BUILD-OUT PLAN FOR

NANOOS

PART ONE: ISSUES AND PRODUCT TEMPLATES

1. MARINE OPERATIONS

Issue 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 crab industry alone is a $45 million dollar industry). Access to reliable and consistent ocean and climate conditions and forecasts remains paramount for this industry.

1.1.1 PRODUCT AND SERVICES: WEATHER AND SEA STATE CONDITIONS FOR MARINERS

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 Boater Information System (BIS) (Tides and currents)
- Nowcast/Forecast Coastal Currents and Water Temperatures
- ProbCast - Probability Weather Forecasting
- Forecast Information and Data Products for Tuna Fishers
- High-Frequency (HF) Radar Surface Currents
- Regional PNW Wave and Wind Forecasts
- NOAA - Tides and Currents

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 Tilaamook Bay).

1.1.2 PRODUCT AND SERVICES: IMPROVED WIND AND OCEAN CURRENT FORECASTS

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 Washington coast at Grays Harbor, Pt. Grenville, and La Push (approximate locations), filling in national capacity to the Canadian border and bringing pivotal ocean observing data to critical coastline and communities currently un-served. Data will be provided as nowcasts approximately every X hours, consistent with existing approaches currently operating on the Oregon coast.
- 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.

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

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

INFORMATION REQUIREMENTS:

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- New HF radar sites located along the Washington coast at Grays Harbor, Pt. Grenville, and La Push (approximate locations), filling in national capacity to the Canadian border and bringing pivotal ocean observing data to critical coastline and communities currently un-served. Data will be provided as nowcasts approximately every hour, consistent with existing approaches currently operating on the Oregon 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.

1.2.2 OTHER PRODUCT AND SERVICES FOR SEARCH AND RESCUE:

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

Issue 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 PRODUCT AND SERVICES: REAL TIME SURFACE CURRENTS USED BY NOAA HAZMAT, COAST GUARD AND OTHERS TO TRACK AND FORECAST OIL & CHEMICAL TRAJECTORIES

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
- Buoys (e.g. supports NERRS (South Sleugh), NH-10 (OSU), Chábă (OSU), Columbia R. (CMOP), Willapa Bay (WDoE).

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 Washington coast at Grays Harbor, Pt. Grenville, and La Push (approximate locations), filling in national capacity to the Canadian border and bringing pivotal ocean observing data to critical coastline and communities currently un-served. Data will be provided as nowcasts approximately every hour, consistent with existing approaches currently operating on the Oregon coast. New products may eventually include the provision of futurecasts (coupled ocean model/surface currents) that may be used to assist with tracking spills.
- 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 PRODUCT AND SERVICES: OCEAN CIRCULATION MODELS & FORECASTS

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

- Nowcast/Forecast Coastal Currents and Water Temperatures
- High-Frequency (HF) Radar Surface Currents

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:

- Develop and operationalize a coupled ocean model that incorporates ocean circulation, waves, and wind forcing, which can be used to provide real-time SAR support.

Issue 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 PRODUCT AND SERVICES: OCEANOGRAPHIC AND LAKE INFORMATION TO ASSIST WITH OFFSHORE ENERGY PLANNING, SITING AND OPERATIONS

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 Boater Information System (BIS) (Tides and currents)
- 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:

- More detailed bathymetry
- Coastal nearshore and beach monitoring
- Detailed numerical wave and current modeling
- Electromagnetic impacts

2. CLIMATE VARIABILITY AND CHANGE

Issue 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 PRODUCT AND SERVICES: COASTAL CLIMATE RECORDS ON KEY PARAMETERS OVER TIME. REGIONAL CONTRIBUTIONS TO CLIMATE INDICES.

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.)
- CMOP - Center for Coastal Margin Observation & Prediction
- Marine Water Monitoring
- Puget Sound Regional Synthesis Model (PRISM) Cruise Data
- Puget Sound Princeton Ocean Model
- High-Frequency (HF) Radar Surface Currents
- Pacific Coast Habitat Server
- NDBC Buoy Anomalies
- Oregon Beach and Shoreline Mapping
- Southwest Washington Coastal Mapping
- Buoys (e.g. supports NERRS (South Sleugh), NH-10 (OSU), Chábă (OSU), Columbia R. (CMOP), Willapa Bay (WDoE).
- Gliders (e.g. support OSU, CMOP and UW efforts)

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 Washington coast at Grays Harbor, Pt. Grenville, and La Push (approximate locations), filling in national capacity to the Canadian border and bringing pivotal ocean observing data to critical coastline and communities currently un-served. Data will be provided as nowcasts approximately every X hours, consistent with existing approaches currently operating on the Oregon coast.

- 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.
- Add new buoys/instrumentation in estuaries.
- 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 Tilaamook Bay).
- Additional sensors (tide gauges) in several key estuaries (e.g. Umpqua R. and Alsea Bay).
- Support one nearshore PISCO OR hypoxia mooring
- Support Newport biology line
- Add one new biology line adjacent to Grays Harbor
- Add OA monitoring at several critical estuary nodes

Issue 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 PRODUCT AND SERVICES: WARNING SENT TO INTERESTED PARTIES WHEN OCEAN CONDITIONS MAY BECOME UNFAVORABLE DUE TO CHANGES IN OCEAN ACIDIFICATION

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.)
- ProbCast - Probability Weather Forecasting
- Puget Sound Networked Profiling Buoy
- Puget Sound ORCA
- Puget Sound Princeton Ocean Model
- Water Quality Data for Shellfish Growers

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.
- Sustain existing LOBO time-series at the Yaquina estuary, and expand LOBO capability to other critical estuaries.

Issue 2.3: Sea Level and Lake 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 PRODUCT AND SERVICES: IMPROVED FORECASTS FOR SEA LEVEL RISE AND LAND SUBSIDENCE AND FOR CHANGES IN WATER LEVELS FOR THE GREAT LAKES.

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).
-

Issue 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.

2.3.1 PRODUCT AND SERVICES:
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. ECOSYSTEMS, FISHERIES AND WATER QUALITY

Issue 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 PRODUCT AND SERVICES: INTEGRATED MAPS AND DISPLAYS LINKING HABITATS WITH PHYSICAL OCEANOGRAPHIC PROPERTIES (HABITAT GIS/SEABIRD DATA PORTALS)

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

- Pacific Coast Habitat Server

INFORMATION REQUIREMENTS:

3.1.2 PRODUCT AND SERVICES: REGIONAL ECOSYSTEM ASSESSMENT THAT INTEGRATES BIOLOGICAL, CHEMICAL AND PHYSICAL CONDITIONS

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.)
- Center for Coastal Margin Observation & Prediction (CMOP)
- High-Frequency (HF) Radar Surface Currents
- OSU Regional Ocean Modeling System (ROMS) Surface Fields
- Puget Sound Networked Profiling Buoy
- Puget Sound ORCA
- Puget Sound Princeton Ocean Model
- Puget Sound Regional Synthesis Model (PRISM) Cruise Data
- Water Quality Data for Shellfish Growers
- Buoys (e.g. supports NERRS (South Sleugh), NH-10 (OSU), Chábă (OSU), Columbia R. (CMOP), Willapa Bay (WDoE).
- Gliders (e.g. support OSU, CMOP and UW efforts)

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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:

- Add new buoys/instrumentation in estuaries.
- 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 Tilaamook Bay).
- Support one nearshore PISCO OR hypoxia mooring
- Support Newport biology line
- Add one new biology line adjacent to Grays Harbor
- Add OA monitoring at several critical estuary nodes
- Add zooplankton monitoring in Puget Sound
- Add ecological modeling
- Add citizen science capability

Issue 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 *Psuedo-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 PRODUCT AND SERVICES: SEASONAL AND ANNUAL CLIMATOLOGIES OF FUNDAMENTAL ECOSYSTEM PARAMETERS FOR FISHERIES MANAGEMENT AND ECOSYSTEM-BASED MANAGEMENT.

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.)
- Forecast Information and Data Products for Fishers
- Center for Coastal Margin Observation & Prediction (CMOP)
- CMOP/NANOOS Phoebe Glider (Quinault) Transect
- Puget Sound Networked Profiling Buoy

- Puget Sound ORCA
- Puget Sound Regional Synthesis Model (PRISM) Cruise Data
- Water Quality Data for Shellfish Growers
- Buoys (e.g. supports NERRS (South Sleugh), NH-10 (OSU), Chábă (OSU), Columbia R. (CMOP), Willapa Bay (WDoE).
- Gliders (e.g. support OSU, CMOP and UW efforts)

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 one nearshore PISCO OR hypoxia mooring
- Support Newport biology line
- Add one new biology line adjacent to Grays Harbor
- Add OA monitoring at several critical estuary nodes
- Add crabpot monitoring network
- Add acoustics to gliders
- Add zooplankton monitoring in Puget Sound
- Add ecological modeling
- Add citizen science capability

Issue 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 PRODUCTS AND SERVICES: EARLY INFORMATION TO COASTAL MANAGERS FOR WHEN CONDITIONS ARE CONDUCIVE FOR HARMFUL ALGAL BLOOMS (INCLUDES ALERTS FOR SHELLFISH HARVESTORS, GROWERS AND OTHERS)

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.)
- Center for Coastal Margin Observation & Prediction (CMOP)
- Puget Sound Networked Profiling Buoy

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- Puget Sound Regional Synthesis Model (PRISM) Cruise Data
- Water Quality Data for Shellfish Growers
- Buoys (e.g. supports NERRS (South Sleugh), NH-10 (OSU), Chábă (OSU), Columbia R. (CMOP), Willapa Bay (WDoE).
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- More buoys/sensors in critical estuaries
- Support one nearshore PISCO OR hypoxia mooring
- Add crabpot monitoring network

Issue 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 PRODUCTS AND SERVICES: EARLY WARNINGS FOR WHEN CONDITIONS ARE CONDUCIVE FOR HYPOXIA

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.)
- Center for Coastal Margin Observation & Prediction (CMOP)
- Puget Sound Networked Profiling Buoy
- Puget Sound ORCA

- Puget Sound Regional Synthesis Model (PRISM) Cruise Data
- Buoys (e.g. supports NERRS (South Sleugh), NH-10 (OSU), Chábă (OSU), Columbia R. (CMOP), Willapa Bay (WDoE).
- Gliders (e.g. support OSU, CMOP and UW efforts)

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- More buoys/sensors in critical estuaries
- More gliders
- Support one nearshore PISCO OR hypoxia mooring

4. Coastal Hazards

Issue 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 (M_W>9) and accompanying tsunami in the future, resulting in catastrophic damage to coastal communities and loss of life.

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

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 Boater Information System (BIS) (Tides and currents)
- High-Frequency (HF) Radar Surface Currents
- Regional PNW Wave and Wind Forecasts
- ProbCast - Probability Weather Forecasting

- Oregon Beach and Shoreline Mapping
- Southwest Washington Coastal Mapping
- Coastal Processes in the Pacific Northwest
- Honshu Earthquake and Tsunami 2011 special topic page
- Tsunami Evacuation Zones for the Pacific Northwest Coast

INFORMATION REQUIREMENTS:

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- 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 Tilaamook Bay).

INFORMATION REQUIREMENTS:

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

- Additional sensors (tide gauges) in several key estuaries (e.g. Umpqua R. and Alsea Bay).

NANOOS SUBSYSTEM

OBSERVING -- MOBILE PLATFORMS	Gliders: surface	Gliders: profiling	Vessel Transects	Vessel Transects	GPS based In-Situ Platforms	Crab pots/fishermen of opportunity
Observing platform-Mobile Name (e.g. Glider: water quality or Glider: Coastal or ...) Provide a brief narrative for each of the platform types. - Gliders - AUVs - Ships - Beach transects - Drifters - Other	Wavegliders (aka Liquid Robotics) are AUVs that measure surface properties	Seagliders (aka iRobot) are autonomous underwater vehicles (AUVs) optimized for use to survey the coastal ocean in transects for water quality, water properties Teledyne-Webb Slocum Glider are autonomous underwater vehicles (AUVs) do the same but are optimized for use for nearer-shore water properties, including water quality sampling	Nearshore Transects (e.g., California Cooperative Oceanic Fisheries Investigations-CalCOFI stations)	Event-based ship sampling for water quality (HABs, outfalls, stormwater, hazardous spills)	GPS Based ATV and JetSKI instruments providing beach transects for monitoring storm (event based) and long term shoreline change due to climate variability and change (e.g. sea level rise).	Add 150 tidbits for Temp and DO on crab pots of opportunity
Theme Issues Addressed						
1. Marine Onerations						
1.1 Safety	X	X				
1.2 Search and Rescue	X	X				
1.3 Spill Response	X	X		X		
1.4 Offshore Energy	X	X				
1.5 Other						
2. Climate Variability						
2.1 Change in ocean conditions	X	X	X		X	
2.2 Ocean acidification	X	X	X			
2.3 Water level change					X	
2.4 Other					X	
3. Ecosystem						
3.1 Health and productive ecosystems	X	X	X	X		
3.2 Sustainable fisheries	X	X	X	X		
3.3 Harmful algal blooms	X	X	X	X		
3.4 Hypoxia		X	X	X		
3.5 Minimizing effects of pollution	X	X	X	X		
4. Coastal Hazards						
4.1 Hazard and disaster information	X	X	X		X	
5. Integrated Products						
Variables Observed and Resolution (Spatial, Temporal, Accuracy) Requirements (e.g., Water Temperature: 1, 10, 50 m; hourly for 10 mins @1Hz; 0.1°C)	Temperature Water: ±0.1 degree C, continuous Salinity: ±0.1 psu, continuous Ocean pCO2: ± 1 ppm, continuous Chlorophyll Fluorescence: ±0.1 ug/l, continuous Transmissivity: .003m^{-1} @ 1Hz, continuous	Temperature Water: ±0.1 degree C, continuous Salinity: ±0.1 psu, continuous Pressure: ±0.1 db, continuous Chlorophyll Fluorescence: ±0.1 ug/l, continuous Transmissivity: .003m^{-1} @ 1Hz, continuous	Temperature Water: ±0.1 degree C, stations along transect Salinity: ±0.1 psu Pressure: ±0.1 db Oxygen Ocean pCO2: ± 1 ppm Transmissivity: .003m^{-1} @ 1Hz Nitrate: ±0.028 mg/l Chlorophyll Fluorescence: ±0.1 ug/l Plankton Fish acoustics Fish, larvae, eggs	Temperature Water: ±0.1 degree C, stations Salinity: ±0.1 psu Pressure: ±0.1 db Oxygen Water toxins Transmissivity: .003m^{-1} @ 1Hz Nitrate: ±0.028 mg/l Chlorophyll Fluorescence: ±0.1 ug/l Oil (DOC)	Vertical and horizontal errors: ±1-2 cm (shore-based) for GPS plus an additional ±2 cm for operator error Vertical and horizontal errors: ±6-15 cm (bathy vertical error). Horizontal GPS errors comparable to shore-based, although PWC can deviate significantly from lines due to conditions	
Sensors (and number) (e.g., CTD: 3) IF POSSIBLE PROVIDE LINK TO SENSOR URL. THIS WILL ASSIST COST ESTIMATORS	Seabird Thermosalinograph: 1/glider x 3 gliders (3) Wetlabs Wetstar: 1/glider x 3 gliders (3) Wetlabs C Star: 1/glider x 3 gliders (3) http://www.seabird.com/products/ThermoS.htm; http://www.sunburstsensors.com/products.html; http://www.satlantic.com; http://www.wetlabs.com/products/index.htm	Seabird CTDs: 1/glider x 5 gliders (5) SAMI pCO2: 1/glider x 5 gliders (5) Wetlabs Wetstar: 1/glider x 5 gliders (5) Wetlabs C Star: 1/glider x 5 gliders (5) Satlantic SUNA: 1/glider x 5 gliders (5) http://www.seabird.com/products/ThermoS.htm; http://www.sunburstsensors.com/products.html; http://www.satlantic.com; http://www.wetlabs.com/products/index.htm			Presently utilize Trimble GNSS GPS sensors. Consists of 1 base, base radio and rover GPS for shore=based operations. Total cost ~$60K Wave runners required for nearshore work @ $12K per boat. Require two boats for safety purposes Additional instrumentation costs for boats include, GPS, screens, echo sounder,onboard computer and power. Total comes to ~$40K/boat. http://www.trimble.com/, http://powersports.honda.com/water.aspx, http://www.odomhydrographic.com/products/category/single-beam-echo-sounders/	
Sensors (and number) (e.g., CTD: 3) IF POSSIBLE PROVIDE LINK TO SENSOR URL. THIS WILL ASSIST COST ESTIMATORS	Wavegliders = 3 http://liquidr.com/	Gliders = 5 *http://www.irobot.com/gi/maritime/1KA_Seaglider/* *http://www.webbresearch.com/slocumglider.aspx*	Lines = 2 needed in addition to current 5 (?)	As needed, but likely 4 per year in 5 locations	Presently monitoring 47 static locations in WA. Expand to 100 to include Puget Sound Presently monitoring 95 static locations in OR. Expand to 350 to include other critical areas of the Oregon coast	
Geographic cover / Location and number:	WA and OR coasts	La Push, mid WA, Col River, Newport, S of Newport	Need new lines off Grays Harbor and La Push	Puget Sound, Columbia River, La Push, South Slough, Newport	Select beaches that are affected by storm events Add Puget Sound Add tsunami innudation mapping in WA to the OR effort Add Oregon ground-based LIDAR mapping Add Oregon estuary shoreline and bathymetry mapping	
Operational Requirements - Deployment / Operations - Maintenance - Personnel - Replacement needs - Other	Deployment/Operations: Maintenance: 3-4 times per year (after every 100 day deployment) Personnel: 2 FTE Replacement: Other:	Deployment/Operations: Maintenance: 3-4 times per year (after every 100 day deployment) Personnel: 2 FTE Replacement: Other:	Ouarterly. as nart of PaCOOS an Deployment/Operations: 500K for current Maintenance: 100K for current effort Personnel: 400K for current effort Replacement: Other:	Event-based ship sampling for water quality (HABs, outfalls, stormwater, hazardous spills) Deployment/Operations: 200K Maintenance: 50K Personnel: 220K	regular seasonal to bi-annual surveys + event based. Deployment/Operations: Maintenance: Personnel: 2 FTEs/survey for shore-based For bathy: 5 FTE/survey	
Development Needs If necessary, describe development efforts required for advancing, operationalizing or refining each of the identified issues.						

Observing System Synthesis Table for Cost Estimation

Observing Platform	Theme issues addressed	Variables Observed	Sensors (#)
Platform A (single purpose water quality			
Platform B (_____)			
Platform C (_____)			
Platform D (___)			
.....			

Part 2: NANOOS Subsystems

MODEL REQUIREMENTS

	A Weather
Model Name	We do not plan to develop NANOOS-specific capabilities in weather models. We will resort to best-available NOAA and NAVY weather simulations as atmospheric forcing to our circulation models.
Type of Model (see above – e.g. circulation model)	Atmospheric circulation
Geographic Domain (entire region, specific harbor, etc)	Nested: Areas within Regions
Theme Issues Addressed	
1. Marine Operations	
1.1 Safety	X
1.2 Search and Rescue	X
1.3 Spill Response	X
1.4 Offshore Energy	X
1.5 Other	
2. Climate Variability	
2.1 Change in ocean conditions	X
2.2 Ocean acidification	
2.3 Water level change	
2.4 Other	
3. Ecosystem	
3.1 Health and productive ecosystems	X
3.2 Sustainable fisheries	X
3.3 Harmful algal blooms	X
3.4 Hypoxia	
3.5 Minimizing effects of pollution	X
4. Coastal Hazards	
4.1 Hazard and disaster information	X
5. Integrated Products	
Important Variables to be modeled (see	Wind speed

terms and definitions**)**	Wind direction Pressure Precipitation Temperature Air Humidity
Spatial (horizontal and vertical requirements)	1 km
Temporal	Hourly nowcasts/twice daily forecasts
Computing infrastructure, including redundancy of operations	
Personnel (FTEs/year)	1 FTE/Region x 3 (3)
Expected Initial and Boundary conditions (to identify resource needs, e.g. basin-scale circulation model)	
Development Needs If necessary, describe development efforts required for advancing, operationalizing or refining each of the identified issues.	

Synthesis Table for Cost Estimation

Model Name	
Example *NECOFS*	

*Combine with map showing location of platforms to help address the coverage

For each required model component provide:

Dynamical Models: Most regions will deploy a dynamical numerical modeling
one or more end-user products. Most of the models work with each other (e
ROMS) are capable of performing numerous tasks. For this task, please use t

1) Atmospheric models
2) Circulation models
3) Inundation models
4) Wave models
5) Hydrologic models
6) Sediment transport models
7) Water Quality/Ecosystem models
8) Fisheries models

Statistical Models: For some applications a dynamic model is not practical/fe
the form of a regression of one or more input variables that are combined to

i) statistical surface current prediction – Short Term Prediction Systems (STF
ii) statistical water quality model – uses varied inputs to predict harmful pat
iii) statistical rip current forecast – uses surface wave information to estimat

B Waves	C Eastern North Pacific	D OR and WA continent shelf
SWAN	We do not plan to develop NANOOS-specific capabilities in Eastern North Pacific models. We will resort to bert-available NAVY simulations as ocean forcing to our shelf and estuary circulation models.	Regional Ocean Model System (ROMS), Semi-implicit Eulerian–Lagrangian Finite-Element model (SELFE), and Finite Volume Coastal Ocean Model (FVCOM)
Waves	Ocean circulation	Ocean circulation
NE Pacific	NE pacific	Nested: Full continental shelf; selected areas in OR and WA
X	X	X
X	X	X
X	X	X
X	X	X
X	X	X
	X	X
	X	X
X	X	X
X	X	X
X	X	X
		X
X	X	X
X	X	X
Wave height		

Wave period Wave direction		
1 km		
Hourly nowcasts/twice daily forecasts		
2 FTE (2)	1 FTE	1FTE/Region

Modeling Subsystems		
Atmos, circ, inun, wave,		*$133K/y*

g framework that consists of one or more models providing forecasts, nowcasts, and/or
.g. an atmospheric model provides forcing for the circulation or wave models). Some n
the following categories: (see terms and definitions for fuller description)

easible/available, and a statistical approach is employed to relate observations to a des
estimate the output and serve as decision support tools. Please indicate the type of ou
PS) – uses HF radar input and produces a 24 hour forecast
hogen levels in shellfish areas
e the likelihood of dangerous rip currents

E PNW estuaries	D Ecosystem	E Morphology
Regional Ocean Model System (ROMS), Semi-implicit Eulerian–Lagrangian Finite-Element model (SELFE), and Finite Volume Coastal Ocean Model (FVCOM)	Various versions of NPZD-type models (part of the ROMS, SELFE and FVCOM systems)	SELFE system, perhaps others
River-to-ocean circulation	Biogeochemical	Cohesive and non-cohesive sediments
Major estuaries, selected smaller estuaries	Major estuaries, selected smaller estuaries	Columbia River estuary; perhaps other estuaries
X		X
X		X
X		
X		X
X	X	
X	X	
X		X
X		X
X	X	X
X	X	X
X	X	
X	X	
X	X	X
X		X
Current speed	Nitrate	

Current direction Temperature Water Salinity Pressure	Phosphate Dissolved Oxygen pH phytoplankton (several) zooplankton (several)	
50 m to 3 km, 50 vertical levels		
Hourly nowcasts/twice daily forecasts	Hourly nowcasts/twice daily	
3 FTE/Region	6 FTE/Region	0.5FTE
The circulation modeling systems are already well developed and operationalized, and have been validated to variable degrees against observations. Further development anticipated to ensure skill consistent with the needs of ecological models	Development necessary for many of these models. Very little operationalization has been done. Careful validation and improvements necessary, which will take advantage of expanding interdisciplinary observation networks	Developmentis in early stages, and no operationalization has been done. Careful validation and improvements necessary, which will take advantage of expanding observation networks
$400K/y	$800K/y	$66K/y

r hindcasts to produce
nodels (for instance,

sired output. Most take
tput provide. Examples:

NANOOS DMAC System Components	Metadata	Data Aggregation/Assembly
General description of DMAC Operations to be compliant with IOOS Standards (as described in Whitepaper and includes discovery, QA/QC, archives)	Metadata describes the organization and structure of the observational and model data sets. Metadata provides the necessary information about how and when the data were gathered, as well as information about the web services available. Metadata standards that are available include both general-purpose standards for representing metadata (e.g., FGDC CSDGM, Dublin Core, ISO 19115/19139) and OGC Sensor Model Language (SensorML).	Data Aggregation/Assembly combines observational data collected by multiple data providers within the NANOOS region and provides integrated data access points to the end users as one-stop shopping for their needs via online and mobile applications. This assembly service also serves national cataloging efforts, particularly the IOOS Catalog, by providing unified access points to national service registries, using standards such as OGC CSW and SensorML, CF conventions, and THREDDS catalogs.
Identify the themes that this will support	1. Maritime Operations: Safe and efficient commercial shipping and recreational boating, Search and Rescue, Spil 2. Climate Variability and Change: Changes in ocean conditions over time. 3. Ecosystems, Fisheries and Water Quality: Healthy & Productive Ecosystems, Sustainable Fisheries, Harmful Al 4. Coastal Hazards: Providing hazard and disaster information when and where it is needed. 5. Integrated Products: Coastal Marine Spatial Planning, general data-access and visualization products	

NANOOS DMAC System (Existing State) on sub-components based on IOOS DMAC white paper	NANOOS currently aggregates and delivers thousands of near-real-time in-situ observations every hour from federal and a variety of sub-regional providers. Characteristics of platform and measurements are homogenized by NANOOS and distributed with consitent information, such as Climate and Forecast (CF) parameter names and IOOS station naming conventions via OGC SOS services. NANOOS also makes available model output and remotely sensed (land based and satellite) images via NANOOS Visualization System (NVS) tool. NVS serves as an asset inventory for active platforms. **NANOOS will enhance this inventory functionality to encompass platforms and datasets without telemetry or that are no longer active. NANOOS will develop new metadata components that to support external cataloging efforts and internal project monitoring using ISO metadata, OGC cataloging services (CSW), and OGC SensorML for sensor information. This information will also be distributed via other OGC standard services to encourage wide usage.**	NANOOS has published technical documentation and given conference presentations describing our data aggregation processes, available on the NANOOS web site. Near-real-time data are aggregated into the NVS asset data store from heterogeneous data formats and services made available by sub-regional and federal providers. Regular data-feed monitoring is carried out to identify problems and implement solutions as they emerge. This integrated data are then available for access by end users via NVS and NVS mobile apps; by other regional systems via NVS light-weight web services; and by IOOS and standard compliant systems via OGC SOS, THREDDS and other services. Long-term data are managed by sub-regional providers with NANOOS assistance and coordination; some of these long-term archives are made available to IOOS via standard services. Some NANOOS partners also push the data to the National Data Buoy Center to further distribute to end users and to the Global Telecommunications System (GTS) for use in atmospheric and ocean forecast models. **NANOOS will develop enhanced, more systematic, more comprehensive, and well documented approaches for data integration, storage, and redistribution to user applications and standard-compliant systems such as the IOOS Catalog.**

Regional Data Management Enhancements Describe regional data management requirements not covered by the IOOS DMAC Whitepaper (regional data portals)	NANOOS is engaged in collaborative discusssions and prioritizations with its stakeholders and other partners to i - **NVS data-handling enhancements**: handling historical data via common data interfaces and a user-friendly, co presentation of climatological anomaly plots and annotated thresholds (such as low-oxygen thresholds); extende - General **tools to define and disseminate alerts** based on data thresholds. - **Biological data handling, access, and visualization**: includes support for taxonomic and abundance informati - **Model data access and visualization**, including interoperable access to irregular-grid model output, user-frien - **NANOOS Integrated Data Aggregation Service(NIDAS)**, enhancements to the ERDDAP service to provide data
Maintenance Actions (outline specific maintenance actions required to maintain DMAC operations)	Sub-daily monitoring of the data management system to ensure appropriate aggregation and delivery of data to s Sub-daily monitoring of the data feeds from sub-regional and federal data providers (in-situ, model and remote s Regional partnering and communication to regularly identify and adapt to new data feeds, assets, and asset confi Alerting and working with sub-regional data providers to identify and fix data posting issues; NANOOS web site/data portal upkeep; Event driven (Oil Spill, Tsunami, Harmful Algal Blooms, etc) data display and access needs; Data archival; System Administration duties (system monitoring and diagnostics, server upkeep and replacement with minimal Enhancements to NANOOS mobile applications.

Development Needs (If necessary, describe development efforts required for advancing, operationalizing or refining each of the identified issues)	Substantial analyses, reengineering and dedicated resources will be required to make existing, distributed efforts efforts will include the following areas: Redundancy (Failover, Reliability and availability, response); Redundancy of Systems and Data; Training of sub-r Train Personnel to advance their technical expertise (attending courses and conferences on data management an Upgrade to 24X7 quasi manned/automatic operations (Consistency, reliability and accuracy); QA/QC algorithm development and implementation for existing and new data types that may become available; Server Capacity Requirements (Needs of new servers to meet the growing demands), Need to upgrade to provide Work with NOAA (NODC, NCDC, NDBC) on the archival of observations and model data; Provide redundancy to sub-regional coastal ocean observing systems (Data Telemetry and Processing, storage ar Provide access to historical data to support end users needs, including baseline analyses and Fisheries and Ecosy Support the development of products for all theme areas; Registering the data services with IOOS; Develop and Upgrade consistent performance measures and data portal usage statistics; Work toward IOOS DMAC Data Certification; Develop best practices and practical tools for new data providers to serve data to NANOOS; Work with NDBC to determine their best practices for more indepth quality control; Develop dedicated, responsive in-situ recent and archival database servers; Test operations in Cloud Computing environment; Further expand mobile application portfolio including location based services, event processing and notification,
Operational Requirements **• Personnel (# of FTEs)** **• Replacement needs (computers, redundant systems)** **• servers**	**DMAC System Personnel needs:** Software Engineer – IOOS DMAC recommended DMAC technologies knowledge as to web services etc. (1.0 FTE); GIS developer (1.0 FTE) Web Developer with Graphics Artist capabilities, Technical Documentation (1.0 FTE); Hardware/Software/Network Engineer (2.0 FTE); Support to sub-regional data systems (Personnel and hardware costs; 2.0 FTE) Off-site redundancy and fail-over systems hosted by other NANOOS partners (1.0 FTE) **Other System Costs:** Software Costs (GIS, Graphics, Microsoft and adobe etc.); Hardware Costs (10 servers), including maintenance and replacement costs; Uninterrupted Power Supplies as well as backup generators for NANOOS DMAC centers and off-site redundancy s
Participate in national and inter-RA data management coordination and collaboration	NANOOS Staff and NANOOS DMCC members continue to participate in discussions with the IOOS RA DMAC and N and coordinate the RA DMAC activities to move IOOS RA DMAC forward; Tiger teams and other working groups t Catalog and Asset Inventory. NANOOS DMAC members also actively participate in national cyberinfrastructure a participates actively and has co-led regional CMSP coordination efforts in the Pacific Northwest and the West Coa sharing and leveraging their data management expertise via meetings, conference calls, and joint participation in are some examples in sharing and leveraging the RAs strength and expertise. NANOOS DMAC partner Boeing part

Provision of in-situ observations data to WMO GTS from NANOOS Region and Providing HF Radar data to National HF Radar Portal	NANOOS regional coastal ocean observations (in-situ) are submitted to Global Telecommunication System (GTS) observing stations by providing necessary metadata to NDBC. NANOOS DMAC/DMCC will coordinate with sub-re providers come online, NANOOS will have the capacity to provide guidance and technical expertise to submit data

Synthesis Table for Cost Estimation		
DMAC Needs	**Computing Resources Required**	**FTE**
IOOS-compliant DMAC		
Regional Data Management		
Maintenance		
Development Needs		

Data Catalog/Discovery	Quality Assurance/Quality Control	Data Access/Transport
NANOOS will provide catalogs that allow an end user to search for data (observations and model) in a variety of ways. Using the catalog, an end user can search for a desired parameter and can narrow that search by location of the sensor, time and date of the observation, level of quality control, and metadata offered. Catalog searches allow customers to identify a source for the data they need. NANOOS will also produce service metadata and dataset metadata that can be harvested by the IOOS Catalog, by other standard-compliant thematic or geographic catalogs such as NSF OOI Cyberinfrastructure and NSF CUAHSI HIS Central registry, and by commercial search engines such as Google.	NANOOS will provide best practices and guidance to sub-regional data providers within the NANOOS Region to implement the IOOS Recommended QARTOD/QARTOD to OGC (Q2O) QA/QC tests, as well as emerging QA/QC standard practices and encodings. NANOOS will work with the data providers to ensure data integrity, and with IOOS and RA partners to foster and support the development of appropriate QA/QC standard practices and encodings.	These services allow customers to "pull" data on request from data assembly centers. Different data types may require different services, and a variety of services may be offered to satisfy different customers, but all data access services are expected to enable the customer to (1) make an explicit request at the moment of need and (2) specify the desired subset of the data based on the location of interest, the time of interest, or other criteria. NANOOS implements and will regularly reassess the implementatation of IOOS-Reccommended data-access services, including OGC SOS for in-situ data, THREDDS/OPeNDAP for gridded data, and OGC WMS access to georeferenced, pre-styled map visualizations.

l Response, Offshore Energy.

gal Blooms, Hypoxia, Minimizing the Impact from polluted waters.

NANOOS is participating in the IOOS Catalog development by providing data access in IOOS-reccommended services and actively engaging in national DMAC groups that are defining and refining conventions for global identifiers, discovery metadata and service implementation. We will strive to aggregate the region's data and register it in the IOOS Catalog for wide accessibility. NANOOS is also collaborating with regional (Pacific NW, West Coast, etc) and national partners to foster the development and support of thematic catalogs in support of diverse user communities and projects such as CMSP, biological data, NSF OOI, and water quality and ecosystem health networks. These collaborations will require ongoing engagement and dedicated system development and implementations.	NANOOS currently applies low-level QA/QC steps on aggregated near real-time in-situ observations in the NVS data store; mechanisms for enhancing these schemes have been implemented and will be explored. Sub-regional providers apply more robust QA/QC tests and flagging on their long-term archived data, in coordination with NANOOS. More comprehensive and well documented approaches are necessary; NANOOS will work with sub-regional providers, IOOS and relevant national efforts such as QARTOD to help develop and implement such approaches.	NANOOS has implemented or is assessing a variety of output formats and web services for widespread access to data and asset status information. These include custom, light-weight JSON web services, to OGC SOS (Sensor Observing Service), THREDDS, OGC Web Mapping and Web Feature Services (WMS and WFS), KML, GeoRSS, CSV files, and reusable time-series graphs and Google Maps tiled overlays. The GeoServer software is being deployed for broadcasting data in multiple, GIS-accessible forms, including styled WMS access to situational awareness layers. Likewise, the ERDDAP application is being implemented and greatly enhanced via the development of a generic data and service access layer and a custom user interface for easier access and to incorporate a presentation consistent with NVS. In addition, NVS and its associated mobile applications (iOS & Android) provide user-friendly, consistent data access. We have developed new, rich online and mobile applications for access to information about tsunami risks and events. NANOOS aggregated data are reused by other sub-regional entities to server their internal needs and those of their stakeholders. **NANOOS will develop event notification and alerting applications for deployment online and via mobile access, based on the data stores and applications already in place. The scope will include tsunamis, water quality issues relevant to shellfish growers, and other events of concern.**

identify and support new, high-value DMAC capabilities and requirements, and data-driven enhancements to existing tools. These include:
onsistent time slider; dynamic cross-section (depth vs time) and depth-profile plots; glider data access and visualization; dynamic
d user customization capabilities.

ion, animal tracking and identification via tags and acoustic signatures, habitat maps, and integration with physical oceanographic data.
idly visualizations of transects through modeled fields, and model-data integrations.
a access and transformation to large NANOOS data sets including model output and long time series.

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take holders, end users, and the IOOS Catalog;
ensing);
guration changes;

downtime, installing software updates etc.);

; highly robust, scalable, clearly documented, and well coordinated, while remaining responsive to new technologies and needs. Such

·egional data providers;
d web services);

24/7 operations;

ıd delivery);
·stem management needs;

and information tayloring.

systems;

IFRA groups, which are working to coordinate the RAs DMAC activities. Activities include- an annual meeting of the RA DMAC to evaluate
o address Sensor Observation Service, SensorML and THREDDS, Ontology development, water quality data standards, and the IOOS
:tivities led by NSF, including OOI, CUAHSI HIS and the CZO Network; as well as IOOS Data Certification Standards. NANOOS also
ıst, and has ties to OBIS-USA and other biological monitoring groups. NANOOS collaborates with neighboring RAs CeNCOOS and SCCOOS in
proposals and other efforts focused on the West Coast. Expertise and components shared from the NANOOS Visualization System (NVS)
ticipates in the national IOOS DMAC Steering Committee.

via the National Data Buoys Center (NDBC). Sub-regional data providers are directly in contact with NDBC to obtain WMO ID for their egional data providers as well as NDBC to make sure all near real-time coastal ocean observations are disseminated to GTS. As new data a to NDBC/WMO. The OSU HF Radar operators within the NANOOS region submit directly to the National HF Radar Portal.
