Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS
NOAA Award: NA16NOS0120019 Reporting period: 12/01/2016 to 05/31/2017

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 FY16 period (= Y1 of this award; Y10 of NANOOS RCOOS operations) our objectives were to:

1) **Maintain NANOOS as the U.S IOOS PNW Regional Association:** Sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement, engaging federal and non-federal (tribal, academic, state, local, industry, NGO, etc.) partners.
2) **Maintain surface current and wave mapping capability.** Maintain existing HF-radar foundational capability providing critical national capacity; continue, to the extent possible, existing investment in wave mapping at critical ports.
3) **Sustain existing buoys and gliders in the PNW coastal ocean, in coordination with national programs.** Maintain these essential assets providing regional observations, with focus, to the extent possible, on hypoxia, HABs, ocean acidification (OA), climate change detection.
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. Sustain observing ability including to the extent possible, hypoxia and OA.
5) **Maintain core elements of beach and shoreline observing programs.** Contribute to hazard mitigation by providing, to the extent possible, essential observations and better decision support tools for coastal managers, planners and engineers.
6) **Provide sustained support to a community of complementary regional numerical models.** Contribute, to the extent possible, 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 OR and WA.
7) **Maintain NANOOS' Data Management and Communications.** Sustain, to the extent possible, the DMAC system NANOOS has built, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS.
8) **Continue to deliver existing and, to the extent possible, create innovative and transformative user-defined products and services for PNW stakeholders**. Continue our NVS innovation to succeed in this vital translation: meaningful and informative data products that connect with user applications and serve society.
9) **Sustain NANOOS outreach, engagement and education.** Foster ocean literacy and facilitate use of NANOOS products for IOOS objectives, the core task for which NANOOS was constructed, via existing approaches for engaging users and increasing ocean awareness.

NANOOS has the following additional task during FY16 from the NOAA Ocean Acidification Program:

10) Support collection of OA measurements on our La Push [UW] and NH10 [OSU] 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 16:

Area	**Y1 Award = Y10 NANOOS**
Observations	
Shelf:	-Maintain La Push buoy; deliver NRT datastreams via NANOOS Visualization System (NVS) -Support collection of OA data from La Push buoys with NOAA OAP funding -Maintain Newport buoy; deliver NRT datastreams via NVS -Support collection of OA data from NH-10 buoys with NOAA OAP funding -Maintain Columbia R. buoy; deliver NRT datastreams via NVS -Maintain N CA shelf glider transect; deliver data via NVS -Bring all data QA/QC to meet Certification standards
Estuaries:	-Maintain Puget Sound estuarine moorings; deliver data via NVS -Maintain US-Canada ferry-box; deliver data via NVS -Maintain Columbia R. estuarine moorings; deliver data via NVS -Maintain South Slough estuarine moorings; deliver data via NVS -Bring all data QA/QC to meet Certification standards
Shorelines:	-Maintain shoreline observations in OR; deliver data via NVS -Maintain bathymetric observations in WA and OR; deliver data via NVS -Bring all data QA/QC to meet Certification standards
Currents:	-Maintain OR Priority-One HF radar sites to the national operations standard; deliver data via NVS and the National HF Radar system -Maintain X-band radar sites; deliver data via NVS -Bring all data QA/QC to meet Certification standards

Modeling	
OR/WA estuaries and coast models	-Maintain modeling & forecasting capabilities at UW at reduced level; make model output available via NVS -Maintain modeling & forecasting capabilities at OHSU at reduced level; make model output available via NVS -Maintain modeling & forecasting capabilities at OSU at reduced level; make model output available via NVS -Model verification and validation
DMAC	
Web Site Improvement	-Sustain & enhance existing data streams, IOOS web services, GTS submission -Sustain, refresh and enhance hardware and software environment; appropriate staffing; and operations documentation -Initial, limited implementation of NCEI data archiving, Glider DAC submission, QARTOD -Engage new local providers (not NANOOS funded), integrate their data into NVS and IOOS DMAC services, and assist with their data management & workflows -Strengthen DAC capabilities and resources through regional and thematic partnerships -Deploy ERDDAP to leverage web services, serve NANOOS applications and users -Sustain participation in IOOS DMAC community activities, including QARTOD development, semantic mapping, OGC WMS/WFS support, climatology data development, UGRID support, and shared code development and testing -Engage and leverage OOI and NSF EarthCube, international GOA-ON activities and Canadian collaborations -Engage West Coast and Pacific efforts, including WCGA and IPACOA -Improve ease of usability and user tracking capabilities -Develop and implement user customization and notification capability on NVS -Depth vs. time plots and multivariate plotting
Tailored Product Development	-Climatology and Tsunami resilience apps -Tsunami mobile app re-build -With E&O committee, evaluate usefulness of web and product suite
Education and Outreach	
Networking	-Maintain existing and build new relationships to stakeholder user groups and the education community enabling NANOOS to achieve affective outreach, engagement, and education -Engage with regional formal education communities to use ocean observing and NANOOS products to support STEM education.
Product Development	-Work with DMAC and User Products Committee on tailored product development to meet specific user needs, as per above, and through Tri-Committee meetings; for each new product engage users in product development. -Evaluate website and product suite annually; interpret evaluation results with recommendations discussed at weekly Tri-Com tag-up calls
User Engagement	-Gain feedback and conduct self-assessment after product release. -Conduct trainings to broader user groups and evaluate trainings to optimize NANOOS help functions -Engage with regional non-formal education communities to facilitate the use of NANOOS products to engage citizens to increase their ocean literacy.

	-Maintain up-to-date success stories, employing effective use of social media -Be responsive to regional and local events (e.g., blooms, floods, etc.) to enhance relevancy to public and highlight regional stories with NANOOS members and partners. -Support national communication through IOOS Program Office and IOOS Association collaborations.
Administration	
Meetings	-Represent NANOOS at IOOS Program Office and IOOS Association meetings, and at national meetings of significance (e.g., Oceans 20xx, CERF, Ocean Sciences). -Engage at a regional level at meetings and workshops affecting PNW stakeholders and NANOOS. -Conduct annual GC meeting.
Project oversight	-Provide NANOOS with oversight, coordination, and management of the full suite of activities that comprise NANOOS. -Share project evaluation at the annual PI meeting.
Coordination	-Assure that NANOOS has transparent, effective, and representational governance via its Governing Council and the NANOOS Executive Committee composed of its elected Board and its functional committee chairs. -Assure these bodies are engaged in NANOOS prioritization of regional needs, work effort, and product development. -Assure balance of stakeholders represented in NANOOS reflects the diversity found in PNW. -Conduct annual all-PI meetings and Tri-Committee meetings, providing clear feedback and direction. -Coordinate with West Coast RAs and other RAs to optimize and leverage capabilities and assure consistencies. -Engage in sub-regional and user-group specific workshops to aid coordination and optimization of effort.
Accountability	-Submit required IOOS progress reports and respond to other requests. -Seek certification as a Regional Information Coordination Entity of US IOOS.

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

• ***Shelf***

***Washington Shelf Buoy*:** The Washington Coast buoy observation program, led by J. Mickett, Applied Physics Laboratory, University of Washington (APLUW), continued to maintain and operate two real-time moorings 13 miles NNW of La Push, Washington. The new "winter version" Chaba surface mooring, funded by NOAA OAP, which was deployed in fall, broke free in mid-December because of hardware failure. Due to multiple and redundant beacons on the mooring and a fast response, the mooring was recovered quickly. Prior to re-deploying along with the ESP-equipped subsurface profiling mooring the first week of May, a number of upgrades were made to this mooring, including a much more robust mooring bail (connection point). We anticipate the bail upgrade will prevent the same failure mechanism that caused the mooring to break free. Other upgrades include the addition of a 3-axis accelerometer that will allow estimates of wave height and direction. Prior to re-deploying along with the ESP-equipped subsurface profiling mooring the first week of May, a number of upgrades were made to this mooring, including a much more robust mooring bail (connection point).

We anticipate the bail upgrade will prevent the same failure mechanism that caused the mooring to break free. Other upgrades include the addition of a 3-axis accelerometer that will allow estimates of wave height and direction. As of the end of the reporting period the mooring was operating on station. One positive outcome of this hardware failure is that it helped us to identify a reliable, willing, capable vessel on the outer Coast that can be called upon on short notice for such emergencies (F/V Alyeska out of Neah Bay).

The subsurface mooring (NEMO-ESP), equipped with the IOOS OTT-supported HAB/DA-detecting Environmental Sample Processor, was successfully deployed operationally for the third time on May 2nd and continues to operate as planned, with HAB species and DA quantification observations displayed on NANOOS roughly every three days since deployment.

One clear observational highlight from this period is the comparison of same-depth surface observations on Cha'Ba, which allows a better estimate of sensor errors and, as is the case for the PMEL-maintained SAMI pH sensor, assists with identifying instrument problems. Chlorophyll records are remarkably similar between adjacent instruments---an observation not entirely expected. Oxygen measurements between different make-instruments show a ~0.2 to 0.3 mg/l nearly-constant offset between instruments.

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. Newton and Mickett have also continued to work closely with both the Olympic Coast National Marine Sanctuary and coast First Nations (Quileute) in maintaining and operating the two moorings, with the Quileute Marine Biologist, J. Hagen participating in the May mooring deployment cruise. Additionally, the Sanctuary recently provided generous support in helping to provide on-site verification of the operation of the pump system on the NEMO ESP mooring, while our mooring team assisted with the deployment of one of their moorings.

As this program is entering it's 7th year, meaningful inter-annual comparisons are now possible. The 2016 observations in comparison to other years were presented and submitted by Newton in March (Canadian State of the Pacific Ocean Report) and April (2016 Puget Sound Maine Waters Report).

Oregon Shelf Glider: Starting in early December 2014, the Oregon State University glider research group 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 and CeNCOOS.

From its first occupation of the TH line on December 4, 2014, until the end of this reporting period (5/31/2017), the glider was on the TH line for 912 days during six deployments, sampled along approximately 16,500 km of track line covering the transect about 30 times, and collected about 7,400 vertical profiles of ocean properties. For the reporting period 12/1/2016 to 5/31/2017 the glider was on the TH line for 182 days during one deployment, sampled along nearly 3600 km of track line covering the transect about 7 times, and collected about 1356 vertical profiles of ocean properties. The glider "uptime" was 99%. Data are being sent in near real-time to the IOOS Glider Data Acquisition Center and, simultaneously, to the CeNCOOS and NANOOS data centers. When an individual glider deployment is complete, we submit the data to NODC.

Data from the Trinidad Head glider line are being used to monitor and understand the contributions of both the "Warm Blob" and the 2015-2016 El Niño to the warm anomalies observed in the northeast Pacific over the last several years. The glider data show that for the January to September 2015 period, the 50-m temperature, when averaged from the coast out to 200 km offshore, was 1-3 degrees C warmer than the historical average for this area (Figure 1). Temperatures over the continental shelf during the 2015 and 2016 summer upwelling seasons varied from slightly above normal to average, due to wind-driven coastal upwelling bringing cold, deeper water up to 50-m depth. Starting in September 2015, warm water associated with the 2015-2016 El Niño arrived at the TH line, with a positive 0.5-degree C anomaly extending to 500 m depth (Figure 1). The maximum temperature anomaly of over 2-degree C descended from the surface during the Warm Blob event to a depth of around 100 m during early 2016. There remained a warm anomaly, up to 1-degree C, from Fall 2016 to May 2017 off northern California, a time period when the Oceanic Niño Index was slightly negative (cool).

Jack Barth is a member of the Interagency Ocean Observation Committee Glider Task Team, the primary goals of which are to enable increased engagement with the glider community and to advance the coordinated use of glider observing systems to meet global, national and regional sub-surface observing requirements. Jack Barth attended the "U.S. Underwater Glider Workshop" held in Pearlington, MS, from January 18-19, 2017. Jack Barth also attended the "Autonomous and Lagrangian Platforms and Sensors – ALPS II" workshop held in La Jolla, CA, from February 21-24, 2017.

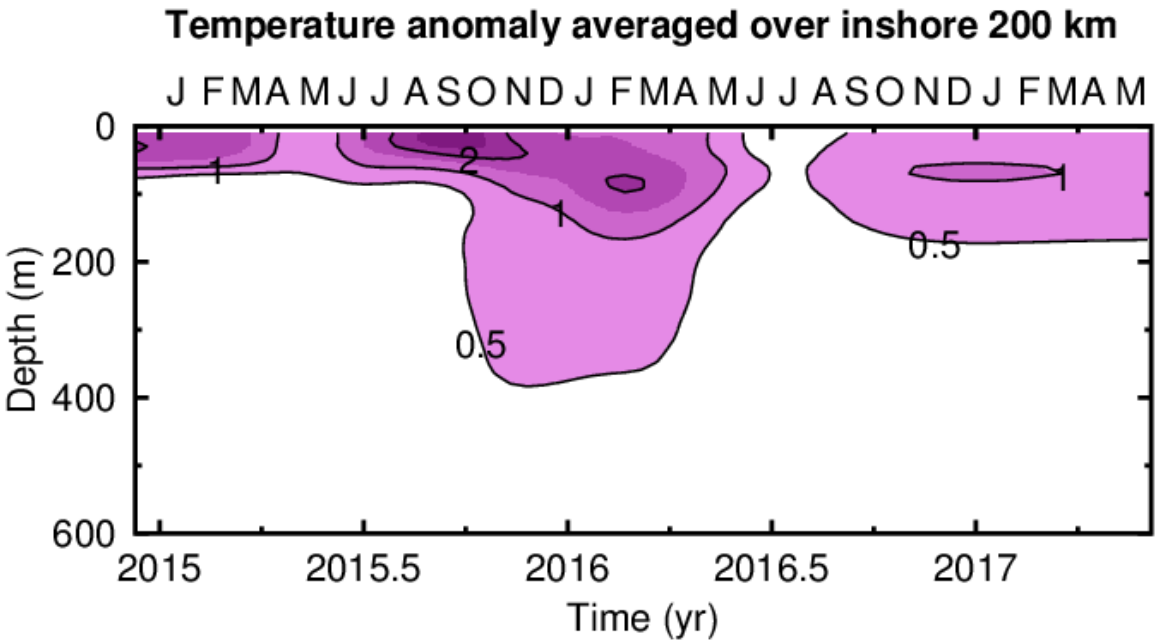

Figure 1: Temperature anomaly on the Trinidad Head, CA, (41° 3.5'N) glider line, averaged over the inshore 200 km of the 500-km long glider line.

Oregon Shelf Moorings: A mooring about 10 miles off Newport, Oregon, in 83 m of water (site NH-10) has been maintained since mid-2006, primarily through support by NANOOS (PI for physical oceanography is Kosro, for pCO_2 / biogeochemistry is Hales). Deployed on 8/26/2016 with a modified anchor, the mooring remained in place through severe storms (waves exceeding 25 ft) until it was recovered on 4/23/2017 from R/V Sikuliaq. Return of internally logged data was excellent, although some systems (e.g. ADCP) were halted early following a strong storm in October.
This was the final deployment of the Oregon shelf mooring at the NH10 location – its long-term mission is being taken on by the Oceans Observatory Initiative. A new long-term site (CB-06) is being established in 100m of water, 6 nm offshore just south of Coos Bay. A long-term reference site was operated at this depth during the early 1980's (Huyer and Smith, 1985[1]), during SuperCODE (Strub et al., 1987[2]) and during the GLOBEC era (Hickey et al., 2016[3]). After consultation with the local fishing community and trawlers, we selected a site somewhat farther north, at 43°18'N, 124°32'W, but at the same isobath, to minimize interference with area fishing and still retain comparability with the historic site (which is now subject to heavy fishing pressure). The mooring and sensors will be the equivalents of those used at NH-10.

[1] Huyer, A., & Smith, R. L. (1985). The signature of El Nino off Oregon, 1982–1983. *Journal of Geophysical Research: Oceans*, *90*(C4), 7133–7142.

[2] Strub, P. T., Allen, J. S., Huyer, A., Smith, R. L., & Beardsley, R. C. (1987). Seasonal cycles of currents, temperatures, winds, and sea level over the Northeast Pacific Continental Shelf: 35-DEGREES-N TO 48-DEGREES-N. *Journal of Geophysical Research-Oceans*, *92*(C2), 1507–1526.

[3] Hickey, B., Geier, S., Kachel, N., Ramp, S., Kosro, P. M., & Connolly, T. (2016). Alongcoast structure and interannual variability of seasonal midshelf water properties and velocity in the Northern California Current System. *Journal of Geophysical Research-Oceans*, *121*(10), 7408–7430. http://doi.org/10.1002/2015JC011424

The buoy was redeployed on June 10, and is reporting data via cell phone. After data quality is reviewed, the results will be sent out via the usual channels including NVS and NDBC.
Physical oceanography measurements include atmospheric data (solar insolation, wind speed and direction, air temperature, barometric pressure), currents (downward-looking ADCP), temperature, salinity and pressure at 18, 4, and 5 depths respectively, and dissolved oxygen 10m off the bottom; the atmospheric and near-surface oceanographic data are returned in real time by cell-phone telemetry. The bio-geochemical measurements are built around the NOAA PMEL MAP-CO_2 sensor suite for pH and CO_2 concentration in water and air.
The National Data Buoy Center has assigned CB-06 a WMO ID of 46128 for reporting of real-time measurements, once we have completed initial QA/QC data checks

Northern Oregon to Central Washington shelf: Led by A. Baptista (OHSU), the Center for Coastal Margin Observation & Prediction (CMOP) maintains observational assets in the Columbia River coastal margin, with partial support from NANOOS and the National Science Foundation. These assets are anchored on SATURN-02 (a seasonal inter-disciplinary buoy at ~30m depth, off the mouth of the Columbia River; deployed during the reporting period) with additional data collected by glider operations (as allowed by available funding; no deployment during the reporting period).

- **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, while the field team carried out regular maintenance and repairs to keep this real-time system operational.

Over this reporting period this mooring system was critical in assessing the response of Puget Sound to anomalous atmospheric forcing over the region, with Seattle registering one of the coldest and wettest winters on record. The lingering warm anomaly of the North Pacific Heat Wave in late 2016 has largely been erased, and the water column has become significantly fresher, with some places such as Carr Inlet and Twanoh exceeding two standard deviations below climatology for near-bottom water. The ability to track the influence of these events in real time and have some predictive success (as with the 2015 fish kill or reduced concern in 2016) highlights the importance and utility of the ORCA program---specifically a long-term, high-frequency (> daily), real-time system that collects *profiles* of oceanic properties.

The integration of shallow SeaFET pH sensors at the Carr Inlet and Twanoh moorings, funded through the Washington Ocean Acidification Center, continued to provide invaluable, unprecedented time series of shallow pH changes in the South Sound and Hood Canal respectively. Unfortunately, the reliability of these instruments has been less than acceptable, and we have been working actively with SeaBird Scientific to resolve the issues. Seabird is presently servicing and upgrading the pH sensors in groups, with the first two upgraded units recently received.

During this period, we also continued our organized, formal effort to increase mooring reliability and to decrease maintenance costs. Prototype designs for a new, more robust winch control module and communications system have been deployed on several moorings and initial trials have been very

successful. 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.

The project PIs and oceanographer W. Ruef, the ORCA operational lead, submitted an article for publication in the Puget Sound Marine Waters 2016 Overview Report, highlighting the evolution and end of the North Pacific Heat Wave and influence of local weather anomalies on Puget Sound. Additionally, Newton presented and submitted a report in March to the State of the Pacific Ocean (SOPO) workshop.

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. Additional collaborations included work with J. Keister and D. Grunbaum of UW Oceanography to deploy a real-time, profiling Zooplankton camera on the Twanoh mooring, J. Padilla-Gamino of UW Fishery Sciences to investigate the influence of OA on mussels and scallops, and King County to deploy a pH sensor on the Pt. Wells mooring,.

Washington State estuarine monitoring: Led by C. Maloy and C. Krembs (WA State Department of Ecology), en route ferry-based monitoring is one part of Ecology's extensive long-term monitoring program covering Puget Sound and the coastal estuaries. Ferry monitoring complements Ecology's larger program by focusing on surface processes (e.g., temperature variations, frontal systems, tidal currents, blooms, river plumes etc.), and provides a means of continuously groundtruthing remote sensing techniques to greatly leverage and expand capabilities for Puget Sound environmental monitoring.

Ecology has two sensors (measuring temperature and chlorophyll fluorescence) and a GPS on the *Victoria Clipper IV* passenger ferry vessel that runs twice daily between Seattle and Victoria, BC. Data are uploaded daily to a cloud computing server at: http://107.170.217.21/VictoriaClipper30/level2/ and stored as daily files in a NetCDF database, the repository of the monitoring data. Routine field visits and calibrations continued diligently, approximately every six weeks.

During the reporting period, two highlights occurred. In early spring, the fluorometer was repaired by the manufacturer to maintain high quality of the data. Chlorophyll fluorescence data associated with algal blooms were presented at the annual PSEMP Marine Waters workshop in April and submitted for the annual report. Trends of algal blooms and *Noctiluca* clearing the blooms were compared between 2011, 2012, 2015, and 2016 using fluorescence data and aerial photography.

Ferry observations are powerful tools to capture large scale surface temperature and chlorophyll patterns. Data from regular ferry routes are analyzed in combination with data from Ecology's monthly water column stations and aerial photographs documenting the extraordinary impacts of global and regional climate variations of recent years.

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. Joseph Needoba with CMOP/NSF and regional stakeholder funding.

SATURN physical and biogeochemical observations have been extensively used 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 have also been integral to CMOP science, which addresses estuarine the estuary as a physically mediate bioreactor.

Of particular interest during the period, SATURN stations have enabled the characterization of the effects on the Columbia River estuary of climate change, by underlying the calibration for contemporary conditions of models used to predict extensive impacts of sea level rise on the Columbia River (Baptista 2017; and paper in review). SATURN data also informed modeling of sediments (Lopez and Baptista 2017) and wind-driven circulation (Scroccaro et al. 2017).

The symbiosis of modeling and observations within SATURN was one of the examples used in the development of the recommendation of the IOOS Modeling Task Force (Wilkin et al. 2017).

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 water quality observing stations as part of the NERRS System-Wide Monitoring Program with additional support provided by NANOOS. Four real-time water quality monitoring stations located along the estuarine salinity gradient provided continuous water temperature, salinity, dissolved oxygen, pH, turbidity, and water level data over the period 12/01/16 –5/31/17. Monthly station maintenance, instrument deployments/retrievals, data downloads and data management were completed for the weather and water quality stations during this reporting period. The telemetry transmissions at the Winchester station were interrupted temporarily during March/April 2017 due to malfunctioning equipment, and the signal output adapter (SOA) was replaced and the station resumed transmissions on 4/10/17. Staff reinforced the telemetry enclosure hardware at the Valino Island water quality station in April 2017. In May 2017, Reserve staff identified a suitable new location for the Charleston Bridge water quality station on a nearby pier, owned by the North Bend Oyster Company. The current location of the Charleston Bridge station equipment on a dock owned by the same oyster company has been deteriorating over the years. Currently, no instruments are deployed at the fifth water quality station (Boathouse) due to platform evaluation and assessment.

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. Real-time data transmissions were continuous for the reporting period.

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. The South Slough Reserve and CTCLUSI stations also provide environmental data for research, monitoring and education programs conducted at the reserve. During this reporting period, data from SWMP/NANOOS stations were referenced and utilized for two outreach purposes, including a presentation for the Reserve non-profit Friends of South Slough new board members in March 2017 (6 participants) and a Leadership Coos class in April 2017 (20 participants); Leadership Coos is a local program for presenting city, county, state, and federal issues to the community via topics, tours, and speakers**.**

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 Coos estuary. One station, North Point, is located near commercial oyster cultivation areas and will be prioritized for adding real-time capability for growers and bar pilots to provide water quality data along with incorporating this site into NVS once telemetry is installed. Reserve staff attended monthly Coos Bay Harbor Safety Committee meetings in March – May 2017, promoted NANOOS and NVS, and continued to give updates about the water quality stations at the meetings. Staff also gathered input from Coos Bay bar pilots regarding functionality of a future NANOOS station located at the North Bend, McCullough Bridge (North Point station). South Slough added *p*CO2/ pH monitoring equipment at the Valino Island station in 2015 and continued data collection and monthly instrument maintenance with future intentions to explore including these datasets through NVS.

• **Shorelines**

Washington Shorelines: NANOOS funds contribute to the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. In December 2016, CMAP completed fall seasonal beach monitoring surveys in the Columbia River Littoral Cell (CRLC). Forty-six seasonal beach profiles and two surface maps were collected. In addition, CMAP collected 6 supplemental profiles in Westport and 13 supplemental profiles in Ocean Shores.

When compared to last fall at the start of the strong El Niño, the primary dune at Westport (profile Worm) is completely eroded, but the beach face was 20-70 cm higher. The dune scarp at Spice has retreated landward by 3 m since last fall. At Ocean Shores, the X1 South profile shows ~11 m of dune scarp retreat since last fall. At Benson Beach to the north of the mouth of the Columbia River, significant dune erosion occurred since last fall at profiles Philo (20-m scarp retreat) and Hans RM (25-m scarp retreat). Profile Canby shows significant beach lowering of 2 m across the entire profile with a 2-m high scarp present that isn't usually seen.

Analysis of beach profiles following the 2015-2016 El Niño showed that 14 profiles recovered more than their average amount in summer 2016, 20 profiles recovered approximately their average amount in summer 2016, and 15 profiles recovered less than their average amount in summer 2016. However, the amount of summer recovery was less than the previous winter erosion volumes for the majority of beaches: 8 profiles recovered more than the amount eroded in winter 2016, 9 profiles recovered approximately the amount eroded in winter 2016, and 33 profiles recovered less than the amount eroded in winter 2016.

The data collected in Westport were provided to a consultant working on an assessment of coastal protection options for mitigating future erosion hazard impacts. G. Kaminsky provided technical

advice and additional information on the erosion, drawing from beach and dune volume change analysis. The seasonal and supplemental beach profiles are providing important information to be integrated into the next update of the Grays Harbor Hazard Mitigation Plan.

In March and April 2017, CMAP conducted winter seasonal beach monitoring surveys in the CRLC, collecting 50 seasonal beach profiles (plus a total of 19 supplemental profiles as in the fall), 5 surface maps, and 63 sediment samples from multiple cross-shore locations along 13 of the profiles. The Ocean Shores scarp extended for approximately 500 m further north than its northern point in December. The Westport scarp remained in the same alongshore position as it was in December with the southern end being inactive during the survey. Approximately 100 acres of dunes in the Willapa National Wildlife Refuge at northern Long Beach were bulldozed to enhance habitat for Snowy Plovers. This affects the upper portion of the two northernmost beach profiles, PC055 and LB1, and we may be restricted to only collecting data across the active beach at these profiles in the foreseeable future.

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). Beach profile data were collected in the Neskowin (15 sites) – fall survey – and in the Rockaway (25 sites), Clatsop cells (6 sites), and Neskowin (15 sites) littoral cells this past winter (March 2017). Datum-based shorelines were also collected during the same beach monitoring campaigns. In addition, beach profile data were also collected in the Port Orford cell (10 sites), the first time since 2013. Processing of new lidar data collected in April 2017 has been undertaken for several areas on the north (Cannon Beach) and south coast (Port Orford) and is continuing for other areas that are being monitored for coastal change. Beach profile data have been processed, QA/QC'd, and archived both locally and remotely. The reduced profile plots, change plots and trends have been posted to the NANOOS beach and shoreline portal (http://nvs.nanoos.org/BeachMapping).

***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 2016 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. 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). 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. During spring 2017 Ruggiero's group collected >200 profiles within Coos Bay to support hydrodynamic and water quality modeling. Without NANOOS support over the years for maintaining the PWC-based Coastal Profiling System, this work would not have been possible.

These data continue to provide a critical source of information for improving coastal hazard mitigation along the coastlines of the CRLC and for understanding the morphodynamics of high energy beaches.

In particular, this NANOOS funded nearshore bathymetric data is being incorporated in a coastal hazards decision support tool supported by NOAA's Climate Program Office in both Tillamook County, OR and Grays Harbor County, WA.

• **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.

During this period, presentation of HF currents were greatly improved on the NANOOS Visualization System thanks to work by the DMAC team. Maps are available on the timeline (user can choose date/time to examine, and move easily between dates), vector density adjusts to enlargement level, and users can view the 2km or 6km data, with or without tidal (25hr) filtering.

Erik developed a tool to provide a text-message alert when a power failure occurs at a site, using the Raspberry Pi platform. New dome-style antennas were installed at WSH1 (12 MHz) and at LOO1 (5 MHz); the antenna box from the old LOO antenna was repaired at CODAR and is available as a hot spare. The transmit antenna at WIN1 was found broken in April, about 2/3 of the way up; CODAR sent a part to use during repair, and a new antenna has been ordered. Equipment repairs were required at WSH (Receiver & Transmitter) and WIN1 (Transmitter). Documentation of cell-phone-modem configurations was upgraded at all sites. Power outages due to a big storm occurred at 3 sites, and STV2 experienced several short power outages during the period. An additional battery pack was added to the UPS at STV2 to increase the time it can bridge during a power outage. Remote swapping of operation between dehumidifiers (winter) and air conditioners (summer) is aided by our web power switches; we have had to replace several of these in past months. Poorly-performing landline phones at LOO have been replaced with cell-phones and external antennas; issues with the intruder alarm are being worked on.

In spite of these problems, HFRnet diagnostics (https://hfrnet.ucsd.edu/diagnostics/) indicate uptime during the period using the NOAA metric was 95% in Q1 and 90% in Q2, which is quite good (top nationally).

During this period, Kosro was a participating member of the IOOS HF Team examining Operations and Maintenance costs. He also served on an NSF Physical Oceanography review panel in May 2017.

Port X-band Radar: Led by M. Haller (OSU), during March-April 2017, we cooperated with a small business (Areté Associates) on a NOAA (Office of Coast Survey) SBIR Phase-III project to generate quasi-real-time (hourly) bathymetry estimates for the Yaquina Bay Inlet and surrounding coastal beaches at Newport, Oregon. This was a continuous one-week demonstration project using our observations from our new site atop the USCG Yaquina Bay Station observation tower. Radar image data were recorded in hourly, 15-minute bursts and then pushed to an Amazon EC2 cloud computing resource. There, regularly timed processing jobs ingested data as it became available to produce mean radar images and put through the bathymetric estimator algorithm. This algorithm is still computationally expensive and in the present configuration requires a 16-core Amazon EC2 instance to produce real-time products. Going forward we would like to develop our real-time bathymetry at this site using our OSU servers and make the bathy data available through NVS.

b) NANOOS Modeling Subsystem:

Shelf: Computer circulation modeling and forecasting 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, using the assimilation system developed at OSU. 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. The OpenDAP link also provides access to the real-time fields by the Cyberinfrastructure group of the IOOS-sponsored Coastal Ocean Modeling Testbed (COMT) project. Routines for pre- and post-assimilation quality control have been established, along with new online tools (http:// http://ingria.coas.oregonstate.edu/rtdavow/, L. Erofeeva, OSU).

Our recently upgraded system extends between 41-50N and includes both OR and WA coasts. The timing of the ebb tides in the Columbia River estuary was verified and river channel configuration was improved and extended, which led to improvement in the prediction of the phase of the maximum currents. During the report period we continued our real-time operation and made steps toward more effective data assimilation, transferring to operations new minimization methods first developed and tested by PhD student Ivo Pasmans as part of the companion IOOS Coastal Ocean Modeling Testbed project.

Methods for accurate model set-ups and data assimilation are being transferred to NOAA/OCS/CSDL, where we contribute to development of the West Coast Ocean Forecast System (WCOFS).

Estuaries

Puget Sound:

NANOOS PI P. MacCready (UW School of Oceanography), working with Drs. Siedlecki, McCabe (UW Joint Institute for the Study of Atmosphere and Ocean), and Banas (U. Of Strathclyde) have created 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 (i) continue model validation of carbon chemistry using 2016 NOAA cruise data and moored data from Netarts Bay, (ii) expand the river database from 16 to 45, and (iii) develop a high resolution grid. All of these are moving rapidly toward implementation of a high resolution (~300 m) Salish Sea grid for the next generation of the daily forecast system. In addition Nitrate, Oxygen, and Phytoplankton have been added to the model fields being sent daily to NANOOS NVS. 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 development MacCready gave a total of 4 scientific or outreach talks on the project (see Presentations). 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. The model system is being used in the new NOAA-funded MERHAB PNW project to make short-term forecasts of when Pseudo-nitzschia HABs may reach WA beaches.

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 modeling capabilities of the VCR has assisted 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. Recent applications of the Virtual Columbia River include the Columbia River Treaty Review and the post-construction assessment of the ecological impact of the Columbia River Channel Improvement Project, multi-institutional collaborations reported on previous NANOOS reports.

Recent peer-reviewed publications report on rigorous benchmarking of the circulation (see previous NANOOS report) and sediment (Lopez and Baptista 2017) models, and offer insights into important estuarine processes, including water age (see previous NANOOS report) and climate change impacts in the estuary (paper in review). An invited presentation to the Gordon Research Conference on Coastal Ocean Dynamics (next reporting period) has summarized the status of in silico oceanography using the Columbia River as an example. An invited presentation to the League of Women (Baptista 2016) showcased the outreach power of modeling analyses of estuaries changing under increased human stresses. The role of local winds on estuarine physics is being documented, through presentations including (Scroccaro et al. 2017) and a paper in preparation.

Participation in the multi-institutional IOOS Modeling Task Force led to recommendations for moving the ocean modeling field forward, as described in (Wilkin et al. 2017).

c) Data Management and Communications (DMAC) Subsystem:

Chaired by E. Mayorga (APL-UW), this committee is composed of members from 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 calls; 2) monthly NANOOS DMAC technical calls; 3) NANOOS DMAC mini-hackathon (Jan 18, Portland); 4) annual NANOOS Tri-Committee meeting (Mar 27-28, Seattle); 5) annual IOOS Regional DMAC meeting (Mar 15-17, Silver Spring); and 6) high-level conference calls with West Coast RA's and national partners regarding "BigData" opportunities for West Coast RA's (April & May).

The ***NANOOS Visualization System (NVS)*** was upgraded in January (version 5.2) and February (5.3), with DMAC-supported additions focusing on enhancements to the data supporting the Salish Cruises App and safety destination points in the Tsunami Evacuation App. NVS enhancements also encompass asset additions and continuous updates: 1) new or newly incorporated near-real-time in-situ monitoring assets (a new shellfish aquaculture ocean acidification (OA) monitoring site in Fanny Bay, British Columbia; and a new Ocean Networks Canada (ONC) / VENUS benthic site in the Strait of Georgia) and an overhauled and greatly enhanced HF Radar data stream; 2) updated monthly anomalies for many climatology/anomaly overlay assets, and oxygen, nutrient and OA variables added to the LiveOcean forecasts; and 3) many redeployments and smaller upgrades, including restored or expanded sensors at OOI moorings and depth-profile plots for ORCA Hoodsport. In

addition, the ONC/VENUS data harvester was overhauled to use a more robust and well maintained data service, restoring access to these assets.

NANOOS and IOOS DMAC system implementation. During this period NANOOS DMAC engaged in two important high-level activities: a new annual RA DMAC review with the IOOS Program Office (IOOS PO), carried out in April; and preparation of the NANOOS DMAC package for the NANOOS application to be certified as a Regional Information Coordination Entity (RICE). These activities helped to advance the maturity of the NANOOS DMAC effort and led to concrete system enhancements, including expanded documentation of operations, enhanced system monitoring, and initial steps towards much more robust backup procedures.

Other highlights in these areas included:

1. Formal archiving of NANOOS CMOP-OHSU data with NCEI following the preferred IOOS recommendations was finalized. Complete time series of historical data have been submitted and are publicly available from NCEI. The process is now in operation for automated monthly archive updates. This process will be adapted to other NANOOS data providers to implement NCEI archiving for their data.
2. Complete glider data from the former La Push Seaglider transect were submitted to the IOOS Glider DAC, spanning 2010-7 – 2016-1. These data are now available via IOOS Glider DAC products and the IOOS Catalog.
3. NANOOS continued its support of the IOOS QARTOD QA/QC project by providing feedback and engagement with the IOOS PO for the update of the Manual for Oceanographic Data Quality Control Flags.
4. Enhanced provision of NANOOS data service resources and metadata for registration with the IOOS Registry and Catalog, via implementation of automated processes for providing service metadata for models and monitoring sites from our distributed set of DMAC services hosted by APL-UW, CMOP-OHSU and OSU.
5. Substantial expansion of initial, experimental provision of long time-series and climatology data access for NDBC, CDIP and other monitoring sites, via THREDDS and ERDDAP servers.
6. NANOOS contributed to IOOS DMAC community implementation and engagement activities, particularly in these areas: a. pyoos code package: contributed discussions and code to address a change in the NOAA HADS data access impacting one of the South Slough NERRS stations; b. service registration: contributed to discussions and testing of the SensorMLl2ISO and ncISO tools.

West-Coast Coastal and Marine Geospatial Data. NANOOS continued its support of the West Coast Ocean Data Portal (WCODP) efforts through E. Mayorga's participation in several conference calls of the newly restructured Portal Coordination and Development Teams. Previous contributions from NANOOS and other West Coast RA's were highlighted in a WCODP interactive Story Map ("How are Ocean Conditions Changing?", http://wcodp.maps.arcgis.com/home/gallery.html) released in late 2016. Finally, continued enhancements and strengthening of the NANOOS GeoServer instance, including a new, daily updated station assets layer (nvs:nvs_stations), are intended to also serve these needs at the West Coast and regional scales.

Ocean Acidification (OA) Data. NANOOS continued its ongoing support for OA data efforts. As mentioned in the NVS section, the new Fanny Bay site in the Strait of Georgia (Salish Sea), British Columbia, was added in collaboration with the Hakai Institute, a Canadian NANOOS member, providing near-real-time data. The NANOOS LiveOcean forecast model was enhanced on NVS to

integrate oxygen, nutrient, phytoplankton and OA variables, and generate new site forecasts. In the cross-regional scope of IPACOA (IOOS Pacific Region Ocean Acidification), we continued to support Burkolator data stream ingest by the IPACOA application and other RA DMAC teams. In addition, the Fanny Bay (Canada) site was added, and a new set of data streams from CeNCOOS OA-relevant sites was added through the development of a new data harvester for ERDDAP servers, bringing in 4 sites in central and northern California. This harvester will be leveraged to other regions in the future. Globally, the data portal for GOA-ON (Global OA Observation Network), released in Sept. 2016, was enhanced in several ways. The Fanny Bay (Canada) site was added. New pH and TCO2 variables were added to the GLODAPv2 multi-depth overlay asset. The asset inventory on the portal is now automatically updated, once a day. The data portal presentation was improved to enhance usability. Finally, in collaboration with the GOA-ON Data Management lead (Benjamin Pfeil, Norway), the Data Management section of the GOA-ON Implementation Strategy was drafted, and European OA data providers were engaged to identify and assess target candidates for data integration into the portal.

d) User Products Committee (UPC):

The UPC operates in concert with and is informed by both the DMAC and Education & Outreach subsystems. The objective of the NANOOS UPC is to guide the conceptual development of the data/analysis products (i.e. observations, time series, models, applications, etc.) identified by NANOOS stakeholders, and guide the development of appropriate graphical formats and lines of communications for product dissemination. Critical to this process has been the recognition that the UPC works closely with other NANOOS committees, most importantly the DMAC and Education/Outreach teams to ensure product concepts are effectively developed and tested prior to their release.

Chaired by J. Allan (DOGAMI) this committee is composed of members from Boeing, OHSU, UW, OSU, NANOOS E&O, OR Sea Grant, and NOAA. NANOOS UPC chair Allan participates in weekly "tag-up" calls with a smaller sub-group comprised of members from DMAC, UPC, E&O, and Web development in order to facilitate consistent work efforts, synergy across the committees, and improvements to product development and enhancements. Activities for this 2017 period included: 1) multiple weekly NANOOS DMAC and UPC teleconferences; 2) Attendance at the annual NANOOS governing council and all PI meeting.

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. A "Define your route" customization tool was completed during this period and is available in a number of the NVS web apps (e.g. Tuna Fishers, Boaters, and Maritime Operators apps).
Added as part of NVS 5.0 release, a new Depth vs Time plotting tool was completed during this period, and is currently available for a select number of sensors.

The NVS Climatology web app has updated model layers for water temperature, chlorophyll, and sea level anomalies. We are continuing to refine the scripts for downloading and processing the hourly measurements from the NDBC buoys, C-MAN met stations and NOS tide gauges. We have also added various climate indices (MEI, NINO 3.4, NPGO, PDO) to the NVS climatology app, and are working towards providing historical climatology products via NVS ERDDAP service.

The Tsunami Evacuation Zones web app was improved; updated tsunami evacuation zones for the Washington coast have been compiled and are ready for assimilation into the Tsunami resilience app.

NVS Mobile App: NANOOS released v4.0 of its NVS mobile app in March 2017. We are currently working on v4.0.2, which corrects minor bugs in the iPhone application. A newer more comprehensive release incorporating a google map view of the NANOOS region and sensor platforms is also under development for both the Android and iOS version.

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, Lebrec, and Wold, with support from DMAC and UPC subsystems and many NANOOS member collaborators. Newton, Sprenger Lebrec, and Wold 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 Wold 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 was on the coordination team and staffed an exhibit table for the "Storming the Sound" one-day conference for environmental educators in La Conner WA - northern Puget Sound. This year over 175 educators attended.
- Sprenger and WSG OA Specialist Meg Chadsey piloted a 7th grade West Coast upwelling and OA lesson plan with 3 classes of 7th graders at the Northwest School in Seattle, the lesson is based on a lesson from the Channel Islands Marine Sanctuary - http://www.cisanctuary.org/ocean-acidification/PDFs-WorkshopPage/CINP%20CINMS%20OA%20Curriculum_1_17_17.pdf
- Sprenger work with NANOOS member Ocean Inquiry Project to plan curriculum for summer high school program to introduce high schoolers to maritime careers with Seattle Maritime Academy.
- Sprenger, Lebrec work with NANOOS member Salish Sea Expeditions to write new curriculum using buoy data from WA Coast, Bellingham Bay and south Puget Sound, to be reviewed by teachers coming school year.

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.

- Sprenger and Lebrec staffed a table at the 'Sound Waters - A one-day university for all' on Whidbey Island, WA where they engaged with interested citizens, the event was attended by over 600 individuals
- Sprenger and Wold demonstrated NVS and hosted the "Great Build a Buoy Challenge" at American Meteorological Society's 16th annual WeatherFest in Seattle, an all ages event promoting weather, water and climate.
- Lebrec held a NANOOS booth at the Pacific Seabird Group annual meeting in Tacoma, WA. Attendees learned ways in which they could use NVS to plan safe trips in the field, and using the Climatology App to relate climate variations their research interests.
- Lebrec attended the 2-day Saltwater Sportsman Show in Salem, OR, to promote the Tuna Fishers App to the local fishing community.
- Wold presented the NVS Boaters App during an educational seminar hosted by the Coho Ho Ho, a sailing rally out of Seattle.

- NANOOS continues efforts on social media, regularly posting on Facebook with news, pictures, and interesting data. NANOOS also has a growing audience for its quarterly newsletter, the NANOOS Observer.
- Sprenger, Lebrec, and Wold 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.
- Baptista has explored innovative forms of scientific outreach to a local target community: (a) by writing multiple letters to the editor of Hood River News on water and climate change issues, and expanding their impact via Facebook; and (b) by successfully running for commissioner of the Crystal Springs Water District, an elected position in a public Board that supervises a water distribution system that is fed by a single water source with high potential sensitivity to climate change.

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 during the period. Newton and Kosro participated in weekly Tri-Comm calls. Key events for this period included:

- NANOOS held its annual Tri-Com meeting on 27-28 March 2017 in Seattle, WA, at the University of Washington campus.
- Newton was asked to present on West Coast OA observing efforts, "West Coast Ocean Acidification Observations Summary", at the NOAA OAP PI Meeting, Seattle, Washington, 4-5 January 2017.
- Newton spoke at the NOAA NOS Hydrographic Services Review Panel meeting on 18-20 April in Seattle, WA, detailing what NANOOS offers mariners and recreational boaters via our NANOOS Visualization System web apps. This talk was covered in a media story: http://www.threesheetsnw.com/blog/2017/05/charting-changes-noaas-plans-for-the-future-of-charts-poll/.
- Newton participated in IOOS Board and ExCom calls throughout reporting period and attended the Spring IOOS meeting in DC in March 2017.
- Newton was invited to and participated in the AOOS OA meetings in Alaska, offering insights from the PNW and NANOOS, as well as IPACOA.
- Newton worked with the three west coast and Alaska RA Directors were on the Pacific Coast Collaborative/OA-IWG Task Force to identify monitoring assets for OA and hypoxia and their biological responses.
- Newton presented "Forecasting Marine Ecosystem Change with Quasi-operational Models in the California Current System" at the American Meteorological Society's (AMS) 97th Annual Meeting in Seattle, Washington, on 26 January, 2017 jointly with CeNCOOS and SCCOOS, using results from all three regions.

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

- Newton was invited to speak 18-20 January in Tokyo, Japan, by the Sasakawa Peace Foundation's Ocean Policy Research Institute regarding the experience that PNW shellfish growers faced due to

OA and how observations aid their ability to grow shellfish. Newton gave a Keynote Speech: "Towards Building an Ocean Acidification Network" relating this experience and offering insights to Japan's contribution to GOA-ON. https://www.spf.org/opri/news/OA%20Conference%20Agenda.pdf

- Newton gave a talk on the NANOOS west-coast wide OTT project on OA monitoring in shellfish hatcheries, "Turning the headlights on high: improving ocean acidification observations and networks in support of shellfish growers" at the Aquatic Sciences Meeting in Honolulu, HI, on 28 February 2017.
- Newton was invited to speak at the Canadian "State of the Pacific Ocean" workshop in Sidney, BC, Canada, on 22-23 March regarding Puget Sound and WA coastal buoy observations.
- Newton attended the Blue Planet Symposium in College Park, MD, 31 May-2 June. She co-chaired a session "Threats from Pollution, Warming, and Acidification" and spoke on "Global to local: Understanding ecosystem response and stakeholder needs in a changing ocean" including information from the IOOS OTT OA project with shellfish growers NANOOS leads along with three other IOOS RAs.
- Newton was on the Blue Planet Program Committee, and represented IOOS at JERICO SAC; MEOPAR ISAC; and the GOA-ON Executive Committee and GOA-ON Biology Working Group.

Additional NANOOS coordination:

Newton led two OTT coordination calls for the OA project with AOOS, CeNCOOS, and SCCOOS.

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 quarterly meetings.

Presentations and Publications acknowledging NANOOS support: underline indicates NANOOS PI

Presentations:

Helms, A. South Slough NERR Research and Monitoring Program: System-Wide Monitoring Program, NANOOS, and Sentinel Sites. Friends of South Slough board member meeting, Coos Bay, Oregon, March 28, 2017.

Helms, A. NERRS System-Wide Monitoring Program and NANOOS Visualization System overview. Leadership Coos class, Coos Bay, Oregon, April 11, 2017.

MacCready, P., "Oysters, Upwelling and Ocean Acidification." Public talk for the Bainbridge Island Oatmeal Club, Winslow, WA, Jannuary 2017.

MacCready, P., S. Siedlecki, R. McCabe, N. Banas, "The LiveOcean model for MERHAB-PNW What goes into the model and how to transition it." Presentation for: NOAA Ecoforecasting Meeting, NOAA NWFSC, Seattle, WA, January 2017.

MacCready, P., S. Siedlecki, R. McCabe, N. Banas, S. Ferriera, B. Bartos, "LiveOcean contribution to WCOFS & COMT: Rivers, Estuaries, Carbon, and Phytoplankton." Presentation for: WCOGS Webinar, February 8, 2017.

MacCready, P., S. Siedlecki, R. McCabe, N. Banas, "The LiveOcean model Short-Term Forecasts of Ocean Acidification." WOAC Symposium, UW, May 2017.

Newton, J. "West Coast Ocean Acidification Observations Summary" NOAA OAP PI Meeting, Seattle, Washington, 4 January 2017.

Newton, J. Keynote Speech: "Towards Building an Ocean Acidification Network" Sasakawa Peace Foundation's Ocean Policy Research Institute, Tokyo, Japan, 18 January 2017. https://www.spf.org/opri/news/OA%20Conference%20Agenda.pdf

Newton J., C. Anderson, P. MacCready, S. Siedlecki, C. Edwards. Forecasting Marine Ecosystem Change with Quasi-Operational Models in the California Current System. American Meteorological Society's 97th Annual Meeting, Seattle, Washington, 26 January 2017.

Newton, J., Invited talk: "Buoy observations from the Washington Coast and Puget Sound" State of the Pacific Ocean during 2016, Sidney, B.C., Canada, 22 March 2017.

Newton, J. Invited talk: "Global to local: Understanding ecosystem response and stakeholder needs in a changing ocean" 3rd Blue Planet Symposium, College Park, Maryland, 31 May 2017.

Newton, J.A., Hales, B., Beck, J., Evans, W., Alin, S., Hill, T., Martz, T., Mayorga, E., McCammon, M., Anderson, D., Thomas, J., Barrette, M. "Turning the headlights on high: improving ocean acidification observations and networks in support of shellfish growers" ASLO 2017, Honolulu, Hawaii, 1 March 2017.

Nick Cohn, Peter Ruggiero, and Sierd de Vries. *Intertidal Sandbar Welding as a Source of Sediment for Dune Growth: Evidence from a Large Scale Field Experiment*. AGU Fall Meeting. San Franscisco, 2016.

Peter Ruggiero, Nick Cohn, George Kaminsky, Guy Gelfenbaum, Sally Hacker, Laura Moore, Orencio Duran, Sierd de Vries. *Beach and Dune Building Processes: Linking Nearshore to Backshore and Events to Decades*. AGU Fall Meeting, 2016.

Publications:

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