Progress Report

Project Title: Sustaining NANOOS, the Pacific Northwest component of the U.S. IOOS
Award Number: NA21NOS0120093
Period of Activity: 07/01/2021 - 12/31/2021
Principal Investigator(s): Jan Newton, NANOOS Executive Director

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 the 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 FY 2021 (= Y1 of the new award = Y15 of NANOOS RCOOS) 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, partnering with federal and non-federal (tribal, academic, state, local, industry, NGO, etc.) entities.
2) **Maintain surface current and wave observations:** Maintain existing HF-radar and wave mapping capabilities, providing critical national capacity along coasts and at critical ports.
3) **Sustain and enhance buoys and gliders in the PNW coastal ocean in coordination with national and regional programs:** Maintain, harden, enhance existing buoys and gliders, with focus on hypoxia, HABs, OA, and climate.
4) **Maintain multidisciplinary observational capabilities in PNW estuaries and the nearshore, in coordination with local and regional programs:** Sustain observing ability to aid sustainable resource management, water quality assessment, and sub-regional climate change evaluation.
5) **Maintain core elements of beach and shoreline observing:** Measure nearshore bathymetry, topographic beach profiles, and shoreline morphodynamics along OR and WA, contributing to hazard mitigation by providing 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 operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the Exclusive Economic Zone (EEZ) in both OR and WA.
7) **Maintain, harden, and enhance NANOOS' Data Management and Cyberinfrastructure (DMAC) system for routine operational distribution of data and information:** Sustain and enhance the DMAC system, including the NANOOS Visualization System (NVS), for dynamic and distributed data access.
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 for meaningful and informative data products that address user needs and serve society.
9) **Sustain and diversify NANOOS engagement to the extent possible:** Continue ongoing engagement with diverse stakeholders and the public, increasing ocean awareness and

literacy; to diversify the ocean and coastal workforce; to improve our ability to provide relevant ocean and coastal data and information to underserved or underrepresented communities; and to facilitate use of NANOOS products for societal objectives, the core task for which NANOOS exists.

During FY21, NANOOS has the following additional tasks (2-6) from the NOAA Ocean Acidification Program, coordinated via IOOS, and (1, 7-9) from IOOS and other sources:

1) Further HABs understanding and prediction to be distributed to tribes, UW, WA Sea Grant, OSU, and for data services relevant to HABs in service of the PNW HAB Bulletin for WA and OR and other PNW HAB observing
2) Support for salary for Newton as GOA-ON Co-Chair (Newton, UW)
3) Sustain NANOOS' work to develop and maintain the GOA-ON data portal (Tanner, UW)
4) Support efforts for OA observing on NANOOS NOA-ON CB-06 off the OR shelf (Hales, OSU)
5) Support efforts for OA observing on NANOOS NOA-ON Cha'ba on the WA shelf (Manalang, UW)
6) Support Cha'ba Ship-Time (Manalang, UW)
7) NOS funds for "Enhancement of NOS modeling capabilities for the Northern Pacific in support of disaster prevention and safe navigation" (Seaton, CRITFC)
8) NOAA/NOPP funds for the BIO GO-SHIP pilot on US-supported GO-SHIP cruises (Graff, OSU)
9) Support execution of OceanHackWeek (Mayorga, UW)

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) Governance and Management Subsystem; b) Observing Subsystem (surface currents and waves, shelf buoys/moorings/gliders, estuary buoys/moorings, and beaches and shorelines); c) Modeling and Analysis Subsystem (estuaries and shelves); and d) Data Management and Communications Subsystem (Data Management and Cyberinfrastructure (DMAC), User Products Committee (UPC), and Education and Outreach (E&O)).

A. Observing Subsystem:

Data from all assets reported here are served via NVS.

CURRENTS AND WAVES

PNW Coastal HF Surface Current Mapping [Mike Kosro, OSU]:

During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Wave Imaging at Critical PNW Ports [Mick Haller, OSU]:

During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

SHELF

Washington Shelf Buoys/Moorings [Dana Manalang, APL-UW]:

Maintenance of the recovered Summer Cha'ba and NEMO-Subsurface moorings began following recovery in late September 2021. These mooring systems will be refurbished for redeployment, planned for May 2022. Refurbishment includes full system inspection, instrument calibration, and electromechanical hardware repairs and replacement on an as-needed basis.

The McLane Moored Profiler (MMP) system that collects summer profiles of conductivity, temperature, oxygen, chlorophyll, and nutrients on the NEMO-Suburface mooring was returned to McLane for upgrades to the latest revisions of hardware and software. This extended maintenance includes replacement of the electronics stack, inductive modem, cabling, drive motor, shaft and pins, spring, drive wheels and battery pack. In addition, velocity and turbidity sensors will be integrated onto the MMP.

The Winter Cha'ba mooring, deployed off of La Push, WA in September 2021. The winter Cha'ba mooring supports instrumentation for measuring temperature, salinity, dissolved oxygen, and pH at fixed depths along the mooring line in addition to surface water and air pCO2 and meteorological variables.

Data delivery in near-real time was maintained, with the exception of those systems seasonally offline or being serviced, as described above. Bringing all data to meet QA/QC certification standards continues to be an aspiration, and the team continues to work with NANOOS on planning for implementing improved data flow.

Non-core Task 5 [Dana Manalang & Jan Newton, APL-UW]: *Support efforts for OA observing on NANOOS NOA-ON Cha'ba on the WA shelf*

Carbon measurements are conducted in partnership with PMEL Carbon Programs. The Cha'ba mapco2 carbon system went out of span in early December and has been taken offline.

Non-core Task 6 [Dana Manalang & Jan Newton, APL-UW]: *Support Cha'ba Ship-Time*

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Washington Shelf HAB Buoy/Mooring [John Mickett, APL-UW]:

Due to constraints caused by the COVID19 pandemic this deployment was delayed from the spring of 2021, as originally planned, to the spring of 2022. The team is presently preparing equipment, purchasing supplies, and building mooring components to allow for back-to-back deployments in 2022, with the spring-summer deployment funded via NANOOS and the late summer/fall funded via the NOAA NCCOS MERHAB program.

The Real-time HABs website was updated prior to the fall 2021 ESP deployment (supported by NOAA NCCOS MERHAB) and is ready for serving data for the planned spring 2022 deployment. Data QA/QC will be completed upon completion of the deployment in July-August 2022.

Washington Shelf Glider [Craig Lee, APL-UW]:

SG249 was deployed on 26 April 2021 and continues its occupation of the LaPush line as of 28 Jan 2022. From 1 July - 31 Dec 2021 SG249 collected 701 profiles. SG249 is on track to operate into March 2022, at which time it will be replaced by a fresh vehicle. This will provide an 11-month mission. Fabrication has begun on a second NANOOS glider. Completing the pathway for moving LaPush data into the IOOS glider DAC is taking longer than expected. The IOP team took over this task from Beth Curry after she left the NANOOS team, and have been trying to get the effort restarted. Data processing and QC have been updated to our current standards, and the resulting data sets are available through NANOOS. We will focus on completing the pipeline to the DAC in the coming months.

Oregon Shelf Buoy [Mike Kosro, OSU]:

During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Non-core Task 4 [Burke Hales, OSU]: *Support efforts for OA observing on NANOOS NOA-ON CB-06 off the OR shelf*

Delay in receipt of funding and limited access to vessels during favorable ocean conditions have prevented the re-deployment of CB06. We are hopeful for a deployment window in early February. During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Columbia River Shelf Mooring [Charles Seaton, CRITFC]:

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Columbia River Shelf Glider [Jack Barth, OSU & Charles Seaton, CRITFC]:

Through a collaboration with the Columbia River Inter-Tribal Fish Commission (CRITFC), the OSU Glider Research group has restarted the NANOOS-funded glider sampling on the central Washington shelf. 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 shelbreak (~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.

During the July-December, 2021, reporting period, two glider maps were made off central Washington in July and September using a glider on loan to OSU from CRITFC. The glider was deployed for a total of 31 days, and produced 13 cross-shelf sections over 716 km with 5305 vertical profiles of water properties. Glider data from July and September 2021 show low oxygen (hypoxic) water near the bottom over the mid shelf. High oxygen, near bottom waters returned inshore of the 50-m isobath in late September due to the end of the summer upwelling season.

Northern California Shelf Glider [Jack Barth, OSU]:

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 (12/31/2021), the glider was on the TH line for 1915 days during 14 deployments, sampled along approximately 35,203 km track line covering the transect about 100 times, and collected about 15,653 vertical profiles of ocean properties. For the reporting period 7/1/2021 to 12/31/2021 the glider was on the TH line for 50 days during one deployment, sampled along 875 km of track line covering the transect 2.5 times, and collected about 438 vertical profiles of ocean properties. Glider uptime during this period was only about 30% due to loss of a Seaglider in Feb 2021. Data are being sent in near real-time to the IOOS Glider Data Acquisition Center and, simultaneously, to the CeNCOOS and NANOOS data centers. When an individual glider deployment is complete, we submit the data to NODC.

Data from the Trinidad Head glider line are being used to monitor 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 and the hint of anomalously warm conditions in the upper 100 m at the end of 2021.

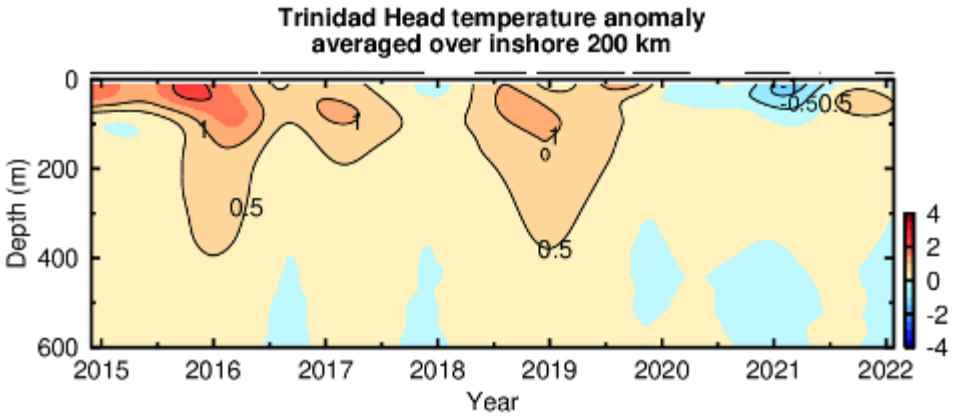

Figure 1: *Temperature anomaly from the Trinidad Head, CA (41° 3.5'N) glider line. Horizontal lines above the panel indicate when the TH-Line glider was in the water.*

Non-core Task 1 [McCabe, Osborne, MacCready, Callender/King, Newton]: *Further HABs understanding and prediction to be distributed to tribes, UW, WA Sea Grant, OSU, and for data services relevant to HABs in service of the PNW HAB Bulletin for WA and OR and other PNW HAB observing [McCabe, Osborne, MacCready, Callender/King, Newton]*

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Non-core Task 8 [Jason Graff, OSU]: *NOAA/NOPP funds for the BIO GO-SHIP pilot on US-supported GO-SHIP cruises*

The Bio-GO-SHIP pilot project is on-track and efforts towards field efforts in 2022 are underway. The first field campaign was to take place from January 5 to February 18 on the NOAA Ship Ron Brown in collaboration with the GO-SHIP A13.5 campaign. Original ports for mobilization and demobilization were planned for Cape Town, South Africa and Praia, Cape Verde, respectively. Due to the prevalence of the omicron variant of SARS-CoV-2 in South Africa, ports were altered to include Praia, Cape Verde for mobilization and Recife, Brasil for demobilization. Travel of the science party to Praia began on December 30th.

Logistics in the port of Praia and with the vessel, as well as positive cases of Covid within the ship's crew and science party resulted in delays during mobilization and ultimately a termination of the A13.5 transect. The Bio-GO-SHIP team will participate on the upcoming GO-SHIP P02 research line in late spring and early summer of 2022.

ESTUARIES

Puget Sound, WA, Profiling Buoys [Dana Manalang, APL-UW]:

Work on Puget Sound Profiling Buoys was completed using no-cost-extension funds from the previous 5-year award through November 2021. During December 2021, ongoing maintenance was conducted at buoy sites, including instrument package swaps, winch repairs, and electrical and mechanical maintenance.

Due to low temperatures causing excessive battery drain and limited sunlight for solar charging, most profilers were offline throughout late Dec 2021. Bringing all data QA/QC to meet certification standards continues to be an aspiration, and the team continues to work with NANOOS on planning for implementing improved data flow.

Puget Sound, WA, US ferry-box [Christopher Krembs, WA Ecology]:

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Columbia River, OR, Moorings [Charles Seaton, CRITFC]:

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award for all but two weeks. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

South Slough/Coos Bay, OR, Moorings [Alicia Helms, South Slough NERRS]:

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

BEACH AND SHORELINES

Washington Beach and Shoreline [George Kaminsky, WA Ecology]:

NANOOS funds contribute to the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) led by G. Kaminsky. Following COVID-safety precautions, CMAP completed summer seasonal beach monitoring surveys in the Columbia River Littoral Cell (CRLC) between July and September 2021 collecting 50 beach profiles, 14 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. An additional 2 surface maps were collected in October after the ATV required maintenance in September. CMAP also completed fall seasonal surveys which included 46 beach profiles and two surface maps. Seasonal beach profile data and contour change plots are made available through the NANOOS Visualization System.

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. CMAP collected 13 supplemental profiles at the south end of Ocean Shores in August and 7 supplemental profiles in Westport to monitor the dune nourishment area fronting the Westport by the Sea Condominiums in September. The data at Westport were used to inform the design of a cobble dynamic revetment to be installed this winter.

Additional data around the Columbia River South Jetty was collected for the U.S. Army Corps of Engineers including 4 profiles south of South Jetty and 4 perpendicular to the South Jetty on the north side in July 2021. These profiles, set up to capture the ridge-runnel morphology around the jetty, now require extra time and safety precautions because they extend into the jetty construction area. In September 2021, CMAP collected 7 beach profiles and a surface map on Clatsop Spit.

CMAP continues to monitor the performance of the dynamic revetment at North Cove. Beach topography surveys were conducted in September and December 2021, 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. A storm response survey was also conducted in November of 2021. During the summer, there was sand accumulation on the upper beach and significant dune grass establishment at the west side of the project area. After storm events in fall 2021, more of the revetment rock is exposed than previous fall seasons and maintenance of some

components of the project design was required. Continued mapping of features will help determine if the revetment is still effectively holding the upland in place, and profiles will help assess beach recovery after high wave and water events.

CMAP also continues to collect seasonal beach profiles near Kalaloch at South Beach on the Olympic Peninsula, where 14 profiles were collected in September of 2021. Monitoring results from Kalaloch will be used for comparison to the North Cove dynamic revetment site, which is intended to mimic functions of a natural composite beach similar the setting and conditions at Kalaloch.

Outside of the CRLC, CMAP worked with surveyors from the U.S. Geological Survey to collect beach profiles at the Elwha River delta in July 2021. CMAP also conducted a topographic and bathymetric survey of Makah Bay funded by the Makah Tribe in July of 2021.

Oregon Beach and Shoreline [Jonathan Allan, DOGAMI]:

The Oregon Beach and Shoreline Mapping Analysis Program (OBSMAP) efforts are led by J. Allan and his team at the Oregon Department of Geology and Mineral Industries (DOGAMI). Beach profile data – fall surveys – were successfully collected in the Rockaway littoral cell (25 sites, December 2021), along the Clatsop Plains (6 sites, December 2021), along the Columbia River south jetty dynamic revetment (28 sites, December 2021), and in the Neskowin cell (15 sites, January 2022). A new ATV vehicle and trailer purchased by the State of Oregon continued to be adapted to meet our surveying needs over the fall period. In addition to measurements of the transects, datum-based shorelines were also collected along each of the study areas. 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).

Data collected as part of OBSMAP continue to be used by regional coastal managers (e.g. Oregon State Parks, Oregon Department of Land Conservation and Development agency), geoconsultants and the public to assess local and regional coastal changes taking place on Oregon beaches. As of December 2021, our monitoring data indicated that beaches in the Rockaway and Clatsop littoral cells are on average in the "normal" range of responses as the Pacific Northwest enters the more intense period of storm waves that typify January through March. In contrast, observations from the northern section of the Neskowin cell at Pacific City indicate that the beach there has continued to degrade and is now characterized by a significant reduction in the beach volume not seen in almost 2 decades of monitoring, with homes now at risk should beach and dune erosion continue over the remainder of the winter season. Beach erosion at Pacific City has now fully exposed the toe of a major boat launch ramp used by Dory boats in Pacific City, which could allow storm waves to damage the structure's toe, or undermine its structural integrity along its flank.

Washington and Oregon Bathymetry [Peter Ruggiero, OSU]:

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 2021 extending from the lower inter-tidal to ~12 m of water depth (~2000 m from the shoreline). Approximately 400 kilometers of nearshore mapping took place within ~6 days of field data collection. These data have been processed from their raw format into deliverable text files and have passed a rigorous quality assurance process. In all cases, these nearshore bathymetry measurements have been combined with topographic measurement collected by Ecology developing complete maps of the nearshore planform. Data are available via *Stevens et al.* (2021), listed in the Publications section, below, and example output is shown in Figure 2.

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. For example, nearshore and beach data were heavily relied upon in the development of the Pacific Northwest National Shoreline Management Study, a product of the US Army Corps of Engineers National Shoreline Management Study. The report, which will be released in January of 2022, provides a regional assessment of coastal change and current management actions based on existing available data (i.e., NANOOS supported data) and input from stakeholders and tribal partners. It considers the effects of erosion and accretion on socioeconomics and the environment and provides recommendations and example actions to restore and maintain resilient shorelines. The recommendations of the report are intended to inform the U.S. Congress and other decision-making parties interested in future investments in the nation's coast.

As with summer 2020, field data collection was impacted due to the pandemic, and we were unable to collect additional data along the Oregon coast during summer 2021.

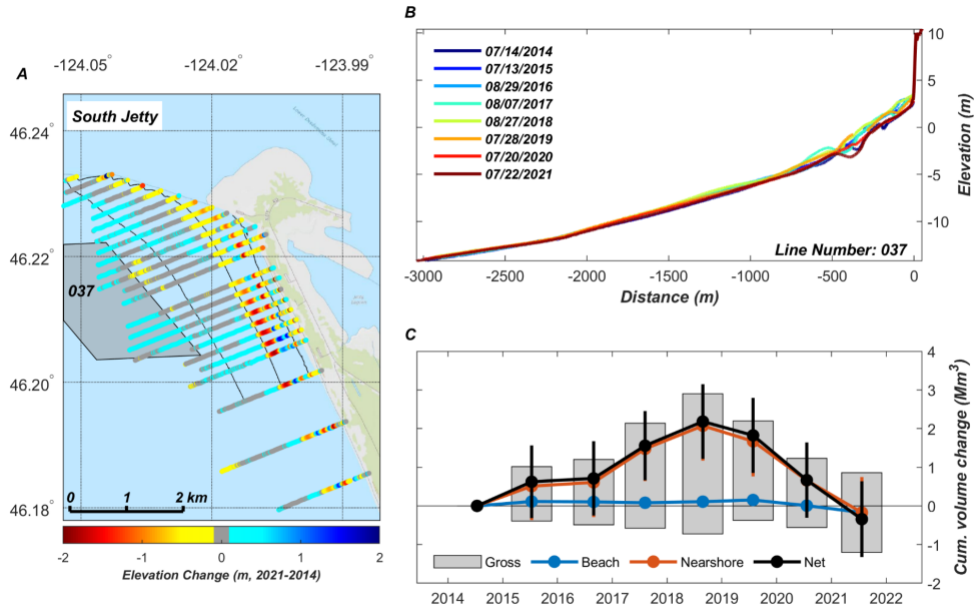

Figure 2. *A, Map showing cumulative elevation changes between 2014 and 2021 for the South Jetty region within the Clatsop Plains subcell; depth contours (5-m interval between –10 and 0 m) based on 2014 survey. B, Example profile showing changes in beach and nearshore morphology along survey line 037 (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.*

B. Modeling & Analysis Subsystem:

NE Pacific and Salish Sea [Parker MacCready, UW]:

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Columbia River Estuary and Plume [Charles Seaton, CRITFC]:

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award for all but two weeks. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

Non-core Task 7 [Charles Seaton, CRITFC]: *NOS funds for "Enhancement of NOS modeling capabilities for the Northern Pacific in support of disaster prevention and safe navigation"*

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award for all but two weeks. That work was reported in the progress report submitted by 31 December 2021. We look forward to conveying our achievements for the new award in the next 6-month progress report.

PNW Coastal Waters [Ed Zaron, OSU]:

During this reporting period we continued producing real-time ocean forecasts and delivering them to the NVS system. Efforts included ongoing verification and validation of forecasts, and research into new forecast products.

C. Data Management & Communications Subsystem:

DATA MANAGEMENT & CYBERINFRASTRUCTURE (DMAC)

Mature Regional DAC Operations [Troy Tanner, APL-UW]:

Development of BlueHarvest, a new internal NANOOS DMAC application for harvesting data from a wide range of data providers. The new system is more robust and maintains flexibility to accommodate a wide range of data providers/sources. It still populates the NANOOS internal database in a standardized way so the data can be easily integrated into the various data products served on NVS. BlueHarvest also provides more immediate feedback about data transmission frequency/latency, which enables NANOOS to identify and fix data flow issues more efficiently. BlueHarvest assets updated: King County, Hakai, CeNCOOS, OOI.

NVS Support and Development [Troy Tanner & Roxanne Carini, APL-UW]:

Added platforms from Friday Harbor Labs and the Quileute Nation. Deployed new server for sharing LiveOcean fields. New glider harvesting/visualization python code (automatic) by APL-UW/Carini. New cruise processing code by APL-UW/Boyar. Set up and operationalized the LiveOcean model output server at APL-UW. Steady progress was made to add assets to NANOOS ERDDAP for NDBC harvest. The assets made available to NDBC through NANOOS ERDDAP during this reporting period are Oregon shelf CB-06 (46128) and the Puget Sound ORCA platforms (46120, 46121, 46122, 46123, 46124, 46125). NCEI queue continues to be the bottleneck for getting relevant data nationally archived. Data providers (typically those with one or two platforms) struggle to make their data available in ways that are straightforward (standardized) to harvest

Engagement in National and Cross-regional DMAC Efforts [Troy Tanner & Roxanne Carini, APL-UW]:

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USER PRODUCT COMMITTEE (UPC)

Web Site [Troy Tanner, APL-UW]:

Updated the slideshow, documents, and other content.

Non-core Task 3 [Troy Tanner, APL-UW]: *Sustain NANOOS' work to develop and maintain the GOA-ON data portal*

Updated slideshow, webinar, and other content. Created web pages for regional hubs.

Tailored Products Development [Jonathan Allan, DOGAMI]:

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 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 2021 period mainly centered around weekly NANOOS DMAC and UPC teleconferences.

NANOOS continues to modernize its web and data harvesting scripts, centralizing these scripts to the University of Washington. NANOOS implemented several minor improvements to its Tsunami evacuation webapp. More recently, NANOOS received considerable traffic to its Tsunami Evacuation web app and smartphone application as a result of the recent (15th January 2022) Tongan tsunami; we will provide an update on this activity in the next reporting cycle.

EDUCATION & OUTREACH (E&O)

Communication [Rachel Wold & Jan Newton, APL-UW]:

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Product Co-Development [Rachel Wold, APL-UW & Jonathan Allan, DOGAMI]:

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Non-core Task 9 [Emilio Mayorga, APL-UW]: *Support execution of OceanHackWeek*

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Diversity, Equity, and Inclusion [Jan Newton & Rachel Wold, APL-UW]:

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D. Governance & Management Subsystem:

Governance [Jan Newton, Nick Rome, & Roxanne Carini, APL-UW]:

J. Newton (NANOOS Executive Director), A. Barnard (NANOOS Board Chair), and M. Kosro (NANOOS Board Vice Chair) continued to provide leadership to NANOOS operations and connection to the US IOOS enterprise. During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021.

Non-core Task 2 [Jan Newton, APL-UW]: *Support for salary for Newton as GOA-ON Co-Chair*

During this reporting period, work was completed using no-cost-extension funds from the previous 5-year award. That work was reported in the progress report submitted by 31 December 2021.

Representation [Jan Newton, Nick Rome, & Roxanne Carini, APL-UW]:

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. During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021.

Project Oversight [Jan Newton, Nick Rome, & Roxanne Carini, APL-UW]:

Newton, Rome, and Carini participated in weekly Tri-Comm calls.

Coordination [Jan Newton, Nick Rome, & Roxanne Carini, APL-UW]:

During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021.

Accountability [Jan Newton, Nick Rome, & Roxanne Carini, APL-UW]:

During this reporting period, work was completed using no-cost extension funds from the previous 5-year award. That work was reported in the progress report submitted 31 December 2021.

Additional NANOOS coordination and representation included:

- Barth participated in Oregon US Representative Susan Bonamici's Roundtable Discussion on Ocean Science, Estuaries, and the Climate Crisis, October 13, 2021
- 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 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 supported the Oregon Ocean Science Trust in issuing a Request for Proposals to use state-supported funds to measure OAH parameters in each of Oregon's five marine reserves and in Yaquina Bay.

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 8, 2021 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.
- Barth is active in the North Pacific Marine Science Organization (PICES, pices.int), reporting on US ocean observing efforts through his membership on the MONITOR Committee and the Advisory Panel on North Pacific Ocean Observing Systems. Barth was recently named as the US academic representative to the PICES Governing Council. He participated in the 2021 (Virtual) Annual Meeting of PICES in October 2021.

E. Presentations & Publications Acknowledging NANOOS Support:

Underline indicates NANOOS PI

Stevens, A.W., Weiner, H.M., Wood, J.M., Ruggiero, P., Kaminsky, G.M., and Gelfenbaum G.R., 2019, Beach topography and nearshore bathymetry of the Columbia River littoral cell, Washington and Oregon (ver. 3.0, December 2021): U.S. Geological Survey data release, https://doi.org/10.5066/P9W15JX8.

Whitefield, C. R., C. Braby, J. A. Barth, and M. Dalton, 2021. Marine and coastal change, In "Fifth Oregon Climate Assessment," M. Dalton and E. Fleishman (eds.), Oregon Climate Change Research Institute, Oregon State University, Corvallis, Oregon. https://blogs.oregonstate.edu/occri/oregon-climate-assessments/.

F. Milestones Table:

Subsystem / Area	Milestone	Status
Governance & Management Subsystem		
Governance, Representation, Oversight, Coordination & Accountability	**Maintain NANOOS as the U.S. IOOS PNW Regional Association:** Sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement, partnering with federal and non-federal (tribal, academic, state, local, industry, NGO, etc.) entities.	
	Governance: *PIs: Newton, Rome & Carini, UW* - 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 GC meeting	On track
	Representation: *PIs: Newton, Rome & Carini, UW* - Represent NANOOS at IOOS Program Office and IOOS Association meetings, and at national meetings of significance - Engage at a regional level at meetings and workshops affecting PNW stakeholders and NANOOS	On track
	Project Oversight: *PIs: Newton, Rome & Carini, UW* - Conduct annual all-PI meetings and Tri-Committee meetings, providing clear feedback and direction - Share project evaluation at the annual PI meeting	On track
	Coordination: *PIs: Newton, Rome & Carini, UW* - 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 with Canada (CIOOS, MEOPAR, etc.)	On track
	Accountability: *PIs: Newton, Rome & Carini, UW* - Submit required IOOS progress reports and respond to other requests - Attain recertification in 2023 as the Regional Information Coordination Entity of US IOOS for the PNW	On track

Observing Subsystem		
Currents & Waves	**Maintain surface current and wave observations:** Maintain existing HF-radar and wave mapping capabilities, providing critical national capacity along coasts and at critical ports.	
	<u>PNW Coast HF Surface Current Mapping:</u> *Lead PI: Kosro, OSU* - Maintain and operate 10 SeaSonde HF sites designated as Priority 1 sites by the national HF program; these are six long-range sites in OR, two in WA, and two standard-range sites in OR - As resources allow, 3 Priority 2 standard-range sites covering Heceta Bank, which is a source for HABs and of strong bathymetric flow perturbation, as well as the shelf portion of the OOI Endurance Array - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	On track
	<u>Wave Imaging at Critical PNW Ports:</u> *Lead PI: Haller, OSU* - Sustain the existing marine radar observing station at USCG Station Yaquina Bay - Provide both real-time and historical wave information via NVS; mean and snapshot radar images are real-time viewable for use in environmental characterization - Bring all data QA/QC to meet Certification standards	On track
Shelf	**Sustain and enhance buoys and gliders in the PNW coastal ocean in coordination with national and regional programs:** Maintain, harden, enhance existing buoys and gliders, with focus on hypoxia, HABs, OA, and climate.	
	<u>WA shelf buoys/moorings:</u> *Lead PI: Manalang, UW* - Maintain the WA shelf (off La Push) Cha'ba buoy and the NEMO subsurface profiler at existing levels - Deliver NRT data streams via NVS - Bring all data QA/QC to meet Certification standards	On track
	<u>WA shelf HAB buoy/mooring:</u> *Lead PI: Mickett, UW* - Support for the HAB ESP deployment on NEMO mooring - Deliver NRT data streams via NVS - Bring all data QA/QC to meet Certification standards	On track
	<u>WA shelf glider:</u> *Lead PI: Lee, UW* - Maintain the La Push line glider at existing levels - Deliver NRT data streams via NVS - Bring all data QA/QC to meet Certification standards	On track; some data delivery delays (see Gliders section for details)
	<u>OR shelf buoy:</u> *Lead PI: Kosro, OSU* - Maintain the CB-06 buoy off Coos Bay at existing levels - Deliver NRT data streams via NVS	On track

	- Bring all data QA/QC to meet Certification standards	
	Columbia River shelf mooring: *Lead PI: Seaton, CRITFC* - Maintain the CMOP shelf mooring at existing levels - Deliver NRT data streams via NVS - Bring all data QA/QC to meet Certification standards	On track
	Columbia River shelf glider: *PIs: Seaton, CRITFC & Barth, OSU* - Maintain the CMOP Columbia glider at existing levels - Deliver NRT data streams via NVS - Bring all data QA/QC to meet Certification standards	On track
	N. CA shelf glider: *Lead PI: Barth, OSU* - Maintain the Trinidad Head glider, shared with CeNCOOS, at existing levels - Deliver NRT data streams via NVS - Bring all data QA/QC to meet Certification standards	On track
Estuaries	**Maintain multidisciplinary observational capabilities in PNW estuaries and the nearshore, in coordination with local and regional programs:** Sustain observing ability to aid sustainable resource management, water quality assessment, and sub-regional climate change evaluation.	
	Puget Sound, WA, profiling buoys: *Lead PI: Manalang, UW* - Maintain 6 Puget Sound estuarine profiling moorings at existing levels - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	On track; some data delivery delays (see Other Core Observation Activities section for details)
	Puget Sound, WA, US ferry-box: *Lead PI: Krembs, WDOE* - Maintain US-Canada ferry-box at existing levels, assuming COVID-19 does not preclude its operation - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	On track
	Columbia River, OR, moorings: *Lead PI: Seaton, CRITFC* - Maintain CMOP estuarine moorings at existing levels - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	On track
	South Slough/Coos Bay, OR, moorings: *Lead PI: Helms, ODSL* - Maintain South Slough/Coos Bay estuarine moorings for the NERRS at existing levels - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	On track
Beaches & Shorelines	**Maintain core elements of beach and shoreline observing:** Measure nearshore bathymetry, topographic beach profiles, and shoreline	

	morphodynamics along OR and WA, contributing to hazard mitigation by providing essential observations and better decision support tools for coastal managers, planners, and engineers.	
	<u>WA beach and shoreline:</u> *Lead PI: Kaminsky, WDOE* - Maintain shoreline observations in WA at existing levels - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	Seasonal surveys complete
	<u>OR beach and shoreline:</u> *Lead PI: Allan, DOGAMI* - Maintain shoreline observations in OR at existing levels - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	Seasonal surveys complete
	<u>WA and OR bathymetry:</u> *Lead PI: Ruggiero, OSU* - Maintain nearshore bathymetric observations of beach and shoreline morphodynamics in WA and OR at existing levels - Deliver data via NVS - Bring all data QA/QC to meet Certification standards	Seasonal surveys complete
Modeling & Analysis Subsystem		
WA & OR Estuaries & Coast Models	**Provide sustained support to a community of complementary regional numerical models:** Contribute to the operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the Exclusive Economic Zone (EEZ) in both OR and WA.	
	<u>NE Pacific and Salish Sea:</u> *Lead PI: MacCready, UW* - Support, at existing levels, the daily forecast model, LiveOcean, which simulates ocean circulation and bio-geochemistry in the Salish Sea and in coastal waters of the NE Pacific, including Oregon, Washington, and British Columbia - Deliver model output via NVS - Model verification and validation	On track
	<u>Columbia River estuary and plume:</u> *Lead PI: Seaton, CRITFC* - Support, at existing levels, the CRITFC circulation modeling and forecasting system, which covers the Columbia River estuary and plume - Deliver model output via NVS - Model verification and validation	On track
	<u>PNW Coastal Waters:</u> *Lead PI: Zaron, OSU* - Support, at existing levels,the OSU real-time coastal ocean forecast model, which covers the coastal waters off OR and WA - Deliver model output via NVS	On track

	- Model verification and validation	
Data Management & Communications Subsystem		
Data Management & Cyberinfrastructure (DMAC)	**Maintain, harden, and enhance NANOOS' Data Management and Cyberinfrastructure (DMAC) system for routine operational distribution of data and information:** Sustain and enhance the DMAC system, including the NANOOS Visualization System (NVS), for dynamic and distributed data access.	
	<u>Mature Regional DAC Operations:</u> *Lead PI: Tanner, UW* - Sustain, refresh, and enhance a highly available, robust, distributed hardware and software environment; maintain appropriate staffing and team coordination; maintain up-to-date operations and system documentation to ensure transparent and clear descriptions of DAC architecture - Engage new local providers (not NANOOS funded), integrate their data into NVS and IOOS DMAC services; strengthen DAC capabilities and resources through regional and thematic partnerships	On track
	<u>NVS Support and Development:</u> *PIs: Tanner & Carini, UW* - Maintain NVS support leveraging regional user needs, feedback, and data reviews to continually improve the relevance and quality of metadata for observing and modeling data assets integrated and served by NANOOS - Sustain & enhance existing data streams, IOOS web services, GTS submission; implement NCEI data archiving, NDBC data archiving, Glider DAC submission, QARTOD; maintain and expand ERDDAP to leverage web services, serve NANOOS applications and users; evaluate where new tech (e.g., cloud, AI, etc.) may afford NANOOS better efficiencies and robustness	On track
	<u>Engagement in National and Cross-regional DMAC Efforts:</u> *PIs: Tanner & Carini, UW* - 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 - Extend to other areas via pan regional products with sister IOOS RAs; engage and leverage NSF-funded OOI, international GOA-ON activities, and Canadian collaborations; engage with other West Coast and Pacific efforts, including WCGA and IPACOA	On track
User Products Committee (UPC)	**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 for meaningful and informative data products that address user needs and serve society.	

	Web Site: *Lead PI: Tanner, UW* - Continue to evaluate and update web content relevant to stakeholder issues, especially those related to Maritime Operations, Ecosystem Assessment, Fisheries & Biodiversity, Coastal Hazards, and Climate; improve ease of usability and user tracking capabilities	On track
	Tailored Products Development: *Lead PI: Allan, DOGAMI* - Annually evaluate priorities for products at the Tri-Com meeting (DMAC, UPS, and E&O), based on outreach feedback, regional issues, and GC input, and will implement new tailored products to the extent possible	On track
Education & Outreach (E&O)	**Sustain and diversify NANOOS engagement to the extent possible:** Continue ongoing engagement with diverse stakeholders and the public, increasing ocean awareness and literacy; to diversify the ocean and coastal workforce; to improve our ability to provide relevant ocean and coastal data and information to underserved or underrepresented communities; and to facilitate use of NANOOS products for societal objectives, the core task for which NANOOS exists.	
	Communication: *Lead PIs: Wold & Newton, UW* - Maintain up-to-date success stories, employing effective use of social media and newsletters - Support national communication through IOOS Program Office and IOOS Association collaborations - Be responsive to regional and local events (e.g., harmful algal blooms, fish kills, marine heat waves, hypoxia, floods, etc.) to enhance relevancy to public and highlight regional stories with NANOOS members and partners - Maintain existing and build new relationships to stakeholder user groups and the education community enabling NANOOS to achieve effective education and outreach	On track
	Product Co-Development: *Lead PIs: Wold, UW & Allan, DOGAMI* - Engage users in product co-development through focus groups; use targeted interviews or surveys to garner feedback and input on products as they are developed; gain feedback and conduct self-assessment after product release - Conduct trainings to broader user groups and evaluate trainings to optimize NANOOS functionality - Engage with regional formal education communities to use ocean observing and NANOOS products to support STEM education, and with regional non-formal education communities to facilitate the use of NANOOS products to foster community ocean literacy	On track

	Diversity, Equity, and Inclusion: *Lead PIs: Newton & Wold, UW* - Work with the other IOOS regions and the Program Office on workforce development initiatives to expand and diversify the ocean, coastal, and Great Lake workforces and to improve our ability to provide relevant ocean and coastal data and information to underserved or underrepresented communities. - On a more immediate and local scale, the NANOOS "Enabling Change" working group, made up of NANOOS staff and partners (currently federal, university, and state agency) will move forward with actions that match NANOOS' commitment ability.	On track