Northwest Association of Networked Ocean Observing Systems

August 25, 2015

Ms. Regina Evans
NOAA, U.S. IOOS Program Office
1315 East-West Highway
Room 2605
Silver Springs, MD 20910

Dear Ms. Evans:

Following the guidance in the FY2016 Implementation of the U.S. Integrated Ocean Observing System (IOOS) Federal Funding Opportunity, this 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. Implementation and Development of Regional Coastal Ocean Observing Systems**

Complete information for the Principal Investigator:
Dr. Jan Newton, Applied Physics Laboratory, University of Washington; 1013 NE 40th St.; Seattle, WA 98105; (206) 543-9152 (Voice); (206) 616-3142 (FAX); newton@apl.washington.edu

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Duration of proposed project:
Five years, from 01 June 2016 to 30 May 2021

Proposed funding type requested:
Cooperative Agreement

Funding requested:
$20.0M

Sincerely,

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: Mike Kosro (OSU), Emilio Mayorga (APL-UW), David Martin (APL-UW)
Jonathan Allan (DOGAMI), Antonio Baptista (OHSU)

Project Summary

The Governing Council of the Northwest Association of Networked Ocean Observing Systems (NANOOS), on behalf of its 60 members, presents this proposal to maintain and enhance NANOOS as the U.S. Integrated Ocean Observing System (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 by charter 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. Sixty NANOOS members, who have signed our Memorandum of Agreement (MOA), have identified the priority areas for product development within this end-to-end RCOOS to be: **a) maritime operations; b) ecosystem assessment (including PNW priority topics of hypoxia, ocean acidification, and Harmful Algal Blooms (HABs)); c) fisheries and biodiversity; d) mitigation of coastal hazards; and e) climate**.

Our goal is to sustain and enhance NANOOS to continue as the PNW regional coastal ocean observing system serving regional stakeholders in alignment with the vision and operations of U.S.IOOS. NANOOS has been maintained via U.S. IOOS program funding and a significant array of leveraged resources. NANOOS used two strategies to build and maintain operations: coordinate existing assets and place strategic focus on new investments, with the result that NANOOS has produced a distributed observing system yielding informative and decision-relevant data products serving PNW stakeholders and the broader society in five areas of concern (maritime operations, ecosystem assessment, coastal hazards, biodiversity, climate) across three spatial domains (coastal ocean, estuaries, shorelines). The PNW-managed and operated NANOOS, with its essential subcomponents (Governance and Management, Observing Systems, Data Management and Communications, Modeling and Analysis, and Outreach, Stakeholder Engagement and Education), is closely integrated with US IOOS. NANOOS currently provides significant societal benefits to a wide spectrum of users including federal, tribal, state and local governments, industries, scientific researchers, non-governmental organizations (NGOs), educators, and the general public. The NANOOS goal for each of the next five years is to sustain and enhance this significant capability.

For this period, our specific objectives are annually to:

1) Maintain NANOOS as the U.S. IOOS PNW Regional Association.

2) Maintain and enhance surface current and wave mapping capability.

3) Sustain existing buoys and gliders in the PNW coastal ocean, in coordination with national programs.

4) Maintain and expand observation capabilities in PNW estuaries, in coordination with local and regional programs.

5) Maintain and enhance core elements of beach and shoreline observing programs.
6) Provide sustained support to a community of complementary regional numerical models.
7) Maintain, harden, and enhance NANOOS' Data Management and Communications (DMAC) system for routine operational distribution of data and information.
8) Continue to deliver existing and create innovative and transformative user-defined products and services for PNW stakeholders.
9) Sustain and strengthen NANOOS outreach, engagement and education.

While sustaining and hardening the observing assets and model forecasts we currently support, proposed enhanced developments for NANOOS include filling critical gaps; namely addressing conditions in the nearshore with a focus on hypoxia and ocean acidification, addressing biodiversity by supporting biological sampling of plankton, eliminating spatial gaps in surface currents for Washington state, providing forecasts of coastal hazards in the nearshore, namely waves and flood/erosion. NANOOS will remain focused on delivering data-based products and services that are easy to use to diverse stakeholders for addressing high-priority issues and aiding 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 in order to serve PNW resiliency, coastal intelligence, and conservation.

This proposal submission for the PNW region 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 comprised of Board Members with diverse sector representation and Chairs of NANOOS RCOOS operational standing committees. The NANOOS Governing Council, the guiding body for this work, has approved the content of this proposal for submission.

Partners

Partnering is strong within NANOOS, through our PIs, through our regional prominence as a coordinating body, and through our governance. The proposed efforts will be conducted in partnership by PIs at several NANOOS membership organizations who have maintained NANOOS to date: *University of Washington (UW); Oregon State University (OSU); Oregon Health & Science University (OHSU); Oregon Department of Geology and Mineral Industries (DOGAMI); Oregon Department State Lands (ODSL); Washington Department of Ecology (WDOE)*. Additional collaborative partners in this proposed work include: the *Quinault Indian Nation; Northwest Indian College; West Coast Governors' Alliance (WCGA) Coastal States Stewardship Foundation/West Coast Ocean Data Portal; Western Washington University; NOAA Olympic Coast National Marine Sanctuary (OCNMS); and NOAA Northwest Fishery Science Center (NWFSC).*

NANOOS coordinates specific PNW efforts with or receives funding from several federal and local entities, including the *NOAA Ocean Acidification Program, NOAA Pacific Marine Environmental Laboratory, National Estuarine Research Reserve System (NERRS), West Coast Governors' Alliance (WCGA), and Washington Ocean Acidification Center.* Additionally, NANOOS has coordinated with the *National Science Foundation* which through its *Ocean Observing Initiative* (OOI) has PNW observing assets. NANOOS and OOI PIs coordinated a single design that optimizes spatial coverage and will serve data jointly, when OOI data are available. The NSF-funded *Center for Coastal Margin Observation and Prediction* (CMOP) is an essential part of NANOOS. In their 2008 Action Plan, West Coast Governors specifically called out the importance of ocean observations to achieve many of the action plan's goals. In 2012, NANOOS, with partner IOOS regional associations *CeNCOOS* and *SCCOOS* in California, and the WCGA signed a Memorandum of Understanding to advance effective management of coastal ocean resources on the West Coast.

The 60-member NANOOS Governing Council (http://www.nanoos.org/about_nanoos/members.php), the guiding body for this work, reflects a balanced composition of academic and research institutions (15), tribal governments and tribal organizations (4), federal, state and local governments (16), industries (10), and non-governmental organizations (15). That partnership offers this proposal for submission.

3. PROJECT DESCRIPTION

A. Background

The Pacific Northwest (PNW) waters of the United States are critically linked 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 PNW states of Washington and Oregon need access to coastal ocean data and products. 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, 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 to serve citizenry of the PNW. NANOOS 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 U.S. 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 been executed with substantial stakeholder involvement in every aspect: in defining the NANOOS RA, its governance structure, regional coordination, and prioritization. Additionally, stakeholders contribute to and help define our RCOOS subsystems: observations; modeling; data management and products; and outreach, engagement and 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 its governance, NANOOS has an established Governing Council (GC) that is thriving, diverse, and continues to grow. Membership has grown from 25 in 2007, 45 in 2010, to 60 today. Representation is from many sectors: 27% local, state, and federal government, 7% tribes and tribal organizations, 25% NGO/education organizations, 17% industry, and 25% academic institutions. NANOOS has a demonstrated effective governance structure, with an elected Board (15) of the GC with designated sector representation. The Executive Committee, comprised of the Board plus Chairs of the three NANOOS operational standing committees (DMAC, User Products, Education & Outreach, collectively known as the Tri-Committee), advise the Board Chair and Executive Director (ED), who are responsible for leadership and overall management. The Board Chair and ED direct the NANOOS RCOOS efforts, which PIs from multiple institutions have implemented since 2007 with guidance from the GC and close interaction with the Tri-Committee who meets regularly to review progress and set priorities. PIs have authored 72 publications (NANOOS, 2015).

NANOOS is an active participant in IOOS Association and U.S. IOOS activities and is well-integrated with regional observing systems in California (CeNCOOS, SCCOOS), as evidenced by our letter of support from the West Coast Governors' Alliance, and in Alaska (AOOS), as evidenced by our joint project with the NOAA Ocean Acidification Program that funds all five of use to work with shellfish growers. NANOOS has close involvement with British Columbia (e.g., Canadian coastal observing project Ocean Networks Canada is a Governing Council member) and the NANOOS ED is on the MEOPAR Advisory Committee.

NANOOS's development was guided by many 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 meet user needs. A host of data and user-defined data products are currently available through NANOOS (http://www.nanoos.org) and its NANOOS Visualization System (NVS, Fig 1). 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 to sustain and enhance NANOOS: to maintain NANOOS as the PNW regional arm of U.S. IOOS; 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, thus serving PNW resiliency, coastal intelligence, and conservation.

B. Goals and Objectives

i. Goal: Our goal is to sustain and enhance NANOOS to continue as the PNW regional coastal ocean observing system serving regional stakeholders in alignment with the vision and operations of U.S.IOOS. NANOOS has been maintained via U.S. IOOS program funding and a significant array of leveraged resources. NANOOS used two strategies to build and maintain operations: coordinate existing assets and place strategic focus on new investments, with the result that NANOOS has produced a distributed observing system yielding informative and decision-relevant data products serving PNW stakeholders and the broader society in five areas of concern (maritime operations, ecosystem assessment, coastal hazards, biodiversity, climate) across three spatial domains (coastal ocean, estuaries, shorelines). The PNW-managed and operated NANOOS, with its essential subcomponents (Governance and Management, Observing Systems, Data Management and Communications, Modeling and Analysis, and Outreach, Stakeholder Engagement and Education), is closely integrated with US IOOS. NANOOS currently provides significant societal benefits to a wide spectrum of users including federal, tribal, state and local governments, industries, scientific researchers, non-governmental organizations (NGOs), educators, and the general public. The NANOOS goal for each of the next five years is to sustain and enhance this significant capability.

ii. Objectives: For this period, our specific objectives annually are to

1) **Maintain NANOOS as the U.S. IOOS PNW Regional Association:** Sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement, engaging federal-non federal (tribal, academic, state, local, industry, NGO, etc.) partners.
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 a new portion of critical national capacity; continue investment in wave mapping at critical ports.
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 (OA), climate change detection and invest in biological observations.
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. Sustain and enhance observing ability including new investments in hypoxia, OA, and biological observations.
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.
6) **Provide sustained support to a community of complementary regional numerical models.** Contribute to the operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the EEZ in both OR and WA, with strategic improvements to capabilities and scope, including new forecasts for waves, flood and erosion.
7) **Maintain, harden, and enhance NANOOS' Data Management and Communications (DMAC) system for routine operational distribution of data and information.** Sustain and enhance the DMAC system NANOOS has built, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS.
8) **Continue to deliver existing and create innovative and transformative user-defined products and services for PNW stakeholders.** Continue our NVS innovation to succeed in this vital translation: meaningful and informative data products that connect with user applications and serve society.
9) **Sustain and strengthen NANOOS outreach, engagement and education.** Foster ocean literacy and facilitate use of NANOOS products for IOOS objectives, the core task for which NANOOS was constructed, via existing and new approaches for engaging users and increasing ocean awareness.

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 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.

C. Connection to Users and Benefits

Our targeted audience is PNW user communities that stand to gain real benefit from NANOOS data products. Years of workshops and ongoing outreach has informed NANOOS that efforts are best focused in five high-priority, PNW stakeholder-defined topical areas: **a) maritime operations; b) ecosystem assessment including PNW priority topics of hypoxia, ocean acidification, and Harmful Algal Blooms (HABs); c) fisheries and biodiversity; d) mitigation of coastal hazards; and e) climate**.These topics are intimately linked to economy, health, resiliency, 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 its formative years (2004-2007) 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 60-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 feedback on our NANOOS web-based user products (e.g., NVS, theme pages, decision tools) and RCOOS activities. ***Many of our RCOOS implementers are also our users (e.g., state agencies) or play vital roles on our operational standing committees (e.g., industry, tribes, NGOs), thus feedback interactions are direct, frequent, and two-way.***

Primary benefits to NANOOS audiences, with examples of tailored NVS products, are provided:

i. Maritime Operations: NANOOS provides water, wave and weather observations and forecasts to ship and boat operators **for safe operations and planning.** Audience: Commercial Port Authority offices in Puget Sound, Columbia R and along the coast, coast and bar pilots, USCG District 13, regional USCG coastal stations, and boaters of all types. ***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. Both commercial maritime operations and recreational boaters benefit from NANOOS apps: http://nvs.nanoos.org/MaritimeOps and http://nvs.nanoos.org/Boaters.

ii. Ecosystem Assessment: NANOOS provides time-series and real-time observations and data products used **to evaluate, and in some cases forecast, HABs, hypoxia, ocean acidification, 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, WA Dept. Health, 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 Marine Labs, Seattle Aquarium, Surfrider Foundation, and Nature Conservancy. Benefits are from NVS http://nvs.nanoos.org/Explorer (Fig 1) and NANOOS theme pages on hypoxia, OA, HABs.

iii. Fisheries and Biodiversity: 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 include*** NOAA NWFSC, Quileute Tribe, NW Indian Fisheries Commission, Port Gamble S'Klallam Tribe, Quinault Indian Nation, WA Dept of Fish & Wildlife, OR Dept of Fish & Wildlife, PNW Salmon Center, Columbia River Crab Fisherman's Association, and Puget Sound Partnership. NVS apps are used by fishers http://nvs.nanoos.org/TunaFish and growers http://nvs.nanoos.org/ShellfishGrowers for business decisions that sustain PNW economies.

iv. Mitigation of Coastal Hazards: 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 enhance coastal resiliency, and to track local shoreline change in coastal 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, Raincoast GeoResearch, and Northwest Research Associates. Key apps include tsunami evacuation http://nvs.nanoos.org/TsunamiEvac and beach mapping http://nvs.nanoos.org/BeachMapping.

v. Climate: NANOOS provides climatology and anomaly products from regional buoy and satellite time series **to improve understanding of climate variation and change.** Audience: WA and OR natural resource, tribes, local government planners, and the public-at-large. ***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, Surfrider Foundation and Nature Conservancy. Our NVS climatology app http://nvs.nanoos.org/Climatology provides context and a greater understanding, e.g., re the Pacific 'blob', El Niño, and climate change.

vi. Educators: NANOOS provides learning tools, real-time data lesson plans and other education materials to formal and informal educators **to increase ocean literacy.** 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, Olympic Coast National Maine Sanctuary, NERRS, Seattle Aquarium, WA & OR Sea Grants, OHSU, OSU, UO, UW, and WWU. NANOOS provides a clearinghouse for applicable learning resources and lesson plans: http://www.nanoos.org/resources/marine_science.php; http://www.nanoos.org/education/introduction.php.

D. Work Plan

Our work plan addresses how NANOOS will apply its efforts to address the five PNW user-defined topical area applications. To illustrate this, we have mapped NANOOS' "effort versus application" (Table 1) in order to visualize where our observing and modeling efforts are being applied; to portray the balance across our three spatial domain and the topical application areas; and to highlight how existing gaps that NANOOS proposes to fill will fit in to our overall effort. Our DMAC and outreach, engagement and education subsystems span across and support all these efforts. In this work plan we present our objectives and how we will achieve those, noting the technical approach, partner roles and responsibilities, user involvement, and Milestones (Table 2). We discuss three levels of work effort based on the requested funding levels: $1.5M which is a ~60% cut to our current budget, significantly reducing NANOOS' core capacity, putting in question the relevance of NANOOS and feasibility of many of its sub-systems, requiring serious rethinking of our vision and design; $2.5M which allows NANOOS to maintain current capacity; and $4.0M which allows for hardening of our existing capacity and new investments to fill significant gaps. Our prioritization with stakeholders and our GC has focused on NANOOS priorities for the latter two scenarios.

i. Governance and Management Subsystem: Objective 1. Maintain NANOOS as the U.S. IOOS PNW Regional Association: *As the US IOOS Regional Association for the PNW, NANOOS proposes to sustain our proven role for regional coordination, administrative infrastructure, and stakeholder engagement, engaging federal-non federal (tribal, academic, state, local, industry, NGO) partners.*

NANOOS has designed and implemented regional IOOS infrastructure for the PNW. We propose to sustain management of NANOOS to continue its successful 11-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 for DMAC, User Products, and Outreach, Engage-

ment, & Education (OEE); 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.

PI Newton (UW), NANOOS Executive Director, aided by co-PI Kosro (OSU), NANOOS Board Vice Chair, will oversee sustained management, development, and operation of NANOOS in accordance with IOOS principles and according to the objectives of this proposal. Together they will provide more than 1 FTE to lead the organization. NANOOS Management also includes: co PIs NANOOS Board Chair Martin (UW); DMAC Chair Mayorga (UW); and User Products Chair Allan (DOGAMI). For this and previous proposals, UW acts as the fiscal authority on behalf of NANOOS, entering legally binding agreements, receiving and dispersing funds, and ensuring accountability. The CVs for NANOOS leaders and the lead from each major subcontracted fiscal institution responsible for this work are attached in the Appendix.

NANOOS engages its 60-member GC, with representation from diverse sectors and a regionally equitable distribution, to define and refine its regional priorities. Annual GC meetings are used to identify priorities, new members, and deficiencies of the NANOOS enterprise. In the 2014 10-year review, Newton identified end-to-end linkage from user requirements to RCOOS implementation for NANOOS subsystems, presenting results to the GC for assessment of system performance. Consensus was to retain all efforts. The 15-member elected GC Board, with sector representation from federal, state/local agencies, tribes, academia, industry, and NGOs, and the operational Standing Committee Chairs (DMAC, User Products, and OEE) comprise the ExCom, providing a more agile yet still representative advisory body for NANOOS. The ExCom provides decision-making authority on annual budgets and other prioritization decisions.

NANOOS plays a vital regional coordination role, both within the PNW and along the west coast. For the PNW, NVS serves an order of magnitude more data streams than we financially support. NANOOS is turned to for coordination and assistance with important regional issues, as exemplified by the letter of support (Appendix) from NOAA PMEL acknowledging our regional role coordinating ocean acidification efforts coast wide. Appreciation for our role extends to the entire west coast; NANOOS is recognized along with the other RAs by the West Coast Governors' Agreement whose letter offers support for this proposal (letter, Appendix). NANOOS cooperates extensively with west coast and Pacific RAs, co-hosting workshops (e.g., Pacific Anomalies), sharing competencies (e.g., IPACOA), and strategically planning resources.

NANOOS will continue to participate actively with the U.S. IOOS Program Office, regularly attending semi-annual meetings, and with the IOOS Association, on whose Board Martin and Newton sit; Newton also serves on its ExCom. Newton will assure NANOOS submission of required IOOS progress reports. NANOOS will seek certification as a Regional Information Coordination Entity of US IOOS. Our work plan for this subsystem requires salaries and travel in each year for oversight, coordination, and evaluation under all funding levels. With $1.5M, our effort would be 60% of current, necessitating reduced effort and little travel; with $4.0M, this budget would increase modestly ($30k) for staff support to the Executive Director.

ii. Observing Subsystem: We propose to sustain and enhance observing assets within three observational domains: coastal ocean, estuaries, and shorelines according to our RCOOS Conceptual Design (Fig 2), which derives from NANOOS' Build-Out Plan. We use our Effort vs. Application Map (Table 1) to show how these collectively address NANOOS' priority topical areas and feed user data product development.

Objective 2. Maintain and enhance surface current and wave mapping capability. *NANOOS proposes to maintain existing HF-radar foundational capability and extend it to un-served areas in Washington, northward to the international border, providing a new portion of critical national capacity; continue investment in wave mapping at critical ports.*

PNW Coast HF Surface Current Mapping: Surface currents are fundamental ocean data, serving diverse users. Consistent with the National Surface Current Mapping Plan, we propose to continue to operate a suite of current measurement sites using HF radar in a continuous mapping array from southern WA to northern CA (PI Kosro, OSU). Each year this system produces approximately 50 million individual hourly-averaged radial current measurements. Vector currents are made available to NVS and IOOS, and used by

a wide array of stakeholders, including the US Coast Guard for search-and-rescue, NOAA's Office of Response and Restoration for oil spill and pollution response, ecosystem analysts for tracing transport of HABS, fishermen and other ocean users for route planning, the US Weather Service through AWIPS, field scientists for operational planning, ocean modelers for data assimilation to improve their model fidelity, and for assessment of ocean interannual variability due to the long history. We will continue collaboration with the modeling community to assist in facilitating the assimilation of HF data into regional circulation models. These measurements will contribute to the improvement of maritime operations (search and rescue, vessel routing), to ecosystem assessment, including analysis and modeling of HAB transport. They contribute to the assessment of interannual variability, based on histories extending back to 1997. Our work plan for this subsystem element is to: operate eight SeaSonde HF sites designated as Priority 1 sites by the national HF program (six long-range sites and two standard-range sites) and three Priority 2 standard-range sites.

GAP: WA: Under the $4M annual funding scenario, NANOOS places very high priority to purchase 4 HF systems (Y1, 3-5) to extend surface current mapping farther into WA state along the coast, to complete full coverage of the US West coast. The importance of this coastline stretch for maritime transport, HAB development, fisheries, and coastal hazards cannot be over-emphasized and is a major regional gap. We will collaborate with Canadian efforts in British Columbia at the entrance to the Strait, a major shipping area.

Wave Imaging at Critical PNW Ports: Because of critical potential pay-off to save 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 (PI Haller, OSU). We propose to continue this system, providing 64 images per hour, available in real-time through NVS, including wave directional spectra, both the latest observations and one-week historical records, and a wave-averaged product for viewing current fronts from the most recent tidal cycle. In 2013 OSU installed an additional station on Cape Disappointment to monitor the Mouth of the Columbia River (MCR) supported by the Office of Naval Research (Coastal Geosciences) for DARLA field experiments. The MCR radar installation has proven extremely valuable; data quality at the site is exceptional. We propose to add this station as a real-time station with NANOOS support, consistent with the National Operational Wave Observational Plan. There is significant stakeholder interest in the Columbia River site. We have been working with the Columbia River Bar Pilots (Captain Jordan letter, Appendix) to develop a better understanding of frontal dynamics at the MCR and their impact on navigation, including development of a new "front-imaging" data product indicating sharp surface current gradients that can affect navigation. Our work plan for this element is to continue X-band radar monitoring of waves and currents at two important navigational inlets, Yaquina Bay under a $2.5M budget and to add MCR with the $4.0M budget, and to continue software and product development commensurate with the funding level.

Objective.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 regional coastal ocean observations, with focus on hypoxia, HABs, ocean acidification (OA), climate change detection, and new investment in biological observations.*

NANOOS proposes continued support for coastal shelf buoys and gliders. Though configurations vary, the moorings and gliders measure T, S, pressure, chlorophyll, particles, oxygen, nitrate; surface moorings measure meteorology (wind, radiation, air temperature, etc.). All assets' data are served via NVS. Glider operation is consistent with the U.S. IOOS Underwater Glider Network Plan. NANOOS collaborates closely with NSF's Ocean Observatory Initiative (OOI) PNW observatory and with NSF's Center for Coastal Margin Observation and Prediction (CMOP). The assets NANOOS proposes for ongoing support complement these programs maximizing spatial coverage of oceanographic features and user needs. Collectively, these shelf observing assets provide timely information about seasonal hypoxia severity and extent, OA status, and HAB dynamics, and potentially can be used to predict PNW-wide ocean ecology impacts. Data from these shelf assets are assimilated into and used to verify the results of circulation and ecosystem models.

WA shelf buoy and glider: This system, acquired with Murdock Charitable Trust funding and deployed in 2010, is comprised of three components: a surface mooring ("Cha-ba", meaning "whale tail," named for us by a Quileute Tribal leader) and a sub-surface profiling mooring (PI Mickett, UW), and a Seaglider autonomous underwater vehicle (PI Lee, UW). Collectively these yield an unprecedented synthesized view of WA's coastal processes, which includes 37-m internal waves (Alford et al., 2012). Strong community support from Makah, Hoh, and Quileute Tribes, Quinault Indian Nation (Letter, Appendix), Olympic Coast National Marine Sanctuary, and Washington State was instrumental in sampling justification and defines ongoing system implementation. Interest in OA, hypoxia, and HABs is high, with impacts on these communities.

OR shelf buoy: Continued support for the NH-10 buoy (PI Kosro, OSU) 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, supporting investigation to understand the influence of hypoxia on coastal ecosystems, and observations on OA. Both the Newport and La Push buoys are located at 80m depth to aid inter-comparison of coastal dynamics; both are NOAA Ocean Acidification Program buoys and receive federal support for OA monitoring, adhering to Strategic Plan for Federal Research and Monitoring of Ocean Acidification guidelines.

Columbia River shelf mooring and glider: In between WA and OR is a major driving influence on the coastal waters: the Columbia River. NSF's CMOP, with NANOOS support, has developed a shelf mooring at 30m just south of the Columbia R. on the OR shelf, as well as a Slocum glider on the WA shelf (PI Baptista) as part of the SATURN "collaboratory", serving science and science translation to society (Baptista et al. in review). The glider samples seasonally between Grays Harbor and Quinault, operated in coordination with NANOOS member the Quinault Indian Nation (Letter, Appendix) in response to their management needs, and who advise on the desired sampling pattern and provide logistical field support.

CA shelf glider: In collaboration with CeNCOOS and NMFS, the NANOOS Newport Line glider (co-PIs Barth, Shearman, OSU) was re-positioned to northern CA, to sample off Trinidad Head (Fig 2), coordinated as NSF's OOI glider team took over Newport operations. Bounding NANOOS' southern border, this dynamic region with fronts and eddies is known to have concentrated commercial and recreational fish species.

Our work plan for this objective is to sustain these assets at the $2.5M budget level and to harden them to withstand the elements with uninterrupted service at the $4.0M level. Milestones include QA/QC. Under this scenario, a second glider will be purchased for the La Push line in Y2, enabling year round operations. Based on stakeholder input, the NANOOS GC Executive Committee recommends investments in new directions that expand our coastal ocean shelf observations to the nearshore region and to add biology:

GAP: nearshore hypoxia and acidification: National attention has been drawn to the outbreak of more intensive and nearer-shore hypoxia off the PNW coast and impact of ocean acidification on shellfish growing and ecosystem integrity (Alin et al., 2015). NANOOS proposes to address gaps in our RCOOS coverage with strategic contributions to regional capability to assess ocean acidification and hypoxia (OAH).

1. Broader coverage: We 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 (PI Shearman, OSU). Building on a successful 2005 pilot, temperature and oxygen observations over OR and WA shelf would be expanded to 60-80 crab pots deployed by commercial and tribal fishermen, covering within estuaries to nearshore (5 m depth) to shelf break (200 m depth) over 100's of km alongshore.

2. Inner shelf coverage: Lack of observations comparing OAH shelf observations with the fertile nearshore renders our current understanding less complete. NANOOS proposes support for a set of OAH ocean observing activities: a cross-shelf observation array along 44.25N from the intertidal to 70 m in central OR (PI Chan, OSU); and an along-shelf array of moorings from Cape Flattery to Grays Harbor at a wa-

ter depth of 35 m (PI Grant, OCNMS); both regions are at high risk from OAH due to upwelling patterns. Both receive critical though insufficient funding: the former from the David and Lucile Packard Foundation for the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO); the latter from Olympic Coast National Marine Sanctuary (OCNMS). Proposed investments from NANOOS for both are relatively small but would make a pivotal difference to sustaining high quality data for better understanding OAH.

GAP: biological observations: NANOOS currently does not monitor any biological species. The recently released IOOS Core Biological Variables report to be adopted by the IOOC identifies "Phytoplankton species/abundance" and "Invertebrate species/abundance" as core IOOS variables. NANOOS proposes partial support for a 20-year time series of biweekly observations of hydrography and plankton along the Newport Hydrographic Line (PI Peterson, NWFSC). These data have demonstrated a mechanistic link between basin-scale forcing (PDO and ENSO), food chain structure, and salmon returns in the northern California Current; allowing forecasts of adult Chinook salmon returns to the Columbia River, critical to the PNW region and used by a variety of tribal, state, and federal agencies, which NANOOS would serve.

Objective 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, water quality assessment, sub-regional climate change evaluation, and to sustain and enhance observing ability including new investments in hypoxia, OA, and biological observations.* Our estuarine observing effort is concentrated in the two PNW estuaries with largest economic and ecological footprints (Columbia R and Puget Sound), and in the South Slough/Coos Bay estuaries of coastal OR.

Puget Sound, WA: Our Puget Sound effort benefits from 6 profiling buoys with physical, chemical, and biological sensors constructed through federal (Navy) funding. We propose continued partial support for these buoys (co PIs Mickett and Devol, UW). Two are located in Hood Canal and one each in Admiralty Inlet, Dabob Bay, Puget Sound Main Basin and South Puget Sound. Slower water circulation and other factors in Hood Canal and South Sound result in hypoxia and enhanced OA, of strong concern in Puget Sound (Feely et al., 2010). Exacerbating this situation are projections of high human population growth. These buoys, registered with NDBC, provide several daily depth profiles and 15-min. surface weather, allowing assessment of hypoxia, algal blooms, and climate effects. IOOS/NOAA OAP investment enabled the first estuarine profiling SeaFET pH records (South Sound), with surface pH and pCO_2 sensors provided by NOAA PMEL (Dabob and Hood Canal), NANOOS member King County (Main Basin) and WOAC (rest). Many shellfish growers rely on these data (PCSGA Letter, Appendix). Complementing these fixed assets is NANOOS support for a ferry-box between Seattle, WA and Victoria, BC (PI Maloy, WDOE). WDOE has a successful collaboration with Clipper Navigations, Inc. to collect high frequency, continuous water quality data using sensors on the Victoria Clipper IV. This extremely cost-effective partnership is the only monitoring effort crossing the US/Canadian border, enabling measurement of dynamic water exchange between Puget Sound and the Strait of Juan de Fuca, monitoring surface water, sediment, and river influences.

Columbia River, OR and WA: We propose to maintain and strengthen SATURN (Baptista et al. in review), an established observation and prediction infrastructure for science and societal applications in the Columbia River estuary (co PIs Baptista and Needoba, OHSU). SATURN collects interdisciplinary data served via NVS used extensively in fisheries, navigation improvements, ecosystem restoration and hydropower management, numerical modeling and scientific exploration. SATURN helps bridge across stakeholder communities (federal and state agencies, tribes, others) and provides direct support to major regional decisions, including the Columbia R Channel Improvement Project, the Columbia R Treaty Review, and the Bradwood Landing LNG terminal application. Since 2006, SATURN has been partially funded by NSF through a Science and Technology Center cooperative agreement, non-renewable beyond June 2016 and tapering down since July 2014. CMOP, the center, will remain active and multi-institutional (OHSU, OSU, UW and PSU, plus non-academic partners) beyond July 2016. However, without NSF support, continued NANOOS support will be essential to maintain SATURN for science and science translation.

South Slough/Coos Bay, OR: NANOOS proposes to help support observations in the South Slough / Coos Bay estuary cluster, including major ecological reserves and oyster and fisheries industries. This links NANOOS' estuarine network with the NOAA network of National Estuarine Research Reserve System (NERRS), co-managed by OR Dept of State Lands (ODSL) who has been a NANOOS participant since our inception (PI: Helms, ODSL). Local shellfish growers use the real-time water quality station data available through the NVS for several aspects of their business, including nursery tank operations and during grow out, outplant and monitoring of their established oyster grounds. The water quality data also serve to document reference conditions for restoration projects such as salt marsh restoration projects.

Our work plan for this objective is to sustain these regional estuarine assets at the $2.5M budget level and to harden them to withstand the elements with uninterrupted service at $4.0M level. Milestones include QA/QC. Based on stakeholder input, NANOOS GC Executive Committee recommends investments in new directions that expand our estuarine observations to the central Salish Sea region and to add biology:

GAP: central Salish Sea: Starting in FY16, funding is sought for on-going operations and maintenance (O&M) of a buoy in Bellingham Bay, representing an area where no observations exist (co-PIs Mickett and Hatch). A legacy product of CMOP's education effort, the buoy built by UW to measure water quality upholds CMOP's and NANOOS' goal to engage traditionally underrepresented communities in ocean science via our partner, Northwest Indian College (NWIC), to provide opportunities to learn and use ocean observing technologies and practices, and to engage potential ocean science/ocean observing scientists and workforce in transformative ways. UW will continue its 10-y relationship with NWIC and its students through active NWIC student intern involvement. It includes surface and deep oxygen sensors, with surface pH and meteorological sensors. Ship surveys revealed seasonal hypoxia in Bellingham Bay; scientists at WWU and the Lummi Indian Nation are interested in the data for science and fisheries, respectively.

GAP: biological observations: NANOOS currently does not monitor any biological species. The recently released IOOS Core Biological Variables to be adopted by the IOOC identifies "Phytoplankton species/abundance" as a IOOS core variable. NANOOS proposes partial support for weekly monitoring to identify and enumerate phytoplankton from two OR estuaries: South Slough and Yaquina Bay. Each is instrumented to collect continuous, high-resolution environmental data, providing necessary context to interpret phytoplankton assemblage fluctuations. Samples collected by collaborators at South Slough NERRS and Hatfield Marine Science Center will be sent to OHSU for flow cytometric and microscopic analysis, with digital images archived and shared via a dedicated website (PI Peterson, OHSU). Citizen scientists (students and teachers) in Newport, OR will assist in the collection of samples from Yaquina Bay. While this project is not specifically focused on HAB species, new or emerging HAB threats would be identified.

Objective 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.* NANOOS' shoreline observing effort is a collaboration between WDOE, DOGAMI, and OSU that focuses on WA and OR shorelines.

WA and OR beach, shoreline and bathymetry: In WA, beach monitoring along the Columbia R. littoral cell (CRLC) began in 1997 and was integrated with NANOOS in 2004 (PI Kaminsky, WDOE) directly supporting NANOOS priorities coastal hazards, climate change, and with strong links to maritime operations of navigation through coastal inlets. Monitoring components 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. With the $4.0M budget, we would expand monitoring to Puget Sound, establishing a network of at least 6 sites measured annually or semi-annually, depending on site conditions, to address regional effects of climate change on beaches and nearshore ecosystems.

In OR, with NANOOS funding in 2004, DOGAMI implemented a pilot beach monitoring program along the Rockaway littoral cell (PI Allan, DOGAMI). Monitoring uses the same technique as WA, RTK-DGPS,

capable of accurately documenting seasonal, interannual, and long-term changes (Ruggiero et al., 2005, Allan et al., 2012). With additional NANOOS and other leveraged funding, DOGAMI expanded beach and shoreline monitoring to 178 permanently maintained NANOOS sites, 410 sites established for FEMA coastal flood hazard inundation mapping, and 86 sites observed ad hoc, including monitoring potential effects of wave energy arrays (Oregon Wave Energy Trust), Snowy Plover dune restoration (USFWS), landslide changes (ODOT/FHWA), and erosion control and engineering design at MCR (USACE) and Hatfield Marine Science Center (OSU). With a $4M budget, we will expand spatial and temporal coverage.

In WA and OR, NANOOS-supported nearshore bathymetric observations document seasonal to long-term changes in beach and shoreline morphodynamics and identify coastal hazards (PI Ruggerio, OSU), information critical to state and federal coastal resource managers, geotechnical consultants, and the public. 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 PNW coastlines, supporting US Army Corps' Regional Sediment Management at MCR; Oregon Wave Energy Trust's ocean wave energy conversion projects; FEMA flood mapping activities; and coastal hazards climate change research. With a $4M budget we will expand collection of nearshore bathymetry to the Neskowin littoral cell, with one of the highest coastal erosion rates in all of OR.

Our work plan for this objective is to sustain this bi-state network, with enhancements noted above. These data are of considerable interest and are presently served in a variety of forms via the NANOOS Visualization System beach mapping portal (http://nvs.nanoos.org/BeachMapping). These efforts document beach and shoreline morphodynamics, yield an improved awareness of the spatial and temporal response of beaches to major winter storms and to climate events, and provide information that is being used by state agencies to assist with coastal resource management, coastal geotechnical consultants, federal agencies such as FEMA for coastal flood inundation and erosion mapping, and the public at large.

iii. Modeling and Analysis Subsystem: NANOOS will focus on numerical modeling and analyses to enable now-cast and forecasting capabilities, with efforts serving NANOOS user applications (Table 1).

Objective 6. Provide sustained support to a community of complementary regional numerical models. *Contribute to the operation of regional models, and the tools and products they support, covering the head of tide of estuaries to the outer edges of the EEZ in both OR and WA, with strategic improvements to capabilities and scope, including new forecasts for waves, flood and erosion.*

Currently, NANOOS supports forecast circulation models for coastal OR and WA, Columbia R plume and estuary and NE Pacific and Salish Sea, biogeochemical forecast models in the NE Pacific and Salish Sea and a fish habitat/sediment forecast model of the Columbia R estuary. Our work plan for this objective is to support these models at the $2.5M budget level and to add forecast modeling capability for coastal waves and coastal floods/erosion at $4.0M level. NANOOS' suite of forecast models addresses PNW user needs, is responsive to IOOS National Modeling Strategy, fulfills some goals of NOAA's Ecological Forecasting Roadmap, and leverages IOOS COMT (two NANOOS PIs in West Coast Ocean Forecast System).

NE Pacific and Salish Sea: The daily forecast model, LiveOcean, simulates ocean circulation and biogeochemistry in the Salish Sea and in coastal waters of the NE Pacific, including Oregon, Washington, and British Columbia (PI MacCready, UW). The model is used for research on river plumes, phytoplankton growth, harmful algal blooms (HABs), ocean acidification and hypoxia (OAH), and has been extensively validated against a wide variety of observational data. With NANOOS and WOAC funding, the first daily forecasts (T & S only) are available through NVS since July 2015. The WA shellfish industry lobbied for state funding of OA research, including a forecast model designed to deliver information needed by shellfish growers, specifically several days advanced warning of corrosive (low aragonite saturation state) waters flowing over shellfish beds. NANOOS proposes a number of extensions and improvements to the modeling system that will greatly enhance its utility to stakeholders: high resolution nested sub-model of the

Salish Sea; improvement of Puget Sound biogeochemical model, addition of smaller rivers to coastal and Salish grids, high resolution nested sub-models of coastal estuaries like Willapa Bay, development of decade-to-century hindcasts, and improvement of web access to the model output and data comparisons, developed in collaboration with stakeholders. Extension of the model with higher spatial resolution into Puget Sound and coastal estuaries will allow understanding of and potential response to HAB and OAH events in these heavily utilized regions. A well-validated forecast model would be useful for oil spill response. Longer term, the model can be transitioned to NOAA for operational ecological forecasting, allowing the knowledge gained by over a decade of federal science funding to be most effectively applied to societal problems.

Columbia River estuary and plume: 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 (PI Baptista, OHSU). NANOOS proposes support to maintain daily forecasts of river-to-shelf circulation in the Columbia R., maintain multi-year climatology of river-to-shelf circulation in the Columbia R (aka Climatological Atlas), operationalize daily forecasts of (a) estuarine salmon habitat, in support of adaptive management strategies for dam operation and fish releases, and (b) estuarine sediment dynamics, based on simulations calibrated and validated through independently funded research.

PNW Coastal Waters: As part of NANOOS' effort, a real-time coastal ocean forecast model has been developed and run routinely by the OSU modeling group (PI Kurapov, OSU). The model assimilates satellite and land-based observations (altimetry, SST, HF radar surface currents) and provides everyday updates of oceanic forecasts (surface currents, SST, etc.) along the OR coast (model domain = 41-47N). A new model has been developed, currently at the testing stage. The new system features the extended domain (41-50N, including entire OR and WA coasts), improved model resolution (2 km in horizontal), and Columbia R discharge. This new OR-WA predictor for ocean circulation has been run in near-real time with data assimilation. In 2015, we plan to make it the main ocean data assimilation system, providing outputs to NVS, phasing out the old model. NANOOS proposes to continue supporting and advancing the OR-WA data assimilation system, with improvements to include: adding temperature and salinity vertical sections from gliders (NANOOS, OOI) to the routinely assimilated data, assimilation of surface velocity radial component data, which will improve utilization in areas where data from only one HF radar are available, implementation of the hybrid ensemble-variational data assimilation method, in which the initial condition error covariance will be dynamic, determined from an ensemble of forecasts, adding fresh water inputs in British Columbia and Puget Sound, and develop tools for crab industry (such as conditions for recovering crab pots, depending on three-dimensional velocity information). With NANOOS support for sustainable 24/7 operational implementation, in collaboration with UW (MacCready) and supported by NOAA MERHAB, we will advance toward coupled physical/biochemical forecasts constrained by physical variable assimilation.

Based on stakeholder input, the NANOOS GC Executive Committee recommends investments in new directions that expand our forecasting to coastal waves, floods and erosion:

GAP: Wave Forecasting: Large swell waves and strong ebb tidal currents co-exist at the Mouth of the Columbia River (MCR), with especially pronounced navigational hazards. The large physical scale of the MCR causes long transit times (hours) from the nearest harbor to the actual MCR bar; therefore requiring predictive knowledge about the waves at the bar. The OR coastal wave forecasts and MCR wave forecasts are currently pre-operational under Sea Grant and US DOE funding, though this funding is coming to an end, with forecasts to be discontinued (PI Ozkan-Haller, OSU). The forecasts are robust and operational, hence ready to be fully incorporated into the NANOOS framework. As part of NANOOS, continuing updates to the forecasting physics and extensions of the model to other hazardous navigational inlets can occur.

GAP: Flood and erosion forecasting: While many coastal communities are at high risk of coastal flooding and erosion, decision makers lack both the information and tools to reduce vulnerability, particularly in light of the uncertainty of climate change and extreme events. Various stakeholder sectors, such as emer-

gency management and coastal planning, are struggling to define appropriate responses to the perceived recent increase in the frequency and magnitude of coastal hazards and uncertainty in future predictions. Within this context of uncertainty and urgent societal need we propose to develop and implement detailed forecasts of storm-induced coastal flooding and erosion over the PNW coast using a modified version of CoSMoS (Coastal Storm Modeling System; Barnard, et al., 2014) (PI Ruggerio, OSU).

iv. Data Management and Communications (DMAC) Subsystem: NANOOS will continue its ongoing DMAC collaborations to develop a sustainable system providing IOOS standards-based open data services, tools and products 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 – particularly West Coast – RA's and IOOS to leverage ongoing work, contribute to the maturation of the IOOS DMAC enterprise, and meet IOOS/DMAC Guidance functional roles. NANOOS DMAC is conducted by a highly collaborative team: PI Mayorga, Tanner, UW, Batista/Seaton, OHSU, Kosro/Risien, OSU, Allan, DOGAMI. Our strategic DMAC work plan is focused on sustaining and expanding the NANOOS DMAC Information System and user-facing Web and Products suite, including the integrated and thematically customized NANOOS Visualization System (NVS) framework.

Objective 7. Maintain, harden, and enhance NANOOS' DMAC system for routine operational distribution of data and information. *NANOOS proposes to sustain and enhance the DMAC system NANOOS has built, including the NANOOS Visualization System (NVS), for dynamic and distributed data access and visualization for IOOS.* We will sustain and enhance our DMAC information system, and the Regional Data Assembly Center (DAC) that supports it, in the following areas:

Mature Regional DAC Operations: NANOOS will continue its regular strategic assessment of current and future needs for DAC operations, to sustain, refresh and enhance a highly available, robust, distributed hardware and software environment; maintain appropriate staffing and team coordination; and maintain up-to-date operations and system documentation to ensure transparent and clear descriptions of DAC architecture. We will expand our growing suite of tools and procedures to monitor system servers, web services, data flows and processing, and user application status; will provide complete ingestion and processing of all NANOOS supported observing and modeling assets, building up to full IOOS/DMAC Guidance compliance; and will expand engagement of local providers (not NANOOS funded), integrating their data into NVS and DMAC services and assisting with data management & workflows as possible. DAC capabilities and efficiencies will be additionally strengthened through the regional and thematic partnerships with state agencies, municipalities, tribes and industry NANOOS has successfully engaged in.

IOOS/DMAC Functional Roles: NANOOS is already meeting, or engaging in pilots, to meet all IOOS/DMAC Functional Roles (per IOOS/DMAC Guidance) for at least a subset of assets. This compliance will extend to all NANOOS-funded assets and as many non-NANOOS-funded assets as resources and partnerships allow. NANOOS already provides wide open data sharing, with only limited exceptions; it contributes some of its data to the WMO GTS; employs a Service-Oriented Architecture; and has registered many of its standards-based data services which offer data in approved common formats and using IOOS semantics and identifiers, and are described using standard-compliant metadata. These capabilities will be greatly expanded, with a plan leading to extensive compliance. Current pilots implementing Glider DAC submission and NCEI data archiving will be extended to all assets once refined and matured. A QARTOD pilot will be initiated soon, leading to operational implementation. Service implementation using 52North IOOS SOS, THREDDS, GeoServer WMS, and Web-Accessible Folder (WAF) metadata will be expanded to an ERDDAP server on top of some of these services and, later, OGC CS/W catalog services.

NVS Support and Development: The user-friendly NVS data discovery, access and visualization application framework has served a critical role in NANOOS' service to its stakeholders. The NANOOS DAC will maintain NVS support as one of its central roles, leveraging regional user needs, feedback and data reviews to continually improve the relevance and quality of metadata for observing and modeling data assets

integrated and served by NANOOS. DMAC support will cover more complex data types, including multi-deployment long time series, depth profilers, drifters and gliders; as well geospatial ("GIS") datasets.

Engagement in National and Cross-regional DMAC Efforts: NANOOS will continue to actively participate in IOOS DMAC community development activities, particularly QARTOD (Mayorga is currently a co-editor of the Dissolved Nutrients manual and member of the QARTOD technical committee); vocabulary management and semantic mapping (to which Mayorga has contributed); OGC WMS/WFS support for geospatial data; climatology data development and dissemination (Risien & Allan); unstructured grid support (Seaton); and collaborative code development and testing via github and other channels, including the Python common environment for IOOS (all). NANOOS DMAC will sustain its collaborations with West Coast RA DMAC teams, via the West Coast Ocean Data Network, IOOS Pacific region Ocean Acidification (IPACOA) data integration, and other efforts. Moreover, we will proactively leverage and interact with marine-DMAC relevant efforts team members are engaged in, particularly NSF OOI (Risien), the NSF EarthCube cyberinfrastructure initiative (Mayorga), estuarine and watershed monitoring initiatives (Seaton & Mayorga), international ocean acidification monitoring activities (Mayorga) and Canadian collaborations.

The Citizen Science Data project will provide a data service registration and access service integrated with NVS to manage public and private sector stakeholders contributions of their own data sets.

Objective 8. Continue to deliver existing and create innovative and transformative user-defined products and services for PNW stakeholders. *Continue our NVS innovation to succeed in this vital translation: meaningful and informative data products that connect with user applications and serve society.* The NANOOS web and products team (PI Tanner, UW; NANOOS User Products Chair Allan, DOGAMI), will continue to enhance the web interface, NVS, user products, and visualization and data discovery tools. Our work plan for this objective, per below, will be evaluated and prioritized annually by the Tri-Com based on user feedback, GC input, outreach results for regional priorities.

Web Site: Web content relevant to stakeholder issues, especially those related to Maritime Operations, Ecosystem Assessment, Fisheries & Biodiversity, Coastal Hazards, and Climate, will continue to be evaluated and updated as new information/issues become available. Our flexible framework has proven to be an effective and cost-efficient approach for making information quickly available, responding to events as they happen. We will commence work on an advanced search and discovery web app that will allow users to interactively select assets and variables for data searching. We will implement new in-page web-tracking capabilities using Google Analytics in order to better understand the needs of our users, the content they use the most, and content and products they would like us to provide. With recent enhancements and expansion of the NVS suite of web apps, considerable attention will be directed at updating our help sections.

NVS Improvements: Over the past several years, NANOOS stakeholders have highlighted two important needs: user customization and notification capabilities. We will commence development of a *user customization* functionality within NVS enabling users to interactively select assets of interest, and store them in their MyNANOOS account. We will add additional capabilities (e.g. maps and overlays), culminating with development of a dedicated web app builder allowing our stakeholders to custom build their own web application. With growing need for real-time information and conditional thresholds for undertaking critical job related activities, NANOOS will implement development of a new notification capability, to be integrated across all assets. This new capability will enable automatic user notification when measured values fall outside a specified range. We will then implement user interface development, message broadcaster via email, text or mobile applications, and a receiver to display notice messages within NVS.

Visualization Tools: We will continue to build on the success of NVS by developing new plotting capabilities that will significantly enhance the capabilities of NVS, and ultimately our user needs and experience. We will implement development of a new multi-variable plotting capability that will allow users to evaluate several assets and variables within a single plot. Additional plotting capabilities will be developed, including depth vs. time, depth vs. value, and a transect plotting tool. The latter will enable users to interactively que-

ry 3D models. Essentially the user will be able to draw arbitrary transects on a map in NVS, and plots from the model output would be generated. Recognizing that many of our assets contain information about conditions throughout the water column, a unified depth tool will be developed to allow stakeholders to evaluate and interact with depth related information. This new capability will be similar to how the NVS timeline currently functions, by providing a consistent manner for viewing and interacting with variables over both depth and time. Once the depth control is functional, we will add new depth layers to appropriate overlays.

Tailored Products Development: NANOOS annually evaluates priorities at the Tri-Comm meeting, based on outreach feedback, regional issues, and GC input. High priority products are briefly described here, though we will regularly adapt this plan. Top contenders are: climatology related products that summarize ocean, estuarine, and shoreline conditions; a new Tsunami Resilience web app that integrates important tsunami overlay information, including how long it takes to evacuate from any point in the inundation zone to safety; a model-based, particle tracker for predicting oil spill trajectory and SAR; and web graphics to delineate hypoxia conditions in specific NANOOS areas. Through collaborations with K-12 educators and the public at large, we have received numerous requests for inclusion of non-scientific data collected by citizen scientists. To address this gap, we propose to develop a new citizen science web-based application for K-12 educators to enable uploading and plotting of data collected at the many ocean observing stations established by PNW educators. Lastly, with the rapid expansion of mobile phone use, we recognize the importance of developing dedicated mobile applications that can meet the needs of NANOOS stakeholders, with plans for two new mobile phone apps for development (Tuna Fisher and Shellfish Grower).

v. Outreach, Engagement, and Education Subsystem:

Objective 9. Sustain and strengthen NANOOS outreach, engagement and education. *NANOOS proposes to foster ocean literacy and facilitate use of NANOOS products for IOOS objectives, the core task for which the NANOOS RCOOS is constructed, via existing and new approaches for engaging users and increasing ocean awareness.* We propose to build from and strengthen ongoing Outreach, Engagement, and Education (OEE) efforts, further developing current activities and products in order to maximize their effectiveness (PI Jones, with Sprenger and Wold staff, UW). Conducted in coordination with other regional efforts, this fosters ocean literate citizens and facilitates the informed use of NANOOS products in the PNW by targeted user groups, decision makers, and other citizens. Our OEE efforts will focus on four main areas: *Product Development*; *User Engagement*; *Ocean literacy*; *Communications*.

The primary mission of the user-driven NANOOS is to provide PNW stakeholders with 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 our *product development* and *user engagement* activities. For new NANOOS products, OEE will provide the link between users and DMAC/UPC, engaging users in product development through focus groups, targeted interviews, or surveys to garner feedback and input on products as they are developed.

To engage users in accessing and using NANOOS products in a manner appropriate to their needs, we will search out opportunities to reach targeted user groups, including fishers, shellfish growers, boaters and resource managers. Activities such as presenting and exhibiting at user group meetings, submitting articles to user group publications (recreational boating publications, industry newsletters etc.) and providing trainings will be used to engage users to use NANOOS products and tools. Engagement efforts are critical to reach new potential users at a grassroots level and inform about NANOOS and what we can offer. We propose to continue face-to-face outreach to new communities of potential users. In particular, we propose to engage with PI Waterhouse, OHSU, to better engage OR tribes. Coupling facilitation of two-way *user engagement* between end-users and NANOOS with product development is essential to NANOOS' dedication of being a user-driven RA. We use weekly Tri-Com tag-up calls to bring user feedback gained from trainings and other interactions with users to DMAC/UPC. We work collectively with DMAC/UPC to find solutions to optimize NANOOS user experience. The Tri-Com evaluates the website and product suite annually.

In their 2008 Action Plan, West Coast Governors cited the importance of ocean observations to achieve many of their goals. In 2012, NANOOS, CeNCOOS and SCCOOS and the WCGA signed a Memorandum of Understanding to advance effective management of West Coast coastal and ocean resources. WCGA sponsored a Sea Grant Fellow to connect West Coast IOOS data to managers and stakeholders through the West Coast Ocean Data Portal (WCODP). We plan continued collaboration (PI Hallenbeck, WCGA).

To foster ocean literacy, we will engage with regional non-formal education and formal education communities to bring knowledge and understanding of the ocean ecosystem we have gained through ocean observing to the public. We will work with education communities to facilitate the use of ocean observing data and NANOOS products to support STEM education. We will utilize our developed partnerships with key education programs of NANOOS members, including WA and OR Sea Grants, South Slough and Padilla Bay NERRs, NAME, CMOP, Ocean Inquiry Project, Seattle Aquarium, Port Townsend Marine Science Center and NOAA NWFSC to accomplish this. Five of these are already involved in citizen science efforts related to ocean observing; we will work with these programs and NANOOS DMAC/UPC to develop a citizen science app enabling citizen and student collected data to become part of NANOOS' portal.

Communicating our impact is essential to increase public's understanding of and support for NANOOS and IOOS and the benefits of an ocean observing system for our region and nation. We will work to keep the NANOOS web portal content fresh and current, maintain up-to-date success stories shared via nanoos.org and IOOS, and employ effective use of social media through Facebook, Twitter and our blog. We will be responsive to regional and local events (e.g., blooms, floods, etc.) to enhance relevancy to public and highlight regional stories with NANOOS members and partners. We will support national communication through IOOS Program Office and IOOS Association collaborations.

E. Milestone Schedule

Our milestones for the next five years, with the outcomes these will enable, are in Table 2. These milestones and outcomes were guided by and are consistent with the NANOOS Business Plan (NANOOS, 2009), adopted by the GC in June 2009, the 2012 NANOOS Build-Out Plan (NANOOS, 2012; IOOS Association, 2012), a 2014 10-y retrospective NANOOS Review (NANOOS, 2014), and focused Governing Council meetings on NANOOS growth based on the 2012 IOOS Summit outcomes (IOOC, 2013).

F. Cost Proposal

We submit a five-year, $20M budget, designed to sustain and enhance a robust, end-to-end RCOOS (Table 3) with prioritization budgets (Table 4). Costs can be cross-linked with NANOOS objectives and efforts in our Work Plan and as shown in our Milestone Schedule and NANOOS Effort vs. Application Map.

Budget is requested each year to support the NANOOS RA for regional coordination and its RCOOS subsystems. Indirect charges are collected at each institution's legal rate. Personnel salary and benefits are requested for PI Newton, aided by co-PI Kosro, to oversee and direct all elements of this enterprise. Regional and national travel is requested for coordination, meetings, and workshops associated with IOOS, and NANOOS. For the Observing Subsystem, funds are for personnel/benefits (lead PIs and technicians), supplies, contractual costs, and travel that are required to maintain and harden existing assets: NANOOS HF and port Radars, coastal buoys and gliders, and estuarine and shoreline observations with strategic focus on hypoxia, OA, and biodiversity observations. Equipment is requested for 4 HF radars to extend coverage along WA and for a second glider for WA for year-round operations. 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 forecast models; travel is for IOOS Modeling coordination and regional meetings. Equipment funds are requested for computing and disk storage servers. For the Education and Outreach Subsystem, costs are for salaries for staff, outreach supplies, workshop costs, and travel for IOOS Education and Outreach coordination and regional outreach meetings. Further details are in the Appendix.

APPENDIX

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WEST COAST GOVERNORS ALLIANCE on OCEAN HEALTH
CALIFORNIA OREGON WASHINGTON

8/5/15

Jan Newton
Executive Director
NANOOS
1013 N.E. 40th Street
Seattle, WA 98105-6698

David Anderson
Program Director
CeNCOOS
7700 Sandholdt Road
Moss Landing, CA 95039

Dear Dr. Newton and Dr. Anderson,

On behalf of the West Coast Ocean Data Portal (WCODP), I enthusiastically endorse proposaed 5 year budget of the West Coast IOOS Regional Associations. IOOS provides a valuable and essential service in bringing real-time and historic oceanographic data to a broad suite of stakeholders for emergency response, decision-making, and planning.

The WCODP is a project of the West Coast Governors Alliance on Ocean Health (WCGA) and is dedicated to increasing the access and connectivity of ocean and coastal data and people to better inform regional ocean management, policy development, and planning. The WCODP has collaborated closely with the three Regional Associations of IOOS on the West Coast and have benefited greatly from this partnership. As partners, we rely on CeNCOOS, SCCOOS, and NANOOS expertise in connecting oceanographic data to priority ocean health issues identified by the WCGA. In particular, Jennifer Patterson, Emilio Mayorga, and Darren Wright helped mentor a Sea Grant fellow who developed monthly averaged ocean surface current maps for the West Coast that were used to help plan beach cleanups for marine debris. We look forward to expanding this partnership into other priority ocean health issues such as ocean acidification, hypoxia, and coastal hazards.

We value the efforts made by the West Coast regional associations (SCCOOS, CeNCOOS, and NANOOS), and also the efforts made by their partners from universities and other institutions that comprise the observing system. These additional contributions by others extend the reach and impact of the IOOS investment.

There is a clear, continuing need to fully fund operations, maintainer, and improvements to the the regional observing systems. We are fully committed to partnering with the West Coast IOOS Regional Associations on continued work to make valuable data available for regional decision-making.

Sincerely,

Andy Lanier,
Oregon Coastal Management Program
WCODP Co-Chair

Dr. Steve Steinberg,
Southern California Coastal Water Research Project, WCODP Co-Chair

WEST COAST OCEAN DATA PORTAL

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
OAR Laboratories
Pacific Marine Environmental Laboratory
NOAA Building Number 3
7600 Sand Point Way NE
Seattle, WA 98115

August 21, 2015 R/PMEL

To Whom It May Concern:

As the laboratory leading NOAA's West Coast ocean acidification monitoring program, we are writing to express our strong support for the proposal of Dr. Jan Newton and colleagues entitled *Sustaining NANOOS, the Pacific Northwest component of the US IOOS*. NOAA has been mandated by Congress to lead the nation's ocean acidification monitoring and research effort. NOAA's ocean acidification monitoring network in Pacific Northwest coastal waters, detailed in the *NOAA Ocean and Great Lakes Acidification Research Plan*, has been designed to capitalize on existing NANOOS assets, which provide essential platforms as well as extremely valuable ancillary sensors that facilitate and complement NOAA's ocean acidification observations, respectively. Without NANOOS assets, our ability to effectively monitor the development and effects of ocean acidification in Pacific Northwest coastal waters would be significantly curtailed.

The Pacific Northwest is a sentinel region for ocean acidification nationwide, because waters upwelled along our coastline are naturally CO2-rich, such that the addition of anthropogenic CO2 can render them corrosive to marine organisms sooner than in other regions. We have been extensively collaborating with NANOOS on both infrastructure development and outreach and educational efforts over the past few years. We envision that together these components of NANOOS will provide a test bed for the development of an ocean acidification early warning system that would benefit the shellfish industry and other stakeholders in the Pacific Northwest. Thus, we cannot overstate the importance of maintaining NANOOS's infrastructural, data management, and outreach assets for the successful development of NOAA's West Coast and national ocean acidification monitoring networks and information products.

Sincerely,

Richard A. Feely

Richard A. Feely
Senior Scientist

THE COLUMBIA RIVER BAR PILOTS

Providing Safe Passage Since 1846

21 August 2015

Dear NANOOS:

I offer strong support for the continuation of NANOOS at a high level, as you propose in your 5-y "Sustaining NANOOS, the Northwest Association of Networked Observing Systems" proposal application to NOAA.

NANOOS has been a valued partner and regional coordinating body, providing unique and effective data for mariners. Ships crossing the Columbia River Bar face one of the most dangerous harbor entrances in the world. The Columbia River Bar Pilots rely on weather forecasts, real time buoy data along with wave and current models when determining safe times for ships to cross the bar. NANOOS provides an excellent location for us to see and compare all the available data sources.

Further, NANOOS has proven itself as a critical link between NOAA management and PNW stakeholders. Most recently, the NDBC buoy 46089 was being decommissioned. I appreciated working with NANOOS, to codify the requirements for coastal ocean data from the Columbia Bar Pilots and from others. I believe that getting the extent and type of data usage known to the highest levels of NOAA NOS and NWS was a large factor in their decision to preserve this buoy critical to our safe operations.

I am pleased to let you know that NANOOS is making a very real difference to the safety and efficiency of maritime operations in the Columbia River area of the PNW. I wish you success.

Best Regards

Captain Daniel Jordan

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Quinault Indian Nation
PO Box 189 * Taholah, WA 98587

Dr. Jan Newton
Executive Director, NANOOS
Applied Physics Laboratory
University of Washington
1013 N.E. 40th Street
Seattle, WA 98105-6698

August 21, 2015

RE: Northwest Association of Networked Ocean Observing Systems (NANOOS).

The Quinault Indian Nation is pleased to support the ongoing efforts of NANOOS and is hopeful for this organization's continued funding and enhancement. As an original NANOOS member, our 11-year relationship has been very successful and fruitful. Our collaboration includes access to seasonal hypoxia information from an OHSU glider in our treaty ocean area, real-time sea and weather information from the NVS, and the new Live Ocean forecasts off our coast, among others. Of high interest to us lately is the new focus on Harmful Algal Blooms (HABs), which we hope this 5 year effort can sustain.

The coastal tribes of Washington State are shellfish harvesters and at the mercy of changing winds that transport HABs from incubation sites offshore. Harvesters seldom get warning before HABs are already on the shores where tribal HAB samplers spot them and managers can take action to restrict harvest of shellfish should toxins be present. Having the NANOOS automated HAB sampler, with toxin assessment capability, offshore between our harvest beaches and the HAB generation sites will give tribes forewarning they need to adjust sampling protocols and better protect the health of coastal residents, tribal and non-tribal.

The information we secure from NANOOS assists us in the continued safe harvest of our treaty resources and assuring that our cultural practices are safer than if we did not have this knowledge.

Sincerely,

Joe Schumacker, Marine Resources Scientist
Quinault Indian Nation, Department of Fisheries

PCSGA

PACIFIC COAST SHELLFISH GROWERS ASSOCIATION

August 18, 2015

Jan Newton, Ph.D.
Applied Physics Laboratory
University of Washington
1013 NE 40th St
Seattle WA 98105-6698

Dear Dr. Newton,

I write on behalf of the members of the Pacific Coast Shellfish Growers Association (PCSGA) in support of your 5-y proposal for continuation of NANOOS. The work of NANOOS contributes significantly to the region's shellfish industry which in turn supports coastal economies dependent on the industry for jobs. Shellfish have been an essential part of Pacific NW communities for over a century. During this time, farming techniques have evolved in response to environmental do citizens and market demands. This current generation of shellfish farmer is reliant upon data and services from NANOOS. Checking the NANOOS app or website before seeding a beach or filling a setting tank has become standard practice.

PCSGA and shellfish growers individually enjoy our partnerships regarding monitoring of ocean acidification all along the Pacific Coast. Most recently, we appreciate the work NANOOS did with the Washington State Department of Health to provide surface temperature sensors that enhance our ability to safely and efficiently address Vibrio pathogen outbreaks.

Please keep up the good work! It makes a big difference to us. We wish you luck in securing funding for this on-going effort so valuable to our members. Please keep me posted on your progress and be sure to let me know how I may assist you further.

Respectfully,

Margaret Pilaro Barrette
Executive Director

120 State Ave. NE, #142 • Olympia, WA 98501 • phone: 360-754-2744 • fax: 360-754-2743
www.pcsga.org

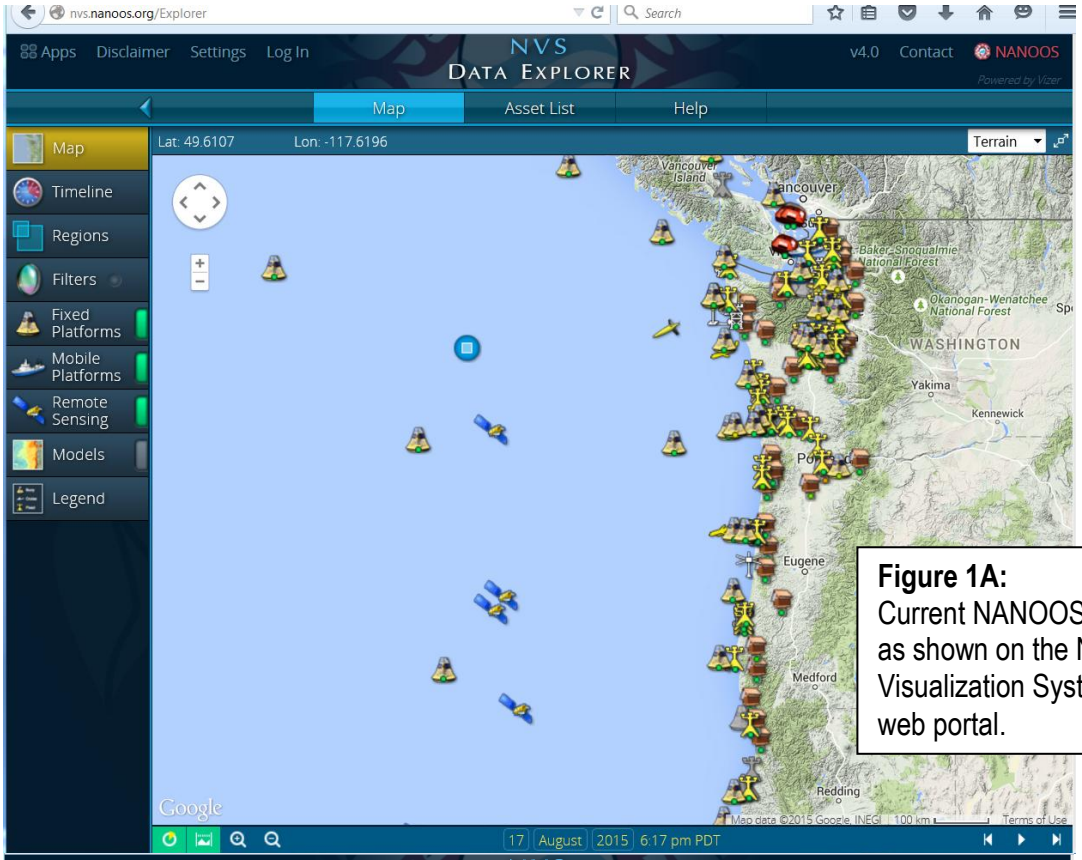

Figure 1A:
Current NANOOS assets, as shown on the NANOOS Visualization System (NVS) web portal.

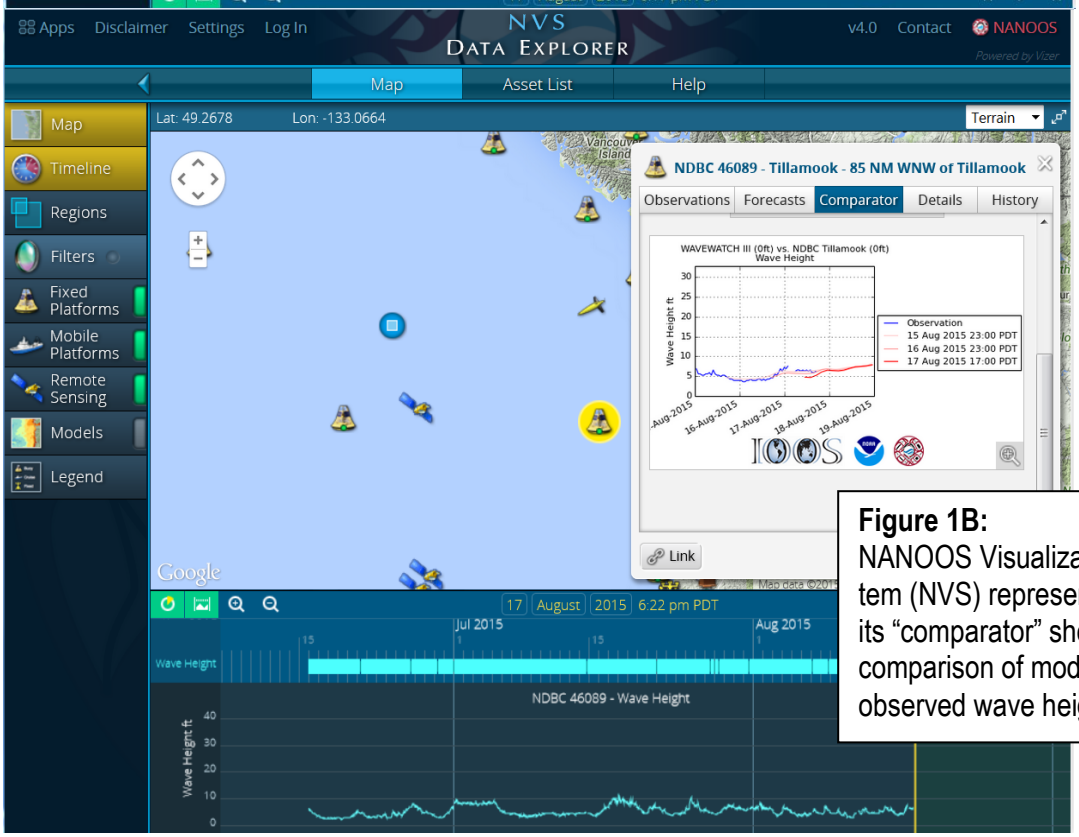

Figure 1B:
NANOOS Visualization System (NVS) representation of its "comparator" showing comparison of modeled and observed wave height data.

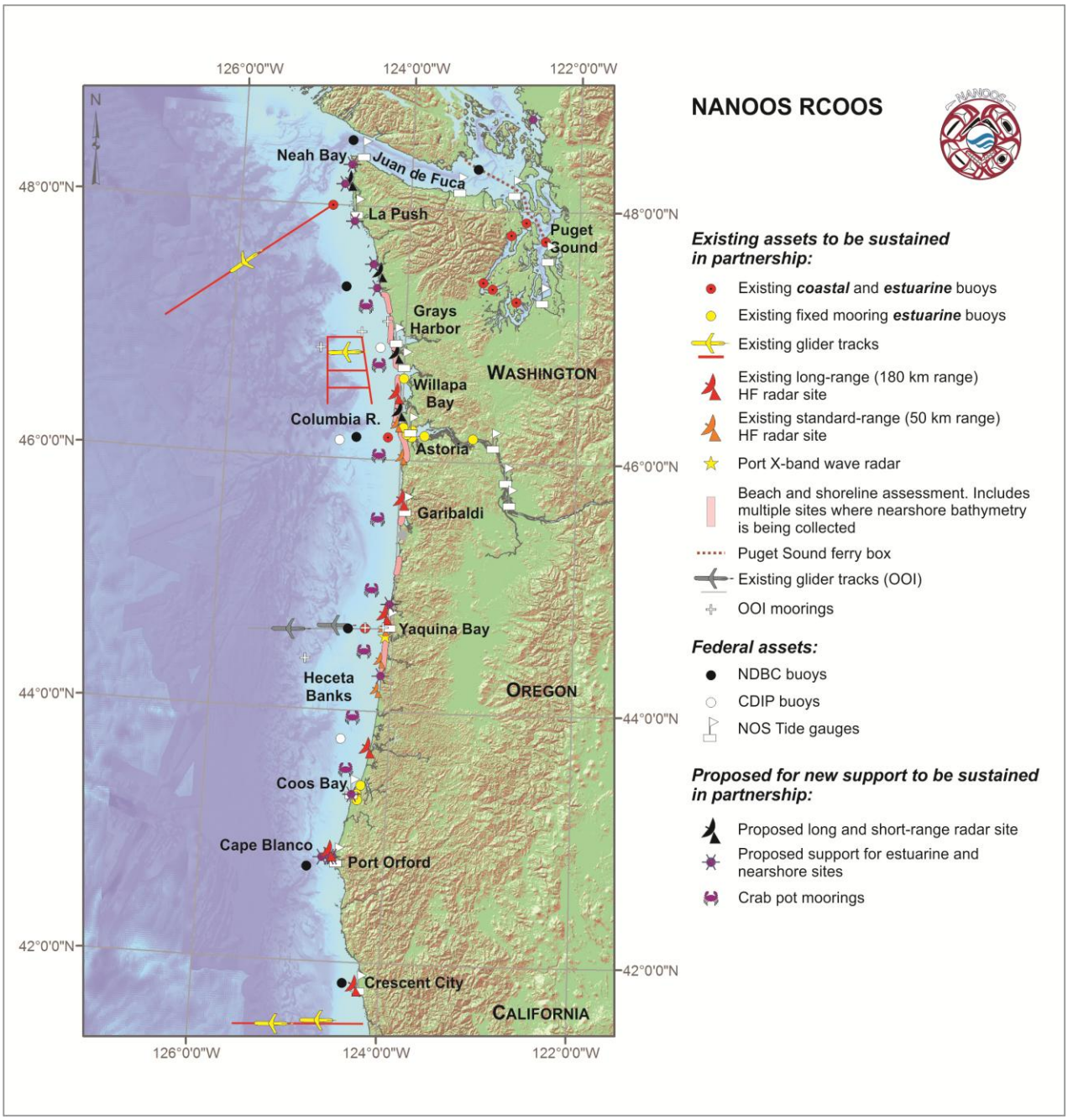

Figure 2: Conceptual design of the NANOOS RCOOS observing subsystem for its implementation years 10-14 (= FY16-20). The original design upon which this current figure is based was conceived by NANOOS stakeholders during numerous NOAA-funded NANOOS workshops during the early 2000s; it was adopted by the NANOOS Governing Council in 2007 and forms the basis of our Conceptual Design document (http://www.nanoos.org/about_nanoos/documents.php). This updated design reflects input from stakeholders, PIs, and users, and is responsive to the LOI process that NANOOS used for determining its efforts for the next five years and the design that will serve that. NANOOS and OOI PIs coordinated a single design that optimizes spatial coverage and will serve data jointly. The NANOOS RCOOS design's content shown here was approved by the NANOOS Governing Council Executive Committee in July 2015.

Table 1: NANOOS "Effort versus Application" Map for Observing and Modeling. The "Applications" were established as PNW priorities by the NANOOS Governing Council and ratified periodically. The "Efforts" represent a mix of sustained (blue) and new (green) investments within our Conceptual Design (NANOOS 2007) and Business Plan (NANOOS 2009) with input from NANOOS Governance; new efforts, all found within our 2012 NANOOS Build-out Plan (NANOOS, 2012), were prioritized by our GC.

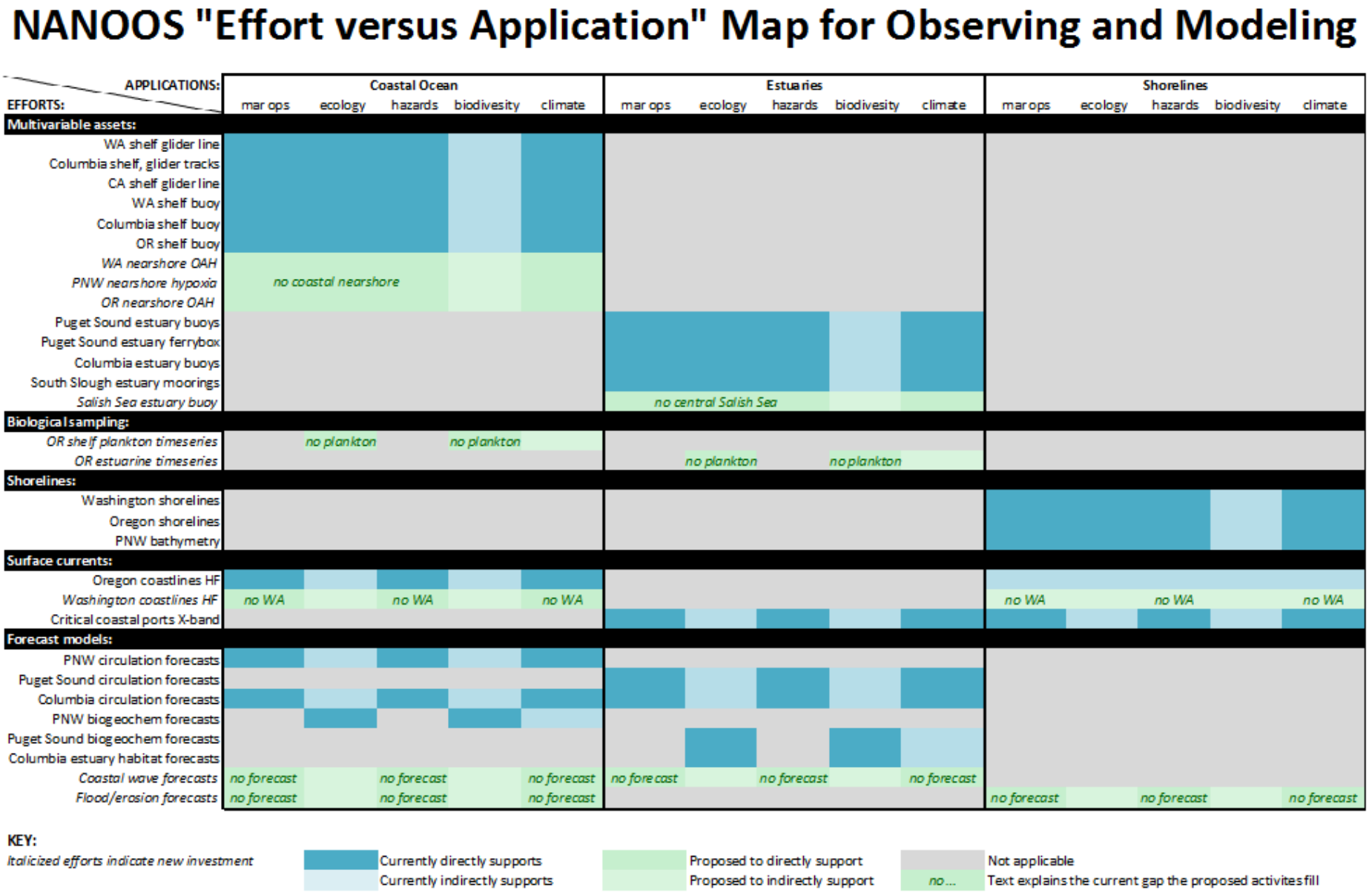

Table 2: Milestone Schedule for NANOOS RCOOS Implementation Years 10-14 (FY16-20)

Area	Y1	Y2	Y3	Y4	Y5	Outcomes
Observations						
Shelf: *Throughout 5 years:* **- Maintain La Push, Newport, and Columbia R. buoys; deliver NRT data streams via NANOOS Visualization System (NVS)** **- Maintain WA, OR, and N CA shelf glider transects; deliver data via NVS** **Estuaries:** *Throughout 5 years:* **- Maintain Puget Sound, Columbia R., and South Slough estuarine moorings; deliver data via NVS**	- Bring all data QA/QC to meet Certification standards - Support collection of OA data from La Push and NH-10 buoys with NOAA OAP funding - Add WA shelf hypoxia observations via tribal/commercial fishers and OR & WA shelf OAH observations via collaboration with OCNMS and PISCO; add Bellingham Bay OAH obs with NWIC - Add plankton monitoring in Col R and Newport	- Assure all data QA/QC meets Certification standards - Further develop data products from assets - Support collection of OA data from La Push and NH-10 buoys with NOAA OAP funding - Purchase Seaglider to bring La Push glider operations to year-round coverage	- Assess whether product development needs are being met with observing system design - Support collection of OA data from La Push and NH-10 buoys with NOAA OAP funding	- Assess whether and how observing investments are providing valuable information that meet stakeholder needs - Support collection of OA data from La Push and NH-10 buoys with NOAA OAP funding	- Identify shelf and estuarine observing gaps of highest priority to region - Support collection of OA data from La Push and NH-10 buoys with NOAA OAP funding	NANOOS provides users real-time and time-series data to assess ecosystem impacts (HABs, hypoxia, and ocean acidification); assimilation / verification to models (circulation and ecological forecasting); climate baseline and assessment.
Shorelines: *Throughout 5 years:* **- Maintain shoreline observations in WA and OR; deliver data via NVS**	- Bring all data QA/QC to meet Certification standards	- Assure all data QA/QC meets Certification standards -Further develop data products from assets	- Assess whether product development needs are being met with observing system design	- Assess whether and how observing investments are providing valuable information to meet stakeholder needs	- Identify shoreline observing gaps of highest priority to region	NANOOS provides users data to assess coastal hazards, shoreline stability, tsunami preparedness, climate change effects.
Currents: *Throughout 5 years:* **- Maintain OR Priority-One HF radar sites to the national operations standard; deliver data via NVS and the National HF Radar system** **- Maintain X-band radar sites; deliver data via NVS**	- Bring all data QA/QC to meet Certification standards - Purchase/install 1st HF in WA - Add maintenance of 2nd X-band site at mouth of Columbia R (MCR)	- Assure all data QA/QC meets Certification standards - Bring 1st WA HF on-line - Further develop data products from assets	- Purchase/install 2nd HF in WA	- Bring 2nd WA HF on-line - Purchase/install 3rd HF in WA	- Bring 3rd WA HF on-line - Purchase/install 4th HF in WA	NANOOS provides users in Washington state with data to address maritime operations safety, coastal transport, and climate change effects. NANOOS provides mariners at the dangerous MCR with data to address maritime safety.

Area	Y1	Y2	Y3	Y4	Y5	Outcomes
Modeling						
Throughout 5 years: **- Maintain modeling & forecasting capabilities at OSU, OHSU, & UW at reduced level; make model output available via NVS**	- Model verification and validation - Add OR coastal wave forecasting at Col R mouth - Add flood and erosion hazards forecasting	- Further develop data products from model outputs	- Assess whether product development needs are being met with current modeling efforts	- Assess whether and how modeling investments are providing valuable information that meet stakeholder needs	- Identify modeling gaps of highest priority to region	NANOOS has model output for products on web, e.g.,Tuna Plots for ocean fishers, circulation forecasts for tracking HABs; OA forecasts. NANOOS provides forecast capability in dangerous MCR region.
DMAC						
Throughout 5 years: Mature Regional DAC Operations	- Sustain, refresh and enhance hardware and software environment; appropriate staffing; and operations documentation - Engage new local providers (not NANOOS funded), integrate their data into NVS and IOOS DMAC services, and assist with their data management & workflows - Strengthen DAC capabilities and resources through regional and thematic partnerships					NANOOS applications, NANOOS users and IOOS DMAC system are supported by a mature, reliable regional DAC meeting all core IOOS/DMAC Functional Roles, and actively engaged in local to national partnerships.
IOOS/DMAC Functional Roles	- Sustain & enhance existing data streams, IOOS web services, GTS submission - Initial, limited implementation of NCEI data archiving, Glider DAC submission, QARTOD - Deploy ERDDAP to leverage web services, serve NANOOS applications and users		- Mature-expand Y1-Y2 implementations - OGC CSW catalog service	- Sustain, refine and harden all web service operations, data distribution, and core IOOS/DMAC Function Roles		
Engagement in National and Cross-regional DMAC Efforts	- Sustain participation in IOOS DMAC community activities, including QARTOD development, semantic mapping, OGC WMS/WFS support, climatology data development, UGRID support, and shared code development and testing - Engage and leverage OOI and NSF EarthCube, international GOA-ON activities and Canadian collaborations - Engage West Coast and Pacific efforts, including WCGA and IPACOA					
Web Site Improvement	- Improve ease of usability - Improve user tracking capabilities					NANOOS users have reliable and informative access to data and data products, with a, user-friendly interface and services they want.
NVS Improvement	- Develop and implement user customization - Develop and implement notification capability					
Visualization Tool Improvement	- Depth vs. time plots - Multivariate plotting	-Glider data/AIS track - Unified depth tool	- Data comparison tools	- Transect plots	- 3-D visualizations	
Tailored Product Development	- Climatology app - Tsunami resilience app - Tsunami mobile app rebuild	- Climatology app - Particle tracking (SAR) app - NVS mobile app rebuild	- Climatology app - Citizen science app - Tuna fisher mobile app development	- Climatology app - Shellfish grower mobile app	- Climatology app	
Citizen Science Data Project	- Advisory Group, identify pilot test groups	- Develop “user data input” capability to private access NVS - Pilot test groups	- Launch capacity on public access NVS	- Evaluation and alterations	- Completion	Citizen Science Data can be uploaded to NVS, engaging several regional groups and the public.

Area	Y1	Y2	Y3	Y4	Y5	
Outreach, Engagement, and Education						
Throughout all 5 years: **- Maintain existing and build new relationships to stakeholder user groups and the education community enabling NANOOS to achieve effective outreach, engagement, and education (OEE)** *Effective OEE must occur consistently throughout the project period in these four on-going efforts:*	Assure products are developed to meet users' needs: - Work with DMAC and User Products Committee on tailored product development to meet specific user needs, as per above, and through Tri-Committee meetings; for each new product engage users in product development. - Gain feedback and conduct self-assessment after product release.					Diverse user communities benefit from NANOOS tools and products for everyday decisions; citizens increase their ocean literacy through interactions with NANOOS
	Engage stakeholders to use NANOOS products and tools: - Conduct trainings to broader user groups and evaluate trainings to optimize NANOOS help functions - Evaluate website and product suite annually; interpret evaluation results with recommendations discussed at weekly Tri-Com tag-up calls					
	Foster ocean literacy: - Engage with regional non-formal education communities to facilitate the use of NANOOS products to engage citizens to increase their ocean literacy. - Engage with regional formal education communities to use ocean observing and NANOOS products to support STEM education.					
	Communicate our impact: - Maintain up-to-date success stories, employing effective use of social media - Be responsive to regional and local events (e.g., blooms, floods, etc.) to enhance relevancy to public and highlight regional stories with NANOOS members and partners. - Support national communication through IOOS Program Office and IOOS Association collaborations.					
Administration: *Throughout all 5 years:*						
Management	- Provide NANOOS with oversight, coordination, and management of the full suite of activities that comprise NANOOS.					NANOOS has a reliable, accountable, interactive, and representative management structure and operating system.
Governance	- Assure that NANOOS has transparent, effective, and representational governance via its Governing Council and the NANOOS Executive Committee composed of its elected Board and its functional committee chairs. - Assure these bodies are engaged in NANOOS prioritization of regional needs, work effort, and product development. - Assure balance of stakeholders represented in NANOOS reflects the diversity found in PNW. - Conduct annual GC meeting.					
Representation	- Represent NANOOS at IOOS Program Office and IOOS Association meetings, and at national meetings of significance (e.g., Oceans 20xx, or bi-annual meetings of CERF and Ocean Sciences). - Engage at a regional level at meetings and workshops affecting PNW stakeholders and NANOOS.					
Project oversight	- Conduct annual all-PI meetings and Tri-Committee meetings, providing clear feedback and direction. - Share project evaluation at the annual PI meeting.					
Coordination	- Coordinate with West Coast RAs and other RAs to optimize and leverage capabilities and assure consistencies. - Engage in sub-regional and user-group specific workshops to aid coordination and optimization of effort.					
Accountability	- Submit required IOOS progress reports and respond to other requests. - Seek certification as a Regional Information Coordination Entity of US IOOS.					

Table 3: Five-year NANOOS budget FY2016-2020. Italics indicate new investments for NANOOS.

RCOOS Element:	Lead Institution	Lead PI(s)	Y10 FY16	Y11 FY17	Y12 FY18	Y13 FY19	Y14 FY20
Observations:							
WA shelf glider	APL-UW	Lee	100,000	220,000	100,000	100,000	100,000
CA shelf glider	OSU	Barth/Shearman	100,000	100,000	100,000	100,000	100,000
WA shelf buoys	APL-UW	Mickett	160,000	160,000	160,000	160,000	160,000
OR shelf buoy	OSU	Kosro	150,000	150,000	150,000	150,000	150,000
Columbia shelf glider, buoy, estuarine moorings	OHSU	Baptista/Needoba	300,000	300,000	300,000	300,000	300,000
WA nearshore OAH	*OCNMS*	*Grant*	29,442	29,442	29,442	29,442	29,442
PNW nearshore hypoxia	*OSU*	*Shearman*	90,000	90,000	90,000	90,000	90,000
OR nearshore OAH	*OSU*	*Chan*	70,000	70,000	70,000	70,000	70,000
Puget Sound estuary buoys	APL-UW & UW Ocean	Mickett/Devol	280,000	280,000	280,000	280,000	280,000
Puget Sound estuary ferry box	WA Ecology	Maloy	60,000	60,000	60,000	60,000	60,000
South Slough estuary moorings	OR DOSL	Helms	45,000	45,000	45,000	45,000	45,000
Salish Sea estuary buoy	*APL-UW / NWIC / WWU*	*Mickett / Hatch / McPhee-Shaw*	41,200	41,200	41,200	41,200	41,200
OR shelf plankton timeseries	*NOAA NWFSC*	*W. Peterson*	75,000	75,000	75,000	75,000	75,000
OR estuarine plankton timeseries	*OHSU*	*T. Peterson*	30,755	30,755	30,755	30,755	30,755
WA shoreline observations	WA Ecology	Kaminsky	100,000	100,000	100,000	100,000	100,000
OR shoreline observations	DOGAMI	Allan	90,000	90,000	90,000	90,000	90,000
PNW nearshore bathymetry	OSU	Ruggerio	75,000	75,000	75,000	75,000	75,000
OR coastlines HF	OSU	Kosro	405,000	405,000	405,000	405,000	405,000
WA coastlines HF	*OSU*	*Kosro*	240,000	120,000	240,000	240,000	240,000
Critical coastal ports X-band radar	OSU	Haller	70,000	70,000	70,000	70,000	70,000
			2,511,397	**2,511,397**	**2,511,397**	**2,511,397**	**2,511,397**
Modeling:							
PNW circulation forecasts	OSU	Kurapov	100,000	100,000	100,000	100,000	100,000
Columbia shelf/estuarine circ and BGC forecasts	OHSU	Baptista	55,000	55,000	55,000	55,000	55,000
WA Coast-Puget Sound circ and BGC forecasts	UW Ocean	MacCready	75,000	75,000	75,000	75,000	75,000
Coastal Wave forecasts	*OSU*	*Ozkan-Haller*	58,603	58,603	58,603	58,603	58,603
Flood/erosion forecasts	*OSU*	*Ruggerio*	50,000	50,000	50,000	50,000	50,000
			338,603	**338,603**	**338,603**	**338,603**	**338,603**
DMAC:							
DMAC UW	APL-UW	Mayorga	170,000	170,000	170,000	110,000	110,000
DMAC OSU	OSU	Kosro	80,000	80,000	80,000	80,000	80,000
DMAC CMOP	OHSU	Baptista	40,000	40,000	40,000	40,000	40,000
			290,000	**290,000**	**290,000**	**290,000**	**290,000**
Education & Outreach:							
Web Devel. & User Products	APL-UW	Tanner	250,000	250,000	250,000	250,000	250,000
Outreach, Engagement & Education	APL-UW / OHSU / WCGA	Jones /Waterhouse/ Hallenbeck	171,000	171,000	171,000	171,000	171,000
User Products Committee Chair	DOGAMI	Allan	20,000	20,000	20,000	20,000	20,000
			441,000	**441,000**	**441,000**	**441,000**	**441,000**
Administration							
NANOOS Management, Contracts, Governance	APL-UW	Newton	419,000	419,000	419,000	419,000	419,000
			419,000	**419,000**	**419,000**	**419,000**	**419,000**
			4,000,000	**4,000,000**	**4,000,000**	**4,000,000**	**4,000,000**

Table 4: Prioritization budgets for FFO-requested funding levels. The $1.5M budget is a ~60% reduction in current budget; functionality across the system at this level has not been evaluated, and would require hard analysis.

Element:	Lead Institution	Lead PI(s)	$1.5M	$2.5M	$4.0M
Observations:					
WA shelf glider	APL-UW	Lee	45,000	75,000	100,000
CA shelf glider	OSU	Barth/Shearman	45,000	75,000	100,000
WA shelf buoys	APL-UW	Mickett	66,000	110,000	160,000
OR shelf buoy	OSU	Kosro	60,000	100,000	150,000
Columbia shelf glider, buoy, estuarine moorings	OHSU	Baptista/Needoba	120,600	201,000	300,000
WA nearshore OAH	*OCNMS*	*Grant*	0	0	29,442
PNW nearshore hypoxia	*OSU*	*Shearman*	0	0	90,000
OR nearshore OAH	*OSU*	*Chan*	0	0	70,000
Puget Sound estuary buoys	APL-UW & UW Ocean	Mickett/Devol	108,000	180,000	280,000
Puget Sound estuary ferry box	WA Ecology	Maloy	18,000	30,000	60,000
South Slough estuary moorings	OR DOSL	Helms	18,000	30,000	45,000
Salish Sea estuary buoy	*APL-UW / NWIC / WWU*	*Mickett / Hatch / McPhee-Shaw*	0	0	41,200
OR shelf plankton timeseries	*NOAA NWFSC*	*W. Peterson*	0	0	75,000
OR estuarine plankton timeseries	*OHSU*	*T. Peterson*	0	0	30,755
WA shoreline observations	WA Ecology	Kaminsky	36,000	60,000	100,000
OR shoreline observations	DOGAMI	Allan	27,000	45,000	90,000
PNW nearshore bathymetry	OSU	Ruggerio	25,800	43,000	75,000
OR coastlines HF	OSU	Kosro	243,000	405,000	405,000
WA coastlines HF	*OSU*	*Kosro*	0	0	240,000
Critical coastal ports X-band radar	OSU	Haller	30,600	51,000	70,000
Modeling:					
PNW circulation forecasts	OSU	Kurapov	42,000	70,000	100,000
Columbia shelf/estuarine circ and BGC forecasts	OHSU	Baptista	12,000	20,000	35,000
WA Coast-Puget Sound circ and BGC forecasts	UW Ocean	MacCready	36,000	60,000	75,000
Coastal Wave forecasts	*OSU*	*Ozkan-Haller*	0	0	58,603
Flood/erosion forecasts	*OSU*	*Ruggerio*	0	0	50,000
DMAC:					
DMAC UW	APL-UW	Mayorga	63,000	105,000	110,000
DMAC OSU	OSU	Kosro	36,000	60,000	80,000
DMAC CMOP	OHSU	Baptista	36,000	60,000	60,000
Education & Outreach:					
Web Devel. & User Products	APL-UW	Tanner	114,000	190,000	250,000
Outreach, Engagement & Education	APL-UW / OHSU / WCGA	Jones /Waterhouse/ Hallenbeck	84,000	140,000	171,000
User Products Committee Chair	DOGAMI	Allan	0	15,000	20,000
Administration					
NANOOS Management, Contracts, Governance	APL-UW	Newton	234,000	375,000	419,000
		TOTAL:	**1,500,000**	**2,500,000**	**4,000,000**

Table 5: NANOOS Annual and Summary Budgets

RCOOS YR 10-14 PROPOSAL EFFORT DISTRIBUTION BREAKDOWN SUMMARY
YEAR 10

UNIVERSITY OF WASHINGTON:

Title / Lead	Mngmt Newton	DMAC Mayorga	Product & Web Dev Tanner	Outreach & Education Jones	WA Shelf Buoys Mickett	Salish Sea Buoy Mickett	Puget Snd Buoys Mickett	WA Shelf Gliders Lee	IDC on Sub Awards	**APL TOTAL**	ATMOS Atm Model Mass	**Other UW** OCN PS Model MacCready	OCN PS Buoys Devol	**Combined Yr 10 Grand TOTAL**
Salaries	140,233	63,920	98,469	57,533	35,824	7,273	59,095	26,623	0	**488,970**	4,959	31,436	43,026	**568,391**
Benefits	74,744	34,070	52,484	30,665	19,613	3,877	31,091	14,190	0	**260,734**	1,513	8,517	12,700	**283,464**
Equipment	0	4,500	5,000	0	10,540	0	0	0	0	**20,040**	0	2,300	0	**22,340**
Travel	30,660	8,996	6,045	3,628	3,824	950	2,580	0	0	**56,683**	0	0	1,595	**58,278**
Sub Awards	2,369,800	0	0	0	0	0	0	0	0	**2,369,800**	0	0	0	**2,369,800**
Services	16,140	450	0	4,100	40,523	6,080	28,060	12,062		**107,415**	0	630		**108,045**
Supplies	1,165	137	215	1,788	10,910	358	10,247	19,212	0	**44,032**	0	0	931	**44,963**
Grad Op Fees	0	0	0	0	0	0	0	0	0	**0**	0	0		**0**
Prorated Direct Costs	74,323	33,878	52,189	30,492	17,050	3,855	31,320	14,110	0	**257,217**	0	0	0	**257,217**
Total Direct	2,707,065	145,951	214,402	128,206	138,284	22,393	162,393	86,197	0	**3,604,891**	6,472	42,883	58,252	**3,712,498**
Indirect Coss	57,335	24,049	35,598	21,794	21,716	3,807	27,607	13,803	24,400	**230,109**	3,528	22,117	31,748	**287,502**
TOTAL	**2,764,400**	**170,000**	**250,000**	**150,000**	**160,000**	**26,200**	**190,000**	**100,000**	**24,400**	**3,835,000**	**10,000**	**65,000**	**90,000**	**4,000,000**

SUBAWARDS Breakdown Summary:

OREGON STATE UNIVESITY:

Area / Lead	CA Shelf Glider Barth	OR Shelf Buoy Kosro	Nearshore Bathymetry Ruggerio	HF Radar Kosro	Port Radar Haller	OR-WA Coast Model Kurapov	OSU DMAC Kosro	Wave Forecasts Ozkan	PNW near-shore T/02 Shearman	Flood Forecasts Ruggiero	OR near-shore OAH Chan	**OSU TOTAL**
Salaries	29,447	43,631	29,257	175,811	27,372	33,363	24,813	23,896	7,619	19,105	9653	**423,967**
Benefits	14,113	22,647	8,608	93,774	15,876	14,334	13,151	11,077	3,557	4,371	8060	**209,568**
Equipment	0	25,000	0	135,000	0	17,999	0	0	60,000	0	0	**237,999**
Travel	1,300	2,500	10,000	6,000	1,500	4,500	5,000	978	1,500	500	500	**34,278**
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	**0**
Services	1,275	2,900	0	9,100	3,034	300	5,400	2,851	675	169	400	**26,104**
Supplies	14,124	13,647	3,330	14,000	0	267	6,243	1,200	7,127	3,566	5418	**68,922**
Other	8,000	0	0	49,438	0	0	0	0	0	0	23750	**81,188**
Grad Op Fees	0	0	0	0	0	4,702	0	0	0	9,404	0	**14,106**
Total Direct	68,259	110,325	51,195	483,123	47,782	75,465	54,607	40,002	80,478	37,115	47,781	**1,096,132**
Indirect Cost	31,741	39,675	23,805	161,877	22,218	24,535	25,393	18,601	9,522	12,885	22219	**392,471**
TOTAL	**100,000**	**150,000**	**75,000**	**645,000**	**70,000**	**100,000**	**80,000**	**58,603**	**90,000**	**50,000**	**70,000**	**1,488,603**

Table 5: NANOOS Annual and Summary Budgets

OTHER SUB AWARDS:

Sub Awardee	OHSU				WCGA	WA Eco.	DOGAMI	OR DOSL	NWIC	WWU		NOAA		
Area	Col shf Obs Model, DMAC	Columbia R Moorings	Columbia R Phytoplank	Indigenous Network	Data Synthesis	WA Shore Obs/PS ferry	OR Shore Observ	S. Slough Moorings	Salish Sea Tribal	Salish Sea Buoy sup	**TOTAL**	Newport Zooplankton	WA near-shore OAH	**TOTAL**
Lead	Baptista	Needoba	Peterson	Waterhouse	Hallenbeck	Kaminsky	Allan	Helms	Hatch	McPee-Shaw	**OTHER**	Peterson	Grant	**NOAA**
Salaries	167,908	14,731	7,974	2,325	12,500	63,703	49,939	0	5,610	2,560	327,250	54,791	0	54,791
Benefits	54,817	5,042	2,579	721	0	22,883	23,456	0	1,049	0	110,547	0	0	0
Equipment	0	0	0	0	0	6,500	0	38,270	0	0	44,770	0	0	0
Travel	4,642	552	500	1,500	1,000	12,220	12,535	0	1,636	0	34,585	1,956	0	1,956
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Services	0	7,300	6,418	0	0	16,559	0	0	0	2,400	32,677	1,000	21,945	22,945
Supplies	30,211	1,237	1,500	0	0	15,537	0	6,730	0	40	55,255	2,499	7,497	9,996
Other	0	360	1,000	0	0	0	3,720	0	0	0	5,080	0	0	0
Grad Op Fees	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Direct	257,578	29,222	19,971	4,546	13,500	137,402	89,650	45,000	8,295	5,000	610,164	60,246	29,442	89,688
Indirect Cost	92,422	15,778	10,784	1,454	1,500	22598	20,350	0	1,705	0	166,591	14,754	0	14,754
TOTAL	350,000	45,000	30,755	6,000	15,000	160,000	110,000	45,000	10,000	5,000	776,755	75,000	29,442	104,442

Table 5: NANOOS Annual and Summary Budgets

RCOOS YR 10-14 PROPOSAL EFFORT DISTRIBUTION BREAKDOWN SUMMARY
YEAR 11

UNIVERSITY OF WASHINGTON:

Title Lead	Mngmt Newton	DMAC Mayorga	Product & Web Dev Tanner	Outreach & Education Jones	WA Shelf Buoys Mickett	Salish Sea Buoy Mickett	Puget Snd Buoy Mickett	WA Shelf Gliders Lee	IDC on Sub Awards	**APL TOTAL**	ATMOS Atm Model Mass	**Other UW** OCN PS Model MacCready	OCN PS Buoys Devol	**Combined Yr 11 Grand TOTAL**
Salaries	141,640	63,733	98,425	56,631	36,135	7,253	59,941	26,847	0	**490,605**	4,959	32,694	42,913	**571,171**
Benefits	75,494	33,970	52,460	30,184	19,794	3,866	31,605	14,309	0	**261,682**	1,513	8,858	12,740	**284,793**
Equipment	0	4,635	5,000	0	10,540	0	0	120,000	0	**140,175**		0	0	**140,175**
Travel	31,542	9,271	6,218	6,540	3,824	982	2,580	0	0	**60,957**		0	1,595	**62,552**
Sub Awards	2,249,800	0	0	0	0	0	0	0	0	**2,249,800**		0	0	**2,249,800**
Services	16,140	464	0	4,100	39,925	6,080	26,260	12,062	0	**105,031**		519	0	**105,550**
Supplies	799	121	133	1,755	10,910	368	10,238	18,750	0	**43,074**		0	1,004	**44,078**
Grad Op Fees	0	0	0	0	0	0	0	0	0	**0**		0	0	**0**
Prorated Direct Costs	75,069	33,778	52,165	28,995	17,156	3,844	31,769	14,229	0	**257,005**		0	0	**257,005**
Total Direct	332,692	145,971	214,401	128,205	138,284	37,393	162,393	206,197	0	**1,365,536**	6,472	42,071	58,252	**1,472,331 0**
Indirect Coss	57,916	24,028	35,599	21,795	21,716	3,807	27,607	13,803	20,400	**226,671**	3,528	22,929	31,748	**284,876**
TOTAL	**2,648,400**	**170,000**	**250,000**	**150,000**	**160,000**	**26,200**	**190,000**	**220,000**	**20,400**	**3,835,000**	**10,000**	**65,000**	**90,000**	**4,000,000**

SUBAWARDS Breakdown Summary:

OREGON STATE UNIVESITY:

Area Lead	CA Shelf Glider Barth	OR Shelf Buoy Kosro	Nearshore Bathymetry Ruggerio	HF Radar Kosro	Port Radar Haller	OR-WA Coast Model Kurapov	OSU DMAC Kosro	Wave Forecasts Ozkan	PNW near-shore T/O2 Shearman	Flood Forecats Ruggiero	OR near-shore OAH Chan	**OSU TOTAL**
Salaries	30,030	47,303	28,815	179,327	27,919	40,464	25,309	24,374	30,807	19,636	9,943	**463,927**
Benefits	14,693	25,060	8,825	97,444	16,472	18,161	13,667	11,543	5,391	4,679	8,302	**224,237**
Equipment	0	21,500	0	0	0	0	0	0	5,000	0	0	**26,500**
Travel	1,300	4,500	10,000	6,000	1,560	4,500	5,000	978	1,500	1,500	500	**37,338**
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	**0**
Services	1,275	1,400	0	9,100	0	300	5,400	1,971	675	169	400	**20,690**
Supplies	13,729	9,152	3,380	14,000	1,668	1,260	5,045	1,000	6,223	1,343	4,011	**60,811**
Other	7,000	0	0	51,272	0	0	0	0	0	0	24,463	**82,735**
Grad Op Fees	0	0	0	0	0	4,914	0	0	19,444	9,828	0	**34,186**
Total Direct	68,027	108,915	51,020	357,143	47,619	69,599	54,421	39,866	69,040	37,155	47,619	**950,424**
Indirect Cost	31,973	41,085	23,980	167,857	22,381	30,401	25,579	18,737	20,960	12,845	22,381	**418,179**
TOTAL	**100,000**	**150,000**	**75,000**	**525,000**	**70,000**	**100,000**	**80,000**	**58,603**	**90,000**	**50,000**	**70,000**	**1,368,603**

Table 5: NANOOS Annual and Summary Budgets

OTHER SUB AWARDS:

Sub Awardee	OHSU				WCGA	WA Eco.	DOGAMI	OR DOSL	NWIC	WWU		NOAA		
Area	Col shf Observ Model, DMAC	Columbia R Moorings	Columbia R Phytoplank	Indigenous Network	Data Synthesis	WA Shore Obs/PS ferry	OR Shore Observ	S. Slough Moorings	Salish Sea Tribal	Salish Sea buoy sup.	**TOTAL**	Newport Zooplankton	WA near-shore OAH	**TOTAL**
Lead	Baptista	Needoba	Peterson	Waterhouse	Hallenbeck	Kaminsky	Allan	Helms	Hatch	McPee-Shaw	**OTHER**	Peterson	Grant	**NOAA**
Salaries	167,484	14,779	8,182	2,323	12,500	64,257	49,939	0	5,610	2,560	327,634	54,941	0	54,941
Benefits	54,745	5,071	2,646	720	0	23,098	23,456	0	1,049	0	110,785		0	0
Equipment	0	0	0	0	0	6,500	0	38,670	0	0	45,170		0	0
Travel	4,602	552	500	1,503	1,000	12,220	12,535	0	1,636	0	34,548	2,500	0	2,500
Sub Awards	0	0	0	0	0	0	0	0	0	0	0		0	0
Services	0	7,300	6,143	0	0	16,559	0	0	0	2,400	32,402		22,085	22,085
Supplies	30,745	1,158	1,500	0	0	14,566	3,720	6,330	0	40	58,059	1,425	7,357	8,782
Other	0	360	1,000	0	0	0	0	0	0	0	1,360	1,200	0	1,200
Grad Op Fees	0	0	0	0	0	0	0	0	0	0	0		0	0
Total Direct	257,576	29,220	19,971	4,546	13,500	137,200	89,650	45,000	8,295	5,000	609,958	60,066	29,442	89,508
											0			
Indirect Cost	92,424	15,780	10,784	1,454	1,500	22800	20,350	0	1,705	0	166,797	14,934	0	14,934
TOTAL	350,000	45,000	30,755	6,000	15,000	160,000	110,000	45,000	10,000	5,000	776,755	75,000	29,442	104,442

Table 5: NANOOS Annual and Summary Budgets

RCOOS YR 10-14 PROPOSAL EFFORT DISTRIBUTION BREAKDOWN SUMMARY
YEAR 12

UNIVERSITY OF WASHINGTON:

											Other UW			
Title	Mngmt	DMAC	Product & Web Dev	Outreach & Education	WA Shelf Buoys	Salish Sea Buoy	Puget Snd Buoy	WA Shelf Gliders	IDC on Sub	**APL**	ATMOS ATM Model	OCN PS Model	OCN PS Buoys	**Combined Yr 12 Grand**
Lead	Newton	Mayorga	Tanner	Jones	Mickett	Mickett	Mickett	Lee	Awards	**TOTAL**	Mass	MacCready	Devol	**TOTAL**
Salaries	149,024	63,682	98,330	57,840	37,434	7,221	59,936	27,047	0	**500,514**	4,959	31,702	43,479	**580,654**
Benefits	79,430	33,942	52,410	30,828	20,503	3,849	31,666	14,416	0	**267,044**	1,513	8,511	12,948	**290,016**
Equipment	0	4,774	5,000	0	7,204	0	0	0	0	**16,978**	0	0	0	**16,978**
Travel	32,490	9,220	6,410	3,856	3,824	1,013	2,580	0	0	**59,393**	0	0	1,595	**60,988**
Sub Awards	2,369,800	0	0	0	0	0	0	0	0	**2,369,800**	0	0	0	**2,369,800**
Services	16,140	477	0	4,100	40,523	6,080	26,260	12,062	0	**105,642**	0	1,858	0	**107,500**
Supplies	1,327	146	137	1,967	10,526	403	10,185	18,337	0	**43,028**	0	0	230	**43,258**
Grad Op Fees	0	0	0	0	0	0	0	0	0	**0**	0	0	0	**0**
Prorated Direct Costs	78,983	33,751	52,115	29,614	17,785	3,827	31,766	14,335	0	**262,176**	0	0	0	**262,176**
Total Direct	332,692	145,993	214,402	128,205	137,799	37,393	162,393	86,196	0	**1,245,073**	6,472	42,071	58,252	**1,351,868 0**
Indirect Coss	60,756	24,008	35,598	21,795	22,201	3,807	27,607	13,803	850	**210,425**	3,528	22,929	31,748	**268,630**
TOTAL	**2,787,950**	**170,000**	**250,000**	**150,000**	**160,000**	**26,200**	**190,000**	**100,000**	**850**	**3,835,000**	10,000	**65,000**	**90,000**	**4,000,000**

SUBAWARDS Breakdown Summary:

OREGON STATE UNIVESITY:

Area	CA Shelf Glider	OR Shelf Buoy	Nearshore Bathymetry	HF Radar	Port Radar	OR-WA Coast Model	OSU DMAC	Wave Forecasts	PNW near-shore T/O2	Flood Forcasts	OR near-shore OAH	
Lead	Barth	Kosro	Ruggerio	Kosro	Haller	Kurapov	Kosro	Ozkan	Shearman	Ruggiero	Chan	**OSU TOTAL**
Salaries	30,624	48,236	28,345	182,915	27,291	38,661	25,815	23,470	31,734	20,186	10,241	**467,518**
Benefits	15,288	26,032	9,048	101,222	16,375	18,427	14,198	11,313	5,553	4,843	8,551	**230,850**
Equipment	0	9,000	0	135,000	0	0	0	0	5,000	0	0	**149,000**
Travel	1,450	2,500	10,000	6,000	1,622	4,500	5,000	978	1,500	1,500	500	**35,550**
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	**0**
Services	1,275	2,900	0	9,100	0	1,300	4,400	2,905	675	169	400	**23,124**
Supplies	13,390	16,250	3,627	14,000	2,331	1,645	5,009	1,200	4,536	328	2,731	**65,047**
Other	6,000	0	0	33,702	0	0	0	0	0	0	0	**39,702**
Grad Op Fees	0	0	0	0	0	5,136	0	0	20,322	10,272	25,196	**60,926**
Total Direct	68,027	104,918	51,020	481,939	47,619	69,669	54,422	39,866	69,320	37,298	47,619	**1,071,717**
Indirect Cost	31,973	45,082	23,980	163,061	22,381	30,331	25,578	18,737	20,680	12,702	22,381	**416,886**
TOTAL	**100,000**	**150,000**	**75,000**	**645,000**	**70,000**	**100,000**	**80,000**	**58,603**	**90,000**	**50,000**	**70,000**	**1,488,603**

Table 5: NANOOS Annual and Summary Budgets

OTHER SUB AWARDS:

Sub Awardee	OHSU				WCGA	WA Eco.	DOGAMI	OR DOSL	NWIC	WWU		NOAA		
Area	Col shf Obs Model, DMAC	Columbia R Moorings	Columbia R Phytoplank	Indigenous Network	Data Synthesis	WA Shore Obs/PS ferry	OR Shore Observ	S. Slough Moorings	Salish Sea Tribal	Salish Sea Buoy sup.	**TOTAL**	Newport Zooplankton	WA near-shore OAH	**TOTAL**
Lead	Baptista	Needoba	Peterson	Waterhouse	Hallenbeck	Kaminsky	Allan	Helms	Hatch	McPee-Shaw	**OTHER**	Peterson	Grant	**NOAA**
Salaries	167,957	14,736	8,427	2,313	12,500	64,257	49,939	0	5,610	2,560	328,299	54,760	0	54,760
Benefits	54,980	5,072	2,725	717	0	23,099	23,456	0	1,049	0	111,098	0	0	0
Equipment	0	0	0	0	0	6,500	0	39,070	0	0	45,570	0	0	0
Travel	4,780	552	500	1,516	1,000	12,220	12,535	0	1,636	0	34,739	2,500	0	2,500
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Services	0	7,300	6,173	0	0	16,559	0	0	0	2,400	32,432	0	23,943	23,943
Supplies	29,859	1,200	1,145	0	0	14,565	3,720	5,930	0	40	56,459	1,352	5,499	6,851
Other	0	360	1,000	0	0	0	0	0	0	0	1,360	1,500	0	1,500
Grad Op Fees	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Direct	257,576	29,220	19,970	4,546	13,500	137,200	89,650	45,000	8,295	5,000	609,957	60,112	29,442	89,554
Indirect Cost	92,424	15,780	10,785	1,454	1,500	22800	20,350	0	1,705	0	166,798	14,888	0	14,888
TOTAL	350,000	45,000	30,755	6,000	15,000	160,000	110,000	45,000	10,000	5,000	776,755	75,000	29,442	104,442

Table 5: NANOOS Annual and Summary Budgets

RCOOS YR 10-14 PROPOSAL EFFORT DISTRIBUTION BREAKDOWN SUMMARY
YEAR 13

UNIVERSITY OF WASHINGTON:

Title / Lead	Mngmt Newton	DMAC Mayorga	Product & Web Dev Jones	Outreach & Education Jones	WA Shelf Buoys Mickett	Salish Sea Buoy Mickett	Puget Snd Buoys Mickett	WA Shelf Gliders Lee	IDC on Sub Awards	**APL TOTAL**	ATMOS Atm Model Mass	**Other UW** OCN PS Model MacCready	OCN PS Buoys Devol	**Combined Yr 13 Grand TOTAL**
Salaries	148,486	65,071	98,284	57,803	38,337	7,286	59,956	26,856	0	**502,079**	4,959	32,970	43,291	**583,299**
Benefits	79,143	34,683	52,386	30,809	21,001	3,883	31,743	14,314	0	**267,962**	1,513	8,851	12,973	**291,299**
Equipment	0	4,917	5,000	0	5,652	0	0	0	0	**15,569**	0	0	0	**15,569**
Travel	33,456	6,742	6,604	3,956	3,824	1,039	2,580	0	0	**58,201**	0	0	1,356	**59,557**
Sub Awards	2,369,800	0	0	0	0	0	0		0	**2,369,800**	0	0	0	**2,369,800**
Services	16,140	0	0	4,100	39,647	6,080	26,176	12,062	0	**104,205**	0	250	0	**104,455**
Supplies	1,470	112	37	1,942	10,910	243	10,161	18,732	0	**43,607**	0	0	632	**44,239**
Grad Op Fees	0	0	0	0	0	0	0	0	0	**0**	0	0	0	**0**
Prorated Direct Costs	78,698	34,488	52,091	29,595	18,202	3,862	31,777	14,233	0	**262,946**	0	0	0	**262,946**
Total Direct	332,692	146,013	214,402	128,205	137,573	37,393	162,393	86,197	0	**1,244,868**	6,472	42,071	58,252	**1,351,663**
Indirect Coss	60,757	23,987	35,598	21,795	22,427	3,807	27,607	13,803	850	**210,631**	3,528	22,929	31,748	**U 268,836**
TOTAL	**2,787,950**	**170,000**	**250,000**	**150,000**	**160,000**	**26,200**	**190,000**	**100,000**	**850**	**3,835,000**	**10,000**	**65,000**	**90,000**	**4,000,000**

SUBAWARDS Breakdown Summary:

OREGON STATE UNIVESITY:

Area / Lead	CA Shelf Glider Barth	OR Shelf Buoy Kosro	Nearshore Bathymetry Ruggerio	HF Radar Kosro	Port Radar Haller	OR-WA Coast Model Kurapov	OSU DMAC Kosro	Wave Forecasts Ozkan	PNW near-shore T/O2 Shearman	Flood Forecasts Ruggiero	OR near-shore OAH Chan	**OSU TOTAL**
Salaries	31,230	51,480	27,843	184,281	27,595	39,461	26,332	23,585	32,688	20,750	10,548	**475,793**
Benefits	15,901	27,483	9,277	102,998	16,833	19,167	14,746	11,594	5,720	5,010	8,808	**237,537**
Equipment	0	6,000	0	135,000	0	0	0	0	5,000	0	0	**146,000**
Travel	1,450	4,500	10,000	6,000	1,687	4,500	5,000	978	1,500	500	500	**36,615**
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	**0**
Services	1,275	1,400	0	9,100	0	300	5,400	2,509	675	169	400	**21,228**
Supplies	13,171	13,096	3,900	14,000	1,504	948	2,944	1,200	2,793	283	3,869	**57,708**
Other	0	0	0	30,560	0	0	0	0	0	0	23,494	**54,054**
Grad Op Fees	5,000	0	0	0	0	5,367	0	0	21,237	10,734	0	**42,338**
Total Direct	68,027	103,959	51,020	481,939	47,619	69,743	54,422	39,866	69,613	37,446	47,619	**1,071,273**
Indirect Cost	31,973	46,041	23,980	163,061	22,381	30,257	25,578	18,737	20,387	12,554	22,381	**417,330**
TOTAL	**100,000**	**150,000**	**75,000**	**645,000**	**70,000**	**100,000**	**80,000**	**58,603**	**90,000**	**50,000**	**70,000**	**1,488,603**

Table 5: NANOOS Annual and Summary Budgets

OTHER SUB AWARDS:

Sub Awardee	**OHSU**				**WCGA**	**WA Eco.**	**DOGAMI**	**OR DOSL**	**NWIC**	**WWU**		**NOAA**		
Area	Col shf Obs Model, DMAC	Columbia R Moorings	Columbia R Phytoplank	Indigenous Network	Data Synthesis	WA shore Obs/PS ferry	OR Shore Observ	S. Slough Moorings	Salish Sea Tribal	Salish Sea buoy Sup.	**TOTAL**	Newport Zooplankton	WA near-shore OAH	**TOTAL**
Lead	Baptista	Needoba	Peterson	Waterhouse	Hallenbeck	Kaminsky	Allen	Helms	Hatch	McPee-Shaw	**OTHER**	Peterson	Grant	**NOAA**
Salaries	167,288	14,761	8,513	2,308	12,500	64,822	49,939	0	5,610	2,560	328,301	56,400	0	56,400
Benefits	54,882	5,095	2,753	715	0	23,318	23,456	0	1,049	0	111,268	0	0	0
Equipment	0	0	0	0	0	6,500	0	39,470	0	0	45,970	0	0	0
Travel	4,744	552	400	1,523	1,000	12,220	12,535	0	1,636	0	34,610	1,500	0	1,500
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Services	0	7,252	6,330	0	0	14,659	0	0	0	2,400	30,641	0	24,146	24,146
Supplies	30,662	1,200	1,100	0	0	15,476	370	5,530	0	40	54,378	1,046	5,296	6,342
Other	0	360	875		0	0	0	0	0	0	1,235	1,000	0	1,000
Grad Op Fees	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Direct	257,576	29,220	19,971	4,546	13,500	136,995	86,300	45,000	8,295	5,000	606,403	59,946	29,442	89,388
Indirect Cost	92,424	15780	10,784	1,454	1,500	23,005	20,350	0	1,705	0	167,002	15,054	0	15,054
TOTAL	350,000	45,000	30,755	6,000	15,000	160,000	106,650	45,000	10,000	45,000	813,405	75,000	29,442	104,442

Table 5: NANOOS Annual and Summary Budgets

RCOOS YR 10-14 PROPOSAL EFFORT DISTRIBUTION BREAKDOWN SUMMARY
YEAR 14

UNIVERSITY OF WASHINGTON:

											Other UW			
Title	Mngmt	DMAC	Product & Web Dev	Outreach & Education	WA Shelf Buoys	Salish Sea Buoy	Puget Snd Buoys	WA Shelf Gliders	IDC on Sub	**APL TOTAL**	ATMOS Atm Model	OCN PS Model	OCN PS Buoys	**Combined Yr 14 Grand**
Lead	Newton	Mayorga	Tanner	Jones	Mickett	Mickett	Mickett	Lee	Awards		Mass	MacCready	Devol	**TOTAL**
Salaries	147,935	65,413	98,198	59,279	39,141	7,242	59,876	27,363	0	**504,447**	4,959	32,632	44,010	**586,048**
Benefits	78,850	34,865	52,340	31,595	21,446	3,860	31,475	14,584	0	**269,015**	1,513	8,700	13,186	**292,414**
Equipment	0	0	5,000	0	2,826	0	0	0	0	**7,826**	0	0	0	**7,826**
Travel	34,420	9,766	6,795	4,080	3,824	1,040	2,580	0	0	**62,505**	0	0	1,057	**63,562**
Sub Awards	2,369,800	0	0	0	0	0	0	0	0	**2,369,800**	0	0	0	**2,369,800**
Services	16,340	506	0	1,100	40,523	6,080	26,459	12,062	0	**103,070**	0	739	0	**103,809**
Supplies	1,442	80	24	1,800	10,839	333	10,269	17,686	0	**42,473**	0	0	0	**42,473**
Grad Op Fees	0	0	0	0	0	0	0	0	0	**0**	0	0	0	**0**
Prorated Direct Costs	78,406	34,669	52,045	30,351	18,564	3,838	31,734	14,502	0	**264,109**	0	0	0	**264,109**
Total Direct	332,692	145,299	214,402	128,205	137,163	37,399	162,393	86,197	0	**1,098,451**	6,472	42,071	58,253	**1,205,247**
Indirect Coss	60,757	24,701	35,598	21,795	22,837	3,807	27,607	13,803	850	**211,755**	3,528	22,929	31,747	**269,959**
TOTAL	**2,787,950**	**170,000**	**250,000**	**150,000**	**160,000**	**26,200**	**190,000**	**100,000**	**850**	**3,835,000**	10,000	**65,000**	**90,000**	4,000,000

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SUBAWARDS Breakdown Summary:

OREGON STATE UNIVESITY:

Area	CA Shelf Glider	OR Shelf Buoy	Nearshore Bathymetry	HF Radar	Port Radar	OR-WA Coast Model	OSU DMAC	Wave Forecasts	PNW near-shore T/O2	Flood Forecasts	PR near-shore OAH	
Lead	Barth	Kosro	Ruggerio	Kosro	Haller	Kurapov	Kosro	Ozkan	Shearman	Ruggiero	Chan	**OSU TOTAL**
Salaries	31,848	52,497	28,401	187,965	27,900	40,278	26,858	23,695	33,666	21,182	10,865	**485,155**
Benefits	16,217	28,029	9,361	103,410	17,019	19,556	15,040	11,638	5,892	5,012	9,072	**240,246**
Equipment	0	0	0	135,000	0	0	0	0	5,000	0	0	**140,000**
Travel	1,450	4,500	10,000	6,000	1,755	4,300	5,000	978	1,500	0	500	**35,983**
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	**0**
Services	1,275	1,400	0	9,100	0	0	4,400	2,955	675	169	400	**20,374**
Supplies	13,237	15,615	3,258	14,000	945	78	3,124	600	994	21	4,553	**56,425**
Other	4,000	0	0	26,464	0	0	0	0	0	0	22,229	**52,693**
Grad Op Fees	0	0	0	0	0	5,608	0	0	22,191	11,216	0	**39,015**
Total Direct	68,027	102,041	51,020	481,939	47,619	69,820	54,422	39,866	69,918	37,600	47,619	**1,069,891**
Indirect Cost	31,973	47,959	23,980	163,061	22,381	30,180	25,578	18,737	20,082	12,400	22,381	**418,712**
TOTAL	**100,000**	**150,000**	**75,000**	**645,000**	**70,000**	**100,000**	**80,000**	**58,603**	**90,000**	**50,000**	**70,000**	**1,488,603**

Table 5: NANOOS Annual and Summary Budgets

OTHER SUB AWARDS:

Sub Awardee	**OHSU**				**WCGA**	**WA Eco.**	**DOGAMI**	**OR DOSL**	**NWIC**	**WWU**		**NOAA**		
Area	Col shf Obs Model,DMAC	Columbia R Moorings	Columbia R Phytoplank	Indigenous Network	Data Synthesis	WA Shore Obs/PS ferry	OR Shore Observ	S. Slough Moorings	Salish Sea Tribal	Salish Sea buoy sup.	**TOTAL**	Newport Zooplankton	WA near-shore OAH	**TOTAL**
Lead	Baptista	Needoba	Peterson	Waterhouse	Hallenbeck	Kaminsky	Allan	Helms	Hatch	McPee-Shaw	**OTHER**	Peterson	Grant	**NOAA**
Salaries	167,985	14,774	8,768	2,300	12,500	64,823	49,939	0	5,610	2,560	329,259	54,217	0	54,217
Benefits	55,062	5,115	2,836	713	0	23,318	23,456	0	1,049	0	111,549	0	0	0
Equipment	0	0	0	0	0	6,500		39,870	0	0	46,370	0	0	0
Travel	4,564	552	500	1,532	1,000	12,220	12,535	0	1,636	0	34,539	2,500	0	2,500
Sub Awards	0	0	0	0	0	0		0	0	0	0	0	0	0
Services	0	7,220	5,767	0	0	14,659		0	0	2,400	30,046	0	25,140	25,140
Supplies	29,965	1,200	1,100	0	0	15,476	3,720	5,130	0	40	56,631	2,037	4,302	6,339
Other	0	360	1,000	0	0	0		0	0	0	1,360	1,500	0	1,500
Grad Op Fees	0	0	0	0	0	0		0	0	0	0	0	0	0
Total Direct	257,576	29,221	19,971	4,545	13,500	136,996	89,650	45,000	8,295	5,000	609,754	60,254	29,442	89,696
Indirect Cost	92,424	15779	10,784	1,455	1,500	23004	20,350	0	1,705	0	167,001	14,746	0	14,746
TOTAL	350,000	45,000	30,755	6,000	15,000	160,000	110,000	45,000	10,000	5,000	776,755	75,000	29,442	104,442

RCOOS YR 10-14 PROPOSAL EFFORT DISTRIBUTION BREAKDOWN SUMMARY
YEAR 10-14 TOTAL COST

UNIVERSITY OF WASHINGTON:

											Other UW			
Title Lead	Mngmt Newton	DMAC Mayorga	Product & Web Dev Tanner	Outreach & Education Jones	WA Shelf Buoys Mickett	Salish Sea Buoy Mickett	Puget Snd Buoy Mickett	WA Shelf Gliders Lee	IDC on Sub Awards	**APL TOTAL**	ATMOS Atm Model Mass	OCN PS Model MacCready	OCN PS Buoys Devol	**Combined Yr 10 -14 TOTAL**
Salaries	727,318	321,819	491,706	289,086	186,871	36,275	298,804	134,734	0	**2,486,613**	24,795	161,434	216,719	**2,889,561**
Benefits	387,660	171,529	262,080	154,081	102,357	19,335	157,580	71,813	0	**1,326,435**	7,565	43,437	64,548	**1,441,985**
Equipment	0	18,826	25,000	0	36,762	0	0	120,000	0	**200,588**	0	2,300	0	**202,888**
Travel	162,568	43,995	32,072	22,060	19,120	5,024	12,900	0	0	**297,739**	0	0	7,198	**304,937**
Sub Awards	11,729,000	0	0	0	0	0	0	0	0	**11,729,000**	0	0	0	**11,729,000**
Services	80,900	1,897	0	17,500	201,141	30,400	133,215	60,310	0	**525,363**	0	3,996	0	**529,359**
Supplies	6,203	597	546	9,252	54,095	1,705	51,100	92,717	0	**216,215**	0	0	2,796	**219,011**
Grad Op Fees	0	0	0	0	0	0	0	0	0	**0**	0	0	0	**0**
Prorated Direct Costs	385,479	170,564	260,605	149,047	88,757	19,226	158,366	71,409	0	**1,303,453**	0	0	0	**1,303,453**
Total Direct	13,479,128	729,228	1,072,009	641,026	689,103	186,965	811,965	550,984	0	**18,160,408**	32,360	211,167	291,261	**18,695,196**
Indirect Costs	297,522	120,773	177,991	108,974	110,897	19,035	138,035	69,017	47,350	**1,089,594**	17,640	113,833	158,739	**1,379,806**
TOTAL	**13,776,650**	**850,000**	**1,250,000**	**750,000**	**800,000**	**131,000**	**950,000**	**620,000**	**47,350**	**19,175,000**	**50,000**	**325,000**	**450,000**	**20,000,000**

SUBAWARDS Breakdown Summary:

OREGON STATE UNIVESITY:

Area Lead	CA Shelf Glider Barth	OR Shelf Buoy Kosro	Nearshore Bathymetry Ruggerio	HF Radar Kosro	Port Radar Haller	OR-WA Coast Model Kurapov	OSU DMAC Kosro	Wave Forecasts Ozkan	PNW near- shore T/O2 Shearman	Flood Forecasts Ruggiero	OR near- shore OH Chan	**OSU TOTAL**
Salaries	153,179	243,147	142,661	910,299	138,077	192,227	129,127	119,020	136,514	100,859	51,250	**2,316,360**
Benefits	76,212	129,251	45,119	498,848	82,575	89,645	70,802	57,165	26,113	23,915	42,793	**1,142,438**
Equipment	0	61,500	0	540,000	0	17,999	0	0	80,000	0	0	**699,499**
Travel	6,950	18,500	50,000	30,000	8,124	22,300	25,000	4,890	7,500	4,000	2,500	**179,764**
Sub Awards	0	0	0	0	0	0	0	0	0		0	**0**
Services	6,376	10,000	0	45,500	0	2,200	25,000	13,191	3,375	844	2,000	**108,486**
Supplies	67,650	67,760	17,496	70,000	9,482	4,198	22,365	5,200	21,673	5,541	20,582	**311,947**
Other	30,000	0	0	191,436	0	0	0	0	0	0	119,132	**340,568**
Grad Op Fees	0	0	0	0	0	25,727	0	0	83,194	51,454	0	**160,375**
Total Direct	340,367	530,158	255,276	2,286,083	238,258	354,296	272,294	199,466	358,369	186,613	238,257	**5,259,437**
Indirect Cost	159,633	219,842	119,724	818,917	111,742	145,704	127,706	93,549	91,631	63,387	111,743	**2,063,578**
TOTAL	**500,000**	**750,000**	**375,000**	**3,105,000**	**350,000**	**500,000**	**400,000**	**293,015**	**450,000**	**250,000**	**350,000**	**7,323,015**

Table 5: NANOOS Annual and Summary Budgets

OTHER SUB AWARDS:

Sub Awardee	**OHSU**				**WCGA**	**WA Eco.**	**DOGAMI**	**OR DOSL**	**NWIC**	**WWU**		**NOAA**		
Area	Col shf Obsr Model, DMAC	Columbia R Moorings	Columbia R Phytoplank	Indigenous Network	Data Synthesis	WA Shore Obs/PS ferry	ORShore Observ	S. Slough Moorings	Salish Sea Tribal	Salish Sea buoy sup.	**TOTAL**	Newport Zooplankton	WA near-shore OAH	**TOTAL**
Lead	Baptista	Needoba	Peterson	Waterhouse	Hallenbeck	Kaminsky	Allan	Helms	Hatch	McPee-Shaw	**OTHER**	Peterson	Grant	**NOAA**
Salaries	838,622	73,781	41,864	10,156	62,500	321,861	249,695	0	28,050	12,800	1,639,329	275,108	0	275,108
Benefits	274,486	25,395	13,539	3,148	0	115,715	117,280	0	5,245	0	554,808	0	0	0
Equipment	0	0	0	0	0	32,500	0	195,350	0	0	227,850	0	0	0
Travel	23,332	2,760	2,400	7,475	5,000	61,100	62,675	0	8,180	0	172,922	10,956	0	10,956
Sub Awards	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Services	0	36,372	30,831	0	0	78,997	0	0	0	12,000	158,200	0	117,260	117,260
Supplies	151,442	5,995	6,345	0	0	75,619	18,600	29,650	0	200	287,851	8,359	29,950	38,309
Other	0	1,800	4,875	0	0	0	0	0	0	0	6,675	6,200	0	6,200
Grad Op Fees	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Direct	1,287,882	146,103	99,854	20,779	67,500	685,792	448,250	225,000	41,475	25,000	3,047,635	300,623	147,210	447,833
Indirect Cost	462,118	78,897	53,921	9,221	7,500	114208	101,750	0	8,525		836,140	74,377	0	74,377
TOTAL	1,750,000	225,000	153,775	30,000	75,000	800,000	550,000	225,000	50,000	25,000	3,883,775	375,000	147,210	522,210

E. Budget Narrative

Justification for how the NANOOS Observing and Modeling efforts serve PNW priority user applications is shown in Table 2. The Governance, DMAC, OEE subsystems support these efforts and make the users' applications of our products possible. Detailing this work, NANOOS has Statements of Work (SOWs), including priorities under the three funding scenarios ($1.5M, $2.5M, $4.0M), and Budget Justifications (BJs) from each of the nine institutions and two NOAA regional offices that make up our proposal. These documents total far more than the 50 pages allotted in the Appendix. Each year, during de-scope of our annual funding, NANOOS will provide the detailed SOWs and BJs as part of our package. For this submission, we highlight the main details and justification from the submitted budget information that NANOOS has. Benefits on all salaries are charged at the PI's institutional rates; indirect costs are also per legal institutional rates and base is according to their practices. UW, the lead fiscal agent for NANOOS has an indirect rate of 17%. For subcontracts, indirect is charged on the first $25,000 only. NANOOS' work is highly leveraged throughout by all project partners; although a quantitative assessment is not available, we know that the combined direct leverage exceeds $7M, plus the $37M NSF decadal investment in CMOP.

Funding requests ordered by subsystem are as follows.

Governance and Management Subsystem: NANOOS continues its proven governance and management capacities. Salaries are for PIs Newton and Martin (UW) and Kosro (OSU) to oversee and direct all elements of the NANOOS RA and RCOOS (Newton and Kosro) and for management and representation of the NANOOS Board (Martin and Kosro). Travel is for regional and national coordination meetings and for workshops/conferences associated with NANOOS, IOOS Association, and IOOS. Permission for international travel is requested. If given permission by the IOOS Program Office via Grants Online, NANOOS may choose to re-budget domestic travel to foreign travel, if necessary to represent IOOS or NANOOS outside the U.S., following all Fly USA requirements. Service costs are for IOOS Association dues ($10k/y) and for regional workshops (rental, permissive travel, meals).

Observing Subsystem: NANOOS needs to cover observing efforts in the coastal ocean, estuaries, and shorelines of WA and OR. To conduct these efforts, salaries are for observing asset PIs: Mickett, Lee, Devol (UW); Barth, Kosro, Haller, Shearman, Chan (OSU); Baptista, Needoba, Peterson (OHSU); Kaminsky, Maloy (Ecology); Allan (DOGAMI); Helms (ODSL); Peterson (NOAA NWFSC); Grant (OCNMS) and their field technicians to provide operations and maintenance (O&M) for various observing assets (buoys, gliders, moorings, HF and X-band radars, shoreline surveying equipment). McPhee-Shaw (WWU) will provide buoy O&M support. Equipment is primarily for sensors or new assets; all items above $5,000 are detailed below. Travel is for local trips associated with observing asset O&M. Services are typically for fabrication, repair, calibrations, or sample analysis. Supplies are primarily for repair /replacement parts (e.g., cables, motors) and consumables (e.g. batteries, chemicals).

Modeling and Analysis Subsystem: NANOOS supports three overlapping forecast models. The three forecast modeling systems allow optimal use of the scientific groups in the region. The groups share knowledge, forcing fields, and observational data for validation, but develop separate systems in order to most rapidly address different concerns that would be inefficient to bundle into a single system. Salaries are for lead modeling PIs: MacCready (UW); Baptista (OHSU); Kurapov, Ruggeiro and Ozkan-Haller (OSU) and their technicians to run forecast models for NANOOS to aid our users decision-making needs. PI Mass (UW) provides atmospheric forecast input to the modelers. Equipment is for increasing processing capacity of the model; all items above $5,000 are detailed below. Travel is for IOOS Modeling coordination and regional meetings. Supplies are needed to maintain numerical models. Services are for related items, e.g., cloud data storage.

DMAC Subsystem: NANOOS will sustain its robust and renown DMAC system, including NVS, user specific data products and our web portal. *DMAC operations:* Salaries are for lead DMAC PIs: Mayorga (UW); Kosro (OSU); Baptista (OHSU) and their technicians (including Risien, OSU, and Seaton, OHSU).

Equipment is for expanding capacity or replacing servers (database and disk storage servers) to harden the system and expand it for the growing user base; all items above $5,000 are detailed below. Travel is for IOOS DMAC coordination and regional meetings. Supplies are to maintain DMAC capabilities. Services are for related items, e.g., registration fees. *Web and Products development:* Salaries are for lead PIs: Tanner (UW); Allan (DOGAMI) and their technicians to maintain and create innovative NANOOS data products for diverse PNW users including development of a web application for submission of Citizen Science observations. Travel is for federal and regional coordination. Supplies are to maintain and expand the NANOOS website, plus increase the functionality of the NVS web application.

Outreach, Engagement and Education Subsystem: NANOOS values inclusivity and prioritizes connections with diverse stakeholders and educators to fulfill our stated mission. Salaries are for PI Jones (UW) and OEE staff (Sprenger and Wold, nee Vander Giessen) to oversee and conduct NANOOS outreach, user engagement, and education in the PNW. Additionally, PI Hatch (NWIC) will enable NANOOS to better engage tribal students in marine observing and STEM associated with the central Salish Sea buoy, and PI Waterhouse (OHSU) will help us increase our engagement with Oregon tribes increase their use of NANOOS' data products and services. PI Hallenbeck (WCGA) will provide engagement with the West Coast Governors' Alliance and the West Coast Ocean Data Portal. Travel is for IOOS-wide Outreach, Engagement and Education coordination and for regional outreach and meetings. Supplies are for outreach materials. Services are for training and workshop costs, including permissive travel.

As shown in Table 5, in addition to the work at UW for management, observing asset O&M, model forecasts, DMAC subsystem leadership, and OEE subsystem leadership, the strong partnerships of NANOOS' RCOOS require that subcontracts be established for various subsystem elements: to OSU for management, observing asset O&M, regional DMAC support, and model forecasts; to OHSU for observing asset O&M, regional DMAC support, model forecasts, biological sampling, and tribal outreach; to WCGA for data synthesis and coordination; to WA Ecology for estuarine and shoreline observing; to DOGAMI for shoreline observing and User Products leadership; to OR Dept. State Lands for estuarine observing; to NWIC for tribal education outreach; and to WWU for observing asset support. Additionally, NANOOS requests that NOAA hold back funding to be directed to NOAA Northwest Fisheries Science Center Newport for biological sampling and salmon forecasts; and to NOAA Olympic Coast National Marine Sanctuary for observing asset O&M.

Equipment for purchase by UW and its subcontractors is listed in the accompanying table showing task, year, amount, and justification. As detailed in each institution's SOW and BJ, rental of the requested equipment is either not available or not cost-effective for sustained operations. Equipment purchased will be owned by UW or its subcontractors, but will be used for NANOOS as long as funding is provided. The cost of the equipment listed in the budget is based on quotes from the manufacturer or distributor. Quotes are available upon request.

EQUIPMENT (>$5,000) TO BE PURCHASED BY UNIVERSITY OF WASHINGTON:

Task	Yr	Equipment	Amt ea	Justification
APL-DMAC	1-4	Computer hardware	$18,826	Expanding capacity for growing user base
APL- Web Dev	1-5	Replacement Servers	$5,000	Replacing older database and disk storage servers to avoid system failure
APL-WA Buoy	1-2	SBE37 Micro Cat IMP with Optical DO sensors	$10,540	Facilitate year-round operations, replace aging components
APL-WA Buoy	3	SBE IMP inductive temperature logger	$7,204	Facilitate year-round operations, replace aging components
APL- Buoy Bellingham	2	Seaglider	$120,000	Extend operations to year-round

Currently the University of Washington considers items costing more than $2,000 to be equipment. Only the items costing more than $5,000 each are listed above. As a result the budgeted equipment amounts may exceed the costs of the items listed above because some items budgeted as equipment costs less than $5,000. Budgeted equipment costing more than $2,000 are not subject to indirect costs.

EQUIPMENT (>$5,000) TO BE PURCHASED BY SUBCONTRACTORS

Task	Yr	Equipment	Amt ea	Justification
OR Shelf Buoy	1	Surface buoy	$25,000	Fabricate 2nd surface buoy to allow gapless recovery and redeployments
OR Shelf Buoy	2	ADCP	$21,500	Replace aging mooring critical equipment
OR Shelf Buoy	3	SBE Microcat sensors	$9,000	Replace aging mooring critical equipment
OR Shelf Buoy	4	Anchor	$6,000	Replace aging mooring critical equipment
OR HF Radar	1,3,4,5	Seanode CODAR Ocean Sensor	$135,000	Equipment for four additional HF radar sites
OR-WA Coast Model	1	Computer cluster and storage disk	$17,999	Additional computer nodes for routine near-time data assimilation and storage
PNW Near-shore T/O2	1	DO/T sensor network	$60,000	Construct the DO/T Sensor Network for crab pot deployment
PNW Near-shore T/O2	2-5	DO/T sensor network	$5,000	Expand and update the DO/T Sensor Network
OR DOSL	1-5	YSI EXO2 Dataloggers	$31,600	Multi parameter water quality sondes, 1 per year, to be assembled for NERRS/NOAA SWMP program

F. NANOOS Partner Information

Collaborator	City, State	Congressional District	Performance Location
University of Washington (UW)	Seattle, WA	WA-007	Seattle, Puget Sound, La Push, Salish Sea, WA shelf
Oregon State University (OSU)	Corvalis, OR	OR-004	Corvallis, Newport, OR shorelines & shelf waters, Trinidad Head, CA
Oregon Health and Science University (OHSU)	Portland, OR Beaverton, OR	OR-003 (Portland) OR-001 (Beaverton)	Beaverton, Portland, Columbia River estuary and shelf waters off WA and OR, OR estuaries
Washington State Department of Ecology	Olympia, WA	WA-010	Olympia, WA, waters between Seattle, WA, and Victoria, BC, WA shorelines

Oregon Department of Geology and Mineral Industries (DOGAMI)	Portland, OR	OR-003	Portland, OR, Oregon shorelines
Oregon Department of State Lands	Salem, OR Coos Bay, OR	OR-005 (Salem) OR-004 (Coos Bay)	South Slough, Coos Bay OR estuaries
Northwest Indian College (NWIC)	Ferndale, WA	WA-001	Ferndale, Bellingham, WA, Salish Sea
Western Washington University (WWU)	Bellingham, WA	WA-002	Anacortes, Bellingham, WA, Salish Sea
West Coast Governors Alliance on Ocean Health (WCGA)	Alameda, CA	CA-013	Seattle, WA; Alameda, Monterey, San Diego, CA
NOAA National Marine Fisheries Service, Northwest Fisheries Science Center	Newport, OR	OR-005	Newport, OR shelf waters
NOAA Olympic Coast National Marine Sanctuary (OCNMS)	Port Angeles, WA	WA-006	Pt Angeles, OCNMS waters off WA shelf

G. Key Investigator Resumes

NANOOS Operational Leads:
Jan Newton, NANOOS Executive Director
Mike Kosro, NANOOS Board Vice Chair, deputy Director, OSU lead
Emilio Mayorga, NANOOS DMAC Chair
Antonio Baptista, OHSU lead

NANOOS Partner Leads:
Jonathan Allan, NANOOS User Products Chari, DOGAMI lead
Todd Hallenbeck, WCGA liaison
Marco Hatch, NWIC liaison
Alicia Helms, South Slough NERRS lead
David Jones, NANOOS OEE manager
George Kaminsky, Washington Dept. of Ecology liaison
David Martin, NANOOS Board Chair
John Mickett, UW observing lead
Troy Tanner, Web Development lead

Jan A. Newton
Principal Oceanographer, Affiliate Assistant Professor
Applied Physics Laboratory, University of Washington
1013 NE 40th St, Seattle, WA 98105 janewton@uw.edu 206 543 9152

Professional Preparation:

Western Washington University	Biology	B.S., 1981
University of Washington	Oceanography	M.S., 1984
University of Washington	Oceanography	Ph.D., 1989
MBARI Postdoctoral Fellow	Oceanography	1989-1991

Appointments:

2004-present Principal Oceanographer, Applied Physics Lab, University of Washington

- Executive Director of the Northwest Association of Networked Ocean Observing Systems (NANOOS), the PNW Regional Association of U.S. Integrated Ocean Observing System
- Co-Director of the Washington Ocean Acidification Center at the University of Washington
- Instructor, UW Friday Harbor Laboratories (FHL) since 1991

2009-present Affiliate Assistant Professor, University of Washington, School of Marine Affairs
1998-present Affiliate Assistant Professor, University of Washington, School of Oceanography
1994-2004 Senior Oceanographer, Washington State Department of Ecology
1993-2005 Senior Research Scientist, Northeastern University, Marine Science Center
1991-1993 Research Associate, University of Washington, School of Oceanography

Publications:

Alin, S., R. Brainard, N. Price, J. Newton, A. Cohen, W. Peterson, E. DeCarlo, E. Shadwick, S. Noakes, and N. Bednaršek. 2015. Characterizing the natural system: Toward sustained, integrated coastal ocean acidification observing networks to facilitate resource management and decision support. Oceanography 28(2):92–107.

Barton, A., G. Waldbusser, R. Feely, S. Weisberg, J. Newton, B. Hales, S. Cudd, B. Eudeline, C. Langdon, I. Jefferds, T. King, A. Suhrbier, and K. McLaughlin. 2015. Impacts of coastal acidification on the Pacific Northwest shellfish industry and adaptation strategies implemented in response. Oceanography 28(2):146–159.

McLaughlin, K., S. Weisberg, A. Dickson, G. Hofmann, J. Newton, D. Aseltine-Neilson, A. Barton, S. Cudd, R. Feely, I. Jefferds, E. Jewett, T. King, C. Langdon, S. McAfee, D. Pleschner-Steele, and B. Steele. 2015. Core principles of the California Current Acidification Network: Linking chemistry, physics, and ecological effects. Oceanography 28(2):160–169.

Reum, J., S. Alin, C. Harvey, N. Bednarsek, W. Evans, R. Feely, B. Hales, N. Lucey, J. Mathis, P. McElhany, J. Newton, and C. Sabine. 2015. Interpretation and design of ocean acidification experiments in upwelling systems in the context of carbonate chemistry co-variation with temperature and oxygen. ICES J Mar. Science, doi: 10.1093/icesjms/ fsu231.

Newton, J.A., R.A. Feely, E.B. Jewett, P. Williamson, and J. Mathis. 2014. Global Ocean Acidification Observing Network: Requirements and Governance Plan. IAEA. 57 pp.

Reum J.C.P., Alin S.R, Feely R.A., Newton J., Warner M., et al. 2014. Seasonal carbonate chemistry covariation with temperature, oxygen, and salinity in a fjord estuary: Implications for the design of ocean acidification experiments. PLoS ONE 9(2): e89619.

Feely R.A., T. Klinger, J. Newton, and M. Chadsey. 2012. Scientific Summary of Ocean Acidification in Washington State Marine Waters. NOAA ORR Special Report. 157 pp.

Alford, M.H., J.B. Mickett, S. Zhang, P. MacCready, Z. Zhao, and J. Newton. 2012. Internal waves on the Washington continental shelf. *Oceanography* 25(2):66–79.

Feely R.A., S.R. Alin, J.A. Newton, C.L. Sabine, M. Warner, A. Devol, C. Krembs, C. Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. *Est., Coast. Shelf Science* 88: 442-449.

Moore, S. K., N. J. Mantua, J. A. Newton, M. Kawase, M. J. Warner, and J. P. Kellogg. 2008a. A descriptive analysis of temporal and spatial patterns of variability in Puget Sound oceanographic properties. *Est., Coast. Shelf Science* 80: 545-554.

Moore, S. K., N. J. Mantua, J. P. Kellogg, and J. A. Newton. 2008b. Local and large-scale climate forcing of Puget Sound oceanographic properties on seasonal to interdecadal timescales. *Limnol. Oceanogr.* 53: 1746-1758.

Banas, N., B. Hickey, J. Newton, and J. Ruesink. 2007. Tidal Exchange, bivalve grazing, and patterns of primary production in Willapa Bay, WA. *Mar. Ecol. Progr. Ser.* 341:123-139.

Rynearson, T.A., J.A. Newton, and E.V. Armbrust. 2006. Spring bloom development, genetic variation, and population succession in the planktonic diatom *Ditylum brightwellii*. *Limnol. Oceanogr.* 51(3): 1249–1261.

Newton, J.A., E. Siegel, and S.L. Albertson. 2003. Changes in Puget Sound and the Strait of Juan de Fuca during the 2000-01 drought. *Canadian Water Resources J.* 28(4): 715-728.

Newton, J. A. and Horner, R. A. 2003. Use of phytoplankton species indicators to track the origin of phytoplankton blooms in Willapa Bay, Washington. *Estuaries*, 26: 1071-1078.

Synergistic Activities:

I work to promote observations of the marine ecosystem, spanning estuaries, coastal waters, and the open ocean, using a systems view approach to assess climate forcing and human drivers, and with a specific focus on OA and hypoxia.

Communication with elected officials: Invited to brief U.S. Senate Committee on Commerce, Science and Transportation, June 2013 on ICOOS and FOARAM Acts; briefed WA State Legislature during 2005-2008 on science needs and research. Governor appointee to WA Governor's Blue Ribbon Panel on Ocean Acidification; Member of West Coast Ocean Acidification and Hypoxia Science Panel. As Co-Director for the WA OA Center, serve the Marine Resource Advisory Council and support/provide WA Legislature briefings.

Ocean Acidification Observing Network: Participate in global to local scale ocean acidification observing efforts. Lead author for report to design global-scale OA observing network (GOA-ON). Presented GOA-ON overview at GEO Summit in Geneva, UNESCO SIDS in Samoa, and US State Department Roundtable. Member of GOA-ON Steering Committee; hosted the first GOA-ON workshop (62 scientists, 23 countries) to scope global effort.

Tribal STEM and experiential education: Work with Northwest Indian College to entrain their students and develop peer-to-peer knowledge transfer from shared cruises through my UW Friday Harbor Laboratories Research Apprenticeship on the "Pelagic Ecosystem Function." This FHL program is designed to mentor undergraduate apprentices in ecosystem-wide research, cutting across traditional research lines and using discovery methods of research.

Regional research: As Co-Director of Washington OA Center, coordinate academic, state, federal, tribal and industry partners in monitoring, forecasting, and biological effects experiments. Co-manager and PI for Hood Canal Dissolved Oxygen Program, oversight of hypoxia observational and modeling; included volunteer involvement, stakeholder outreach, and public education in community. Worked with two tribes to include HCDOP science into their programs and mentored tribal members/scientists. This work was featured at UW Tribal Summits 2007-2010.

P. MICHAEL KOSRO July 28, 2015

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A. EDUCATION AND EMPLOYMENT

B.A.	Physics	University of Calif., Santa Cruz	1973
M.S.	Petr. Engr.	Stanford University	1977
Ph.D.	Oceanography	University of Calif., San Diego	1985

PROFESSIONAL BACKGROUND

Research Associate (Postdoctoral), Oregon State University	1984-1986
Assistant Professor (Senior Research), OSU	1986-1992
Associate Professor (Senior Research), OSU	1992-2001
Associate Professor, OSU	2001-2007
Professor, OSU	2007-present
Outer Continental Shelf Scientific Committee, MMS/BOEM	2003-2011
Vice Chair, NANOOS regional association of IOOS	2012-present

B. Selected Recent Publications (of 68 peer-reviewed publications)

Kim, Sung Yong, Alexander L. Kurapov, and P. Michael Kosro. Influence of varying upper ocean stratification on coastal near-inertial currents. Manuscript 2015JC011153, submitted to Journal of Geophysical Research, 7/20/2015.

Sherman, Kate, Jack Barth, Flaxen Conway, Craig Risien, Mike Kosro. The Oregon Nearshore Research Inventory project: the importance of science and the scientific community as stakeholders in marine spatial planning. Submitted to Ocean and Coastal Management, April 2015.

Mazzini, Piero L., Craig M. Risien, John A. Barth, Stephen D. Pierce, Anatoli Erofeev, Edward Dever, Michael Kosro, Murry D. Levine, R. Kipp Sherman, Michael Vardaro, 2015 (submitted). Anomalous near-surface low-salinity pulses off the central Oregon coast. Submitted to Science Reports, 2015.02.12.

Yamada, Sylvia Behrens, William Peterson, P. Michael Kosro. Biological and physical ocean indicators predict the success of an invasive crab, carcinus maenas, in the northern California Current. Accepted for *Marine Ecology Progress Series*. doi: 10.3354/meps11431.

Kim, Sung Yong, P. Michael Kosro, and Alexander L. Kurapov, 2014. Evaluation of directly wind-coherent near-inertial currents off Oregon using a statistical parameterization and analytical and numerical models. *J. Geophys. Res*., 119(10): 6631-6654, doi: 10.1002/2014JC010115

Osborne, J.J., A.L. Kurapov, G.D. Egbert, and P.M. Kosro, 2014: Intensified Diurnal Tides Along the Oregon Coast. *J. Phys. Oceanogr*., 44(7): 1689-1703, doi:10.1175/JPO-D-13-0247.1.

Kim, Sung Yong, and P. Michael Kosro, 2013. Observations of near-inertial surface currents off Oregon: decorrelation time and length scales. *Journal of Geophysical Research*, 118, doi: 10.1002/jgrc.20235.

Hickey, Barbara M., Vera L. Trainer, P Michael Kosro, Nicolaus G. Adams, Thomas P. Connolly, Nancy Kachel, Susan L. Geier, 2013. A springtime source of toxic *Pseudo-nitzschia* cells on razor clam beaches in the Pacific Northwest. *Harmful Algae*, 25:1-14. doi: 10.1016/j.hal.2013.01.006

Yu, P., A.L. Kurapov, G.D. Egbert, J.S. Allen, P.M. Kosro, 2012. Variational assimilation of HF radar surface currents in a coastal ocean model off Oregon. *Ocean Modelling*, v49-50, 86-104, doi: 10.1016/j.ocemod.2012.03.001.

Osborne, J.J., A.L. Kurapov, G.D. Egbert, P.M. Kosro, 2011. Spatial and temporal variability of the M2 internal tide generation and propagation on the Oregon shelf. *Journal of Physical Oceanography*, 41(11), 2037-2062, doi: 10.1175/JPO-D-11-02.1.

Kim, S.Y., E. Terrill, B. Cornuelle, B. Jones, L. Washburn, M. Moline, J. Paduan, N. Garfield, J.L. Largier, G. Crawford, P.M. Kosro, 2011. Mapping the U.S. West Coast surface circulation: A multiyear analysis of high-frequency radar observations. *Journal of Geophysical Research*, 116, doi:10.1029/2010JC006669.

Hickey, B.M, R.M. Kudela, J.D. Nash, K.W. Bruland, W.T. Peterson, P. MacCready, E.J. Lessard, D.A. Jay, N.S. Banas, A.M. Baptista, E.P. Dever, P.M. Kosro, L.K. Kilcher, A.R. horner-Devine, E.D. Zaron, R.M. McCabe, J.O. Peterson, P.M. Orton, J. Pan and M.C. Lohan, 2010. River Influences on Shelf Ecosystems: Introduction and Synthesis. *Journal of Geophysical Research*, 115, C00B17, doi:10.1029/2009JC005452.

Research Interests

Coastal oceanography; shelf/deep-sea exchange processes; mesoscale currents and fronts; response to winds and topography; interannual variability; eastern boundary currents; California Undercurrent; physical-biological interactions; ocean observing systems.

Participation in National and International Experiments

Coastal Ocean Dynamics Experiment (1981-82); Central California Coastal Circulation Study (1984-85); Coastal Transition Zone experiment (1987-88); Gulf of Tehuantepec Experiment (1989); WOCE Hydrographic Program, Pacific (1992,1994) and Indian (1995) Oceans; TOGA Coupled Ocean-Atmosphere Response Experiment (1992-93); Mesoscale Interactions/Dynamics of Eastern Boundary Currents (1992-94) ; Coastal Mixing and Optics (1996-97); N.E. Pacific GLOBEC (1997-2004); NOPP: Prediction of Wind-Driven Coastal Circulation (1998-2000); Coastal Ocean Advances in Shelf Transport (2000-2004); River Influences on Shelf Ecosystems (RISE) (2003-2007); Coastal Margin Observation and Prediction (NSF STC) (2006-2010); Oregon Coastal Ocean Observation System (OrCOOS) (2006-07); Integrated Ocean Observing System (IOOS)/NANOOS (2003-present)

Major Seagoing Expeditions

At-sea participant in more than 60 research cruises, many as chief scientist, since 1979 (FRONTS) to present, including CODE, CTZ, WOCE, TOGA/COARE, EBC, Coastal Mixing and Optics, NOPP, COAST and GLOBEC, in N. Pacific, S. Pacific, N. Atlantic and Indian Oceans. Mapping of hydrography and currents, with fixed station (CTD) and underway mapping (ADCP, SeaSoar) tools, and time-series measurements from fixed moorings. Since 1996, have added remote-sensing of time-series maps of ocean surface currents from shore, using HF radiowaves (CODAR/SeaSonde).

EMILIO MAYORGA – BIOGRAPHICAL SKETCH

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(a) Professional Preparation

Massachusetts Institute of Technology	Environmental Engineering Science	B.S., 1992
University of Washington	Chemical Oceanography	M.S., 1997
University of Washington	Chemical Oceanography	Ph.D., 2004
Rutgers University	Global River Nutrient Exports	2007-2008

(b) Appointments

Senior Oceanographer, Jan. 2009 – present, Applied Physics Laboratory, University of Washington, Seattle, WA, USA.

Research Associate, Jan. 2007 – Dec. 2008, Institute of Marine & Coastal Sciences, Rutgers University, New Brunswick, NJ, USA.

Principal GIS Analyst, Sept. 2001 – Dec. 2006, Surface Water Management, Snohomish County, Everett, WA, USA.

Research Assistant, 1993-2001, School of Oceanography, University of Washington, Seattle.

(c) Products – Five most closely related to this project

Haines, S., V. Subramanian, **E. Mayorga**, D. Snowden, R. Ragsdale, C. Rueda and M. Howard. 2012. IOOS vocabulary and ontology strategy for observed properties. *Proc. MTS/IEEE Oceans'12, doi:10.1109/OCEANS.2012.6405083*

Newton, J., D. Martin, **E. Mayorga**, A. Devol, R. Feely, S. Alin, B. Dewey, B. Eudeline, A. Barton, A. Suhrbier, A. Baptista and J. Needoba. 2012. NANOOS partnerships for assessing ocean acidification in the Pacific Northwest. *Proc. MTS/IEEE Oceans'12, doi:10.1109/OCEANS.2012.6405086*

Mayorga, E., T. Tanner, R. Blair, A.V. Jaramillo, N. Lederer, C.M. Risien and C. Seaton. 2010. The NANOOS Visualization System (NVS): Lessons learned in data aggregation, management and reuse, for a user application. *Proc. MTS/IEEE Oceans'10*, doi:10.1109/OCEANS.2010.5663792

Mayorga, E., S.P. Seitzinger, J.A. Harrison, E. Dumont, A.H.W. Beusen, A.F. Bouwman, B. Fekete, C. Kroeze and G. Van Drecht. 2010. Global Nutrient Export from WaterSheds 2 (NEWS 2): Model development and implementation. *Environmental Modeling & Software* 25: 837-853, doi:10.1016/j.envsoft.2010.01.007

Risien, C.M., J.C. Allan, R. Blair, A.V Jaramillo, D. Jones, P.M. Kosro, D. Martin, **E. Mayorga**, J.A. Newton, T. Tanner and S.A. Uczekaj. 2009. The NANOOS Visualization System: Aggregating, displaying and serving data. *Proc. MTS/IEEE Oceans'09*

Five Other Significant Products

Raymond, P. A., Hartmann, J., Lauerwald, R., Sobek, S., McDonald, C., Hoover, M., Butman, D., Striegl, R., **Mayorga, E.**, Humborg, C., Kortelainen, P., Dürr, H., Meybeck, M., Ciais, P. and Guth, P. 2013. Global carbon dioxide emissions from inland waters. *Nature* 503 (7476): 355-359, doi:10.1038/nature12760

Aufdenkampe, A.K., **E. Mayorga**, P.A. Raymond, J. Melack, S.C. Doney, S.R. Alin, R.E. Aalto and K. Yoo. 2011. Riverine coupling of biogeochemical cycles between land, oceans and

atmosphere. *Frontiers in Ecology & Environment* 9(1): 53-60, doi:10.1890/100014
Seitzinger, S., **E. Mayorga**, A.F. Bouwman, C. Kroeze, A.H.W. Beusen, G. Billen, G. Van Drecht, E. Dumont, B.M. Fekete, J. Garnier and J.A. Harrison. 2010. Global nutrient river export: A scenario analysis of past and future trends. *Global Biogeochemical Cycles* 24: GB0A08, doi:10.1029/2009GB003587
Mayorga, E. 2008. Carbon cycle – Harvest of the century. *Nature* 451: 405-406
Mayorga, E., A.K. Aufdenkampe, C.A. Masiello, A.V. Krusche, J.I. Hedges, P.D. Quay, J.E. Richey and T.A. Brown. 2005. Young organic matter as a source of carbon dioxide outgassing from Amazonian rivers. *Nature* 436: 538-541

(d) Synergistic Activities

Reviewer. *Journals:* Biogeochemistry, Biogeosciences, Ecosystems, Global Biogeochemical Cycles, Hydrological Processes, Limnology and Oceanography, Nature. *Proposals and Research Programs:* NASA, NSF, USGS.

Member. American Geophysical Union (AGU), American Society of Limnology and Oceanography (ASLO), Ecological Society of America (ESA)

Working Group Participation.

West Coast Ocean Data Network, 2011 – present.
REgional Carbon Cycle Assessment and Processes (RECCAP), 2010 – 2014.
Carbon in Tropical Rivers, Organization for Tropical Studies (OTS) NSF Research Coordination Network, 2010 – 2012.
Global Nutrient Export from Watersheds (Global NEWS – UNESCO's Intergovernmental Oceanographic Commission), 2007 – present.
Merging terrestrial and aquatic perspectives of biogeochemistry, National Center for Ecological Analysis and Synthesis (NCEAS), 1999 – 2002.

Environmental Informatics Involvement. *US Integrated Ocean Observing System (IOOS), Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI), NSF Critical Zone Observatories (CZO), NSF EarthCube, NOAA Consortium for the Integrated Management of Ocean Acidification Data, West Coast Ocean Data Network Portal.*

(e) Collaborators & Other Affiliations

Collaborators and Co-Editors in the last 48 months

Anthony Aufdenkampe	Stroud Water Research Center, Avondale, PA
Lex Bouwman	Environmental Assessment Agency (MNP), The Netherlands
John Harrison	Washington State University, Vancouver, WA
Jens Hartmann	University of Hamburg, Germany
Jeff Horsburgh	Utah State University, Logan, UT
Albert Kettner	University of Colorado, Boulder, CO
Carolien Kroeze	University of Wageningen, The Netherlands
Kerstin Lehnert	Lamont-Doherty Earth Observatory, Columbia University, NY
Jan Newton	Applied Physics Lab., University of Washington, Seattle, WA
Peter Raymond	Yale University, New Haven, CT
Ilya Zaslavsky	San Diego Supercomputer Center, University of California, CA

Graduate and Postdoctoral Advisors

Jeffrey E. Richey	M.S. & Ph.D. Advisor	University of Washington, Seattle, WA
Allan Devol	M.S. Co-advisor	University of Washington, Seattle, WA
John I. Hedges	Ph.D. Co-advisor	University of Washington, Seattle, WA
Paul Quay	Ph.D. Co-advisor	University of Washington, Seattle, WA
Sybil Seitzinger	Postdoctoral Supervisor	Rutgers University, New Brunswick, NJ

António Melo Baptista
Professor, Oregon Health & Science University (OHSU)
Phone: 503-346-3418 Fax: 503-346-3427 E-mail: baptista@ohsu.edu

Education

Massachusetts Institute of Technology	Civil Engineering	Ph.D., 1987	M.Sc., 1984
Academia Militar, Portugal	Civil Engineering	B.S., 1978	

Appointments

s. 2011	*Director*, Institute of Environmental Health, OHSU
s. 2006	*Director*, NSF Science and Technology Center for Coastal Margin Observation & Prediction
2003-2006	*Chair*, Department of Environmental & Biomolecular Systems, OHSU
2000-2002	*Chair*, Department of Environmental Science and Engineering, OHSU
1999-2008	*Professor* (joint appointment), Dep. of Computer Sci. & Electrical Engng., OHSU[1]
s. 2003	*Professor*, Department (then Division) of Environmental and Biomolecular Systems, OHSU
1987-2002	*Assist.* to *Assoc. Professor*, then *Professor*, Dep. of Environmental Sci. & Engng, OHSU[1]
1979-1987	*Researcher*, Estuaries Division, Laboratório Nacional de Engenharia Civil, Lisboa, Portugal

Select Peer-Reviewed Publications

I have published, often collaboratively, in areas including computational science; physical, biogeochemical & microbial oceanography; fisheries; natural hazards; and computer science. Examples:

1. T Kärnä, AM Baptista, JE Lopez, PJ Turner, C McNeil, TB Sanford. 2015. Numerical modeling of circulation in high-energy estuaries: A Columbia River estuary benchmark. Ocean Modelling. DOI: 10.1016/j.ocemod.2015.01.001
2. BJ Burke, JJ Anderson, AM Baptista. 2014. Evidence for multiple navigational sensory capabilities by Chinook salmon. Aquatic Biology. DOI: 10.3354/ab00541
3. Gilbert M, Needoba JA, Koch C, Barnard A, Baptista AM. 2013. Nutrient Loading and Transformations in the Columbia River Estuary Determined by High Resolution In Situ Sensors. Estuaries and Coasts. DOI: 10.1007/s12237-013-9597-0
4. Maier D, VM Megler, AM Baptista, A Jaramillo, C Seaton, P Turner. 2012. Navigating Oceans of Data. DOI:10.1007/978-3-642-31235-9_1
5. Roegner GC, JA Needoba, AM Baptista. 2011. Coastal Upwelling Supplies Oxygen-Depleted Water to the Columbia River Estuary. *PLoS ONE*. 6(4):e18672. DOI:10.1371/journal.pone.0018672
6. Smith M, L Herfort, K Tyrol, D Suciu, V Campbell, B Crump, T Peterson, P Zuber, AM Baptista, H Simon. 2010. Seasonal changes in bacterial and archaeal gene expression patterns across salinity gradients in the Columbia River coastal margin. PLoS ONE. DOI:10.1371/journal.pone.0013312
7. Burla M, AM Baptista, Y Zhang, S Frolov. 2010. Seasonal and interannual variability of the Columbia River plume: A perspective enabled by multiyear simulation databases. *J. of Geophysical Res*. DOI: 10.1029/2008JC004964
8. Hickey BM, RM Kudela, JD Nash, KW Bruland, WT Peterson, P MacCready, EJ Lessard, DA Jay, NS Banas, A Baptista et al. 2010. River Influences on Shelf Ecosystems: Introduction and synthesis. *J. of Geophysical Research.* DOI:10.1029/2009JC005452
9. Frolov S, AM Baptista, Y Zhang, C Seaton. 2009. Estimation of ecologically significant circulation features of the Columbia River estuary and plume using a reduced-dimension Kalman filter. *Continental Shelf Research.* DOI:10.1016/j.csr.2008.11.004
10. 10. Baptista AM, Howe B, Freire J, Maier D, Silva CT. 2008. Scientific Exploration in the Era of Ocean Observatories. Computing in Science & Engineering. DOI: 10.1109/MCSE.2008.83

[1] The Oregon Graduate Institute and the Oregon Health Sciences University merged on July 1st, 2001, to form the Oregon Health & Science University. Because the appointment extends across the merger date, OHSU is listed as the affiliation.

Synergistic Activities

- Center for **C**oastal **M**argin **O**bservation & **P**rediction (CMOP): I am the director of this multi-institutional NSF **S**cience and **T**echnology **C**enter, one of few STCs to address ocean issues and the only ever focused on coastal margins. Using a blend of data-driven and hypothesis-driven science, we are learning how specialized biological hotspots enable a fast-flowing estuary to remain an effective bioreactor—and are characterizing the estuary's variability and susceptibility for change. Our research catalyzes workforce development, broadening participation and science-driven regional management and decision-making. Partners include research universities, 4-year colleges, K-12 programs, industry, and state, federal and tribal agencies. Formal resolutions of the Affiliated Tribes of Northwest Indians support our approach to tribal engagement. http://www.stccmop.org
- **S**cience **a**nd **T**echnology **U**niversity **R**esearch **N**etwork (SATURN): I provide scientific leadership for this *collaboratory* focused on the Columbia River estuary. Initiated in 1996 (then CORIE, **Co**lumbia **Ri**ver **E**stuary), and substantially expanded since the inception of CMOP, it integrates interdisciplinary observations, simulations and information flows. It anchors all CMOP research and regional applications that include estuarine and plume oceanography; ocean/estuarine survival conditions for salmon stocks; coastal and estuarine hypoxia and acidification; and physical and ecological impacts of climate change and human activities. http://www.stccmop.org/saturn
- 1964 US-Canada Columbia River Treaty Review: In a high-profile example of the transformative power of collaboratories in support of regional policy, my team used legacy SATURN simulation databases (with credibity established through comparisons with observations), together with multi-variate regressions and fast model surrogates, to simulate in ~1 month the 70-year impact on the estuary of 11 alternative scenarios of flow regulation. We then helped translate the results for high-level inclusion in the *U.S. Entity Regional Recommendation for the Future of the Columbia River Treaty after 2024*
- Our Global Estuary: Recognizing the opportunity and urgency to add a global perspective to estuarine science, policy and management, I co-chair the steering committee of a community-driven initiative launched to (a) promote the role of estuaries as essential but sensitive elements of regional and global sustainability; (b) facilitate the flow of information to enable management decisions that preserve the economic, ecosystem, and human experiential benefits of estuaries, and (c) foster more consistent collection and use of data through development of a network of estuarine observation and prediction systems. A workhop in late 2013 generated broad national consensus, and a follow-up international workshop is being planned for 2016, in Chennai, India. http://ourglobalestuary.org
- Select software: I co-developed (with YJ Zhang) SELFE, a community **S**emi-Implicit **E**ulerian-**L**agrangian **F**inite **E**lement model for 3D estuary/ocean circulation that is applied worldwide and which scope has been expanded to sedimentary, biogeochemical and ecosystem processes. I also co-developed (with T Leen, S Frolov et al.) RDDA, a software for **R**educed-**D**imension **D**ata **A**ssimilation. I supervise the development of SATURN products, including Data Explorer, Virtual Columbia River and Watches.
  SELFE: http://www.stccmop.org/knowledge_transfer/software/selfe
  RDDA: http://www.ohsu.edu/tech-transfer/portal/technology.php?technology_id=830317

Select Collaborators: Bradley Tebo, Joseph Needoba, Twanya Peterson, Holly Simon, Peter Zuber (OHSU); Fred Prahl, Yvette Spitz, James Lerczak (OSU); Tom Sanford, Barbara Hickey (UW); David Maier (PSU); Margaret Leinen (SIO); Megan Davis (FAU); others

Post-Docs Supervised: T Kärnä, C Llebot (with Spitz) (current); A Chawla, K Cho, S Das, A Farrenkopf, S Frolov, B Howe, E Myers, Z Yang, Y Zhang, JP Rinehimer (with Sanford) (former)

Students Supervised: J Lopez, M Rostaminia, K Morrice (PhD; current); M Burla, A Fortunato, S Frolov, E Myers III, A Oliveira, Y Wang and T Wood (PhD; graduated); P Welle, N Bandolin, J Darland, N Hyde, R Kilgren, E Myers III, A Oliveira, A Racicot, J Remédio, C Seaton, W Sommerfield and M Vantrease (MSc; graduated); C Boshell, K Buddemeyer, C DeSouza, M Flier, P Frazeur, S Hardy, E Martinez-Soto, L Pallin, S Radford, S Reisberg, A Walker (undergraduate interns); M Conti, M Espie, A Franco, M George, K Haynes, W Johnson, C Kim, J McDowell, J McQueen, R Mead, S Reid, M Reyna, N Shah, P Shah, G Tobar-Dupres (high school interns)

Jonathan C. Allan, Coastal Geomorphologist, Coastal Field Office, Oregon Department of Geology and Mineral Industries, P.O. Box 1033, Newport, OR97365; Ph: (541) 574-6658; jonathan.allan@state.or.us

Education: Ph.D./Geography: University of Canterbury, Christchurch, New Zealand (1998); M.Sc. (Honours)/ Geography: University of Canterbury, Christchurch, New Zealand (1992); B.Sc./Geography: University of Canterbury, Christchurch, New Zealand (1990)

Employment: Coastal Geomorphologist with the Oregon Department of Geology and Mineral Industries (2001-present); Courtesy Faculty Staff Member with the College of Oceanic & Atmospheric Sciences, Oregon State University (2001-present); Post-Doctoral Research Associate working with Professor Paul Komar in the College of Oceanic & Atmospheric Sciences, Oregon State University (1999-2001);

Memberships, Professional Associations and Awards: American Geophysical Union; Coastal Education & Research Foundation, Inc.; 2015 GSA Environmental and Engineering Geology Division (EEGD) E.B. Burwell, Jr. Award

Selected Publications

Allan, J.C., Ruggiero, P., Garcia, G., O'Brien, F., Roberts, J.T., and Stimely, L., 2015, Coastal Flood Hazard Study, Tillamook County, Oregon: Oregon Department of Geology and Mineral Industries, *Special Paper 47*, 283 p.

Hapke, C.J.; Adams, P.N.; Allan, J.; Ashton, A.; Griggs, G.B.; Hampton, M.A.; Kelly, J., and Young, A.P., 2014. *Rocky Coast Geomorphology: A Global Synthesis – The USA*. In: Kennedy, D.M.; Stephenson, W.J., and Naylor, L. (ed.), Rock Coast Geomorphology: A Global Synthesis. London, Geological Society Publishing House, Memoirs, 40. pp. 135-152.

Komar, P.D., Allan, J.C. and Ruggiero, P., 2012. U.S. Pacific Northwest Coastal Hazards: Tectonic and Climate Controls. In: C.W. Finkl (Editor), *Coastal Hazards*. Springer.

Allan, J.C. and Ozkan-Haller, T., 2012. Mapping the wave climate in the nearshore offshore the Pacific Northwest coast, Sidelights. The Council of American Master Mariners, Inc, Vancouver, WA, 18-19.

Allan, J.C., Martin, D.L. and Newton, J., 2012. Using social networking, mobile apps to distribute tsunami hazard information, Sea Technology. Compass Publications, Arlington, Virginia, pp. 61-64.

Allan, J.C.; Komar, P.D.; Ruggiero, P., and Witter, R.C., 2012. The March 2011 Tōhoku Tsunami and Its Impacts Along the U.S. West Coast. *Journal of Coastal Research*, 28(5), 1142-1153.

Martin, D.L., Allan, J.C., Newton, J., Jones, D.W., Mikulak, S., Mayorga, E., Tanner, T., Lederer, N., Sprenger, A., Blair, R., Uczekaj, S.A., *2011*: Using Web-based and social networking technologies to disseminate coastal hazard mitigation information within the Pacific Northwest component of the Integrated Ocean Observing System (IOOS). *Proc. Oceans'11, Oceans of Opportunity: International cooperation and partnership across the Pacific, Marine Technology Society,* Kona, Hawaii.

Komar, P.D., Allan, J.C. and Ruggiero, P., 2011. Sea Level Variations along the U.S. Pacific Northwest Coast: Tectonic and Climate Controls, *Journal of Coastal Research*, 27(5): 808-823.

Barnard, P., Allan, J., Hansen, J, Kaminsky, G., Ruggiero, P. and Doria, A., 2011. The impact of the 2009-10 El Niño on U.S. West Coast beaches, *Geophysical Research Letters*, 38, L13604.

Allan, J.C., P.D. Komar, P. Ruggiero, *2011*: Storm surge magnitudes and frequency on the central Oregon coast. *Proc. Solutions to Coastal Disasters Conf., Amer. Soc. Civil Engrs,* Anchorage, Alaska: 53-64.

Komar, P.D., Allan, J.C., and Ruggiero, P., *2011.* Sea Level Variations along the U.S. Pacific Northwest Coast: Tectonic and Climate Controls. *Journal of Coastal Research*.

Allan, J.C., Witter, R.C., Ruggiero, P., and Hawkes, A.D., 2009. Coastal geomorphology, hazards, and management issues along the Pacific Northwest coast of Oregon and Washington. *In:* O'Connor, J.E.; Dorsey, R.J., and Madin, I.P. (ed.), *Volcanoes to vineyards: Geologic field trips through the dynamic landscape of the Pacific Northwest*: Geological Society of America Field Guide 15, The Geological Society of America, pp. 495-519.

Todd Russell Hallenbeck

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PROFESSIONAL INTERESTS

Increasing the discovery and use of best available science to inform sustainable fishery management and the design of spatial approaches to regional ocean resource management.

EDUCATION

California State University, Monterey Bay (Seaside, CA)
M.S, Coastal Watershed Science and Policy, May 2011

City College of San Francisco (San Francisco, CA)
Geographic Information Systems Certification Program (01/07 – 05/08)

University of California, Santa Cruz (Santa Cruz, CA)
B.S, Marine Science (7/03-6/05)

EXPERIENCE

West Coast Ocean Data Portal Program Coordinator (*01/13-present*)
Provide all aspects of coordination, administration, and outreach for West Coast Ocean Data Portal. Lead and facilitate a team of data managers and users from state and federal agencies, tribes, NGOs, and universities to guide development of West Coast Ocean Data Portal with monthly calls, newsletters, social networking, and annual meetings. Provide technical support for server administration, web development, data, metadata, and service creation and publishing. Data analysis and QAQC. Work with large network of partners to develop and communicate best practices for data sharing. Attend meetings and give presentations to wide variety of technical and non-technical audiences about West Coast Ocean Data Portal. Administer all aspects of grant writing, grant management, and progress reporting.

Principle and Founder *(10/12-present)*
Sustainable Ocean Solutions LLC (Alameda, CA)
Sustainable Ocean Solutions LLC provides robust decision support services for ocean resource management through data analysis, project management, data networking, strategic visioning, coalition building, and stakeholder communication and outreach. SOS LLC specializes in effective organization, facilitation, and coordination of small groups to achieve desired outcomes.

West Coast Governors Alliance on Ocean Health Sea Grant Fellow *(03/11-03/13)*
Oregon Governors Natural Resource Office (Salem, OR)
Assisted and briefed the Natural Resource Policy Advisor on ocean and coastal issues including the National Ocean Policy (NOP), fisheries, climate change, marine debris, and tribal engagement. Assisted the Deputy Natural Resources Advisor in tracking legislation during the 2012 session by developing and maintaining a tracking spreadsheet. Supported the West Coast representative to the National Ocean Council Governance Coordinating Committee by helping to review, compile and collate state comments on NOP documents. Developed and maintained aspects of the Governors website and assisted with CMS migration.

Marco B.A. Hatch, PhD

Director

National Indian Center for Marine Environmental Research and Education

Northwest Indian College | 360-594-4082 | marcoh@nwic.edu

(a) Professional Preparation

PhD, Biological Oceanography: June 2012

Scripps Institution of Oceanography, University of California San Diego

Research focus: The mechanistic understanding of how natural climate variability alters the productivity of exploited marine species

M.S., Marine Biology

Scripps Institution of Oceanography, University of California San Diego, 2007

B.S. Magna Cum Laude, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, 2005

- Developed molecular methods to identify archaeological salmon vertebrae to the species level

A.A.S., Whatcom Community College, Bellingham, WA, 2001

(b) Appointments

National Indian Center for Marine Environmental Research and Education, Associate Director, Northwest Indian College.

Bellingham, WA 2012-current

- Cultivates and strengthens relationships between Northwest Indian College and tribal, federal, and state government agencies and other institutions
- Provides leadership for the development of an active research program in the biological and environmental sciences at Northwest Indian College

Researcher: Center for the Study of Coast Salish Environments, Samish Indian Nation

Anacortes, WA 2003-2005

- Created a pre-European ecological baseline for the Salish Sea
- Worked with citizen groups, resource users, and resource managers
- Part of an interdisciplinary team of ecologists, botanists, and archaeologists

Researcher: Puget Sound/Georgia Basin Historic Conditions Project

Seattle, WA 2003

- Used original explorer maps, ethnographic and archaeological data to define the prehistoric distribution of Olympia oysters

Researcher: Submerged Vegetation Monitoring Project Seattle, WA 2003

Marine Biology, Graduate teaching assistant, UCSD Fall 2010

Instructor: Hands on introduction to the marine invertebrates, UCSD 2009

(c) Products (relevant)

Hatch, M.B.A., S.A. Schellenberg, M. Carter. 2013. Utilization cross-dated sub-annual growth increments to date Ba/Ca variations in the modern intertidal bean clam *Donax gouldii*. *Palaeogeography, Palaeoclimatology, Palaeoecology*.

Braje, T.J., J.M. Erlandson, T.C. Rick, P.K. Dayton, M.B.A. Hatch. 2009. Fishing from Past to Present: Continuity and Resilience of Red Abalone Fisheries on the Channel Islands, California. *Ecological Applications*. 19(4)906-919.

Alicia Rene Helms
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Charleston, OR 97420
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Professional Experience

Estuarine Monitoring Coordinator — South Slough National Estuarine Research Reserve
Oregon Department of State Lands, Charleston, OR
Feb 2013-present & July 2006-Oct 2011

Coordinate and implement laboratory and field-based operations associated with the National Estuarine Research Reserve System-Wide Monitoring Program. Manage the acquisition and transfer of environmental data. Plan and conduct research, monitoring and analysis for a variety of projects. Participate in conferences, workshops and trainings related to estuarine and coastal environments. Develop proposals for monitoring and research of estuarine and coastal ecosystems

Acting Research Coordinator — South Slough National Estuarine Research Reserve
Oregon Department of State Lands, Charleston, OR
Nov 2011-Feb 2013

Served as lead scientist by developing plans and goals to advance the scientific programs at the Reserve. With the direction of the South Slough Management Commission and Manager, developed, led, and coordinated scientific programs and work undertaken by Reserve personnel and visiting investigators using the Reserve resources. Managed projects and programs designed to characterize conditions in estuaries and coastal watersheds. Developed proposals to support scientific studies conducted by Reserve personnel and partner organizations.

Research Associate — Washington State University, Vancouver, WA
October 2005-July 2006

Organized and led research projects in Willapa Bay, WA on the ecology of burrowing shrimp

Education

Master of Science, Marine Biology, University of Oregon, September 2004
Bachelor of Science, Biology, University of New Mexico, May 1999

Publications / Presentations available on request

David W. Jones

Applied Physics Laboratory
University of Washington
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Seattle, WA 98105-6698
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Professional Employment

2012-Present	Director, Applied Technology and Engineering Group, Applied Physics Laboratory, University of Washington, Seattle, WA
2007-Present	Director, Center for Environmental and Information Systems, Applied Physics Laboratory, University of Washington, Seattle, WA
2000-2007	Senior Oceanographer/Principal Investigator, Applied Physics Laboratory
1998-2000	Director of Operations: Fleet Numerical Meteorology and Oceanography Center
1996-1998	Chief Science Officer: Fleet Numerical Meteorology and Oceanography Center
1993-1996	Master Instructor: United States Naval Academy, Annapolis, MD

Education

1989: University of Washington, Seattle, WA. MS, Physical Oceanography
1979: N.Y. Maritime College, Bronx, NY. BS, Meteorology and Oceanography, with Honors. Commission in U.S. Navy & obtained a US Coast Guard Third Mates license

Selected Relevant Publications

Jones, D., R. Carr & B. Schwartz-Gilbert. (2011). GLMPC: An Integrated System for Glider Command and Control. *Proceedings of the MTS/IEEE Oceans 2011 Conference*, Kona, HI., September 19-23, 2011

Jones, D and J. Olsonbaker (2009). Developing Best Practices for IOOS Web Portals. *Proceedings of the MTS/IEEE Oceans 2009 Conference*, Biloxi, MS., October 26-29, 2009.

Joslyn, S. and D. Jones (2008). Strategies in Naturalistic Decision Making: A Cognitive Task Analysis of Naval Weather Forecasting. In Schraagen, J.M.C., Militello, L., Ormerod, T., & Lipshitz, R. (Eds) *Naturalistic Decision Making and Macrocognition*. Aldershot, UK: Ashgate Publishing Limited.

Jones, D and S. Maclean (2007). RCOOS and Ocean Information Tools for Decision Makers. *Proceedings of the MTS/IEEE Oceans 2007 Conference*, Vancouver, B.C., October 1-5, 2007

Joslyn, S., Pak, K., Jones, D., Pyles, J., and Hunt, E., (2007). The effect of probabilistic information on threshold forecasts. *Weather and Forecasting*, 22, 10, 804-812

Jones, D W., M. H. Miller, J. A. Ballas, and J. I. Olsonbaker, (2004). Analysis of Human-Computer Interaction in the Expeditionary Warfare Decision Support System (EDSS). *APL-UW Technical Report 0402*. Applied Physics Laboratory-University of Washington, September, pp 61.

Research & Professional Accomplishments

David Jones is the Director of the Center for Environmental and Information Systems (CEIS), at the Applied Physics Laboratory, University of Washington. CEIS has over 60 personnel involved in research and development in areas of ocean acoustics, signal processing, ocean observations, environmental modeling, information security, and computer science. His own research has focused on the development of cognitive engineering solutions for applied decision-making and problem-solving domains. He is the Principal Investigator (PI) for several multi-disciplinary efforts including: the Glider Monitoring, Piloting, and Communication System (PEO C4I funded), a human-computer control interface for autonomous ocean observing vehicles; and MOISA, a human-centered systems engineering approach to safety and security in Puget Sound. He is a co-PI for several tasks of the NANOOS Regional Association (NOAA/IOOS funded) including: the development of web-tools for visualizing observations and model information, and the development of an operational POM model for Puget Sound. David served 21 years as a naval officer, the last four as director of operations and department head at Fleet Numerical Meteorology and Oceanography Center, Monterey, CA.

George M. Kaminsky

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Education

Ph.D., 2008, Marine Science, University of Sydney, Sydney, NSW, Australia
Dissertation: *Shoreface Behaviour and Equilibrium*
M.S., 2000, Oceanography, University of Washington, Seattle, Washington, USA
B.S., 1989, Ocean Engineering, Florida Institute of Technology, Melbourne, Florida, USA

Licensing

Registered Professional Engineer (Civil), State of Washington

Professional Experience

2007-present	WA Department of Ecology, Senior Coastal Engineer (Environmental Engineer 5)
1997-2007	WA Department of Ecology, Coastal Engineer (Environmental Engineer 4)
1995-1997	WA Department of Ecology, Coastal Engineer (Environmental Engineer 3)
1991-1995	WA Department of Ecology, Shoreline Engineer (Environmental Engineer 2)
1989-1991	US Army Corps of Engineers, General Engineer

Selected Publications

Stevens, A.W., Gelfenbaum, G., Ruggiero, P., and **Kaminsky, G.M.**, 2012. Southwest Washington littoral drift restoration—Beach and nearshore morphological monitoring: US Geological Survey Open-File Report 2012-1175, 67 p.

Barnard, P. L., Allan, J., Hansen, J. E., **Kaminsky, G.M**., Ruggiero, P. and Doria, A., 2011. The impact of the 2009–10 El Niño Modoki on U.S. West Coast beaches, *Geophysical Research Letters*, 38, L13604, doi:10.1029/2011GL047707.

Gelfenbaum, G., and **Kaminsky, G.M.**, 2010. Large-scale coastal change in the Columbia River littoral cell: An overview, *Marine Geology*, doi:10.1016/j.margeo.2010.02.007

Ruggiero, P, Buijsman, M., **Kaminsky, G**., and Gelfenbaum, G., 2010. Modeling the effects of wave climate and sediment supply variability on large-scale shoreline change, *Marine Geology*, v. 273, pp 127-140.

Kaminsky, G.M., Ruggiero, P., Buijsman, M., McCandless, D., and Gelfenbaum, G., 2010, Historical evolution of the Columbia River littoral cell, *Marine Geology*, v. 273, pp. 96-126.

Warrick, J.A., George, D.A., Gelfenbaum, G., Ruggiero, P., **Kaminsky, G. M**., and Beirne, M., 2009. Beach morphology and change along the mixed grain-size delta of the dammed Elwha River, Washington, *Geomorphology*, doi:10.1016/j.geomorph.2009.04.012.

Kaminsky, G.M., Ferland, M.A., Cowell, P.J., Moritz, H.R., and Ruggiero, P. 2007. Shoreface response to sediment deficit, *Proceedings of Coastal Sediments '07*, ASCE, pp. 633–646.

Ruggiero, P., **Kaminsky, G.M.**, Gelfenbaum, G., and Voigt. B., 2005. Seasonal to interannual morphodynamic variability along a high-energy dissipative littoral cell, *Journal of Coastal Research*, (21) 3 pp. 553-578.

Kaminsky, G.M., Ruggiero, P., and Gelfenbaum, G.R. 1998. Monitoring coastal change in southwest Washington and northwest Oregon during the 1997/98 El Niño, *Shore & Beach*, Vol. 66, 3, pp. 42-51.

Biographical Sketch

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Citizenship: U.S.

Professional Preparation

University of Washington: Zoology, BA, 1976; Oceanography, BS, 1976
Naval Postgraduate School: Meteorology and Oceanography, M.S., 1983
University of Washington: Oceanography, Ph.D., 1992

Relevant Appointments

2002 -	Associate Director, Applied Physics Laboratory, University of Washington
2000 - 2002	Director, Ocean.US, the federal interagency program office for the IOOS
1998 - 2000	Assistant for Environmental Sciences for the Deputy Undersecretary of Defense for Science and Technology
1997 - 1998	Director, National Ice Center, Washington, D.C.

Five Significant Publications Most Closely Related to this Project:

Allan, J.C., D. Martin, J. Newton, 2012, "Hazard Information and the Integrated Ocean Observing System", *Sea Technology* **53,4**, 61-64.

Martin, D.L., J.C. Allan, J. Newton, D.W. Jones, S. Mikulak, E. Mayorga, T. Tanner, N. Lederer, A. Sprenger, R. Blair, and S.A. Uczekaj, 2011, "Using Web-based and Social Networking Technologies to Disseminate Coastal Hazard Mitigation Information within the Pacific Northwest Component of the Integrated Ocean Observing System (IOOS)", *Proceedings of MTS/IEEE Annual Oceans Conference (Oceans11)*, Kona, HI.

Briscoe, M.G., D.L. Martin, and T.C. Malone, 2008, "Evolution of regional efforts in international GOOS and U.S. IOOS",*Mar. Tech.*, **42**, 4-9.

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Ocean.US, 2002b. "Building Consensus: Toward An Integrated and Sustained Ocean Observing System (IOOS)". Martin, D.L., Atkinson, L., Malone, T., Nowlin, W.: Executive Committee. Ocean.US, Arlington, VA. 175pp

JOHN B. MICKETT

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SUMMARY

A sea-going physical oceanographer with extensive technical and field experience, Dr. Mickett has participated in or led more than 40 oceanographic research cruises over the past 14 years. He is presently a Senior Oceanographer at the Applied Physics Laboratory, University of Washington where he is a principal investigator on six projects. For three of these projects Dr. Mickett leads a team of 5-6 scientists and engineers who design, build, maintain and analyze the data from 8 coastal real-time research moorings.

PROFESSIONAL PREPARATION

- PhD Physical Oceanography, August 2007, University of Washington, *Turbulent Entrainment Fluxes in the Eastern Pacific Warm Pool*, Prof. M. Gregg, advisor
- MSc Physical Oceanography, 2002, University of Washington, *Direct measurements of diapycnal mixing in a fjord reach—Puget Sound's Main Basin*, Prof. M. Gregg, advisor
- BSc Marine Science, 1994, U.S. Coast Guard Academy (High Honors)

APPOINTMENTS

- 2010–present: Senior Oceanographer, Applied Physics Laboratory, University of Washington (APL-UW)
- 2008–2010: Oceanographer III, APL-UW
- 2007–2008: Postdoctoral Researcher, APL-UW
- 1999–2007: Research Assistant, APL-UW
- 1994–2002: Commissioned Officer, United States Coast Guard

SELECT PUBLICATIONS

1. Zhang, S., M. H. Alford and J. B. Mickett, 2015: "Characteristics of Nonlinear Internal Waves on the Washington Continental Shelf", *Journal of Geophysical Research*, in press.
2. Voet, G., J. B. Girton, M. H. Alford, G. S. Carter, J. M. Klymak and J. B. Mickett, 2015: "Pathways, Volume Transport and Mixing of Abyssal Water in the Samoan Passage", *Journal of Physical Oceanography*, in press.
3. Alford, M. H., J. B. Girton, G. Voet, G. S. Carter, J. B. Mickett and J. M. Klymak, 2013, "Turbulent mixing and hydraulic control of abyssal water in the Samoan Passage" *Geophys. Res. Lett.*, 40, 4668–4674.
4. Alford, M. H., J. Mickett, S. Zhang, P. MacCready, Z. Zhao, and J. Newton, 2012, "Internal Waves on the Washington Continental Shelf," *Oceanography*, 25, 32–46.
5. Newton, J., M. Alford, J. Mickett, J. Payne, and F. Stahr, 2011, "The Northwest Association of Networked Ocean Observing Systems and opportunities for acoustical applications," *J. Acoust. Soc. Am.*, 129, 2371, doi:10.1121/1.3587676
6. Mickett, J.B., Y.L. Serra, M.F. Cronin, and M.H. Alford, 2010, "Resonant forcing of mixed layer inertial motions by atmospheric easterly waves in the northeast tropical Pacific," *J. Phys. Oceanogr*., 40, 401-416
7. Mickett, J. B., 2007, *Turbulent entrainment fluxes within the eastern Pacific warm pool*, Ph.D. Thesis, University of Washington, URI: http://hdl.handle.net/1773/11005.
8. Wijesekera, H. W., D. L. Rudnick, C. A. Paulson, S. D. Pierce, S. Pegau, J. B. Mickett and M. C. Gregg, 2005: "Upper ocean heat and freshwater budgets in the Eastern Pacific Warm Pool," *Journal of Geophysical Research*, 110, C08004.
9. Mickett, J. B., M. C. Gregg and H. E. Seim, 2004: "Direct measurements of diapycnal mixing in a fjord reach—Puget Sound's Main Basin," *Estuarine Coastal and Shelf Science*, 59, 539–558.

Curriculum Vitae

TROY TRAVIS TANNER

Software / Interface Engineer

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EDUCATION

B.A., University of Washington, Seattle, WA — 1997

WORK EXPERIENCE

Senior Software Engineer, Applied Physics Laboratory, UW — 2011 - Present
Software Engineer, Applied Physics Laboratory, UW — 1997 - 2011
Undergraduate Software Engineer, Applied Physics Laboratory, UW — 1993 - 1997

EXPERTISE

- Interface design and development
- Project management
- Data visualization
- Software development
- Usability testing
- Client-server architecture
- Relational databases
- Graphic design
- 3-D modeling
- Animation

AWARDS & ACTIVITIES

Director's Award, Applied Physics Laboratory — 2007
Winner of the American Physical Society fluid motion animation competition — 1999
Innovative Technology Award — 1997
Guest instructor for post-graduate oceanography and interface design classes — 1997

PUBLICATIONS

Mayorga, E., T. Tanner, R. Blair, A.V. Jaramillo, N. Lederer, C.M. Risien, and C. Seaton, "The NANOOS Visualization System (NVS): Lessons learned in data aggregation, management and reuse, for a user application," In Proceedings, MTS/IEEE OCEANS 2010, Seattle, 20-23 September, doi:10.1109/OCEANS.2010.5663792 (MTS/IEEE, 2010).

Risien, C.M., J.C. Allan, R. Blair, A.V. Jaramillo, D. Jones, P.M. Kosro, D. Martin, E. Mayorga, J.A. Newton, T. Tanner, and S.A. Uczekaj, "The NANOOS Visualization System: Aggregating, displaying, and serving data," In Proceedings, MTS/IEEE Oceans, Biloxi, MS, 26-29 October (MTS/IEEE, 2009).

Olsonbaker, J., T. Tanner, and D. Jones, "Improved decision making with Boater Information System," Proc., Georgia Basin Puget Sound Research Conference, 26-29 March, Vancouver, B.C. (2007).

H. NEPA documentation

Question C1. Is the proposed activity going to be conducted in partnership with NOAA or would the proposed activity require NOAA's direct involvement, activity, or oversight? If yes, describe NOAA's involvement, activity, or oversight, including the name of the office or program that is involved. **Answer: NANOOS is part of IOOS, which is administered by NOAA, but the work will be conducted by the NANOOS institutions which are not NOAA.**

Question C2. Would the proposed activity involve any other federal agency(ies) partnership, direct involvement, activity, or oversight? If yes, provide the name(s) of the agency(ies) and describe its involvement, activity, or oversight. **Answer: No**

Question D1. Provide a brief description of the location of the proposed activity. **Answer: The entire project is located in the coastal shelf waters, shorelines and estuaries of the Pacific Northwest United States.**

Question E1. List any federal, state, or local permits, authorizations, or waivers that would be required to complete the proposed activity. Provide the date the permit, authorization, or waiver was obtained or will be obtained. Provide copies of the permit, authorization, or waiver as appropriate. Was a NEPA analysis prepared for the permit, authorization, or waiver? If yes, state the title of the NEPA analysis and provide copies of the NEPA analysis. **Answer: N/A**

Question F1. Is there the potential for the proposed activity to cause changes that would be different from normal ambient conditions (e.g., temperature, light, turbidity, noise, other human activity levels, etc.)? If yes, describe the changes and the circumstances that would cause these changes. **Answer: No**