FY13 project for a West Coast OA data portal.

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.

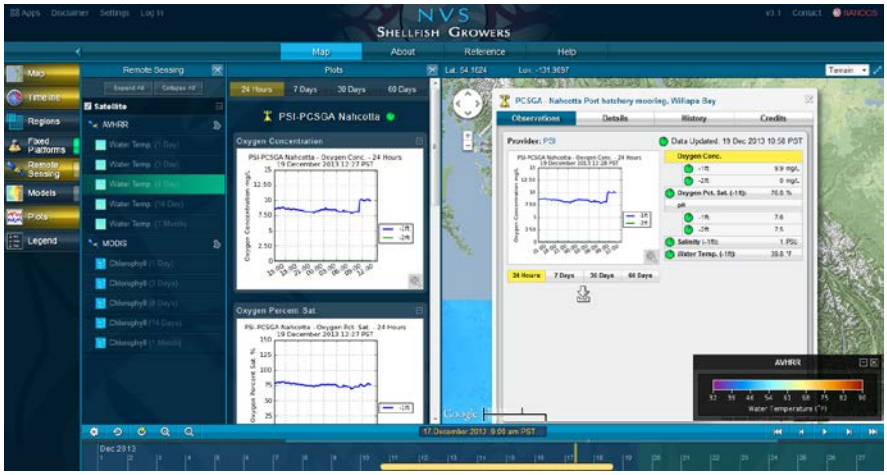
Chaired by J Allan (DOGAMI) this committee is composed of members from Boeing, OHSU, UW, OSU, NANOOS E&O, OR Sea Grant, and NOAA. NANOOS UPC chair Allan participates in weekly "tag-up" calls with a smaller sub-group comprised of members from DMAC, UPC, E&O, and Web development in order to facilitate consistent work efforts, synergy across the committees, and improvements to product development and enhancements. Activities for this 2013 period included: 1) multiple weekly NANOOS

[4] http://portal.westcoastoceans.org

DMAC and UPC teleconferences; 2) annual GC and All-PI meeting (Aug 19-20, 2013); 3) development of a UPC/DMAC planning document; and 4) commenced initial efforts at the development of 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).

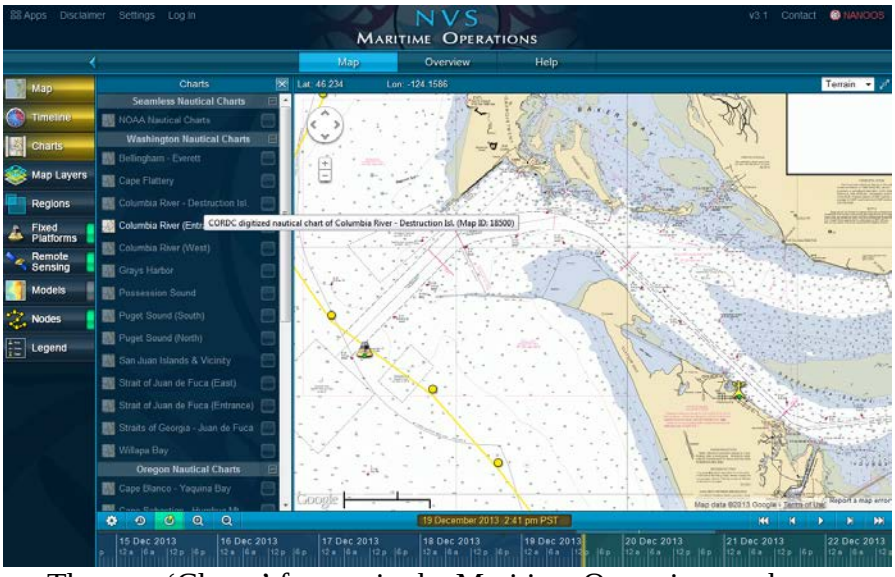
NVS: The backbone of the NANOOS RCOOS is the NANOOS Visualization System (NVS) that currently distributes data from a myriad of regional and federal assets. On June 26th, NANOOS released NVS v3.1, which included several enhancements to the overall data explorer experience, including one brand new web application targeting PNW shellfish growers (http://nvs.nanoos.org/ShellfishGrowers). The web app, designed expressly for the shellfish industry and with their input, integrates only those sensors that are of greatest interest to the industry, a new plot feature that allows multiple plots to be shown in a single column, and satellite information of water temperature and chlorophyll for multiple time frames.



The Shellfish Growers web app.

Another major feature included in v3.1 is the addition of a timeline feature located at the bottom of the web apps (depicted Shellfish Growers figure). This new capability enables the user to access recent model and satellite (overlay) data, as well as having the capability to run model forecast simulations. In time, we anticipate providing the user the ability to access time-series data from the various in situ instruments, using the same timeline functionality. However, development of this latter capability will require significant amount of time to implement and raises important questions about accessing and storing archived data.

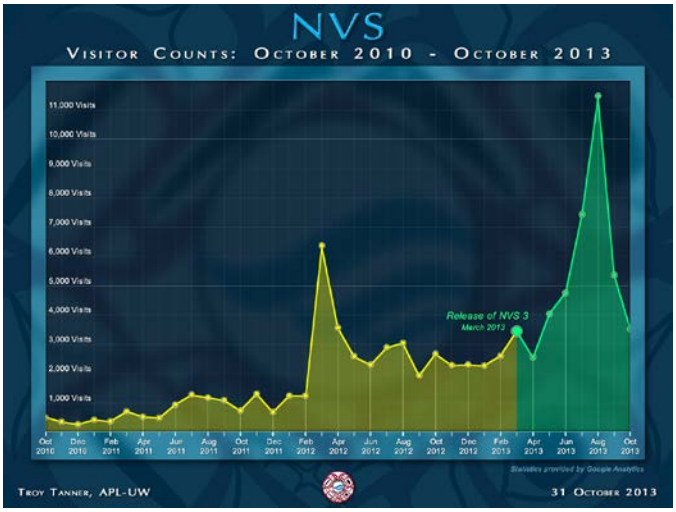
NVS v3.1 includes the addition of two new chart features, which may be interactively selected by the user in order to visualize nearshore and basin-wide bathymetry. This feature, unique to the Maritime Operations web app, includes: NOAA RNC charts,



The new 'Charts' feature in the Maritime Operations web app.

which dynamically change as the user pans and zooms; and, CORDC digitized charts that are manually controlled by the user. The latter provides slightly better resolution and detail compared with the former.

As noted in our previous report, a major effort over the past year has been the transition to an entirely new Google application programming interface (API), which necessitated a complete re-build of the NVS platform. The shift to the newer API (completed in March this year) has also necessitated ongoing refinements to the NVS database, which is presently underway. We anticipate having much of this completed during the next reporting period. Finally, interest in NVS by NANOOS stakeholders continue to climb, evident in the above figure, which shows numbers spiking at around 11,500 visits in August 2013, while the long-term pattern is one of gradual increase.



NVS visitor counts 2010 to 2013

Mobile Applications[5]: 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, significant enhancements were made to the Android version of NVS bringing it in line with the iPhone version. This version update was released in September. Minor enhancements were also undertaken to the Tsunami mobile apps during this period to correct a bug in the code. Discussions were had to release an updated version of the Tsunami app during the next reporting period. This latest version will include a complete listing of all the available tsunami evacuation zones in pdf form, which will make it easier for users to download to their smart phone.

Ecological Forecasting: Newton coordinated NANOOS participation in a project, J-SCOPE[6] which is featured on the NANOOS website. J-SCOPE, JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem, is a seasonal forecast system for the Washington and Oregon coasts, a partnership between NOAA's Northwest Fisheries Science Center, UW-JISAO and NANOOS-IOOS, funded by NOAA FATE. J-SCOPE forecasts SST, chlorophyll, hypoxia, pH, sardine habitat, and regional climate indices 6-9 months into the future. The NOAA FATE-funded project team, included modelers: (Samantha Siedlecki UW Coastal Modeling Group & JISAO, Nick Bond and Al Hermann, JISAO); fisheries scientists (Isaac Kaplan and Phil Levin, NOAA NWFSC); ocean acidification collaborators (Simone Alin and Richard Feely, NOAA PMEL) and NANOOS web designer Troy Tanner who worked to produce the web product.

As part of the NOAA FATE team, NANOOS will work with fisheries managers to evaluate this forecasting tool. We hope to obtain FATE funding to improve and test the model and then seek other funding

[5] http://www.nanoos.org/mobile_apps/index.php
[6] http://www.nanoos.org/products/j-scope/

sources to sustain this forecasting capability. Its release was featured in a UW press release[7]:

Newton also fostered a partnership between NOAA's Northwest Fisheries Science Center and NANOOS-IOOS to provide live data on harmful algae and pathogens at shellfish growing areas through NANOOS-IOOS via our NVS data explorer[8]. Data were obtained using an advanced robotic sampling and analysis unit called an Environmental Sample Processor (ESP). The team included Stephanie Moore, NOAA NWFSC lead PI of the project; John Stein, NOAA NWFSC Director & NANOOS GC member; and Emilio Mayorga & Troy Tanner, NANOOS DMAC, and Brent Roman, the MBARI software engineer, who collectively worked the electrons to allow the data serving. NANOOS is involved in a proposal response through the marine sensor innovation FFO to continue this work.

e) NANOOS Education and Outreach Subsystem:

In early June 2013, NANOOS E&O staff S. Messier left her position at UW-APL and NANOOS, decreasing the NANOOS funded E&O staff from 1.5 FTE to .5 FTE for the duration of this reporting period. Despite this decrease in staff, NANOOS education and outreach efforts continued through the efforts of NANOOS staff and NANOOS Education and Outreach committee members. Both Newton and Sprenger are active members of the NANOOS User Products Committee (UPC) and participate in the weekly DMAC/UPC conference calls. Sprenger continues participation in IOOS E&O calls.

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. See Appendix for pictures of these efforts.

- In mid June 2013 Sprenger along with UW research scientists Wendi Ruef and Gretchen Thuesen demonstrated technology at the WA State LASER (Leadership in Science Education Reform) STEM Explosion, a showcase for how different careers use science, technology, engineering, and math.
- 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. In June, Sprenger helped facilitate an OA curriculum workshop led by Suquamish Tribe and WA Sea Grant with middle and high school life science teachers where the group worked to link OA topics and curriculum into standard high school biology curriculum.
- Sprenger also continues to facilitate and promote using student built buoys as a research project for K-12 students both in and out of school. For the second year, Sprenger was an instructor with the WA Sea Grant led NOAA Science Camp, working with the Junior Leadership Program, the high school aged students, to design, build and deploy buoys near the NOAA campus on Lake Washington to answer student derived research questions. In October, Sprenger and Maile Sullivan, Education Specialist with WA Sea Grant, presented on the 2 years of NOAA Science Camp at the National Science Teachers Association conference in Portland. At this same NSTA conference, NANOOS partnered with OR Sea Grant, WA Sea Grant and NW and Aquatic Marine Educators (NAME) to host an exhibit table at the NSTA regional conference.
- In November Sprenger partnered with NANOOS member Ocean Inquiry Project (OIP) to provide a one day workshop for 12 middle and high school teachers called “Finding a Story in Data” aimed to help teachers become more comfortable and familiar with ocean data – how it is collected, where to find data online and how to look for stories within the data. The morning portion of the workshop was a 4-hour research cruise on Puget Sound collecting plankton, CTD data and bottle samples, with

[7] http://www.washington.edu/news/2013/08/30/new-ocean-forecast-could-help-predict-fish-habitat-six-months-in-advance/

[8] Robotic Sensing System Provides Real-Time Information On Harmful Algae And Pathogens: Now Available On NVS

an afternoon at UW, first at the Oceanography 101 lab doing density experiments and then in the computer lab working with data from the NANOOS Visualization System. OIP used funds from a grant (from The Russell Family Foundation) to cover the ship time and clock hours for the teachers.

Summary of Outreach Accomplishments: NANOOS outreach efforts have been focused on engaging with target user groups, including shellfish growers, and community members and supported the continued development of the NANOOS Visualization System.

- In September, Newton, Cathy Angell from Padilla Bay NERR and Sprenger presented on the NVS Shellfish Grower web app to the Pacific Coast Shellfish Growers Association annual conference. Sprenger also staffed an exhibit table for the duration of the conference, demonstrating the NVS SG web app to many growers, researchers and managers attending the conference.
- In November, NANOOS provided the "Great Build a Buoy Challenge" activity at the Seattle Aquarium's Discover Science Weekend. The buoy challenge was wildly popular with aquarium attendees with non-stop buoying making the entire day and over 100 parents and kids working together to do the challenge. See Appendix for pictures of these efforts.

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 was re-elected to the IOOS Association Executive Committee on and participates in those teleconferences. From November 6th – 8th, Martin and Newton participated in IOOS Association and IOOS Fall meetings at the Scripps Institution of Oceanography that covered a wide range of national and regional IOOS-related issues. A specific task requested by the U.S. IOOS office was for Dr. Craig Lee to work with the IOOS Program Office to develop a national glider plan and glider asset map. This work was completed by Lee and a draft has been produced.

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 participated in the annual site visit for this effort in Washington, D.C. this year during June.

Newton and Martin ran three NANOOS annual meetings during this period: the Tri-Committee meeting (April 2013, Seattle, WA), and Governing Council and all-PI meetings held back to back in Vancouver, WA, 19 and 20 August 2013. Martin served as Chair of the NANOOS Board during the GC Meeting. 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.

Newton was invited by the U.S. Senate Committee on Commerce, Science, and Transportation's Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard to testify on 11 June at their hearing "Deep Sea Challenge: Innovative Partnerships in Ocean Observation." She provided an overview of NANOOS and recommendations for the potential reauthorization of the Integrated Coastal and Ocean Observation System Act as well as testified on the implications of climate change on ocean waters, including ocean acidification and recommendations for the potential reauthorization of the Federal Ocean Acidification Research and Monitoring Act.

Martin participated in the semi-annual meeting on 17-19 June of the Ocean Networks Canada (ONC) International Science Advisory Board (ISAB). This Board provides guidance and counsel to the Canadian effort to field, evolve, and improve two research-focused ocean observatories (VENUS and NEPTUNE Canada) that simultaneously serve emergent operational societal needs. In this context, Martin provides both scientific expertise and as well as serves to communicate the U.S. experience with IOOS and operational ocean observing efforts that are part of the unique hybrid nature of ONC. ONC has now elected to participate in NANOOS GC meetings including the fall of 2013 meeting as a NANOOS member.

Newton and Martin welcomed IOOS Director Zdenka Willis to the PNW and other NANOOS members at OSU (Barth) and OHSU (Baptista) facilitated her site visits there. Zdenka was able to see observing assets in situ and visit with stakeholders, such as PNW shellfish growers, to hear their concerns on her visit in August 2013.

NANOOS PI and GC member Barth and Newton were appointed to the West Coast Ocean Acidification and Hypoxia Science Panel in July 2013 (http://calost.org/science-advising/?page=ocean-acidification-and-hypoxia-panel) and attended their workshop on 25-26 November 2013.

NANOOS PI and GC member Baptista co-chaired a national workshop (21-23 October 2013) held at FAU Harbor Branch Oceanographic Institute to launch Our Global Estuary, an initiative designed to:

- promote the role of estuaries as essential but sensitive elements of regional and global sustainability,
- facilitate the flow of information to enable management decisions that preserve the economic, ecosystem, and human experiential benefits of estuaries, and
- foster more consistent collection and use of data through development of a network of estuarine observation and prediction systems.

There were 50 invited participants (including several representatives of NANOOS and other IOOS regional associations) from the U.S. east and west coasts, the Gulf of Mexico region, Alaska, and Australia whose expertise included estuarine and coastal observatory science, technology, data management, and models; fisheries, biogeochemistry, and oceanography; resource management and policy; socio-economics; environmental law; tribal perspectives and culture; and education. A follow-up international workshop is being planned for 2015 to expand the initiative globally.

The Coastal and Estuarine Research Federation (CERF) 2013 meeting was well attended by IOOS and NANOOS representatives, including meeting vice chair Newton. She worked to organize: the Ignite session “The Power of Observations” featuring IOOS Director Zdenka Willis and 8 regional US stories highlighting IOOS pay-off; an ocean acidification symposium within the meeting, highlighting NANOOS region shellfish grower Alan Barton and contributed talks by NANOOS-affiliated scientists at OHSU, OSU and UW; and highlight this meeting to IOOS Association members and their stakeholders.

Additional coordination:

Newton was appointed Co-Director, with Dr. Terrie Klinger (UW), of the Washington Ocean Acidification Center at the University of Washington’s College of the Environment (URL) in July 2013. In this post she will coordinate OA observing within the state with regional (NANOOS & MSI-West coast activities) national (NOAA OAP) and global (GOA-ON) efforts.

Newton attended the second international workshop to develop a Global Ocean Acidification Observing Network (GOA-ON) on 24-26 July in St. Andrews, Scotland, UK. She is on the Steering Committee for GOA-ON, and helps to represent IOOS capabilities to this global effort. Newton will be presenting the highlights of the report “Global Ocean Acidification Observing Network: Basic Requirements and Governance” she is the lead author for at GEO in Geneva Switzerland, in January 2014.

Newton participated in several National Water Monitoring Network calls that concluded with the EPA leads for the NWM agreeing to link to IOOS for marine observations of the Network. Newton suggested that Josie Quintrell, IOOS Association Director, be part of the working group, and the integration effort was coordinated with Rob Ragsdale of the IOOS Program Office.

Newton participated in the NOAA OA PI meetings in DC in September 2013. While there, she was invited by COMPASS to be part of a panel to brief staffers of the House and Senate on OA on 20 September.

Newton continued to fill the Research seat as a member of the Olympic Coast National Marine Sanctuary Advisory Council, attended their meeting in November. She also worked on a sub-committee working group focused on ocean acidification monitoring and research needs.

Newton, a member of the Scientific Advisory Committee of the Joint European Research Infrastructure Network for Coastal Observatories (JERICO), reviewed their Trans National Access (TNA) proposals and as a member of the Selection Panel 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.

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

There were no changes in key scientific or management personnel for this period. Sarah Messier, NANOOS Outreach, left her position during this period and we are evaluating a replacement.

6) Budget Analysis

At the end of this reporting period, the project period for the NANOOS RCOOS Yr1-3 award was 83% complete and we have encumbered or spent 84% of the funds provided ($6,545,133). 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.

The actual invoiced expenditures at the end of this reporting period are $5,185,136, or 67%. This difference (83% vs. 67%) 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 is solid and suitable for maintaining robust execution of NANOOS plans to meet our objectives.

Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS®:
NOAA Award: NA11NOS0120036
December 2013 Progress Report Annual Supplemental
(The information request from IOOS Program office is underlined and in quotes)

- **Products and Services**

"The number and brief description of contributions to new or improved regional products or services, and national products or services:"

During 2013, NANOOS offered four new or improved regional products/services.

1. NANOOS Visualization System (http://nvs.nanoos.org/): NANOOS released NVS v3.1, which included several enhancements to the overall data explorer experience. See our Progress Reports for more information on NVS v3.1 and its associated apps.
2. PNW shellfish growers (http://nvs.nanoos.org/ShellfishGrowers): This web app, accessed through NVS, was designed expressly for the shellfish industry and with their direct input, integrates only those sensors that are of greatest interest to the industry, and provides a new plot feature that allows multiple plots to be shown in a single column, and satellite information of water temperature and chlorophyll for multiple time frames.
3. Maritime Operations (http://nvs.nanoos.org/MaritimeOps): This new web application targets the maritime community. The web app was designed with input from NANOOS GC members involved in maritime operations. The app includes the ability to use NOAA maritime charts as the background, and provides observations and enhanced forecasts of nearshore waves and currents applicable to the maritime and fishing communities.
4. J-SCOPE: JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE) is a seasonal forecast system for the Washington and Oregon coasts. This product represents a partnership between NOAA's Northwest Fisheries Science Center, JISAO and NANOOS, funded by NOAA's FATE program. J-SCOPE forecasts SST, chlorophyll, hypoxia, sardine habitat, and regional climate indices 6-9 months into the future. It was designed to support regional (federal, tribal, state) fisheries managers and the California Current Integrated Ecosystem Assessment.

Regarding national products, during 2013 Emilio Mayorga and Jan Newton participated in the IOOS and IOOS Association meetings, workshops and calls to assess priorities for national products. This culminated with a listing of prioritized national products and next steps forward.

- **Data Management**

"The Progress towards a standards-based foundation for DMAC capabilities:
-Demonstrated progress towards: open data sharing; provision of data to WMO GTS; implementation of a service-oriented architecture; use of common vocabularies and identifiers; improved use of metadata conventions; and data storage and archiving.
-On-going program-level participation in: data management planning and coordination; and IOOS maturity levels and certification standards."

NANOOS has made great progress towards a standards-based foundation for its DMAC capabilities, and has played a leading role in the development of national capabilities, in collaboration with the US IOOS Program Office, IOOS RA's and other cross-regional programs, and the hydrological and water quality communities engaged in the hydrological data standards like CUAHSI and WaterML 1 and 2.

NANOOS continues to make all its data holdings openly accessible via NVS custom, light-weight, JSON-based web services which will be published soon on a NANOOS portal DMAC page currently under development. In addition, plans for the overhaul of the NANOOS SOS service to comply with the IOOS

SOS Milestone 1 standard are in place, and will involve both the near-term adoption of the IOOS-supported 52North SOS server as an interim solution and the development of a Python-based data server that will leverage additional NSF support to Emilio Mayorga (NANOOS DMAC Lead) and linkage to the hydrological and water quality communities to deliver data in standards-based, interoperable forms to both the hydrological and marine communities (see project references here: http://www.nsf.gov/awardsearch/showAward?AWD_ID=1339834 and https://github.com/UCHIC/ODM2/wiki).

NANOOS Co-Chair Stephen Uczekaj is a member of the IOOS DMAC Steering Committee. E. Mayorga has been a leading member of the IOOS SOS Reference Implementation working group, and is one of the administrators and most active contributors to the IOOS DMAC *ioostech* Google Code wiki (http://code.google.com/p/ioostech/), the associated SOS XML template repository, *ioostech_dev* Google group, and IOOS vocabularies hosted at the Marine Metadata Interoperability Project (http://mmisw.org/ont/ioos). Mayorga delivered the final version of the IOOS Controlled Vocabularies wiki page (http://code.google.com/p/ioostech/wiki/ControlledVocabularies) in Fall 2013. In 2013 NANOOS also continued its contributions to activities on ocean acidification data management, discussions on IOOS certification, climatology common product development, irregular-grid modeling and data issues, biological data activities, and West Coast coastal and marine geospatial data partnerships, and IOOS international data integration activities.

Mayorga has co-led a system-integration and tools dissemination effort (https://github.com/ioos/ipython-notebooks) with Rich Signell (USGS), configuring, testing and developing Python-based tools for standards-based data access and integration, using the free, cloud-based "Wakari" environment (http://wakari.io) to provide access and a test environment for anyone in the IOOS community. In a related effort (https://github.com/ioos/ioossos2kml), NANOOS is collaborating with SECOORA and the IOOS P.O. to adapt the previous "EyeOnEarth KML" project to ingest IOOS SOS Milestone 1-compliant data services using Python tools, helping to improve those services and other IOOS system components in the process.

NANOOS, IOOS, the Ocean Tracking Network (OTN) and their regional, national and international partners presented the outcomes of this IOOS-supported project (https://code.google.com/p/ioostech/wiki/AnimalAcousticTelData) addressing animal acoustic tracking data at a workshop hosted by NANOOS on June 13, attended in person by NOAA, state agency and OTN staff, and remotely by a broad audience that included the Australian IMOS program. The ERDDAP and GeoServer pilot web services were presented and demonstrated live through access from different client software. The meeting was a great success, and project results are being operationalized by OTN. In addition, NANOOS collaborations with the West Coast Governors Alliance Regional Data Framework (WCGA RDF) initiative, SCCOOS and CeNCOOS strongly supported: the delivery of the first live version of the West Coast Ocean Data Portal catalog (http://portal.westcoastoceans.org); a new SeaGrant fellow funded by the WCGA, hosted by SCCOOS and supervised by NANOOS, who will focus on the application of oceanographic data to meet Ocean Acidification and Marine Debris information needs; and the 2nd RDF network meeting, Nov 19-20 in Costa Mesa, CA (Mayorga, 2013a & 2013b). As IT working group lead, NANOOS contributed directly to the technical specifications of the WCGA Portal catalog and has been leading the testing enhancement of its standards-compliant OGC CSW catalog service.

- **Observing Assets**

"Current inventory of all regional observing assets:"

A live, dynamic, up-to-date inventory of NANOOS Observing System Assets, both those funded by NANOOS and those funded by other parties but served through our system, is part of NVS. It is accessed from the NVS Data Explorer at http://nvs.nanoos.org/Explorer by clicking on the "Asset List" button on the top bar, at the center. This list is pulled live from NVS database. It currently shows a subset of all the

metadata information found on the NVS database, but the downloadable csv file ("Download Asset List" button) includes attributes not shown online, such as latitude & longitude. Note the sorting and filtering functionality, and the "History" column on the right, which displays complete asset status history via the "Show" link. Asset offline status is indicated by a grayed-out asset icon on the left. The same inventory is also available for download as a simple link under *About NANOOS > Documents > Key Documents* (http://www.nanoos.org/about_nanoos/documents.php), as "NANOOS Asset List" (http://nvs.nanoos.org/services/download_asset_list.php). A listing of recent (3 months) asset updates history is available via the NVS Asset History Web App at http://nvs.nanoos.org/AssetHistory.

The inventory and asset history are also available programmatically via the NANOOS/NVS SOS service documented at http://code.google.com/p/ioostech/wiki/NANOOSNVSPythonSOS; its *GetCapabilities* and *DescribeSensor* responses include much of the asset inventory and latest-status information available on NVS. This service is limited to *in-situ* assets at fixed locations having functioning near-real-time data streams within the previous several months. The NVS custom, lightweight JSON web services also provide the asset inventory and history information; these web services will be fully documented soon on a NANOOS Portal DMAC page currently under development.

Finally, older, static inventories are available from the NANOOS portal, including two inventories at these links:

- http://www.nanoos.org/documents/key/nanoos_asset_list.pdf
- http://www.nanoos.org/documents/key/nanoos_asset_list.xls

"A list of 'platforms of opportunity' that are being used to support monitoring of ocean acidification:"

NANOOS has compiled and continuously updates an inventory of **Pacific NW** telemetry-enabled assets directly relevant for ocean acidification monitoring. Near-real-time (NRT) data streams from most of these are already ingested into NVS, and most are available also on the new NVS Shellfish Growers Web App (http://nvs.nanoos.org/ShellfishGrowers); this web app was released in June 2013 as a complete overhaul and integration into the NVS framework, from a previous stand-alone Shellfish Growers application.

The set of directly OA-relevant assets is accessible from the NVS Data Explorer (http://nvs.nanoos.org/Explorer) by clicking on Filters, then scrolling down and selecting pH/pCO2 under "Variables". Current operational status is indicated via status colored icons, asset marker gray-out, and the asset status information. In 2013, NANOOS started ingesting into NVS PMEL CO_2 sensor data from the NDBC Cape Elizabeth buoy, and pH and other water quality sensor data from a Stillaguamish Tribe buoy in Port Susan (Puget Sound) and a Vancouver Island University shellfish research station in Baynes Sound (Strait of Georgia, Canada). We also initiated contacts and code development for ingesting PMEL pH & CO_2 sensor data based at the Seattle Aquarium, and high-quality pH, CO_2 and Omega sensor data from the regional network of shellfish growers at 3 sites in Oregon and Washington; these sites are currently offline for repairs, but NANOOS has overhauled the data harvesting code in preparation to ingest these when back online. NANOOS also initiated discussions with PennCove Shellfish (Puget Sound) and the NSF-funded OMEGAS project (CA & OR) to ingest their data streams into NVS. All these data streams are expected to be on NVS in the first half of 2014.

Additional information on OA monitoring in the Pacific NW is available from the NANOOS Ocean Acidification Theme Page, particularly at
http://www.nanoos.org/products/noaa_ocean_acidification/real-time_data.php and
http://www.nanoos.org/products/noaa_ocean_acidification/who_is_doing_what.php

At the West Coast scale, NANOOS is leading a collaboration with CeNCOOS, SCCOOS, the California Current Acidification Network (C-CAN), and the West Coast Governors Alliance on Ocean Health (WCGA) to overhaul and update the previous inventory compiled by the 3 RA's in 2012 (http://c-

can.msi.ucsb.edu/resources/links-to-california-current-environmental-data/c-can-asset-inventory). In November a new SeaGrant fellow started a positioned under the joint guidance of the 3 RA's and the WCGA, with a focus on marine debris and ocean acidification data and the joint supervision of Julie Thomas (SCCOOS Director) and Emilio Mayorga (NANOOS DMAC Lead). The fellow has already started building off the RA 2012 inventory and coordinating with similar, overlapping OA inventory efforts from the NOAA PMEL and the West Coast National Marine Sanctuaries. The greatly enhanced inventory will be available around Spring 2014, and will be integrated into a new online data access and visualization application being developed by NANOOS using the NVS framework and focusing on West Coast OA monitoring assets.

Presentations and Publications acknowledging NANOOS support: underline indicates NANOOS PI

Presentations:

Adams, K. and Barth, J.A. 2013: Physical versus biological contributions to hypoxic waters off central Oregon. Gordon Research Conference on Coastal Circulation, Biddeford, Maine, June 2013.

Baptista, A.M. (2013) Managing to timing, thresholds and change -- a view from estuarine and plume physics. Ocean Science Workshop. February 14, 2013. Portland, OR

Baptista, A.M. (2013) Predicting and steering environmental change - A global health challnege. 10th Annual Western Regional Health Conference. April 5, 2013. Portland, OR

Baptista, A.M., J.A. Needoba, M. Davis, M. Leinen. 2013. Estuarine "collaboratories:" regional and global perspectives. 2013 AGU Fall Meeting. December 12, 2013. San Francisco, CA [Invited]

Baptista, A.M., S. Frolov, T. Karna, J. Lopez, C. Seaton, P. Turner. 2013. You need results by WHEN ?!?? The 12th International workshop on Multi-scale (Un)-structured mesh numerical Modeling for coastal, shelf, and global ocean dynamics. Austin, TX [Keynote]

Barth, J. A., 2013: The influence of wind-driven upwelling and three-dimensional coastal ocean circulation on low-oxygen waters over the Pacific Northwest continental shelf. Gordon Research Conference on Coastal Circulation, Biddeford, Maine, June 2013.

Barth, J. A., O. Pizarro, K. Adams, and N. Ramirez, 2013: Comparing hypoxia over the continental shelves off central Oregon, U.S.A., and Concepción, Chile. North Pacific Marine Science Organization (PICES) Annual Meeting, Nanaimo, British Columbia, October 2013.

Green V, Bueno Watts N, Wegner K, Thompson M, Johnson A, Baptista AM. 2013. Coastal Margin Science and Education in the Era of Collaboratories. Currents. 28(3)

Karna, T., J. Lopez and A.M. Baptista. 2013. Modeling salt wedge dynamics in the Columbia River Estuary. The 12th International workshop on Multi-scale (Un)-structured mesh numerical Modeling for coastal, shelf, and global ocean dynamics. Austin, TX

Kurapov, A. 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.

Lopez, J., T. Karna and A.M. Baptista. 2013. Two approaches for capturing ETM dynamics in a partially mixed estuary. The 12th International workshop on Multi-scale (Un)-structured mesh numerical Modeling for coastal, shelf, and global ocean dynamics. Austin, TX

Mayorga, E. 2013a. West Coast IOOS Regional Associations: NANOOS. *West Coast Ocean Data Network Meeting, Costa Mesa, CA, Nov 19-20*

Mayorga, E. 2013b. Data diplomats in the West Coast Ocean Data Network: Data service facilitators. *West Coast Ocean Data Network Meeting, Costa Mesa, CA, Nov 19-20*

Mayorga, E., J. Newton, T. Tanner, R. Blair, C. Risien and C. Seaton. 2013. Addressing multiple marine data needs from local to national scales: The NANOOS/IOOS regional case illustrated with ocean acidification applications. *CERF2013, Coastal and Estuarine Research Federation Conference, San Diego, CA, Nov 3-7*

Mazzini, P. L. F. and Barth, J.A. 2013: Freshwater observations from underwater gliders off the Oregon coast during fall-winter. Gordon Research Conference on Coastal Circulation, Biddeford, Maine, June 2013.

Newton, J., C. Angell, and A. Sprenger. NANOOS and IOOS: Serving shellfish grower needs: we want your input! Pacific Coast Shellfish Growers Association Conference Oct 1 2013, Sun River, OR.

Sprenger, A. and M. Sullivan. "Observing Buoys by Students (OBS): An Authentic STEM Field Investigation". NSTA Regional Conference, October 24 2013, Portland, OR.

Publications:

Adams, K. A., J. A. Barth and F. Chan, 2013. Temporal variability of near-bottom dissolved oxygen during upwelling off central Oregon. J. Geophys. Res., 118, doi:10.1002/jgrc.20361.

Hickey, Barbara M., Vera L. Trainer, P Michael Kosro, Nicolaus G. Adams, Thomas P. Connolly, Nancy Kachel, Susan L. Geier, 2013. A springtime source of toxic Pseudo-nitzschia cells on razor clam beaches in the Pacific Northwest. Harmful Algae, 25:1-14. doi: 10.1016/j.hal.2013.01.006

Kim, Sung Yong, and P. Michael Kosro, 2013. Observations of near-inertial surface currents off Oregon: decorrelation time and length scales. Journal of Geophysical Research, 118, doi: 10.1002/jgrc.20235.

Kurapov, A., P. Yu, K. R. 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., submitted.

PSEMP Marine Waters Workgroup. 2013. Puget Sound marine waters: 2012 overview. S.K. Moore, K. Stark, J. Bos, P. Williams, J. Newton, and K. Dzinbal (Eds). http://www.psp.wa.gov/downloads/psemp/PSmarinewaters_2012_overview.pdf

Washington State Department of Ecology. 2013a. Eyes Over Puget Sound, Surface Condition Report, June 17, 2013. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2013_06_17.pdf.
July 15, 2013. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2013_07_15.pdf
August 21, 2013. http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2013_08_21.pdf
September 11, 2013. Publication No. 13-03-078.
http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2013_09_11.pdf
October 28, 2013. Publication No. 13-03-079.
http://www.ecy.wa.gov/programs/eap/mar_wat/eops/EOPS_2013_10_28.pdf
November 21, 2013.
ftp://www.ecy.wa.gov/eap/Flight_Blog/latest_pictures/EOPS_2013_11_21.pdf

Appendix: NANOOS Outreach and Education Pictures

NOAA Science Camp 2013:



NSTA:

Our NANOOS presentation was one of the featured presentations at NSTA.

One of the small groups from our NSTA session working through a scenario:

Finding a Story in Data Workshop:

Teachers lowering the CTD, and sharing a story they found in the UW PRISM data available on NVS


Discover Science Weekend: