



NANOOS BUILD-OUT PLAN

The NANOOS Build-out Plan (BOP) describes the existing products and services and those NANOOS seeks to address in the future. The BOP is organized around NANOOS' Areas of Emphasis: Maritime Operations, Climate, Ecosystem Assessment, Fisheries & Biodiversity, and Coastal Hazards. Discussion of Ecosystem Assessment and Fisheries & Biodiversity are combined in the BOP due to the strong overlap of products/services applications. The "NANOOS Effort versus Application" matrix (appended) displays NANOOS' current and desired future observing and modeling capacity. Lastly, please reference the most recent NANOOS 5-year proposal for details on specific projects currently funded (Tier I) and those that will be prioritized as additional funding opportunities arise (Tier II).

1. MARITIME OPERATIONS

1.1. Safe and efficient commercial shipping and recreational boating.

The PNW is a vital hub of maritime transportation with major port facilities located in Puget Sound (e.g., Seattle, Tacoma) and the Columbia River (e.g., Portland, Vancouver), as well as other secondary ports along the Washington and Oregon coasts (e.g., Grays Harbor, Astoria, Tillamook Bay, Coos Bay, Newport). Commercial and recreational fisheries offshore the PNW coast generates considerable revenue and jobs for the region (for example the [Washington](#) and [Oregon](#) crab industry alone is a \$176 million dollar industry). Access to reliable and consistent ocean and climate conditions and forecasts remains paramount for this industry.

1.1.1. WEATHER AND SEA STATE CONDITIONS FOR MARINERS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- The NVS [Maritime Operations](#) application
- The NVS [Boaters](#) Nowcast/Forecast Coastal Currents and Water Temperatures
- Forecast Information and Data Products for [Tuna Fishers](#) (NVS Tuna Fishers, NVS SeaCast)
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [Regional PNW Wave and Wind Forecasts](#)
- [NOAA - Tides and Currents](#)
- [National Weather Service Forecasts](#) and [Satellite Imagery](#)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- High resolution nearshore (SWAN/WWIII) wave modeling for areas adjacent to critical Port facilities in Oregon, Washington and California (e.g. Humboldt Bay) remains a critical need.
- Introduce new X-band radar installations at key Port sites (e.g. Tillamook Bay, Columbia River). Upgrade system to a fully-coherent Doppler system to support better understanding of wave-current interaction processes in the inlet as well as water quality modeling efforts.
- Additional wave buoys located along the outer-shelf region (e.g. southern Oregon coast and central Washington coast), and at mid-shelf (e.g. offshore Tillamook Bay).

1.1.2. IMPROVED WIND AND OCEAN CURRENT FORECASTS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)

- [Model forecasts on NVS](#) from HYCOM, NAM, OSU ROMS, and WAVEWATCH III
- [HF Radar](#) from NANOOS array on NVS and [HFR IOOS DAC](#)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems.
- Introduce new X-band radar installations at key Port sites (e.g. Tillamook Bay, Columbia River). Upgrade system to a fully-coherent Doppler system to support better understanding of wave-current interaction processes in the inlet as well as water quality modeling efforts.

1.2. Search and rescue

The US Coast Guard (USCG) District 13 stations annually conduct thousands of Search and Rescue (SAR) missions, typically saving hundreds of lives.

1.2.1. REAL TIME SURFACE CURRENTS SENT TO COAST GUARD'S ENVIRONMENTAL DATA SERVER FOR USE IN SEARCH AND RESCUE OPERATIONS

Products and services: NANOOS and partner OSU is presently collecting HF radar along the Oregon coast. These data are provided to both the IOOS HF data server which passes it to NOAA's National Data Buoy Center (NDBC) and the Coastal Observing Research and Development Center (CORDC) where they are available for SAR operations. Data are also available directly from NANOOS through the following products:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [Regional PNW Wave and Wind Forecasts](#)
- [National Weather Service Forecasts](#) and [Satellite Imagery](#)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems. Data will be provided as nowcasts approximately every hour, consistent with existing approaches currently operating on the Oregon and Washington outer coast. New products may eventually include the provision of futurecasts (coupled ocean model/surface currents) that may be used to assist USCG with SAR

operations.

Other products and services for search and rescue:

- Sustain numerical ocean models that couple ocean circulation, waves, and winds, which can be used to provide real-time SAR support.

1.3. Spill response

With two refinery complexes and a web of distribution routes to coastal and estuarine waters, transportation of oil is another major industry in the PNW region. Since 1985, regional spills from vessels and land facilities have included five of over 50,000 gallons.

1.3.1. REAL TIME SURFACE CURRENTS USED BY NOAA HAZMAT, COAST GUARD AND OTHERS TO TRACK AND FORECAST OIL & CHEMICAL TRAJECTORIES

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [Regional PNW Wave and Wind Forecasts](#)
- [West Coast Ocean Data Portal](#)
- [Buoys and moorings](#) (e.g. supports NERRS (South Slough), CB-06 (OSU), Chábă (UW), Columbia R. (CRITFC), Willapa Bay (WA Ecology))

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems.
- Introduce new X-band radar installations equipped with capabilities to track waves and currents at key Port sites (e.g. Tillamook Bay, Columbia River).
- More buoys/sensors in critical estuaries

1.3.2. OCEAN CIRCULATION MODELS & FORECASTS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [Nowcast/Forecast Coastal Currents and Water Temperatures](#) on NVS from HYCOM, OSU ROMS (combined temperature and currents), LiveOcean, CMOP Columbia, and UBC SalishSeaCast

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic

failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- Sustain coupled ocean models that incorporate ocean circulation, waves, and wind forcing, which can be used to provide real-time spill response support.

1.4. Offshore Energy (includes oil and gas, wind, tidal, waves)

The PNW coast is recognized as one of the leading regions for the development and application of renewable energy sites, including wind and wave sites, and tidal energy. However, little information is presently available concerning the potential impacts such activities might have to both the physical and biological environment.

1.4.1. OCEANOGRAPHIC INFORMATION TO ASSIST WITH OFFSHORE ENERGY PLANNING, SITING AND OPERATIONS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- The NVS [Boaters](#) application
- [Regional PNW Wave and Wind Forecasts](#)

Information requirements: Improvements in the likely affects associated with these types of uses will likely come from increased observation of both the physical and biological communities. Investment in the following areas would significantly assist resource managers in both the identification of appropriate sites for development and the potential impacts associated with the activity, including:

- Undertake more detailed bathymetry along coast
- Sustain the coastal nearshore and beach monitoring
- Enhance numerical wave and current modeling

2. CLIMATE

2.1. Changes in ocean conditions over time

PNW Scientists are continuing to demonstrate the short- to long-term effects associated with earth's changing climate. For example, PNW ocean wave heights have been progressively increasing throughout the North Pacific since the mid 1970s, while analyses of storms indicate that their frequency and intensity has been increasing since at least the late 1940s.

2.1.1. COASTAL CLIMATE RECORDS ON KEY PARAMETERS OVER TIME AND REGIONAL CONTRIBUTIONS TO CLIMATE INDICES

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)

- [NVS Climatology](#) application
- NVS [Beach and Shoreline Changes](#) application
- [Puget Sound Metric Dashboard](#)
- [CMOP - Center for Coastal Margin Observation & Prediction](#)
- Salish Sea/Puget Sound Regional Synthesis Model (PRISM) [Cruise Data](#)
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [Buoys and moorings](#) (e.g. supports NERRS (South Slough), CB-06 (OSU), Chábă (UW), Columbia R. (CRITFC), Willapa Bay (WA Ecology))
- Gliders (e.g. support [OSU](#), [CRITFC](#) and [UW](#) glider lines)
- [West Coast Ocean Data Portal](#)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems.
- Introduce new X-band radar installations at key Port sites (e.g. Tillamook Bay, Columbia River). Upgrade system to a fully-coherent Doppler system to support better understanding of wave-current interaction processes in the inlet as well as water quality modeling efforts.
- Sustain existing and add new buoys/instrumentation in estuaries, particularly Puget Sound, Columbia River, Willapa Bay, Grays Harbor, Yaquina Bay, Coos Bay and others indicated by stakeholders.
- Additional wave buoys located along the outer-shelf region (e.g. southern Oregon coast and central Washington coast), and at mid-shelf (e.g. offshore Tillamook Bay).
- Additional sensors (tide gauges) in several key estuaries (e.g. Umpqua R. and Alsea Bay).
- Support nearshore Oregon MPA hypoxia moorings
- Add one new biology line adjacent to Grays Harbor
- Add OA monitoring at several critical estuary nodes

2.2. Ocean acidification

Ocean acidification is presently increasing at an alarming rate that could potentially devastate entire fishery and shellfish populations.

2.2.1. REAL-TIME DATA AND FORECASTS OF OCEAN CONDITIONS TO ASSESS WHEN THEY ARE UNFAVORABLE DUE TO CHANGES IN OCEAN ACIDIFICATION

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges,

surface currents, wave forecasts, satellite data, model overlays etc.)

- [LiveOcean](#)
- [West Coast OAH Inventory](#)
- [IOOS Partners Across Coasts Ocean Acidification \(IPACOA\)](#)
- JISAO Seasonal Coastal Ocean Prediction of the Ecosystem ([JSCOPE](#))
- [Northwest Environmental Moorings](#) (ORCA, Chaba, etc.)
- [NVS Shellfish Growers](#) application
- [West Coast Ocean Data Portal](#)
- [Ocean Acidification Info Page](#)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- Support an increased focus on regional capability to assess OA in multiple estuaries. Such an effort would include installation of multiple estuarine pCO₂ from flow-through systems.

2.3. Sea Level Change

Sea level is presently rising along much of the coasts of Oregon and Washington, and in many places is exceeding regional tectonic uplift in those locations, increasing the incidence of both coastal erosion, ocean flooding and inundation to low lying communities. Coastal sites where tectonic uplift is presently exceeding relative sea level rise are likely to see a reversal in their patterns over the next 30-50 years as sea level rise is projected to begin to accelerate.

2.3.1. IMPROVED FORECASTS FOR SEA LEVEL RISE AND LAND SUBSIDENCE AND FOR CHANGES IN WATER LEVELS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [NVS Climatology](#) application
- [West Coast Ocean Data Portal](#)

Information requirements: NANOOS is seeking to expand its network of assets to include the following:

- Develop regional sea level trends for the NANOOS region encompassing responses presently being observed at individual tide gauges, plus trends that incorporate satellite based altimetry data for the ocean.
- Explore the role of regional GCMs in the development of PNW estimates of future relative sea level changes.
- Additional sensors (tide gauges) in several key estuaries (e.g. Umpqua R. and Alsea Bay).

2.4. Other

Beaches are an integrated indicator of the effects of climate change, primarily through the influence of regional changes in relative sea level, along with effects associated with changing wave climates and sediment budgets. As a result, monitoring the short- to long-term response of both the sub- aerial and sub-aqueous beaches provides an important measure of the effects of regional climate change. To better understand these effects, NANOOS partners, Oregon Department of Geology and Mineral Industries, Washington Department of Ecology, and Oregon State University have been monitoring the response of beaches and the nearshore with the aid of RTK-DGPS technology, ATV's and personal watercrafts.

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- [NVS Beach and Shoreline Changes](#) application
- [NVS Beach View](#) application

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- An expanded coastal monitoring network encompassing much of the Puget Sound region.
- Enhancements to the Oregon beach shoreline monitoring efforts to include high resolution terrestrial Lidar mapping of coastal bluffs.
- Increased capabilities for the monitoring of nearshore bathymetry along the open coast and within critical estuarine environments.

3. ECOSYSTEM ASSESSMENT / FISHERIES & BIODIVERSITY

3.1. Healthy and Productive Ecosystems

Water quality degradation of Pacific Northwest coastal waters and estuaries is an increasing concern for environmental management agencies, municipal governments, aquaculturists and coastal residents. Some evidence suggests that eutrophication from human society effluents can lead to harmful algal blooms that periodically decimate shellfisheries and have even resulted in the need to eviscerate crabs prior to allowing them to be marketed. Low oxygen levels have caused massive die-offs of organisms along the central Oregon coast and this seems to spreading into Washington waters. PNW IOOS observations and predictions of physical oceanographic conditions such as dissolved oxygen, temperature, salinity and currents coupled with bio-chemical information on water column and sedimentary pollutants, chlorophyll concentrations, primary productivity, and species abundance would allow managers to enhance their ability to describe and predict conditions to better protect ecosystem quality.

3.1.1. INTEGRATED MAPS AND DISPLAYS LINKING HABITATS WITH PHYSICAL OCEANOGRAPHIC PROPERTIES (HABITAT GIS/SEABIRD DATA PORTALS)

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- [West Coast Ocean Data Portal](#)
- [Coastal and Marine Spatial Planning](#) info page

Information requirements: NANOOS is seeking to expand its network of assets to include the following:

- Better linkage with existing maps on NANOOS website and NVS

3.1.2. REGIONAL ECOSYSTEM ASSESSMENT THAT INTEGRATES BIOLOGICAL, CHEMICAL AND PHYSICAL CONDITIONS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [Puget Sound Metrics Dashboard](#)
- JISAO Seasonal Coastal Ocean Prediction of the Ecosystem ([JSCOPE](#))
- [Center for Coastal Margin Observation & Prediction](#) (CMOP)
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [OSU Regional Ocean Modeling System](#) (ROMS) outputs
- [Northwest Environmental Moorings](#) (ORCA, Chaba, etc.)
- Salish Sea/Puget Sound Regional Synthesis Model (PRISM) [Cruise Data](#)
- [NVS Shellfish Growers](#) application
- [Buoys and moorings](#) (e.g. supports NERRS (South Slough), CB-06 (OSU), Chábă (UW), Columbia R. (CRITFC), Willapa Bay (WA Ecology))
- Gliders (e.g. support [OSU](#), [CRITFC](#) and [UW](#) glider lines)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- Enhance buoys for ecosystem capacities such as acoustics, IFCB, eDNA, etc.
- West Coast ATN: Working with CeNCOOS, SCCOOS, and their PIs, we propose to unify a west coast acoustic receiver data network, which is currently lacking and to bring it into the IOOS data stream and the ATN. In the NANOOS region, large coastal sharks, regionally under-sampled, will be the focus of our tagging efforts.
- West Coast Ocean Sound: sustain a critical network of passive sound listening stations along the West Coast in partnership of NANOOS, CeNCOOS, SCCOOS, with three mooring sites in the NANOOS region in the Olympic Coast region, to monitor the underwater soundscape, understand its composition and measure the variability of sound levels at various frequencies and on different time scales representing geophysical,

biological, and anthropogenic sounds.

- National HAB Observing Network: continued support of key elements needed to produce the popular Pacific Northwest Harmful Algal Bloom Bulletin including offshore and ESP sampling, beach sampling by tribes, analysis, and circulation modeling. NANOOS acknowledges other un-met HAB needs, including support for Imaging Flow Cyto-Bots, eDNA, etc.
- Additional wave buoys located along the outer-shelf region (e.g. southern Oregon coast and central Washington coast), and at mid-shelf (e.g. offshore Tillamook Bay).
- Refabricate four real-time mooring systems with hourly real-time data from the OCNMS sensors served through NANOOS NVS
- Support Newport biology line
- Add one new biology line adjacent to Grays Harbor
- Enhance OA monitoring at several critical estuary nodes
- Use crab pots as platforms of opportunity to extend the NANOOS network coverage and engages fisherman directly in ocean observing thereby building support for NANOOS from a key sector of the coastal economy.
- Support community science monitoring in OR Marine Reserves via a network of community scientist partners (i.e. Redfish Rocks Community Team, Friends of the Cape Falcon Marine Reserve, Oregon Surfrider, The Nature Conservancy) using Durafet-based pH sensors custom-developed by MBARI for use in open coast rocky benches in all five OR marine reserves.

3.2. Sustainable Fisheries

*Fishing opportunity for groundfish, as regulated by the government, has in some if not most instances in the Pacific Northwest, significantly diminished to keep wild stocks from complete exhaustion. The ultimate causes for groundfish population declines are a matter of some controversy and although fishing is advanced as a candidate for the drastic decline, environmental forcing could and probably does also contribute to these population fluctuations. Lack of consistent, long-term environmental data capable of adequately characterizing the coastal and ocean environment makes precise determinations of the root causes of these events at best problematic. The sport and commercial razor clam fishery in the Pacific Northwest has been plagued by recurring blooms of harmful algae such as *Pseudo-nitzschia* spp. that can cause domoic acid shellfish toxicity. These blooms have had a devastating economic effect on coastal communities already suffering from changes in forest practices and harvests. The Dungeness crab fishery is one of the most valuable commercial fisheries in the Pacific Northwest coastal waters. Population fluctuations and incomplete understanding of environmental forcing of larval recruitment for this species can make effective stewardship and harvesting schemes managerially difficult.*

3.2.1. SEASONAL AND ANNUAL CLIMATOLOGIES OF FUNDAMENTAL ECOSYSTEM

PARAMETERS FOR FISHERIES MANAGEMENT AND ECOSYSTEM-BASED MANAGEMENT

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [NVS Tuna Fishers](#) application
- [Real-Time HABs](#)
- [Puget Sound Metrics Dashboard](#)
- JISAO Seasonal Coastal Ocean Prediction of the Ecosystem ([JSCOPE](#))
- [Center for Coastal Margin Observation & Prediction](#) (CMOP)
- [Northwest Environmental Moorings](#) (ORCA, Chaba, etc.)
- Salish Sea/Puget Sound Regional Synthesis Model (PRISM) [Cruise Data](#)
- [NVS Shellfish Growers](#) application
- [Buoys and moorings](#) (e.g. supports NERRS (South Slough), CB-06 (OSU), Chábă (UW), Columbia R. (CRITFC), Willapa Bay (WA Ecology))
- Gliders (e.g. support [OSU](#), [CRITFC](#) and [UW](#) glider lines)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- Use crab pots as platforms of opportunity to extend the NANOOS network coverage and engages fisherman directly in ocean observing thereby building support for NANOOS from a key sector of the coastal economy.
- Refabricate four real-time mooring systems with hourly real-time data from the OCNMS sensors served through NANOOS NVS

3.3. Harmful algal blooms

Of concern to scientists and researchers have been recent spates of HAB events in coastal shelf areas near the Juan de Fuca eddy and Heceta Bank as well as the numerous coastal estuaries including Puget Sound, Willapa Bay, South Slough, and many others with rich shellfish growing areas for tribal and commercial use. In response to these efforts and as part of the existing RCOOS, NANOOS has been coordinating efforts with various offshore programs/assets to enhance the geographic coverage and range of measured variables on the PNW shelf through the prioritized deployment of offshore buoys and buoyancy driven glider platforms particularly in areas impacted by hypoxia/anoxia and HABs to provide advance information on these adverse conditions.

3.3.1. EARLY INFORMATION TO COASTAL MANAGERS FOR WHEN CONDITIONS ARE CONDUCIVE FOR HARMFUL ALGAL BLOOMS (INCLUDES ALERTS FOR SHELLFISH HARVESTORS, GROWERS AND OTHERS)

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [Real-Time HABs](#)
- JISAO Seasonal Coastal Ocean Prediction of the Ecosystem ([JSCOPE](#))
- [Center for Coastal Margin Observation & Prediction](#) (CMOP)
- [Northwest Environmental Moorings](#) (ORCA, Chaba, etc.)
- Salish Sea/Puget Sound Regional Synthesis Model (PRISM) [Cruise Data](#)
- [NVS Shellfish Growers](#) application
- [Buoys and moorings](#) (e.g. supports NERRS (South Slough), CB-06 (OSU), Chábă (UW), Columbia R. (CRITFC), Willapa Bay (WA Ecology))
- Gliders (e.g. support [OSU](#), [CRITFC](#) and [UW](#) glider lines)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- National HAB Observing Network: continued support of key elements needed to produce the popular Pacific Northwest Harmful Algal Bloom Bulletin including offshore and ESP sampling, beach sampling by tribes, analysis, and circulation modeling. NANOOS acknowledges other un-met HAB needs, including support for Imaging Flow Cyto-Bots, eDNA, etc.
- Support SoundToxins in Puget Sound
- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems.

3.4. Hypoxia

Since 2000, fish and crab kills in the Puget Sound and the Oregon coast shelf have become more common and frequent occurrences. NANOOS presently sustains several buoys (fixed) and glider (mobile) programs in the PNW coastal ocean shelf in coordination with emerging national programs to provide advanced information on hypoxia/anoxia, ocean acidification, and HABs, which are major regional concerns affecting ecosystem and human health, fisheries, and coastal economies and long-term information on climate change.

3.4.1. EARLY WARNINGS FOR WHEN CONDITIONS ARE CONDUCIVE FOR HYPOXIA

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [Puget Sound Metrics Dashboard](#)
- JISAO Seasonal Coastal Ocean Prediction of the Ecosystem ([JSCOPE](#))

- [Center for Coastal Margin Observation & Prediction](#) (CMOP)
- [Northwest Environmental Moorings](#) (ORCA, Chaba, etc.)
- Salish Sea/Puget Sound Regional Synthesis Model (PRISM) [Cruise Data](#)
- [NVS Shellfish Growers](#) application
- [Buoys and moorings](#) (e.g. supports NERRS (South Slough), CB-06 (OSU), Chábă (UW), Columbia R. (CRITFC), Willapa Bay (WA Ecology))
- Gliders (e.g. support [OSU](#), [CRITFC](#) and [UW](#) glider lines)
- [Coastal and Estuarine Hypoxia Info Page](#)

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems.
- More buoys/sensors in critical estuaries
- More gliders
- Use crab pots as platforms of opportunity to extend the NANOOS network coverage and engages fisherman directly in ocean observing thereby building support for NANOOS from a key sector of the coastal economy.
- Refabricate four real-time mooring systems with hourly real-time data from the OCNMS sensors served through NANOOS NVS
- Support citizen Science monitoring in OR Marine Reserves via a network of community citizen scientist partners (i.e. Redfish Rocks Community Team, Friends of the Cape Falcon Marine Reserve, Oregon Surfrider, The Nature Conservancy) using Durafet-based pH sensors custom-developed by MBARI for use in open coast rocky benches in all five OR marine reserves.

4. COASTAL HAZARDS

4.1. Providing hazard and disaster information when and where it is needed

Beaches along the coast of Oregon and Washington can be significantly impacted by the occurrence of high magnitude storm events, particularly during enhanced periods of storm activity such as the 1982-83 and 1997-98 El Niños, and 1998-99 winters. Researchers have identified a progressive increase in North Pacific wave heights, that correlates with a progressive increase in the frequency and magnitude of extratropical storms that has taken place since the late 1940s. While long-term trends might relate to warming of sea surface temperatures in the eastern North Pacific, ENSO modes likely play a role in storm frequency. e.g., the 1997/98 El Niño and 1998-99 La Niña winters produced 17-22 major storms, five of which exceeded the 100-year storm wave. Collectively, winters with enhanced storm activity have contributed to some of the most significant and costly examples of coastal retreat observed during the past three decades: e.g. beach erosion affected a multimillion

dollar sewer drain field constructed in a dune by the city of Port Orford on the southern Oregon coast (now abandoned); between 1997 and 2001, Oregon property owners spent approximately \$1.5 million on new coastal engineering structures; Washington's sandy beaches experienced regional scale shoreline re-orientation due to the anomalous storm conditions during the El Niño winter of 1997/1998. Most recently, the USACE spent tens of millions of dollars to rebuild portions of both the Columbia River North and South Jetties which had been damaged by a combination of higher wave energy conditions and the fact that wave breaking today is occurring closer to the jetties than in previous decades. Had these jetties breached during a major winter, allowing sand to infill the main shipping channel, a significant detrimental impact would have been felt by the economies of both Oregon and Washington. Notwithstanding these hazards, the PNW coast faces an even greater threat due to its proximity to the Cascadia Subduction Zone and the certainty that it will experience a great earthquake (MW>9) and accompanying tsunami in the future, resulting in catastrophic damage to coastal communities and loss of life.

4.1.1. IMPROVED FORECASTS FOR COASTAL COMMUNITIES ABOUT THE RISKS OF FLOODING, EROSION, SEA LEVEL RISE AND LAND SUBSIDENCE, EXTREME WEATHER EVENTS AND TSUNAMIS

Products and services: NANOOS is presently serving or providing access to several key products and visualizations. These include:

- The NANOOS Visualization System ([NVS](#)) (wave buoys, tide gauges, surface currents, wave forecasts, satellite data, model overlays etc.)
- [NVS Tsunami Evacuation Zones](#)
- [NVS Beach and Shoreline Changes](#) application
- [High-Frequency \(HF\) Radar](#) Surface Currents
- [Regional PNW Wave and Wind Forecasts](#)
- [NOAA - Tides and Currents](#)
- [Honshu Earthquake and Tsunami 2011](#) special topic page

Information requirements: An immediate critical need is to provide the capacity to sustain existing efforts at the necessary funding level to avoid catastrophic failure of the program(s). NANOOS is seeking to expand its network of assets to include the following:

- New HF radar sites located along the Strait of Juan de Fuca, collaborating with Canadian colleagues and observing systems.
- High resolution nearshore (SWAN/WWIII) wave modeling for areas adjacent to critical Port facilities in Oregon, Washington and California (e.g. Humboldt Bay) remains a critical need.
- An expanded coastal monitoring network encompassing much of the Puget Sound region.
- Enhancements to the Oregon beach shoreline monitoring efforts to include high resolution terrestrial Lidar mapping of coastal bluffs.
- Increased capabilities for the monitoring of nearshore bathymetry along the open coast and within critical estuarine environments.

- Additional sensors (tide gauges) in several key estuaries (e.g. Umpqua R. and Alsea Bay).
- Additional wave buoys located along the outer-shelf region (e.g. southern Oregon coast and central Washington coast), and at mid-shelf (e.g. offshore Tillamook Bay).
- Additional sensors (tide gauges) in several key estuaries (e.g. Umpqua R. and Alsea Bay)

Table 1: NANOOS “Effort versus Application” Map for Observing and Modeling. The “Applications” are PNW priorities established by the NANOOS Governing Council over three PNW domains. The “Efforts” represent a mix of sustained (blue) and new (green) investments, with gaps noted.

NANOOS "Effort versus Application" Map for Observing and Modeling

EFFORTS:	COASTAL OCEAN					ESTUARIES					SHORELINES				
	Mar ops	Ecology	Hazards	Biodiv	Climate	Mar ops	Ecology	Hazards	Biodiv	Climate	Mar ops	Ecology	Hazards	Biodiv	Climate
MULTI VARIATE ASSETS															
WA shelf glider line															
Columbia shelf glider tracks															
CA shelf glider line															
WA shelf buoy															
Columbia shelf buoy															
OR shelf buoy															
<i>WA nearshore OCNMS RT</i>	<i>no coastal nearshore</i>														
<i>WA nearshore OAH</i>	<i>no coastal OAH nearshore</i>														
<i>PNW nearshore hypoxia</i>	<i>no coastal nearshore; engage fishing industry</i>														
<i>OR nearshore OAH</i>	<i>no coastal OAH nearshore; engage citizens</i>														
<i>Fishing vessel shelf obs</i>	<i>expand shelf obs; engage fishing industry</i>														
<i>Shelf drifters</i>	<i>expand currents; engage students</i>														
Puget Sound estuary buoys															
Puget Sound estuary ferrybox															
Columbia estuary buoys															
South Slough estuary moorings															
Central Salish Sea cabled OO						<i>no central Salish Sea</i>									
Contaminant obs in Columbia						<i>no contaminant assessment</i>									
BIOLOGICAL SAMPLING															
<i>Animal tracking</i>											<i>no animal obs</i>				
<i>Passive acoustics</i>											<i>no animal/sound obs</i>				
<i>HAB observations</i>	<i>sustain PNW HABs Bulletin</i>														
SHORELINES															
Washington shorelines															
Oregon shorelines															
PNW bathymetry															
Add coastal bluffs											<i>no coastal bluff obs</i>				
Extend to Puget Sound											<i>no Puget Sound obs</i>				
SURFACE CURRENTS															
OR/WA coastlines HF															
NW WA coastlines HF	<i>final WA HFR</i>														
Port wave band imaging X-band															
FORECAST MODELS															
PNW circulation forecasts															
Puget Sound circulation forecasts															
Columbia circulation forecasts															
PNW biogeochem forecasts															
Puget Sound biogeochem forecasts															
Columbia estuary habitat forecasts															
Wave forecasts for navigational inlets	<i>no forecast</i>					<i>no forecast</i>					<i>no forecast</i>				

KEY:

Italicized efforts indicate new investment

Currently directly supports

Proposed to directly support

Not applicable

Currently indirectly supports

Proposed to indirectly support

no ...

Text explains the current gap the proposed activities fill