Northwest Association of Networked Ocean Observing Systems

September 20, 2010

Ms. Regina Evans
NOAA IOOS
1100 Wayne Avenue, Suite 1225
Silver Spring, Maryland 20910

Dear Ms. Evans;

Following the guidance in the FY2011 Implementation of the U.S. Integrated Ocean Observing System (IOOS) Federal Funding Opportunity, this **Proposal Cover Sheet** forwards our proposal to sustain the Northwest Association of Networked Ocean Observing Systems (NANOOS) for the Pacific Northwest region as part of the US IOOS. Specifics include:

Proposal Title**: Sustaining NANOOS, the Pacific Northwest component of the US IOOS**

Topic Area: **1. Continued Development of Regional Coastal Ocean Observing Systems**

Complete information for the co-Principal Investigators:
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Duration of proposed project:
Five years, from 01 June 2011 to 30 May 2016

Proposed funding type requested:
Cooperative Agreement

Funding requested:
$20.0M

Sincerely,

e-sig

Dr. Jan Newton
NANOOS Executive Director

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2. PROJECT SUMMARY

Project Title: Sustaining NANOOS, the Pacific Northwest component of the US IOOS
Primary Contact: Dr. Jan Newton
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Recipient Institution: The University of Washington will serve as the funding administrator.
Other Key Investigators: David Martin (APL-UW; lead co-PI), Mike Kosro (OSU), Antonio Baptista (OHSU), Steve Uczekaj (Boeing), Jonathan Allan (DOGAMI), George Kaminsky & Carol Maloy (WDOE), Steve Rumrill (ODSL), et al.

Project Summary

The Governing Council of the Northwest Association of Networked Ocean Observing Systems (NANOOS), on behalf of its members, presents this proposal to maintain and enhance NANOOS as the IOOS Regional Association for the Pacific Northwest (PNW) and to fund the sustained operation of its Regional Coastal Ocean Observing System (RCOOS). The primary mission of the user-driven NANOOS is to provide PNW stakeholders with the ocean data, tools, and information they need to make responsive and responsible decisions, appropriate to their individual and collective societal roles. Sustained funding for NANOOS will ensure NANOOS' mission is successful.

Established in 2003, NANOOS used results from several years of NOAA-funded efforts and other regional contributions to build regional partnerships in the PNW, coordinate regional activities, and to identify high priority user needs and requirements. NANOOS members have identified the priority areas for product development within this end-to-end RCOOS to be: **a) maritime operations; b) ecosystem assessment and climate change, including PNW priority topics of hypoxia, ocean acidification, and Harmful Algal Blooms (HABs); c) fisheries and biodiversity; and, d) mitigation of coastal hazards**. We also recognize that these four priorities operate within the essential context of Coastal Marine Spatial Planning (CMSP), in which NANOOS is presently engaged with state, federal, and NGO regional partners.

Our goal is to sustain, and, depending on funding, enhance NANOOS, the PNW RCOOS that serves regional stakeholders in alignment with the vision of IOOS. NANOOS established its RCOOS with NOAA IOOS program and substantial leveraged funding, with much coordination of existing assets as well as strategic focus on new investments to produce data products serving PNW stakeholders and society in general. The PNW-managed and operated RCOOS with its essential subcomponents (integrated in-water and land-based Observing Systems, Data Management and Communications, Modeling and Analysis, and Education and Outreach) that are closely integrated with the US IOOS system has begun to provide significant societal benefits across a wide spectrum of users including federal, tribal, state and local governments, marine industries, scientific researchers, Non-Governmental Organizations (NGOs), educators and the general public.

For this period, our specific objectives are to:

1) **Maintain NANOOS as the PNW IOOS Regional Association:** Sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement.
2) **Maintain and enhance surface current and wave mapping capability.** Maintain existing HF-radar foundational capability and extend it to un-served areas in Washington, northward to the international border, providing critical national capacity, and continue investment in wave mapping at a critical port.
3) **Sustain existing buoys and gliders in the PNW coastal ocean, in coordination with national programs.** Maintain and harden these essential assets providing regional observations, with focus on hypoxia, HABs, ocean acidification, climate change detection and modeling input.
4) **Maintain and expand observation capabilities in PNW estuaries, in coordination with local and regional programs.** Maintain these to aid sustainable resource management, water quality assessment and sub-regional climate change evaluation, with high priority new feeds.
5) **Maintain and enhance core elements of beach and shoreline observing programs.** Contribute to hazard mitigation by providing essential observations and better decision support tools for coastal managers, planners and engineers, improving coverage and accuracy.

6) **Maintain, harden, and enhance NANOOS' Data Management and Communications (DMAC) system for routine operational distribution of data and information.** Sustain and enhance the robust DMAC system NANOOS has built, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS.
7) **Sustain and improve a community of complementary numerical regional models.** Sustain the operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the EEZ in both OR and WA, with strategic improvements to capabilities and scope.
8) **Create innovative and transformative user-defined products and services for PNW stakeholders.** Continue to provide and innovate to succeed in this vital translation: meaningful and informative data products that will connect with user applications and serve society.
9) **Sustain and strengthen NANOOS education and outreach efforts.** Foster ocean literacy and facilitate use of NANOOS products for IOOS objectives, the core task for which the entire NANOOS RCOOS is constructed, via existing and new approaches for engaging users.

NANOOS seeks to maintain and harden the RCOOS subsystems it has developed, implemented, and integrated with NOAA IOOS and substantial leveraged funding. Proposed enhanced developments for NANOOS include a focus on hypoxia, ocean acidification, biodiversity, within the context of CMSP and MPAs. NANOOS will remain focused on delivering to diverse stakeholders data-based products and services that are easy to use, to address high-priority issues and aid decision-making. NANOOS will continue its proactive interactions and regional coordination with a wide range of PNW stakeholders, to prioritize and refine our observations, products, and outreach efforts.

This 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 composed Board Members with diverse sector representation and Chairs of NANOOS RCOOS operational standing committees.

Partners

Partnering is strong within NANOOS. As detailed in the text, the proposed efforts will be conducted in partnership by several NANOOS membership organizations *(proposal partners: University of Washington (UW); Oregon State University (OSU); Oregon Health & Science University (OHSU); The Boeing Company; Oregon Department of Geology and Mineral Industries (DOGAMI); Oregon Department State Lands (ODSL); Washington Department of Ecology (WDOE); WETLabs, Inc., Pacific Ocean Shelf Tracking (POST); OR Sea Grant; WA Sea Grant and OSU Cooperative Institute for Marine Resources Studies (CIMRS))*. Additional collaborative partners in this work include the *NOAA Pacific Marine Environmental Laboratory (PMEL); NOAA Olympic Coast National Marine Sanctuary (OCNMS); NOAA Northwest Fishery Science Center (NWFSC); Quileute Tribe; Quinault Indian Nation; Padilla Bay and South Slough National Estuarine Research Reserves (NERRS); and The Nature Conservancy.*

There are three NANOOS Standing Committees: Data Management and Communication (DMAC), User Products (UPC), and Education & Outreach (E&O). Each committee has voluntary membership from a variety of groups, stakeholders, users, and interested parties. DMAC: Boeing, APL-UW, OSU, OHSU, Victoria Experimental Network Under the Sea (VENUS), DOGAMI (UPC Chair); UPC: DOGAMI, OR Sea Grant, NOAA CoastWatch, OHSU, APL-UW, OSU, Boeing, NANOOS E&O Chair and staff; E&O: OSU, Ocean Inquiry Project, Hood Canal Salmon Enhancement Group, OR Sea Grant, OHSU, WA Sea Grant, Hatfield Marine Science Center, Padilla Bay NERRS, COSEE Pacific Partnerships. All three committees interact intimately with each other and with the PIs.

NANOOS also coordinates with the National Science Foundation, which through its Ocean Observing Initiative will locate many observing assets in the region. NANOOS and OOI PIs have extensively coordinated a single design.

Beyond the PIs and collaborators, the NANOOS Governing Council, the guiding body for this work, currently is at 45 members composed of: academic and research institutions (10), tribal governments and tribal organizations (4), state and local governments (12), industries (7), and non-governmental organizations (12). See member list at http://www.nanoos.org/about_nanoos/members.php. All NANOOS members have signed the NANOOS MOA and participate on its Governing Council, which has approved the content of this proposal for submission.

3. PROJECT DESCRIPTION

A. Background

The Pacific Northwest (PNW) waters of the United States (US) 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 the Nation's national security, support a productive ecosystem, including significant natural and cultural resources, and provide exceptional recreational opportunities. The US Integrated Ocean Observing System (IOOS) was authorized by Congress to fill the gap between the importance of coastal ocean data and its lack of availability to various sectors of society.

In response in the PNW, the Northwest Association of Networked Ocean Observing Systems (NANOOS) was assembled by charter in 2003 and formally established by Memorandum of Agreement (MOA) in 2005. It has engaged representatives from a diverse set of stakeholders who are directly involved in the definition and execution of NANOOS within the region and as part of the US IOOS effort. Since 2004, NANOOS has received NOAA funds to build the PNW IOOS Regional Association (RA) and its Regional Coastal Ocean Observing System (RCOOS). NANOOS has executed this with substantial stakeholder involvement in every aspect: in defining the NANOOS RA, its governance, regional coordination, and prioritization, and in contributing to the RCOOS subcomponents: observations (e.g., note degree of leverage in Fig A.1); data management; analysis products; and outreach/education. NANOOS governance and practices are guided by its MOA, Conceptual Design, and Business Plan, all available at the NANOOS website: http://www.nanoos.org/about_nanoos/documents.php.

For governance, NANOOS has succeeded in establishing a Governing Council (GC) that is thriving and diverse. Membership has grown from over 25 in 2007 to 45 today. Its representation is from many sectors: 27% local, state, and federal government, 10% tribes and tribal organizations, 27% NGO/education organizations, 16% industry, and 20% academic institutions. NANOOS has a demonstrated governance structure, including an elected Board (15) of the GC with designated sector representation. The Executive Committee, comprised of the Board plus Chairs of three NANOOS operational standing committees (DMAC, User Products, Education & Outreach, collectively known as the Tri-Committee), advise the Board Chair and an Executive Director, who are responsible for leadership and overall management. They direct the NANOOS RCOOS, which PIs from seven institutions have operated since 2007 with guidance from the GC and close interaction with the Tri-Committee, which meets regularly to review progress and set priorities.

NANOOS has close involvement with British Columbia (e.g., Canadian coastal observing project VENUS is a Governing Council member) and is well-integrated with regional observing systems in Alaska (AOOS) and California (CeNCOOS, SCCOOS), and the California Current (PaCOOS). NANOOS is an active participant in the National Federation of Regional Associations (NFRA) and the US IOOS efforts.

NANOOS's development was guided by numerous years of meetings and stakeholder input that NANOOS continues to collect. Key developmental factors have been an equitable focus on coastal ocean, estuarine, and shoreline observations and on product development. To build the RCOOS for NANOOS, we integrated and leveraged regional scientists, agencies, and other entities who maintain coastal ocean observing assets (Fig A.2). Data and user-defined data products from these assets are currently available through NANOOS (http://www.nanoos.org) and its NANOOS Visualization System (NVS). Prioritization for NANOOS activities/products continues to be advised by our outreach and from active stakeholder involvement within NANOOS governance and within the RCOOS and its committees.

The NANOOS GC proposes here to sustain and enhance NANOOS: to maintain NANOOS as the IOOS RA for the PNW; to harden and strengthen existing infrastructure and capacity, assuring the reliability our users need; and to make selective increases in our capabilities in strategic topical areas dictated by our stakeholders.

B. Goals and Objectives

i. Goal: Our goal is to sustain, and, depending on funding, enhance NANOOS, the PNW RCOOS that serves regional stakeholders in alignment with the vision of IOOS. NANOOS seeks to maintain the integrated in-water and land-based observing systems, data management and communications, analyses and products, and education and outreach subsystems that it has developed, implemented, and integrated with NOAA IOOS and substantial leveraged funding. NANOOS will remain focused on delivering to diverse stakeholders data-based products and services that are easy to use, to address high-priority issues and aid decision-making. NANOOS will continue its proactive interactions with a wide range of PNW stakeholders, to prioritize and refine our observations, products, and outreach efforts.

ii. Objectives: Our NANOOS objectives (NO) are necessarily the sustained objectives we identified at the outset of creating of our RCOOS. These have been ratified for every proposal submittal by the NANOOS Governing Council, who put forth this request for continuance:

1) **Maintain NANOOS as the PNW IOOS Regional Association:** Sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement.
2) **Maintain and enhance surface current and wave mapping capability.** Maintain existing HF-radar foundational capability and extend it to un-served areas in Washington, northward to the international border, providing critical national capacity, and continue investment in wave mapping at a critical port.
3) **Sustain existing buoys and gliders in the PNW coastal ocean, in coordination with national programs.** Maintain and harden these essential assets providing regional observations, with focus on hypoxia, HABs, ocean acidification, climate change detection and modeling input.
4) **Maintain and expand observation capabilities in PNW estuaries, in coordination with local and regional programs.** Maintain these to aid sustainable resource management, water quality assessment and sub-regional climate change evaluation, with high priority new feeds.
5) **Maintain and enhance core elements of beach and shoreline observing programs.** Contribute to hazard mitigation by providing essential observations and better decision support tools for coastal managers, planners and engineers, improving coverage and accuracy.
6) **Maintain, harden, and enhance NANOOS' Data Management and Communications (DMAC) system for routine operational distribution of data and information.** Sustain and enhance the robust DMAC system NANOOS has built, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS.
7) **Sustain and improve a community of complementary numerical regional models.** Sustain the operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the EEZ in both OR and WA, with strategic improvements to capabilities and scope.
8) **Create innovative and transformative user-defined products and services for PNW stakeholders.** Continue to provide and innovate to succeed in this vital translation: meaningful and informative data products that will connect with user applications and serve society.
9) **Sustain and strengthen NANOOS education and outreach efforts.** Foster ocean literacy and facilitate use of NANOOS products for IOOS objectives, the core task for which the entire NANOOS RCOOS is constructed, via existing and new approaches for engaging users.

Because we seek sustained operation of a fully functioning RA and RCOOS, our objectives purposefully do not change from year to year of this 5-y proposal, although the work plan necessarily phases various efforts throughout the 5-y period, as budgets allow and technologies mature. NANOOS maintains the flexibility to respond to emergent regional needs, e.g., Marine Protected Areas (MPAs), by evaluating the specific work effort, in light of stakeholder input and evaluations of products and services, to see where improvements and/or re-direction are needed.

In achieving these objectives, NANOOS will adhere to a three-fold prioritization strategy that will guide our year to year efforts: 1. Our highest priority is to sustain the successful system we have in place, that is, the assets, capabilities, and policies that form our RA and RCOOS; 2 Moderate enhancement to the NANOOS budget will allow needed improvements to existing capabilities, allowing for equipment hardening and resolving sub-critical workforce issues; 3 Further enhancement will allow selected improvements to RCOOS, inclusion of strategic data streams and capabilities relevant to the objectives above and the topical priorities established by PNW stakeholders, per below.

C. Audience and Benefits

Our targeted audience is PNW user communities that stand to benefit from NANOOS products. Years of workshops and ongoing outreach has informed NANOOS that these are focused in four high-priority, PNW stakeholder-defined topical areas: **a) maritime operations; b) ecosystem assessment and climate change, including PNW priority topics of hypoxia, ocean acidification, and Harmful Algal Blooms (HABs); c) fisheries and biodiversity; and, d) mitigation of coastal hazards**. These topics are intimately linked to economy, health, and ecology of the region so NANOOS' audience and benefits map to society as a whole, in the PNW, the Pacific Rim, and beyond.

NANOOS established these priorities in the early years and has regularly sought input to ratify ongoing relevancy, user requirements, and to assess how well needs are being met. Input is from two main sources: formally we seek input from our 45-member Governing Council during our annual in-person meeting; throughout the year we interact directly with our stakeholders, users, and collaborators through on-going outreach and partnership, requesting feed-

back on our NANOOS web-based user products (e.g., theme pages, decision tools, NVS) and RCOOS activities (through PI meetings). ***Many of our RCOOS collaborators are our users (e.g., state agencies, NGOs) or play vital roles on our three operational standing committees (e.g., tribes, educators), so the interactions for feedback are direct, frequent, and two-way.***

We recognize that these four priorities operate within the essential context of Coastal Marine Spatial Planning (CMSP). NANOOS is presently engaged with a diverse group of regional parties (federal, state, NGO) involved in CMSP who have identified NANOOS' important and unique contribution to this wide-ranging effort and have sought NANOOS' involvement. See their letter of support (Appendix, p 3).

In addition, specifics on our four primary NANOOS audiences are offered here:

i. Maritime Operations: **Currently, NANOOS offers forecasts and observations of interest and utility to this audience for safety and planning.** Audience: Many commercial Port Authority Offices in Puget Sound, Columbia R, and along the coast, pilotage services, the Vessel Traffic System, USCG District 13, and numerous USCG coastal stations. **NANOOS members engaged in this area include** the Maritime Exchange of Puget Sound, Ports of Newport, OR and Neah Bay, WA, Council of American Master Mariners, and Puget Sound Harbor Safety Committee.

ii. Ecosystem Assessment and Climate Change: **Currently, NANOOS provides time-series and real-time observations and data products used to evaluate, and in some cases forecast, HABs, hypoxia, ocean acidification, climate change, and water quality.** Audience: U.S. EPA, Tribes; OR, WA and CA natural resource, environmental quality, and ecology agencies; and local/county resource divisions. **NANOOS members currently engaged include** WA Dept. Ecology, OR Dept State Lands, Puget Sound Partnership, Quileute Tribe, Pt Gamble S'Klallam Tribe, Quinault Indian Nation, Olympic Coast National Marine Sanctuary, WETLabs, Western Assn. of Marine Labs, Seattle Aquarium, Surfrider Foundation, and Nature Conservancy.

iii. Fisheries and Biodiversity: **Currently, NANOOS's forecasts and data on the bio-physical environment permit better-informed management decisions by fishers (from tuna fishers to shellfish growers) and regional managers.** Audience: OR, WA and CA health and natural resource departments; Tribal governments and enterprises; Aquaculture companies, commercial and academic researchers and shellfish trade associations. **NANOOS Members currently engaged in this area are** the NOAA NWFSC, Quileute Tribe, NW Indian Fisheries Com., Port Gamble S'Klallam Tribe, Quinault Indian Nation, WA Dept of Fish & Wildlife, OR Dept of Fish & Wildlife, Hood Canal Salmon Enhancement Group, PNW Salmon Center, Pacific Ocean Shelf Tracking Project, Columbia River Crab Fisherman's Association, and Puget Sound Partnership.

iv. Mitigation of Coastal Hazards: **Currently, NANOOS provides observations and analysis of topographic beach profiles, shoreline change, nearshore bathymetry, sea level change, and waves to improve planning and response to coastal hazards, to assist with engineering design, to aid with research on climate change impacts on the coast, and to track shoreline change in specific communities.** Audience: WA and OR natural resource departments, FEMA, USACE, USGS, local government planners, geotechnical engineers, shipping interests and the public-at-large. **NANOOS Members currently engaged include** OR Dept of Geology & Mineral Industries, the WA Dept of Ecology, OR Dept State Lands, OSU, and Northwest Research Associates.

v. Educators: Currently, NANOOS provides learning tools, real-time data lesson plans, exhibits, and other education materials to formal and informal educators. Audience: K-12 teachers, community colleges, aquaria and marine science centers, and other non-profit education groups. **NANOOS Members currently engaged include** Ocean Inquiry Project, Northwest Aquatic and Marine Educators Association, Hood Canal Salmon Enhancement Group, The Nature Conservancy, NOAA Olympic Coast National Maine Sanctuary, Seattle Aquarium, UW, Washington Sea Grant, OSU, Oregon Sea Grant, OHSU, UO, and the South Slough NERR. Other engaged groups include: three regional COSEE efforts, and the NFRA Education & Outreach Committee.

We provide in Table C.1 a table of specific products and their benefits to these audiences, both for products we intend to maintain, and for those we propose to develop in the next 5 years. Outreach to users to make use of these web-based products has been via our engaged NANOOS members, via workshops and one-on-one discussions.

As independent documentation that our activities and plans are actually providing benefit (i.e., does our table reflect reality; is NANOOS actually providing benefit?), we offer this observation: The NANOOS RCOOS proposal submitted in 2007 had strong regional support evidenced by 12 letters of support from users who anticipated benefits. We note that ALL of those organizations have stayed engaged in NANOOS; nearly all are now NANOOS members. Moreover in 2010, we note that 17 NANOOS users offered letters to the US Congress on the importance of NANOOS' work and the benefit they receive. Due to space limitation, these are only listed in the Appendix (p.1), but re-

flect the diversity of entities recognizing benefit from NANOOS. Their letters are available at http://doc.aoos.org/nfra/NFRA%20Letters%20of%20Support/NANOOS%20LOS_33.pdf .

D. Work Plan

Our work plan addresses the four PNW user-defined topical areas, education and outreach across all four, and by doing so, provides unique and essential input to CMSP. It carries out the objectives listed in section B, covering all subsystem elements of a RA/RCOOS. Per our strategic prioritization, we advance three levels of work effort and funding: maintaining core capability (A) and two levels of enhancement (B and C). Level A will support only essential existing observing and modeling assets, operations, and their data delivery. Level B hardens the infrastructure and capabilities, allowing NANOOS to replenish operational equipment and supplies, relieve system support personnel that are over-stretched, and increase our product and analysis capabilities. Level C will add additional capabilities, seeking to enhance product development and delivery in areas of high stakeholder interest. **With this modular plan (see Cost Proposal Table F2), NANOOS can meet its goal to maintain and assure current capacity and to strategically add improvements, relative to funding available, throughout all subsystem elements.**

i. Coordinated Regional Management for the PNW: NO.1. Maintain NANOOS as the PNW IOOS Regional Association, as an effective service to IOOS and PNW stakeholders. NANOOS proposes to sustain our proven capacity for regional coordination, administrative infrastructure, and stakeholder engagement and to maintain its role as the US IOOS Regional Association for the PNW. NANOOS has designed and implemented regional IOOS infrastructure for the PNW, based on seven years of stakeholder engagement, explained in the "Background" section. We propose to sustain management of NANOOS to continue its successful 5-y old governance structure, codified by our MOA, comprised of: 1) a decision-making Governing Council (GC) of representatives from member (MOA-signatory) institutions; 2) an Executive Committee to serve the GC's needs, composed of elected GC Board members and NANOOS operational committee chairs; 3) a Board Chair and Vice Chair for leadership; 4) an Executive Director for project oversight; and 5) distributed partner PIs who execute the subsystems of the NANOOS RCOOS.

For this and other proposals, UW acts as the fiscal authority on behalf of NANOOS, entering legally binding agreements, receiving and dispersing funds, and ensuring accountability. The co-PIs, *Martin (NANOOS Board Chair, UW)* and *Newton (NANOOS Executive Director, UW)*, will oversee sustained management, development, and operation of NANOOS in accordance with IOOS principles and according to the objectives of this proposal. The work plan for this element requires salaries and travel for the co-PIs in each year, to be used for oversight, reporting, coordination and evaluation that be required under each funding level. Our related work plan for Outreach and Education efforts that support NANOOS and its regional coordination is described in that subsystem element (v.) of this proposal.

In addition to results of seven years of regional workshops, both via NANOOS and other regional entities (e.g., Sea Grant, West Coast Governors), NANOOS has engaged its 45-member GC, with representation from diverse sectors and a regionally equitable distribution, to define and refine regional priorities. Its elected GC Board, with sector representation from federal, state and local agencies, tribes, academia, industry, and NGOs, and the operational Standing Committee Chairs (for DMAC, User Products, and Education & Outreach) comprise the ExCom, providing a more agile yet still representative advisory body for the co-PIs on behalf of NANOOS. Annual GC meetings are used to identify priorities, new members, and deficiencies for the NANOOS enterprise. The ExCom is consulted when decision-making issues arise. In its current year of the RCOOS funds (NANOOS RCOOS Y4=FY10), NANOOS is engaging the ExCom to develop metrics to evaluate end-to-end linkage from user requirements to NANOOS RCOOS implementation and feedback on its existing system performance.

NANOOS plays a vital regional coordination role, both within the PNW and along the west coast. Within the PNW, NANOOS is turned to for coordination and assistance with important regional issues, as exemplified by letters of support acknowledging our regional role with CMSP from state offices in WA and OR, The Nature Conservancy, and NOAA Western Region Collaboration Team (Appendix p.3), and for our role coordinating ocean acidification efforts from NOAA PMEL (Appendix p.2). Appreciation for our role extends to the entire west coast, as NANOOS is recognized along with the other RAs by the West Coast Governors' Agreement who offer support for our West Coast Integrated Ocean Observing System Implementation Proposals (Appendix p.4). NANOOS cooperates extensively with the west coast and Pacific RAs, co-hosting workshops, sharing competencies, and strategically planning resources.

NANOOS will continue to participate actively with NFRA and US IOOS. Martin and Newton are on the NFRA Board; Newton serves on its ExCom. Both will continue to attend NOAA IOOS Regional Coordination meetings. Through their efforts, NANOOS will submit required IOOS progress reports, assessments, and performance metrics and will seek certification as a member of US IOOS once certification standards and processes are determined.

NANOOS, Martin, and Newton are recognized nationally for leadership in helping to define the RA role, nationally and locally, as one that links and leverages regional capabilities into consistent national capacity.

ii. Observing Subsystem: We propose to sustain and enhance observing assets within four observational domains: coastal ocean surface currents/waves, coastal ocean shelf, estuaries, and shorelines according to our RCOOS Conceptual Design (Fig. D.1). These collectively address NANOOS' four priority topical areas and feed data product development for each. These can be leveraged for data vital to CMSP and MPA planning. NANOOS has emphasized both real-time and time-series observing, the latter critical to our capability to evaluate climate change.

Coastal ocean surface currents and waves: **NO.2. Maintain and enhance surface current and wave mapping capability.** NANOOS proposes to maintain existing HF radar foundational capability and extend it to currently unserved areas, providing critical national capacity, and to continue our investment in wave imaging at a critical port.

1. WA-OR-CA coast HF assets: Surface currents are fundamental ocean data, serving many (most) users. An IOOS national plan for HF current mapping has been produced (Allen et al., 2009), which describes the rationale, background, design, and implementation overview for a nationwide network to provide real-time surface current maps to serve national interest in science, navigation, search & rescue, pollution monitoring, etc. Our proposed work is fully consistent with that plan.

We propose to sustain operation of a land-based array of surface current mapping instruments, SeaSondes, and transmission of those measurements in near real-time for analysis and dissemination. This will assure HF data continue being provided through our NVS (maps plus ASCII) and also to the national IOOS HF data server which passes it to NOAA's National Data Buoy Center (NDBC). The data also reach the US Coast Guard for search and rescue, contributing to safe and efficient maritime navigation, and are employed in scientific studies and operational forecasts of HABs by government and academic scientists. Another important use is for numerical model verification and data assimilation; we propose to continue to facilitate assimilation of HF data into NANOOS regional circulation models.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Sustain the existing 11 HF installations in spanning N CA to S WA operated by *Kosro (OSU)*; B. Harden existing HF installations, both hardware and personnel, and to expand our data and product delivery; and C. Add 3 new HF installations in central and N WA, filling in national capacity to the Canadian border and bringing pivotal ocean observing data to critical coastline and communities currently un-served. The importance of this coastline stretch for maritime transport, HAB development, fisheries, and coastal hazards cannot be over-emphasized. Also, if Level C funds are available, we be able to invest in a regional node to prepare and distribute mapped data from the US West coast array in near real-time, working in collaboration with the national server group at Scripps; this will provide the best regional access by user groups to real-time currents and allow improved displays through NVS and regionally-developed data products, including trajectories.

2. *Port wave imaging:* Because of critical potential pay-off to saving lives at dangerous ports, NANOOS has invested in a marine radar wave observing station that began regular observations at the Newport (OR) jetties in 2009. We propose to continue this system, which collects image sequences (64 images) each hour, available in real-time through our NVS. For the current year (FY10), using NANOOS funds, we are developing two new real-time data products. They are: 1) a global wave directional spectrum, and 2) a bathymetric estimate for the nearshore. The "global" spectrum represents a measure of the wave spectrum taken over a large (1 km x 1km) section of the image and is a straightforward application of existing image processing algorithms. The second product is based on local (not global) estimates of the dominant wave direction and speed in order to produce a bathymetry estimate through bathymetric inversion. We will apply this method to the Nye Beach portion of the images (just north of the north jetty) and this product will provide bathymetry information in the seasons between the ongoing summer in-situ collections, capturing seasonal cross-shore sand transport processes.

Following our strategic prioritization levels and with the above mentioned new data products online in the coming year, our work plan for this subsystem element is to: A. Continue operation and maintenance of the Newport site, along with limited but continued algorithm development and verification, led by *Haller (OSU)*; B/C. Maintain present operations plus add a new observing capability through upgrade 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 for Yaquina Bay. The new NOAA vessel base at Newport should drive increased user interest in such capabilities.

Coastal ocean shelf: **NO.3. Sustain existing buoys and gliders in the PNW coastal ocean, in coordination with national programs.** NANOOS proposes to maintain and harden these essential assets providing observations

of regional dynamics, with a focus on hypoxia, HABs, ocean acidification (OA), which are major regional concerns affecting ecosystem and human health, fisheries, and coastal economies, and for input to modeling.

NANOOS proposes to continue support for: two offshore buoys, one in OR waters at Newport and one in WA waters at La Push, both associated with cross-margin autonomous underwater vehicle gliders; and both far- and near-field plume moorings just south of the Columbia River on the OR shelf, with an associated glider on the WA shelf, between Grays Harbor and Quinault. Though configurations vary, the moorings and gliders measure T, S, pressure, chlorophyll, suspended particle load, dissolved oxygen, and nitrate, and surface moorings measure standard meteorological parameters (wind, radiation, air temperature, etc.). All assets' data are currently served through our NVS.

1. Coast-wide coordination: NANOOS collaborates closely with the offshore observing plans and capabilities of NSF's Ocean Observatory Initiative (OOI) PNW observatory elements, as they are coming on line, and with NSF's Center for Coastal Margin Observation and Prediction (CMOP). The assets NANOOS proposes for ongoing support complement the OOI assets planned for Grays Harbor and help maximize spatial coverage of important oceanographic features and major ocean user focus areas. Collectively, these shelf observing assets provide timely information about the severity and extent of seasonal hypoxia, OA status, and HAB dynamics, and potentially can be used to predict PNW-wide ocean ecology impacts. ***Such use of IOOS regional association efforts for coastal coordination of observations and data dissemination is specifically requested for IOOS to provide in two recent proclamations: 1) by the "West Coast Regional Harmful Algal Bloom Summit" in response to the West Coast Governors' Agreement and a 2) by the "NOAA Sea Grant West Coast Workshop" in their Recommendations.***

2. Newport, OR buoy and glider: Continued support for the NH-10 buoy and glider extends coastal ocean observations that have been made since the 1950's along the east-west line near Newport, OR known as the Newport Hydrographic Line with NANOOS support since 2007. These measurements are used to inform ocean users and managers about the current state of OR coastal waters and will be assimilated into and/or used to verify the results of numerical circulation and ecosystem models. These sustained observations also support investigation aimed at understanding the influence of hypoxia on coastal ecosystems, and new observations on OA.

Support will be used for glider sampling on the Newport line (44 39.1N) during 2011-2012. Starting in mid-late 2012, we propose to relocate our glider observations to off Crescent City, California, (41 54'N), after NSF's OOI glider observations commence covering Coos Bay, OR, (43 30'N) to the Strait of Juan de Fuca, WA (48N) including the Newport Hydrographic Line. Sampling off Crescent City, CA, will provide immediate benefits to NANOOS, to: 1) extend the spatial footprint of NANOOS observations to the southern range of the region including fronts and eddies known to have concentrated commercial and recreational fish species.; 2) obtain subsurface ocean data co-located with existing NANOOS-supported surface velocity measurements from land-based, coastal HF radar; 3) obtain data at the southern boundary of NANOOS numerical models for model verification and data assimilation, to considerably improve ocean circulation model predictions.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operation of the NH-10 buoy, led by *Levine (OSU)*, and the heavily leveraged operation of the gliders, led by *Barth and Shearman (OSU)*; B/C: Maintain these operations plus allow longer deployments with better sensor and technician support.

3. La Push, WA buoy and glider: We propose to continue operation of the WA coast observational array. This system, successfully deployed in summer 2010, was acquired with funding from the Murdock Charitable Trust, leveraged by UW and NANOOS. It is comprised of three primary components: a surface mooring ("Cha-ba", meaning "whale tail," named for us by Quileute Tribe), a sub-surface profiling mooring, and a Seaglider autonomous underwater vehicle. The respective components of the system give conventional fixed-depth measurements with high temporal resolution, hourly profiles for continuous resolution in depth, and 200-km transects normal to the coast each ~2 weeks, together affording an unprecedented synthesized view of Washington's coastal processes. Strong community support from the Olympic Coast National Marine Sanctuary, the Makah, Hoh, Quileute Tribes and the Quinault Indian Nation, and the State of Washington, coordinated by the Olympic Coast Intergovernmental Policy Council, was instrumental in defining justification and application of this system. Local interest in OA, hypoxia, and HABs is high. The Newport and La Push buoys are both located at 80m depth to aid inter-comparison of coastal dynamics.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operations of the Cha-ba and subsurface buoys and conduct short-term operation of the glider, led by *Alford (UW)*; B/C: Maintain these operations plus allow longer glider deployments with better sensor and technician support for all components.

4. Columbia River plume and shelf mooring and glider: NSF's CMOP developed a far-field plume mooring at 100m just south of the Columbia R. on the OR shelf, a near-field plume mooring at 30m just south of the Columbia R. on the OR shelf, and a Slocum glider ("Phoebe"; NSF funding) on the WA shelf. NANOOS proposes to partially support these assets, to assure continued operations. The glider, which will sample at least seasonally in a radiator pattern between Grays Harbor and Quinault, is operated in coordination with the Quinault Indian Nation, a NANOOS member, who advises on the sampling pattern and provides logistical field support.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operations of Columbia R. plume buoys and conduct short-term operation of the glider, led by *Baptista/Needoba /Peterson (OHSU)*; B: Maintain these operations with better sensor and technician support for all components; C. allow longer glider deployments.

At funding level C, the NANOOS GC Executive Committee recommends investments in new directions that expand or complete our focused efforts on coastal ocean shelf observations:

Focus on coastal hypoxia: National attention has been drawn to the outbreak of more intensive and nearer-shore hypoxia off the OR and WA coast. NANOOS proposes support to sustain two new time-series data threads with strategic and vital contributions to a regional capability to assess hypoxia:
1. Temperature and oxygen on the OR/WA shelf, through crab industry-tribal-academic collaboration, led by *Shearman (OSU)*; 2. Oxygen in the inner shelf, leveraging PISCO resources, led by *Chan/Menge/Milligan, (OSU)*. Both address gaps in our current spatial context and ability to address stakeholder needs.

1. Broad shelf coverage: We currently lack observations with high enough temporal and spatial resolution to document the area impacted by seasonal hypoxia on PNW continental shelves. This approach uses crab pots as platforms of opportunity to extend coverage of the NANOOS network; also, it engages fisherman directly in ocean observing thereby building support for NANOOS from an important sector of the coastal economy. Building on a successful pilot project with commercial crab fishermen begun in 2005, we will make observations of temperature and oxygen over the continental shelf off OR and WA. We will equip 60-80 crab pots, deployed by commercial and tribal fishermen, with temperature sensors and inexpensive oxygen sensors we developed ourselves recording on approximately 10 minute intervals. Spatial coverage will be from within estuaries to the near-shore (5 m depth) to the shelf break (200 m depth) over 100's of km along-shore. Finally, crab fishermen keep detailed logs of their catch, which will be compared to oceanographic data.

2. Inner shelf coverage: NANOOS proposes support to help sustain a near real-time fixed mooring for detecting hypoxia in inner-shelf waters. The mooring is currently deployed ca. 1 km from shore at 15m-depth on the Strawberry Hill (SH)-line (44.25ºN). This mooring platform will provide integrated observations of hypoxia and other critical aspects of ecosystem variability and change. It leverages the experiences, resources and long-duration of the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) program to provide a cost-efficient mechanism for continued monitoring the highly dynamic inner-shelf. Characterizing oxygen dynamics on the inner-shelf is crucial because the onset of shallow water hypoxia typically signals the development of hypoxia as a shelf-wide phenomenon and the loss of refugia from outer- and mid-shelf oxygen stress. In addition, inner-shelf oxygen deficit signals can be imported to estuaries that serve as key nursery habitats and mariculture resources. A number of sources have funded the development and historical operation of this mooring, which we propose to continue.

Estuaries: **NO.4. Maintain and expand observation capabilities in PNW estuaries, in coordination with local and regional programs.** NANOOS proposes to maintain these assets to aid sustainable resource management, CMSP, integrated ecosystem/water quality assessment, maritime operations, fisheries, and to evaluate sub-regional climate change effects. Large observation networks are maintained at the two PNW estuaries with largest economic and ecological footprints (Columbia R and Puget Sound). Smaller networks in Willapa and South Slough/Coos Bays provide geographic breadth and locally needed information. All serve data via NVS.

Both Columbia River and Puget Sound observation networks manage complex real-time observatories and export technology and standards. Both will have lead responsibility in setting NANOOS standards for operational maintenance and data quality control of estuarine observatories. Both networks will seek ways to assist with other observation assets in their regions, to help create replicable models of system-specific optimization and integration of resources, entraining existing sub-regional assets such as from community colleges, Marine Labs (e.g. WAML, a NANOOS member), and tribal colleges (e.g., the Northwest Indian College).

1. Columbia River, OR and WA: The multi-institutional "collaboratory," SATURN includes an extensive observation network in the Columbia R estuary, with river, plume and shelf distribution of 18 in-situ endurance stations, of which

14 have decade-scale records. We propose to leverage support for SATURN, which currently collects physical and interdisciplinary data served via NVS that are extensively used in fisheries, navigation improvements, ecosystem restoration and hydropower management, numerical modeling and scientific exploration. NSF supports the pioneer array and development of new capabilities for the endurance observations. Regional stakeholders support the creation and/or maintenance of stations for project-specific purposes. NANOOS will provide long-term support for mature endurance components.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operations of several of the Columbia R. moorings, led by *Baptista/Needoba/Peterson (OHSU)*; B/C: Maintain these operations plus allow better sensor and technician support.

2. Puget Sound, WA: Puget Sound is the site of two highly leveraged programs to build and instrument profiling buoys with physical, chemical, and biological sensors (Hood Canal Dissolved Oxygen Program; Networked Profiling Buoy Program). We propose to continue leveraged support for five profiling moorings operating in Puget Sound, currently part of NANOOS. Three are located in Hood Canal, a fourth in Dabob Bay, a fifth in the Sound's main basin; a sixth, due on-line this fall, will be in S. Puget Sound. Due to slower water circulation areas of S. Puget Sound are subject to low dissolved oxygen concentration and OA. Exacerbating this situation are projections of population growth with its accompanying impacts. We propose sustained operation of all six moorings and to make enhancements for OA, of strong concern in Puget Sound (Feely et al., 2010).

These moorings currently provide depth profiles every hour and surface weather. Additionally nitrate, current velocity and direction, photosynthetically available radiation and optical backscatter are on selected moorings, allowing assessment of issues of concern including hypoxia, algal blooms, and climate effects. For OA, two moorings are equipped with PMEL/NOAA instruments measuring pCO_2 in surface waters and atmosphere, in collaboration with C. Sabine (NOAA) and Puget Sound Partnership investigating shellfish larvae viability.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operations of the Puget Sound moorings, led by *Devol/Newton (UW)*; B/C: Maintain these operations plus add pCO_2 and pH sensors on select moorings, allow better sensor and technician support, upgrade data processing capability.

3. Willapa Bay, WA and South Slough/Coos Bay, OR: NANOOS will also help support observation networks in Willapa Bay and South Slough/Coos Bay estuary clusters, which include major ecological reserves plus industries (e.g. oysters, fisheries). The latter links NANOOS' estuarine network with the NOAA network of National Estuarine Research Reserve System (NERRS), co-managed by OR Dept of State Lands (ODSL). The former brings in WA Dept of Ecology (WDOE) and its state-wide monitoring program for the federal Clean Water Act. Both institutions have been effective participants in NANOOS since its inception. Both interact with OHSU and UW towards compatible standards and protocols in data collection and quality control.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operations of the Willapa Bay observations, led by *Maloy (WDOE)* and South Slough/Coos Bay observations, led by *Rumrill (ODSL)*; B/C: Maintain these operations plus allow better sensor and technician support.

At funding level C, the NANOOS GC Executive Committee recommends investments in new directions that expand our focused efforts on estuarine observations:

Focus on ocean acidification (OA): The west coast of the US is particularly vulnerable to lower pH from rising CO_2 levels, due to ocean circulation and upwelling; the situation is compounded in estuaries from hypoxia and organic loading (Feely et al., 2010). Working with NOAA, NANOOS already contributes to our overall assessment of OA (NOAA letter in Appendix p.2). We propose to support an increased focus on regional capability to assess OA in estuaries: 1. Estuarine pCO2 from flow-through systems, led by *Hales (OSU)*; 2. Sustained LOBO timeseries at the Yaquina estuary, led by *Barnard (WETLabs, Inc.)*.

1. Estuarine pCO_2: NANOOS proposes to leverage the monitoring effort that has been built with the support of the Pacific Coast Shellfish Growers Association. For this, Hales (OSU) has deployed pCO2 analyzers based on flow-through bench-top showerhead equilibrators coupled with inexpensive IR detectors in a variety of situations including small boats, coastal marine facilities, and oyster hatcheries. These have significant advantages over traditional analyzers and moored systems, as they deal particularly well with rapid, large-magnitude changes, as have been documented in Netarts Bay, and do not require extensive infrastructural support. NANOOS proposes to deploy in one estuary, potentially to a variety of regional sites with emphasis on sites stakeholders (e.g. shellfish growers) and educators (e.g. small- and community-college field sites) would maintain.

2. Sustaining Yaquina timeseries: A factor in forecasting OA in estuaries is documenting how estuarine, watershed, oceanic processes drive water quality. NANOOS proposes to partially sustain the Yaquina Bay LOBO observing station, installed in 2007, that quantifies terrestrial inputs of nutrients, organic material, sediments, and pollutants. The Yaquina Bay station provides an important and needed ability to monitor the daily changes in the biogeochemistry of a regional estuarine system. This site would be a prime candidate for adding OA measurements, per above.

At funding level C, the NANOOS GC Executive Committee recommends investments in new directions that expand or complete our focused efforts on fisheries and biodiversity:

Focus on biodiversity: IOOS has been sometimes criticized for lacking a focus on biological or biodiversity measurements. NANOOS stakeholders demand a well-rounded RCOOS and encourage our expansion to this capacity. We propose to fund two projects with potential high payoff for the region and for NANOOS development. 1. Tracking migrations via acoustics, led by *Payne (POST)*; 2. Adding zooplankton monitoring to existing ship observations, led by *Keister (UW)*.

1. Tracking migrations via acoustics: The proposed project is to develop methods for integrating instruments for tracking the migrations of fish and marine mammals into ocean observing networks, a critical need for fisheries management and CMSP. The POST array of acoustic receivers is a relatively new technology that has been successfully used over the last 6 y to track 18 marine species over large distances and has proven valuable for measuring the movements and survival of animals as small as juvenile salmon. POST and UW-APL will work with Vemco (the manufacturer of acoustic receivers and tags) to integrate a miniaturized tracking receiver into the NANOOS La Push Seaglider, so that tracking data can be transmitted back from the glider at the end of each dive, along with oceanographic data. We also propose to add a Vemco tracking receiver to the NANOOS Cha'ba buoy off La Push. The location is in the middle of a "highway" used by many species, including salmon coming north from the Columbia R., where around 2000 fish are acoustically tagged each year.

2. Zooplankton monitoring: We repeatedly hear from WA fisheries managers that they desperately lack zooplankton information to assist with their management goals. Zooplankton are the trophic link between primary production and fish, so variability in zooplankton is of direct relevance to ecosystem modelers and fisheries managers. In addition, zooplankton species composition and diversity are sensitive to climate and environmental variability (including hypoxia and OA), with direct implications to diversity and survival of upper trophic organisms. We propose modest support for opportunistic sampling on cruises that are already planned (WA buoy servicing cruises, UW Puget Sound cruises, etc.) that will supplement observations in OR and provide this needed information.

Shorelines: **NO.5. Maintain and enhance core elements of beach and shoreline observing programs.** NANOOS proposes to contribute to hazard mitigation by providing essential observations and better decision support tools for coastal managers, planners and engineers, improving coverage and accuracy. Shoreline observing is a collaboration between WDOE, DOGAMI, and OSU.

1. WA and OR beach, shoreline and bathymetry observations:

In WA, beach monitoring along the Columbia R. littoral cell (CRLC) began in 1997 and became integrated with NANOOS RCOOS as part of a pilot project in 2004. This monitoring program directly supports NANOOS priorities to address coastal hazards and climate change and has strong links to maritime operations associated with navigation through coastal inlets. We propose to maintain CRLC beach monitoring including support for the Coastal Profiling System, through collaboration with OSU and DOGAMI. Components of the monitoring now include geodetic control, topographic beach profiles, sediment size distributions, topographic 3D beach surface maps, and nearshore bathymetry. Beach monitoring is done using a variety of Real-Time Kinematic Differential Global Positioning System (RTK-DGPS) surveying techniques.

In OR, with funding from NANOOS, DOGAMI implemented in 2004 pilot beach monitoring along the Rockaway littoral cell in Tillamook County, OR using a state-of-the art RTK-DGPS, as used in WA, in order to begin documenting the seasonal, interannual, and long-term changes taking place at multiple beach study sites and at a range of spatial scales. The data are used by coastal resource managers, geotechnical consultants, scientists, and the public-at-large. We propose to maintain the beach and shoreline monitoring, which due to NANOOS and funds leveraged through other state agencies, DOGAMI has expanded to now include 119 permanently maintained NANOOS sites and an additional 200 plus sites that are observed on ad hoc basis (e.g. monitoring the potential effects of wave energy arrays).

NANOOS proposes to sustain this bi-state network of beach and shoreline stations that has documents beach and shoreline morphodynamics, yields an improved awareness of the spatial and temporal response of beaches to major winter storms and to climate events, and provides information that is being used by state agencies to assist with coastal resource management, coastal geotechnical consultants, federal agencies such as the Federal Emergency Management Association (FEMA) for coastal flood inundation and erosion mapping, and the public at large (e.g. communities of Neskowin and Rockaway).

In WA and OR, NANOOS-supported nearshore bathymetric observations have documented seasonal to long-term changes in beach and shoreline morphodynamics and identified coastal hazards, information critical to state and federal coastal resource managers, geotechnical consultants, and the public-at-large. We propose to sustain annual nearshore bathymetric surveys, measured using a PWC-based Coastal Profiling System from approximately MLLW out to water depths greater than 10 m, at selected sites in OR and WA. Nearshore bathymetric data provide a critical source of information for improving coastal hazard mitigation along the coastlines of the Pacific Northwest. NANOOS-funded nearshore bathymetric data supports the US Army Corps' Regional Sediment Management at the Columbia R Mouth; Oregon Wave Energy Trust's ocean wave energy conversion projects; FEMA flood mapping activities; and research on coastal hazards and climate change.

Following our strategic prioritization levels, our work plan for this subsystem element is to: A. Maintain current operations of WA and OR shoreline observations led by *Kaminsky (WDOE)* and *Allan/McConnell (DOGAMI)* and of bathymetry led by *Ruggerio (OSU)*; B: Maintain these operations with more robust technician and analytical support; C. Add a Lidar to each state to implement monitoring along coastal bluffs.

iii. Data Management and Communications (DMAC) subsystem: NANOOS will continue its ongoing DMAC collaboration to develop a sustainable system providing IOOS standards-based data products, tools and services to local, regional and national users. We focus on both a robust DMAC Information System and an informative Web and User Products capacity. We continue to work closely with other RAs and IOOS to leverage ongoing work and contribute to the definition and implementation of a consistent set of certification criteria and follow guidelines set forth in the IOOS DMAC implementation document (IOOS, 2010). NANOOS DMAC is conducted by a highly collaborative industry-university-agency team: *Uczekaj/Blair (Boeing Research and Technology), Jones/Tanner/Mayorga (UW), Batista/Jaramillo/Seaton (OHSU), Kosro/Risien (OSU)*, and *Allan (DOGAMI)*.

Following our strategic prioritization levels, our work plan for this subsystem is to: A. Sustain existing data infrastructure system and user products, including components in WA and OR; B. Harden, mature, and evolve existing capacity, including hardware, data archival, system documentation, user products, and personnel; and C. Expand the scope of DMAC and User Products into new areas, including the "Citizen Science Data Project" explained below.

DMAC Information System: **NO.6. Maintain, harden, and enhance NANOOS' DMAC system for routine operational distribution of data and information.** NANOOS proposes to sustain and enhance their robust DMAC system, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS. Below is our approach for developing DMAC information system capabilities meeting overall IOOS goals and objectives.

1. Data Discovery and Regional Coordination: The NANOOS DMAC architecture supports metadata, tools, and services supporting in-situ observation and model data access through standard IOOS interfaces and the NVS. An additional NANOOS standardized data distribution service based on NOAA's Environmental Research Division's Data Access Program (ERDDAP) is currently under development (NANOOS ERDDAP or "NERDDAP"). Specific activities will include a) constructing metadata profiles of all regionally collected data sets including asset description, service interface, update rates and quality metric, building on the NVS DMAC infrastructure already in place, b) ensure all regionally collected observation data and model output is accessible through IOOS recommended standard service interfaces, and c) coordinate with other regions to ensure regionally collected observation data and model output uses common vocabulary, interoperable formats, and is discoverable nationally by supporting regular updates to the IOOS Catalog registry.

2. Standards-Based Service-Oriented Architecture: NANOOS supports interoperability standards through implementation of IOOS recommended standard interfaces and services based on a service-oriented approach. Specific activities include a) collaborating with NANOOS and non-NANOOS regional data providers to ensure collected observation data and model output are accessible through IOOS standards-based, service-oriented network interfaces, and b) develop a process for automating integration of data sets by new data providers including citizen-scientists.

3. Information System Components: NANOOS provides tools and services for delivering regional data meeting local, regional and national stakeholder needs for viewing, searching, and downloading data. The components consist of (or will be added/enhanced): a) NVS– a data discovery tool and visualization framework that aggregates existing observation and modeling data across the Pacific NW and lower British Columbia, and presents near-real-time, historical and forecast data to users in a consistent, user-friendly fashion independent of provider (Risien et al., 2009). NVS incorporates a lightweight, JSON-based internal data exchange web service interface serving its multiple components, including the NVS Mobile Apps currently supporting the iPhone and Android platforms (Mayorga et al., 2010); b) standard interfaces and distributed services– these conform to IOOS requirements and recommendations including Sensor Observation Services (SOS) for in-situ observation data sets, THREDDS (Thematic Realtime Environmental Distributed Data Services) server for gridded data sets, OGC Web Map, Feature and Catalog Services (WMS, WFS and CSW) for discovery and distribution of geospatial data and georeferenced images, and ERDDAP; c) the "Citizen Scientist Data Project" – this will provide a data service registration and access service integrated with NVS to carefully manage public and private sector stakeholders contributions of their own data sets; d) CMSP data services- this will extend existing data management and distribution tools to serve geospatial data and incorporate biological data in collaboration with OBIS-USA and IOOS DMAC; e) DMAC Metrics and Alerting Services –advanced capabilities for metrics collection, visualization and reporting of service/data availability, response time and summary usage as well as user data alerting through email or text messages.

4. Robust, Mature Infrastructure and Archiving: NANOOS will analyze the current and future needs for NANOOS DMAC and determine the best approach for maturing to a robust distributed hardware/software system operating 24/7. We will implement an equipment purchase plan to ensure all NANOOS nodes have robust computing and server capacity. To ensure ready access to real-time data and full access to large data collected over time, we will develop a regional archive plan consistent with IOOS needs and objectives, including provision of data to WMO GTS via a collaborative agreement with NDBC if appropriate. NANOOS DMAC will continue to expand its growing system documentation (Risien et al., 2009; Mayorga et al., 2010) to ensure transparent and clear descriptions of the overall architecture.

5. Certification and Governance: NANOOS will actively participate in regional and national IOOS standards working groups and committees meetings including regular participation in weekly IOOS DMAC steering team meetings to establish a NANOOS DMAC governance process that meets IOOS objectives for data certification standards and compliance of DMAC services.

NANOOS will actively collaborate with the other IOOS regional associations along the Pacific Ocean coastlines (AOOS, CeNCOOS, and SCCOOS) over the course of the funding cycle to advance stakeholder access to cross-regional data services as defined by commonalities in specified user requirements. At a minimum and initially, NANOOS and the other Pacific RAs propose to improve access to existing data services (products, map-based visualizations, information) through collaborative effort to establish common website linkages. Future effort will focus on the development of shared visualization services (common Application Programming Interface (APIs) and Web-Map Services) that focus on data and products common to all regions (i.e. glider data, model nowcasts and forecasts, key climate variables and high frequency radar). These common data services will be established and maintained as a core component of our DMAC effort.

Web and User Products: **NO.7. Create innovative and transformative user-defined products and services for PNW stakeholders.** As a fundamental and intimate part of both our DMAC and Outreach, NANOOS proposes to continue to provide and innovate for success in this vital translation: meaningful, informative data products that connect with user applications and serve society.

The NANOOS web and products team, in coordination with the NANOOS User Products Committee (UPC), DMAC, and Education & Outreach (E&O) committees, will continue to enhance the web interface, user products, and visualization and data discovery tools in the following areas:

1. Web Site: The first priority will be to enhance the NANOOS help section by providing a more dynamic help functionality, e.g., user clicking a Help button and then being able to roll the mouse across the screen and have help information pop-up. In the later proposal years, we will integrate across the NANOOS website the suite of interactive data searching and product discovery user interfaces currently implemented in NVS and under development in NERDDAP. Similar to the NVS assets section, filters (including complex filters), sliders and the map interface will be available to interactively specify search criteria. Finally, we will coordinate with the E&O Committee in developing NVS user-interface enhancements and web site learning modules in support of our Citizen Science Data Project.

2. Visualization Tools: We will build on the success of NVS by adding the capability of viewing transects through 3D models. Users would be able to draw arbitrary transects on the map, and plots from model output would be generated. Other NVS enhancements will include a re-coding of the asset pop-up window framework to greatly expand its display capabilities, and the addition of a timebar. Without a unified timebar each asset exists within its own timeframe. A unified timebar will provide clear representation of NVS' timeframe, show data availability for assets, align all assets to the same timeframe, and provide play controls to allow animation of changes in values.

3. Tailored Products Development: With initial focus on Ecosystem Assessment and Climate Change, we address on all four topical areas. For example, we will implement a model-based, particle tracker that can be used for predicting oil spill trajectory, and create web graphics for hypoxia conditions in specific NANOOS areas. For climate change we will experiment with a "weather-page" like graphic of dissolved CO_2, key to ocean acidification, and daily/monthly water temperature compared to climatology. Also of high regional interest, we will develop a coherent strategy for prioritizing and delivering data and user products tailored to the needs of the CMSP community.

iv. Modeling and Analysis Subsystem: NANOOS will focus on numerical modeling and specific analyses to facilitate now-cast and forecasting capabilities.

Modeling: **NO.8. Sustain and improve a community of complementary numerical regional models.** NANOOS proposes to sustain the operation of regional models, and the tools and products they support, covering from the head of tide within estuaries to outer edges of the EEZ in OR and WA, with strategic improvements to capabilities and scope.

Currently, NANOOS has circulation models covering coastal OR (OSU), Columbia R and other estuaries (OHSU) and Puget Sound (UW). We propose to maintain these models, while adding existing modeling capability in WA coastal waters (UW). We intend to build on previous investments, both IOOS and non-IOOS, with the goal of integrating the various NANOOS sub-regional modeling efforts into a unified ocean analysis and prediction system that incorporates NOOA/IOOS standards for model validation and data availability. The NANOOS ocean analysis and prediction effort will not be focused on improving the numerical modeling for its own sake, but will emphasize useful, validated products and tools that support a full range of critical decision making and problem solving domains, including crisis response and marine spatial planning.

Advancements in the operational versions of the NANOOS models will be closely tied to the procedures and standards outlined by the Coast Survey Development Laboratory (CSDL) of NOAA's National Ocean Service. We will communicate frequently with the Frank Aikman III, Chief of the Marine Modeling and Analysis Programs at CSDL, Richard Patchen, CSDL Chief Scientist, and others in the NOAA modeling community. We will perform validation of model sea level and currents according to NOAA standards per Zhang et al. (2010) and Hess et al. (2003). We will also leverage the nascent OOI assets in our region by providing model data to the OOI cyber-infrastructure and ingesting OOI observations into our regional models. Both UW and OSU are participants in the OOI; APL-UW is developing a joint operational control and visualization center for the OOI Regional Scale Node and NANOOS.

To maximize the utility of the NANOOS model output, we will provide the data in several formats, including NOAA standards such as NetCDF; a key tool for users will be our NVS. NVS offers a variety of methods for viewing ocean forecast data. For example, in NVS a user has the option of selecting overlays of both observational data and model forecasts via an intuitive interface. Fig D.2 shows an overlay of Wave Watch III forecast information, but also highlights gaps in the global model's coverage near the coast. A goal of this work will be development of a suite of operational models that provide data for seamless overlays of the NANOOS region.

In addition to maps and overlays, we have found that users may need other tools to help their decision making process (Jones and Maclean, 2007). The ability to see time trends in data and view comparisons of observations and model forecasts for specific geographic positions can be very powerful. NVS provides the ability to select key observing assets, view graphics of past observations, select different model forecasts for that geographic position, and then view the differences between the two. Users can also download the observations and forecasts in several formats. An objective of this proposal will be to incorporate regional model forecasts into the NVS database and make that data available in the NVS asset pop-up windows (Fig D.3).

Following our strategic prioritization levels, our work plan for this modeling subsystem is to: A. Sustain existing numerical modeling systems in WA and OR, as operated by UW *(Jones, MacCready, Banas)*, OHSU (*Baptista*), and OSU (*Kurapov*); B. Harden existing modeling capacity, both hardware and personnel, and validate model output; C. Assimilate regional observations and, based on results of model-data verification, facilitate future model improve-

ments; Expand to new model capabilities, including wave modeling at navigational inlets led by *Ozkan-Haller (OSU)* and improved Salish Sea modeling led by *MacCready, Banas, Jones* (UW).

While each modeling sub-region will work toward meeting the overarching NANOOS goal for ocean analysis and prediction, each has objectives unique to their area. As stated above, Level A funding will provide basic continuation of status quo for these sub-regional models, with B enabling system hardening and some validation. At Level C, sub-regional modeling objectives include:

Washington Coastal Waters and Puget Sound (part of the Salish Sea): Given Level C funding, UW will transition a new biophysical ocean model of the Salish Sea and Washington-Oregon coast from research hindcast use to a continuous operational implementation, and to present visualizations of model output and integrative model-data comparisons through the NANOOS website. The model (MoSSea, Modeling the Salish Sea) is implemented using the Regional Ocean Modeling System (ROMS) and builds on the biophysical model of the Columbia River Plume region described by Liu et al. (2009) and Banas et al. (2009). The model has 20 sigma levels and 300 m resolution in Puget Sound, expanding to ~1 km on the shelf and 3 km at its westward (open ocean) boundary. Sutherland et al. (2010) presents a detailed validation of a 2006 hindcast against temperature, salinity, and velocity data. A preliminary version of the coupled ecosystem model (including nutrients, phytoplankton, zooplankton, detritus, and oxygen) successfully reproduces mid-summer chlorophyll patterns in Puget Sound's Main Basin, although the parameterization of detrital processes and oxygen is still underway. Validation of the base ecosystem model on the outer coast has been conducted (Banas et al. 2009).

The operational version of the model will be implemented, and model products integrated with NVS and the NANOOS website, in four stages: 1) long-range tidal current predictions, 2) physical model nowcasts (temperature, salinity, and currents); 3) ecosystem model nowcasts (chlorophyll, nutrients, and oxygen); 4) 48-hr forecasts of 2) and 3). UW will also continue the work of Sutherland et al. (2010) to develop other validation metrics specific to Puget Sound processes that strongly affect ecosystem function, such as vertical stratification; and develop a supplemental suite of site-specific skill assessments focused on processes important to residence time, hypoxia, and HABS.

Colombia River and Coastal Margin: OHSU has developed a circulation modeling system that includes self-redundant quality-controlled operational simulations and products, inclusive of daily forecasts, decade$^+$ simulation databases, and simulations of impacts of climate change and local human activity. OHSU will continue to upgrade their modeling capability by including a verification component as advocated by NOS. New value added products to serve regional needs will be developed, such as the Oxygen Watch and a Climatological Atlas.

Oregon Coastal Waters: OSU has developed and maintained the pilot real time Oregon coastal ocean forecast model that has provided daily updates of 3-day forecasts of the ocean conditions off Oregon. Efforts have been made to incorporate a data assimilation component in this system that combines the model output and observations, to provide improved initial conditions for forecasts. At present, OSU has achieved the goal of assimilating the data in the near-real time (utilizing mapped HF radar surface currents and hourly GOES SST maps). The correction to initial conditions in the recent past is obtained at 6-km resolution, which is then interpolated on the 3-km model grid of the nonlinear forecast model. Due to assimilation, geometry of the modeled SST fronts has been improved, compared to the model without assimilation, and the cold bias in the prior model in the beginning of summer 2010 was removed. OSU will need to perform additional quality control tests of the new solutions and then share these solutions, constrained by the data, with the rest of the NANOOS community and users, via the NVS. Next steps proposed are to: 1. Incorporate assimilation of satellite along track altimetry in near-real time (using NOAA-RADS); 2. Develop means of regular quality control of the assimilative solutions by comparing them to assimilated and unassimilated data (mooring velocity and temperature time series, glider transects); 3. Develop tools for interactive display of the data and model forecasts, in particular using capabilities of the new OSU Coastal Ocean Modeling Lab; 4. Incorporate assimilation of glider data; 5. Improve parallelism of the assimilation codes to enable assimilation at higher (3-km) resolution, to allow better compatibility of the data and model; 6. Provide boundary conditions from Navy's Global NCOM operational model (12-km resolution) instead of the presently utilized monthly climatologic fields.

Wave Prediction at Navigational Inlets: The Mouth of the Columbia River (MCR) is a site where large swell waves and strong ebb tidal currents co-exist, with especially pronounced navigational hazards. Adding to the problem is the large physical scale of the MCR, causing long transit times (hours) from the nearest harbor to the actual MCR bar, and therefore requiring advance knowledge about the waves at the bar. This work addresses this problem by developing and validating a forecasting system for waves at the MCR. The system will involve the SWAN model over a 40km×40km domain centered around the MCR and utilize tidal circulation model results from existing NANOOS ef-

forts. We will invest significant time in model validation with existing observations (primarily buoy and radar); a critical step that can positively affect the attitude of potential users towards these forecasts and increase their use. Active engagement of end users will be used to aid this process also.

Analysis: At funding level C, the Governing Council Executive Committee recommends that NANOOS invest in detailed analysis to improve a key desired forecasting capability for the PNW:

Focus on Salmon Forecasting: Led by *Peterson (NOAA NWFSC-OSU CIMRS),* extensive biological and physical measurements in the PNW have been used to relate zooplankton and fisheries fluctuations to ecosystem indicators, in order to enhance fisheries forecasting skill. This analysis has identified ocean conditions that accurately forecast salmon survival and returns of salmon to their natal streams, one year in advance.

Although the forecasts are accurate, because drivers are not yet fully understood, forecast skill could be improved. To do so, this project will develop an index of transport in coastal northern CA Current, based on analysis of NANOOS Newport buoy current meter and HF surface current data. Water mass analyses will compare NMFS CTD data against ARGO data, to determine source waters for the coastal branch of the northern CA Current. These analysis products will be used to improve salmon forecasts and posted on the NANOOS website as a "salmon forecasting" theme page.

v. Education and Outreach (E&O) Subsystem: For NANOOS to succeed as an IOOS RA, it is critical to provide users with products and support necessary to further their needs and to foster ocean literacy in our region. **NO.9. Sustain and strengthen NANOOS education & outreach efforts.** NANOOS proposes to do so using existing and new approaches to further engage PNW users.

We propose to build from and strengthen ongoing NANOOS E&O efforts, further developing current activities and products in order to maximize their effectiveness. Conducted in coordination with other regional efforts, this fosters a network of ocean literate citizens and facilitates the use of NANOOS products in the PNW by targeted user groups, decision makers, and other citizens.

Over the course of initial NANOOS RCOOS funding, E&O efforts have been focused on education and user engagement in these three main areas: 1. *Networking*: to increase awareness about NANOOS and products; 2. *Product Development*: to engage users in NANOOS ocean observing efforts through NANOOS designed communication tools and products; 3. *User Engagement*: to support users in accessing and interpreting NANOOS data in a manner appropriate to their needs.

We propose to build on these accomplishments with a focus on strengthening two way communication between NANOOS (PIs, Tri-committees, and GC) and end-user groups. This is a necessary next step as NANOOS matures in efforts to effectively meet user needs through product development and engagement.

Our *networking* efforts are critical to initially engage potential users at a grassroots level and inform about NANOOS and what we can offer. These activities target specific user groups, including educators, fishers, shellfish growers, and resource managers. We propose to continue face-to-face outreach to new communities of potential users. NANOOS E&O staff are currently located in Seattle, WA, Portland, OR; we propose to engage with OR Sea Grant staff (*Emmanuel*) in Tillamook, OR, to effect outreach to this more remote NANOOS area.

The results of *product development* are the nuts and bolts of what NANOOS has to offer the PNW community. We, with guidance and support from the NANOOS Tri-committees, put much effort to create successful communication tools that assist stakeholders to understand and stay informed on NANOOS data, services, and products. Three outreach products: newsletters, theme pages, and social networking, tap into three different media and dissemination types, ensuring a broad communications net is cast. We propose to maintain and continue expanding these efforts: to publish the "NANOOS Observer" newsletter; to refine our web-based theme pages (e.g., HABs, OA, El Niños) and design new ones of topical interest; and to provide timely snapshots of the state of our regional and national ocean through social networking tools, e.g. Facebook and blogging.

Coupling the facilitation of two-way *user engagement* between end-users and NANOOS with NANOOS product development is essential to NANOOS' dedication of being a user-driven RA. E&O activities to enhance user engagement are broadly to allow 1) end-user input on new and existing data and E&O products and 2) transmittance of synthesized science from PIs, though user engagement activities are typically tailored to specific user groups. We propose to continue to strengthen our commitment such two-way communication.

Our developed partnerships with key programs in the PNW and nationally – including OR Sea Grant, Padilla Bay NERR, COSEE Ocean Learning Communities, COSEE Pacific Partnerships, COSEE Networked Ocean World, the NFRA EOC, and NANOOS members such as NAME, CMOP, and Ocean Inquiry Project – provide learning opportun-

ities surrounding ocean observing data for classrooms and non-classroom audiences. We will continue to utilize this partner network to participate in professional development workshops for educators and present and receive feedback on NANOOS educational materials. These workshops, along with our networking efforts to educators, have begun to develop a community of educators engaged and interested in bringing ocean observing data into their classrooms and educational programs. The resources we have developed include lesson plans for classroom teachers and interactive computer exhibits at two informal learning centers to allow non-classroom audiences the opportunity to interact with and understand ocean data.

We have several proposed new initiatives to expand our footprint in the education community: provide professional development for educators through in-person and online workshops developed in partnership with our education network and web development team; facilitate in-person and online forums for educators to exchange ideas amongst themselves and with experts; support regional citizen science efforts by developing online learning modules; organize in-person and online workshops for citizen scientists to interact with NANOOS scientists; and expand our partnerships with marine science centers in the NANOOS region to create a network of NANOOS themed exhibits.

The primary mission of the user-driven NANOOS is to provide PNW stakeholders with the ocean data, tools, and information they need to make responsive and responsible decisions, appropriate to their individual and collective societal roles. Identifying and meeting user needs within NANOOS' priority topical areas will focus NANOOS product development and user engagement activities. We propose to build on our successful products for user groups like fishers ("tuna-plots"), shellfish growers (R-T water quality) to expand and develop new targeted data products.

Following our strategic prioritization levels, our work plan for this subsystem element is fairly level, recognizing a steady necessary commitment to E&O. Our strategy will be: A. Maintain current E&O efforts *(Sprenger/Mikulak, with Jones/Newton (UW)*; B: Add more web-based theme pages; C. Extend E&O activities to more remote areas.

E. Milestone Schedule

All facets of this effort will be managed by co-PIs David Martin and Jan Newton. Details of deliverables and milestones shown are in Table E1 and are consistent with the NANOOS Business Plan, adopted by the GC in June 2009. Because this proposal is to sustain and maintain existing observational assets, much of the work plan does not have appreciable milestones. Improvements or changes are noted, as well as scheduling new assets/capabilities.

F. Cost Proposal

We submit a five-year, $20M budget, designed to sustain and enhance a robust, end-to-end RCOOS as shown in Table F1. We also provide in Table F2 a modular budget for Y1, showing a base capacity budget at $2.2 M (Level A), with a modest enhancement at $3.2M (Level B), and the full request of $4M (Level C), reflecting our three-fold NANOOS prioritization strategy guiding our year to year efforts, as explained on p.3 of this text. These costs can be cross-linked with NANOOS objectives and efforts as described in our Work Plan and as shown in our Milestone schedule.

Budget is requested each year to support the NANOOS RA for regional coordination and its four RCOOS subsystems for the tasks described in our Work Plan. Indirect charges are collected at each institution's legal rate. Personnel salary and benefits are requested for co-PIs Martin and Newton to oversee and direct all elements of this enterprise. Regional and national travel is requested for coordination, meetings, and workshops associated with NANOOS, NFRA, and IOOS. For the Observing Subsystem, funds are for personnel/benefits (lead PIs and technicians), supplies, contractual costs, and travel that are required to maintain existing assets: NANOOS HF and port Radars, coastal buoys and gliders, and estuarine and shoreline observations. Enhancement funds go toward more of these same categories, expended to harden the system and for strategic focus on hypoxia, OA, and biodiversity observations. Equipment is requested for 3 HF radars to extend coverage along WA and for a Lidar for OR and WA each to enhance shoreline observations. For the DMAC Subsystem, salaries for lead PIs and technicians and supplies are needed to maintain DMAC capabilities; travel is for IOOS DMAC coordination and regional meetings. Equipment is requested for web, database, and disk storage servers. For the Modeling and Analysis Subsystem, salaries for lead PIs and technicians and supplies are needed to maintain numerical models; travel is for IOOS Modeling coordination and regional meetings. Equipment funds are requested for computing and disk storage servers. Enhancement funds are for strategic modeling improvements. For the Education and Outreach Subsystem, costs are for salaries for E&O staff, outreach supplies, workshop costs, and travel for IOOS Education and Outreach coordination and regional outreach and meetings. Further details for the base budget and subcontracts are in the appendix.

Figures:

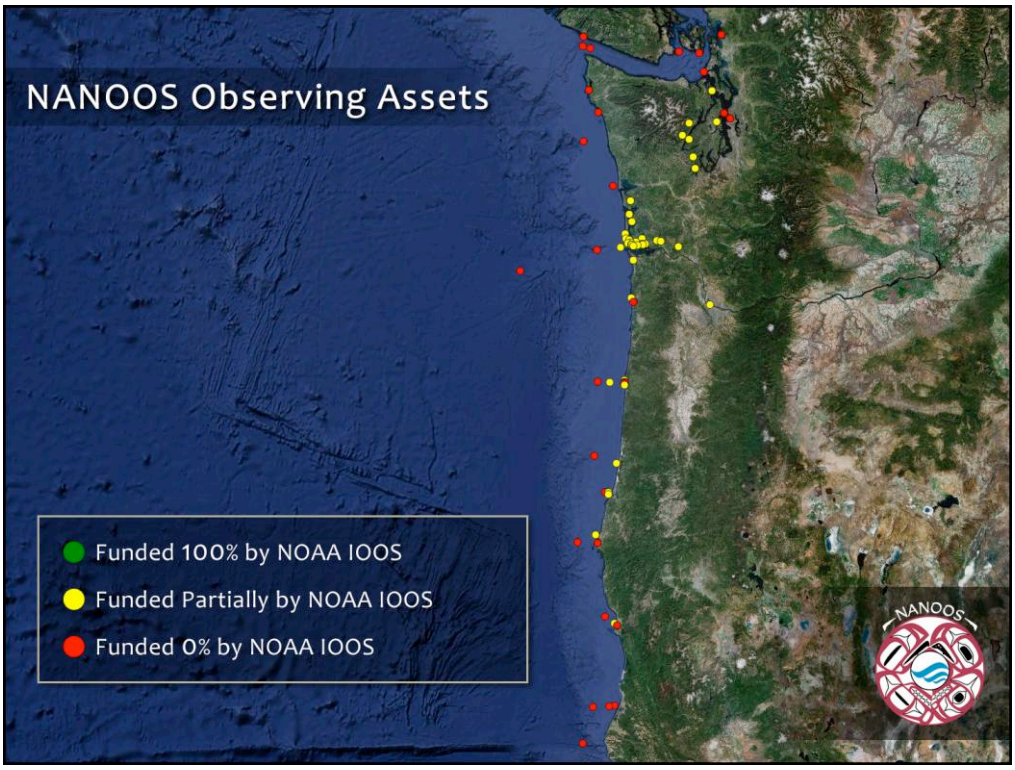

Figure A.1 Ocean observing assets in the NANOOS RCOOS region. Many of these assets are not operated by NANOOS but data are served by NANOOS.

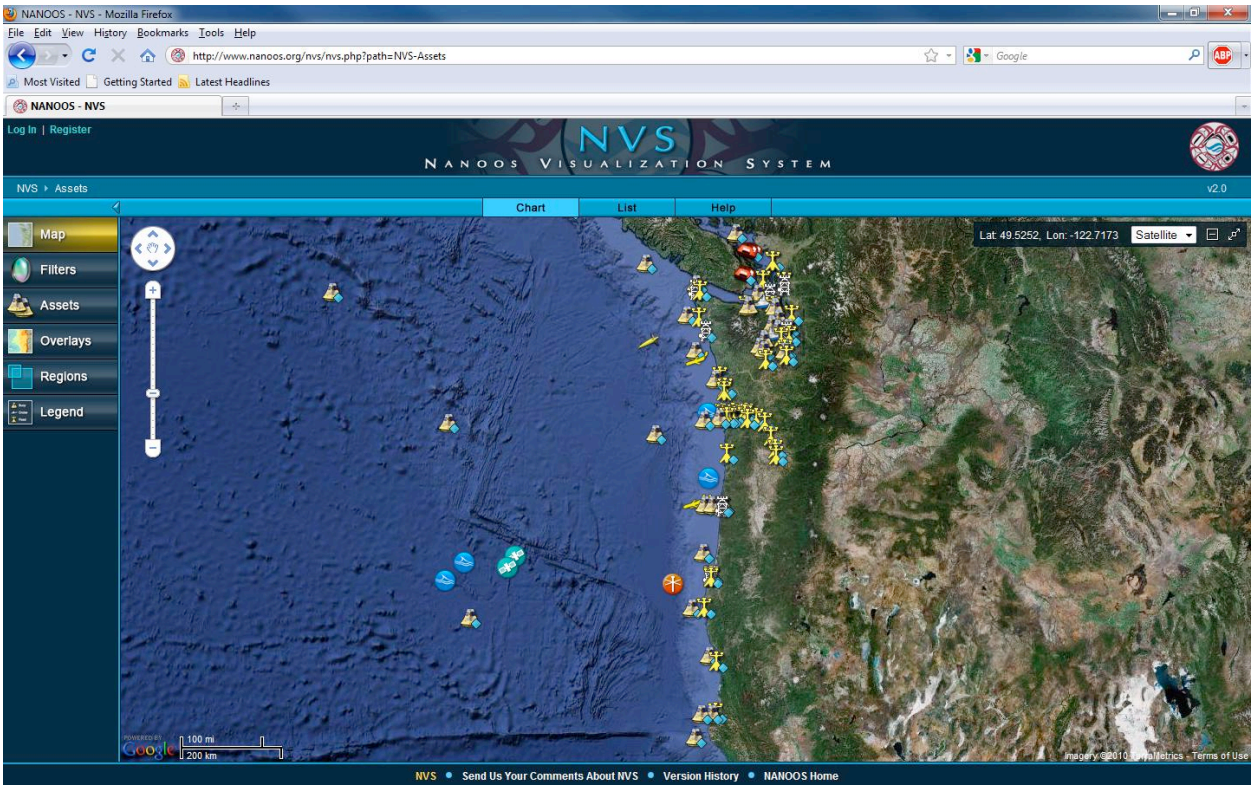

Figure A.2 Current NANOOS assets, as shown on the NANOOS Visualization System (NVS) web portal.

Figure D.1 Conceptual design for Y5-9 of the NANOOS RCOOS observing assets and enhancements. The original figure upon which this one is based was conceived by NANOOS stakeholders during numerous NOAA-funded NANOOS workshops during the early 2000s; it was adopted by the NANOOS Governing Council in 2007 and forms our Conceptual Design document (http://www.nanoos.org/about_nanoos/documents.php). This updated version reflects input from stakeholders, PIs, and users. Its content was approved by the NANOOS Governing Council in May 2010.

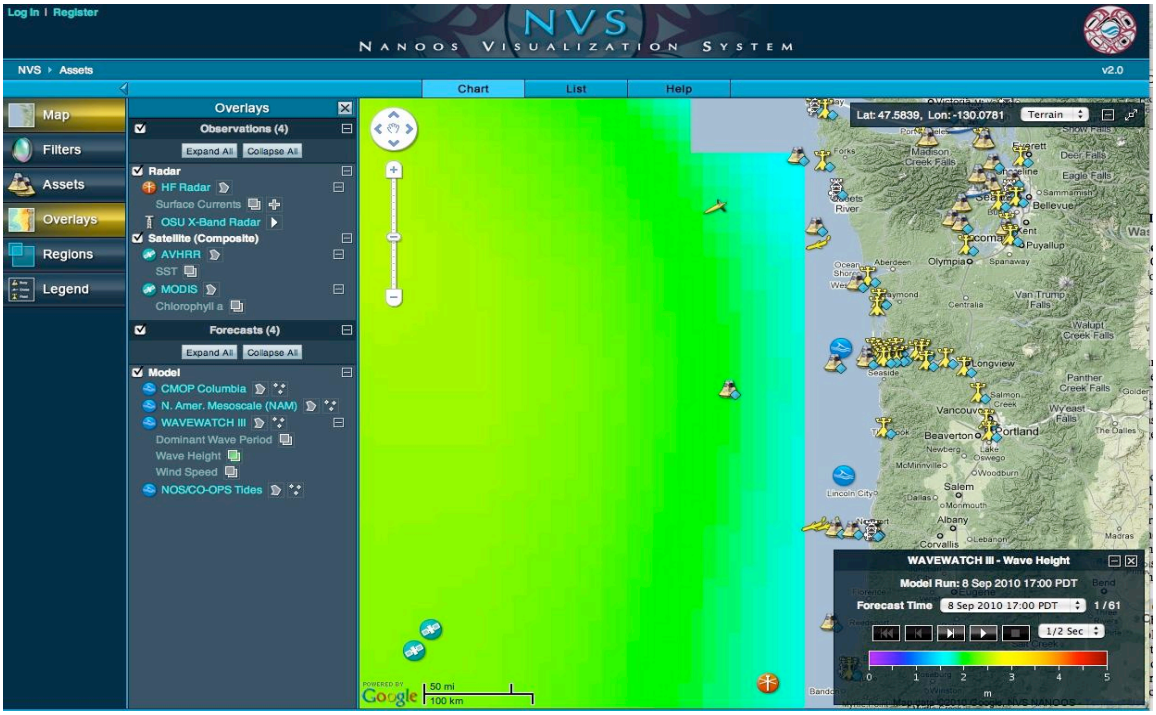

Figure D.2 NANOOS Visualization System (NVS) overlay of Wave Watch III forecasts of wave height.

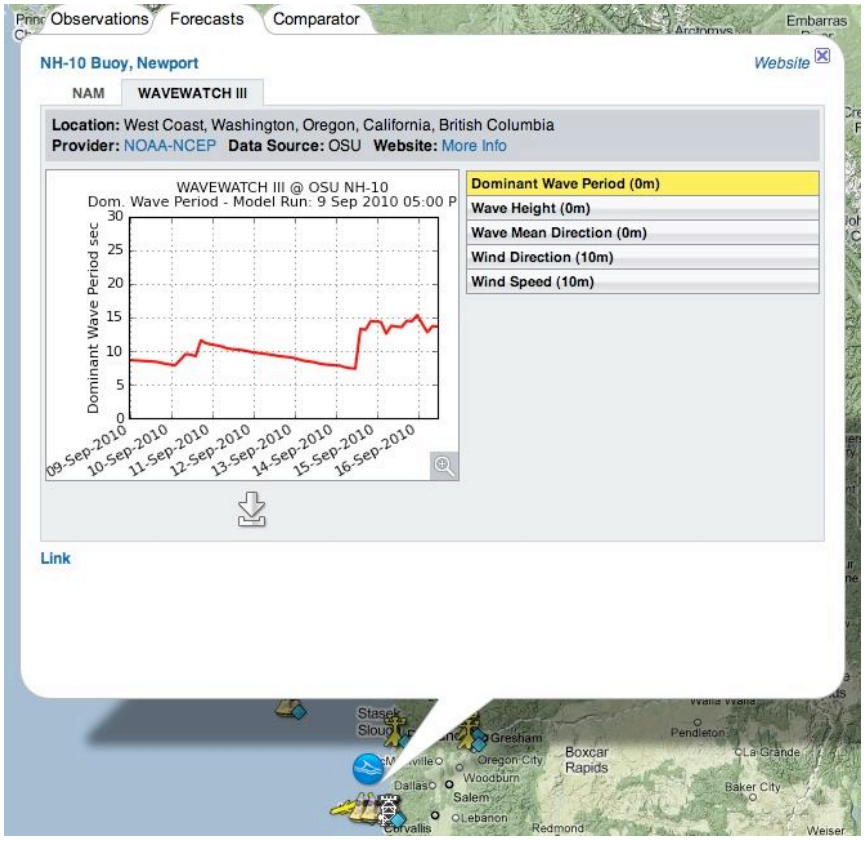

Figure D.2 NVS pop-up window showing point forecast information for the NANOOS-supported NH-10 buoy.

Tables:

Table C.1 Specific benefits to users from proposed NANOOS product developments in the four NANOOS stakeholder prioritized areas.

Maritime Operations Presently being served:

Value added Asset	Product	Users and benefits
HF radar array (hourly measurements of surface currents).	Fully incorporated into the NANOOS Visualization System (NVS), including the ability to query individual vectors.	• Fishermen (SAFE, CRCFA), 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 have more accurate sea condition data to improve safety of their personnel and operations.
X-Band port radar (real-time measurements of wave spectra)	Nowcast images of conditions around the mouth of Yaquina Bay are accessible through NVS.	• Fisherman (SAFE), Search & Rescue (Coast Guard), research vessels, and recreational boaters have accurate wave condition data at the mouth of Yaquina Bay, OR, which helps to improve public safety on the ocean.
Wave climate, meteorological information, and sea level data (Historical, nowcast and futurecast data)	NDBC and CDIP wave buoys, C-Man climate stations, and NOS tide gauges are fully integrated into NVS, providing both real-time and recent (past 30 day) historical wave climate data. Futurecasts of wave climate and meteorological conditions utilizing WaveWatch III wave forecasts, NAM climate forecasts are now integrated for each buoy site in NVS.	• Fishermen (SAFE, CRCFA), 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, recreational boaters, coastal emergency responders, can now access a suite of information on ocean waves, climate and sea level, improving physical safety of their personnel and operations and enjoyment of these products.

Proposed future enhancements (i.e. key stakeholder products that NANOOS is working to develop):

Value added Asset	Product	Users and benefits
HF radar array.	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).	• The above audiences from more of the NANOOS region will have more accurate sea condition data to improve safety of their personnel and operations.
X-Band port radar	Develop enhanced nowcast products of wave frequency and direction. Integrate with proposed wave modeling to explore delivery of wave height estimates at the mouth of Yaquina Bay.	• Fisherman (SAFE), Search & Rescue (Coast Guard), research vessels, and recreational boaters will have more accurate wave condition, as well as forecasts, at the mouth of Yaquina Bay, OR.
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 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.
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.

Coastal Hazards Presently being served:

Value added Asset	Product	Users and benefits
Beach and shoreline monitoring data	Cross-shore beach profiles (from landward dune edge to ~ -1.5m MLLW), 3-D surface maps of complete nearshore planform, and time-series plots of beach contour changes are accessible through both OR and WA state agencies.	• State coastal managers (DLCD, OPRD, ODFW, WDFW, WDoE), USFWS, local government planners, geotechnical engineers, public-at-large, researchers, have access to both current and historical information on the changing state and stability of OR and WA beaches.
NANOOS tsunami web interface	Web-based tsunami evacuation information and hazard preparedness information developed by the state of Oregon and NOAA.	• State coastal managers, FEMA, emergency managers (state and local government), local planners, geotechnical engineers, insurers, and the public-at-large have better access to information depicting modeled tsunami inundation.

Proposed future enhancements (i.e. key stakeholder products that NANOOS is working to develop):

Value added Asset	Product	Users and benefits
Beach and shoreline monitoring data	Develop NVS 'beaches' portal that integrates all PNW beach profile cross-section data. Develop a web-mapping service that integrates time-series plots of shoreline and contour changes.	• Same audiences as above will have valuable information on the changing state and stability of OR and WA beaches and shorelines from one coordinated portal with easier and more informative data access.
Bathymetry. Assimilate 220 nearshore profiles (3 littoral cells) on the WA coast and another 70 (2 littoral cells) on the Oregon coast.	Integrate bathymetry data in NVS 'beaches' portal.	• Same audiences as above 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	Expand tsunami web portal to include evacuation brochures developed by WA and northern CA state agencies.	• 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.

Ecosystem Impacts Presently being served:

Value added Asset	Product	Users and benefits
Real-time data from shelf buoys and glider transects including chlorophyll, temperature, salinity, and dissolved oxygen	Time series of chlorophyll, temperature, salinity, and dissolved oxygen fully integrated into NVS for all NANOOS supported assets	• Resource Managers (WA and OR Depts of Health, WDFW, ODFW) and Tribes (Quileute Tribe, Quinault Indian Nation) have better information on coastal conditions to aid in environmental management in light of coastal hypoxia.
Real-time data on conditions in coastal ocean near 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, WDFW, ODFW) and Tribes (Quileute Tribe, Quinault Indian Nation) have forecast information on coastal conditions associated with HABs and so can make better decisions regarding harvest and chronic exposure risks.
Real-time data from estuary buoys	Time series of chlorophyll, temperature, salinity, and dissolved oxygen fully integrated into NVS for all NANOOS supported assets	• Resource Managers (WA and OR Depts of Health, WDFW, ODFW, Puget Sound tribes) have better information on estuarine conditions, such as hypoxia, to aid in environmental management.
Circulation models	Surface temperature, salinity, currents (nowcast and future cast e.g. 24h, 48h etc.) are fully accessible through the NA-	• Resource Managers, Tribes, and Researchers have better idea of when/where harmful conditions, such as hypoxia and HABs will reach

	NOOS products page.	their areas. • Fisherman (e.g. Tuna) can better define areas to fish, potentially increasing their success.

Proposed future enhancements (i.e. key stakeholder products that NANOOS is working to develop):

Value added Asset	Product	Users and benefits
Circulation models	Surface temperature, salinity, currents (nowcast and future cast e.g. 24h, 48h etc.) to be fully integrated into NVS enabling interactive access to data and model output.	• Same audiences as above will have more easily accessed and interactive information on they need for decisions, management.

Regional Fisheries Presently being served:

Value added Asset	Product	Users and benefits
HF Radar	Nowcast surface currents	• Fishermen (recreational/commercial) have information on fishing conditions offshore, assisting decision-making and safety.
Ocean circulation model	Surface and bottom temperature & salinity (futurecast maps: 24hr, 48hr) fully accessible through NANOOS products page	• Fishermen (recreational/commercial) have information on where fish can be found, contributing to efficiency, effectiveness, and safety.
Satellite data	Sub-sample satellite data for PNW region that targets SST, chlorophyll, and sea surface heights fully accessible on NVS	• Fishermen have enhanced access to regional ocean environmental data.

Proposed future enhancements (i.e. key stakeholder products that NANOOS is working to develop):

Value added Asset	Product	Users and benefits
HF Radar	Particle trajectory maps – larval transport	• Fishermen (recreational and commercial) will have better information on potential fishery hotspots along the coast.
Ocean circulation model	Develop next generation ocean circulation model that is benchmarked against existing ocean observing assets. Develop surface and bottom temperature & salinity futurecast maps at a range of temporal scales (e.g. 24, 48h).	• Fishermen (recreational and commercial) will have better 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	Develop NANOOS regional ocean climatologies web portal.	• Fishermen will have enhanced access to current conditions as they relate to previous years.
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.

Table E.1 Milestone Schedule and Project Timeline

Area	Y1	Y2	Y3	Y4	Y5	Outcomes
Observations						
Shelf: Throughout 5 years: - Maintain La Push, Newport, and Columbia R. buoys - Maintain WA and OR glider transects	Bring new data streams, funded under level C, on-line to the NANOOS NVS.	Transition Newport glider to Crescent City, if OOS Newport glider is on-line. Develop data products from new assets	Assess whether product development needs are being met with observing system design	Assess whether focus on hypoxia, HABs, OA, biodiversity investments are providing enhanced/valuable information.	Engage in time-series analysis to show annual/anomaly values for suitable NANOOS observation data series	NANOOS provides users real-time and time-series data to assess ecosystem impacts (HABs, hypoxia, ocean acidification); assimilation / verification to models of circulation; climate change baseline and assessment.
Estuaries: - Maintain Puget Sound, Columbia R., Willapa and South Slough moorings	Add pH to one PS buoy	Add pCO2 to one PS buoy	Add pH to one PS buoy	Add pCO2 to one PS buoy		
Shorelines: Throughout 5 years: - Maintain shoreline observations in WA and OR	Further develop data products from assets	Further develop data products from assets	Assess whether product development needs are being met with observing system design	Purchase Lidar for WA	Purchase Lidar for OR	NANOOS provides users data to assess coastal hazards, shoreline stability, tsunami preparedness, climate change effects.
Currents: Throughout 5 years: - Maintain OR HF radar sites and X-band radar site	Purchase/install 1st HF in WA Further develop data products from assets	Purchase/install 2nd HF in WA Bring 1st WA HF on-line.	Purchase/install 3rd HF in WA Bring 2nd WA HF on-line.	Bring 3rd WA HF on-line.	Assess if product development needs are being met with observing system design	NANOOS provides users expanded data to address maritime operations safety, coastal transport, and climate change effects.
Modeling						
OR/WA estuaries and outer coast models	Maintain modeling & forecasting capabilities at OSU, OHSU, & UW	Model verification and validation	Model products and integration: phase I Visualization products used for verification tie into NVS to create an interactive way to discover what the model tells users about the environment.	Model products and integration: phase II Continue and refine	Make model improvements, as needed	NANOOS has model output for products on web, e.g.,Tuna Plots for ocean fishers, circulation forecasts for tracking HABs.
New Puget Sound/Salish Sea	Transition Salish Sea model to operations					NANOOS has offshore WA model data.
New Wave modeling in Navigational inlets	Bring wave modeling in navigational inlets model on-line					NANOOS provides forecast capability in dangerous MCR region.

Area	Y1	Y2	Y3	Y4	Y5	Outcomes
DMAC						
Web Site Improvement	Enhance NANOOS help section	Develop "MyNANOOS" customization	Expand observational data searching and data downloading	Support citizen science input and visualization	Based on web site evaluation, update web site	NANOOS users have reliable and informative access to data and data products, with a, user-friendly interface and services they want.
Visualization Tool Improvement	Add capability of viewing transects through 3D models	Add unified timebar to NVS	Create cross-platform, mobile web version of NVS	Provide tool for observational data set visualization	Improve data flow though NVS to speed delivery	
Tailored Product Development	Focus on Ecosystems and Climate change (OA)	Focus on Maritime Operations	Focus on Coastal Hazards	With E&O committee, evaluate usefulness of web and product suite	Based on product suite evaluation, add, improve, remove products	
Operational Center Support Requirements	High-transaction web server	Large capacity data backup system	Add system admin support	Upgrade web servers	Upgrade data back-up system	
Citizen Science Data Project	Establish Advisory Group and commence work	Development and deployment of capacity with test groups	Development and deployment of capacity on NVS	Project complete, evaluate	Make changes if necessary	Citizen Science Data can be uploaded to NANOOS, engaging several regional groups and the pubic
Education and Outreach						
Networking	Maintain existing and build new relationships with NANOOS priority area users and the education community					NANOOS has a connected, relevant, and well-served community of users who reap benefit.
Product Development	Work with DMAC, User Products Committee on Tailored Product Development, as per above schedule, and in Tri-Committee meetings					
User Engagement	Conduct trainings to select user groups	Evaluate trainings, to ascertain if NANOOS help functions working	Plan evaluation of web site and product suite	Execute evaluation of web site and product suite	Interpret results of evaluation and make recommendations	
Administration						
Meetings	Represent NANOOS at all NOAA IOOS, NFRA, and national meetings of significance (e.g., Oceans 20xx).					NANOOS has a reliable, accountable, interactive, and representative management structure and operating system.
Project oversight	Conduct regular PI meetings, Tri-Committee meetings, and assist with evaluations, as scheduled					
Coordination	Conduct annual GC meeting as well as sub-regional, and user-group specific workshops (e.g., for CMSP; ocean acidification, etc). Coordinate with West Coast RAs and other RAs to optimize and leverage capabilities and assure consistencies.					
Accountability	Submit required IOOS progress reports, assessments, and performance metrics and seek certification as a member of US IOOS once certification standards and processes are determined					