

Proposal submitted to the Integrated Ocean Observing System (IOOS) Program,
National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA),
Department of Commerce

in compliance with the IOOS Programmatic Environmental Assessment (PEA),
specifically the Project Design Criteria (PDC)

**Pursuant to FY 2016 Implementation of the U.S. Integrated Ocean Observing System
(IOOS)**

**Topic Area 1: Implementation and Development of Regional Coastal Ocean Observing
Systems**

Enhancing and Sustaining the Pacific Islands Ocean Observing System (PacIOOS)

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2. Project Summary

a. Project Name/Title

Enhancing and Sustaining the Pacific Islands Ocean Observing System (PacIOOS)

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e. Brief Project Summary including objectives and intended benefits

The Pacific Islands Ocean Observing System (PacIOOS) is a partnership of data providers and users working together to enhance ocean observations and to develop, disseminate, evaluate, and apply ocean data and information products to address the environmental, economic, and public safety needs of stakeholders who call the U.S. Pacific Islands (Appendix 1) home. Eight years after its inception, PacIOOS is a successful and mature enterprise providing data and information to more than 250,000 people per year¹. PacIOOS owns and operates data and observing infrastructure throughout the U.S. Insular Pacific as one of the eleven regional observing programs that support the U.S. Integrated Ocean Observing System (IOOS), and **is the first and only regional association to have met all the criteria to be certified as fully integrated into IOOS.**

Over the next five years, PacIOOS aims to continue to provide ocean data and information to support science-based decision-making to ensure a safe, clean, and productive ocean and resilient coastal zone for the U.S. Pacific Islands. We will continue to generate public benefit by sustaining and enhancing a mature, cost-effective, and stakeholder-driven observing system that: 1) maintains and enhances the existing observing and modeling capacity in Hawai‘i and the U.S. Insular Pacific; 2) enhances its data management and engagement sub-systems to continue the provision of integrated, customized, and timely ocean information, data products, and tools; 3) sustains public education and engagement at all learning levels to enable ocean-literate and well-informed public and private sectors; and 4) engages with and responds to priorities from stakeholders in non-governmental organizations, local, state, territorial and federal agencies, academia, commercial entities, industry, K-12 schools, and the general public.

We propose to continue our focus on sub-system efforts that inform policy, conservation, operational, commercial, and recreational decision-making related to **marine operations, water quality, coastal hazards and resiliency, and living marine resources**. In addition, we will continue to engage users, stakeholders, and system partners in the use, education, and outreach of technical capacity, data visualization, and ocean information.

f. Partners

PacIOOS partners are essential to the vision, prioritization, development, implementation and maintenance of the program. Many agencies and organizations have been instrumental in the development, operations, and enhancement of ocean observing capacity in the Pacific Islands region and have provided and/or continue to provide resources and funds for component systems, contributions to data and products, maintenance and management of observing instrumentation, participation in strategic planning, and/or service on the PacIOOS Governing Council (whose current members are shown in Section 2d). A subset of the complementary funding from partners that has helped build and sustain the system is available in Appendix 2.

PacIOOS is honored to be close partners with over 100 federal, state, territorial, international, and local agencies, academic institutes, non-governmental organizations, and private industry. Fifty-two of these are signatory partners to the organizational Memorandum of Agreement that established the oversight and stakeholder management of PacIOOS. For a more detailed list of PacIOOS partners, please see Appendix 3.

¹ Determined from unique user counts on PacIOOS web-based services as recorded by Google Analytics and AWStats services embedded in PacIOOS products.

² Calculated from AWStats records of data transfer from core PacIOOS data transport services, including

3. Project Description

a. Background

Ocean data and information can help save the lives and resources (environmental, capital, and cultural) of ocean stakeholders. This is the premise behind the Pacific Islands Ocean Observing System (PacIOOS). As one of 11 Regional Associations (RAs) comprising the coastal component of the U.S. Integrated Ocean Observing System (IOOS), PacIOOS contributes to the national effort to provide an “eye on our oceans, coasts and Great Lakes.”

PacIOOS sustains ocean observations in the State of Hawai‘i, territories of Guam and American Samoa, Commonwealth of the Northern Mariana Islands (CNMI), Republic of Palau, Republic of the Marshall Islands, Federated States of Micronesia, and U.S. Minor Outlying Islands of Howland, Baker, Johnson, Jarvis, Kingman, Midway, Palmyra, and Wake (Appendix 1).

Spanning six time zones across the Pacific Ocean, the PacIOOS region is the largest within the IOOS system. The region is bisected by the International Date Line, straddles all four hemispheres, is distributed over an area of nearly 35 million km², and includes 2,500 km of coastlines and over 2,300 individual islands. Though each island constituent in the region is distinct in terms of their respective governments, languages, legal systems, geographical setting, cultural norms, societal structure, economies, and level of infrastructure, all are uniquely tied to the ocean. The open and coastal waters of the region are a leading source of food, place of recreation, fuel for a tourism-based economy, network for transportation, foundation of island cultures, and dominant driver of regional weather patterns and global climate.

In addition, the Pacific Islands are home to some of the richest, most diverse, and commercially important ecosystems in the world. This diversity is protected by the world’s largest network of marine conservation zones, supports a multi-billion dollar tourism industry, and sustains pelagic and coastal commercial fisheries with an annual economic value over \$1.5 billion. The area also hosts the largest fish auction in the U.S., providing seafood throughout the Pacific and the nation.

Initial regional coastal ocean observing system (RCOOS) development within the PacIOOS region began in 2007 with a cooperative agreement between SOEST and NOAA to establish a pilot observing system in Hawai‘i known as the Hawai‘i Ocean Observing System (HiOOS). Given the prohibitive cost associated with developing a new observing system over an area four times larger than the continental U.S., HiOOS was designed as a demonstration project jump-started by leveraging substantial SOEST capacity, partner assets, and funding. The intent of HiOOS development was to expand to the other archipelagos in the PacIOOS region following the initial demonstration through the transfer of technology, expertise, and best practices.

Development of the initial observational, modeling, data management, and outreach capability within the limited geographic area of the Hawaiian Islands generated the foundation from which PacIOOS has grown and continues to serve stakeholder needs. PacIOOS is now a fully-functional RCOOS: an end-to-end network of observations, data management and delivery, data analysis and modeling, research and product development, education and outreach, and organizational structure and management that links the needs of users to observations of coastal marine and estuarine environments throughout the U.S. Pacific Islands and beyond. This comprehensive foundation is key to PacIOOS’ ability to serve ocean stakeholders. Each piece of the system is essential to inform or operate at the regional level. Indeed, while some users rely on the direct data feeds, most rely upon products that combine various data sets and/or make the data user-friendly for decision-making.

Over the last five years, PacIOOS deployed new observing system assets and expanded modeling capacity almost exclusively beyond the initial pilot project area. Assets are now deployed in each PacIOOS jurisdiction, and modeling capacity has increased by an order of magnitude (Appendix 1), with numerous international, federal, and non-federal partners relying upon output for operational decision-making. The outreach sub-system of the program has built long-lasting, reciprocal relationships with partners throughout the region. Our data management infrastructure is modern, mature, fully compliant with all IOOS requirements, and serves millions of data requests to hundreds of thousands of unique users throughout the Pacific and beyond².

In 2010, strategic oversight of PacIOOS transitioned from a steering committee comprised solely of University of Hawai'i investigators to include a Governing Council (Section 2d) populated by a geographically and sectorally diverse membership elected by stakeholders. The Council provides strategic and policy guidance to PacIOOS leadership and works with the program to align and execute PacIOOS' vision, engage the broader stakeholder community, evaluate the efficacy of existing efforts, and set short- and long-term priorities for future investment.

b. Goals and Objectives

The primary goal of our proposed work is to provide ocean data and information through integrated, customized, and timely products that enable an ocean-literate and well-informed public and decision makers. In order to achieve this goal, the main objective of this proposal is to sustain and enhance observing, modeling, data management, governance, and outreach sub-systems that comprise PacIOOS. We propose to continue our focus on sub-system efforts that inform policy, conservation, operational, commercial, and recreational decision-making related to **marine operations, water quality, coastal hazards and resiliency, and living marine resources**. In addition, we will continue to engage users, stakeholders, and system partners in the use, education, and outreach of technical capacity, data visualization, and ocean information. Specific objectives towards the project goal are detailed in the Work Plan (Section 3d) with further detail, including objectives to be completed in each year of the proposed work, included in the Milestones (Section 3e) and the detailed budget narrative (Section 3f).

c. Connection to Users/ Stakeholders and Benefits

A wide-range of user groups have actively defined and refined PacIOOS. This ongoing engagement is both geographically and programmatically wide-reaching, including many levels of federal, state and local/regional government, ocean recreation and commerce (fisheries, transportation, offshore energy) sectors, hotel and tourism industry, non-governmental organizations, media, community and indigenous groups, as well as visitors to the islands within the PacIOOS region. Despite the inherent diversity among these groups and their interests, commonalities surface in their requests for ocean-related data products. Stakeholders are asking for focused, innovative, timely, and accurate products upon which to base decision-making, policy, safety, and future cultural and community planning efforts.

Stakeholder engagement

The collection, assessment, and adoption of PacIOOS system priorities are built upon an inclusive, iterative, and bottom-up stakeholder input process paired with scientific inquiry and integrity. Engagement of stakeholders continues to be both geographically and programmatically extensive. Input is gathered at community and in-person meetings, workshops, training sessions, focus groups, through web-based feedback, and through review of strategic plans, prioritization documents, and needs assessments compiled by partner organizations at local, regional, and

² Calculated from AWStats records of data transfer from core PacIOOS data transport services, including THREDDS, DChart, LAS, and ERDDAP.

federal levels. Through these ongoing and various modes of engagement, PacIOOS maintains a diverse and engaged user base that provides regular input on needs and priorities within their cohorts as well as critical assessment on the effectiveness of the regional system.

Consistent engagement with stakeholders ensures a continuous feedback loop with the PacIOOS staff and researchers, regional partners, and the IOOS Program Office. In addition to the Honolulu-based staff, PacIOOS supports staff to manage extension and stakeholder engagement work outside Hawai‘i. PacIOOS has active partners and liaison staff in Palau, Guam, CNMI, Federated States of Micronesia, the Marshall Islands, and American Samoa. The liaison staff ensure regular engagement, stakeholder feedback, and input into short-term annual priority setting as well as long-term strategic planning.

Governing Council

In addition to ongoing contributions to needs assessments, gap identification, and priority identification, stakeholders can choose to participate in higher-level priority adoption and planning through our governance framework. Stakeholder groups and organizations are invited to become partners with PacIOOS by signing a Memorandum of Agreement (MOA). It is through the MOA signatories that the Governing Council members are nominated and elected. Signatories to the MOA populate electing cohorts (i.e., regional partners, Hawai‘i-specific partners, Palau-specific partners, etc.), each of which vote to determine their representative(s). Governing Council members provide general oversight and policy guidance, adopt implementing documents and strategic plans, and advise on major decisions for PacIOOS. The Council works with PacIOOS staff, through annual meetings, individual discussions, and through a five-member Executive Committee to review region-wide needs from all stakeholders (see Section 2d for members of the PacIOOS Governing Council and Executive Committee).

Strategic Planning and Priority Setting

Guided by rich stakeholder input, PacIOOS executes annual work-plans that are designed to meet the long-range goals and objectives articulated in the 5-year Strategic Operational Plan (PacIOOS, 2012). The Plan, adopted by the Governing Council, is reviewed annually to ensure that the organization is focused on relevant, appropriate, and timely activities while maintaining its focus on large-scale goals and objectives tied to the national observing enterprise, such as those detailed in the regional build-out plan (PacIOOS, 2011). The goals, objectives, and recommended actions represent a collection of expressed needs, gathered over years and geographies, carefully matched with the capabilities of the PacIOOS researchers, staff, and Governing Council to create a cost-effective, operational ocean observing system.

A number of factors are taken into consideration when prioritizing annual allocation of resources within the organization. PacIOOS leadership evaluate funding levels, progress toward strategic plan goals/objectives, and existing program capabilities along with partner support for activities, and the potential impact of an investment to individuals, organizations, and populations as a whole. The results of these comparisons are presented to the members of the Executive Committee, who then provide guidance on balancing resources and priority setting for the most efficient and effective operations in both the short- and long-term.

Benefits

Island communities, industry, and transportation officials point to maritime commerce as providing a critical lifeline for food, material goods, and transportation within the Pacific Islands and to North America, Australia, and East Asia. The ocean is the regional inter- and intra-state highway and railway system, with every shipping route to and between the islands using one of six primary ports on O‘ahu (Honolulu Harbor, Barber’s Point Harbor, Pearl Harbor), Guam

(Apra Harbor), American Samoa (Pago Pago Harbor) and Saipan (Saipan Harbor). Harbor-masters, recreational and commercial boat owners, and government maritime agencies rely on accurate measurements and predictions of the state of the coastal and open ocean and of seiche amplitude in their harbors during wind, high swell, storm surge, and tsunami events.

The PacIOOS website presently serves model and observational data on open and coastal ocean conditions around the Pacific region. Expanded wave buoy observations and ocean, wind, and wave model capacity proposed herein will grow existing web-based visualization capacity in both resolution and spatial area. Harbor surge, wave run-up, and water level forecasting systems in place will be expanded, guided by NOAA Storm Surge Roadmap priority areas in the region, to inform mariners, harbormasters, and coastal land owners, and to support multi-billion dollar infrastructure projects ongoing and pending for Hawaiian harbors renovation, Navy carrier berthing and turning basin facilities on Guam, amphibious landing sites in the CNMI, and expansion of naval facilities at Pearl Harbor.

The U.S. Coast Guard, territorial emergency responders, and maritime rescue agencies in Hawai'i, the territories, and the U.S.-affiliated nations of the Pacific require real-time, accurate, and highly resolved information on coastal currents, waves, and offshore conditions for effective search-and-rescue (SAR) operations. To support such data provision, we have developed operational data-assimilating models, deployed 7 high-frequency radars (HFR), operate 15 wave buoys, and run profiling glider missions. We propose to sustain and expand this effort to meet ever-growing user demand for real-time ocean information and forecasts in other areas of the PacIOOS region. Lives have been and continue to be saved by the data PacIOOS provides (PacIOOS, 2014), and the safe operation of commercial, recreational, and defense vessels in the region is ensured by the provision of timely and accurate wave, current, and wind data.

National and local marine protected area managers (e.g., Palau Protected Area Network site managers), regulatory agencies (e.g., State of Hawai'i Department of Health Clean Water Branch), and environmental non-profit organizations (e.g., Conservation Society of Pohnpei) identify sewage spills, sediment plumes, reef dredging, upland deforestation, industrial pollution, rising ocean temperatures, and ocean acidification as major threats to coastal ecosystems. They ask for, and benefit from, real-time monitoring of water quality parameters and knowledge of the fate of spills, plumes, and discharge in the coastal waters. We measure and provide map-based visualizations of water quality parameters throughout the region and propose to sustain and enhance that capability in concert with the deployment of new sensor platforms through focused partnerships with local community groups. This enhanced spatial network of water quality sensors, coupled with enhanced numerical modeling capability, will allow for near real-time predictions of plume dispersal, particle trajectory, and water quality in priority coastal areas.

Maintaining healthy ecosystems and marine resources benefits both the environment and the economy of the Pacific. Management of commercial fishery and conservation activities in a manner that sustains and enhances ecosystem services requires the collection and delivery of survey data, and real-time and modeled physical and bio-chemical parameters that support ecosystem-based management. PacIOOS aims to greatly improve the integration of biological, chemical, geological and physical information. PacIOOS is advancing the collection and delivery of biological datasets (e.g., fish presence, absence and abundance) and guiding the integration of these datasets into new bio-physical numerical models, visualizations, and decision-making tools. These tools provide information to resource managers, public officials, and policy makers interested in coral reef health, ecosystem response to a changing climate, and the location, movement patterns, and population sizes of pelagic species.

As populations grow so too does the inevitable conflict and competition for limited ocean resources. Planners, resource managers, policy makers, and the public are increasingly asking for centralized data portals that provide integrated visualization of marine and coastal information to inform commercial, planning, policy, and conservation decisions. Various federal, state, and local agencies have requested PacIOOS to help make their data more accessible by integrating their data into our data management system. We have developed and deployed an advanced data portal, including catalog, storage, and advanced data access features, for the full PacIOOS region. **In the past year, PacIOOS systems fielded more than 16 million data and page requests from more than 250,000 unique users, totaling more than 1.5TB of data transfers³.** We propose to continue populating our data portals with historical, real-time, forecast, and spatial data to improve access of ocean data to inform industry, managers, policy makers, and the public for integrated planning, management, commerce, and conservation.

d. Work Plan

Work proposed for the 2016-2021 phase of PacIOOS operation and enhancement is presented below and organized by PacIOOS thematic areas of effort. Numerical modeling, data management, education/outreach, and project management—components that are linked to each PacIOOS thematic area—are presented individually. A timeline of major tasks, product development, and key outcomes are detailed in the milestones schedule (Appendix 4). Base capacity and enhancements to the system are outlined below with the corresponding budget for each focus area (Appendix 5) detailing distribution of expenses between each of three prioritized budget scenarios. Costs and details of equipment, supplies, travel, personnel, contractual commitments, fringe benefits, and partner responsibilities are presented in the detailed budget narrative (Appendix 6).

Marine Operations

The main objective under this thematic focus area is to collect and provide ocean observations that improve decision-making for marine operations, including maritime commerce, search and rescue operations, and local harbors. Essential to the efficiency, safety, and timeliness of transit in the marine environment is reliable information on the state of the ocean and timely and accurate forecasts of future conditions. Generally, stakeholders have identified this ocean-state information as the highest priority for observing system development and, along with modeling, is the principle thematic focus of our proposed work. PacIOOS currently operates the core components of an observational network of high-frequency radars (HFR), wave buoys, and coastal ocean and harbor moorings in order to produce the most accurate information possible. This information is served in real-time and near real-time via the PacIOOS website. Funds requested herein will maintain existing regional capacity for ocean-state observations and forecasting and expand select PacIOOS capabilities to additional geographic priority areas.

PacIOOS currently operates seven HFR systems within the region, all at priority locations defined within the National Surface Current Mapping Plan (IOOS, 2013). Five systems are active along the southern and western shores of O‘ahu, with two additional systems operating in Hilo Bay, Hawai‘i. HFR allows for real-time imaging of coastal currents and wave spectra over a large spatial area extending more than 100 km from shore. The data derived from HFR are processed in real-time, yielding derived surface current products that are made available on the PacIOOS website and assimilated into numerical models. HFR output is also consumed by the U.S. Coast Guard to support search-and-rescue operations (SAROPS), by the City and County of Honolulu to support rescue and recovery, and by NOAA Office of Response and Restoration as

³ Calculated from AWStats records of data transfer from core PacIOOS data transport services, including THREDDS, DChart, LAS, and ERDDAP; and unique user visits from Google Analytics.

part of a data package for oil spill response. At a minimum, PacIOOS requests funds to maintain the five existing HFR systems on O‘ahu. If funds are available, we will also maintain the two existing systems in Hilo. While surface current mapping with HFR is a high priority for search-and-rescue, pollution tracking, and interisland shipping in the Hawaiian Islands, stakeholders in the Insular Pacific have not identified it as a high priority. That prioritization, coupled with the significant cost of system expansion over a large geographic area, has led to our limited focus on Hawai‘i for HFR operation.

Collaborating with the Coastal Data Information Program (CDIP), the U.S. Army Corps of Engineers, NOAA Coastal Storms Program, and local partners, PacIOOS has deployed a fleet of fifteen Datawell directional waverider buoys in the waters surrounding Hawai‘i, Guam, CNMI, American Samoa, and Marshall Islands. These buoys support the priorities detailed within both the National Operational Wave Observation Plan (NOAA NDBC, 2009) and the PacIOOS Strategic Plan (2012), and they provide critical real-time wave information for recreational and commercial mariners in coastal waters. They are also essential validation points for existing and proposed regional wave models. While the capital costs to establish the observational network in the region were borne by PacIOOS and partners, we request support, at a minimum, for annual maintenance of all wave buoys in the region. These funds will allow for routine service and maintenance, recovery in the event of a buoy/mooring separation, and data processing (telemetry, QA/QC, archiving) by CDIP. This buoy array is a core component of PacIOOS operations and provides essential observational data for NOAA National Weather Service (NWS) forecasts as well as our own provision of coastal inundation, harbor condition, and nearshore safety products. We request additional funds in Year 1 to purchase one wave buoy to be deployed between Yap and Palau, in response to multiple requests from local governments, partners, and NWS. We request additional staff support in each program year, to be based at the University of Guam (UOG), to facilitate prompt recovery, repair, and maintenance of the three wave buoys in the Mariana Islands and the additional buoy proposed for Yap/Palau.

We have begun addressing the needs of the small-boat maritime industry through a focus on Hale‘iwa Harbor, the only marina on the north shore of O‘ahu. In consultation with harbor users and the harbormaster, we identified harbor surge as a major safety concern and potential source of damage to vessels, piers, and other harbor infrastructure. We have deployed current meters, a wave buoy, and water level stations in the harbor and entrance channel to produce an integrated picture of real-time conditions in the immediate vicinity of the harbor. These data are used to create a Surge Current Index that provides a five-day warning of potentially damaging and dangerous water motion in the harbor. At a minimum, we request funds to maintain this existing capacity and, should funding be available, propose to expand this capability to four other harbors on O‘ahu (Barber’s Point), Lāna‘i (Kaunapau), Maui (Kahului), and Hawai‘i Island (Hilo).

Water Quality

The central objective of our water quality focus area is to collect and provide access to coastal ocean information to address the needs of marine resource managers, non-governmental organizations, as well as state and county health officials to effectively respond to and protect ecosystem, wildlife, and human health. Indeed, automated sensing of coastal water quality parameters is a high-priority within each of the PacIOOS jurisdictions. In order to accurately assess water quality we have deployed an observational network of real-time and near real-time coastal moorings in the nearshore waters of Hawai‘i and the Insular Pacific.

PacIOOS currently operates an array of fourteen nearshore sensor packages. Ten of the sensor packages measure light attenuation (turbidity), temperature, salinity, pressure (water depth), and fluorescence. Two of the sensor packages measure the afore-mentioned parameters plus

dissolved oxygen and pH, and another two of the packages monitor only temperature, salinity, and pressure (water depth). These nearshore sensor packages are a core component of both our water quality network and our extension effort to build public awareness and technical capacity in the region. Working with our PacIOOS liaisons and local partners, we have developed school curriculum utilizing the data collected and have installed at least one sensor package in each of the PacIOOS jurisdictions.

PacIOOS staff at the University of Hawai‘i (UH) at Hilo operate three real-time buoys around Hawai‘i Island. The buoys provide our users with measurements of biological activity, light attenuation, dissolved oxygen, phycoerythrin, salinity, temperature, pH, PAR, and nitrate in Hilo Bay, Kiholo Bay, and Pelekane Bay (deployment planned Q4 2015). Hilo Bay is heavily influenced by surface runoff and ground water discharge and is a major center of commercial and recreational maritime activity. The Hilo Bay buoy also provides marine science students at UH Hilo with valuable field studies research opportunities and capacity building. Pelekane and Kiholo Bays are within the West Hawai‘i focus area of NOAA’s Habitat Blueprint. We request funds for operation and maintenance of the water quality buoys around Hawai‘i Island and the sensor array throughout the region.

Place-based community stewardship efforts are gaining momentum and recognition throughout our region, and stakeholders are turning to PacIOOS for monitoring and science support of these efforts. In Hawai‘i, this includes partners such as Conservation International and The Nature Conservancy who are asking for assistance to: 1) monitor water quality in Hawaiian fishponds restored as potentially viable aquaculture enterprises for local communities; 2) describe the atmospheric and coastal oceanographic processes at scale; and 3) evaluate the efficacy of land-based stewardship efforts (e.g., sediment controls) adjoining priority coral reefs. In the freely associated states of Micronesia (Palau, FSM, Marshall Islands), this includes a suite of coral-reef monitoring programs seeking to improve their ability to generate locally-scaled environmental data to inform adaptive management efforts such as the Micronesia Challenge.

With additional funds, we propose the addition of new sensors and staff support with a focus on supporting place-based community stewardship groups in need of monitoring and science support to increase knowledge of the localized, coastal environments, evaluate the efficacy of stewardship efforts, and inform future management decisions. Specifically, the enhanced observational array will include three components. The first component includes the purchase of two nitrate sensors to complement existing nearshore sensors in Palau and American Samoa to address questions and concerns of local regulatory agencies regarding nutrient loading in the nearshore waters of these island jurisdictions.

The second component is the development and deployment of 14 low-cost water quality sensors (\$3,500 per unit) in He‘eia watershed and fishpond within Kāne‘ohe, Hawai‘i to support the nascent effort of the only National Estuarine Research Reserve System (NERRS) in the PacIOOS region and feed into proposed model enhancements discussed below. The sensors will measure temperature, dissolved oxygen, chlorophyll, turbidity, conductivity (salinity), and pressure (depth). This component builds upon a UH Sea Grant pilot project to use new, but proven, technology that employs open-source hardware components and custom software that can be assembled, tested, deployed, and maintained by fishpond caretakers, students, or environmental managers, thereby building local capacity and increasing the accessibility to ocean science. An additional value of these low-cost sensors is how accessible they make data collection and the resultant understanding of the local processes affecting water quality biogeochemistry in estuarine environments.

The third component of the proposed expanded water quality observing array will be conducted via services contract with the University of Guam (UOG) and includes the purchase and deployment of 15 temperature and water level loggers per year to grow the sensing array associated with coral-reef monitoring across the freely associated states of Micronesia. As these loggers are known to last up to two years in the warm waters of the Western Pacific, we propose having up to 30 deployed at any one time across conservation management areas within the main islands of the Marshall Islands, Kosrae, Pohnpei, Chuuk, Yap, and Palau. The data collected by these loggers will address a key deficiency identified among stakeholders—the inability to consistently generate locally-scaled data to help understand environmental phenomena such as the bleaching events that are increasingly occurring across coral reefs of the PacIOOS area and worldwide. This will enable resource managers to better plan for long-term temperature changes in ocean conditions and adapt management to mitigate the impacts of low-frequency environmental phenomena like El Niño-Southern Oscillation and the Pacific Decadal Oscillation. In concert with this effort, the UOG will develop science-support decision-making tools for conservation efforts in Micronesia, including the development of predictive ecosystems-based tools using existing satellite data. A significant piece of this effort is making the data available in user-friendly formats for resource managers with limited capacity and resources.

PacIOOS currently helps support the operation of two CO₂ and water quality buoys inside and outside of Kāneʻohe Bay in cooperation with NOAA’s Pacific Marine Environmental Lab (PMEL). These two systems, detailed as important assets in the Strategic Plan for Federal Monitoring of Ocean Acidification (2014), are core components of both the U.S. and the global CO₂ monitoring network and provide a coastal, shallow-water signal of climate variability (one buoy is designated as a Class III site and is a key component of the NCRMP program while the other has provided the longest time series record in the world of pCO₂ and ancillary parameters on a coral reef). The inner reef location, additionally, has been used extensively as a test site for the development and evaluation of marine sensors through both the Alliance for Coastal Technology (ACT) and other interactions with NOAA and other researchers. In addition to the variables measured by the nearshore sensor packages, these buoys measure barometric pressure, relative humidity, dissolved oxygen and CO₂ in both the atmosphere and ocean surface water, and pH. Should funds be available, we propose to maintain these existing important nearshore and CO₂ climate buoy arrays.

Coastal Hazards and Resiliency

The coastal communities of the Pacific Islands are vulnerable to both long-term and episodic changes in coastal water levels, and accurate forecasting of these changes is a priority among all PacIOOS jurisdictions. PacIOOS aims to assist coastal hazard planning, mitigation, and response by providing real-time and forecast ocean conditions in appropriate scales and formats. Observing systems are in place to assess sea-level rise and inter-annual to decadal sea level variations; however, **the immediate local need is for predictions of short-term, high-water level events.** The combination of spring tides with seasonal swell events leads to frequent over-topping of coastal roads, flooding of storm drains, and inundation of low-lying shorelines and coastal margins. The addition of positive water level anomalies associated with mesoscale eddies and other ocean circulation features can exacerbate the impacts of these events, and the frequency and severity of inundation will only increase with rising sea levels.

During the initial phase of PacIOOS, we developed the data streams (water level, swell, wave set-up, atmospheric pressure) needed to specify all components of high-water level events. Using these data sources, we developed an empirical model for high water level based on incident wave and water level conditions. Our observational and model data streams were combined to offer a nowcast and up to 6-day forecast product of high sea level events at nine locations. In addition to

the impacts on coastal communities of high water levels, the reach of wave run-up that rides atop high-water level causes additional damage and disruption. Building upon NSF-funded, site-specific wave energy transfer studies at select locations in Hawai‘i and the Marshall Islands, and using established high-resolution bathymetry and LIDAR mapping of the coastal zone, we generated nowcast and 6-day forecast products of wave run-up at four locations in Hawai‘i and the Marshall Islands. These wave run-up forecasts, and the high sea level forecasts they build upon, have proven to be an essential resource to emergency managers and communities throughout the region. Our Department of Defense, public safety, and NWS partners rely upon these tools for daily decision-making. We are discussing with NWS the potential to transition our operational products into their publicly available coastal flood warning tool, and we propose to continue that discussion and facilitate initial transition during this proposal’s performance period.

At a minimum, we request funding to maintain the staff, observational components (wave buoys, pressure sensors), and modeling components (forecast wave heights) that go into the high-water level and wave run-up products and to use existing personnel to continue to refine the water level prediction tool. The present network of PacIOOS near-shore sea-state instrumentation and wave buoys (in partnership with CDIP) requires ongoing maintenance to remain in operation. Should funds be available, we propose expanding our staff and equipment resources to allow for water level and wave run-up forecast expansion to nine additional sites in Hawai‘i and the Insular Pacific and the enhanced validation of existing forecasts through focused field validation studies.

Living Marine Resources

The objective behind this PacIOOS focus area is to collect and provide ocean observations that improve decision-making with regard to the health of ecosystems and living marine resources. PacIOOS and SOEST are major partners in the Ocean Tracking Network, and PacIOOS has been a driver behind the U.S. development of a national capability through the Animal Telemetry Network. Within the region, PacIOOS maintains an array of fifty-four automated acoustic receivers that span the Hawaiian archipelago, from Midway Atoll to the Island of Hawai‘i. These receivers monitor the presence of fish tagged with acoustic transmitters that broadcast both a unique identification code and other information (depth, water properties). In addition, PacIOOS regularly tags large sharks in the Hawaiian Archipelago with satellite-tracked tags and publishes movement and identifying information to the public as an information and outreach tool.

Animal-borne sensors can effectively collect oceanographic data and, in some circumstances, may be able to provide wider, more detailed, and more cost-effective coverage than traditional oceanographic sensors for the generation of data necessary for ocean model assimilation (depth, temperature, salinity, oxygen). These environmental data are collected simultaneously with information concerning the habitat use and behavior of the tagged animals, making animal-borne sensors a truly innovative and cost-effective tool with the potential to disrupt the current paradigm of ocean data collection. With IOOS support, and in collaboration with industry partners, PacIOOS researchers have developed and tested the components necessary for a fully operational demonstration project using tagged sharks as the primary collector of oceanographic data for model assimilation. FY15 IOOS funding to PacIOOS has initiated this demonstration.

For this proposal, we plan to maintain our existing array of acoustic receivers, and we propose to increase our distribution of satellite- and land-tracked animals to relay oceanographic data in real-time and near real-time; building upon the investment IOOS has made in the proof-of-concept of this capability. Data will be acquired from tiger, six-gill, and hammerhead sharks via the Argos satellite system and through land-based relay receivers installed on several islands. Relevant data will be available via PacIOOS services and relayed to the GTS. Previous results indicate that areal coverage will range from very nearshore out to several hundred miles from the

Hawaiian coastlines. New types of tags will be tested as they become available from our industry partner (Wildlife Computers, Inc.).

In addition to relying on marine animals to generate oceanographic data, PacIOOS has invested substantial resources on the integration of biological data into existing PacIOOS data systems, both from animals we tag as well as biological data collected by others (NOAA, academia, National Park Service). Should funds be available, we propose to significantly increase the amount of biological data available through PacIOOS systems by building a close data exchange partnership with the NOAA Pacific Islands Fisheries Science Center (PIFSC). PIFSC has collected decades of data in the region (acoustic recordings, benthic surveys, fish population surveys, habitat mapping, bathymetric mapping, time series data), most of which is not publicly available. PIFSC and PacIOOS propose to build upon prior collaboration on data sharing and biological standards development to expose the full PIFSC data archive via PacIOOS services.

Modeling and Analysis

PacIOOS modeling efforts aim to provide near-term forecasts for response and planning. At present, three modeling systems (atmospheric, waves, and ocean circulation) produce a comprehensive high-resolution package for ocean-state prediction in the main Hawaiian Islands, the Mariana Islands, and the Samoa Archipelago. These model systems were developed to meet clearly-defined user needs as well as complement and support existing federal modeling systems and meet the strategic guidelines for model development and product capability detailed in the IOOS Modeling and Analysis Workshop Report, NOAA's Ecological Forecasting Roadmap: 2015-2019, and the NOAA Storm Surge Roadmap. Growth of PacIOOS modeling capacity is proposed to support both existing and proposed federal capacity, including the potential for future IOOS Coastal and Ocean Modeling Testbed work in the region.

The atmospheric Weather Research and Forecasting (WRF) model with assimilation generates daily nowcast and forecasts for each archipelagic domain, as well as higher resolution runs for each major island complex (O'ahu, Maui, Guam). These are provided directly to the local NWS forecast offices and are used by the wave and ocean circulation models for boundary conditions.

Using Wave Watch III and the Simulating Waves Nearshore (SWAN) models, daily nowcast and forecasts of wave conditions are produced for the entire Pacific Basin (100km resolution), each aforementioned archipelago (5km resolution), the Northwestern Hawaiian Islands (5km) and each major population center (0.5 to 1km resolution for O'ahu, Kauai, Maui, Hawai'i, Guam, and Tutuila). These forecasts feed into our high-resolution ocean circulation models and into tools estimating wave run-up and plume trajectory, equipping communities and responders with valuable information.

Estimates of general ocean circulation are produced using the Regional Ocean Modeling System (ROMS) in a nested configuration. Each day, nowcast and forecasts of the ocean-state are generated using advanced 4D-Var data assimilation to combine the observations and the models in a dynamically consistent way such that the result should be more accurate than either component alone. Output is provided at 3km resolution for the Samoa Archipelago, 2km for the Mariana Islands, 4km for the Hawaiian Islands, and 40m to 2km for the highly populated coastlines of O'ahu. The ocean circulation fields are used to generate a number of products for stakeholders including: circulation estimates and forecasts, particle (drifter, plume) trajectories (e.g., Ala Wai turbidity plume forecast), and probable paths of movement for search-and-rescue.

Each modeling group also produces regular climatologies of key marine and atmospheric parameters. At a minimum, we propose to maintain all existing capacity for ocean circulation

modeling and analysis. If sufficient funds are available, we propose to continue our operation of wind and wave modeling systems and enhance the capabilities of each modeling suite as follows:

Atmospheric: We propose to enhance the existing WRF domains by integrating advanced typhoon prediction capabilities into each major grid (Hawai‘i, American Samoa, Mariana Islands). We also plan to improve the integration of the approximation of surface heat flux between the WRF and ROMS models in the Hawai‘i domain as well as expand all domains.

Waves: We propose to enhance the spatial resolution of our Hawaiian Islands SWAN output to 50m, and expand our WWIII (5km) and SWAN (500m) capabilities to include the Republic of Palau, with the population center of Koror as the principle focus. Suitable bathymetry exists in Palau to constrain the model; however, such bathymetry data is not presently available for the Marshall Islands or other parts of Micronesia.

Ocean: We propose to enhance the spatial resolution of the ROMS domain for the Hawaiian Archipelago from 4km to 1km, develop a new model grid for Kāne‘ohe Bay (O‘ahu) with 50m horizontal resolution, to expand existing turbidity plume modeling to Maunalua Bay on O‘ahu, a Special Sanctuary Management Area (SSMA) in the proposed expansion of the Hawaiian Islands Humpback Whale National Marine Sanctuary, and to enhance the high resolution model grids in Waikīkī and Kāne‘ohe to include the integration of biochemical prediction, particularly nutrients and pathogens. This biochemical capability will support the circulation and ecological forecasting science requirements for the NERR in Kāne‘ohe Bay. This enhanced modeling capacity in the Hawaiian Islands is made possible due to the existence of sufficient observational data for model assimilation (HFR, gliders, buoys, WQ buoys and sensors, tide stations, Argo floats). Such data are not yet sufficiently available to enhance the spatial resolution of model grids in other population centers (Samoa, Mariana Islands).

The provision of data for assimilation to the ocean circulation model is an essential element of our modeling capacity. While existing moored and remote measurements of ocean circulation provide essential information assimilation, ocean gliders are currently the most efficient means of generating needed assimilative data. For this purpose, PacIOOS proposes the continuation of an annual 3-month SeaGlider mission within the O‘ahu ROMS grid through use of capacity within the SOEST SeaGlider Operations Group. If funds are available, we propose conducting four 3-month missions per year to increase our ability to constrain our circulation forecasts.

The UH Mānoa recently began operation of a Cray CS cluster supercomputer for research and operational computing. PacIOOS proposes a transition of operational modeling capabilities from existing hardware to the supercomputer, as existing hardware is retired, in order to increase output stability, expand compute capacity, and reduce costs to maintain dedicated clusters.

Data Management and Communications (DMAC)

The overall objective for the PacIOOS DMAC sub-system is to enable the public to discover, access, and understand ocean and coastal information collected by PacIOOS and regional partners. Data management activities are a central and critical component of PacIOOS. Our highest funding priority is the maintenance of core capacity within the data management system by maintaining current DMAC staff and infrastructure. Such capability is essential in any funding scenario. Additional support for server upgrade/ replacement and product development is a desirable enhancement to existing capacity.

DMAC provides the essential link between data (instruments) and information (data-synthesis products). **PacIOOS currently operates a fully functional Regional Data Assembly Center**

and is the first DAC within the IOOS system to have its data management plan certified in accordance with the IOOS Certification Final Rule (2014). PacIOOS provides consistent, clear, and reliable data access to consumers in dozens of countries, hundreds of organizations, and international partners, including serving real-time data to the WMO GTS. In order to operate the data assembly center efficiently and effectively, especially in times of emergency, the main PacIOOS servers for the regional DAC are located in the new UH Information Technology Center building, which is a disaster-hardened, 8,000-square-foot data center for enterprise servers, storage, and communications that provides 24/7 operations with independent power.

The PacIOOS data management sub-system provides the architecture through which data from the observing network are stored, evaluated, integrated, and transmitted to users as raw data and refined products, including PacIOOS web pages. The sub-system, in accordance with the NOAA Environmental Data Management Framework, Guidance for Implementation of the Integrated Ocean Observing System Data Management and Communications Subsystem, and the 2005 Data Management and Communications plan for Research and Operational IOOS, employs a service-oriented architecture (SOA), built on controlled ontologies, vocabularies and identifiers, that enables six essential functions: 1) data storage, 2) metadata management, 3) data discovery tools, 4) data transport servers, 5) on-line browse capabilities, and 6) data quality assurance/quality control (QA/QC). See PacIOOS Data Management System (DMS) Plan (2015) for details.

Data storage: Local storage for data streams is on a Redundant Array of Independent Disks (RAID) system, which is essentially a single unit with multiple hard drives with data stored redundantly across the disks, so in the event of a hardware failure on a single disk data are preserved on another. PacIOOS offers data in approved common data formats, including but not limited to, NetCDF, flat IEEE binary, ASCII, HDF, GRIB, and GIS formats. **Data collected and stored by PacIOOS are openly and publicly available.** The current PacIOOS data servers are owned and operated by University of Hawai‘i/SOEST. As PacIOOS grows, we request support to upgrade and replace the existing PacIOOS data servers and hardware. NOAA NCEI will continue to provide long-term archiving, as appropriate. Wave, glider, HFR, and buoy CO₂ data will continue to run through the national data assembly centers and be re-served through PacIOOS web services. **Metadata:** PacIOOS data sets conform to the Federal Geographic Data Committee (FGDC) and/or ISO. Additional IOOS standards will apply when they are fully developed. A PacIOOS web catalog service provides access to all metadata with query capabilities. **Data discovery tools:** Search utilities are employed via a web-browser to browse the data stores. A catalog web server provides search utility across PacIOOS data servers. **Data transport:** Direct, binary access is provided through standard open-source protocols. Our main service is OPeNDAP (Open-source Project for a Network Data Access Protocol), and the system is built around the Thematic Real-time Environmental Distributed Data Services (THREDDS) DODS Server (TDS). In accordance with IOOS requirements, PacIOOS has also employed Sensor Observation Services (SOS) for providing data from point measurements via the latest version of THREDDS ncSOS service. **Data display/browse:** PacIOOS maintains several web-based data browsing and display tools for gridded, point, and geospatial data, including a Live Access Server (LAS) for gridded data and DChart for gridded and point data. In addition, the Environmental Research Division's Data Access Program (ERDDAP) is used for a variety of services, including display and browse, and a Web Map Server (WMS) based on GeoServer, is used to serve geospatial data. **QA/QC:** PacIOOS participates in national QARTOD community efforts to establish standards for data quality and is actively working to implement adopted QARTOD standards as they are published. As detailed in the PacIOOS DMS Plan (Section VI, 2015), data served through PacIOOS undergo consistent QA/QC procedures by skilled PacIOOS researchers, the originating federal agency, or the non-federal data provider.

The sub-system architecture and functions described above are fully mature and have proven to be essential for serving PacIOOS data to stakeholders. This is also the core foundation by which PacIOOS examines, ingests, stores, and serves or re-serves partner data that is not PacIOOS-funded. PacIOOS currently serves regional partner data and data products (e.g., spatial data layers) from numerous partners, including the U.S. Geological Survey, NOAA NDBC, NOAA CO-OPS, NOAA PMEL, State of Hawai'i, CORAL-Reef Alliance, City and County of Honolulu, the Intergovernmental Oceanographic Commission (IOC), Cascadia Research Collective, The Nature Conservancy, and Pacific Disaster Center. We plan to continue increasing our partner data holdings by: 1) identifying relevant and quality-controlled partner data and data products through our continuous stakeholder engagement, and 2) making them easily-accessible on PacIOOS data servers and portals for our regional users.

In addition to fulfilling the core tenets of data management, we will continue to focus on product development. PacIOOS has a small team of product and user application specialists within the sub-system and proposes to hire an additional product specialist and a mobile developer to enhance our public delivery of data through mobile devices and in areas with limited bandwidth. These individuals will join our existing product development team to work with existing focus groups, partners, regional liaisons, PacIOOS researchers, stakeholder groups, and the education and outreach staff to develop, refine, and display user-defined public information products, such our main data portal—PacIOOS Voyager (<http://pacioos.org/voyager>).

PacIOOS will actively collaborate with the other IOOS regional associations along the Pacific Ocean coastlines during the project period to advance stakeholder access to cross-regional data services. PacIOOS and the other Pacific RAs propose to improve access to existing data services (products, map-based visualizations, information) through collaborative effort to establish common website linkages. Future effort will focus on the development of shared visualization services that focus on data and products common to all regions (i.e., glider data, model nowcasts and forecasts, key climate variables, and high frequency radar).

PacIOOS remains engaged with the U.S. IOOS Program Office, international, and regional partners on the advancement of data standards, the adoption of new data system technologies and procedures, the refinement and automation of QC procedures, and the development standards for the integration of federal and non-federal data into the IOOS data management system. These nationally- and internationally-engaged PacIOOS data standards efforts will continue, including through regular attendance at annual IOOS DMAC meetings, through the duration of the proposal period. PacIOOS will continue to participate as the national and regional capacities for data access, metadata, system reliability, and data format mature and evolve. PacIOOS also proposes to continue involvement in several international collaborative data management efforts including PI-GOOS, Argo, and Asia-Pacific Data Research Center (APDRC).

Education and Outreach

The objective of this sub-system is to strategically identify and address the needs of PacIOOS partners and stakeholders in order to expand the PacIOOS user base and facilitate informed decision-making, thereby advancing NOAA's mission to protect the Nation's natural resources. Throughout the project period, our education and outreach team (coordinator, regional liaison, and sub-regional liaisons) will continue to work with PacIOOS investigators, partners, and technical staff to interpret and effectively communicate complex scientific information to natural resource managers, researchers, educators, industry staff, and the public in a clear, accessible manner. They will focus on two main areas: 1) working with the data management team and stakeholder focus groups to maintain, update, and refine effective data products and web-based information; and 2) increasing impact through effective branding, development and distribution

of outreach materials (flyers, flat panel displays, press releases, articles, web features), generating a monthly newsletter detailing PacIOOS successes, and collaboration with existing ocean outreach efforts. Ongoing feedback received is also a critical component that enables PacIOOS to modify and fine-tune products in response to user input.

PacIOOS has many ongoing efforts to increase awareness of PacIOOS products and activities that will continue for this proposal. Public presentations and lectures showcasing PacIOOS-developed products are a consistent part of our outreach effort. We collaborate with local agencies and the NOAA regional team to leverage resources and maximize utility and messaging to users. PacIOOS collects testimonials and documents success stories for the IOOS Program Office, PacIOOS region elected officials, and partners to illustrate the benefits of regional contributions to the national network. Outreach efforts will continue to focus on user benefits.

For the past 8 years, representatives from all eleven RAs have participated in the IOOS Outreach Committee. This committee provides a forum for discussing effective strategies and techniques, sharing products, and coordinating efforts among the eleven RAs and the IOOS Program Office. By sharing knowledge and experiences, we significantly leverage resources, both financially and programmatically. The Outreach Committee will continue to hold monthly calls, develop effective communication strategies, and share successes and lessons learned. In addition, they will meet in person during Year 2 of the performance period for a strategic outreach workshop. PacIOOS staff will continue to participate in this collaborative effort.

As invested residents, we are dedicated to “K through Gray” public education so that present and successive generations make informed choices to enhance the use and preservation of our ocean resources. As educators, we are dedicated to the preparation of our primary and secondary students and education of undergraduate and graduate students. PacIOOS has collaborated with partners to generate curriculum through various school institutions. The outreach staff supported by this proposal will continue work with the IOOS Outreach Committee, the NOAA Pacific Regional Outreach Group (PROG), Waikīkī Aquarium, Maui Ocean Center, Hawai‘i NERRS, UH Maui College, and the UH Sea Grant College Program to leverage and augment existing ocean science modules that utilize observing data. PacIOOS provides a foundation for research and professional experiences for undergraduate students at the 10-campus UH system, University of Guam, College of Micronesia, College of the Marshall Islands, Palau Community College, and American Samoa Community College. Work proposed herein will continue to develop this research foundation and provide support for undergraduates as well as graduate students in the M.S. and Ph.D. degree programs at UOG and UH Mānoa.

Project Management and Governance

The objective of this sub-system is to ensure effective and strategic operations and successful implementation of the system. In order to ensure that direct project goals are achieved effectively, that appropriate partnerships for system growth are pursued, and that the system continues to generate public products that are valuable and relevant to the user community, a governance framework has been created for PacIOOS through the execution of a Memorandum of Agreement with partner agencies and organizations. The Governing Council of PacIOOS (Section 3c) provides strategic and policy guidance to PacIOOS leadership and helps manage the observing system through an Executive Committee that meets between full Council meetings. Members of the Council are elected by their peers to serve 3-year terms and select from their membership a Chairperson to serve as presiding officer. The current chairperson is Mr. Chris Ostrander, who is also the Principal Investigator for this and existing PacIOOS awards as well as the past founding Director of PacIOOS.

Council members and PacIOOS leadership work together closely to ensure meaningful engagement with stakeholders. Through this effort, PacIOOS maintains a diverse and engaged user base that contributes regular input on needs and priorities and provides critical assessment on the success of the regional system in satisfying user needs. The input received from the broader community shapes our priority setting and influences both the long-term design and the annual review of the PacIOOS Strategic Operational Plan (5-year horizon) and regional Build Out Plan (10-year horizon). Over the course of each five-year performance cycle, long-range strategic objectives are defined and refined to ensure maximum efficiency and value.

The PacIOOS Strategic Operational Plan (SOP) provides goals and objectives for the focus areas described above, with climate variability and change integrated through the marine operations, coastal hazards, water quality, and living marine resources sections. Meeting the goals and objectives of these key societal areas is a driving force behind the efforts of PacIOOS. In addition to annual performance review of progress towards SOP goals and objectives with the Council, PacIOOS has developed a detailed internal evaluation process for all products and services and a set of six high-level diagnostic performance measures. The Council-adopted performance measures allow PacIOOS leadership, the Governing Council, partners, and the IOOS Program Office to quickly assess the data system uptime/reliability, observing asset and model performance, growth of engaged users, and the overall impact of PacIOOS investments.

To ensure further engagement of the diverse stakeholders in the Insular Pacific, PacIOOS supports regional liaisons at partner institutions to assist with solicitation of local requirements, dissemination and evaluation of ocean information and products, and coordination of local stakeholder councils. As the local face of the PacIOOS program, the liaisons are an essential link between stakeholder requirements and the observations, data, products, and services proposed, produced, and delivered by PacIOOS. At a minimum, we request funds to sustain the existing and successful governance framework, including Council meetings, PacIOOS leadership (full-time Director), and liaison salary support. Ms. Melissa Iwamoto currently serves as PacIOOS Deputy Director and is scheduled to transition to the Director position by the fourth quarter of Year 5 of the existing PacIOOS award.

The synergy realized from effective collaboration with existing regional ocean partnerships is a critical focus of PacIOOS leadership. Ongoing participation in various local and regional efforts, such as NOAA's Pacific Islands Regional Team, Sentinel Sites, and Habitat Blueprint initiatives, Hawai'i's Ocean Resource Management Plan working group, Micronesia Challenge's regional support team, the Pacific Islands Regional Planning Body, Pacific Risk Management 'Ohana (PRiMO), and the Pacific Climate Information System enable PacIOOS to document stakeholder requirements, chronicle existing capacity, and ensure collaborative development of observing platforms and public information products. PacIOOS will also continue to collaborate within national and international efforts, including the IOOS Association, IOOS Federal Advisory Committee, Indo-Pacific Reference Panel for the Intergovernmental Oceanographic Commission (IOC), IOC Data Buoy Cooperation Panel for the Pacific Islands, IMOS, and PI-GOOS.

e. Milestone Schedule. See Appendix 4 for timeline of major tasks, product development, and key project outcomes.

f. Project Budget. See Appendix 5 (budget summary and detailed budget) and Appendix 6 (budget narrative) for project budget details.

g. References. See Appendix 11 for bibliographic information on references included in this proposal.

4. Appendices

Appendix 1. Figures

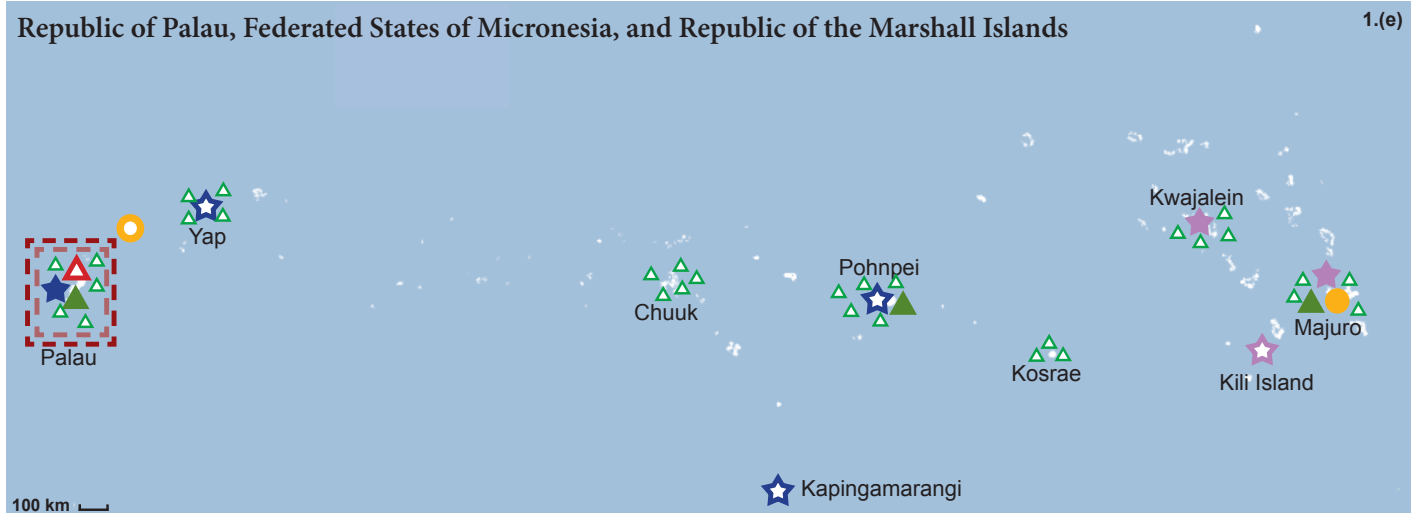
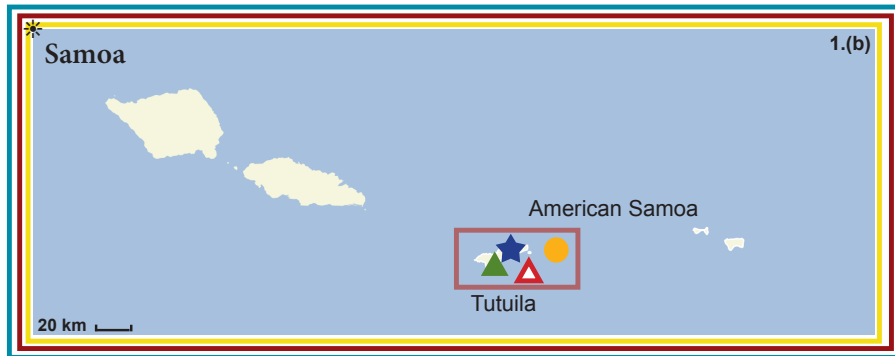
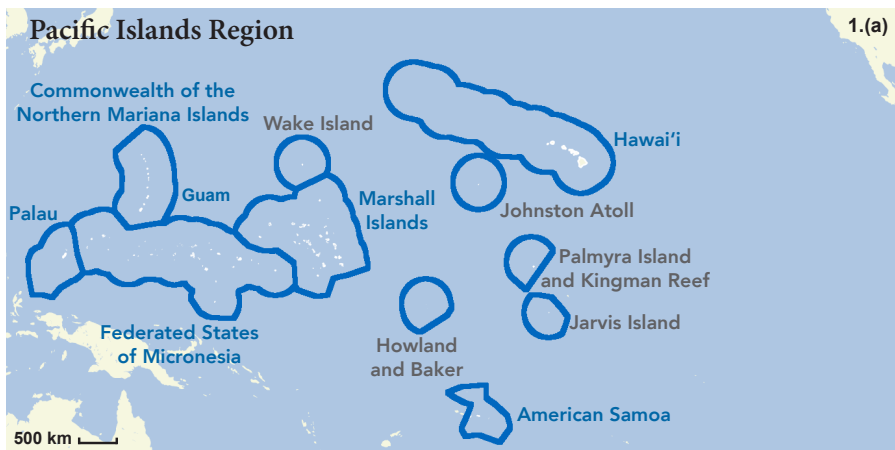
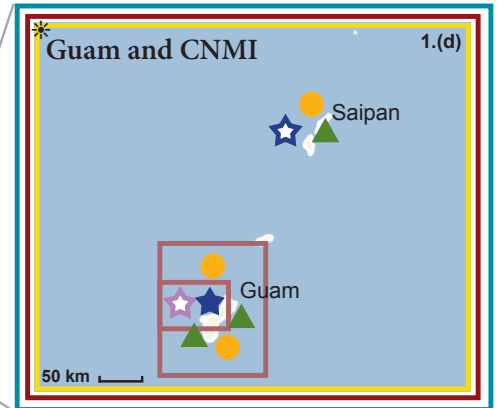
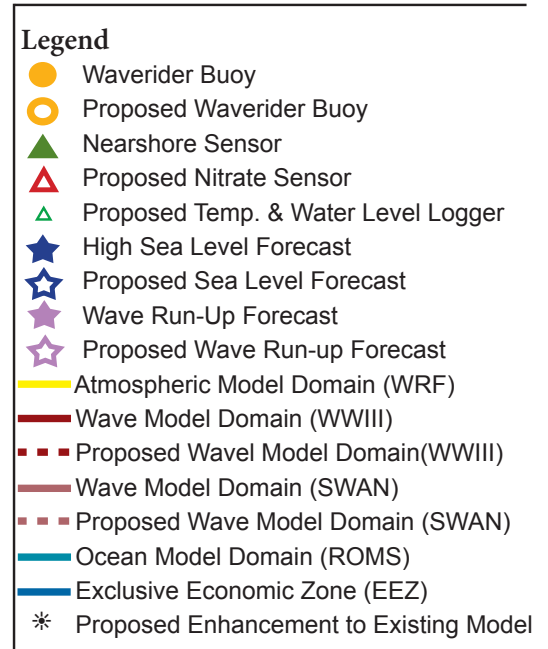
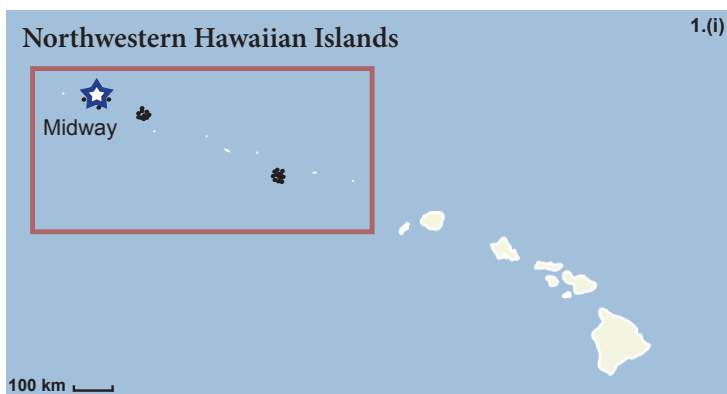
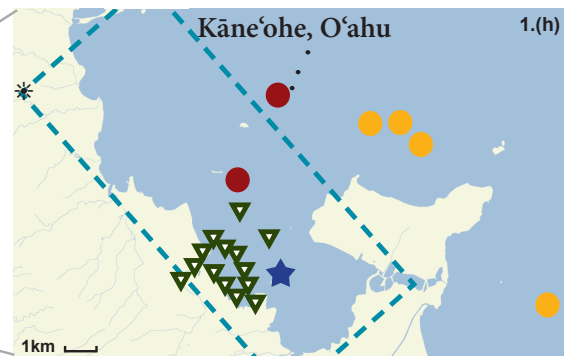
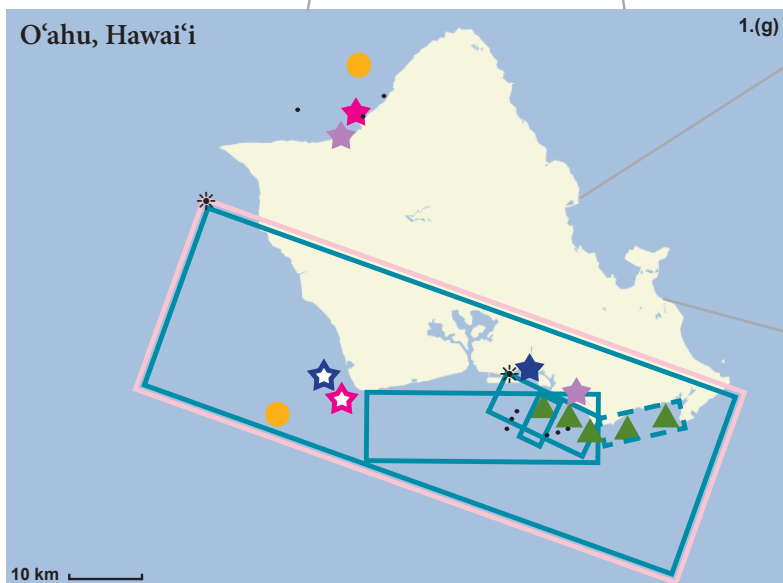
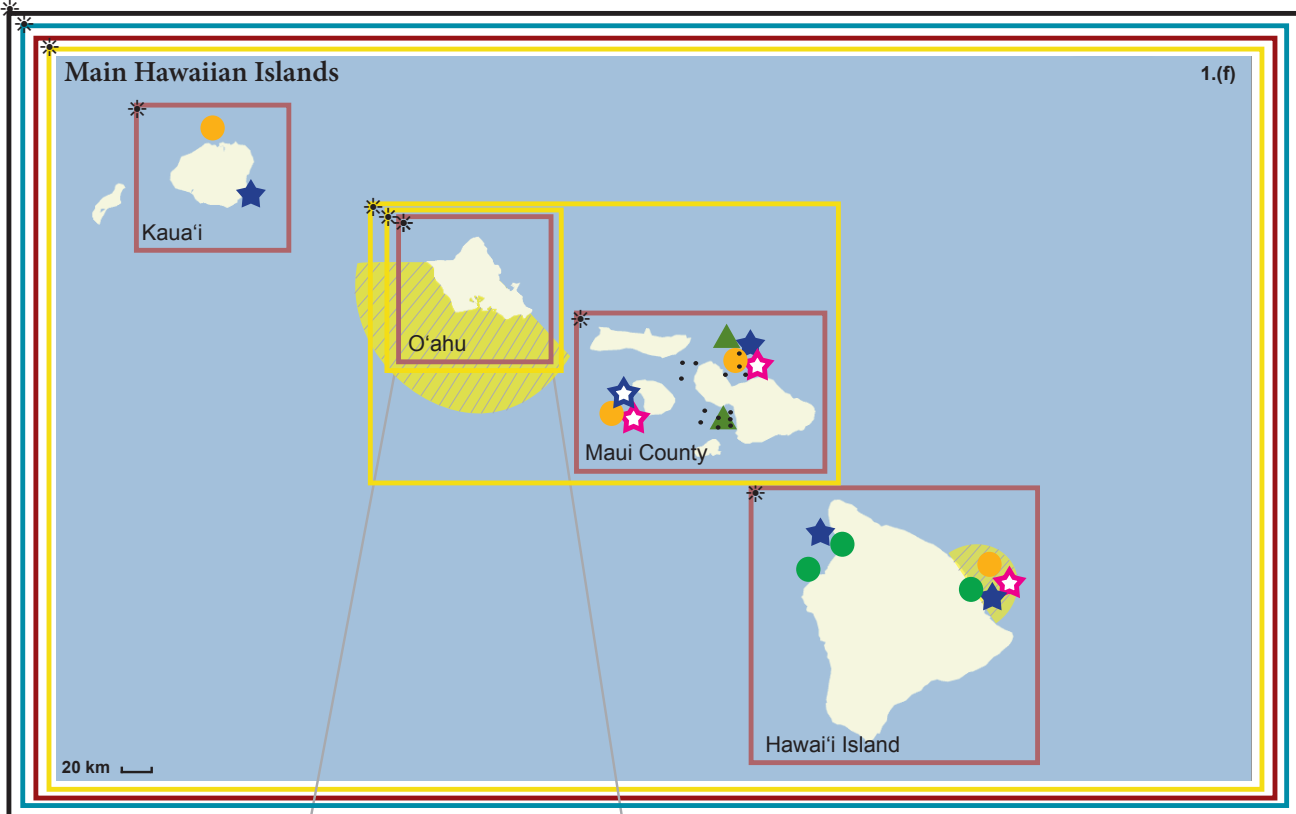


Figure 1. Observing system assets existing (by June 2016) and proposed locations in (a) PacIOOS region, (b) Samoa, (c) Western North Pacific, (d) Guam and CNMI, (e) Republic of Palau, Federated States of Micronesia, and Republic of the Marshall Islands, (f) main Hawaiian Islands, (g) O‘ahu, (h) Kāne‘ohe, O‘ahu, and (i) Northwestern Hawaiian Islands.





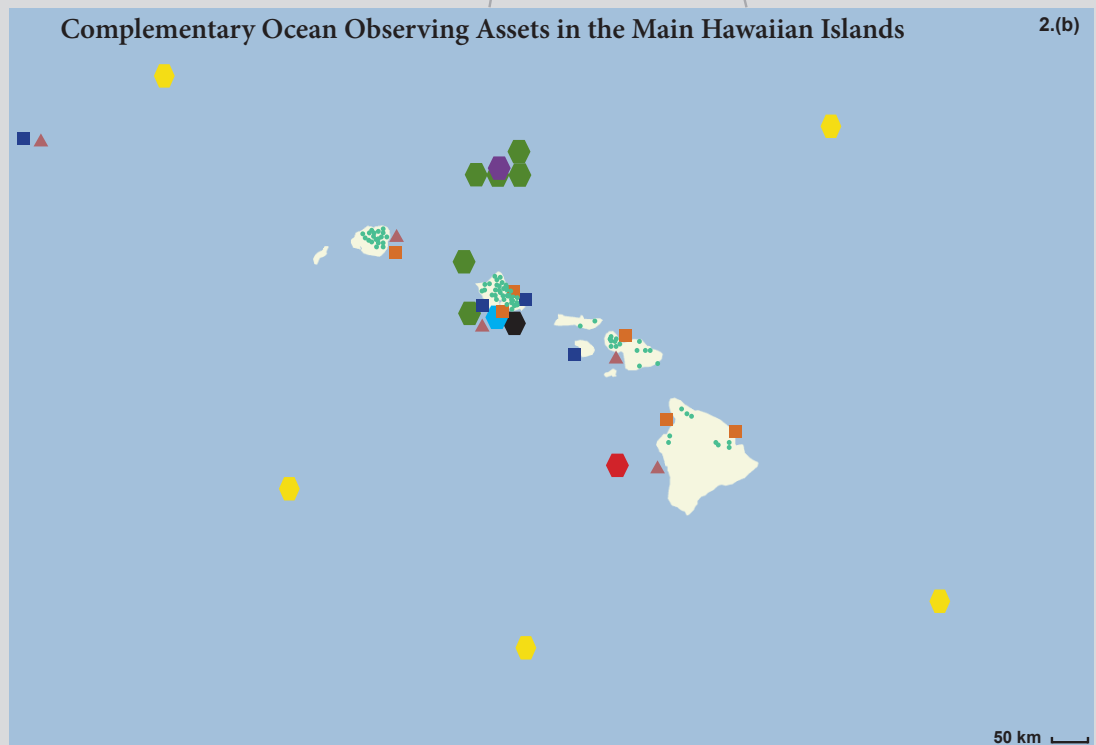
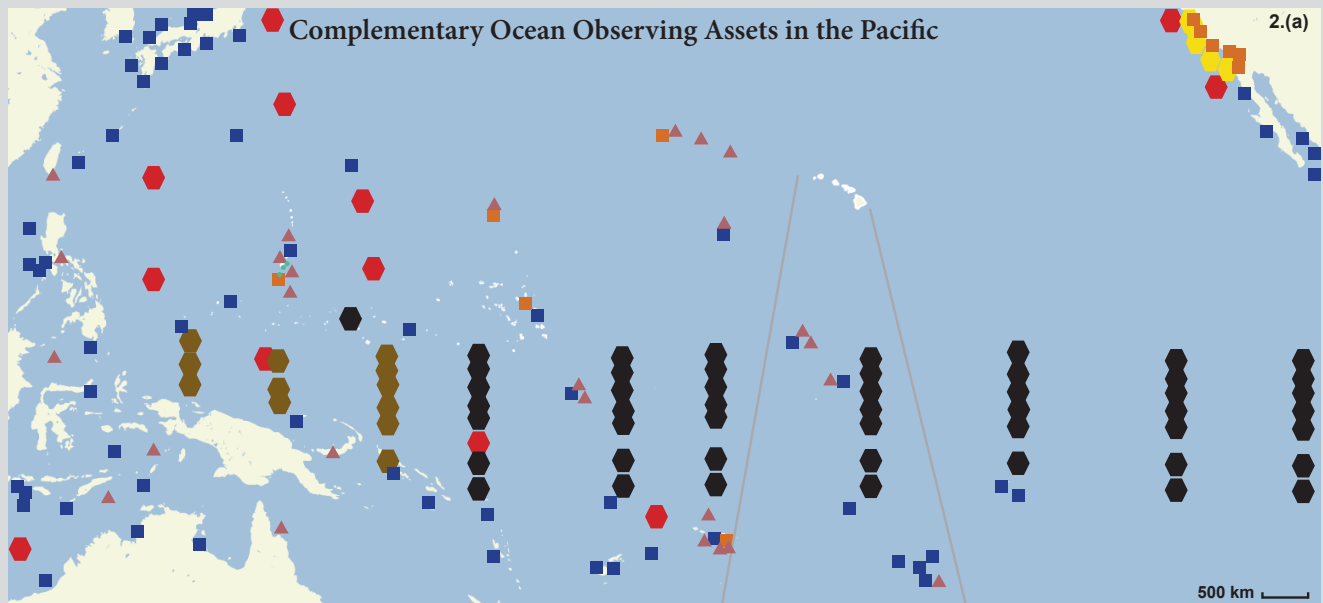
Legend

- Waverider Buoy
- Water Quality Buoy
- ▲ Nearshore Sensor
- ▼ Proposed Low-cost Nearshore Sensor
- CO2 Buoy
- ★ High Sea Level Forecast
- ★ Proposed Sea Level Forecast
- ★ Wave Run-Up Forecast
- ★ Harbor Surge
- ★ Proposed Harbor Surge
- Acoustic Receivers for Tagged Sharks
- Focus Area for Shark Tagging Efforts
- ▨ High Frequency Radar Field
- ▨ Atmospheric Model Domain (WRF)
- ▨ Wave Model Domain (WWIII)
- ▨ Wave Model Domain (SWAN)
- ▨ Ocean Model Domain (ROMS)
- ▨ Proposed Ocean Model Domain (ROMS)
- ▨ Ocean Glider Area of Operation
- * Proposed Enhancement to Existing Model

Figure 2. Complementary ocean observing system assets existing in (a) the Pacific and (b) the main Hawaiian Islands.

Legend

- Deep-ocean Assessment and Reporting of Tsunamis (DART)
- NDBC Buoys
- TAO Array & PMEL CO2 Buoys
- TRITON Array
- Kilo Nalu
- Aloha Cabled Observatory (ALOHA)
- Hawaii Ocean Time-series (HOT)
- IOC Water Level Stations (Various Partner Contributions)
- NOS CO-OPS Water Stations
- USGS Rain and Stream Gauges
- ▲ NOAA CRED Autonomous Reef Monitoring Structures



Appendix 11. References

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