Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS®:
NOAA Award: NA11NOS0120036 Reporting period: 12/01/2014 to 5/31/2015

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 FY14 period (= Y4 of award; Y8 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 our FY14 de-scope letter from the IOOS Program Office, NANOOS has the following additional tasks during FY14:
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 [M. Kosro, OSU, see p. 15-16];
11) Support collection of OA measurements on our La Push [J. Newton, J. Mickett, UW, see p. 3-4] and NH10 [B. Hales, OSU, see p. 5-7] moorings, working with NOAA PMEL and the NOAA OA Program Office through the IOOS Program Office.

2) Progress and Accomplishments

During the project period, NANOOS accomplished its 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 allowed.

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 14*:

Area	**Y4 Award = Y8 NANOOS**
Observations	
Shelf:	-Maintain La Push, Newport, and Columbia R. buoys and deliver NRT datastreams via the NANOOS Visualization System (NVS) (on-going) -Support collection of OA data from La Push buoy and NH-10 buoys (on-going) -Maintain WA and OR glider transects (except funds are insufficient for maintaining La Push, WA glider) and deliver these datastreams via the NVS (on-going) -Transition Newport, OR glider to Crescent City, CA. (Completed, *see p. 4*)
Estuaries:	-Maintain Puget Sound, Columbia R., and South Slough moorings and deliver these datastreams via the NVS (on-going)
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/WAestuaries and coast models	-Maintain modeling & forecasting capabilities at OSU, OHSU, & UW at reduced level and make model output available via the NANOOS web (on-going) -Transition Salish Sea model to operations *(In process, see p. 17 for update)*
DMAC	
Web Site Improvement	-Sustain and refine (on-going)
Tailored Product Development	-With E&O committee, evaluate usefulness of web and product suite (on-going)
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	-Execute evaluation of web site and product suite (on-going)

Engagement	
Administration	
Meetings	-Represent NANOOS at all NOAA IOOS, IOOS Association, and national meetings of significance (e.g., MTS/IEEE, Ocean Sciences) (met for FY14 and on-going)
Project oversight	-Conduct regular PI meetings, annual Tri-Committee meeting, and assist with evaluations, as scheduled (met for FY14 and on-going) -Assess whether focus on hypoxia, HABs, OA, biodiversity investments are providing enhanced and valuable information (met for FY14 and on-going)
Coordination	-Conduct annual Governing Council (GC) meeting (met and on-going) -Conduct sub-regional, and user-group specific workshops 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 for FY14 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 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 the deployment of the Cha'Ba surface and NEMO subsurface mooring components of this array. Both moorings were successfully deployed in late May from the R/V *Thompson*, with ship time generously donated by the UW School of Oceanography. Over the winter both moorings were overhauled, with substantial maintenance work conducted on the surface mooring, Cha Ba, which is now entering the 6th year of deployment. Addressing power shortcomings of the subsurface mooring controller for extended deployments, we upgraded the main battery pack with higher-capacity batteries to provide 75% more power. The most significant upgrade of the mooring system, however, was the addition of a deep pH sensor, specifically a Satlantic SeaFET, at 49 m depth on Cha'Ba. Interfacing this sensor with an underwater inductive modem allows near real-time data telemetry with pH observations presently accessible via NVS. Both mooring systems are working well at the time of writing this report, with an anticipated recovery in October or November 2015 from the R/V *Thompson*.

With the onshore movement of the so-called "blob" of anomalously warm water measured in detail by this mooring pair prior to mooring recovery in late October, 2014, there was significant interest in and motivation to share these observations. Newton presented these data at a West-Coast-wide "blob" workshop in May, while Mickett presented these data and other observations at the Puget Sound Ecosystem Monitoring Program (PSEMP) annual meeting in April. Mooring observations also showed a key link between southerly wind events, current reversals (northerly switching to southerly currents), and local decreases in deep dissolved oxygen at the mooring site.

Outreach and collaboration efforts over this period were numerous. With assistance from A. Sprenger and R. Vander Giessen of APL/UW, we were able to recruit more than 20 students, educators and other volunteers for the 3-day mooring deployment cruise in May, making this cruise a highly-successful outreach opportunity. Volunteers were quickly immersed in the hands-on oceanography we carry out on these cruises including CTDs, mooring deployments, glider deployments, and seawater sample analysis. Biologist J. Hagen of the Quileute Nation was also able to participate in the cruise, collecting

numerous surface water samples to investigate phytoplankton species distribution and for HAB/toxin analysis. Aboard the *Thompson*, Newton and Mickett together gave a well-attended overview presentation of the formation and evolution of the "blob", showing moored observations, and also presented a general overview of the mooring system. Finally, we were also able to support an Oregon elementary school science project by deploying a small, satellite-tracked sailboat.

Again the PIs collaborated with the NOAA Olympic Coast National Marine Sanctuary (OCNMS) to deploy 5 temperature sensors on 2 of their inshore moorings, with these data providing important spatial information on both internal wave patterns and mesoscale structure on the shelf. During this period we also continued collaboration with graduate student S. Bushinsky of UW Oceanography (advisor Dr. S. Emerson) through an NSF funded IGERT program to continue the deployment of a prototype self-calibrating DO measurement system on Cha'Ba.

J. Newton (APL-UW) and J. Mickett have continued to work with NOAA PMEL scientists Drs. Adrienne Sutton, Simone Alin, and Richard Feely, to maintain pCO_2 and pH datastreams and provide calibration samples for NOAA OAP-IOOS Ocean Acidification Monitoring. Sensor data have been transmitted to the NOAA OA and PMEL Carbon Programs and to NANOOS. Using Cha'ba data, Washington Ocean Acidification Center (WOAC) postdoc Dr. Beth Curry has continued work with the PMEL Carbon Group to test pH proxies on the Washington Shelf.

Finally, in March Newton and Mickett received word from NOAA OAP that a build-out proposal to construct and deploy a "winter" Cha'Ba mooring was selected for funding. This work would begin in 2015 with the first deployment in the fall of 2016, allowing year-round real-time measurements at this mooring site.

Washington Shelf Glider: The Applied Physics Laboratory, University of Washington, Integrative Observational Platforms group led by C. Lee (APL-UW) launched Seaglider 187 on 25 June, 2014 and recovered on 15 February, 2015 after completing 890 dives (1780 profiles). A premature fall-off in battery voltage (a sign of impending depletion) forced an early end to this mission. The IOP team is running tests and working with the battery vendor to identify the mode of failure in the battery pack. SG187 was refurbished and redeployed on 16 June, 2015. At the time of this report, the glider has collected 44 profiles.

Oregon Shelf Glider: Starting in early December, 2014, the Oregon State University glider research group led by J. Barth and K. Shearman (OSU) is obtaining vertical sections of ocean properties from off Trinidad Head, CA (41° 3.5'N) using an underwater glider. We use a 1000-m capable Seaglider equipped with the following sensors: CTD, dissolved oxygen (Aanderaa 4831 optode), light backscatter (700 nm), chlorophyll fluorescence and Colored Dissolved Organic Matter (CDOM) fluorescence (WET Labs Ecopuck). The gliders also measure depth-averaged velocity which can be combined with geostrophic estimates of relative velocity to get absolute velocity and hence transport. The glider is flying from approximately the 100-m isobath (~10km offshore) to 130W (~500 km offshore), repeating the line every 30 days. We are collaborating with Dr. Eric Bjorkstedt (NOAA Southwest Fisheries Science Center, Humboldt State University) to facilitate field work off Trinidad Head. We are using two of our Seagliders in order to "hot swap" them on the line when their batteries run low. During this reporting period, this effort is jointly funded by NANOOS, CeNCOOS, and SWFSC.

From its first occupation of the TH line on December 4, 2014, until the end of this reporting period, the glider was on the TH line for 179 days during two deployments, sampled along nearly 3000 km of track

line covering the transect about 6 times, and collected about 1800 vertical profiles of ocean properties. Data are being sent in near real-time to the IOOS Glider Data Acquisition Center and, simultaneously, to the NANOOS and CeNCOOS data centers. When an individual glider deployment is complete, we submit the data to NODC.

Data from the Trinidad Head glider line (Barth and Shearman) was used to contribute to the "2014-2015 Pacific Anomalies Science and Technology Workshop" held on May 5-6, 2015, in La Jolla, CA. The glider data show that for the January to April 2015 period, the average 50-m temperature was 1-3 degrees C warmer than the historical average across the entire glider line out to 500 km offshore. Temperatures over the continental shelf varied from above normal to average, due to wind-driven coastal upwelling bringing cold, deeper water up to 50-m depth.

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

The fall mooring deployed on Oct 12, 2014 was recovered on Mar 16, 2015, with a duration of 154 days. Mooring scope was increased for that deployment to decrease the translation of moorings due to severe winter storms (waves in excess of 22 feet). During that deployment, the buoy was subjected to surface waves of 30 ft. on Oct 25, and again on Dec 11, with waves exceeding 22 ft on Dec 10. There was one event of buoy movement, less than 3km in the Dec 10-11 storm, along-isobath, but otherwise it did not move; this is an improvement over behavior under previous deployments with less scope. Between recovery and redeployment on Mar 29, several startup problems with the new buoy design were corrected. The heavy rudder was removed to reduce the buoy's tilt; the frame was reinforced at several stress points; a lighter, more compact and modern weather station was incorporated and similar improvements were made to the buoy light; the data telemetry routines were largely rewritten. The result has been a strong improvement in the reliability of the data collection. Credit is due the whole team (techs Arnesen and Hubbard, machine shop personnel Russell and Simpkins). Hales did the reprogramming of the telemetry system and oversaw mechanical improvements. Resources are clearly needed for a duplicate MAPCO2 buoy, which would allow us to make a "hot swap" of the mooring at turnaround.

In addition to the physical oceanography and meteorological measurements under this project and the biogeochemical measurements under Hales program, the mooring is hosting a bio-optical package from Angelique White's lab at OSU.

In May, Kosro gave a presentation, co-authored by Craig Risien, using the NH10 data and other regional buoys to describe the arrival of the Warm Pacific Anomaly (aka The Blob) in coastal Oregon waters in Fall of 2014.

B. Hales leads the pCO_2 measurements from the NH-10 buoy for NOAA OAP-IOOS Ocean Acidification Monitoring in Cascadian Coastal Waters. Work on this project continues to be centered on the operation of the MAP-capable NH10 mooring. As of the December Progress Report, we had built the new small-footprint mooring and deployed it in October of 2014, and showed time-series and validation data through 19 December. Shortly after that time, an intense winter storm hit the mooring, with winds over 60-kts and combined waves over 10 m with very short period. This is exactly the kind of weather that in the past had led to the failure of previous designs of NH10 winter moorings, with moorings that broke

free from their anchors, 'hopped' the mooring package great distances to the NNE, or were lost altogether. The new mooring survived this storm event, with only a slight (< 1 nautical mile) northward hopping. However, the MAP equilibrator was damaged such that water entered the intake lines and no useful surface xCO2 data was collected after 22 December. Other data were recorded, and discussed in the Progress Report submitted by Mike Kosro.

The mooring was recovered, refurbished and redeployed in March of 2015, and continues recording data currently (Figure 1). However, the MAP battery pack failed in late April, and sea states and scheduling limitations prevented accessing the mooring to replace the battery pack until 19 June. During this service operation (Figure 2) we were able to download the continuous pH record captured by the SAMI-pH instrument on the buoy.

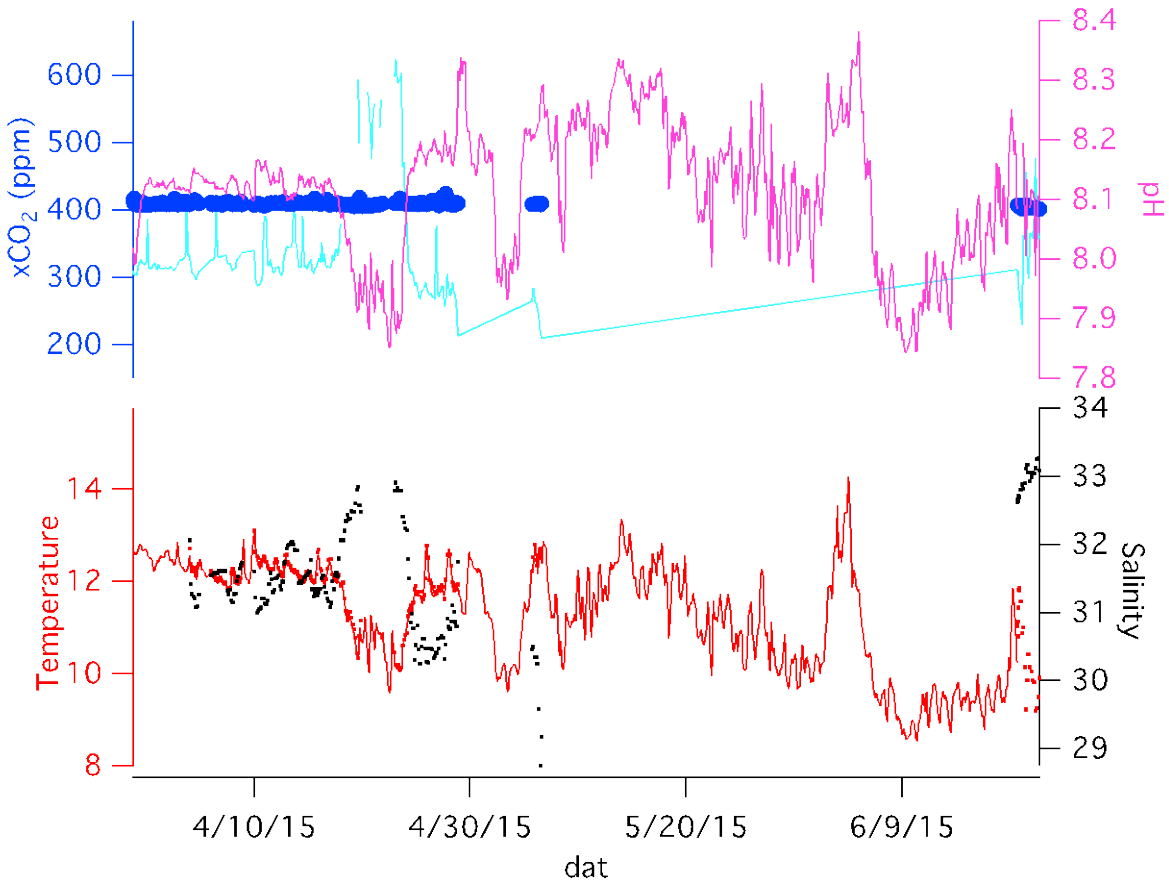
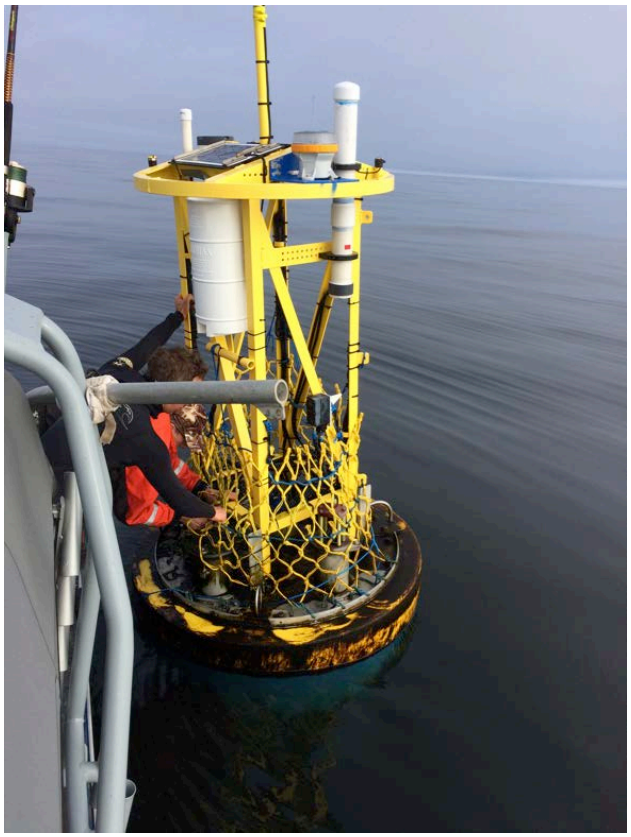


Figure 1: Time-series from NH10 MAPCO2 mooring showing surface water and atmospheric pCO2 (cyan line and solid blue circles, respectively), pH (magenta line), temperature (red) and salinity (black). The interval from 4-30 through 6-19 corresponds to a time when the MAPCO2 system battery failed, and only data stored in the SAMI-pH instrument was collected. A new battery pack was installed in the field on 6-19

The data (Figure 1) show the fairly typical winter conditions of relatively high pH (~8.1) and low xCO2 (~325 ppm), along with moderate salinity (31) and the relatively high temperature waters of the anomalous 'warm blob' (T > 12C) until about 15 April, when an early upwelling event led to high S, low T, high xCO2 and low pH. Following that event, the typical fluctuations of properties continued typical of the spring season before upwelling begins in earnest until about 15 May, with at least one more weak upwelling event, and onshore-offshore oscillations of shelf and warm-blob water. Distinct from the earlier expressions of the blob, however, are the significantly higher pH values associated with the warm-blob waters, over 0.2 pH units higher than similar-temperature waters in the earlier part of the



record. This can only be the signature of productivity associated with the increasing insolation and water column stability with the onset of spring. Persistent upwelling began on 15 May and temperature and pH monotonically fell until a strong reversal brought warm, high pH blob-waters back onshore for about a week until a particularly intense period of upwelling brought cold, low-pH upwelled waters back to the mooring on about 8 June. However, this upwelling event appears to have been accompanied by an increase in productivity, as the pH began to rise while SST stayed cold.

Figure 2. Small-boat service of NH10 mooring in the field.

The accessibility of the NH10 mooring and the current design allow the mooring to be serviced with a small vessel, when weather conditions permit (Figure 2). We were able to replace the MAP battery pack and retrieve data and restart the systems. We were also able to confirm the tremendously high productivity in the area, based on the intensely brown-pigmented water at the mooring, as well as the close proximity of the clearer warm-blob water, which will likely lead to rapid transitions as sub-mesoscale fronts move past the mooring.

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.

SATURN-02 is a station with seasonally changing configuration. The more robust, interdisciplinary and real time configuration is typically in May/Jun through Sep/Oct. For this reporting period, SATURN-02 was deployed in an interdisciplinary configuration starting May 24. 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.

Glider operations have historically been seasonal (April-September), driven in part by collaboration with the Quinault Indian Nation, and focused on characterizing shelf hypoxia for fisheries management. The glider operations are also important for model calibration. Since May 2009, we have had 425 days of glider operations. No glider missions were conducted this reporting period, but the existing glider was refurbish and a second glider was acquired (with NSF funds) to replace one lost in operations in a prior year. A glider mission is scheduled for late June 2015.

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 J. Mickett, J. Newton, and A. Devol (UW), during this report period the ORCA (Oceanic Remote Chemical Analyzer) mooring system continued to undergo significant refurbishment and upgrade, with meteorological stations added to three of the moorings (funding support from the non-profit Long Live the Kings) and two SeaFET pH sensors added to the Carr Inlet mooring (funding support from NANOOS, NOAA OAP and the Washington Ocean Acidification Center). We collaborated with SeaBird Electronics to integrate one of the SeaFETs with the profiling CTD on the Carr Inlet ORCA mooring as part of our FY13 OTT funds that had been stalled due to industry need for sensor integration, now accomplished. Although we are still conducting engineering tests and analysis of this integration, it has largely been successful allowing deep pH values (45 m) at the Carr Inlet mooring and possibly near real-time profiles of pH. During this period we also tested a prototype ORCA mooring that is equipped with a buoyancy-driven float (the APL Mixed Layer Float, or MLF) instead of a winched CTD package. The float, which is equipped with on-board telemetry and power, profiles along a guide line hung from the mooring superstructure. The MLF is able to conduct roughly 10-12 profiles per day in 100 m of water, which is up to 10 times the possible sampling rate of the winched system in the winter months. We will continue to deploy this system into the foreseeable future.

During this period we launched an organized, formal effort to increase mooring reliability and to decrease maintenance costs, addressing the "low hanging fruit" upgrades including an improved, compact cellular modem that can now be housed within the sealed the buoy controller case, a new lower power, weatherproof and more robust winch control box, and circuit protection systems to prevent irrecoverable battery depletion. Although these and other upgrades will take another 6 months to fully implement, they should significantly increase the operational time of our moorings, with a goal of 90% coverage. It is important to note that much of this work has been accomplished with significant contributions from non-NANOOS funding sources such as NOAA OAP and the Washington Ocean Acidification Center.

In late March Mickett presented an overview of the ORCA system a synthesis of what we've learned from a decade of ORCA observations in Hood Canal to the Hood Canal Watershed Education Network (HCWEN) in Port Townsend. In April Mickett, W. Ruef, Newton and Devol then presented 2014 ORCA observations at the Puget Sound Ecological Monitoring Program annual meeting. Noteworthy for 2014 was the anomalously cold and high-dissolved-oxygen deep water of Hood Canal, which formed in the winter as a consequence of prolonged sub-freezing air temperatures along with low rainfall/freshwater input. With a wetter than average spring, this cold, high salinity anomaly was erased by the end of the summer, with ORCA moorings showing a particularly weak fall intrusion of the anomalously warm coastal waters into Hood Canal---the start of a period of anomalously warm and low-density water Puget Sound-wide.

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

We continued to collaborate with the NOAA PMEL Carbon Group (A. Sutton, S. Alin, R. Feely) to support the deployment of the pCO_2 systems operated on the Twanoh and Dabob Bay moorings through system maintenance and collection of water samples to aid system calibration.

Washington State estuarine monitoring: Participation by the WA State Department of Ecology's (Ecology) Marine Waters Monitoring Program is directed by C. Maloy (Marine Monitoring Unit Supervisor) and led by C. Krembs (Senior Oceanographer). Due to a tight budget, Ecology continues to have only one staff, a dedicated Field Technician (S. Pool), partially supported by NANOOS funds.

Ecology is using ferry vessels as a means of cost-effective and representative data collection. En route ferry-based monitoring is valuable because it can capture near-surface events such as blooms, river input, and tidal exchange over a large geographic area and at a fine-scale temporal resolution. Ecology has two sensors and a GPS on the *Victoria Clipper IV* passenger ferry vessel that runs twice daily between Seattle and Victoria, BC. The 80-mi ferry transect has enabled us to temporally resolve the dynamic and interplay of algal and *Noctiluca* blooms, tidal excursions, isotherms, and event-driven freshwater exchanges between Central Sound and Strait of Juan de Fuca. It is also an important asset to acquire daily high-resolution ground truthing information to calibrate satellite images. Data are uploaded daily to a cloud computing server at: http://107.170.217.21/VictoriaClipper30/level0/. We are leveraging some EPA NEP funds towards developing a NetCDF database, which will be a repository of ferry-based monitoring data, with help from APL-UW and with the aim to provide and serve these data via NANOOS. Ecology staff started development of data products and QA/QC methods. To ensure continuous quality of measurements by one fluorometer, we are working with Clipper Navigation, Inc. on installing a parallel fluorometer for QA/QC purposes and data comparisons. Developing this installation began during the vessel's annual dry-dock maintenance in March. . Data products are included in the monthly "Eyes Over Puget Sound" reports. This spring, isothermal conditions appeared across Central Basin and in the Straits (Figures 3 and 4). Phytoplankton (i.e., chlorophyll fluorescence) was observed as early as February in Central Basin before declining (Figure 4). We submitted two poster abstracts describing ferry-based observations in physical and ecological context at the upcoming Coastal and Estuarine Research Foundation meeting.

Ecology maintained its sole nearshore mooring station in Mukilteo, with daily telemetry of real-time data to Ecology's website and NANOOS NVS. Collaboration with Everett Community College and Port of Everett gives a great opportunity for community outreach and training of young professionals in environmental monitoring. The station is uniquely situated between Central Sound and Whidbey Basin. It monitors the dynamic water exchange between the basins and water quality attributes of the Skagit/Snohomish River plume. In January, we added a fluorescence-turbidity sensor to detect changes that may occur during the Old Tank Farm Pier removal and subsequent WSDOT ferry terminal construction on the Mukilteo waterfront. Temperature declined through winter before warming into spring. It is now warmer than the past five years at this station in response to a massive exchange of warm water from "The Blob" and 1.5 to 2 °C warmer than normal water across Puget Sound. Salinity was slightly variable. Dissolved oxygen increased over time with more variation in May. Current budget requires continued suspension of the Admiralty Reach, Manchester, Shannon Point, and Willapa Bay stations. We continued the moorings program's contribution to the monthly "Eyes Over Puget Sound" reports.

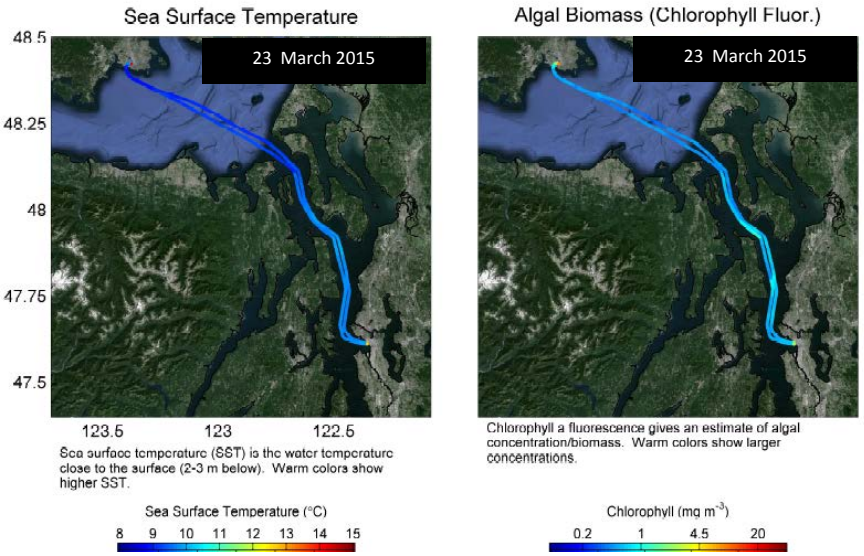


Figure 3. On 23 Mar 2015, isothermal conditions appear across Central Basin and the Straits with little signs of phytoplankton growth.

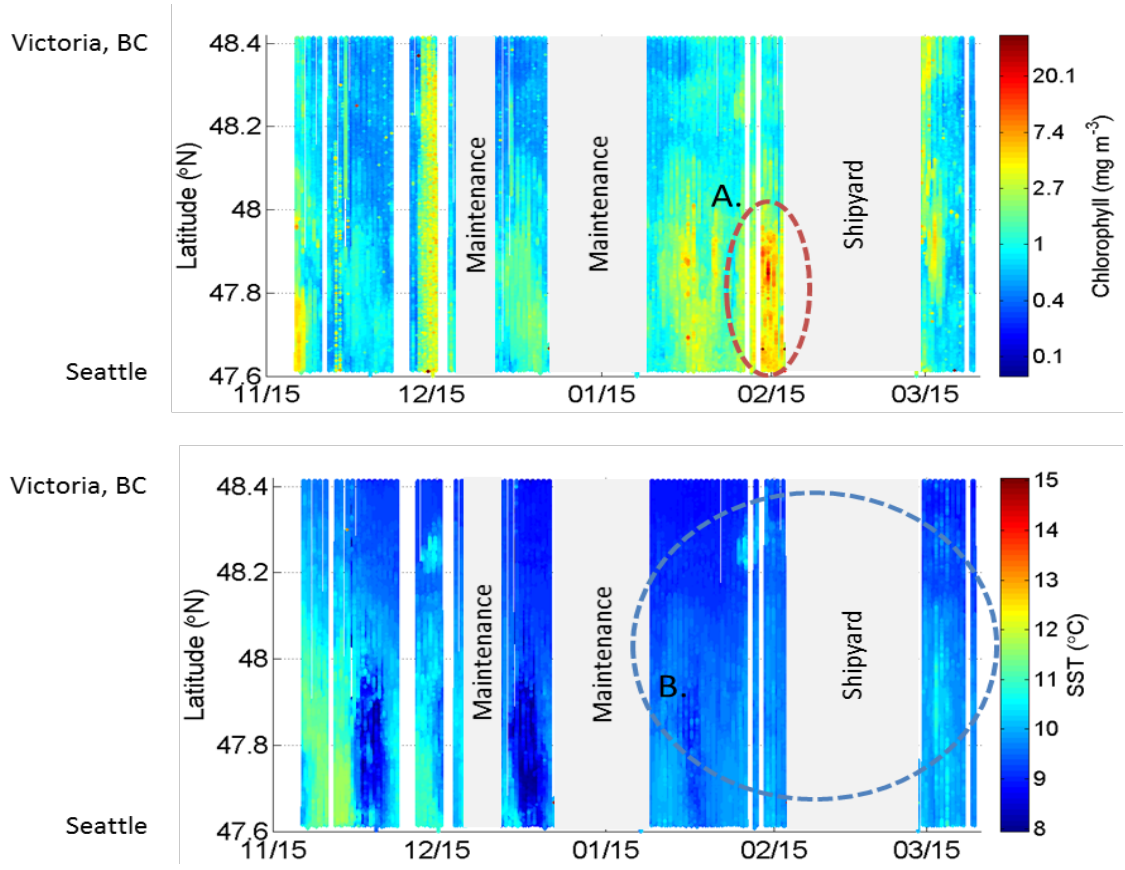


Figure 4. Temporal-spatial distribution of chlorophyll fluorescence (top) and sea surface temperature (SST; bottom) in Nov 2014 to Mar 2015. A. Phytoplankton started to increase during a mild and sunny period in February, but concentrations have dropped across the main part of Central Basin and the Strait of Juan de Fuca. B. Isothermal surface water near 10.5 °C persists for more than a month.

Columbia River estuarine monitoring: Under the direction of A. Baptista, and with a mix of NSF, NANOOS, and regional-stakeholder funding, CMOP maintains a network of 15 endurance stations in the Columbia River estuary, which anchor CMOP's SATURN observation network. Also integral to SATURN, but not funded by NANOOS, are three freshwater stations: SATURN-06, maintained directly by the USGS, and SATURN-05 and SATURN-08, maintained by Dr. Joe Needoba with CMOP/NSF and regional stakeholder funding.

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. A recently installed interdisciplinary station (SATURN-09, at the mouth of Youngs Bay) is fully functional, and is helping characterize the role of this lateral bay in the estuary. This station has a surface-floating package of sensors, measuring temperature, salinity, chlorophyll, phycoerythrin, DO, turbidity and CDOM.

A new station (to be named SATURN-10; Figure 5) is being planned for outside the mouth of the estuary, south of the South Jetty, at the request of the Corps of Engineers. The station will be seasonal and will measure in real-time temperature, salinity, chlorophyll, DO and turbidity. It will supply needed scientific information toward implementation of an adaptive management program for the Corps of Engineers Mouth of the Columbia River Regional Sediment Management Plan (RMCR 2011). A main goal of the RSMP is "to increase the beneficial use of dredged sediment at the MCR to help protect shipping channel jetties, coastal beaches and nearshore habitats from erosion while avoiding and minimizing adverse environmental, resource and navigational safety effects." This process requires research and monitoring to "ensure that disposal practices will not result in unacceptable adverse effects on the nearshore ocean ecosystem, especially commercial and recreational" Dungeness crab populations, deemed among the most susceptible of local fisheries. SATURN-10 will provide ocean conditions context and guidance on timing for crab monitoring.

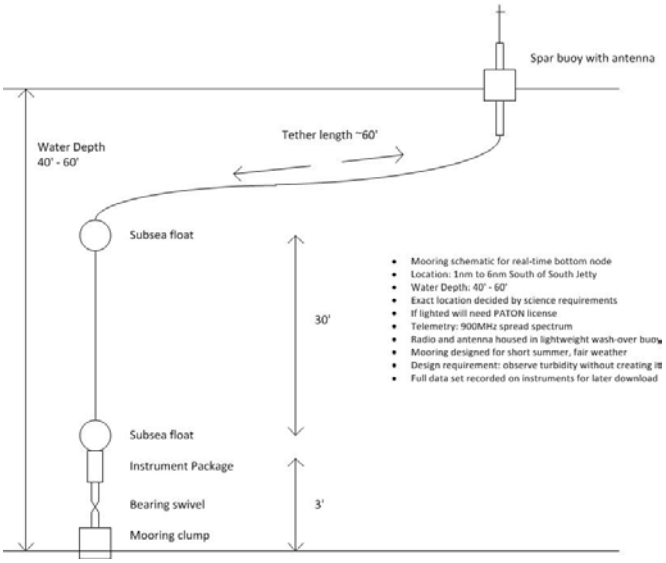


Figure 5: Illustrative sketch for SATURN-10

Two significant "infrastructure" papers were recently accepted with minor revisions. One reports on adaptive sampling of microbial communities through the deployment of an Environmental Sampling Processor at SATURN-03, with automated sampling targeted by select aspects of the function of the estuarine bioreactor [1]. The other provides a comprehensive description of the SATURN infrastructure [2].

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

SATURN stations also enable the characterization of the effects of the PNW "blob" on the Columbia River estuary. A "blob" watch is being developed, and will be reported on the next reporting period.

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

South Slough NERR continued operating a network of moored observing stations and a real-time weather station as part of the NERRS System-Wide Monitoring Program with additional support provided by NANOOS. One meteorological and four real-time water quality monitoring stations located along the estuarine salinity gradient provided water temperature, salinity, dissolved oxygen, pH, turbidity, and water level data over the duration 12/01/14 – 5/31/15. There were periods of missing data at the Charleston Bridge station due to site maintenance associated with new instrument deployments (EXO sondes) as well as conductivity sensor failures due to structural defects in the sensor housing. Data records were missing from 1/16/15 17:00-1/30/15 14:00, 2/3/15 22:00-3/16/15 14:00, and 4/5/15 13:00 – 4/8/15 10:45. There were shorter duration data gaps at Elliot Creek (1/8/15 13:45-1/9/15 15:45), Valino Island (1/8/15 14:45 – 1/13/15 17:15), and Winchester Creek (1/8/15 14:30-1/9/15 14:45) monitoring stations associated with the upgrade from 6600 V2 to EXO sonde instruments. The telemetry transmissions at these four water quality stations were also down temporarily due to site maintenance associated with the EXO instrument deployments. Telemetry was down from 1/16/15–3/17/15 at Charleston Bridge, 3/6/15-3/19/15 at Valino Island, 3/4/15-6/12/15 at Winchester Creek and 3/6/15-present at Elliot Creek. Currently, no instruments are deployed at the fifth water quality station (Boathouse) due to platform installation issues, including securing deployment housing, telemetry components, and cormorant nesting. We are relocating the weather station to Tom's Creek Marsh at the south end of the reserve due to the installation of a nearby wind turbine on the Oregon Institute of Marine Biology Campus last winter. Data collection from the weather station was terminated on 4/01/2015, equipment and sensors are currently being removed, sensors recalibrations will be completed, and construction for the new platform will begin this summer.

We maintain one water quality station in partnership with one of our local tribes, the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). This station, North Spit BLM, is located in lower Coos Bay (NESDID ID # 346F229A; sosnswq) and data are available via the NVS through the programming work of E. Mayorga. He developed Python code and utilized common software libraries from IOOS DMAC to ingest water quality data from HADS (Hydrometeorological Automated Data System) to display through NVS; this effort will help with future stations that are maintained through partnerships or are outside of the scope of the NERRS CDMO.

The South Slough water quality stations provide real-time data access for shellfish growers in South Slough, including North Bend and Coos Bay Oyster Companies, Clausen Oysters, and Qualman Oyster Farms to monitor environmental conditions. The South Slough and CTCLUSI stations also provide environmental data for research and monitoring projects conducted at the reserve, by visiting investigators, and by researchers at the University of Oregon Institute of Marine Biology. The real-time station data are accessed by the SSNERR Education Program for teacher training workshops and K-12 formal education programs. The weather station provides real-time data to assess the short-term effects of local weather on water quality within the estuary.

South Slough expanded the network of water quality stations to include four stations (North Point, Isthmus Slough, Catching Slough, and Coos River) located in the upper Coos estuary through the NERRS

Science Collaborative Partnership for Coastal Watersheds project in 2013. These stations provide time-series measurements and establish baseline conditions important for assessing water quality dynamics in the larger Coos estuary, especially water temperature, dissolved oxygen, and fecal coliform issues identified by Oregon Department of Environmental Quality as concerns. One station, North Point, is located near commercial oyster cultivation areas thus, South Slough will prioritize adding real-time capability for oyster growers and for Coos Bay Bar Pilots to provide water level data. Through NOAA Ocean Acidification program funding, South Slough added pCO_2/pH monitoring equipment at the Valino Island station to understand long term changes in pH from the YSI sonde datasets. Field deployments of *p*CO2/pH instruments began 4/27/15. In the future, we may explore ways to include these datasets through NVS, but currently we are focusing on instrument maintenance, data collection and protocols in the estuary for these ocean designed instruments.

- **Shorelines**

Washington Shorelines: NANOOS funds contribute to the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. In December 2014, CMAP conducted fall seasonal beach monitoring surveys in the Columbia River Littoral Cell (CRLC). Forty-six seasonal beach profiles and two surface maps were collected. Additionally, three seasonal profiles at the southern end of Ocean Shores were repeated following a large storm at the end of December. After the storm, beach lowering of 0.2-0.5 m and retreat of up to 0.5 m were observed. Photographs were taken to document the erosion at the Ocean Shores jetty and geotubes.

At the end of January 2015, CMAP worked with the USGS to collect beach and nearshore profiles at the Elwha River mouth. This survey was conducted in response to heavy rainfall events experienced in the region. In March 2015, CMAP conducted winter seasonal beach monitoring surveys in the CRLC, collecting 50 beach profiles, 5 surface maps, and 63 sediment samples from multiple cross-shore locations along 13 of the profiles.

G. Kaminsky presented Ocean Shores beach profile data and an overview of coastal erosion issues at the Washington Coastal Hazards Resilience Network (CHRN) Meeting on February 19, 2015; he gave a presentation on coastal change and erosion in Ocean Shores at the 28th Annual Beachcombers Fun Fair in Ocean Shores on March 8, 2015; and he participated in the Ocean Shores City Council Erosion Workshop on March 9, 2015 providing data analysis results from our observation time series. The workshop was held to assist in raising the communities' awareness of the issues and science behind understanding the erosion and of the forces at work near the Grays Harbor North Jetty, and approximately 200 people attended the workshop.

One outcome of that workshop was the need for an inter-local technical group that could cooperatively work to identify and recommend alternative strategies to improve shoreline stability in the vicinity of the North Jetty. G. Kaminsky is participating in the North Jetty Technical Committee along with representatives from the Port of Grays Harbor, City of Ocean Shores, Grays Harbor Council of Governments, Grays Harbor County, U.S. Army Corps of Engineers, and Coast & Harbor Engineering. To date, two committee meetings have been held and additional data analysis has been performed to develop coastal erosion management alternatives. NANOOS beach data is being used for engineering design and emergency and longer term erosion management including geotube repair, sand fence installation, and sediment nourishment of the dune and beach.

In April 2015, CMAP collected multibeam, boat-based lidar, and beach topography data of Graveyard Spit to monitor the USACE Shoalwater protective berm near Tokeland. Erosion of the berm on the

western end was detected. The survey was extended to monitor the river channels in more detail. CMAP also performed boat-based lidar surveys of Marrowstone Island and the site of the Ledgewood 2013 landslide on the west side of Whidbey Island. Multibeam data was also collected offshore of the landslide site to compare with data collected by CMAP in April 2013.

Through support from other agencies, CMAP was able to upgrade its bathymetric survey capabilities. The R/V George Davidson was outfitted with a dual-head multibeam sonar system as well as a combined phase differencing bathymetric and side scan sonar system. These systems will improve efficiencies in high-resolution mapping and monitoring of nearshore coastal areas.

Oregon Shorelines: Leveraging NANOOS, the Oregon Beach and Shoreline mapping Analysis Program (OBSMAP) efforts are led by J. Allan of the Oregon Department of Geology and Mineral Industries (DOGAMI). As part of DOGAMI's commitment to NANOOS, the OBSMAP network continues to be sustained, with surveys of beach observation sites having been undertaken in December 2014 and again in March 2015 (Rockaway cell (25 sites), along the Clatsop Plains (6 sites), and in the Neskowin cell (15 sites)).

Data for the OBSMAP monitoring sites are available through the NANOOS Visualization System. Due to the current phase of mild weather conditions and a lack of significant storms in the past four years, many of the beach study sites exhibit a general trend toward accretion. Erosion issues that had plagued a number of sites in the past, for now remain stable. 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 and geotechnical consultants in Neskowin and Rockaway to help guide their understanding of changes taking place along their beach, and more recently by residents in the Cannon beach area, who are concerned about plans to lower dunes in their area.

No significant issues were experienced with equipment during this period. However, as stated in previous reports, problems with aging infrastructure remain an ongoing area of concern.

Nearshore Bathymetry: P. Ruggiero's group at Oregon State University completed processing nearshore bathymetry data along the four sub-cells of the Columbia River littoral cell (CRLC). Over 220 individual cross-shore profiles were collected during summer 2014 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 Ecology developing complete maps of the nearshore planform. These nearshore bathymetric data continue to provide a critical source of information for improving coastal hazard mitigation along the coastlines of the CRLC.

Ruggiero's group also completed the processing of nearshore bathymetric data within the Rockaway littoral cell in Oregon. Over 80 individual cross-shore beach profiles were processed from the lower intertidal to approximately 25 m of water depth (~1500 m from the shoreline). In addition, Ruggiero's group completed the processing of nearshore bathymetric data in Lane County in central Oregon. Over 50 individual cross-shore beach profiles were processed from the lower intertidal to approximately 25 m of water depth (~1500 m from the shoreline). These data have been combined with topographic data collected synoptically by DOGAMI, and have been processed from their raw format into deliverable text

files and have passed a rigorous quality assurance process. The combined beach/nearshore observation dataset now available for Lane County is being used to assess 1% (100-year) coastal flood and erosion risk along the county shorelines for the purposes of developing updated FEMA flood insurance rate maps.

These nearshore bathymetric data continue to provide a critical source of information for improving coastal hazard mitigation along the coastlines of the Pacific Northwest. During this reporting period, NANOOS funded nearshore bathymetric data has supported the US Army Corps' Regional Sediment Management at the Mouth of the Columbia River, FEMA flood mapping activities in Tillamook, Lincoln, Curry, and Lane Counties, Oregon, as well as basic research on coastal hazards, morphodynamics, and the impacts of climate change. In particular, NANOOS funded nearshore bathymetric data is being incorporated in a coastal hazards decision support tool supported by NOAA's Climate Program Office Coastal and Ocean Climate Applications (COCA) program.

- **Currents**

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

We renewed our FCC broadcast licenses for operation of the SeaSonde instruments for 5 years in Jan 2015. To improve our operations in the 12-14 MHz range (standard-range HF), we applied for, and were granted, an additional frequency band in this range.

The severe storm of Dec 20, 2014, washed out the gravel road to our site on US Coast Guard land at Wincheseter Bay (WIN), and undermined the electrical transmission infrastructure. We recovered our equipment from this site while the USCG formulates and oversees a repair plan; the recovered equipment is being used for testing and temporary replacement at other sites. Alternative sites in the region are also being investigated. Following lab diagnostics, we returned the WIN receiver to the factory for replacement of a filter and of the GPS board. At Yaquina Head, a slow drop in range was diagnosed with a bench test of the transmit filter; this filter was sent for factory repair, and we are operating with much improved returns by bypassing the filter temporarily. In a major repair in Jan 2015, we installed 3 new receive cables, buried along their 750-800 ft. length, at Point St. George, CA. The transmitter from a Priority 2 radar at WSH was transferred in Jan 2015 to Priority 1 site STV2 during factory repair of the STV2 transmitter. We have nearly completed construction of a replacement shelter at Loomis Lake, WA, built to better resist break-in attempts there. Research assistant Erik Arnesen passed ground-school training as a requirement to operate an unmanned aerial system in service of performing calibrations of HF radar sites; this work will be undertaken in collaboration with Washburn's group at UCSB. We are also serving as a test site for CODAR to evaluate a new service to determine calibrations using passing ships of opportunity.

We continue scientific collaborations with several groups. Scott Durski and colleagues have a manuscript in review for Ocean Dynamics, on modeling and remote sensing of the winter circulation off Oregon, and the influence of the 2009-10 El Niño. Kate Sherman is lead author on a paper submitted to "Ocean and Coastal Management" describing the process used to include scientists as ocean stakeholders when considering alternative and competing uses. Also under review is a manuscript (Behrens-Yamada, Peterson & Kosro) extending the statistics (from Behrens-Yamada & Kosro, 2008) on successful years for the invasive green crab, based on physical and biological indices. A paper describing the near-coastal river-fed buoyancy current along central Oregon, resulting from the dissertation work

of P. Mazzini, is under review. A manuscript on inertial currents using both HF measurements and a high-resolution circulation model is in late stages of preparation with S.Y. Kim and A. Kurapov.

During 5-6 May, Kosro contributed to a workshop on "2014-2015 Pacific Anomalies Science and Technology", providing a description (co-authored with Craig Risien) of the onset of the coastal Oregon expression of the Pacific Warm Anomaly referred to as "The Blob".

Port X-band Radar: Led by M. Haller (OSU), wave imaging radar operations continue at both the Yaquina Bay Inlet (Newport South Jetty) station and the temporary Columbia River mouth at Cape Disappointment station, with some hardware-related interruptions and degradations. Both systems have been generating wave spectral information, and the Cape Disappointment station has also been taking short thrice-hourly recordings for the observation of slow-moving features (ebb plume fronts, salt wedge bottom and surface intrusion fronts, and oblique internal hydraulic jumps). In December 2014, we were contacted by the National Transportation Safety Board (NTSB) with regard to a boating incident that occurred in the coverage area of our radar. We were able to provide radar imagery showing the vessel in question to the NTSB that will be used in their report on the investigation.

In December, the motor for the Newport radar was replaced. In March, the Newport station stopped capturing waves in the recorded signal; we expect that the transmitter failed. As of the end of May the transceiver tray was out for diagnosis and repair at SI-TEX Marine Electronics. The Cape Disappointment radar has continued operation. We serviced the radar in April and removed some metal dust that had accumulated in the radar housing, apparently from the motor and rotor gears. Both radars have exhibited issues with possibly excessive wear on the motor gear that leads to mechanical noise and dust buildup.

In January, Haller gave a presentation on our Cape D radar station to the meeting of the Lower Columbia River Solutions Group (Vancouver, WA). Recently, Captain Dan Jordan (Columbia River Bar Pilots) has inquired about us sharing our radar feed from the Cape D station. We are pursuing the logistics of this.

Finally, at the request of NOAA Office of Coast Survey (Dave Enabnit, Technical Director) we delivered a two-day technical training course at the Office of Coast Survey in Silver Spring, MD during May 27-28, 2015. The audience for the course ("Wave-imaging Radar for Hydrographic Applications") consisted of NOAA employees (lidar group, POORTS personnel, etc.) as well as a contingent from the Korean Hydrographic Service. The group was very interested in incorporating our high-resolution bathymetric estimation technique into other marine radar stations as a complement to their traditional surveying methods.

b) NANOOS Modeling Subsystem:

Shelf: Computer circulation modeling of PNW coastal ocean shelf conditions has been conducted by A. Kurapov's group at OSU. The system utilizes the Regional Ocean Modeling System (ROMS) as the forecast model. Along-track altimetry observations from Jason-2, CryoSat, and Altika, hourly GOES SST, and surface currents from land-based high-frequency (HF) radars have been assimilated to improve initial conditions for the forecasts. The system produces daily updates of 3-day forecasts of ocean conditions, including currents, temperature and salinity through the water column (at 3-km horizontal resolution). Results are provided to fishermen and public via the NANOOS Visualization System. Via the OpenDAP server, forecast currents are also provided to the NOAA Office of Response and Restoration Lab in Seattle, where they can be used with the tools for oil spill mitigation. Routines for pre- and post-

assimilation quality control have been established, along with new online tools (http://ingria.coas.oregonstate.edu/rtdav/, L. Erofeeva, OSU).

During the report period, we continued to support the data assimilative version of the OR model (41-47N), with results posted online. At the same time we started to assimilate the data into our new model configuration (OR-WA model) that has the domain extended to 41-50N (including both OR and WA shelves) and includes the Columbia River fresh water plume. Transition to the data assimilative OR-WA model as the main NANOOS tool for model-data synthesis is planned this summer.

As a companion effort, OSU PhD student I. Pasmans has run initial tests of a hybrid ensemble-variational data assimilation method, applied to the OR-WA model. In this method, the initial condition error covariance is computed using an ensemble of model forecasts. It has been shown that using such a covariance better represents subsurface variability in temperature and salinity, compared to the independent data (glider, NH10 mooring).

Analyses of the high resolution model of the California Current System (Durski et al., 2015) showed the impact of boundary conditions based on the global HYCOM, and the model skill reproducing interannual variability along the OR and WA coasts.

Estuaries

Puget Sound:

NANOOS PI P. MacCready (UW School of Oceanography), working with Drs. Banas, Siedlecki, and McCabe (UW Joint Institute for the Study of Atmosphere and Ocean), are creating a pre-operational forecast model, called *LiveOcean*, of ocean circulation in Puget Sound and adjacent waters. In the past six months the team used NANOOS support to conduct extensive testing of the forecast model against observations (Figure 6). 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 (UW). The forecast work is also supported by a grant of state funds made through the Washington Ocean Acidification Center (WOAC), greatly accelerating the work and leveraging the impact of NANOOS funds. During this past 6 months in addition to the model testing MacCready presented the work in a TV interview (Al Jazeera America, aired 6/17/2015), and Siedlecki presented model results in an invited talk at the Gordon Conference on Coastal Ocean Modeling (Maine, 6/2015). Two papers documenting the biogeochemical simulations in the model were published in this period (Davis et al. 2015, Siedlecki et al. 2015). MacCready is a member of the NOAA West Coast Ocean Forecast System Technical Working Group, and this model is a candidate for nesting inside of the NOAA operational models of the California Current that are being developed.

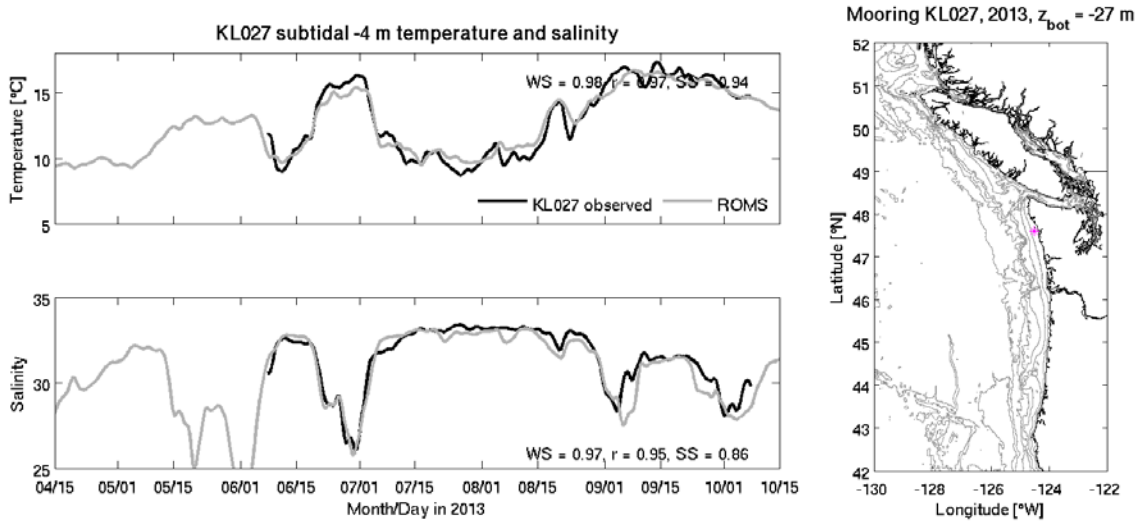


Figure 6. *LiveOcean* model (gray line) near-surface temperature and salinity during 2013 compared to observations (black line) from an Olympic Coast National Marine Sanctuary mooring in 27 m of water near 48° N. The model domain is shown on the right. The model has consistently high skill in the critical nearshore region.

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.

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. Modeling of sediment and biogeochemical dynamics in the estuary has progressed considerably, with papers in preparation on both topics (for submission next reporting period).

Recent applications include (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.

A paper describing a rigorous model benchmark for the Columbia River estuarine circulation was recently published, and another describing the skill of a recent simulation database (DB33; 1999-2013) was submitted.

c) Data Management And Communications (DMAC) Subsystem:

Chaired by E. Mayorga (APL-UW), 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 also an active collaborator in national IOOS DMAC efforts. Meeting highlights for this period include: 1) weekly NANOOS DMAC-UPC teleconferences; 2) monthly NANOOS DMAC technical teleconferences; 3) IOOS DMAC monthly webinars; 4) annual NANOOS DMAC & User Products meeting (Apr 22-23); 5) annual IOOS Regional DMAC meeting (May 27-29), E. Mayorga; 6) Tools for Modeling, Forecasting & Managing

for Vibrio spp. in WA (Apr 28-29), E. Mayorga; and 7) 2014-2015 Pacific Anomalies Science & Technology Workshop (May 5-6), C. Risien (OSU).

NANOOS Visualization System (NVS) enhancements encompass asset additions and continuous updates: a) new or newly incorporated near-real-time in-situ monitoring assets (new meteorological sensors at UW Carr Inlet & Hansville WA moorings and new pH sensor at Carr Inlet); b) new World Ocean Atlas salinity climatology and NCDC Optimum Interpolation SST climatology and monthly anomalies, from OSU (Risien); c) updated monthly anomalies for MODIS-Aqua SST & Chl-a, AVISO mean-sea-level and NCEP NARR model reanalysis winds; and d) many redeployments and smaller upgrades. In addition, the email-based data reception scheme used with monitoring data from shellfish growers, including some "Burkolator" ocean acidification sensor data, was overhauled; and a working prototype was developed for a new, dynamic time series plotting tool that will handle long time series, to be released later in 2015. Work has been initiated to stage observation time series to take advantage of this new plotting capability.

NANOOS and IOOS DMAC system implementation. 1) The THREDDS service endpoint for CMOP-OHSU SELFE irregular-grid forecast model output was enhanced and registered with IOOS in March (C. Seaton, CMOP) after substantial engagement with the IOOS Registry and Catalog teams. The NANOOS 52North SOS service was also improved and strengthened during this period. 2) NANOOS DMAC initiated discussions and planning toward more consistent handling of glider data by glider operators (CMOP-OHSU, OSU and APL-UW), investigating current data workflows and Glider DAC requirements; CMOP-OHSU started working with the Glider DAC team to submit data from historical deployments and, later this year, ongoing deployments. Their experience and that of CeNCOOS DMAC (F. Bahr) in submitting deployments from the co-funded NANOOS-CeNCOOS SeaGlider will be used to develop NANOOS-wide data submission approaches. 3) E. Mayorga volunteered to serve as co-editor for the QARTOD Dissolved Nutrients manual. 4) NANOOS continued its contributions to IOOS DMAC community implementation activities, including an active role in issues discussed in the IOOS Github repositories, particularly: the assessment of duplicate datasets and handling of WMO ID's in the IOOS Catalog; and the use and documentation of controlled vocabularies and semantic searching. E. Mayorga presented IOOS DMAC architecture and practices to broader communities at an RDA-DataONE Semantic Metadata workshop (Feb) and an NSF EarthCube technical meeting (Apr), while C. Risien continued to serve as an interface with the OOI Endurance Array team via his dual funding support from NANOOS and OOI.

West-Coast Coastal and Marine Geospatial Data. NANOOS continued its support of the West Coast Ocean Data Portal (WCODP) efforts. In January, E. Mayorga participated in the IT working group meeting, and provided a key fix for a long-standing bug that prevented proper handling of ISO 19115-2 metadata records in the WCODP Catalog, opening the door for metadata registration for ocean data from West Coast RA's. He also supported discussions between the WCODP team and CeNCOOS and SCCOOS to establish best practices and facilitate the registration of their metadata.

Ocean Acidification (OA) Data. After the release of the IPACOA (IOOS Pacific Region Ocean Acidification) cross-regional data visualization application last November, NANOOS DMAC has continued to engage the "Burkolator" sensor managers and RA DMAC staff from AOOS, CeNCOOS and SCCOOS, as well as NANOOS, to maintain the data ingest into IPACOA and assist RA's with the integration into their own DMAC workflows of sensor data streams in their region. As a result of this direct technical assistance, the Carlsbad (SCCOOS) sensor was integrated into IPACOA for the first time; the Hog Island (CeNCOOS) data stream was transitioned to flow first from the operator workstation to a CeNCOOS/Axiom server rather than a NANOOS server; and AOOS access to the Alutiiq Pride sensor data was restored. Within

NANOOS, near-real-time ingest of data from Whiskey Creek (OR) was restored in April after a long gap, by leveraging the overhaul of an email-based data delivery scheme; and new pH data stream deployments from the UW Carr Inlet and ChaBa moorings were incorporated (the ChaBa data stream was finalized in early June). Finally in late May, E. Mayorga prepared to attend the GOA-ON (Global OA Observation Network) Data Portal meeting that took place June 1-2; outcomes will be discussed in the next report.

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 2015 period included: 1) multiple weekly NANOOS DMAC and UPC teleconferences; 2) Attendance at the annual NANOOS DMAC, UPC & E&O meeting on April 22-23rd, 2015.

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. Considerable work has been implemented on the backend of the NVS platform, with the objective of developing an entirely new NVS timeline capability (Figure 7). Developed by NANOOS web designer Tory Tanner and Robert Carr, the new timeline uses the HTML canvas element to display both the timeline and the plots. This new approach allows the timeline to greatly expand its' maximum range, from ~90 days to over 40 years. Users can interactively pan and zoom the timeline to view desired ranges. By default, when a variable is selected in the info window, the timeline automatically resizes to fit the entire data range in the viewable area. Users can also move the mouse over the plot to see readouts of time and values. The revised version of the NVS timeline is expected to be released early in the next reporting period.

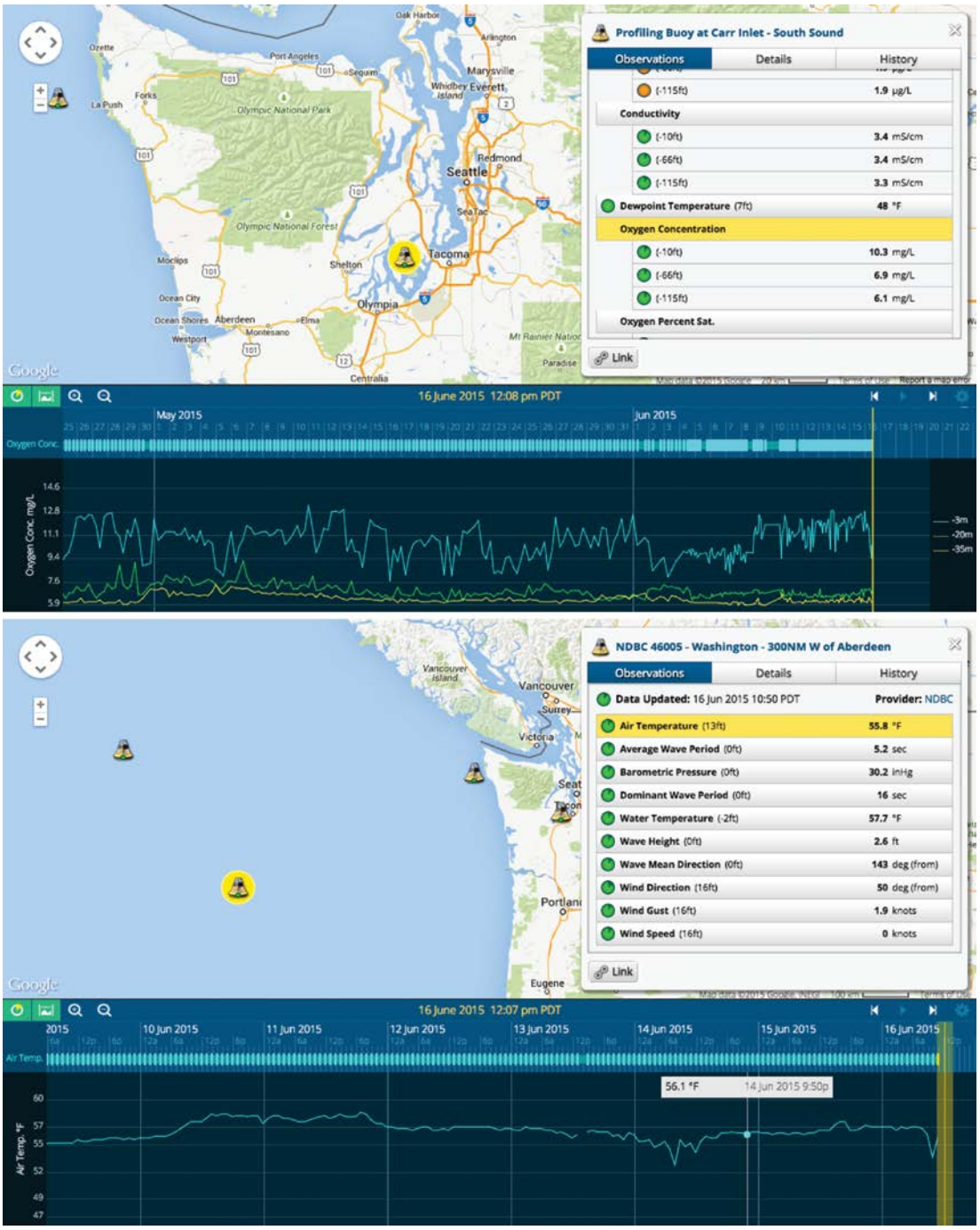


Figure 7 (*top*) The enhanced timeline feature being developed for the NANOOS NVS. The new form will enable all plotting to occur dynamically in the lower section of the screen as opposed to contained in the pop-up, which is currently used. Moving the time slider (vertical yellow line) along the timeline (*bottom*) will show the measured values at that location, and will be reflected in the values shown in the top right callout.

On October 23rd, NANOOS released NVS v3.8, which reflected the addition of the new NVS Climatology web app. This new product provides access to conditions of our region's ocean environment measured on any one particular day relative to conditions measured in the recent past, as well as with respect to

their seasonal to interannual variability, and in terms of their extremes. The web app consists of two components:

- Climatologies derived for selected NDBC (9) and C-MAN (5) stations based around the following core parameters: air and water temperature, wind speed, barometric pressure, significant wave height and peak spectral wave period. The plots depict simple statistics such as daily means and standard deviations (±1σ and +2σ). These data are updated on a daily basis blending data that has already been subject to stringent QC checks, with more recent data (last 45 days) that have been subject to more limited QC; and,
- Ocean overlays depicting:
    - Monthly averages of chlorophyll and sea surface temperatures derived from MODIS satellite data, NCEP North American Regional Reanalysis (NARR) 10m winds, mean sea levels derived from AVISO satellite altimetry data, and NCDC OI sea surface temperatures averaged over the length of the data to depict seasonal changes; and,
    - Monthly changes (expressed as anomalies) in chlorophyll and sea surface temperatures derived from MODIS satellite data (2002-present), NCEP North American Regional Reanalysis (NARR) 10m winds (1993-present), and AVISO sea level heights (1993-present), and NCDC OI sea surface temperatures (1993-present). These latter data show monthly deviations in the observed parameter relative to the long-term mean.

Since releasing the web app, leads Allan and Risien have continued to refine the overall look and feel of the application. Various satellite and model overlays have been updated to reflect the most current information available. For the NDBC in situ observation stations, a new interannual variability tab was added to the existing suite of information. These new plots depict the interannual variations in summer (JAS)/winter (JFM) conditions for each of the stations enabling the user to better understand the degree of variations observed at the buoy from year to year. Figure 8 provides an example of water temperature anomalies at buoy 46005; the buoy is located ~530 km west of the Columbia River mouth. The time series plot provides an example of unusually warm ocean temperatures (termed the 'blob') that have persisted in the northeast Pacific in 2014 and 2015. Measurements derived from multiple NDBC water temperature sensors in the region further highlight the fact that water temperatures are typically exceeding 1-2σ above normal. These types of plots highlight our ability to now showcase conditions that may be perceived to be unusual in our region against longer time series.

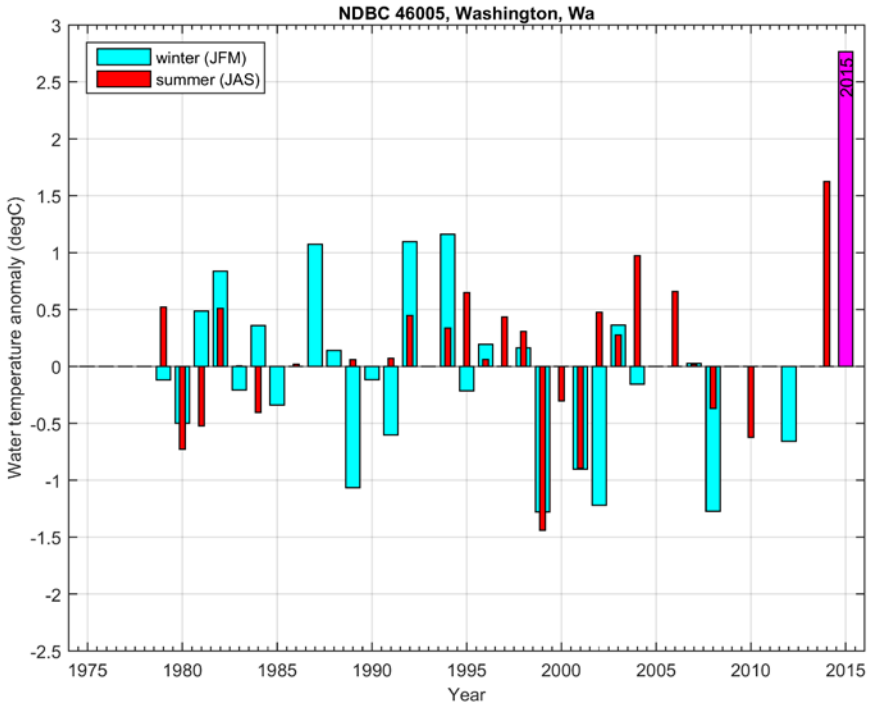


Figure 8: Interannual variations in water temperature derived for NDBC buoy 46005, defined for both summer and winter conditions.

Mobile Applications[2]***:*** The NANOOS UPC/DMAC sub-working group is responsible for the release and maintenance of mobile applications that can access and display data from NANOOS data sources. Currently there are two such applications, ***NVS*** and ***Tsunami Warning NW*** that are available to the general public on both Android and iOS platforms.

Over the past several months, NANOOS users (including members of the UPC/DMAC/E&O team) reported on a number of problems with the mobile applications, which ranged from as simple as layers not showing up (iOS) to a complete failure of the applications (Android). As technical lead on mobile app development, staff from Boeing undertook an evaluation of the two apps in order to identify the problems. This was completed late in this current reporting period. Boeing confirmed that several key areas were in need of upgrading. The simplest were some fixes to the iOS mobile apps, which resolved problems related to markers not showing up in the ***Tsunami Warning NW*** app and map centering; the updated version of this app will be soon posted to the iTunes store. The most significant problem was identified with the Android version of the mobile apps, which experienced a complete failure. Due to major software changes in the Google map API in 2013, the Android Tsunami app broke completely. Because the original Google Map v1 key has been lost, the only option is to initiate a complete rebuild of the Android version of the ***Tsunami Warning NW*** and ***NVS*** apps. Accordingly, both versions of the Android apps have been pulled from Google Play and are no longer available. NANOOS is working towards re-writing the code for both these applications, which is expected to take considerable time.

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

Website: Efforts during this period were largely directed at further improvements in the overall NANOOS web experience (http://www.nanoos.org/products/products.php). The products page was restructured, and introduces a more refined search tool for those looking for coastal and ocean data.

e) NANOOS Education and Outreach Subsystem:

NANOOS Education and Outreach efforts are focused on growing NANOOS' audience of engaged citizens, promoting and facilitating the use of ocean observing data and increasing ocean literacy in our region. These efforts are largely completed by NANOOS staff Newton, Sprenger and Vander Giessen, with support from DMAC and UPC subsystems and many NANOOS member collaborators. Newton, Sprenger and Vander Giessen are all active members of the weekly DMAC/UPC tag-up conference calls, regularly providing support and feedback on UPC and DMAC developments. Sprenger and Vander Giessen continue participation with IOOS E&O calls as they occur.

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

- Sprenger worked with the local non-profit organization Whidbey Watershed Stewards to support Langley Middle School's 7th grade over the course of a semester long investigation into the water quality of Langley Harbor. This included taking 4 classes of students out on half-day education oceanography research cruises and visiting each 7th grade science classroom to present on NANOOS and work with students to use data coming from NVS. From the teachers:

  " Lori, Susan, all the 7th graders and I would like to extend a big THANK YOU to you for coming out to Whidbey Island Wednesday and sharing your knowledge about the NANOOS website with us. I think we all learned a lot. All three of us we're discussing it after you left and are all really excited to think of all the possibilities this window into real-time oceanographic data available for students and teachers supports are STEM goals as well as preparing our students with 21st century skills. I know that we all (Lori, Susan, myself) look forward to future collaborations with you and NANOOS."
- Sprenger continues to facilitate and promote education using student-built buoys as a research project for K-12 students both in and out of school. For the fourth year this coming summer, Sprenger will partner with WA Sea Grant to co-instruct the NOAA Science Camp's Junior Leadership Program's research project. There are a few science programs in the Northwest that have independently begun similar student-led buoy/sensor platforms research projects and Sprenger has begun working with them to collect information on their programs and experiences to share with the broader NANOOS education community.
- Sprenger is co-chairing, with WA Sea Grant Education Specialist Maile Sullivan, the upcoming summer 2015 NW Aquatic and Marine Educators Summer conference, which will be held at UW in Seattle July 20-24 2015 with expected attendance of 80-100 informal and formal educators. NANOOS will be prominently featured during the conference, with Newton as keynote speaker.
- Sprenger and Vander Geissen coordinated more than 20 students, educators and other volunteers for the 3-day mooring deployment cruise for the La Push (Chaba and NEMO) deployments in May, making this cruise a highly-successful educational opportunity. Volunteers were quickly immersed in the hands-on oceanography we carry out on these cruises including CTDs, mooring deployments, glider deployments, and seawater sample analysis. Biologist J. Hagen of the Quileute Nation was also able to participate in the cruise, collecting numerous surface water samples to investigate phytoplankton species distribution and for HAB/toxin analysis. Aboard the *Thompson*, Newton and Mickett together gave a well-attended overview presentation of the formation and evolution of the "blob", showing moored observations, and also presented a general overview of the mooring

system. Finally, we were also able to support an Oregon elementary school science project by deploying a small, satellite-tracked sailboat.

- Barth and Shearman (OSU) hosted a visiting postdoctoral researcher from the University of Tokyo, Dr. Tanaka Takahiro, who worked with the OSU glider research group on Acoustic Doppler Current Profiler and CTD data collected from underwater gliders.
- Haller (OSU) delivered a technical training course at the NOAA Office of Coast Survey (Silver Spring, MD). Course title: "Wave-imaging Radar for Hydrographic Applications", May 27-28, 2015.

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

- NANOOS was invited to support the Washington Ocean Acidification Center's (WOAC) participation in Science Inside Out, a visual and interactive event geared toward decision makers and hosted by the University of Washington's College of the Environment. Vander Giessen presented the NVS Shellfish Growers App alongside WOAC scientists and members of the shellfish industry.
- NANOOS provided the "Great Build a Buoy Challenge" activity at University of Washington's annual Paws on Science Weekend at the Pacific Science Center. The buoy challenge was again incredibly popular among attendees with non-stop buoying by kids of all ages throughout the day.
- On 4 December 2014, Newton spoke to the Friday Harbor School "ORCA Bowl" team about marine science and ocean observing technology.
- On 7 February, Newton gave a SoundWaters seminar on ocean acidification in the Pacific Northwest. SoundWaters is a one-day university for all - on all things Puget Sound held on Whidbey Island, WA.
- On 13 March, Newton spoke to west coast university librarians about OA in PNW waters at the University of Washington, Seattle.
- In March, Sprenger presented on IOOS and NANOOS to the Pacific Rim Shellfish Sanitation Conference in Ketchikan AK, the presentation included slides from each Pacific IOOS region.
- In April, NANOOS DMAC and E&O staff participated in a two day Vibrio Forecasting workshop held in Lacey, WA. The meeting was organized by NOAA NWFSC, NOS, WDOH and FDA and included public health officials, managers, shellfish growers, tribal members and other stakeholders to discuss specific data and information needs in Washington State for improved risk assessment.
- On 10 April, Newton participated in an outreach event for Seattle Girls School highlighting women in science and engineering.
- NANOOS continues efforts on social media, regularly posting on Facebook with news, pictures, and interesting data. Sprenger and Vander Giessen continue to update the NANOOS blog (http://www.nanoos.org/education/blog/blog.php) posting on educational opportunities and research cruises and also work to gather blog post contributions from NANOOS collaborators.
- Sprenger and Vander Giessen continue to update content on the NANOOS portal, as well as continue to improve the site's usability by updating the search tool on the products page and streamlining the documents archive.

f) NANOOS Administration:

D. Martin (NANOOS Board Chair) and J. Newton (NANOOS Executive Director) continued to provide leadership to NANOOS operations and connection to the US IOOS enterprise. They and M. Kosro (NANOOS Board Vice Chair) participate in IOOS Program Office and IOOS Association calls. Newton is a member of the IOOS Association Executive Committee and participated in their teleconferences throughout the period. Newton participated in weekly Tri-Comm calls and at the annual Tri-Comm meeting in Seattle, WA, on 22-23 April. Key events included:

- From March 3 -5, Martin and Newton participated in IOOS Association and IOOS Spring meetings in Washington covering a wide range of national and regional IOOS-related issues including visits to Congressional and Executive offices. Newton was invited by NWFSC Western Regional Coordinator Timi Vann to meet with NOAA Administrator Kathy Sullivan on 26 March and with Vice Admiral Devany on 10 April. In both cases the strong synergies with NANOOS and IOOS were highlighted. Newton also met with David Holst, NOS, Acting Deputy to discuss NANOOS.
- On March 17th, Martin hosted a visit by Mr. Scott Livezy, Technical Director for the Oceanographer of the Navy (CNO-N2/N6F). Principal topics covered were research ocean observatories (OOI), operational ocean observing capabilities (IOOS), and Arctic observing and prediction needs of the country.
- On March 18th, Martin participated in a visit by the senior staff of the President of the University of Washington. NANOOS was presented and discussed as an example of PNW regional participation in a national (IOOS) enterprise.

Newton met twice (January and May) with Rohinee Paranjpye, NOAA NWFSC, to discuss pathogen modeling within NANOOS. This led to the participation of NANOOS modeler (MacCready), DMAC (Mayorga) and Education (Sprenger) and Outreach (Vander Giessen) staff in the pathogen workshop. She also participated in two calls (with Mayorga) with local tribes in OR and WA and Hallenbeck (WCODP) regarding NANOOS hosting of tribal canoe journey data.

Assuring coordination within NANOOS, 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 led a session at the CMOP All Hands meeting on April 13-14 in Portland, OR) and Newton directs the UW Education efforts for this multi-institution project. Newton continued to develop education opportunities for at-sea training with the Northwest Indian College (NWIC) through CMOP. A major new initiative within CMOP, directed by Newton, involves the construction and deployment of a sophisticated ocean sensing buoy to be placed in Bellingham Bay, Washington, to provide data via NVS and to be operated by NWIC as a legacy outcome from CMOP. Progress was made on this project, gaining group input on design, sensors, location, and discussing ongoing maintenance.

For coordination within IOOS, over the period:

- Newton coordinated with other West Coast RAs, following the intent of our mutual MOU, as well as several other RAs to optimize and leverage capabilities and assure consistencies. This included: participation in the OTT – HABS Outer Coast “Road Trip” in December to meetings with OCNMS, Quileute Tribe and Quinault Indian Nation; coordination of the OTT – OA project including meeting 9 February with shellfish growers to assess their science and technology needs; coordination with AOOS, CeNCOOS, SCCOOS and PacIOOS on the IPACOA data portal; participation advising the COMT effort; Steering Committee and participant for the Pacific Anomalies Workshop in San Diego, CA, 5-6 May. Newton ran a quarterly OTT – OA call for that project on 21 April.
- Newton presented the NANOOS summary for the webinar on West Coast Ecological Forecasting on 12 December 2014, summarizing NANOOS and other regional efforts on HABs, OA, ecosystem and other modeling.

- Newton was invited by NERRS Program Director Marie Bundy to provide a webinar presentation to NERRS Research Coordinators on OA and IOOS "OA and West Coast Monitoring" for the NERRS Research Coordinators Virtual Meeting on 4 May 2015.
- NANOOS PI Barth and Newton continued to support the West Coast Ocean Acidification and Hypoxia Science Panel (http://calost.org/science-advising/?page=ocean-acidification-and-hypoxia-panel), working on scientific manuscripts and public interest documents regarding west coast US and Canadian OA issues and effects. PI Barth briefed Oregon's Ocean Policy Advisory Council on May 8, 2015, about ocean acidification and the activities of the West Coast Ocean Acidification and Hypoxia Science Panel.

Keeping the goals and capabilities of NANOOS and IOOS represented internationally, NANOOS Administration and PIs made several important contributions:

- NANOOS PI Barth serves as Co-Chair of the new PICES (North Pacific Marine Science Organization) Advisory Panel on "North Pacific Coastal Ocean Observing Systems." NANOOS achievements and data products will be included in a PICES review of North Pacific coastal ocean observatories due to begin in 2015.
- Newton represented IOOS on the Global Ocean Acidification Observing Network Executive Committee calls and activities. This included invitations to an OAiRUG meeting 13-16 January 2015 in Monaco, giving an invited talk "Local to Global Perspectives on Forecasting OA" and to St. Lucia at the Regional Workshop on OA in the Organization of Eastern Caribbean States, giving two talks: "OA: Global to Local perspectives," "The Global Ocean Acidification Observing Network"; Newton chaired a session on global OA observing at the ASLO meeting in Grenada, Spain with co-chairs from New Zealand and South Africa.
- Newton was sponsored to participate in MEOPAR's International Science Advisory Committee meetings 19-20 January 2015 in Montreal, Canada, providing feedback on MEOPAR vision and messages; and at JERICO's Technical Advisory Council meeting in Brest, France, 28-30 April 2015, providing IOOS input.

Additional NANOOS coordination:

Newton participated in the IOOS Brand Dig and nominated input from several NANOOS members

Newton helped coordinate the C-CAN webinar series on OA

Newton participated in three "OA Round Tables" organized by PMEL and NWFSC

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

Newton continued to represent NANOOS in regional efforts, e.g., C-CAN, PSEMP, Pacific Salmon Marine Survival, and West Coast Ocean Data Portal.

Newton continued to fill the Research seat as a member of the Olympic Coast National Marine Sanctuary Advisory Council, and attended their meetings in January, March, and May 2015. She participated in a OCNMS advisory call on mooring assistance.

3) Scope of Work

With one exception, 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. The one exception is that the Washington Department of Ecology is no longer maintaining the Willapa Bay mooring due to budget shortfalls. Instead they have transferred their NANOOS support to enhancing ferry-box sampling between Victoria, BC and Seattle, WA. 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.

6) Budget Analysis
With an award start date of 1 June 2011 and end date of 31 May 2016, as of 31 May 2015 we are 80% of the way through the project and 100% through FY14. The full project award amount to date is $10,601,208 and the total amount spent as of 31 May 2015 is $9,731,501 with another $794,247 encumbered. This means at 100% of FY14 and 80% the project time, 92% of the awarded funds have been spent and 99% spent or encumbered. These percentages match well, indicating that spending is commensurate with our plan. We anticipate that NANOOS will maintain its budget accordingly. Encumbrances are funds 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. All of the sub-awards are encumbered and thus not available to be spent for any other purpose. Indirect costs are also encumbered. In summary, we assess that the spend rate for this award are solid and appropriate for this point in the reporting period. The expenditures to date are suitable for maintaining robust execution of NANOOS plans to meet our objectives.

Presentations and Publications acknowledging NANOOS support: underline indicates NANOOS PI

Presentations:

Anderson, D. and Ruggiero, P., 2014. Modeling Shoreline Rotation of Headland-bounded Littoral Cells due to Wave Climate Variability, Abstract EP31B-3553, presented at 2014 Fall Meeting, AGU, San Francisco, CA.

Anderson, D. and Ruggiero, P., 2015. Modeling Interannual to Multi-Decadal Shoreline Rotations of Headland-Bounded Littoral Cells, Coastal Sediments 2011, San Diego, CA.

Cohn, N., Anderson, D., and Ruggiero, P., 2015. Observations of Intertidal Bar Welding along a High Energy Dissipative Coastline, Coastal Sediments 2011, San Diego, CA.

Cohn, N., Ruggiero, P., Anderson, D., Honneger, D., Susa, T., Haller, M., 2014. Observations of Intertidal Bars Welding to the Shoreline: Examining the Mechanisms of Onshore Sediment Transport and Beach Recovery, Abstract EP31B-3552, presented at 2014 Fall Meeting, AGU, San Francisco, Calif.

Haller, M.C. "Remote sensing of the MCR from atop Cape D: Rich dynamics with some comparisons to models", Lower Columbia Solutions Group Meeting, Vancouver, WA, January 9, 2015.

Kaminsky G., Coastal change and erosion in Ocean Shores, 28th Annual Beachcombers Fun Fair, Ocean Shores, March 8, 2015.

Kaminsky G., Ocean Shores beach profile data and an overview of coastal erosion issues at the Washington Coastal Hazards Resilience Network (CHRN) Meeting, February 19, 2015.

Kaminsky G., Ocean Shores City Council Erosion Workshop, March 9, 2015.

Kosro, P. Michael and Craig Risien, "Time Series off Newport, Oregon" 2014-2015 Pacific Anomalies Science and Technology Workshop, May 5-6, 2015.

Lipiec, E., Ruggiero, P., Mills, A., Bolte, J., Corcoran, P., Stevenson, J., Serafin, K., 2014. Integrating Climate Change Scenarios and Co-developed Policy Scenarios to Inform Coastal Adaptation: Results from a Tillamook County, Oregon Knowledge to Action Network, Abstract GC21A-0494, presented at 2014 Fall Meeting, AGU, San Francisco, Calif.

Mickett J., An overview of the ORCA system and synthesis of what we've learned from a decade of ORCA observations in Hood Canal, Hood Canal Watershed Education Network (HCWEN), Port Townsend, WA, March 2015.

Mickett, W. Ruef, Newton and Devol, 2014 ORCA observations, Puget Sound Ecosystem Monitoring Program annual meeting, Seattle, WA, April 2015.

Mills, A., Ruggiero, P., Serafin, K., Lipiec, E., Bolte, J., Corcoran, P., Stevenson, J., 2014, Exploring the Impacts of Both Climate Change and Decision Making Uncertainty on Coastal Community Vulnerability Assessments in a Policy-Centric Framework, Abstract GC21A-0493, presented at 2014 Fall Meeting, AGU, San Francisco, Calif.

Newton, J, Mickett, Allan, Observations of the Blob from NANOOS: info over time and over depth, 2014-2015 Pacific Anomalies Science and Technology Workshop, May 5-6, 2015.

Newton, J., Ocean Acidification and West Coast Monitoring, NERRS Research Coordinators Virtual Meeting, 4 May 2015.

Newton, J., Ocean Acidification in Pacific Northwest Waters, SoundWaters, 2015, Langley, WA, 7 February 2015

Newton, J., Local to Global Perspectives on Forecasting OA, OAiRUG Meeting, Monaco, 14 January 2015.

Newton, J., "OA: Global to Local perspectives," and "The Global Ocean Acidification Observing Network," Regional Workshop on Ocean Acidification, Organization of Eastern Caribbean States talks St. Lucia, 25-27 May 2015

Sprenger, A. NANOOS Tools for Accessing Ocean and Coastal Data for the Northwest. Vibrio Forecasting Workshop, April 2015. Lacey, WA.

Sprenger, A. The Pacific Regions Ocean Observing Systems. Pacific Rim Shellfish Sanitation Conference, March 31-April 1 2015. Ketchikan, AK.

Publications:

Alin, S., R. Brainard, N. Price, J. Newton, A. Cohen, W. Peterson, E. DeCarlo, E. Shadwick, S. Noakes, N. Bednaršek. 2015. Characterizing the Natural System: Toward Sustained, Integrated Coastal Ocean Acidification Observing Networks to Facilitate Resource Management and Decision Support. Oceanography (Washington D.C.) 25(2):92-107, May 2015 DOI: 10.5670/oceanog.2015.34

Allan, J., Ruggiero P, Cohn N, Garcia G, O'Brien F, Stimely L, and Roberts J, 2015. Coastal Flood Insurance Study, Lincoln County, Oregon. Oregon Department of Geology and Mineral Industries Open-File Report

Allan, J., Ruggiero P, Cohn N, Garcia G, O'Brien F, Stimely L, and Roberts J, 2015. Coastal Flood Insurance Study, Tillamook County, Oregon. Oregon Department of Geology and Mineral Industries Open-File Report

Anderson, D. and Ruggiero, P., 2015. Modeling Interannual to Multi-Decadal Shoreline Rotations of Headland-Bounded Littoral Cells, Proceedings of Coastal Sediments 2011, ASCE, San Diego, CA.

Baptista AM, Seaton C, Wilkin M, Riseman S, Needoba JA, Maier D, Turner PJ, Karna T, Lopez JE, Herfort L et al.. Accepted with minor revisions. Infrastructure for collaborative estuarine science and societal applications in the Columbia River, United States. Frontiers of Earth Science.

Barton, A., G. Waldbusser, R. Feely, S. Weisberg, J. Newton, B. Hales, S. Cudd, B. Eudeline, C. Langdon, I. Jefferds, T. King, A. Suhrbier, K. McLauglin. 2015. Impacts of Coastal Acidification on the Pacific Northwest Shellfish Industry and Adaptation Strategies Implemented in Response. Oceanography (Washington D.C.) 25(2):146-159, May 2015 DOI: 10.5670/oceanog.2015.38

Cohn, N., Anderson, D., and Ruggiero, P., 2015. Observations of Intertidal Bar Welding along a High Energy Dissipative Coastline, Proceedings of Coastal Sediments 2011, ASCE, San Diego, CA.

David AS, Zarnetske PL, Hacker SD, Ruggiero P, Biel RG, Seabloom EW, 2015. Invasive Congeners Differ in Successional impacts across Space and Time. PLoS ONE 10(2): e0117283.doi:10.1371/journal.pone.0117283.

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Di Leonardo, D. and Ruggiero, P., 2015. Regional scale sandbar variability: Observations from the U.S. Pacific Northwest, Continental Shelf Research, 95,74-88, http://dx.doi.org/10.1016/j.csr.2014.12.012i

Durski, S. M., A. L. Kurapov, J. S. Allen, P. M. Kosro, G. D. Egbert, and K. R. Shearman, 2015: Coastal ocean variability in the U.S. Pacific Northwest region: seasonal patterns, winter circulation and the influence of the 2009-2010 El Nino, Oce. Dyn., in review.

Herfort L, Seaton C, Wilkin M, Roman B, Preston CM, Marin, III R, Seitz K, Smith MW, Haynes V, Scholin CA et al.. Use of continuous, real-time observations and model simulations to achieve autonomous, adaptive sampling of microbial processes with a robotic sampler. L&O Methods. Accepted with minor revisions.

Karna T, Baptista AM, Lopez JE, Turner PJ, McNeil C, Sanford TB. 2015. Numerical modeling of circulation in high-energy estuaries: A Columbia River estuary benchmark. Ocean Modelling. 88:54-71.

Karna T, Baptista AM. Submitted. Evaluation of a long-term hindcast simulation for the Columbia River estuary. Ocean Modelling.

McLaughlin, K., S. Weisberg, A. Dickson, G. Hofmann, J. Newton, D. Aseltine-Neilson, A. Barton, S. Cudd, R. Feely, I. Jefferds, E. Jewett, T. King, C. Langdon, S. McAfee, D. Pleschner-Steele, B. Steele. 2015. Core Principles of the California Current Acidification Network: Linking Chemistry, Physics, and Ecological Effects. Oceanography (Washington D.C.) 25(2):160-169, May 2015, DOI: 10.5670/oceanog.2015.39

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

June 2015 Progress Report Annual Supplemental

The reporting period for this annual supplemental is 6/1/2014-5/31/2015.

- **Regional Ocean Governance Organization activities**

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

NANOOS continued and strengthened its close collaboration with the WCGA in partnership with the two other West Coast IOOS Regional Associations, SCCOOS and CeNCOOS. This collaboration focused particularly – but not exclusively – on the WCGGA Ocean Data Network (WCODN, http://portal.westcoastoceans.org/about/). NANOOS Director Jan Newton is a member of the WCODN Action Coordination Team (ACT). Technical support and guidance from NANOOS DMAC Lead E. Mayorga led to continued improvements to the West Coast Ocean Data Portal (WCODP, http://portal.westcoastoceans.org) and related data and user productsMayorga is one of the core members of the WCODN IT working group. In addition, C. Risien (OSU) participated in the 3rd WCODN network meeting, Nov 3-4 in Costa Mesa, CA (Mayorga & Risien, 2014).

NANOOS collaborations with the WCODN strongly supported the enhancement of ISO 19115-1 and ocean-observing ISO 19115-2 metadata best practices and handling in the WCODP Catalog, and the use of OGC WMS (including temporal WMS, "WMS-T") by both service providers and the WCODP Marine Viewer client (http://maps.westcoastoceans.org). Mayorga provided guidance and direct assistance for resolving the handling of ISO metadata as well as WMS and OPeNDAP web service types in the Catalog. In January 2015, Mayorga provided a key fix for a long-standing bug that prevented proper handling of ISO 19115-2 metadata records in the WCODP Catalog, opening the door for metadata registration for ocean data from West Coast RA's. NANOOS registered several of its metadata records with the WCODP Catalog (http://portal.westcoastoceans.org/discover/#?s=NANOOS) and is using its GeoServer instance to serve WCODN partner datasets via OGC web services (WMS, WFS, etc). Mayorga also supported discussions between the WCODP team and CeNCOOS and SCCOOS to establish best practices and facilitate the registration of their metadata.

Mayorga served as the technical supervisor for the WCODN SeaGrant fellow (L. Lilly) hosted by SCCOOS; this one-year fellowship ended in November. With NANOOS assistance, the fellow successfully created several west-coast data products (surface currents, temperature and wave climatologies, ocean acidification asset inventory, etc) derived from RA datasets and services, and registered these products with the WCODP catalog. Her work, described broadly at http://westcoastoceans.wordpress.com/2014/10/28/coming-full-circle-with-the-west-coast-ocean-observing-systems/ and in detail (including a final report) at http://cdip.ucsd.edu/share/IOOS_WCODP_products/, was very well received by the WCODN and partner communities, and will help WC RA's to better serve our regional users. It includes nearly a dozen metadata records created for and registered with the WCODP Catalog (see http://portal.westcoastoceans.org/discover/#?s=West%20Coast%20IOOS).

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

Presentations acknowledging NANOOS support: underline indicates NANOOS PI
Mayorga, E. and C. Risien. 2014. West Coast IOOS Regional Associations Updates: NANOOS. *West Coast Ocean Data Network Meeting*, Costa Mesa, CA, Nov 3-4

- **Efforts to leverage IOOS funding**

NANOOS is substantially leveraged in every aspect of its effort. None of NANOOS' assets or teams is supported by 100% IOOS funds. Maintaining the sources of the current leverage, in times of budget cuts and shrinking funding levels affecting all sectors of NANOOS, represents a major commitment of time. NANOOS leadership, Newton and Martin, as well as all of its PIs, actively engage to leverage and build capacity for our existing systems. We can honestly say leveraging activities permeate daily practice throughout NANOOS. These include CMOP's NSF funding, UW's EPA-NEP funding, federal investments in NERRS, from NOAA's OAP, and state of Oregon and state of Washington funding.

Additional examples include:

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

The HAB focused OTT IOOS project includes work with the NWFSC, tribes, and NANOOS' La Push mooring. The OA focused OTT IOOS project was written in collaboration with three other RAs, AOOS, CeNCOOS, and SCCOOS, and involves leveraged shellfish grower and hatchery operations utilizing state directed OA monitoring funds in AK, WA, and OR.

NANOOS Puget Sound moorings are partially supported by the State of Washington's Washington Ocean Acidification Center.

NOAA Fisheries and the Ecosystem (FATE) program renewed funding for the JISAO-Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE) project, in which NANOOS is a partner, along with NOAA Northwest Fisheries Science Center and the UW-NOAA Joint Institute for the Study of Atmosphere and Oceans (JISAO).

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

NANOOS gained Western Washington University as a new member. We are still working to get NOAA PMEL, but this is in the hands of a NOAA lawyer now.

One Board member, Vicki McConnell, Governing Council Board Member for OR State Agencies, representing DOGAMI left her position with State of Oregon in April 2015. Jonathan Allan, also with DOGAMI, is filling in for her term as acting. Another Board vacancy, for non-profit organizations, is being filled on an acting basis by Paul Dye, The Nature Conservancy, until the August 2015 election. We will also fill a Member-at-large vacancy by a retired member. All other Board members have not changed during this period and they have stayed engaged. Per IOOS Supplemental Report guidance, we confirm that the NANOOS Governing Council Board affiliation types represented in the IOOS template is accurate and up to date: http://www.ioos.noaa.gov/regions/ra_membrshp_govern_template.xlsx.

- **Governance activities and accomplishments**

Newton and Martin held annual NANOOS meetings for all PIs and the Governing Council in Vancouver, WA on 11-12 August 2014. Newton coordinated with. J. Allan, User Products Committee Chair, to organize the Tri-Comm meeting, held 22-23 April 2015 in Seattle, WA, hosted by APL-UW. At these

meetings, NANOOS reviews progress made to date, priorities for going forward, and tends to the business of NANOOS.

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

Our Governing Council Board members are completing the second year of their 3 year terms. We have two seats held by acting members: OR State Agencies and Non-Governmental Organizations and one vacancy: At Large. We will fill these seats in an election at our upcoming GC meeting in August 2015.

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

Per our NANOOS MOA, the elected Board, plus the Chairs from the DMAC, User Products, Education and Outreach Standing Committees plus the Executive Director comprise the NANOOS EXCOM. Martin and Newton used the NANOOS EXCOM to obtain input and approval of the NANOOS budget for Y5 funds during 2015 and for the process and initial review of NANOOS's process and response to the new 5-y FFO. Newton, using input from the Governing Council on priorities that had been established at the 2014 GC meeting, and having consulted by phone with all NANOOS PIs in early 2015, drafted a Y5 budget that was responsive to NANOOS priorities and reflected realistic operations. Near level funding precluded changes in the existing plan NANOOS chooses to sustain. A modest increase, $20k, will be invested in improving glider data presentation on NVS. There was unanimous consent to adopt the budget. The EXCOM was used to review new LOI's for the FFO. Members identified criteria upon which to judge the 12 LOI's and offered prioritization. This process is still being executed.

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

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