Northwest Association of Networked Ocean Observing Systems

April 9, 2007

Mr. James L. Free
NOAA Coastal Services Center
2234 South Hobson Avenue
Charleston, SC 29405-2413

Dear Mr. Free;

Following the guidance in the FY 2007 Regional Integrated Ocean Observing System Development funding opportunity, this **Cover Page** forwards our proposal to develop an end-to-end Regional Coastal Ocean Observing System (RCOOS) for the Pacific Northwest region. Specifics include:

Proposal Title**:**
Enhancing the Pacific Northwest Regional Coastal Ocean Observing System (RCOOS) of NANOOS

Complete information for the Principal Investigator:
D. Martin, Applied Physics Laboratory, University of Washington; 1013 NE 40th St.; Seattle, WA 98105; (206) 543-2945 (Voice); (206) 543-3521 (FAX); dmartin@apl.washington.edu

Complete information for Financial Representative:
K. Walls, Applied Physics Laboratory, University of Washington; 1013 NE 40th St.; Seattle, WA 98105; (206) 543-1388 (Voice); (206) 543-6785 (FAX); kawalls@apl.washington.edu

Duration of proposed project:
Three years, from 01 October 2007 to 30 September 2010

Proposed funding type requested:
Grant

Funding requested by year:
Year 1 - $2.0M; Year 2 - $3.5M; Year 3 - $3.5M

Sincerely,

Dr. David Martin
NANOOS Governing Council President

2. PROJECT SUMMARY

Project Title: Enhancing the Regional Coastal Ocean Observing Systems (RCOOS) of NANOOS.

Recipient Institution: The University of Washington will serve as the funding administrator for this grant.

Primary Contact: D. Martin, Applied Physics Laboratory, University of Washington
1013 NE 40TH St., Seattle, WA, 98105
206 543-2945 (Voice); 206 543-3521 (FAX); dmartin@apl.washington.edu

Project Summary

The Governing Council of the Northwest Association of Networked Ocean Observing Systems (NANOOS), on behalf of its members, proposes to enhance its Regional Coastal Ocean Observing System (RCOOS). Established in 2003, NANOOS used results of nearly three year's NOAA-funded efforts and other regional contributions to build regional association partnerships in the Pacific Northwest (PNW) and to identify high priority user needs and requirements. We propose enhancements to develop a robust RCOOS for NANOOS that addresses these needs. A PNW managed, operated, and improved RCOOS closely integrated with the National system will provide profound societal benefits across a wide spectrum of users including federal, state, Tribal and local governments, marine industries, scientific researchers, Non Governmental Organizations, educators and the general public. NANOOS members have identified priority areas for product development within this end-to-end RCOOS to be maritime operations, fisheries, ecosystem impacts, and coastal hazards. Proposed enhanced developments of the NANOOS RCOOS include its essential subcomponents, an Observing System, Modeling and Analysis, Data Management and Communications, and Education and Outreach. This is the singular RCOOS proposal submission for the PNW region and represents the cumulative, collaborative consensus of stakeholders from the region. NANOOS has produced this through its established governance structure, a Governing Council composed of representatives from all NANOOS members and an Executive Committee of officers and standing committee chairs.

Partners

As detailed in the text, the proposed efforts will be conducted primarily by the NANOOS membership organizations, which are composed of academic and research institutions *(University of Washington, including Washington Sea Grant, Oregon Health & Science University, Oregon State University, including Oregon Sea Grant, Humboldt University, Pacific Northwest National Laboratory)*, tribal governments *(Quileute Tribe, Northwest Indian Fisheries Commission)*, state and local governments *(OR Dept of Land Conservation & Development, OR Dept of Geology and Mineral Industries, OR Dept State Lands, WA Dept of Ecology, Puget Sound Action Team, Port of Newport)*, industries *(Marine Exchange, The Boeing Company, Wet-Labs, Sea-Bird Electronics, Sound Ocean Systems)*, and non-governmental organizations *(Council of American Master Mariners, Puget Sound Harbor Safety Committee, Scientist and Fishermen Exchange (SAFE), Western Association of Marine Laboratories, Hood Canal Salmon Enhancement Group, PNW Salmon Center, Ocean Inquiry Project, Surfrider Foundation)*. All are NANOOS members who have signed the NANOOS MOA and participate in its Governing Council, which has approved this proposal for submission. Additional partners in this work include: *Quinault Indian Nation, King County Dept of Natural Resources and Parks, Port of Neah Bay, and the Olympic Region Harmful Algal Bloom (ORHAB) collective, USGS, and the Padilla Bay and South Slough National Estuarine Research Reserves (NERRS).*

3. PROJECT DESCRIPTION

A. Goals and Objectives

i. Goal: The goal of this project is to further engage in the process to develop, implement, and integrate the various in-water and land-based systems that will constitute a fully robust and user-driven Regional Coastal Ocean Observing System (RCOOS). This includes all necessary sub-systems to provide PNW, west coast, and national stakeholders with the ocean data, tools, and knowledge they need to make responsive and responsible decisions appropriate to their individual and collective societal roles. Our goal is specifically focused on delivering products and services that facilitate easy use of the products to users who need to address high-priority issues. Our knowledge of prioritized issues and user needs was and is gained through proactive NANOOS interactions with a wide range of PNW stakeholders.

ii. Objectives: To meet our stated goal, we propose to accomplish the following objectives:

1) **Maintain existing surface current mapping capability and expand with new prioritized HF radar sites in the PNW.** This tool is a fundamental foundation block for building an observing system for the coastal ocean and serves a multitude of disparate users.
2) **Maintain and expand observation capabilities in PNW estuaries.** The desired objective is a federated real-time observation network across Oregon and Washington estuaries to address their sustainable management and utilization, with assets strategically prioritized based on societal needs.
3) **Strategically expand coverage and range of observations in the PNW shelf, in coordination with emerging national programs.** Target the use of fixed (buoys) and mobile (glider) assets to provide advanced information on hypoxia/anoxia and HABs, which are major regional concerns affecting ecosystem and human health, fisheries, and coastal economies.
4) **Maintain and expand core elements of existing beach and shoreline observing programs in Oregon and Washington.** This can improve coastal hazard mitigation by providing better decision support tools for coastal managers, planners, engineers, and coastal hazard mitigation decision makers.
5) **Create a federated system of numerical daily forecasts of PNW circulation.** This will span from the head of tide of estuaries to the outer edges of the exclusive economic zone (EEZ). The NANOOS vision requires availability of a range of modeling tools in support of user needs including marine operators, first responders, and environmental managers.
6) **Commence development of state of the art cross-shore profile change models and probabilistic shoreline change models.** Such models can be used by coastal managers to assist with predicting future coastline positions.
7) **Bolster ongoing Data Management and Communications (DMAC) activities to support routine operational distribution of data and information.** The NANOOS DMAC design mandates a collaborative, dynamic distributed system of systems that provides a wide range of products, tools, and services to regional user communities while allowing unfettered access to the IOOS national backbone and national information infrastructure.
8) **Build from and strengthen ongoing NANOOS education and outreach efforts.** Conducted in coordination with other regional efforts, this will foster ocean literacy and facilitate use of NANOOS products in the PNW by stakeholders, decision makers, and the general public.

In addition to meeting regional priorities, the goal and objectives of this project fully support the national IOOS agenda through strong external ties with other regional and national programs. In particular, NANOOS is committed to ensuring that the tools, techniques, and knowledge developed under this effort are expressly exportable to others involved in the IOOS enterprise.

B. Background

The waters of the Pacific Northwest, its coast and estuaries, support a wide range of vital activities and are critically important to the societal and ecological health of the region. They modify and moderate regional weather, serve as highways for marine commerce involving the entire Pacific Rim, are part of an oceanic buffer for our nation's national and homeland security, are a reservoir for bountiful natural resources, provide a rich environment for aquaculture activities, serve as an extensive natural laboratory for scientists and educators, and provide exceptional recreational opportunities.

Representatives from a highly diverse set of stakeholders are directly involved in this proposal to develop a PNW Regional Coastal Ocean Observing System (RCOOS). Following the national debate on this issue led by Ocean.US[1,2], PNW stakeholders began strategizing an RCOOS to serve the needs of their region. In October 2003, NANOOS was created by a non-binding charter signed by a group of stakeholders. Since that time, through NOAA IOOS developmental funding and contributions from stakeholders, a formal NANOOS MOA has been established, several workshops were held to identify regional needs and priorities, and a functional NANOOS governance structure is in operation, including a draft Business Plan. NANOOS currently represents over 25 formal member institutions distributed across societal sectors including 27% local, state, and tribal Government, 27% NGO/Education, 23% Industry, and 23% Research.

Our vision of NANOOS is that of a regional system with broad access and participation by diverse users throughout the PNW that also has close involvement with the Canadian Province of British Columbia and is integrated with other regional systems in Alaska and California, inter-regional programs like PaCOOS, and the larger national IOOS effort. Such an approach is necessary considering not only the extent and complexity of the NANOOS domain but also its inter-relationship with processes in neighboring IOOS and Canadian domains within the Pacific Ocean.

Larger scale oceanographic features that span the Pacific Ocean impact the coastal and estuarine waters of the PNW. The California Current, the eastern portion of the North Pacific Gyre flowing southward along the coast of western North America from Washington and Oregon to Baja California, transports low salinity, cool water equatorward. Its velocity is greatly influenced by prevailing winds. Wind-driven upwelling along the coast and over strongly sloping topography generates a rich eddy field. The importance of these eddies lies in their offshore transport of cool, nutrient-rich, upwelled water[3]. The shelf along the PNW coast is fairly narrow, and deeper, nutrient-rich water can be effectively upwelled by winds[4,5]. These processes vary considerably alongshore with changes in shelf width and coastline orientation[6,7,8].

Properties of NE Pacific coastal waters, such as temperature, nutrients, and primary productivity, are greatly influenced by whether upwelling or downwelling is dominant[9,10]. While seasonally variable, these processes are also influenced by large-scale climate forcing[11,12,13,14]. Impacts of such variation on both estuarine and coastal water properties[15,16,17], phytoplankton abundance[18,19,20], HAB occurrence[21,22,23,24] and higher level biota such as fish and shellfish[25,26,54] are being detected with increasing frequency. Coastal hypoxia is of increasing concern in the offshore coasts of OR and WA[27] as well as in critical estuaries in the region, such as Hood Canal and South Puget Sound[28]. Also of high concern are 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, many with rich shellfish growing areas of importance for tribal and commercial production[29]. Further, the strong energetics and dynamics of the coastal and estuarine waters offer challenges to safe maritime operations, search and rescue[30], and also make the coastline susceptible to erosion and other geological hazards[31,32,33] as well as to sustainable management of variable fishery resources[34,35,54].

While there are several existing Federal observing system assets presently providing long term measurements within the PNW (Appendix 1A), these are not adequate to monitor the multiple spatial scales that characterize these regional waters. The NANOOS RCOOS is strategically designed to assure multiple-scale observations and, further, to utilize both Federal and non-Federal observations for user-driven products and applications to meet regional needs.

To date, NANOOS has capitalized on integrating various regional stakeholders in the PNW that maintain coastal ocean observing assets (Appendix 1B). Data from these assets are available through the NANOOS website (http://www.nanoos.org). This includes coastal shelf assets featuring an extensive array of coastal High Frequency (HF) RADAR current-mapping systems that have been operated continuously since 1997. A sub-regional asset of NANOOS, ORCOOS, integrates available ocean data including long-term seasonally repeated hydrography, ADCP, zooplankton, nutrients, and acoustics, along the Newport Hydrographic Line and other transects, and now a new real-time buoy sited off at the Newport Line. These data have been used to study long-term ocean climate variability[11] and the PNW responses to El Nino/La Nina cycles[12,36,37], to winds and varying shelf width[7,38,39], and to tides[40]. Regional models that assimilate data from both *in-situ* and remote sensing platforms, have been used to describe the present state and predict the future state of the coastal ocean to serve a wide variety of research and operational users[41,42,43]. Washington coastal waters, primarily near the Olympic Sanctuary, have been monitored for ocean physics and biological properties through various projects, including the Olympic Coast National Marine Sanctuary, ORHAB (Olympic Region Harmful Algal Bloom study), and an ECOHAB project, among others. The focus of ORHAB and ECOHAB is monitoring and prediction of the occurrence and dispersion of harmful algal blooms that contaminate shellfish along the coast.

The NANOOS Pilot Project funded by NOAA during 2004-7 has enabled integration of critical estuarine and shoreline monitoring assets into the NANOOS system (Appendix 1B). Estuaries include: Willapa Bay[53, 54], a major Washington coast estuary that provides ~60% of the oysters from Washington State, monitored since the mid 1990s by WA Dept of Ecology (WDOE); Puget Sound, a large, urbanized, and productive estuarine network, with the highest population center in the region and numerous environmental issues including hypoxia, toxics and nearshore degradation, home to real-time autonomous moored profiling systems developed by UW and modeling by a NOPP-funded consortium, Puget Sound Marine Environmental Modeling (PSMEM); the Columbia River estuary, the source of 75% of the freshwater input to the Pacific Ocean from the US west coast, with the Columbia River Estuary Real-Time Observation and Forecasting System (CORIE), a project of Oregon Health & Science University (OHSU), combining real-time data with modeling efforts to produce forecasts for the Columbia River estuary and plume; and South Slough, the site of a National Estuarine Research Reserve. NANOOS Pilot funding has enabled access to data from these diverse groups and estuaries via one web portal, as well as facilitated regional coordination of methodologies and technology.

The Pilot NANOOS funding, by helping to maintain the Coastal Monitoring and Analysis Program initiated in 1997 by WDOE and USGS in response to chronic and episodic coastal erosion events,[55] resulted in a successful technological transfer from WA to OR through the establishment of a similar pilot coastal monitoring network in the Rockaway littoral cell[44]. Monitoring in the Rockaway littoral cell was instigated due to the effects of extreme winter waves during the late 1990s, which resulted in significant erosion and damage to properties along the Oregon coast[45]. Between 1997 and 2002, beaches along the Rockaway littoral cell lost approximately 1.8 million cubic yards of sediment, while homeowners spent about $1 million on coastal engineering. The NANOOS pilot monitoring has revealed that erosion is continuing, raising concern about the future well-being of this section of shore. Following the success of the Rockaway beach effort, the OR Dept. of Geology (DOGAMI) broadened its coverage to include the Neskowin cell, and is about to include two other littoral cells on the central Oregon coast, bringing the total number of stations being monitored to 110 sites.

Considering the extent and complexity of the PNW coastal region, as well as the number of societal/user needs impacted coastal ocean/estuarine conditions, we conclude that the waters of the PNW remain fundamentally under-sampled in time and space to permit timely, scientifically-sound decisions to be made for the benefit of the numerous societal and cultural needs described. The interactions NANOOS has undertaken over the last several years have enabled us to identify a prioritized set of needs and user requirements. We leverage our analyses of user needs and system designs developed with our stakeholders (e.g., http://www.nanoos.org/internal/workshop3/) to guide our implementation of an end-to-end RCOOS for NANOOS, addressing operational observation assets, modeling and products, data management and communication (DMAC), and education and outreach, all to produce user-defined data and information. **We will specifically focus on high-priority PNW applications of: a) maritime operations; b) ecosystem impacts including hypoxia and harmful algal blooms; c) fisheries; and, d) mitigation of coastal hazards to guide our efforts** as these issues represent those having the greatest impact on PNW citizenry and ecosystems and, we believe, are amenable to being substantively improved with the development of a PNW RCOOS.

C. Audience

The PNW RCOOS we propose to develop will benefit many users in the region that depend upon these waters and/or whose activities have profound effects on them. We list below subsets of the PNW user community that will immediately benefit from RCOOS products supporting the four prioritized application areas noted in the above section. A more specific articulation the audience for products in these application areas is provided in the Benefits section of this proposal. This information reflects results from several years of NANOOS efforts to directly engage with the diverse range of PNW stakeholders as we built an understanding of their user needs and requirements.

i. Maritime Operations: 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). Additionally, the US Coast Guard (USCG) District 13 stations annually conduct thousands of Search and Rescue (SAR) missions, typically saving hundreds of lives. With two refinery complexes and a web of distribution routes to coastal and estuarine waters, transportation of oil is a major industry. Since 1985, regional spills from vessels and land facilities include five of over 50,000 gallons. Coast Guard sponsored studies have identified the Central Puget Sound, Rosario Strait and the offshore approaches to the Strait of Juan de Fuca as having the highest relative risk for potential accidents that could also involve petroleum spills. The petroleum transport industry, oil spill response organizations and the existing USCG Vessel Traffic System thus need both real-time surface and sub-surface current data and robust numerical models to predict spill trajectories. Our PNW RCOOS will provide information and near real-time data to enhance the safety of marine operations, improve SAR operations, and increase the effectiveness of oil spill remediation. Audience: Numerous commercial Port Authority Offices in Puget Sound and on the Columbia River, and along the coast (e.g., Grays Harbor, Astoria, Tillamook Bay and Newport), Pilotage services, the Vessel Traffic System, and the USCG District 13. **NANOOS Members engaged to guide our development in this area are** the Maritime Exchange of Puget Sound, the Ports of Newport (OR) and Neah Bay (WA), Council of American Master Mariners, and the Puget Sound Harbor Safety Committee.

ii. Ecosystem Impacts: Water quality degradation of PNW coastal waters and estuaries is an increasing concern for environmental management agencies, municipal governments, aquaculturists and coastal residents. Harmful algal blooms can disrupt the shellfish industry and pose human health concerns. These blooms have had a devastating economic effect on coastal communities already suffering from changes in forest practices and harvests. Low oxygen levels have caused massive die-offs of organisms along portions of the Oregon and Washington coasts. Our PNW RCOOS will provide observations and predictions of physical oceanographic conditions such as temperature, salinity, and currents can be coupled with bio-chemical measurements of dissolved oxygen, water column and sedimentary pollutants, chlorophyll concentrations, primary productivity, and species abundance giving managers enhanced abilities to recognize and forecast conditions and protect ecosystem quality. Audience: U.S. EPA Regional Offices, Oregon, Washington and California natural resource, environmental quality and ecology departments; Tribal governments; and local county resource divisions. **NANOOS Members engaged to guide our development in this area are** the WA Dept. of Ecology, OR Dept of Land Conservation & Development, Puget Sound Action Team, Quileute Indian Tribe, Western Association of Marine Labs (WAML), and the Surfrider Foundation.

iii. Fisheries: Governmental regulation has, in some if not most PNW ground-fish capture fisheries, significantly diminished fishing opportunity in order to keep wild stocks from complete exhaustion. Lack of consistent, long-term environmental data capable of adequately characterizing the coastal and ocean environment makes fisheries management decisions difficult. Determining the environmental links is at best problematic. The Dungeness crab fishery is one of the most valuable commercial fisheries in the PNW coastal waters, yet population fluctuations and incomplete understanding of environmental forcing of larval recruitment for this species can make effective stewardship and harvesting schemes managerially difficult. Our PNW RCOOS will provide data on the bio-physical environment to permit more effective understanding of such forcing and, as our knowledge matures and technologies become more robust, provide coupled bio-physical modeling of coastal regimes on a real-time and forecast basis to permit effective and understandable management decisions. Audience: Oregon, Washington and California health and natural resource departments; Tribal governments and enterprises; Aquaculture companies, commercial and academic researchers and shellfish trade associations. **NANOOS Members engaged to guide our development in this area are** the Quileute Indian Tribe, Northwest Indian Fisheries Commission, Hood Canal Salmon Enhancement Group, PNW Salmon Center, and the Puget Sound Action Team.

iv. Mitigation of Coastal Hazards: Beaches along the Oregon and Washington coast are significantly impacted by 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. Collectively, winters with enhanced storm activity have contributed to some of the most significant and costly examples of coastal retreat. In the majority of cases, direct observation of the effect of the storms or storms-in-series were not measured, with coastal managers having to respond to the erosion without a complete understanding of the spatial and temporal dynamics of coastal change. 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 migration shoreward of wave breaking occurring closer to the jetties than in previous decades. Had these jetties breached during a major winter storm, allowing sand to infill the main shipping channel, a significant detrimental impact would have been felt by the economies of both Oregon and Washington. Our PNW RCOOS will provide observations and modeling results on beach profiles and waves to coastal managers to facilitate better planning and response. Audience: WA and OR natural resource departments, USACE, USGS, local government planners, geotechnical engineers, shipping interests and the public-at-large. **NANOOS Members engaged to guide our development in this area are** the OR Dept of Geology and Mineral Industries, the WA Dept of Ecology, and Oregon State University.

D. Approach

We structure our proposed work plan to address the four prioritized PNW application areas to directly respond to the seven objectives of this proposal we listed in the Goals and Objectives section. In this manner, we directly tie components of the observing system subcomponent of the RCOOS, with the DMAC subcomponent, the modeling and products subcomponent, and the education and outreach subcomponent into what will be the totality of the RCOOS. In the next section, we further this necessary integration by listing specific data products we intent to produce to specific users.

i. Observing system subcomponent: We propose enhancement to four observational domains of the NANOOS RCOOS: the coastal ocean shelf, coastal ocean surface currents, estuaries, and shorelines.

To address the coastal ocean surface currents, we will **maintain existing surface current mapping capability and expand with new prioritized HF radar sites in the PNW.** This tool is a fundamental foundation block for building an observing system for the coastal ocean and serves a multitude of disparate users.

Existing Washington-Oregon-California coast HF assets: We propose to extend deployment of the present HF array, providing operation, maintenance, product delivery and product expansion. Our plans leverage partial funding already committed through the NSF Science and Technology Center CMOP. Products presently delivered include surface current maps at 3 scales for the PNW, delivered in near-real time to the web (http://bragg.coas.oregonstate.edu). Products to be developed and delivered include: (a) delivery of digital data, first in simple ascii tables associated with each map, working toward query-able forms and map-based tools for data selection; (b) short-term current predictions using forecast winds and subinertial current/wind statistics based on Zelenke (2005)[30], with tidal current estimates added to enhance the predictions; (c) particle trajectory tracking based on recent currents and predicted trajectories based on (b). OSU (M. Kosro) will continue lead on this effort.

New Washington coast HF assets: We propose to enhance the HF long-range array to provide coverage north to the Canadian border (Appendix 1C). The present HF array stretches from northern California into southern Washington. The addition of 3 more long-range HF radars would allow us to provide data for the entire offshore Pacific Northwest. In addition, the California Ocean Current Mapping Project (COCMP) is funded to provide similar long-range HF coverage along their entire coast, ramping up over 2-3 years, so that together we would be providing real-time surface current information along the entire U.S. west coast. We propose acquiring one new site in Y2 and two new sites in Y3, working south to north. Nominal locations would be Pacific Beach, La Push, and either Neah Bay or, with Canadian cooperation, a site on western Vancouver Island, which would allow us to map the region of the Juan de Fuca eddy, which plays a large role in HABs[29,47,48]. OSU (M. Kosro) will direct this effort in collaboration with UW staff.

New port HF assets: We propose to install and operate real-time X-band wave radars and short-term forecasting at two coastal ports. We note that five people have died in three separate accidents on the Tillamook bar in just the past year. This site is just one of numerous dangerous navigational channels and inlets found in the PNW. NANOOS products can contribute to marine safety for a wide variety of coastal user groups including the commercial fishing industry, the port industry, and recreational boaters. To address this application we propose to install several mobile marine radar wave observation systems at high-priority navigational inlets in the PNW. Under the NANOOS Pilot Project, a mobile marine radar wave observation system was developed consisting of an X-band imaging radar coupled with a customized data acquisition system[49]. The system is specifically designed for high spatial and temporal resolution, necessary for nearshore applications. The system is wholly contained within a mobile trailer with an attached tower deployable to 30ft elevation and is deployable at remote sites with all-terrain vehicle access. At each inlet where the systems are installed, a short-term deployment of a PUV gage will be used to calibrate radar for wave height extraction, after which the radars will provide real-time information on wave directions, period, height, and breaking. M. Haller (OSU) will lead this effort and will integrate the data into a local wave forecasting model.

To address the coastal ocean shelf, we will **strategically expand coverage and range of observations in the PNW shelf, in coordination with emerging national programs.** We will target use of fixed (buoys) and mobile (glider) assets to provide advanced information on hypoxia/anoxia and HABs, which are major regional concerns affecting ecosystem and human health, fisheries, and coastal economies. We propose to support two offshore buoys, one in Oregon waters and one in Washington waters. We propose to expand the cross-shelf footprint of those moorings by running cross-margin autonomous underwater vehicle glider lines. The moorings and glider will measure temperature, salinity, pressure, cholorophyll fluorescence, suspended particle load, dissolved oxygen and nitrate. Surface moorings will measure standard meteorological parameters (wind, radiation, air temperature, etc.). The following is arranged geographically, from north to south.

Proposed Washington buoy: We propose to place a multi-parameter, near real-time reporting buoy in 80 m depth off the northern Washington coast (48 0'N, 124 56'W) (Appendix 1C). This mooring will capture hypoxia at the mid shelf and filaments of high, often toxic phytoplankton emanating from the Juan de Fuca Eddy[23,46]. These filaments are transported to the coast during downwelling to potentially infect coastal clams with domoic acid.

Proposed Oregon buoy: OrCOOS is currently supporting a mid-shelf (80 m) mooring off Newport, OR, but as noted above, funding for OrCOOS expires in 2007. See Letter of Support by OrCOOS. The central Oregon buoy location (44 38.0'N, 124 18.22'W) is located to sample the high-velocity alongshore coastal jet which has proven valuable for accuracy of a regional data-assimilating coastal circulation model[43]. We propose to continue supporting this central Oregon, mid-shelf mooring. This mooring is on the northern flank of Heceta Bank, a known region of high primary productivity and hypoxic bottom waters[38,27] also thought to incubate HABs which are transported shoreward and northward during downwelling, toward north Oregon and south Washington beaches[52].

Proposed Oregon glider: Also within the OrCOOS system is a coastal glider transect off Newport along 44 39.1'N through fall 2008 (20-m isobath to 45 nm offshore). We propose to continue the existing glider line off Newport (44 39.1N) starting in Y2 of this work.

The two NANOOS moorings will be at the same water depth (80 m) to aid comparisons and for uniformity of data for ocean products and model input. Together, the three shelf observing assets will be used to provide timely information about the severity and extent of recurring summertime hypoxia off the central OR and that has developed off the northern WA coast as well as to understand HAB dynamics and potentially predict PNW-wide ocean ecology impacts. This joint effort will be conducted by UW (M. Alford) for WA and OSU (J. Barth/K. Shearman) for OR.

Relationship to NSF's ORION Ocean Observatory Initiative Program: NANOOS will adjust its in-water observational array as the proposed NSF OOI Pacific Northwest observatory elements come on line. For example, the NANOOS buoys proposed here will be used to maximize the spatial coverage of important oceanographic features and major ocean user focus areas (e.g., ports, fishing grounds). We note that NSF OOI installation plans are still several years off, likely near the end or after this proposed NANOOS effort.

To address the estuaries, we will **maintain and expand observation capabilities in PNW estuaries.** The desired objective is a federated real-time observation network across Oregon and Washington estuaries to address their sustainable management and utilization, with assets strategically prioritized based on societal needs.

Existing estuarine observations: NANOOS observation networks will be maintained at the two estuaries with largest economic and ecological footprint in the Pacific Northwest (Columbia River and Puget Sound). Both estuaries have established but mostly academic or project-driven observatories, which need additional staff to be operated at the higher degree of reliability and service required for ensuring the data quality and consistency envisioned by NANOOS. Through this proposal, field staff and non-personnel resources will be dedicated to each estuary. Staff and resources will be managed respectively by UW (A. Devol/J. Newton) for Puget Sound and by OHSU (A. Baptista) for Columbia River, both of which have established credentials in managing complex real-time observatories, setting regional examples, and exporting technology and standards in the region. Both observatories will also have lead responsibility in setting the NANOOS standard for "operational" maintenance and data quality control of estuarine observatories, will host one regional meeting per year focused on technical coordination across field staff of observatories, and will conduct a technical training session per year in areas of strength of the anchor observatory. Finally, where appropriate and feasible, both estuarine observatories will explore means of providing assistance to other observation assets in their regions of influence – with the goal of creating replicable models of system-specific optimal coordination and integration of resources thus entraining existing sub-regional assets such as Community Colleges, Marine Laboratories (via WAML, a NANOOS member), and other groups.

NANOOS will also help support observation networks in the Grays Harbor/Willapa Bay and South Slough/Coos Bay estuary clusters. Estuaries in these clusters include major ecological reserves as well as extractive industries (e.g. oysters, fisheries). This proposal will supplement already existing field staff and non-personnel resources provided by WDOE (S. Jaeger) for the Grays Harbor/ Willapa Bay cluster and by the OR Department of State Lands (ODSL; S. Rumrill) for the South Slough/Coos Bay cluster. Both institutions were effective participants in the NANOOS Pilot. The latter cluster also links the NANOOS estuarine observation network to the NOAA/states network of National Estuarine Research Reserves. WDOE will accelerate its emergent effort to add real-time capabilities to a station in Willapa Bay and establish a real-time observation station in Grays Harbor. ODSL will expand its South Slough network to include three stations is Coos Bay and will accelerate its emergent effort to add real-time capabilities to the network. Both groups will strengthen ongoing collaborations with OHSU and UW towards compatible standards and protocols in data collection and quality control.

To address the shorelines, we will **maintain and expand core elements of existing beach and shoreline observing programs in Oregon and Washington.** This can improve coastal hazard mitigation by providing better decision support tools for coastal managers, planners, engineers, and coastal hazard mitigation decision makers.

Existing beach observations: Beach and shoreline observing systems were undertaken through a joint program between WDOE and the USGS[50]. Components of the monitoring program include: geodetic control; topographic beach profiles collected quarterly at 47 locations, spaced roughly 2-4 km along the 165 km Columbia River littoral cell; sediment size distributions; topographic 3D beach surface maps covering ~4 km of shore and surveyed annually at 16 sites; and, nearshore bathymetry collected out to water depths of 10 m. Beach monitoring has been undertaken using a variety of Real-Time Kinematic Differential Global Positioning System surveying techniques. The beach and shoreline data (now spanning 10 years) have become a valuable regional resource, providing insight into the impact of climate variability (e.g., ENSO cycles) on beach morphology as well as resolving seasonal to interannual beach variability and trends. In 2004, the NANOOS Pilot monitoring network involving a technology transfer from WA to OR saw the establishment of a beach observation program in the Rockaway littoral cell, later expanded to include the Neskowin cell and the Clatsop Plains. The program includes: Topographic beach profiles, collected quarterly at 46 sites, spaced ~1 km apart; 3D beach surface maps, collected at 3 sites in the Rockaway littoral cell (surveyed annually); and recently, beach profiles, collected biannually at 70 sites, spaced ~1 km apart on Central Oregon beaches. NANOOS will sustain these core beach and shoreline mapping programs, with the expansion of a pilot bathymetric surveying program in the Rockaway littoral cell to develop the fundamental data set necessary for shoreline and beach profile modeling in that cell. WDOE (G. Kaminsky), DOGAMI (J. Allan/V. McConnell), and OSU (P. Ruggerio) will collaborate on this effort.

ii. Modeling and products subcomponent: Our stated objectives for enhancing the modeling capability of NANOOS is to **create a federated system of numerical daily forecasts of PNW circulation** to meet user needs of marine operators, first responders, and environmental managers and to **commence testing of state of the art cross-shore profile change models and probabilistic shoreline change models** that can be used by coastal managers to assist with predicting future coastline positions. The NANOOS vision requires the availability of a range of modeling tools in support of stakeholder needs.

For PNW circulation modeling, we propose to develop integrated daily circulation forecasts of PNW circulation, extending from the head of tide of estuaries to the outer edges of the EEZ. The ultimate goal is to develop the ability to respond on a 24-7 basis to the need for routinely integrating forecasts of PNW circulation in the standard toolkit and knowledge base available to emergency responders and environmental managers. To achieve this goal, we propose a phased approach:

- Integration, demonstration and enhancement of existing forecasting capabilities at OHSU, OSU, UW
- Export of forecasting capabilities to NOAA and other national operational forecasting/response centers
- Creation of a 24-7, operational, NANOOS response team for regional circulation needs

Many of the components exist to provide extensive coverage of the PNW EEZ with circulation forecasts. The following forecasts are already being produced on a regular basis: Multiple daily forecasts of circulation in the Columbia River estuary and extended plume (OHSU, NOAA-NOS); Daily forecasts of circulation in the Oregon continental shelf (OSU); Daily forecasts of circulation in Puget Sound (UW); Daily forecasts of circulation in multiple small PNW estuaries (OHSU); Daily Eastern North Pacific circulation forecasts (NRL). However, the quality of these forecasts is variable, there is little synergy across forecasts generated by different groups, and there is no strategy for integration of forecasts across scales, and no mechanism to support users on a 24-7 basis. NANOOS provides the opportunity to address issues of integration, quality control, technology export and user-oriented operational centers.

NANOOS Member organizations OHSU (A. Baptista, Y. Zhang), OSU (A. Kurapov), and UW (M. Kawase, D. Jones) will develop joint approaches to regional integration and quality control of the circulation forecasts that each institution currently maintains. In particular, these groups will: agree on and implement protocols for model quality control and for exchange of model outputs; develop practical and effective strategies for fusing their various forecasts into a “best guess” daily forecast covering the entire PNW EEZ and characterizing associated uncertainties; conduct demonstrations of forecasting capabilities in Y2 & Y3, in coordination with the NANOOS response team, see below, (we anticipate Y2 demonstration to focus on search and rescue; Y3 demonstration on oil spill response); and continue the enhancement of their institutional forecast products, leveraging other funding.

We propose to create in a state, non-profit, or private sector framework (to be defined) a user-oriented operational center with the expertise and 24-7 operational capability to interpret and add value to daily forecasts generated by both national operational centers and by NANOOS academic partners. The charge of the center will not be to develop models, but rather to foster their effective use for a broad range of regional purposes, and to recommend priorities for future NANOOS-supported development of forecasting capabilities. We intend the staff to be composed of professionals with MS or PhD degrees and experience in interpreting model results and observational data. This staff will have access to professionally maintained computer and storage hardware.

In the formative year of the operational center (Y2), the emphasis will be in internal organization, staff training, cultivation of a user community, and set-up of a demonstration of the integration of the NANOOS forecasting capabilities. This first demonstration, focused on search and rescue, will be planned in collaboration with relevant state and federal agencies, and will involve a field exercise designed to test near real-time forecasting capabilities. In Y3, the center will begin 24-7 operations, will continue the cultivation of the user community, will recommend a process for operational certification of forecasts (necessarily through a government entity), and will set-up a second demonstration (likely focused on oil spill response). Following certification, to explore transitioning technologies, we suggest that OHSU, OSU, UW, or combinations of these institutions, could transition their forecasts to national centers that would be able to run such forecasts on a stable basis. We anticipate that such transitions would allow NANOOS to continue to improve and innovate our forecasts locally.

NANOOS will utilize web portal capabilities to provide a suite of user products and tools. Some will be standard static visualizations that can stand-alone or be viewed via Google Earth. Other data will be made available through a data portal that leverages the work of the Global Ocean Data Analysis Experiment (GODAE).

In a separate modeling effort, NANOOS proposes to enhance sediment transport and morphological change numerical modeling efforts currently underway by the WDOE and the USGS adjacent to the Columbia River[51] and initiate a pilot shoreline modeling effort along the Rockaway littoral cell in Oregon.

NANOOS member organization OSU (Ruggiero), will develop the approach and quality control for cross-shore and probabilistic shoreline change modeling efforts at selected sites in WA and OR (with input WDOE, USGS and DOGAMI) in order to quantify the effects of climate change and variability (variations in wave approach, El Niño, PDO, secular increases in wave heights) on PNW beaches. This effort will include utilizing state of the art cross-shore profile change to quantify event-based cross-shore profile responses and associated coastal hazards on shorelines.

iii. DMAC subcomponent: An essential and enabling capacity for the end-to-end RCOOS is Data Management and Communications (DMAC). NANOOS will **bolster its ongoing DMAC activities to support routine operational distribution of data and information.** The NANOOS DMAC design mandates a collaborative, dynamic distributed system of systems that provides a wide range of products, tools and services to regional and local user communities while allowing unfettered access to the IOOS national backbone and national information infrastructure.

The DMAC architecture supports the functions of observing, processing, archiving and disseminating data through a set of recognized interoperability standards. The system of systems will have as its foundation a Dynamic Clearinghouse and a Web Portal providing public access to an inventory of existing and future data, metadata, services and products. This foundation has four primary requirements: 1) interoperability with national-scale applications, 2) reliable, efficient ingest of data from observational assets, 3) access to models, application tools and information products, and 4) rich yet simple interfaces for end-users available on a routine, unassisted basis.

From our user surveys, users want: real time data; value-added products; sustained information; and global interoperability. In response, NANOOS will emphasize the creation of standard products that are interoperable and sustainable over the long term. Access to the standard product suite includes metadata-driven query and browse interfaces, dynamic 2D plots for scattered observations, and interactive mapping for geo-referenced GIS layers. In addition to the standard products, custom and application products will be available through the NANOOS DMAC. These will be provided through a distributed network of data catalogues accessed through the Clearinghouse that support federally recommended standards and allow users to keyword search, parse data, select regions of interest and address multiple data sets in a consistent and coherent manner. The initial catalogues will come from established regional data sources with each catalogue exposing a set of standard interfaces based on a Service Oriented Architecture (SOA) to allow a dynamic, open system with embedded quality of service attributes that can accommodate long-term growth and support services such as publish/subscribe operations for automatic data delivery.

Although data, information, and products available through the NANOOS Dynamic Clearinghouse will be usable from a wide variety of web applications and sites, NANOOS will have an actively managed access point to the Clearinghouse called the NANOOS Web Portal (WebPortal). This Web Portal will use the Java Portlet Specification Standard, JSR 168, to develop a community-accepted, web portal environment. In order to allow for growth and iterative development, we will also incorporate the Web Services for Remote Portlets (WSRP) standard. This allows for distributed hosting of multiple portlets that are then aggregated into one web portal interface. In addition, the WebPortal will act as a focus for user support and the propagation of standards and common interfaces. As such, the content of the WebPortal will be continuously updated and improved based on user feedback. The chart in Appendix 1D illustrates the proposed architecture for both regional end users and national IOOS-level data calls.

Interoperability with national DMAC efforts will be intrinsic: the internal connections between catalogues will exercise the same DMAC compliant interfaces mandated by national efforts. The NANOOS DMAC is based on a true SOA capability with "automatic" quality assurance and testing. NANOOS DMAC will implement this SOA to enable applications to be created by combining loosely coupled and interoperable services. Services will interoperate based on formal interface definitions that are independent of the underlying platform and programming language. Thus NANOOS users will be able to discover, interact with and use data and capabilities to produce their desired products.

The distributed catalogues that are home to NANOOS data products and information will hold metadata records that describe geospatial information associated with the data and the means to access the data. Efforts to include data quality and uncertainties in metadata will be strongly supported. Remote catalogs not supporting standard interfaces could become "DMAC-enabled" by provisioning a DMAC appliance to them. For these, we propose to examine platforms known as appliances, an emerging paradigm in which hardware, software, and interfaces are built as a complete package that contains no "user-serviceable components." The appliance model alleviates configuration and administrative burdens of distributed systems. Each DMAC appliance will have the ability to: 1) ingest data in a variety of common formats, 2) communicate and share data with other appliances via DMAC formats and standards, 3) generate and serve the standard products suite. For NANOOS, appliances offer an effective means of managing a large distributed network with relatively few personnel.

The NANOOS DMAC organization is a distributed team whose mission will be to 1) design and build a more robust architecture implementation, 2) integrate products into the standard product suite, 3) support DMAC long term expansion and evolution and 4) maintain the core web presence for NANOOS. Three key roles support these objectives: a system architect, an interoperability engineer, and a user-product specialist. These three roles, respectively, have responsibility for: the systems design, construction and operation; direct control over both hardware interoperability and software interfaces; and the user and public interfaces, respectively. Because of the close ties between the three positions and the criticality of using resources most effectively for the team, NANOOS will implement a Lead – Co-lead approach in each position, derived from NANOOS member organizations. The Boeing Company (J. Pearlman) will lead the system architect role with OHSU (B. Howe/A. Baptista/) serving as co-lead. OHSU will lead the network engineering role with Boeing as co-lead. Finally, the UW (D. Jones) will lead the user- product specialist role with co-lead from OSU (M. Kosro/C. Risien).

iv. Education and Outreach subcomponent: For NANOOS to succeed as an IOOS RA, the most critical sub-component of the RCOOS is our collective ability to reach our users through outreach, training, and education. This effort will be aimed at all levels of the public, as well as specific user groups of the NANOOS network. In this subcomponent, we propose to **build from and strengthen ongoing NANOOS education and outreach efforts**. Conducted in coordination with other regional efforts, this will foster ocean literacy and facilitate use of NANOOS products in the PNW by stakeholders, decision makers, and the general public

The proposed NANOOS RCOOS will provide a new level of insight into the oceans around us through 24-7 observations and data delivery not previously available to such a wide audience. The products can yield a more ocean-literate society, but appropriate outreach and education are critical to realizing this improvement. Significant ground work in ocean basics, such as spreading the seven essential principles of ocean literacy as put forth by the Ocean Literacy Campaign (http://www.coexploration.org/oceanliteracy), needs to occur to make the utility of NANOOS assets apparent to citizens. Without these basic building blocks, the wealth of data and specialized products will be less meaningful to a range of users, from the Coast Guard to kindergartners. When citizens realize the benefits provided by their local RCOOS and IOOS, they will be more likely to support on-going funding for all such systems through Congress. The spread of ocean literacy principles using NANOOS products will be an overarching goal of this proposal, inherent in all activities.

For the Education and Outreach (E&O) subcomponent of the NANOOS RCOOS, we propose to sustain and enhance existing NANOOS programs that address three of the four priority user application areas of specific focus in this RCOOS development and we propose new activity for the fourth area. In addition, we address new education and curricula development. The work will be conducted by the NANOOS E&O Coordinator, an E&O Specialist, and a web resource specialist (for "Ed-Web"), working with the NANOOS E&O Standing Committee and OR and WA Sea Grants. We will establish a training group to meet with one user group per month. This will be coordinated with Marine Extension Agents and the NANOOS E&O committee to identify target groups, arrange for and attend meetings, and demonstrate use of NANOOS tools. A member of the NANOOS measurements and/or products team will participate in each of these meetings during the first year. Following each visit, the Coordinator will report on feedback to the NANOOS E&O and User Products committees.

We place priority on sustaining programs, already active within the NANOOS partnership, which accomplish ocean education and user-group outreach. Creating long-term stability for such programs is critical to building and maintaining active users of products delivered by NANOOS. The increase in real-time ocean observing assets will translate into greater demand of products and the subsequent increase in the need to teach and train people how to utilize these systems. There is a functional need for both teaching and training. Teaching addresses larger scale information and knowledge dissemination while training addresses specific details required for use of data output and communications available through NANOOS. The new tools that NANOOS will provide in the four target areas will have the best chance for success if (1) the tools are brought to the user communities, explained and demonstrated, and (2) the user communities provide feedback to the developers, so that the information can be delivered in a form that can be best used.

Our focus for "Fisheries" will be to foster our established NANOOS interaction with the Scientists and Fishermen Exchange (http://www.fishresearchwest.org/). Our enhanced participation will be in training members (both fisherman and scientists) to use NANOOS data and products, and therefore bring them into the NANOOS users group. SAFE is funded by a variety of sources (Sea Grant, NOAA, Pacific States Marine Fisheries Commission). M. Kosro (OSU) has worked to establish their trust of NANOOS for over two years. We will also engage with the NW Indian Fisheries Commission, a NANOOS member, to forge similar contacts with tribal fishermen.

Our focus within "Maritime Operations" will include further development of the Boater Information System (http://bis_portal.apl.washington.edu/) currently available through the NANOOS website. BIS reaches out to a large and economically significant marine sector: recreational boaters. BIS combines already available information on winds, tides and currents into a unique display engine specifically for recreational boaters. Users can see at a glance opposing wind and current data and make the decision to depart for their selected destination at a later time or take a different route. BIS is presently configured for Puget Sound only, but its infrastructure functions serve as a precursor for other tools and future expansion to be developed in this area. D. Jones (UW) has worked extensively for years to poll boaters and test product delivery.

Our focus under "Ecosystem Impacts" will include growing the joint pilot project of NANOOS and the National Estuarine Research Reserves (NERRS) of South Slough (OR), Padilla Bay (WA) and Kachemak Bay (AK). This project, underway with seed funds, is working with shellfish growers to display real-time observations of temperature and dissolved oxygen for shellfish bed management decisions. While the start-up phase of this project is funded, ongoing users will need education and training in its benefits and details. C. Angell, the NERRS co-PI for the pilot, submits her Letter of Support on this activity. We will also work to expand awareness of NANOOS ecosystem products within agencies with co-PIs on this proposal (WA Ecology, DOGAMI, ODSL) as well as to State and Tribal managers new to NANOOS (see Letters of Support by R. Shuman, King County DNR and J. Schumacker, Quinault Indian Nation).

For our focus on “Coastal Hazards,” the E&O Coordinator will engage with the PIs on this proposal for shoreline observations and modeling (J. Allan/V. McConnell, DOGAMI; G. Kaminsky, WA Ecology; P. Ruggerio, OSU) to develop needed delivery and training elements for user groups including state agencies, tribes, engineers, planners, and other stakeholders.

In addition to these four user-defined focus areas, NANOOS will place E&O effort on marine curricula and delivery via web. We call this “Ed-Web”. Other RCOOS (e.g., SEACOOS) have developed and disseminated curricula related to their observatory and provided that information into classrooms. These methods are effective at spreading information to the rest of the population via the students, parents, and communities. NANOOS will make use of materials that it can from other IOOS groups, and COSEE, to develop materials for our area, building on the best of what is in place already and adding regional specificity as necessary. This process of providing and vetting ready-to-use curricula becomes one that builds a community of educators that are users of NANOOS products – an important asset of any RCOOS.

Important contributors to this work will be marine education organizations that NANOOS is already currently engaged with. NANOOS will strengthen ties with the Ocean Inquiry Project (OIP) (http://www.oceaninquiry.org). OIP is a founding NANOOS member, which has been providing on-the-water marine science education coupled with research data collection for over six years. OIP serves community colleges and high-schools in the Puget Sound region and has reached over 1200 students. See Letter of Support by F. Stahr, OIP. In addition, we will engage the Northwest Aquatic and Marine Educators and the Western Association of Marine Laboratories on this element to determine what gaps need filling. This effort will start the development of a community of educators that will be leaders in using NANOOS products in their classrooms. OIP (A. Sprenger) will be a key catalyst of this effort.

E. Benefits

We provide in Appendix 2 a list of specific value added assets and associated products we will produce from this work in the four prioritized product application topics and their anticipated specific benefits to the identified users we elaborated on in the “Audience” section of this proposal. The contents of this table, with a basis in numerous workshops, were produced from meetings of the NANOOS User Products Standing Committee, composed of 10 members from diverse user groups, and have been vetted with representatives from additional user groups. We acknowledge major input from John Veentjer, Marine Exchange of Puget Sound, for Maritime products; Dan Ayers, WA Dept Fish and Wildlife, David Fox, OR Dept Fish and Wildlife, and Joe Schumaker, Quinault Indian Nation, for Ecosystem and Fisheries products; and Jonathan Allan, DOGAMI, for Coastal Hazards products.

The proposed NANOOS RCOOS has substantial regional support, as evidenced by the numerous and strong Letters of Support provided in Appendix 4 from a wide variety of stakeholders.

F. Milestone Schedule and Project Timeline

All facets of this effort, fully developed in the Approach section, will be managed by NANOOS President and proposal PI David Martin and NANOOS Executive Director Jan Newton. Details of deliverables and milestones are provided in Appendix 3. Prioritization of project sequencing is in accordance with the NANOOS stakeholder requirements and the draft Business Plan, co-developed by Casey Moore.

G. Project Budget (Form 424-A) and Justification

We detail a three-year, $9M budget, designed to develop a robust, end-to-end RCOOS for NANOOS. Detailed budgets, signed work statements, and budget justifications are provided in Appendix 5. We note The Boeing Company provides substantial cost-matching to their portion of the effort. This NANOOS effort is focused along needed RCOOS capabilities, not along institutional lines.

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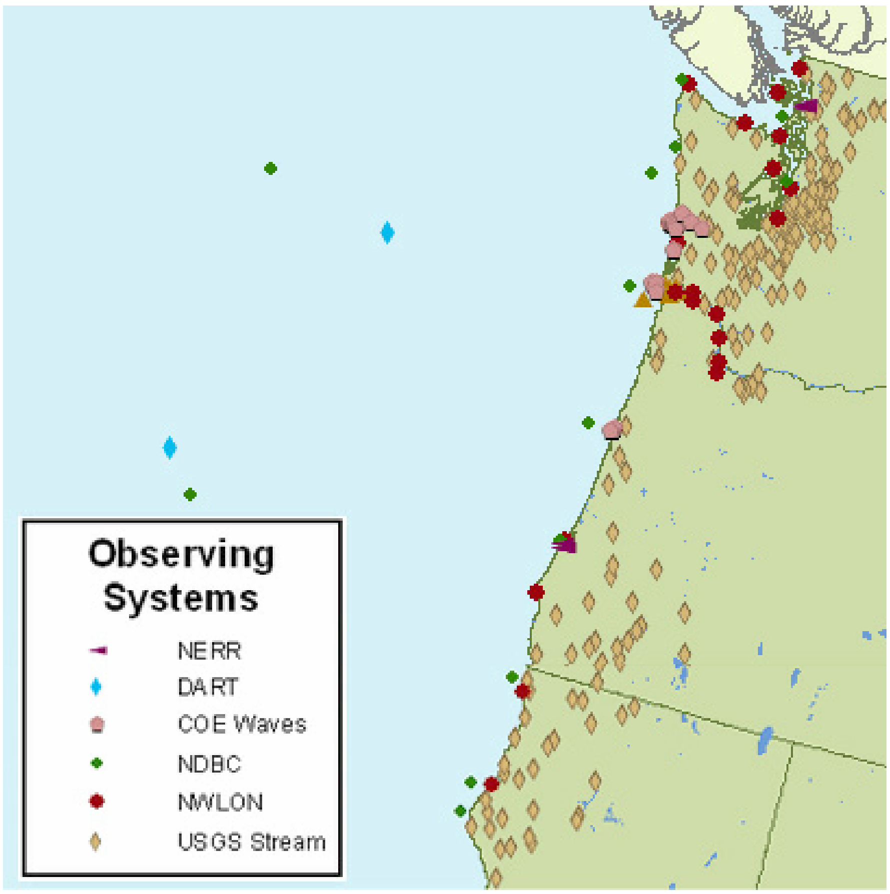
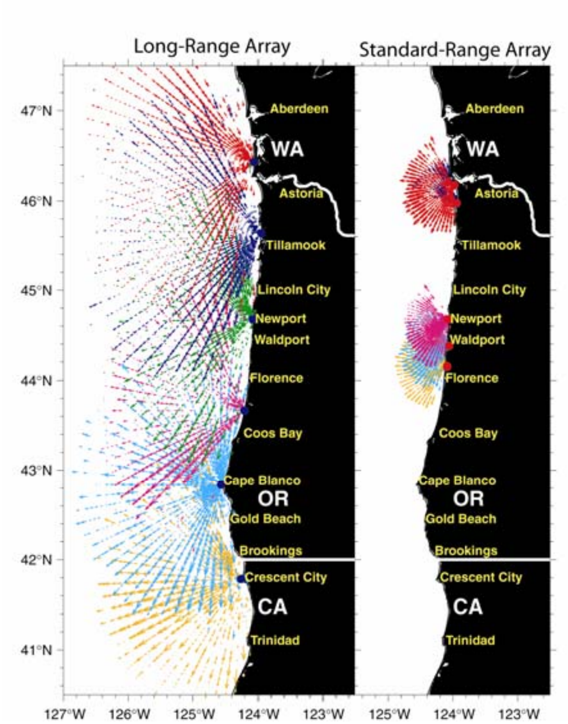
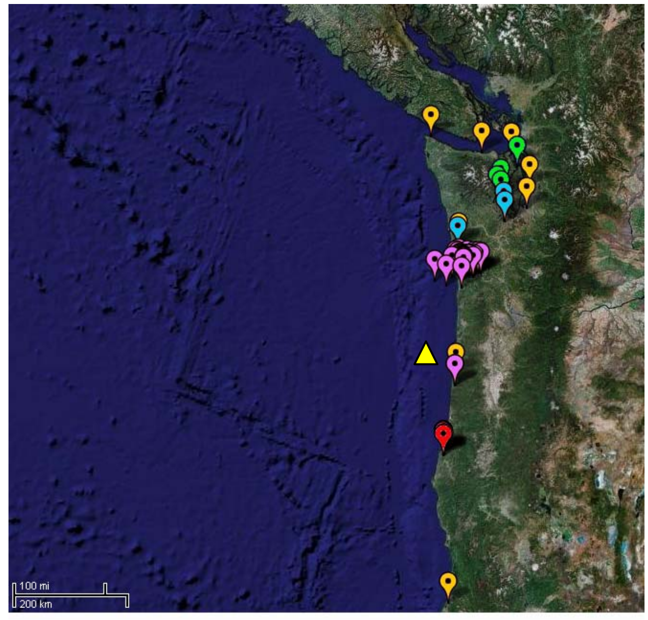
Appendix 1. NANOOS Maps and Charts



A. Existing Federal ocean, estuarine and riparian observing systems in the Pacific Northwest.





Locations of HF sites in the PNW

Six long-range systems (left panel) are operated near 5 MHz, with a range ~180km, range resolution ~6km, and angular resolution ~5 degrees.

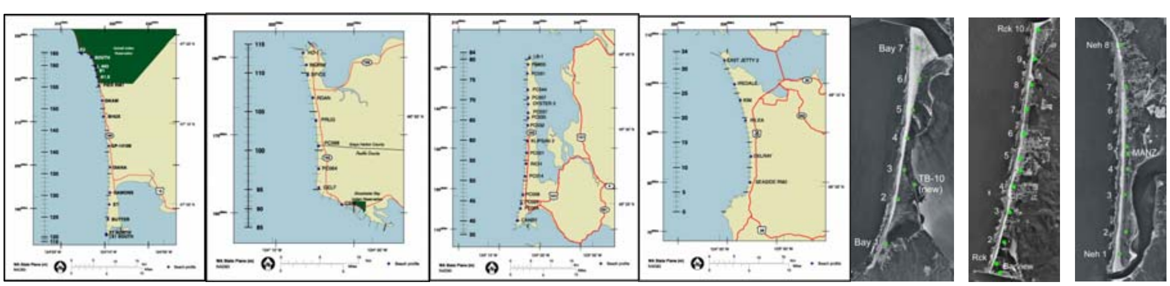
Five standard-range systems (right panel) are operated near 12 MHz, with a range ~50km, range resolution of 2km, and angular resolution of 5 degrees.

http://bragg.oce.orst.edu/

Locations of monitoring buoys in the PNW

Estuarine buoys operated by: golden (NOAA); green (UW); blue WDOE); purple (OHSU); red (ODSL/NERRS)
http://www.ccalmr.ogi.edu/nanoos/

Coastal buoys operated by: yellow (OSU/OrCOOS)
http://bragg.oce.orst.edu/



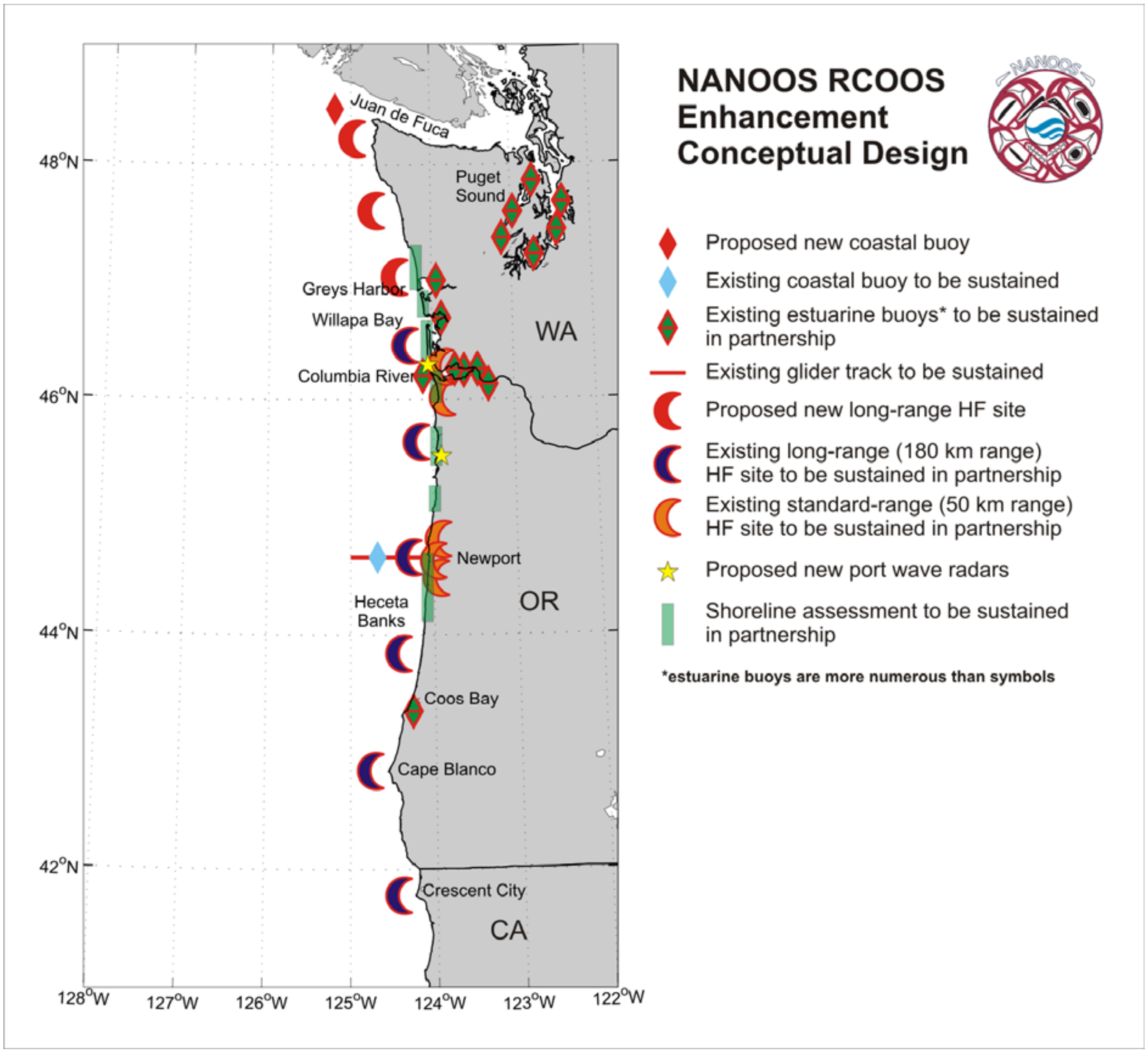
Locations of beach monitoring sites in PNW

Coastal beaches in Washington monitored by WDOE (left four panels): North Beach; Grayland Plains; Long Beach; Clatsop Plains.

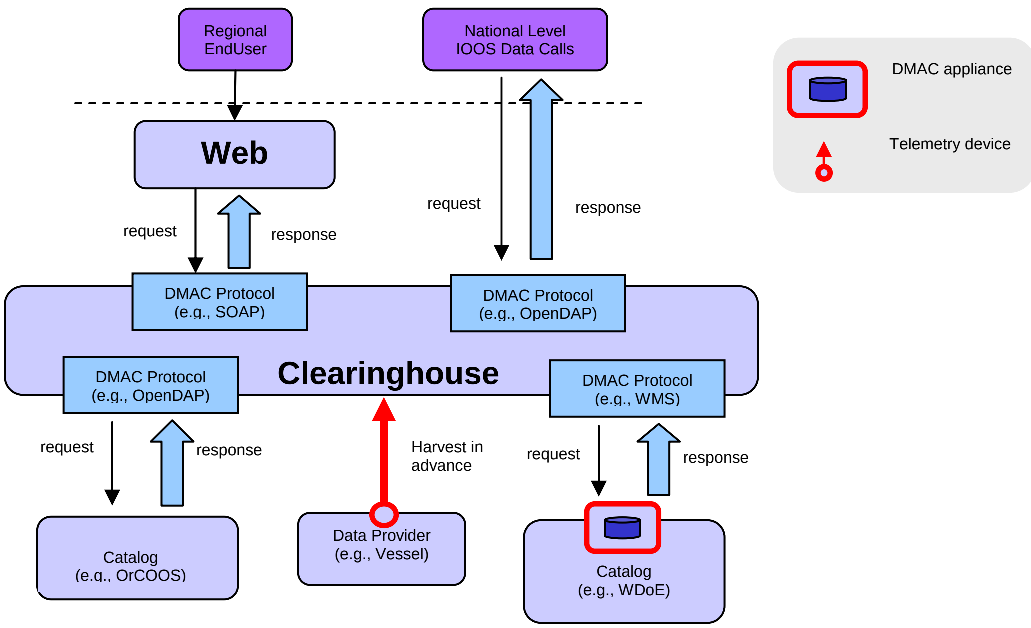
Coastal beaches in Oregon monitored by DOGAMI (right three panels): BayOcean Spit; Rockaway; Nehalem Spit

http://www.ccalmr.ogi.edu/nanoos/

B. Pre-existing observing assets that NANOOS has integrated. Data from all pictured assets are available via link from NANOOS website (http://www.nanoos.org).or directly, as per above.



C. Conceptual design for NANOOS RCOOS enhancements for observing assets to be funded from this proposed effort.



D. Chart showing NANOOS DMAC system of systems centered around a Clearinghouse and Web Portal. Requests may be served directly by the Clearinghouse or forwarded to remote catalogs. Some catalogs will be "DMAC-enabled" by deployment of a DMAC appliance.

Appendix 2. Specific benefits to users from proposed NANOOS product developments in the four NANOOS stakeholder prioritized areas.

Maritime Operations

Value added Asset	Product	Users and benefits
Search and Rescue Trajectory Maps	Integrate winds, tides, current measurements (e.g. HF Radar), models, and develop a full end-to-end Search & Rescue trajectory interface (test success of future cast maps with aide of US Coast Guard, i.e. deploy 'guinea pig' and track)	• Maritime domain Search & Rescue authorities and resources (e.g., District 13 Coast Guard, and local rescue authorities) will have accurate data fields to constrain and aid their search and rescue efforts.
HF radar array: hourly measurements of surface currents (expand low and/or high resolution sites) - proposed low resolution site (e.g. central WA) - possible high resolution site (e.g. Coos Bay or Col. R)	Expand existing surface current maps to include coverage of central WA Coast. Develop futurecast (24hr, 48hr) maps of surface current vector maps for the coast of OR and WA (approach incorporates wind climatology). Provide links to reduced data.	• Fishermen (SAFE), Search & Rescue (Coast Guard), Maritime Industry (including the numerous Port Authorities in the PNW, Marine Exchanges, port pilots, mariners and mariner organizations (e.g., Council of American Master Mariners), oil spill responders, research vessels, and Recreational boaters will have more accurate sea condition data to improve safety of their personnel and operations. • Researchers will have more accurate input data for better predictive modeling work.
Tide model GUI interface for any site along the PNW/ Northern California coast	Develop a GUI interface for depicting tides anywhere along PNW/Northern California coast.	• Mariners, Boaters, Fishermen, Public-at-large will have easily accessed data to assure safer operations and planning for coastal access, oil spill contingency and clean-up responders.

Ecosystem Impacts

Value added Asset	Product	Users and benefits
Real-time data from shelf buoys and glider transects including oxygen	Time series of oxygen and other water properties Circulation model maps	• Resource Managers (WA and OR Depts of Health, WA Dept of Fish and Wildlife) and Tribes (Quileute Tribe, Quinault Indian Nation) will have better information on coastal conditions to aid in environmental management in light of coastal hypoxia.
Circulation models	Surface temperature, salinity, currents (nowcast and future cast e.g. 24h, 48h etc.)	• Resource Managers, Tribes, and Researchers will have better idea of when/where harmful conditions, such as hypoxia and HABs will reach their areas.
Real-time data from shelf buoys near Juan de Fuca eddy and Heceta Head, the "breeding" areas for HABs	HAB predictive variables: Wind climatology, nowcast, forecast (up vs. downwelling) Timing of spring transition Flow direction and strength of Columbia River Plume	• Resource Managers (WA and OR Depts of Health, WA Dept of Fish and Wildlife) and Tribes (Quileute Tribe, Quinault Indian Nation) will have better information on coastal conditions associated with HABs and so can make better decisions regarding harvest and chronic exposure risks. • Researchers will have better data to develop predictive models for HAB dynamics.
ODFW phytoplankton monitoring	Develop interface that incorporates ODFW phytoplankton monitoring efforts as HAB indicator	• Resource Managers (ODFW) will have better information on conditions associated with HABs

Regional Fisheries

Value added Asset	Product	Users and benefits
HF Radar	Nowcast surface currents Particle trajectory maps – larval transport	• Fishermen (recreational and commercial) will have better information on fishing conditions offshore, as well as assisting decision-making and safety.
Ocean circulation model	Surface and bottom temperature & salinity (futurecast maps: 24hr, 48hr).	• Fishermen (recreational and commercial) will have vital information related to where fish can be found, contributing to efficiency, effectiveness, and safety.
Hatfield MSC fisheries web portal	Liaise with WAML/HMSC to get fishery data available online	• Fishery managers (WDFW, ODFW) will have greater access to fishery assessment data and tools to better assess stocks.
Satellite data	Sub-sample satellite data for PNW region that targets SST, chlorophyll, sea surface heights, and vector winds	• Fishermen will have enhanced access to environmental data. • Researchers will have better access to data for analysis and identification of predictive relationships and verification of models.
Fish landing and survey information	Graphical time-series and map products for contemporary and historical data Compile NMFS trawl, acoustic, and other fish surveys data obtained off the west coast in an easily accessible format	• State fishery managers (WDFW, ODFW) and regional enhancement groups (HCSEG, PNWSC) will have easier access to context for stock assessments. • Recreational fishermen better track changes with time.
Beach profile and topographic data	Cross-shore beach profiles (from landward dune edge to ~ -10m MLLW), 3-D surface maps of nearshore benthic habitats.	• State fishery manager (ODFW) will have a better understanding of the relationship between razor clam population density and nearshore and beach morphodynamic characteristics.

Coastal Hazards (plus tsunamis)

Value added Asset	Product	Users and benefits
Beach monitoring data	Cross-shore beach profiles (from landward dune edge to ~ -10m MLLW), 3-D surface maps of complete nearshore planform, time-series plots of shoreline (and other beach contour) change.	• State coastal managers (DLCD, OPRD, ODFW, WDoE) , local government planners, geotechnical engineers, public-at-large, researchers, will have valuable information on the changing state and stability of OR and WA beaches.
Beach and shoreline models	Probabilistic assessment of the short and long-term coastal response to climate change and variability (e.g. to variations in wave approach, El Niños, PDO, secular increases in wave heights etc.).	• State coastal managers (DLCD, OPRD, WDoE) , local government planners, geotechnical engineers, public-at-large will have insight on impact to coast as a result of ENSO, climate change and rising sea levels and scientifically defensible coastal erosion/flood hazard maps for coast.
NANOOS tsunami web interface	Web-based time histories of tsunami arrival and maps of tsunami inundation, including links to evacuation brochures already developed by state agencies (OR, WA and Northern California)	• State coastal managers, FEMA, emergency managers (state and local government), local planners, geotechnical engineers, insurers, and the public-at-large will have better access to information depicting modeled tsunami inundation.

Appendix 3. Milestone Schedule and Project Timeline.

Area	**Sub-element**	**Y1**	**Y2**	**Y3**
Observations				
	Shelf	- Purchase equipment for coastal buoy at Juan de Fuca eddy for HAB warning focus - Maintain OrCOOS (OR) buoy in Newport line for hypoxia/anoxia alerts	-Purchase equipment to refurbish OR buoy - Maintain both WA and OR buoys for HAB & hypoxia alerts - Maintain OrCOOS (OR) glider transects on Newport line for extended range hypoxia assessment	- Maintain both WA and OR buoys for HAB & hypoxia alerts - Maintain OR glider transects on Newport line for extended hypoxia alerts
	Estuaries	- Maintain Puget Sound, Columbia River, Willapa Bay, Gray's Harbor, and South Slough moorings	- Maintain and expand Puget Sound, Columbia River, Willapa Bay, Gray's Harbor, and South Slough moorings - Improve estuarine monitoring systems to provide real-time data	- Maintain and expand capabilities of Puget Sound, Columbia River, Willapa Bay, Gray's Harbor, and South Slough moorings
	Shorelines	- Maintain quarterly profiles at 47 sites - Maintain 3-D mapping at 16 sites - Maintain expanded NANOOS Pilot efforts at 46 sites	Maintain quarterly profiles at 47 sites - Maintain 3-D mapping at 16 sites - Maintain expanded NANOOS Pilot efforts at 46 sites	Maintain quarterly profiles at 47 sites - Maintain 3-D mapping at 16 sites - Maintain expanded NANOOS Pilot efforts at 46 sites
	Currents	- Maintain OR radar sites and survey/obtain permits for three WA HF sites	- Maintain OR sites, purchase two long range HF systems - Purchase and install one X-Band port radar system at high priority port	- Maintain OR sites, purchase one long range HF systems. Install three WA systems - Purchase and install one X-Band port radar system at second priority port

Area	**Sub-element**	**Y1**	**Y2**	**Y3**
Modeling				
	Oregon/Washington Estuaries	- Integrate and enhance existing forecasting capabilities at OSU, OHSU, & UW	- Integrate and enhance existing forecasting capabilities at OSU, OHSU, & UW	- Integrate and enhance existing forecasting capabilities at OSU, OHSU, & UW
	Oregon/Washington Coastal Shelves	- Begin to develop state of the art cross-shore profile change models and probabilistic shoreline change models at OSU	- Continue development of cross-shore profile change models and probabilistic shoreline change models at OSU - Work with state agencies to test use	- Continue development, testing, and use of cross-shore profile change models and probabilistic shoreline change models at OSU
	Integrative Synthesis Operational Modeling	- Liaise with stakeholders to verify prioritized operational modeling requirements	- Initiate establishment of 24/7 operational modeling center. Investigate federal/state organizations for future transition opportunities. Focus on SAR applications.	- Move 24/7 operational modeling center to fully developed status. Confirm federal/state organizations for operational transition. Focus on oil spill applications.

Area	**Sub-element**	**Y1**	**Y2**	**Y3**
Data Management and Communications				
	Task 1: DMAC Systems Architecture Definition and Development	- The Boeing Company lead with OHSU co-lead develop conceptual systems architecture design in compliance with IOOS standards and protocols	- Refine and implement NANOOS DMAC systems architecture across NANOOS domain	- Stabilize fully mature NANOOS DMAC systems architecture across NANOOS domain; ensure exportability to other RA efforts and national enterprise.
	Task 2: DMAC Network Engineering Definition and Development	- OHSU lead with The Boeing Company co-lead develop NANOOS DMAC network engineering design in compliance with IOOS standards and protocols	- Refine and implement NANOOS DMAC network engineering across NANOOS domain	- Stabilize fully mature NANOOS DMAC network engineering protocols across NANOOS domain; ensure exportability to other RA efforts and national enterprise.
	Task 3: DMAC User-product development	- UW lead with OSU co-lead define NANOOS DMAC/Web interface specifications in compliance with IOOS standards and protocols based on direct liaison with NANOOS stakeholders	- Refine and implement NANOOS DMAC user products web interface design across NANOOS domain with initial nodes at UW, Boeing, OHSU, and OSU	- Stabilize fully mature NANOOS DMAC user products web interface across NANOOS domain; ensure exportability to other RA efforts and national enterprise

Area	**Sub-element**	**Y1**	**Y2**	**Y3**
Education and Outreach				
	E&O infrastructure	-Hire a new full time NANOOS Education and Outreach (E&O) Specialist to work with funded NANOOS E&O Coordinator, Executive Director, and education web (Ed-Web) specialist	-NANOOS E&O Specialist to work with NANOOS Administration, E&O Standing Committee, User Products Standing Committee and other stakeholders	-Continued work by NANOOS E&O Specialist and others involved -Liaise with stakeholders to assess efficacy of E&O efforts
	Ocean Literacy	-Focus on 7 basic principles of ocean literacy -Enhance collaboration with PNW COSEE efforts and NSF-funded CMOP STC ocean education efforts	-Initiate delivery of marine education material via web (Ed-Web) Specifically focus on enhancing ongoing PNW marine education efforts including OIP, NAME, and WAML efforts	-Stabilize fully mature marine education material via web (Ed-Web) and ensure exportability to efforts external to NANOOS
	Focus area products	-Begin development of education materials for four NANOOS focus areas of: fisheries, maritime operations, coastal hazards, and ecosystem impacts -Focus on SAFE for fisheries -Focus on BIS for marine operations -Continue joint pilot with NERRS for ecosystem impacts	-Continue development of education materials for four NANOOS focus areas of: fisheries, maritime operations, coastal hazards, and ecosystem impacts -Continue work with SAFE, BIS, and NERRS on educational products -Begin work with DOGAMI and WDOE on focus for coastal hazards	-Continue outreach of materials in four NANOOS focus areas -Sustain work with SAFE, BIS, and NERRS on products -Focus on state agencies and others for coastal hazards -Expand development of products based on user input
	Training	-Establish a training group to meet with one user focus group per quarter	-Implement training of prioritized target groups throughout region	-Continue training of prioritized target groups throughout region

Appendix 4. Letters of Support

1. Quinault Indian Nation
2. King County Department of Natural Resources and Parks
3. Washington Department of Fish and Wildlife
4. Washington Department of Community, Trade and Economic Development
5. Padilla Bay NERRS (National Research Reserve System)/Washington Department of Ecology
6. Oregon Department Fish and Wildlife
7. Oregon Department of Land Conservation and Development, Ocean Coastal Management
8. Oregon Parks and Recreation Department
9. SAFE (Scientist and Fishermen Exchange), Oregon Sea Grant
10. Surfrider Foundation
11. Hood Canal Salmon Enhancement Group
12. Ocean Inquiry Project
13. Marine Operations-UW
14. Coast Harbor and Engineering, Inc.
15. OrCOOS Sub-regional Observing System
16. CORIE Sub-regional Observing System
17. Friends of Grays Harbor
18. United States Department of Interior, Fish and Wildlife Service, Willapa National Wildlife Refuge Service

Budgets and signed work statements of NANOOS Partnership

1. UW
2. OSU
3. OHSU
4. The Boeing Company
5. Washington Department of Ecology
6. Oregon Department of Geology and Mineral Industries
7. Oregon Department of State Lands

Resumes for Principal Investigator and Key Project Co-PIs

1. Martin, UW
2. Newton, UW

3. Alford, UW
4. Allan, OR DOGAMI
5. Baptista, OHSU
6. Barth, OSU
7. Devol, UW
8. Haller, OSU
9. Howe, OHSU
10. Jaeger, WA DOE
11. Jones, UW
12. Kaminsky, WA DOE
13. Kawase, UW
14. Kosro, OSU
15. Kurapov, OSU
16. McConnell, OR DOGAMI
17. Moore, WETLabs
18. Pearlman, The Boeing Co.
19. Risien, OSU
20. Ruggerio, OSU
21. Rumrill, OR DSL
22. Sprenger, OIP
23. Stahr, OIP
24. Zhang, OHSU