Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS

NOAA Award: NA16NOS0120019 Reporting period: 06/01/2020 to 11/30/2020

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 FY20 period (= Y5 of this award; Y14 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 and expand 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 enhance 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 both 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.

During FY20, NANOOS has the following additional tasks (10-12) from the NOAA Ocean Acidification Program, coordinated via IOOS, and tasks 13-18 from IOOS:

10) Support (a) collection of OA measurements on our La Push [J. Newton, J. Mickett, UW] and (b) CB-06 [B. Hales, OSU] moorings, and (c) working with NOAA PMEL on mooring test beds.
11) Support collection of OA measurements at shellfish hatchery locations via technical expertise by (a) [B. Hales, OSU] and (b) [B. Carter, UW], as part of Ocean Technology Transition in support of ocean acidification observing in support of Pacific coast shellfish growers.
12) Support the GOA-ON data portal [J. Newton, UW, T. Tanner, UW].
13) CRITFC observations, modeling, and DMAC transfer [C. Seaton, CRITFC].
14) Support OceanHackWeek [E. Mayorga, UW].
15) Support biological data stewardship [E. Mayorga, UW].
16) Conduct PNW Harmful Algal Bloom (HAB) observations, understanding, and prediction [R. McCabe, R. Osborne, P. MacCready, R. Callender/T. King, J. Newton, UW].
17) Conduct a HAB Environmental Sample Processor (ESP) deployment off Washington [J. Mickett, UW].
18) Support the Columbia River extension of the Salish Sea model [T. Khangaonkar, UW-Tacoma].

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 on progress for: a) Observations (shelf, estuaries, shorelines, and currents); b) Modeling (estuaries and shelves); c) Data Management and Communication (DMAC); d) User Products; e) Education and Outreach; and f) Administration.

Table 1. NANOOS Milestones for FY 20; Y5 specific milestones are in bold.

Area	**Y5 Award = Y14 NANOOS**
Observations	
Shelf:	-Maintain La Push buoy; deliver NRT data streams via NANOOS Visualization System (NVS) **-Support collection of OA data from La Push buoys with NOAA OAP funding** -Maintain Coos Bay buoy CB-06; deliver NRT data streams via NVS **-Support collection of OA data from CB-06 buoy with NOAA OAP funding** -Maintain Columbia R. buoy; deliver NRT data streams via NVS -Maintain N CA shelf glider transect; deliver data via NVS **-Re-establish Columbia glider; deliver data via NVS** **-Begin La Push glider operations** **-Support OA observing as an aid to Pacific coast shellfish growers; deliver data to IPACOA** -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 WA; deliver data via NVS -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 **- Fill gaps in HF Radar operations and maintenance by OSU to complete west coast coverage for health and safety** -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; deliver model output via NVS -Maintain modeling & forecasting capabilities at OHSU; deliver model output via NVS -Maintain modeling & forecasting capabilities at OSU; deliver model output via NVS -Model verification and validation
DMAC	
Data Portal and 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 **-Enhance GOA-ON data portal an OA dashboard to the world** **-Enhance biological data stewardship within NANOOS** **-Support OceanHackWeek**
Tailored Product Development	-Climatology, Tsunami resilience SeaCast, Surfer, and Beachview web app development -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 effective 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 public relevance 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, or bi-annual meetings of CERF and 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. **-Coordinate a west-coast wide regional collaboration team workshop with NOAA West (Y4)**

Accountability	-Submit required IOOS progress reports and respond to other requests. -Comply with 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 Observations*:**

-Maintain La Push buoy; deliver NRT data streams via NANOOS Visualization System (NVS) [Curry, Mickett]

-Bring all data QA/QC to meet Certification standards [Curry, Mickett]

The Washington Coast buoy observation program continued to work towards maintaining and operating two real-time moorings 13 miles NNW of La Push, Washington. B. Curry and R. Daniels are in the process of finalizing the 2020 data, including QA/QC.

Due to the COVID-19 pandemic, the spring cruise that normally occurs in May, occurred this summer during 2-4 July 2020 on the R/V Robertson. The cruise required increased PPE, a field health and safety plan, approval from the Quileute Tribal Council, and additional lodging. Both Cha'ba and NEMO-SS were successfully deployed. Communication between the buoys and shore was tested fully at the dock before leaving Seattle. The deployment of both moorings went very smoothly and quickly due to the good weather window and preparation done before leaving the dock. Unfortunately, NEMO-SS stopped communicating soon after it was deployed. Later, back at the lab, the failure was determined to be caused by a leak in the controller pressure case caused by a bad bulkhead connector.

The fall cruise occurred during 24 September – 1 October 2020 on the R/V Thompson. The cruise required COVID-19 testing, increased PPE, a field health and safety plan and a smaller science party. Though the cruise was not delayed because of the pandemic, the scope of cruise was. We had hoped to bring on many students and use this opportunity to lead a teaching cruise. Both summer Cha'ba and NEMO-SS were recovered on 26 September 2020. The recovery went well but a snarled recovery line on Cha'ba made for a tricky recovery and a damaged wind sensor. Winter Cha'ba was deployed quickly and smoothly on 28 September. In addition to the mooring work, the NANOOS La Push Seaglider was deployed on 27 September just off the 1000 m isobath. The cruise ended with a CTD transect starting at the Cha'ba site, station P381, going up through the Strait of Juan de Fuca and ending just outside Seattle, station P28. The CTD transect included water sampling and net tows in collaboration with the Washington Ocean Acidification Center. The spring cruise to recover winter Cha'ba and deploy spring Cha'ba and NEMO-SS is planned during the first two weeks in May 2021 on the R/V Robertson.

We continued to work closely with both the Olympic Coast National Marine Sanctuary and the Quileute Tribe in maintaining and operating the two moorings. Quileute Marine Biologist, Jenn Hagen, participated on deployment cruises in the past, but COVID-19 restrictions prevented her participation in 2020. She facilitated obtaining approval from the Quileute Tribal Council to enter the reservation to access the marina in July.

-Task 10a: Support collection of OA data from La Push buoys with NOAA OAP funding *[Curry, Mickett, Newton]*

We continued to work with NOAA PMEL scientists Drs. Adrienne Sutton, Simone Alin, and Richard Feely, to maintain pCO_2 and pH data streams 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. The pCO_2 system worked well in the summer but a failure occurred soon after the winter deployment. Engineers went out to try to fix the system but the failure, a broken coupler, could not be fixed at sea. The old system will be recovered and a new system will be deployed during the planned May 2021 spring cruise on the R/V Robertson.

We continue to collaborate with Sea-Bird Scientific and deployed a SeapHOx sensor at 85 m on summer Cha'ba and two SeapHOX sensors on winter Cha'ba, near surface and at 85 m. We deploy the sensors and provide data and useful feedback to Sea-Bird Scientific and they provide calibrated sensors for our project.

- Task 10c: Support NOA-ON OA Mooring Test-beds *[Mickett, Newton]*
To fulfill the need for verification data for the NOAA PMEL prototype mooring (Prawler), this work involves using NEMO-Subsurface McLane profiler data to compliment concurrently deployed Prawler data and to evaluate and publish an assessment of high-frequency, depth-dependent variability of pH/carbon variables on the shelf, with implications to shelf ecology. During this period Mickett continued to carry out QA/QC on processed data and work with PMEL collaborators to assist with data interpretation.

Shelf Glider Observations:
-Maintain N CA shelf glider transect; deliver data via NVS [Barth]
-Bring all data QA/QC to meet Certification standards [Barth]
Starting in early December 2014, the Oregon State University glider research group has been 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 measured depth-averaged velocity, which can be combined with geostrophic estimates of relative velocity to get absolute velocity and hence transport. The glider samples from approximately the 100-m isobath (~10km offshore) to 130W (~500 km offshore), repeating the line every 30 days. We collaborated with Dr. Eric Bjorkstedt (NOAA Southwest Fisheries Science Center, Humboldt State University) to facilitate fieldwork off Trinidad Head. We used two of our Seagliders in order to "hot swap" them on the line when their batteries run low. During this reporting period, this effort was 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 (11/30/2020), the glider was on the TH line for 1779 days during 10 deployments, sampled along approximately 32,776 km of track line covering the transect about 88 times, and collected about 14,370 vertical profiles of ocean properties. From 6/1/2020 to 11/30/2020, the glider was on the TH line for 75 days on one deployment, sampled along nearly 1410 km of track line covering the transect about 5 times, and collected about 668 vertical profiles of ocean properties. Glider uptime was 42% due to loss of a Seaglider at the start of a June 2020 deployment and the inability to deploy another Seaglider until mid-September 2020. Data are sent in near real-time to the IOOS Glider DAC and 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 the demise of the 2014-2017 "Warm Blob" and the 2018-2019 El Niño (Figure 1). Water at depth was warm during mid-2019, like the subsurface warming associated with the 2015-2016 El Niño (Figure 1). The warm upper-ocean temperature anomaly from later summer 2019 was very shallow and dissipated with the advent of winter storms. Note the return to cool conditions in late 2020.

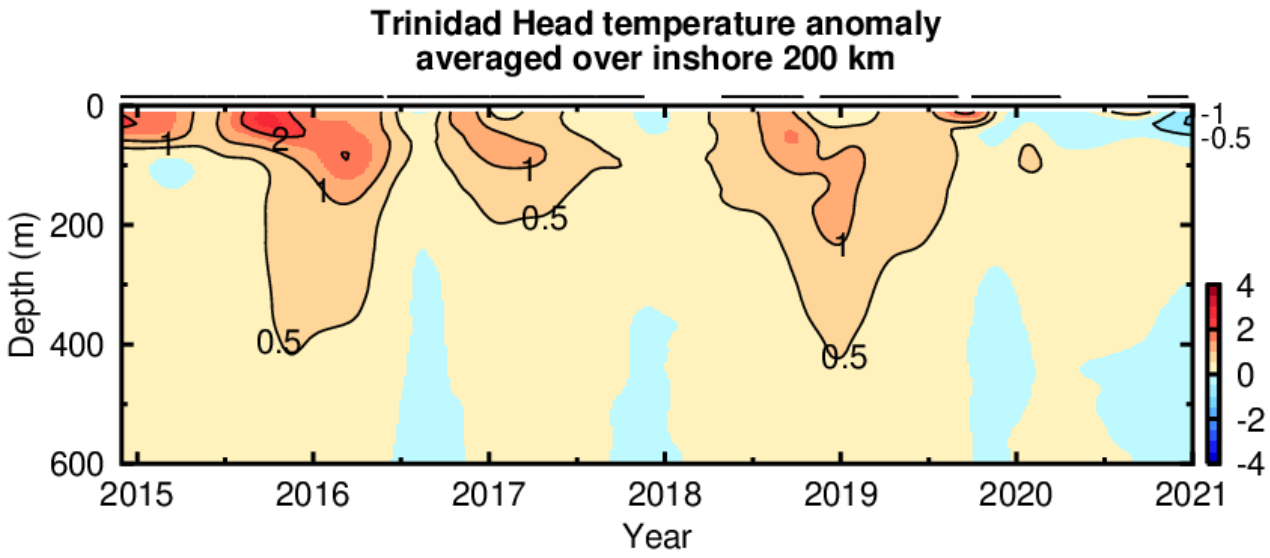

Figure 1. *Temperature anomaly from the Trinidad Head, CA (41° 3.5'N) glider line. Horizontal lines above the panel indicate when the TH-Line glider was in the water.*

-Re-establish Columbia glider; deliver data via NVS *[Seaton/Barth]*
The OHSU glider program was—as a part of the full transition of CMOP assets—transferred, starting June 1, 2020, to the Columbia River Inter-Tribal Fish Commission (CRITFC). Additionally, CRITFC entered into a collaboration with the Oregon State University glider research group (Barth) to manage the Washington shelf glider operations and maintenance. The program is designed to fly gliders off the central Washington coast, centered off Grays Harbor, WA, and south toward the Columbia River. The glider flies a mapping grid, from roughly the 30-m isobath, offshore to the shelf-break (~200 m). The mapping is done in consultation with the Quinault Indian Nation via Joe Schumacker, NANOOS Governing Council Representative and Executive Committee Representative for Tribes.

After a multi-year interruption, glider operations were restarted this year, as glider-specific funding was awarded to OSU. The two CRITFC gliders are on loan to OSU and in August 2020, OSU conducted a successful test of one of them (S/N 551). A successful pilot mission was run October 1-16, 2020, mapping Washington shelf waters off Grays Harbor, WA. Glider data reveal complex structure in the upper ocean associated with the fall transition and the presence of Columbia River water on the Washington shelf. Near-bottom measurements (10 meters above bottom) showed high-oxygen water inshore of about the 100-m isobath with nearly hypoxic bottom waters deeper offshore, consistent with the end of the summer upwelling season. Plans are in place to resume the Washington shelf glider mapping in April 2021.

La Push glider *[Lee]*
Working through the challenges associated with the safe conduct of laboratory and field work during the COVID-19 pandemic, the APL-UW team prepared a SGX glider (next-generation Seaglider, SG236) and resumed operations in the Washington shelf section on 27 September 2020. As of 22 December 2020 SG236 has completed 364 profiles for seven occupations of the repeat section. SG236 carries a RBR Legato CTD, which provides a low-power replacement for the original unpumped Seabird CTD. Current work focuses on finalizing data processing for the new CTD and re-establishing data to the IOOS glider DAC.

Oregon Shelf Mooring Observations:

-Maintain Coos Bay buoy; deliver NRT data streams via NVS [Hales, Kosro]

-Bring all data QA/QC to meet Certification standards [Kosro, Hales]

-Task 10b: Support collection of OA data from CB-06 buoy with NOAA OAP funding *[Hales]*

The CB06 mooring has now been in place for 3.5 years, with a few operational gaps (Figure 2). A clear pattern is being established with more quiescent dynamics in wintertime, with O_2 and pCO_2 values near atmospheric equilibrium, and pHt staying broadly within a range of 8.0 - 8.1. In contrast, summer conditions show large dynamic ranges in all conditions, with O_2 ranging from far below saturation (<175 µmol/kg) to far above (> 450 µmol/kg), pCO_2 from <250 - >1000 µatm, and pH <7.7 - >8.3. Typically, there is mechanistic covariance between these three parameters supporting the metabolic signatures of local net community metabolism as well as those carried by the prevalence of deep upwelling and surface California Current source waters.

The most recent data, June-December 2020 (Figure 3), show a continuation of these broader patterns, but decoupling in some concerning ways. In late June and again in late July, there were instances of large increases in chlorophyll fluorescence suggesting elevated net primary productivity, and these were accompanied by large increases in O_2 and pH, expected for the associated drawdown of TCO_2 driven by net photosynthesis. In between these two events there was a similarly covariant event where O_2 and pHt dropped to very low values coinciding with the introduction of cold, salty, recently upwelled water. Unexpectedly, however, pCO_2 was not tightly anti-correlated with pHt and O_2 through these events, counter to expectations. During the high productivity events, pCO_2 in the first case only minimally fell below atmospheric, and in the second, stayed slightly supersaturated with respect to the atmosphere. This is hard to explain. While we have made much of the condition-dependent departure of carbonate-system parameters from simple covariance, this degree of departure seems unlikely. A change of ~300 µmol/kg in O2 should drive a ~200 µmol/kg change in TCO2, and at the nominal Alkalinity expected for the observed salinity, such a change should drive a pCO2 range of 225 - 750 µatm, far beyond the observed range. The background alkalinity that would be required to proportionately buffer these changes is several-fold higher than could be supported by observations. We must consider an artifact in our data, including biofouling or a problem with the integrity of the MApCO2 equilibrator headspace.

This project has suffered several operational challenges in the past year. COVID-19 operational restrictions made it challenging to travel to and from the port, and to find availability for cruise-of-opportunity chances to collect validation samples, service the mooring, or even perform the ~6-month turnaround. Our preferred local operation vessel, the Miss Linda, fell into disuse due to the health of her captain. Platform of opportunity openings on R/Vs Oceanus and Sikuliaq were scrapped because of ocean conditions. The mooring seems resilient to strong stormy conditions, but some sensors are approaching battery limitations and the aforementioned data questions remain unresolved. We have begun negotiations with a local towboat operator, Pacific Tug Company, and this seems promising.

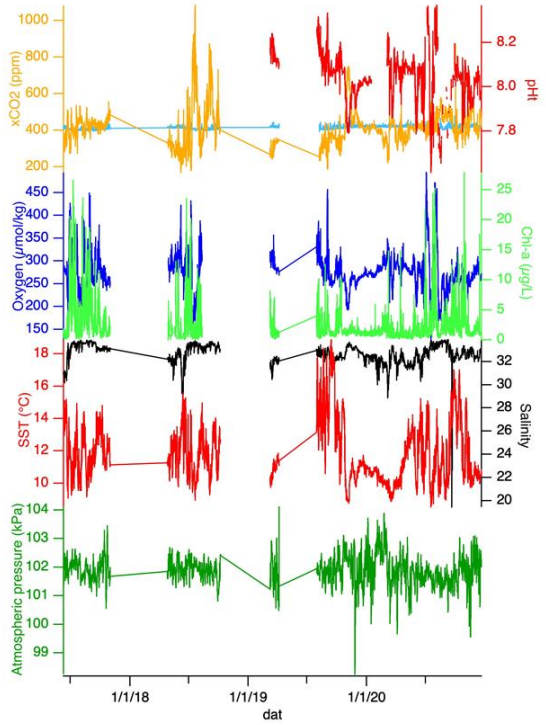

Figure 2. *Cumulative data from CB06 mooring, June 2017 – December 2020.*

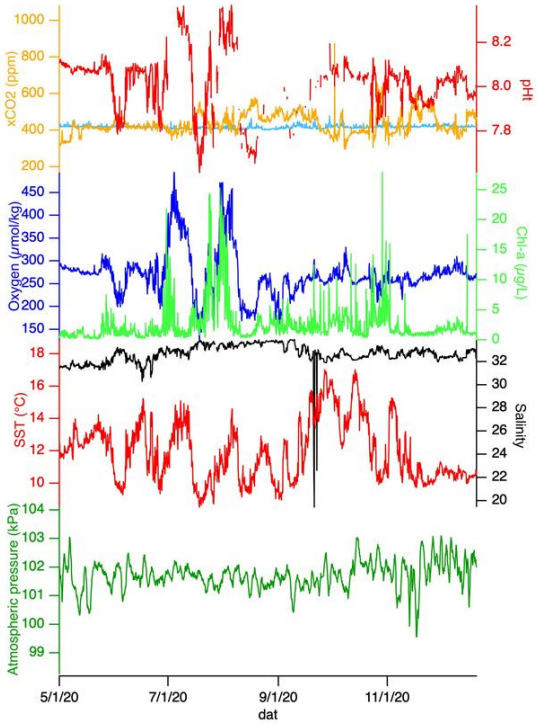

Figure 3. *June - December 2020 data from CB06.*

The CB06 mooring, deployed on Mar 4, 2020 at 43° 17.89 N, 124° 31.88 W, near the 100m isobath, continued to operate through the reporting period, telemetering a large, selected subsample of data back to shore for real-time display, and recording all collected data internally. An example of the telemetered

data is the alongshore current measurements from multiple depths, shown in Figure 4. Periods with southward alongshore flow showed vertical shear between the near-surface (8m, red) and depth (66m shown, light blue), while the periods of northward current show little vertical shear. Two episodes of northward flow are visible early, then primarily equatorward flow (as expected in upwelling) from late May through mid-August. A long period of neutral or poleward flow followed, broken up by a month-long upwelling period starting in mid-October. We piggy-backed on a cruise with a chance for a turnaround in late November/early December on R/V Sikuliaq but were weathered-out. We are prioritizing recovery of the presently deployed buoy, and have the replacement ready to deploy.

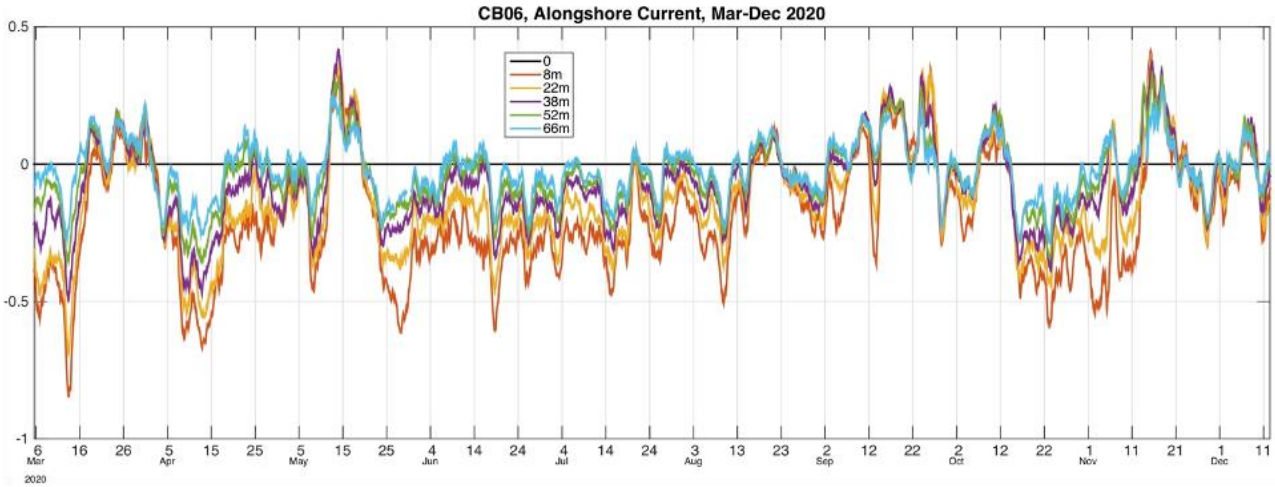

Figure 4. *Alongshore currents (m/s) from five depths at CB06 between 8m and 66m, from the downward-looking ADCP, using data telemetered to shore. Currents have been low-pass filtered. These data are displayed on NVS, and passed to NDBC in realtime, which displays them as buoy 46128.*

-Task 11a: Support OA observing as an aid to Pacific coast shellfish growers; deliver data to IPACOA
[Hales]
Hales continues to assist shellfish aquaculturists on the west coast with water chemistry measurement and interpretation, and mitigation steps. Hales has offered remote consultation to the Alutiiq Pride Shellfish Hatchery in Seward, AK, Taylor Shellfish in Quilcene, WA, and Hog Island's Eureka hatchery facility. Hales' lab completed a rebuild and delivery of a BoL system for Taylor Shellfish, and has provided remote troubleshooting and advice. COVID-related travel restrictions have kept us from making a site visit. Whiskey Creek Hatchery is still not fully ready for resumed monitoring operations, and has greatly reduced production as a result of the pandemic. Hales co-authored a paper in Frontiers (Fairchild et al., in press) detailing the 6-year continuous record of BoL observations there. Hales and team are developing improved liquid-sample pump control for BoL systems based on servo drive motors, which should decrease cost and improve performance for BoL-based TCO_2 measurements. Hales is further developing PC-platform operational software, which will improve support for LabView-based control code.

-Task 11b: Support OA observing as an aid to Pacific coast shellfish growers; deliver data to IPACOA
[Carter]
Via UW technician, Mr. Julian Herndon, we continued to provide ongoing technical assistance for the Burke-o-lator (BOL) seawater chemistry analytical system at Taylor Shellfish Hatchery (TSH). The BOL system sent to Oregon State University for repairs is still there, awaiting finalization of needed repairs (delayed by campus closure due to COVID). TSH has been operating another BOL system from the Washington State network (from Willapa Bay). Mr. Herndon continues to make liquid standards for TSH to

use during BOL operation. However, current COVID work access requirements are making it difficult for Mr. Herndon to obtain access to the NOAA facility where he prepares the standards and to receive travel approval to visit the TSH site. Thus, this year is likely to have unavoidable data gaps. The deployment of the ACDC has unfortunately continued to be delayed due to project partners not having supplied the repaired sensors to support the final stages of this technology transfer project (likely due to pandemic lockdown at this time rather than personnel turnover as previously).

Northern Oregon to Central Washington Shelf Observations:

-Maintain Columbia R. buoy; deliver NRT data streams via NVS [Seaton]
-Bring all data QA/QC to meet Certification standards [Seaton]
The CMOP ocean buoy (SATURN-02) was—as a part of the full transition of CMOP assets—transferred, starting June 1, to the Columbia River Inter-Tribal Fish Commission.

SATURN-02 is a seasonal inter-disciplinary buoy, with real-time telemetry, located off the mouth of the Columbia River at ~35m depth. SATURN-02 data routinely contributes to model validation, capturing near-field Columbia River plume dynamics. Data also routinely offer local temporal context and for specialty buoy deployments and for cruises.

SATURN-02 was last recovered November 8, 2019. Parameters measured were (a) wind speed, direction and gust, air temperature and atmospheric pressure; (b) water velocity; and (c) the scalar water parameters: temperature, salinity, dissolved oxygen/oxygen saturation, chlorophyll, turbidity, CDOM, phycoerythrin and nitrate. Scalar water measurements were made through single at-surface sensors and a multi-level pumping system. Levels measured were 1, 6, 11, 16, 21 and 35m depth.

The 2020 deployment of SATURN-02 had to be postponed, due to COVID-19's restrictions on staff access to OHSU facilities, including CMOP's MERTS Field Station during June, and operational constraints on buoy deployment during July and August due to scheduled maintenance work on the vessel used for buoy deployments. The next seasonal deployment of SATURN-02 is planned for April/May 2021, and work completed in Spring 2020 on preparing the SATURN-02 buoy for deployment will facilitate deployment.

Real time data from SATURN coastal stations are normally displayed on NVS. CMOP also provides access to SATURN long-term datasets via THREDDS, inclusive of a catalog summary—both essential building blocks to support the NVS display of long-term datasets. Seaton participated in planning the integration of QARTOD flagging into the NANOOS centralized ERDDAP server, consistent with IOOS and NDBC policy recommendations. He also continued to monitor the maturation of the IOOS QARTOD library being developed by Axiom.

-Task 16: HAB observations, understanding, and prediction *[McCabe, Osborne, MacCready, Callender, Newton]*
[Osborne]: UW Olympic Natural Resources Center, in collaboration with the ORHAB (Olympic Region Harmful Algae Bloom Partnership) Steering Committee, which includes representation of the four Coastal Treaty Tribes (Hoh, Quileute, and Makah Tribes and the Quinault Indian Nation), oversaw the initial processing and budgetary allocation of $40,000 ($10,000 a piece for each of the four tribes) into the operating budget for ORHAB. These funds are now being used to enhance the capacity of each tribe to undertake offshore sampling, over-and-above the weekly shore-side sampling they do as part of ORHAB's longitudinal monitoring program. Beyond initial administrative processing, at this point in the contract potential offshore sampling activities and equipment needs for each tribe have been identified or are being

finalized. Some tribes have already initiated offshore sampling operations this fall that are drawing on their allocations, others are looking more towards equipment needed to bring them up to capacity. After the 1st of the year, a bulk equipment and supply order is biennially undertaken with all ORHAB partners that will finalize the equipment purchases drawing upon these funds.

[MacCready]: During this period MacCready wrote and published a paper (MacCready et al., in press) documenting the LiveOcean modeling system that is used as part of the PNW HAB Bulletin. He gave two public talks related to this (URI and NOAA CMMB), and a briefing at the NOAA OCNMS Advisory Council meeting. He co-advised a graduate student, Dr. Hally Stone (supported by NANOOS MERHAB grant) who defended her PhD in 8/2020 and published a paper exploring wind and phytoplankton patterns in the PNW (Stone et al. 2020). Stone and MacCready interviewed Matt Hunter (Oregon Shellfish Project Leader) on the use of LiveOcean forecasts by stakeholders. MacCready updated the LiveOcean forecast pages to be mobile-friendly since this is preferred by many users. (http://faculty.washington.edu/pmacc/LO/LiveOcean.html).

[King]: SoundToxins is a diverse partnership of trained monitors from Native tribes, shellfish producers, environmental learning centers, environmental groups, and Puget Sound volunteers designed to provide early warning of harmful algal bloom events in order to minimize both human health risks and economic losses to Puget Sound fisheries.

With the funding received in November 2020, we were able to provide daily support for SoundToxin monitors, field questions on data recording, phytoplankton identification and provide alerts to the Washington Department of Health and overall provide coordination and communication with SoundToxin monitors.

[McCabe]: PI McCabe has continued to collaborate with Barbara Hickey (UW School of Oceanography) and Vera Trainer (NOAA NWFSC) to produce the Pacific Northwest Harmful Algal Blooms Bulletin (PNW HAB Bulletin) for coastal shellfish managers. A total of eight PNW HAB Bulletins are typically produced each calendar year, with nominally four Bulletins during spring razor clam digs and another four during fall razor clam digs. For this project, McCabe worked with Jan Newton to identify an appropriate way to acknowledge the new IOOS/NANOOS support for the PNW HAB Bulletin. The NANOOS logo was added to the upper right of the PNW HAB Bulletin to recognize this support, and to date, has appeared on the 11-Sep-2020 Bulletin as well as on the 08-Oct-2020 Bulletin. The NANOOS logo will continue to be included on future Bulletins supported by this project. PNW HAB Bulletins are made publicly available on both the ORHAB (http://depts.washington.edu/orhab/pnw-hab-bulletin/) and NANOOS (http://www.nanoos.org/products/habs/forecasts/bulletins.php) websites.

To date, McCabe has produced three PNW HAB Bulletins during the fall 2020 razor clam season. A fourth Bulletin was planned, but it was ultimately delayed due to the occurrence of a toxic bloom that shut down shellfish harvests in both Washington and Oregon. State and Tribal shellfish managers recommended delaying the fourth Bulletin; a Bulletin issued during widespread harvest closures would be less useful to the shellfish managers. The PNW HAB Bulletin team will work with coastal managers to produce the delayed Bulletin once harvests resume. This could result in five Bulletins during spring 2021 harvests instead of the typical four, depending on how soon the existing toxins depart from the clams.

-Task 17: HAB ESP deploy *[Mickett, UW]*
During this period, we had several discussions amongst the PNW ESP group to evaluate the ability to carry out this mooring deployment during the pandemic. Due to the inability of PIs S. Moore and N. Adams to access their lab at the NOAA NWFSC, we concluded that the deployment originally planned for the spring of 2021 would need to be delayed until the following spring. In the meantime, the group is working to refine the telemetry and pump control systems for the ESP mooring with MERHAB funds, in support of both the NANOOS spring 2021 deployment and future MERHAB deployments.

- **Estuaries**

Puget Sound Buoy Observations:

-Maintain Puget Sound estuarine moorings; deliver data via NVS [Curry]
-Bring all data QA/QC to meet Certification standards [Curry]
The ORCA (Oceanic Remote Chemical Analyzer) mooring system and Bellingham Bay Se'lhaem buoy continued to be operational during the COVID-19 pandemic. Upgrades to the ORCA system and lab protocols are ongoing and buoy endurance continues to improve. The buoys are fully implemented with real-time pH measurements; the data is being sent and plotted in real-time on the NWEM website. We continue to work with A. Sutton, S. Alin, and R. Feely (NOAA PMEL Carbon Group) deploying pCO_2 systems on Twanoh and Dabob Bay and collecting water sample for system calibration. Data continue to be made available through NANOOS NVS and through the NWEM ORCA server. New summary plots for all the sensors (temperature, salinity, oxygen, and fluorescence) have been added to the NWEM website key products.

Due to the COVID-19 pandemic, the field team has had to wear additional PPE and practice social distancing guidelines but thankfully have been able to carry our regular maintenance and repairs to keep this real-time system operational. The new boat (a 24' Almar Sounder) has been a very effective addition to the project.

The ORCA buoys continued to track the evolution of a large salinity anomaly in Puget Sound that spanned most of the year in 2019 and has lasted into 2020. In addition to above average salinity, warmer than average surface seawater temperatures continue to be observed during the summer. A summary of the 2019 observations collected by the ORCA and Bellingham Bay Se'lhaem buoys are included in the 2019 Puget Sound Marine Waters Report that came out in November 2020.

We continue to work towards quality control (QARTOD) and data archiving for all the ORCA data. The pH nectcdf files will soon be ready to submit for data archiving.

Washington State Estuarine Observations:

-Maintain US-Canada ferry-box; deliver data via NVS [Krembs]
-Bring all data QA/QC to meet Certification standards [Krembs]
Led by C. Krembs (WA State Department of Ecology), en-route ferry-based monitoring is an integral part of Ecology's long-term monitoring program that covers Puget Sound and the Washington coastal estuaries. The ongoing ferry monitoring complements Ecology's extensive marine monitoring program station network by focusing on surface processes (e.g., temperature variations, frontal systems, tidal currents, blooms, river plumes, etc.) thereby leveraging monitoring station stations on finer temporal and larger spatial scales. Twice daily the ferry runs along an 80 mile transect between Seattle and Victoria covering important regions of water exchange of the Salish Sea.

Daily information on surface temperature and salinity data from the Victoria Clipper provide a means of continuously ground-truthing for remote sensing platforms (satellites, planes) critically expanding and extrapolating capabilities for Puget Sound environmental monitoring programs.

In collaboration with Jim Thomson (Applied Physics Laboratory, UW), complementary to the Victoria Clipper, we support acoustic current meters (ADCP's) integrated with the ship's GPS system on two DOT ferries. The DOT ferries deliver continuous tidal current velocity data along a transect perpendicular to the tidal exchange flow through Admiralty Reach, a site of dominant water exchange between Puget Sound and the Strait of Juan de Fuca.

Victoria Clipper ferry: The COVID-19 pandemic and continued lockdown for Washington State has profoundly affected state agencies and ferry operations. While this constituted a severe obstacle for data collection (Victoria Clipper V will be suspended until April 2021), we have been using the time efficiently to upgrade the ferry box wireless communication network and the water plumbing system from the sea-chest to the sensors. The goal is to expand the capability for increased collaboration for NANOOS by providing space for additional instruments which can be easily added and swapped out of the ferry box system water and data streams. Specifically, this required that a) plumbing was updated so that additional sensors can be quickly installed, and seamlessly integrate into the telemetered data stream, b) that georeferenced water flow is bubble-free, and c) that water is provided at constant and known flow rate. To realize these three goals, upgrades to the existing plumbing system and shipboard wireless network are being made. An industrial membrane peristaltic pump used by UNOLS vessels en-route ferry systems is currently being integrated into the plumbing downstream of the sensors. This work continues while the Victoria Clipper V ferry is permanently docked in Seattle. Crucial to our success of the redesign was the exchange of technical experiences and sharing of detailed technical drawing and discussions with our Canadian NANOOS counter parts operating ferry boxes on British Columbia Ferries.

Columbia River Estuarine Observations:

-Maintain Columbia R. estuarine moorings; deliver data via NVS [Seaton]

-Bring all data QA/QC to meet Certification standards [Seaton]

The CMOP estuarine observation network was—as a part of the full transition of CMOP assets—transferred, starting June 1, to the Columbia River Inter-Tribal Fish Commission.

Multiple endurance stations for the lower Columbia River estuary have anchored the CMOP/SATURN network, and will now be under the responsibility of CRITFC. Originally a part of SATURN, but not funded by NANOOS, are two freshwater stations: SATURN-05 and SATURN-08 (maintained by J. Needoba (OHSU) with regional stakeholder funding; those stations do not transfer to CRITFC.

The NANOOS supported estuarine stations that are maintained on a permanent or seasonal basis are SATURN-01 (when possible), SATURN-03, SATURN-04, SATURN-07, SATURN-09, CBNC3, Elliot Point and Woody Island. All except CBNC3 have real-time telemetry. All but CBNC3, Elliot Point and Woody Island (which currently only measure salinity and temperature, or only temperature in the case of Woody Island) are interdisciplinary (physics and biogeochemistry). Each of the stations is designed to capture specific features of the estuary. Woody Island had been an inactive station for several years, but began producing intermittent real-time observations in early 2020. Work in October restored fully functional telemetry and real-time data.

Real time data from SATURN coastal stations are already being displayed on NVS. CMOP also provides access to SATURN long-term datasets via THREDDS, inclusive of a catalog summary—both essential building blocks to support the NVS display of long-term datasets. Data is subject to QA/QC, which is included in data submitted to NCEI via NANOOS. Improvements were made to QA/QC methods for chlorophyll through a benchtop fluorometer purchased with non-NANOOS funds. Additionally, Seaton participated in planning the integration of QARTOD flagging into the NANOOS centralized ERDDAP server, consistent with IOOS and NDBC policy recommendations. He also continued to monitor the maturation of the IOOS QARTOD library being developed by Axiom.

South Slough Estuarine Observations:

-Maintain South Slough estuarine moorings; deliver data via NVS [Helms]
-Bring all data QA/QC to meet Certification standards [Helms]

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 (Research Technician) at the South Slough National Estuarine Research Reserve (SSNERR). As part of the NERRS System-Wide Monitoring Program, South Slough Reserve continued operation of a network of moored estuarine water quality observing stations with additional support provided by NANOOS. Four real-time water quality monitoring stations located along the salinity gradient of the South Slough estuary provided continuous water temperature, salinity, dissolved oxygen, pH, turbidity, and water level data over the period 6/01/20 – 11/30/20. Telemetry transmissions were continuous for three of the stations, the Valino Island, Winchester Creek, and Elliot Creek platforms. The Charleston Bridge station continued to collect continuous data, but the station is still offline in preparation for installation of a new data collection platform and telemetry equipment, Yellow Springs Instruments Turnkey Storm3 system. Tom's Creek weather station provided continuous measurements of air temperature, relative humidity, barometric pressure, and wind speed/direction. The weather station solar radiation cable/wiring and the rain sensor cable were damaged in Spring 2020. The solar radiation damage required a new sensor, which was replaced October 2020 and the rain gauge cable was replaced November 2020. Monthly instrument deployments and retrievals, station maintenance, and data download, QA/QC, and management were completed for the weather and water quality stations during the reporting period following NOAA NERRS Centralized Data Management Office protocols, including 2019 Annual water quality and weather data submissions in April – June 2020. In partnership with the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI), SSNERR maintains one Coos Bay water quality station. The North Spit BLM station is located in the lower Coos estuary and data are available through NVS (NESDID ID # 346F229A; sosnswq).

In addition to the lower Coos Bay CTCLUSI station, South Slough expanded the network of water quality stations into the upper Coos estuary, which includes three stations located at Isthmus Slough, Catching Slough, and Coos River. The Reserve added pCO_2/pH monitoring equipment at the Valino Island and Charleston Bridge water quality stations and data collection was completed August 2019 with current analysis of the time-series data from instruments, and grab data analysis in collaboration with Oregon State University (Chan, Magel, and Hales).

The SSNERR water quality stations provide real-time data access for shellfish growers in the Coos estuary, including North Bend and Coos Bay Oyster Companies, Qualman Oyster Farms, and Clausen Oysters. The South Slough Reserve and CTCLUSI stations provide environmental data for research, monitoring and education programs conducted at the reserve. During this reporting period, data from SWMP/NANOOS stations were incorporated into research projects at the Reserve funded through the

Office of Coastal Management 2019 Margaret A. Davidson Graduate Fellowship including environmental modeling analyses from water quality stations to characterize drivers of native eelgrass declines. The analyses utilized water quality and meteorological data from SWMP/NANOOS stations, including water and air temperature, pH, turbidity, salinity, dissolved oxygen, and solar radiation. A summer 2020 NOAA Ernest F. Hollings undergraduate scholar project assessed salt marsh resilience to sea-level rise, and utilized data turbidity and tidal range data for part of her analyses. NANOOS Visualization System tools were integrated into boating safety plans for the Reserve developed in Spring/Summer 2020.

COVID-19 impacts affected routine SWMP field and laboratory work during the Summer due to social distancing restrictions for fieldwork and lab space, as the Reserve was unable to host interns or volunteers June – September 2020. However, the Reserve was able to host a Fall intern who assisted with monthly field and lab work October - November 2020.

• **Shorelines**

Washington Shoreline Observations:

-Maintain shoreline observations in WA; deliver data via NVS [Kaminsky]

-Bring all data QA/QC to meet Certification standards [Kaminsky]

NANOOS funds contribute to the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. Despite still being in a pandemic, CMAP was able to complete spring seasonal beach monitoring surveys in the Columbia River Littoral Cell (CRLC) in June 2020. Forty-six beach profiles and two surface maps were collected. During July-September 2020, CMAP conducted summer seasonal beach monitoring surveys in the CRLC, collecting 50 beach profiles, 16 surface maps, and 61 sediment samples from multiple cross-shore locations along 13 of the profiles. In addition, over 200 beach profiles were collected to extend the nearshore bathymetry profiles collected by the USGS and OSU using personal watercraft. Seasonal beach profile data and contour change plots are available through the NVS.

In addition to the regular CRLC beach monitoring work, CMAP continues to conduct more detailed surveys in Westport and Ocean Shores, two locations that experienced significant erosion during the winter of 2015-2016, threatening adjacent coastal properties. In both June and September, CMAP collected 7 supplemental profiles in Westport to monitor the dune nourishment area fronting the Westport by the Sea Condominiums and at least 13 supplemental profiles at the south end of Ocean Shores (27 supplemental profiles were collected in September). Where coir matting was applied over the reconstructed dune at the north and central areas, a wider crest elevation has been maintained of 1.5-2 m. In contrast, the south end has experienced more erosion of the seaward face, where there is no coir mat, and has a narrower crest of 0.7 m or less; however, this southern portion of the dune has been more heavily colonized by native dune grass on the landward side, which helps to accumulate aeolian sand. The coir matting appears to stabilize the dune, and make it less dynamic with less aeolian transport and less vegetation growth. Our monitoring data is providing the opportunity to evaluate these different approaches to enhancing coastal resilience.

CMAP collected additional data around the Columbia River North and South Jetties for the Army Corps of Engineers during the summer. In July 2020, CMAP collected topographic data along14 supplemental profiles spaced at 50-m intervals north of the North Jetty at Benson Beach. South of the Columbia River, in Oregon, CMAP collected an extra surface map on Clatsop Spit in September 2020, as well as 7 beach profiles on the Spit, 4 south of the South Jetty, and 4 perpendicular to the South Jetty on the north side to capture the ridge-runnel morphology. The combined beach and nearshore data revealed that Benson Beach accumulated about 900,000 m3 between 2019 and 2020 surveys, with the first significant increase in

nearshore sediment volume since 2014. Nevertheless, dune recovery is slow and dune heights remain 0.5 to 1 m lower than in 2014, which allows overwash to occur during winter storms. The South Jetty nearshore lost about 1.2 Mm3 of sediment between 2019 and 2020. Additional modeling and analyses are required to determine how these changes are related to changes in dredged material placement, wave climate, and fluvial sediment supply from the estuary.

CMAP continues to monitor the performance of the dynamic revetment at North Cove with funding from the Pacific County Conservation District. Beach topography surveys were conducted in June and September 2020, where 48 profiles and a surface map collected during each survey will be used to create a digital elevation model of the survey area and compared for change over time. In addition, individual rocks that were tagged in early 2019 with PIT tags were tracked during each survey. Additional storm response surveys were conducted before and after two large wave events in November 2020. Results indicate the revetment is functioning as expected, with a dynamic upper beach and a steady lower beach, effectively holding the upland in place. Storm response surveys were also conducted at the west end of the Shoalwater Bay USACE berm where the Shoalwater Tribe has built a dynamic revetment. The berm experienced significant erosion and has been totally lost in some areas.

CMAP also continues to collect seasonal beach profiles near Kalaloch at South Beach on the Olympic Peninsula, where 14 profiles were collected in June and October 2020. CMAP performed rock tracking at Kalaloch in June 2020, but decided not to repeat it in October 2020 as only 25 rocks were found out of the 150 placed in October 2019. These observations demonstrate the high mobility of cobbles on the outer coast compared to the north shore of Willapa Bay. Outside of the CRLC, CMAP worked with surveyors from the USGS to collect beach profiles at the Elwha River delta in July 2020. All survey vessel work to collect high-resolution topographic and bathymetric data has been suspended due to COVID.

Oregon Shoreline Observations:

-Maintain shoreline observations in OR; deliver data via NVS [Allan]

-Bring all data QA/QC to meet Certification standards [Allan]

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 – summer surveys – were collected in the Neskowin (15 sites) littoral cell and Rockaway littoral cells (25 sites) in September 2020; summer surveys along Clatsop Spit (6 sites) were deferred to November 2020 due to a series of equipment failures. Summer (July 2020) surveys were also completed for several other study areas including Beverly Beach (15 sites) and from Yachats to Yaquina Head (58 sites). In addition to measurements of the transects, datum-based shorelines were also collected during the same beach monitoring campaigns. 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). As of late summer 2020, our monitoring data indicated that the suite of beach observation sites were within the typical winter range determined from 22 years of beach monitoring.

During this period PI Allan worked with the NANOOS DMAC team (Risien and Mayorga) and NOAA IOOS (Biddle) to develop a process for archiving NANOOS beach change data at NOAA NCEI. At the time of writing, the overall components of the data archiving have been resolved and tested, with profile data successfully pushed to http://data.nanoos.org/ncei/dogami/, where NOAA NCEI will eventually be able to access the data. Work was also undertaken in late November to standardize a metadata template developed by DOGAMI that would eventually accompany the archived profile data.

Nearshore Bathymetry Observations *[Ruggiero]*

In collaboration with the Washington State Department of Ecology and the U.S. Geological Survey, P. Ruggiero's group at Oregon State University collected nearshore bathymetry data along the four sub-cells of the Columbia River littoral cell (CRLC). Over 220 individual cross-shore profiles were collected during summer 2020 extending from the lower intertidal 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 measurements collected by Ecology developing complete maps of the nearshore planform. These data continue to provide a critical source of information for improving coastal hazard mitigation along the coastlines of the CRLC and portions of the Oregon coast and for understanding the morphodynamics of high-energy beaches. In collaboration with the US Geological Survey and the Washington Department of Ecology the nearshore bathymetry and topographic data being collected via NANOOS at the mouth of the Columbia River is being used to inform regional sediment management practices (Figure 5).

Our summer 2020 field data collection was significantly impacted due to the pandemic. Field expenses were significantly higher than usual as every crew member had to drive individual cars and stay in single occupancy hotel rooms. While we were able to continue our long-term time series in the CRLC we were unable to collect additional data along the Oregon coast during summer 2020.

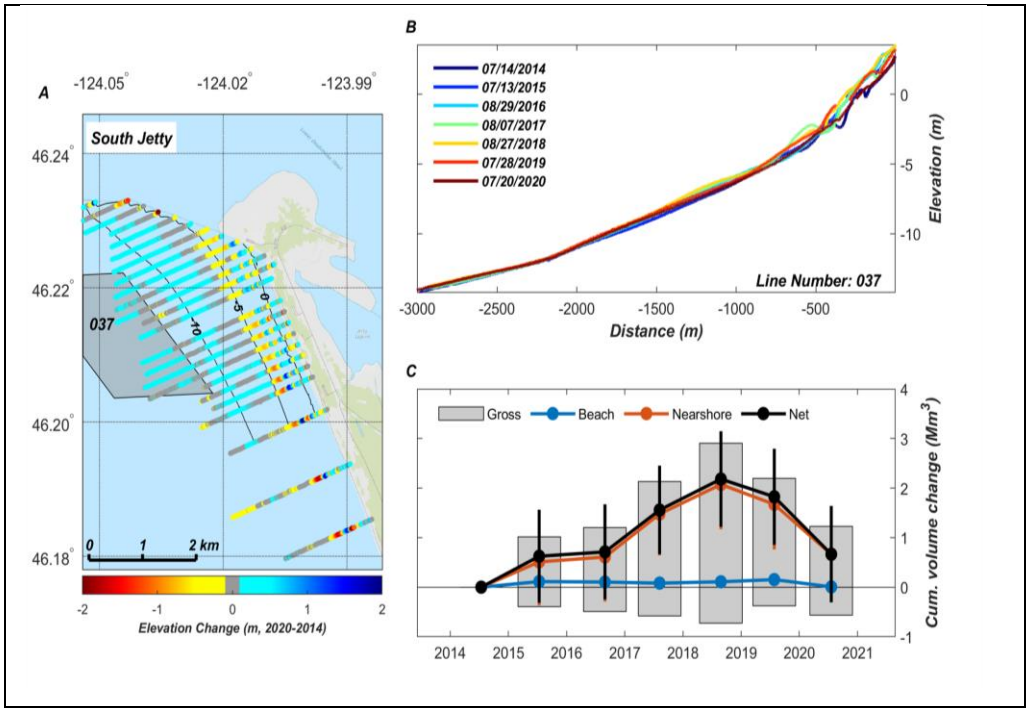

Figure 5. *A: Map showing cumulative elevation changes between 2014 and 2020 for the South Jetty region within the Clatsop Plains subcell; depth contours (5-m interval between –10 and 0 m) based on 2014 survey. B: Example profile showing changes in beach and nearshore morphology along survey line 037 (location shown in A). C, Time-series plot of volume changes calculated for South Jetty region; net volume changes are provided for beach and nearshore depth zones, as well as net volume changes integrated over entire region. This area lost about 1 Million cubic meters of sediment between 2019 and 2020.*

Currents

Coastal Current Observations:

-Maintain OR Priority-One HF radar sites to the national operations standard; deliver data via NVS and the National HF Radar system [Kosro]

-Bring all data QA/QC to meet Certification standards [Kosro]

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, NANOOS scored an HFR Net Performance metric for the 2 main reporting quarters (Q4 of 2020 and Q1 of 2021) of 60% and 94% respectively (https://hfrnet.ucsd.edu/diagnostics), or 77% for the past half year. Sites at PSG1 (Crescent City, CA) and SEA1 (Seaside, OR, Columbia River and Priority 2) were primarily responsible for outages.

In July, we installed a new computer at LOO1 to allow us to run an up-to-date OS/SeaSonde-Release 8. The long-range site at Yaquina Head, YHL1, had intermittent outages related to power. A power supply failed there, and a replacement was ordered. On Nov 29, repairs were made to the electrical breaker box which appear to have fixed things. Our nearby standard-range site, YHS2, also had electrical problems, fixed by using a different outlet. At MAN1, the site damaged by lightning, the damaged antenna cables were dug up and removed; new cable installation needed. Problems at SEA1 included cables cut by landowners landscaper; repairs needed. PSG went down, and remote fixes didn't help; the contractor visited and found the problem was not in the Rx – need a visit. Some of these repairs that involve multi-day travel or multi-party effort are difficult with COVID restrictions.

Fill gaps in HF Radar operations and maintenance by OSU to complete west coast coverage for health and safety *[Kosro]*

We received Fill-the-Gaps funding for 2 new systems. During August, Erik Arnesen, Mike Kosro and Josh Logan travelled to Westport, WA to install the long-range site WSP1, in Westhaven State Park, near 46° 54.2'N, 124°07.9'W. Antennas and fences were erected, cables were trenched, placed in conduit near the shelter, and installed. The electronics were connected in test mode and worked well. We are waiting for the park to install our GPS antenna on the roof, and install a separate power outlet. Before we can operate, we need to get FCC licensing on the ITU frequencies under Part 90. This involves different requirements than we have operated under, but possibly also some international issues. The second site is intended for the Olympic National Park land in the general vicinity of Kalaloch Lodge; we are in communication with a representative of the National Parks Service about this project.

Port X-band Radar Observations:

-Maintain X-band radar sites; deliver data via NVS [Haller]

-Bring all data QA/QC to meet Certification standards [Haller]

We continue to maintain and operate the radar station at the Yaquina Bay inlet in Newport, OR. Imagery, videos, and spectrum plots are posted to our webpage (http://research.engr.oregonstate.edu/haller/Newport) and imagery and spectral plots are available on NANOOS NVS Explorer. Occasional maintenance of the radar system includes replacing backup hard drives and remedying wear and tear issues such as replacing motor brushes.

As of November 2020, we are nearing installation of a new Furuno model radar on the Coast Guard observation tower. We anticipate this new radar will offer better mechanical durability and reliability as

well as reduced image noise. Along with the new radar, we will install a next-generation Cambridge Pixel HPx-model radar data acquisition card and OSU-designed-and-built open-source data acquisition and recording software using the software toolkit from Cambridge Pixel. This new system offers greatly increased configuration flexibility and improved radiometric resolution. As Cambridge Pixel is an established provider of sensor display and processing solutions across many segments from military to coastal surveillance, we have high confidence in their hardware and software offerings as well as their customer service.

With the new radar system we will also have a real-time display of the wave observations that is accessible to the USCG watchstander in the observation tower who will be able to view the radar's display unit with live imagery out to 1.5 nautical miles to enhance their situational awareness. They will continue to have access to our near-real-time data products posted to our website, as noted above.
Finally, our station observations will feature prominently in an upcoming presentation at the 101st American Meteorological Society Meeting (virtual, Jan 2021) entitled "Weather Considerations at Pacific Northwest Hazardous Breaking Bars and the Coast Guard's Commercial Fishing Vessel Accident Investigations" contributed by G. Keith Fawcett (USCG Marine Casualty Investigator; New Orleans, LA).

b) NANOOS Modeling Subsystem:

Shelf Modeling:

-Maintain modeling & forecasting capabilities at OSU; deliver model output via NVS [Kurapov, Zaron]

-Model verification and validation [Kurapov, Zaron]

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, ACSPO Global SST from VIIRS, 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 the public via the NANOOS Visualization System, e.g., as the Tuna Forecast and SeaCast applications. 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 provides access to the real-time fields by the Cyberinfrastructure group of the IOOS-sponsored Coastal Ocean Modeling Testbed (COMT) project.

During the report period, we continued our real-time operation. The model assimilation and forecast quality control tools were updated and improved on account of comparison with new SST data available at NOAA ERDDAP through webread such as NOAA-20 VIIRS, POES and AVHRR 0.25 interpolated, and in-depth profiles of the Sea Glider (http://ingria.coas.oregonstate.edu/rtda_figs/ow2/wp/RTDA_results.html). The assimilation is now done daily providing a reasonable amount of data is available, as opposed to an earlier scheme, where assimilation was done once in 3 days. Additional data sources for assimilation (SST and SSH) are being evaluated. Following the successful tests of the new computer cluster on the vendor site, a new cluster has been obtained and installed at OSU. On-site tests using this new infrastructure with our prediction system are ongoing. The publication of data assimilation tests and analyses aimed at further system improvement has been completed [Pasmans et al., 2020]. This work was leveraged by the Quantitative Observing System Assessment Program (QOSAP) funds, provided earlier through NANOOS. We have also continued transition of details of the data assimilation technology to the NOAA US West Coast Operational Forecast System (WCOFS), which is currently at the testing phase at NOAA NOS.

Shelf and Salish Sea Modeling:

-Maintain modeling & forecasting capabilities at UW; deliver model output via NVS [MacCready]

-Model development, verification and validation [MacCready]

NANOOS PI P. MacCready (UW School of Oceanography), working with Drs. Siedlecki (Univ. Of Connecticut), McCabe (UW Joint Institute for the Study of Atmosphere and Ocean), and Banas (U. Of Strathclyde) run a pre-operational forecast model, called LiveOcean, of ocean circulation in Puget Sound and adjacent coastal waters. The model has 500 m horizontal grid size in the Salish Sea and coastal estuaries and 45 rivers.

Extensive model validation and movies of the daily forecast focused on different stakeholders are presented at: http://faculty.washington.edu/pmacc/LO/LiveOcean.html. Model fields are available through NANOOS NVS. The model fields are also made available through the NOAA IOOS EDS system, and are used as open boundary conditions by Dr. Susan Allen at UBC and Co-PI Seaton for their forecast systems. 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. 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 NOAA-funded MERHAB PNW project to make short-term forecasts of when *Pseudo-nitzschia* HABs may reach WA beaches.

During this period MacCready wrote and published a paper (MacCready et al., in press) documenting the LiveOcean modeling system that is used as part of the PNW HAB Bulletin. He gave two public talks (URI and NOAA CMMB), a briefing at the NOAA OCNMS Advisory Council meeting, and was interviewed for a video on Ocean Acidification being produced by AGU. He co-advised a graduate student, Dr. Hally Stone (supported by NANOOS MERHAB grant) who defended her PhD in 8/2020 and published a paper exploring wind and phytoplankton patterns in the PNW. Stone and MacCready interviewed Matt Hunter (Oregon Shellfish Project Leader) on the use of LiveOcean forecasts by stakeholders. MacCready updated the LiveOcean forecast pages to be mobile-friendly since this is preferred by many users. Working with the advice of stakeholders from NANOOS and elsewhere, MacCready created a daily extraction of selected LiveOcean fields and depths. These are available through the THREDDS server set up by Craig Risien https://wilson.coas.oregonstate.edu/thredds/catalog/NANOOS/LiveOcean_Files/catalog.html and are used by NANOOS NVS. Working with Tiffany Vance at NOAA an automated backup system for the large computational step in LiveOcean forecasts has been developed and tested, using Amazon AWS cloud computing. NANOOS funding this period was used for purchasing supercomputing nodes from the UW hyak system that will allow substantial increases in model development in coming years.

The work of MacCready's group is largely unaffected by COVID-19. We use a number of remote computers and are able to perform all research tasks from home offices.

Columbia River Modeling:

-Maintain modeling & forecasting capabilities at CRITFC; deliver model output via NVS [Seaton]

-Model verification and validation [Seaton]

The CMOP modeling system was—as a part of the full transition of CMOP assets—transferred, starting June 1, to the Columbia River Inter-Tribal Fish Commission.

CRITFC has maintained an extensive modeling system for the Columbia River coastal margin, denoted Virtual Columbia River (VCR). The VCR has evolved from multi-institutional collaborations 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, estuarine pathways, and status under the Endangered Species Act and in relation to hydropower management and climate change. During this reporting period, we completed reporting on simulations in support of FEMA storm surge mapping for Clatsop County.

Anchoring the system are simulations of circulation, conducted in four distinct forms: (1) daily forecasts, (2) multi-year simulation databases, currently 1999-2018, (3) scenario simulations, and (4) process simulations. Of these, daily forecasts are displayed on NVS. To meet the challenges that the highly energetic and strongly stratified Columbia River estuary and plume pose to numerical models, we have experimented with—and contrasted among—multiple codes (Thetis, SLIM, SELFE and SCHISM) representing different classes of unstructured-grid finite element methods.

-Task 13 CRITFC observations, modeling, and DMAC transfer *[Seaton]*

Leveraging the existing modeling system and prior work on implementing SCHISM modeling of the estuary, CMOP worked in collaboration with NOAA/NOS/OCS/Coast Survey Development Lab-Coastal Marine Modeling Branch (with funds transferred through IOOS/NANOOS, for Task 13) on the development of a new SCHISM model for the northern and tropical Pacific Ocean. Initial work is targeted at development of a 2D tide and storm surge model, but model design is planned to accommodate 3D model development with the potential for trans-Pacific port-to-port modeling of surface currents in support of navigation. Work during this period included training new staff at CRITFC and GIS and mesh development work, towards an initial 2D model run in late December.

-Task 18: Columbia River extension of Salish Sea model *[Khangaonkar]*

The overall objective of this project is to incorporate, test, and validate the Columbia River portion of the Salish Sea Model such that the two estuaries may be operated as a single modeling framework by NOAA COOPS. Addition of Columbia River to the SSM-OFS effort is being conducted through a NANOOS grant at the Salish Sea Modeling Center (SSMC), University of Washington (UW), Tacoma. The period of performance is from 6/1/20 to 5/31/21. The project includes a sub-award to Pacific Northwest National Laboratory as part of the dual appointment program between the Pacific Northwest National Laboratory and UW, Tacoma for the PI (Khangaonkar). The sub-award was authorized with a start date of 9/11/20.

During this reporting period, SSMC completed hiring and training of a staff scientist Su Kyong Yun, a former UW Civil Engineering graduate, who will be responsible for data analysis and NOAA skill assessment activities using the SSM-OFS outputs. SSMC has also completed the installation and testing of the Salish Sea Model and associated codes and scripts at the SSMC computational platform at UW HYAK supercomputing facility. At the conclusion of YR 2 of SSM-OFS project, the SSM-OFS project team realized that the stratification response in the Strait of Juan De Fuca needed improvement. This improvement, while less critical for surface currents, is important for biogeochemical modeling work ensuring correct exchange of flow and nutrients between the Strait of Juan De Fuca and Puget Sound regions. The PI and CO-PIs at PNNL have focused on this revision of the existing SSM-OFS calibration through the COMT18 project at PNNL. Model grid refinements and tests with the Columbia River region have been initiated in parallel but will be implemented on the latest version of SSM-OFS. We are awaiting the receipt of a high-resolution Columbia River bathymetry set from NOAA CSDL for use in this effort. Similarly, we are awaiting the receipt of NOAA Columbia River survey data through NOAA-CMIST. We expect the SSM-OFS model to be ready for Columbia improvements by 1/30/21. Similarly, we also expect the survey data to become available for our use for

skill assessment in 2021. Therefore, we have planned for extensive testing and skill assessment efforts to occur in the 3rd and 4th quarters of FY21.

c) NANOOS Data Management and Communications (DMAC) Subsystem:

See Table 1 for milestones [Risien]

Chaired by C. Risien (OSU), this committee is composed of members from CRITFC (formally 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 "tag-up" calls; 2) annual Governing Council and PI meetings (August 18 and 20, respectively); 3) monthly IOOS DMAC webinars; and 4) the annual IOOS DMAC meeting.

The ***NANOOS Visualization System (NVS)*** enhancements encompass asset additions and continuous updates: 1) new data streams from the new CDIP Angeles Point wave buoy, intended to help monitor sediment transport around the Elwha River plume and Port Angeles, and from newly integrated or reestablished data integrations at NWS wind stations north and south of the Columbia River mouth, a USGS river gage in Vancouver, WA, and the Friday Harbor Laboratory weather station; and 2) a a second NVS Glider App for an OOI glider hydrographic line (Grays Harbor Shallow). , to be followed by other transects in the near future; and 3) redeployments and smaller upgrades, including new pH sensors at ORCA buoys at Dabob Bay, Hansville and Point Wells, and an update to the latest version of the SalishSeaCast model output from UBC.

NANOOS and IOOS DMAC system implementation.

- Data Archiving. Monthly NCEI archiving of fixed-location time series data from OHSU CMOP stations continued operationally. Efforts to archive Oregon shoreline change surveys carried out by DOGAMI for the last twenty years, and pH sensor data from Washington Shelf and Puget Sound moorings maintained by the UW NorthWest Environmental Moorings (NWEM) group, are ongoing.
- ERDDAP Implementation. A NANOOS ERDDAP server (http://data.nanoos.org/erddap/index.html) has been released, providing data access and distribution to 111 datasets that include NANOOS gliders, NANOOS-processed time series and climatologies from NDBC, NOS and CDIP, and NANOOS-originated remote sensing products. Ongoing development is focused on enabling access to the same near-real-time station data streams currently available on NVS; an initial release is planned for early 2021.
- Other advancements. NANOOS (Mayorga) was a co-organizer of the 2020 OceanHackWeek (https://oceanhackweek.github.io), a collaborative educational event that took place online in August 2020. The event brought together grad students and young professionals from the US and internationally to advance capabilities in data science focused on oceanographic applications. This event was supported by IOOS, NSF, the UW eScience Institute and other sources.

-Task 12: Enhance GOA-ON data portal an OA dashboard to the world *[Tanner, Newton]*

The GOA-ON Portal now includes slideshow items (10) to provide important updates and news stories. There is a new SDG 14.3.1 page, GOA-ON is addressing Sustainable Development Goal (SDG) 14.3.1 Indicator, which calls for the "Average marine acidity (pH) measured at an agreed suite of representative sampling stations". The Methodology provides the necessary guidance on how to conduct ocean acidification observations, what to measure and how, providing standard operating procedures and methods approved by the ocean acidification community. It further provides support on what kinds of data to collect, and how to submit, towards the SDG 14.3.1 Indicator to IOC-UNESCO to enable the collection

and comparison of ocean acidification data worldwide. The associated data and metadata files enable the collection and submission of the relevant data. Pier2Peer updates are online, including the October 2020 issue of the PIER Review, the monthly GOA-ON Pier2Peer newsletter, which features a recap of Ocean Acidification Week 2020 and other OA-related news, updates, funding and job opportunities, and recently published open-access publications.

The OA Week webinar page was created to highlight Ocean Acidification Week, a virtual multi-day forum to highlight ocean acidification research and initiatives, held 8-10 September 2020. The GOA-ON in a Box Instructional Videos Series was produced by The Ocean Foundation in partnership with GOA-ON, IAEA OA-ICC, and IOC UNESCO. As of November 2020, GOA-ON membership has grown to more than 800 individuals from 105 countries. The list of participating countries are available in the GOA-ON Growth updates. The growth in membership is a remarkable achievement due to the significance of the issue and the willingness of the members to collaborate and contribute their expertise to build the network.

-Task 14: Support OceanHackWeek *[Mayorga]*
OceanHackWeek (OHW, https://oceanhackweek.github.io) successfully concluded 5 days of collaborative data exploration, peer learning and software development on August 14th. The virtual event was attended by 46 accepted participants, 15 organizers and 18 additional presenters and helpers, spread out globally. Participants, helpers and organizers were located in 21 countries and all continents except for Antarctica. Participants and tutorials reflected the interdisciplinary nature of oceanography, from genomics to global surface temperature. The event also embraced the two most widely used open-source programming languages in data science and oceanography, Python and R. Despite the novel challenges of moving the hackweek entirely online and working around a wide span of time zones, feedback from the participants was overwhelmingly positive in the post-event survey (see https://escience.washington.edu/OHW2020-reflections/). The organizers in particular noted the advantage of the online format in accommodating a more diverse group of participants who otherwise would not be able to participate due to logistic and cost constraints. This event was co-led by Emilio Mayorga (NANOOS and UW-APL) and Wu-Jung Lee (UW-APL), and Nick Record and Catherine Mitchell at the Bigelow Laboratory for Ocean Sciences in Maine. The organizers are looking forward to potentially hosting the next OHW in a hybrid in-person and virtual format in 2021. Presentations, tutorials and project presentations are openly accessible from the web site as computational notebooks (Jupyter or R Markdown), pdf presentations and video recordings via the OHW YouTube Playlist (https://www.youtube.com/playlist?list=PLA6PlfxWZPLTPQ_OIr3dDPF9FRiHQXoVF).

-Task 15: Enhance biological data stewardship within NANOOS *[Mayorga]*
Transitions in NANOOS DMAC personnel hindered progress on the integration of biological data into NANOOS products and the delivery of regional biological data to national IOOS networks, including OBIS. However, DMAC staff continued to engage with the Biological Data Standards working group and also actively participated in the 2020 Biological Data Standards Workshop in July and the subsequent ESIP Biological Data Standards Cluster calls.

d) User Products Committee (UPC):

See table for milestones [Allan]

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 OHSU, UW, OSU, NANOOS E&O, 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 to facilitate consistent work efforts, synergy across the committees, and improvements to product development and enhancements. Activities for this 2020 period included: 1) multiple weekly NANOOS DMAC and UPC teleconferences, and 2) Participation in the annual PI and Governing Board meetings held on August 18th and 20th, 2020.

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. During this reporting period, NANOOS did not release any major update to NVS; the last update was V6.3, which was released in June 2019.

During this period work was completed on an "overview" application in order to track the status of every asset, model and satellite overlay, and markers (web cams, marinas and boat launching ramps, and tsunami critical facility markers) via a web-based application. The objective of this tool is to allow core NANOOS staff (Web, DMAC, E&O, User Products, and Admin) to visualize the status of any data stream that is disseminated via NVS in order to identify potential problems or outright failures. This tool was identified as a need due to changes to DMAC leadership, with the resignation of DMAC lead, Emilio Mayorga.

Work commenced on a beta version of a new routable road networking capability that will eventually be rolled out in the NANOOS tsunami portal. This effort is a collaboration between DOGAMI, University of Oregon (UO) Infographics experts and NANOOS. UO are building the routable road networks that can be called up in NANOOS, while NANOOS is building the road plotting capability. At the time of writing a beta version of the tool is fully operational. The purpose behind this work is to allow a user to enter an address, and a route to the nearest safe exit point out of the tsunami inundation zone is automatically generated. The user can then either save/or print a pdf of the map.

A major effort was implemented during this period to modernize the NVS data harvesters. This is needed since the existing platform design is not sufficiently robust enough to sustain future growth needs. Hence, the decision was made to begin the process to update the harvesters to a new format. The expectation is that such an effort could take several months and will preclude any new app development or enhancement until the harvesters have been updated.

NVS Mobile App: No updates during this period to report.

e) NANOOS Education and Outreach Subsystem:

See table for milestones [Wold, Newton]

NANOOS Education and Outreach efforts 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 were largely completed by NANOOS staff Newton and Wold, with support from DMAC and UPC subsystems and many NANOOS member collaborators. Newton and Wold were active members of the weekly DMAC/UPC tag-up conference calls, regularly providing support and feedback on UPC and DMAC developments. Wold continued 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.

- NANOOS has been partnering with a small local non-profit, Whidbey Watershed Stewards, to work with the 7th & 8th graders at South Whidbey Middle School ocean science and technology program. In previous years students design, build, and deploy buoys at the Langley Marina then retrieve and analyze their data. This project is on hold due to COVID-19.
- Newton met with Seattle School District educators through the Technology Access Foundation on 15 September and 21 October to discuss enhancing STEM education using NANOOS data.

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.

- Wold engaged with the recreational boating community, presenting virtually to demonstrate the NVS Boaters App while gaining direct feedback.
- Wold maintained communication with members of various recreational, educational and stewardship organizations while their regular meetings and events were on hold due to COVID.
- Wold continued to update content on the NANOOS portal.
- NANOOS maintained Facebook and Twitter accounts, each with growing audiences. NANOOS also has a growing audience for its bimonthly newsletter, the "NANOOS Observer."

f) NANOOS Administration:

See table for milestones [Newton]

J. Newton (NANOOS Executive Director), D. Martin (NANOOS Board Chair), M. Kosro (NANOOS Board Vice Chair), and N. Rome (NANOOS Program Manager) continued to provide leadership to NANOOS operations and connection to the US IOOS enterprise. Newton participated 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, Rome, and Kosro participated in weekly Tri-Com calls. Key events for this period included:

- Newton, Martin, and Rome attended the virtual Fall IOOS and IOOS Association meetings on 9 October.
- Newton participated in the IOOS Association Strategic Planning sessions on 22-23 July.

Additional coordination and representation included:

- NANOOS Executive Director Newton and NANOOS Program Manager Rome led the development of the 5-year NOFO response for NANOOS, in coordination with the GC, PIs, stakeholder input, and the EOIs from new and current PIs. The GC Executive Committee reviewed the Expressions of Interest that NANOOS received following the open process we used to solicit input for our five-year NANOOS response to the IOOS Notice of Federal Opportunity (NOFO). Our process was detailed here: http://www.nanoos.org/news/index.php?item=NanoosFiveYearEffort200625
- NANOOS held its annual meetings virtually this year, with the GC meeting on 18 August and the GC-PI meeting on 20 August, led by Newton. This was an especially important meeting year, as the proposal investments for the next 5-y proposal were reviewed and feedback given for the Executive Committee to decide on. While the meetings were virtual, lacking personal gathering, the virtual format did allow for higher attendance: we had up to 50 for the GC meeting from diverse NANOOS member institutions, and up to 40 joined our PI meeting.
- The NANOOS Tri-Com held two virtual annual meetings this year. The first, on 28 May 2020, reviewed progress to date and used GC and PI feedback to prioritize work efforts for User Products,

DMAC, and Education/Outreach efforts for this period, which the Tri-Com continued to discuss during weekly tag-up calls. The second, on 18 June 2020 was used to review the IOOS NOFO for the next 5 years and strategize on our priorities.

- This year, as the nation faced the reality of the systemic racism that permeates our country and practices, Newton invited the whole of NANOOS to join an open discussion on 17 June to brainstorm ideas for working towards a more equitable and inclusive observing community. From this initial discussion, the **NANOOS Enabling Change Working Group** was formed, with meetings on 24 July, 28 August, 25 September, and 23 October.
- Barth and Newton were invited to join Oregon US Representative Susan Bonamici's World Ocean Day Panel, June 8, 2020. The panel, "Turning the Tide – a World Oceans Day discussion on revitalizing coastal communities," discussed opportunities for new jobs and increased funding for ocean data with the next recovery package.
- Newton served on the IOOS-OAR Workshop Steering Committee and participated in the Atlantic Workshop on 1 July and Pacific Workshop on 25-26 August. For the Pacific Workshop, she reviewed the goals of the workshop and the process for enhancing collaboration between OAR and IOOS, and co-moderated the Ocean Acidification breakout session to identify opportunities for improving collaborations.
- Newton and AOOS Director Molly McCammon are members of the Ecosystem Sciences and Management Working Group and participated in meetings on 15-16 July and 17-18 November. Both have been selected as co-chairs of the WG for next year.
- Newton participated in a working group to develop the National HAB Observation Network.
- Newton participated in the virtual NOAA HAB-OA Workshop 11-13 August giving a lightning talk on HAB and OA Acidification & Harmful Algal Blooms: Research Products: activity in the NANOOS region.
- Barth, Newton, and Jaime Pinkham (CRITFC) were invited to join Oregon US Representative Susan Bonamici's "Climate Science and Resilience Roundtable" discussion on September 1, 2020.
- Newton served on the Sustaining Ocean Observations (SOO2) National Academies Planning Committee and participated in the workshop that was held on 16-18 September, providing Day 1 summary remarks.
- Newton participated in the NOAA Ocean Acidification Program external review on 29-30 Sept.
- Newton was asked to serve on the Plenary Committee for the CERF 2021 Conference. She is also working with other IOOS RA directors on a contributed session on the Coastal Climate Signal.
- Newton participated in the NOAA Virtual Booth during the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) 2020 Virtual Conference. Newton shared the booth with Darcy Dugan, AOOS, for a joint presentation on ocean acidification on 19 October.
- Barth participated in the NSF-sponsored Ocean Innovation Workshop (https://www.smartoceans2020.org/) the week of October 5, 2020.

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

- Barth participated on June 16 and September 15, 2020 in strategic planning meetings of the Ocean Networks Canada (ONC) International Science Advisory Board (ISAB) that provides guidance and counsel to the Canadian effort to field, evolve and improve two research-focused ocean observatories (VENUS and NEPTUNE Canada) that simultaneously serve emergent operational societal needs. In this context, Barth provides both scientific expertise as they communicate the U.S. experience with IOOS and operational ocean observing efforts that are part of the unique hybrid nature of ONC.
- Throughout the period, Newton continued to participate in OceanObs19 discussions, and, along

with CeNCOOS director Clarissa Anderson, participated in the LENFEST virtual discussions for optimizing Biodiversity Observations.

- Newton represented IOOS on the Global Ocean Acidification Network Executive Committee calls and activities. She is a co-Chair of GOA-ON, along with Bronte Tilbrook, CSIRO. Newton is a member of the GOA-ON Biology Working Group and continued efforts on a paper about recommendations for biological observations.
- Newton gave the GOA-ON talk for the UN High-level Political Forum side event "Developing capacity to address ocean acidification for a sustainable ocean future" on 8 July and participated in the GOA-ON sponsored Ocean Acidification week 18-20 September, including giving one of the Capstone Presentation talks in Session 10 on 20 September.
- Newton stayed involved in Canadian observing activities including for MEOPAR, CIOOS-Pacific, and the Canada Foundation for Innovation. Newton is a member of the Canadian IOOS (CIOOS) Pacific General Oversight Committee, attending meetings on 18 June, 28 July, and 4 November. Newton moderated the opening session of the Marine Environmental Observation, Prediction, and Response Network, a Canadian Center of Excellence (MEOPAR) Annual Scientific Meeting on 26 October. Newton was invited by the Canada Foundation for Innovation to chair an Expert Committee on Oceanography for their 2020 Innovation Fund competition. This involved reviewing expert reviews and chairing the discussion on 2 June.
- Newton is a member of the Science Advisory Team for the Joint European Research Infrastructure in the Coastal Ocean (JERICO). She was asked to be a reviewer for the Joint European Research Infrastructure in the Coastal Ocean (JERICO) Trans-National Access (TNA) selection panel.

Additional NANOOS coordination:

- Newton was renewed as the Research Seat for the Olympic Coast National Marine Sanctuary (OCNMS) Advisory Council; she participated in meetings on 24 July, 25 September, and 6 November. Newton was selected as OCNMS' Volunteer of the Year.
- NANOOS was funded by the West Coast Ocean Data Portal leadership to lead an effort to develop a West Coast-wide ocean acidification indicator. This is being done in coordination with the other RAs and with other stakeholders and user groups. NANOOS Research Associate Roxanne Carini is leading this effort. Phase 1 is for recommendations.
- NANOOS held a discussion with NANOOS Modeling PI Parker MacCready and representatives from Oregon State agencies to discuss output needs on 9 September.
- Newton participated in the Olympic Region Harmful Algal Bloom (ORHAB) Steering Committee calls throughout the period.
- Newton was invited to participate in the Olympic Region OA Centennial site (OASeS) Steering Committee, which met on 11 September.
- Newton participated in the Office of National Marine Sanctuaries Climate Change Virtual focus group (Observer Focus Group) on 28 September and participated in their Qualitative Modelling of Ocean Habitat Networks workshop on 1 October and 5 October.
- Newton participated in NOAA 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, the West Coast Ocean Data Portal, and "OA Round Tables" organized by NOAA PMEL and NWFSC.
- Newton contributed NANOOS updates on oceanographic conditions in the Pacific Northwest for the NOAA WestWatch webinar series on 21 July and 20 October, along with the other two west coast RAs, and a similar but local-scale Salish Sea Marine Conditions webinar on 22 July, 23 September, and 18 November.

- Barth participated in a 2-day OAR/IOOS "Enhancing Coastal and Ocean Observing and Innovation" workshop on August 25-26, 2020.
- Barth participated in the 3-day “Workshop on Sustaining Ocean Observations” sponsored by the National Academy of Sciences on September 16-18, 2020.
- Barth serves on the Oregon Ocean Policy Advisory Council’s (OPAC) Scientific and Technical Advisory Committee (STAC) responsible for providing expertise on ocean issues including the implementation and monitoring of Oregon’s marine reserves and ocean acidification monitoring efforts. Oregon is preparing for review of their network of marine reserves due in 2023.
- Barth serves as the Co-Chair of the new Oregon Ocean Acidification and Hypoxia Coordinating Council, enacted as a state law in fall 2017. Oregon issued its Ocean Acidification and Hypoxia Plan in June 2019 (https://www.oregonocean.info/index.php/oah-action-plan). The OAH Council submitted their second biennial report in September 2020. The OAH Council was awarded an Honorable Mention in the Climate Adaptation Leadership Awards for Natural Resources, National Fish, Wildlife, & Plants Climate Adaptation Network, Association of Fish & Wildlife Agencies, 2020.

Coordinate a west-coast wide regional collaboration team workshop with NOAA West and west coast IOOS RAs *[Newton]* As reported last time, plans for a workshop in person are not relevant due to COVID-19, thus this project is being re-scoped and developed. We have made progress on a vision for this that we will report next time; it will include a paper on best practices and a shorter virtual west coast workshop.

Presentations and Publications acknowledging NANOOS support: underline indicates NANOOS PI

Presentations:

Haller, M.C., *Invited talk:* "Marine radar remote sensing of submesoscale ocean fronts from a mobile tower", *Annual Meeting of the Mexican Geophysical Union* (*RAUGM*) 2020, virtual meeting, Nov. 4, 2020.

Haller, M.C., *Invited seminar:* "Recent applications of marine radar remote sensing: submesoscale frontal features and hydrographic estimation", online webinar *NOAA Coastal Marine Modeling Branch*, November 17, 2020.

Helms, A. Eelgrass Declines in the South Slough estuary, OR. NERRS Annual meeting (virtual), Stewardship Coordinators – GIS professional sharing session, November 5, 2020.

Helms, A. Eelgrass Declines in the South Slough estuary, OR. South Slough NERR Management Commission meeting, December 3, 2020.

Kaminsky, G. Nature-based Dynamic Revetment Construction at North Cove, Washington, USA, Virtual International Conference on Coastal Engineering, October 7, 2020.

Kaminsky, G. Adaptive Building with Nature for a Resilient Coast, American Shore & Beach Preservation Association annual conference, October 14, 2020.

MacCready, P. , R. M. McCabe, S. A. Siedlecki, N. S. Banas: U. of Rhode Island Invited Seminar, The Estuarine Circulation of the Salish Sea, 6/2020.

MacCready, P. , R. M. McCabe, S. A. Siedlecki, N. S. Banas: NOAA CMMB Invited Seminar, The Estuarine Circulation of the Salish Sea, 9/2020.

MacCready, P.: NOAA Olympic Coast National Marine Sanctuary Advisory Council, update on LiveOcean, 9/2020.

MacCready, P. and others: Interviewed for Washington OA Center video for AGU, 11/2020.

Meyer, S. and A. Helms. A decade of change: Assessing local variability in tidal wetland resilience to sea level rise indices in South Slough estuary, OR. 2020 National Coastal and Estuarine Virtual Summit, September 29 - Oct 1, 2020.

Newton, J. Ocean Acidification & Harmful Algal Blooms: Research Products: activity in the NANOOS region. NOAA HAB-OA Workshop, 11-13 August 2020.

Newton, J. "Developing capacity to address ocean acidification for a sustainable ocean future." UN High-level Political Forum side event, 8 July 2020.

Newton, J. Capstone presentation: GOA-ON Ocean Acidification week. Session 10, 20 September 2020. https://www.youtube.com/watch?v=EX2uyGnzaz0

Newton, J. Ocean Acidification: a global issue with local effects. NOAA Virtual Booth at the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) 2020 Virtual Conference, 19 October 2020.

Publications:

MacCready, P., R. M. McCabe, S. A. Siedlecki, M. Lorenz, S. N. Giddings, J. Bos, S. Albertson, N. S. Banas, S. Garnier (in press) Estuarine Circulation, Mixing, and Residence Times in the Salish Sea. J. Geophys. Res. Oceans, DOI: 10.1029/2020JC016738

Magel, C.L., Hacker, S.D., Chan, F., and Helms, A. 2020. 'Eelgrass and macroalgae declines in a US Pacific Northwest estuary highlights the biogeochemical controls and feedbacks for hypoxia and ocean acidification.' Chapter 3, PhD dissertation, Oregon State University, September 1, 2020.

Stevens, A.W., Elias, E., Pearson, S., Kaminsky, G.M., Ruggiero, P.R., Weiner, H.M., and Gelfenbaum, G.R., 2020, Observations of coastal change and numerical modeling of sediment-transport pathways at the mouth of the Columbia River and its adjacent littoral cell: U.S. Geological Survey Open-File Report 2020–1045, 82 p., https://doi.org//10.3133/ofr20201045

Stone, H. B., Banas, N. S., MacCready, P., Kudela, R. M., & Ovall, B. (2020). Linking Chlorophyll Concentration and Wind Patterns Using Satellite Data in the Central and Northern California Current System. Frontiers in Marine Science, 7. doi:10.3389/fmars.2020.551562