

Performance Progress Report
Developing the Pacific Islands Ocean Observing System (PacIOOS)
Cooperative Agreement # NA16NOS0120024
Performance Period: June 1, 2017 through November 30, 2017

Submitted December 2017 by:
Melissa Iwamoto, Principal Investigator and Director
Pacific Islands Ocean Observing System
School of Ocean and Earth Science and Technology, University of Hawai‘i at Manoa

This report covers activities conducted during the first six 6-month performance period of this award. PacIOOS' estimated operating budget for the fiscal year is \$2,321,620.

1.0 Progress and Accomplishments

Waverider buoy operating in HI, Mariana Islands, American Samoa, and the Marshall Islands; Original completion date: Ongoing

***Status:** Ongoing. Keeping all the wave buoys managed by PacIOOS operational continued to be challenging this reporting period. Additional staff and supplies-on-hand have enabled the team to shorten turn-around times when certain buoys break free, but a lack of spares still comes into play. Majuro's mooring set an in situ record of 1.5 years (the old record was 1.4 years).*

The Kaumalapau (Lāna‘i) that was struck and dragged to Moloka‘i by a Young Brothers towline was sent back to the manufacturer (Datawell) for repairs during this reporting period. Another buoy was also ordered for the South Shore of O‘ahu. More about these locations is provided in the paragraphs that follow. Additional unplanned operations this reporting period included the wave buoy off Hilo Bay and a rescue of the Maui wave buoy (to be redeployed as soon as resources and weather permit).

Also during this reporting period, PacIOOS was accepted into the Young Brothers Community Support Program for another year. Through this program, Young Brothers will assist PacIOOS' wave buoy operations team by providing gratis shipment of equipment to neighbor islands.

Work with partners to choose new locations for Barbers Point and Lāna‘i wave buoys; Original completion date: August 2017

***Status:** Complete. The PacIOOS team worked with various stakeholders to identify new locations for the Barbers Point and the Kaumalapau wave buoys that would be less at risk for vessel strikes while still providing the information required by a wide variety of users. Stakeholders consulted during this process include the NOAA NWS Pacific Region Headquarters and Weather Forecasting Office Honolulu, NOAA NESDIS, UH researchers, PacIOOS researchers, UH wave modelers, USACE, CDIP, Young Brothers, Hawai‘i Long Line Association, Waialua Boat and Fishing Club, State of Hawai‘i Harbors Division within the Department of Transportation, Hawai‘i Ocean Safety Team members, Ko Olina harbor users (including commercial operators), port captains, and the USCG.*

Submit permit applications for new locations (S. Shore O‘ahu and Lāna‘i); Original completion date: November 2017

Status: Delayed/ In Progress. The USACE permit applications for both new buoy locations have been submitted. Unfortunately, the Nation-wide Permit for water quality has not yet been renewed this year with the State of Hawai‘i Department of Health. This will require additional permits (and associated fees). Once these permits are in hand, PacIOOS will submit a NEPA Environmental Compliance questionnaires to IOOS for each buoy.

Swap Mokapu wave buoy; Original completion date: August 2017

Status: Complete. Successful wave buoy swap accomplished in June 2017.

Swap Ipan wave buoy; Original completion date: November 2017

Status: Complete. Successful wave buoy swap accomplished in September 2017. Ipan’s mooring set a new in situ record of 3.5 years. The mooring was recovered during the wave buoy swap for precautionary reasons.

Deploy new wave buoy off Pearl Harbor; Original completion date: August 2017

Status: Complete. Deployed in June 2017. PacIOOS deployed a new wave buoy near the entrance to Pearl Harbor, O‘ahu, approximately 1.5 miles offshore. The buoy is the first within PacIOOS’ wave buoy network to measure surface currents in addition to wave height, direction, and period, and sea surface temperature. Wave information, along with currents data, will help to enhance marine safety, navigation, and harbor operations on O‘ahu’s South Shore, and allow for improved wave modeling and surf forecasting. The Hawai‘i Natural Energy Institute (HNEI) at the University of Hawai‘i provided the initial support to purchase this buoy with funding from the Office of Naval Research (ONR).

Re-deploy WETS and Kāne‘ohe Bay wave buoys; Original completion date: Nov. 2017

Status: Delayed. WETS wave buoy was re-deployed in October 2017, but Kāne‘ohe Bay wave buoy re-deployment is delayed due to ongoing issues with its mooring: the acoustic release has not been recovered due to entanglement. The team has conducted two unsuccessful efforts to date to retrieve the old mooring and acoustic release. Another retrieval effort will be conducted when conditions are favorable. Deployment is delayed due to the need for the acoustic release for this mooring as well as for avoidance of additional entanglement with the new mooring.

Real-time wave data and associated products online; Original completion date: Ongoing

Status: Ongoing. New pages for Pearl Harbor wave buoy included.

Nearshore sensors operating and data online; Original completion date: Ongoing

Status: Ongoing. PacIOOS currently has 5 near shore sensors operational in Hawai‘i (4 on O‘ahu and 1 on Maui), and 4 operational in the Insular Pacific (American Samoa, the Federated States of Micronesia, the Republic of the Marshall Islands, and Guam). Partners on the islands other than O‘ahu are key to keeping these sensors operational, and data flowing. A new undergraduate student has been hired to help PacIOOS staff maintain the sensors on O‘ahu. Staff attended a Sea-Bird Scientific training course in Seattle, WA to better understand our instruments and to be able to better serve others in our region.

The PacIOOS Water Quality Sensor Partnership Program (WQSPP) continues to be popular with partners and the PacIOOS Governing Council. The program currently has three sensors deployed. One is in Pohnpei (FSM) measuring water quality at a spawning aggregation site for 3 species of groupers. The second is in Palmyra Atoll to support a U.S. Fish and Wildlife coral rehabilitation study. The third sensor is deployed in Kewalo Basin, O‘ahu, HI to help The Friends of Kewalos, a local non-profit organization, to monitor water quality conditions before and during a construction project in Kewalo Basin Harbor. Because of the popularity of the WQSPP, it would be nice to have additional sensors to commit to this program; however, funds are not currently available for this.

Hilo Bay water quality buoy operational & data online; Original completion date: Ongoing
Status: *Ongoing. PacIOOS co-investigator Dr. Jason Adolf moved to the East Coast for a new faculty position. Dr. Steve Colbert took over supervision of the PacIOOS Hawai‘i Island water quality buoys in August. At that time, the Hilo Bay water quality buoy (WQB) was in need of maintenance and data telemetry upgrades. These were accomplished during this reporting period, and the Hilo WQB is again up and running. In addition, new students supervised by Dr. Colbert are now trained to assist with ongoing maintenance.*

Permit application for Pelekane water quality buoy; Original completion date: Nov. 2017
Status: *Delayed. We have obtained the nationwide permit for the buoy deployment from USACE, but the team is still working on the environmental review by the USCG. There are questions from the USCG about the visual impact of the buoy, which the team is working to address by meeting with community members. Once these issues are addressed, PacIOOS will submit a NEPA Environmental Compliance questionnaire to IOOS for permission to proceed. The new buoy will be highlighted at the upcoming West Hawai‘i Integrated Ecosystem Assessment (IEA) Symposium hosted by NOAA.*

Real-time and Logged water quality data and products online; Original completion date: Ongoing
Status: *Ongoing. Dynamic graphs and map viewers on the PacIOOS website provide a quick way to check the latest observations.*

Real-time surface currents available online for west and south shores of O‘ahu and Hilo Bay; Original completion date: Ongoing
Status: *Ongoing. PacIOOS HFR have had between 80-90% uptime during this reporting period. Focus has been on operations and maintenance of 7 HFR stations on O‘ahu and Hawai‘i Island. Change in ownership of the Kapolei refinery made access challenging, but it has been resolved by acquiring TWIC cards and new points of contact during this reporting period. Changes in management at three other places where we have long range WiFi communication relays have also resulted in intermittent data uploads. Cables at the Kalaeloa station were damaged by mongoose; the team has requested assistance from the SOEST Facilities to pull new cables, in the mean time the radar operates at reduced range. Kaka‘ako HFR is based within the State-managed park that was recently (October 2017) closed to the public and all power shut down in order to conduct major repairs to 30 light posts throughout the park that were damaged by the houseless community utilizing the grounds. This impacted the power to the HFR on the grounds*

as well. As a result, the Kaka'ako HFR will not be available until the power is restored to the park.

The wind and solar power at the Ka'ena HFR site sustained heavy damage during a storm in January 2017, following another storm in January 2016, which destroyed one of the two solar trackers. Three of the four windmills, and 4 of the 6 solar panels sustained major damage. The windmills were replaced, the rooftop static array of 6 panels was repaired in April, and the first solar tracker was rebuilt in May 2017, enabling again 2 acquisitions/hour at 50W/TX. The second solar tracker is being rebuilt in November 2017, with the assistance of the SOEST Facilities, to allow operating during the winter period, which has less solar radiation and lower winds.

Many of the outdoor equipment (cables, antennas) at the HFR sites are aging and will soon require repairs/recapitalization. The UH-designed radar electronics, however, has proven to be rock-solid, with not a single electronics failure since they were installed to replace the failing WERAs in 2012.

Ocean condition products online; Original completion date: Ongoing

Status: Ongoing. Dynamic graphs and map viewers on PacIOOS' new website provide a quick way to check PacIOOS' latest observations and forecasts.

High-water level forecasts upgraded based on feedback/new inputs; Original completion date: Ongoing

Status: Ongoing. Continuously refining forecasts with user feedback and collaborating with partners to obtain on-the-ground validation during predicted events. Extremely high water levels were experienced throughout the Pacific Islands through August 2017. Partners and users helped us learn more about the impacts of these events with photo documentation and reports.

Harbor surge forecast upgraded based on feedback/new inputs; Original completion date: Ongoing

Status: Ongoing. Work ongoing to refine harbor surge forecast and obtain non-IOOS funding to expand locations.

Wave run-up forecasts upgraded based on feedback/new input; Original completion date: Ongoing

Status: Ongoing. PacIOOS continues to refine forecasts with user feedback and collaborating with partners to obtain on-the-ground validation during predicted events. In addition, PacIOOS was awarded a NOAA OCM Coastal Resilience Grant to develop a high-resolution, real-time, numerical-model-based wave run-up forecast and notification system for West Maui. Included in this project is the preparation of future inundation scenarios, taking rising sea levels and increasing wave energy into consideration. The 3-year project started in October 2017. Project partners include the Department of Oceanography at the School of Ocean and Earth Science and Technology, University of Hawai'i Sea Grant College Program, County of Maui, and State of Hawai'i Department of Land and Natural Resources.

Coastal hazard data and products online; Original completion date: Ongoing

Status: Ongoing. In addition, PacIOOS produced two short video introductions that describe the elements of the PacIOOS high sea level forecasts and the PacIOOS wave run-up forecasts.

Research existing package options for a secure backend database of users; Original completion date: November 2017

Status: Complete. After conducting the necessary research, it was determined that it is favorable to create a back-end system in-house using Python and a library that staff is now learning. The bindings and security will be handled by an industry standard system that is off the shelf. The authentication will run through Facebook, Google, Twitter, or other platform already familiar to most of our users.

Continuously upgrade ROMS circulation model in operation for Hawai‘i, Mariana Islands, and Samoan Islands; Original completion date: Ongoing

Status: Ongoing. Extensive development of the operational software to update and improve reliability to deal with new and varying data sources (we collect data from dozens of sources each day for satellites, Argo, HF radar, etc.). These software updates have been rolled into the PacIOOS operational system. There are a few minor issues that still need to be addressed. In addition, the team developed an improved model for the Hawaiian region. They performed a 10+ year reanalysis using over 100M observations. These improvements and the reanalysis are making their way into the PacIOOS data stores and operational system. A manuscript is currently in draft form.

The team also developed and tested a pathogenic microbe model for Ala Wai. Working with other programs at UH, they deployed several sensors in the Ala Wai canal. These came out of the water in June, and in a pilot cooperation program with Iolani school, students are processing those data to compare with the model to perform validation. The PacIOOS team will conduct other validation tests as well. As part of these efforts, Dr. Grieg Steward, a UH researcher, collected water samples and is processing them via QPCR to identify pathogenic bacteria. The team will use these data as a baseline for model parameterization to capture how well we can simulate and predict blooms.

As part of the newly funded OTT project, the team will produce estimates of how the observations used operationally improve our forecasts for a number of metrics, including Search and Rescue.

Model data and products online; Original completion date: Ongoing

Status: Ongoing. All forecasts and data output are available via the PacIOOS website.

Ala Wai plume model online; Original completion date: Ongoing

Status: Ongoing. A revised version of the PacIOOS Turbidity Plume Forecast for the Ala Wai Canal, O‘ahu, is now live. The updated visualization features interactive controls to play, replay, and forward to different timeframes, and to loop the animation in different speeds. The Turbidity Plume Model simulates the possibility of a plume developing at the Ala Wai Canal for the upcoming two days, and also includes a hindcast for the previous three days. Turbidity (water clarity) is impacted by various factors, including rainfall, waves, wind, and tidal movement. Very

high turbidity levels are normally caused by large amounts of storm water runoff that can severely impact the nearshore water quality.

Transmitting tags deployed on pelagics (sharks); Original completion date: Ongoing

Status: Ongoing. During the reporting period, 10 scout tags transmitted oceanographic data through the PacIOOS system. These tags are capable of providing near real-time oceanographic profiles. Also during the reporting period, significant progress was made in installing information transfer infrastructure that now allows “machine to machine” relay of data to the ATN DAC and the PacIOOS web pages. New tracks from 6 of the tagged sharks are now available on the PacIOOS website.

Service land-based receivers for shark tags; Original completion date: Ongoing

Status: Ongoing. Currently 3 land-based receivers are deployed on O‘ahu, and 2 are deployed on Maui. With permission secured to deploy another one on Lāna‘i, plans are in place to deploy one more receiver, which will provide increased coverage of Penguin Banks.

A new research publication, entitled "Motes enhance data recovery from satellite-relayed biologgers and can facilitate collaborative research into marine habitat utilization," was published in July 2017 in the Animal Biotelemetry Journal. Researchers from Wildlife Computers, the Hawai‘i Institute of Marine Biology, and Marine Ecology and Telemetry Research studied the use of land-based receivers as a method to increase data throughput from tags attached to marine animals. The study evaluated signals detected by motes installed in the Hawaiian Islands and Southern California, and it concluded that land-based receivers significantly increase data throughput compared to utilizing only the limited Argos satellite array.

Plan and prepare for ATN workshop with IOOS Program Office and partners; Original completion date: February 2018

Status: In progress. Initial internal conversations have begun to determine optimal timing, location, and potential participants. PacIOOS is also reaching out to other RAs that have either conducted such workshops or are further along in the planning process.

Conduct 2017 Governing Council Elections; Original completion date: August 2017

Status: Complete. September 2017. See more details below in Section 3.0.

Convene Governing Council meeting; Original completion date: November 2017

Status: Complete. November 2017. Members of the PacIOOS Governing Council (GC) gathered for the annual meeting in Honolulu, HI. Following detailed program updates, discussions focused on approving the PacIOOS’ revised Strategic Framework, updating the PacIOOS performance measures, and expanding the network under level funding. GC members from across the region represent various sectors and provide valuable feedback to help guide the future direction of the program.

Ongoing outreach with stakeholders and partners to ensure meeting ocean data needs; Original completion date: Ongoing

Status: Ongoing. Communication with partners is ongoing via e-mail, phone calls, and meetings. Specific activities during this reporting period are listed below.

Communications

- *PacIOOS continues to publish and distribute monthly e-newsletters; more than 155 new contacts were added to the newsletter mailing list, the majority of which signed up through the subscription form on the PacIOOS website; a total of 1900 recipients receive monthly updates.*
- *Increased public awareness and interest in PacIOOS with targeted, engaging press releases to announce the deployment of the new wave buoy off Pearl Harbor, and the Coastal Resilience Grant to increase resiliency and preparedness in West Maui.*
- *Continue to produce updated and relevant flyers and materials for workshops, conferences, partner meetings, and general outreach, including rack cards and postcards.*
- *Increased number of web stories that are easy to share on social media, to provide PacIOOS updates, and announce new tools and data sets.*
- *During this reporting period, the PacIOOS website was visited by over 40K users and had more than 105K sessions.*

Social Media

- *PacIOOS continues its presence on social media, in particular on Facebook and Twitter, with a post frequency of 1-3 posts per week.*
- *PacIOOS' Facebook page has more than 1,340 likes; Twitter following increased by 15% from the last reporting period to 350 followers.*
- *Popular posts included the deployment of a nearshore sensor in Palmyra; new tiger shark tracks on the PacIOOS website; coastal resilience grant for West Maui; fun facts during shark week; and the deployment of the wave buoy off Pearl Harbor.*

Collaborative Efforts/Events

- *Visited ocean observing assets with PacIOOS partners, users, researchers and staff to celebrate PacIOOS' 10-year anniversary.*
- *Participated in outreach and educational events, including the Annual Kewalo Basin Park Clean-up, Marine Educators Night, and SOEST Open House.*
- *Presented at Coastal States Organization Meeting in Honolulu and at Hanauma Bay 'Theater Thursday'.*
- *Participated in Hawai'i Conservation Conference and Hawai'i Fishpond Practitioner Workshop.*
- *Continue to run PacIOOS kiosks at University of Guam, College of Marshall Islands, Windward Community College, Kailua Sailboards & Kayaks, Maui Ocean Center, Dolphin Quest (Kohala Coast, Big Island), Mokupāpapa Discovery Center (Hilo), and Kaua'i Community College.*
- *Continue collaboration with UH Maui College to use PacIOOS Voyager lesson plan as classroom activity for oceanography lab; focusing on data relevant to students and real-world decision-making.*
- *Water quality team continues to mentor undergraduate college students and high school students to support sensor program.*

Internal performance metrics report; Original completion date: August 2017

Status: *Complete. October 2017. Operational uptime was slightly below the 90% targeted metric due to various issues, including vessel strikes, lack of spare instruments, and challenges with maintenance in remote areas of our region. A new spare nearshore sensor is likely to increase uptime for future reporting periods. Operational uptime and spatial coverage of PacIOOS numerical models was well above the 90% target. The operational uptime of the PacIOOS website and data services was above the 99% target. When comparing data only with regard to the new website, website traffic also increased above the target rate. PacIOOS improved overall system effectiveness, annually, across all components, and exceeded the target to increase the number of ocean and coastal data sets available via PacIOOS. The Governing Council suggested PacIOOS re-examine the performance metrics in light of the new Strategic Framework.*

Additional activities not mentioned above that highlight regional observing system successes and occurred during this reporting period include the following:

- *Combined page views of the PacIOOS website and PacIOOS wave buoy pages from NDBC, and CDIP total over 1.04 million. PacIOOS wave buoys accounted for over 3.4 million data requests and over 2.3 million RSS requests through NDBC during this reporting period.*
- *Over 21,000 unique visitors (via direct external access to our servers) accessed more than 9.8 million pages in our servers and transferred over 1.3 TB of data.*
- *PacIOOS secured funding from multiple sources, including UH SOEST, HNEI, ONR, University of Guam EPSCoR, and other NOAA offices (OCM, NWS).*
- *New partner data set for Multi-scale Ultra-high Resolution (MUR) sea surface temperature (to replace GISST) was added to the PacIOOS Voyager.*
- *PacIOOS' Voyager now features a new tool that computes statistics for a user-selected area. The area statistics tool generates the mean, median, minimum, maximum, and standard deviation for a selected area in many of the gridded datasets, including forecasts, satellite data, bathymetry, and elevation. This added functionality is relevant for those examining larger areas (instead of points), and can provide information such as maximum wave height, average sea surface temperature, or minimum wind speed for the selected area. Users can view time series plots in Voyager's dialog boxes or download the data. Development of this new utility was funded by NOAA OceanWatch Central Pacific Node.*
- *Data from the Ocean Tipping Points (OTP) Hawai'i Case Study are now available for download on the PacIOOS website. OTP aims to support effective ecosystem-based management by providing resource managers and practitioners with tools to anticipate, avoid, and respond to coral reef change in Hawai'i and beyond. More than 40 data layers were developed, showing the influence of environmental factors and human-based activities on coral reef ecosystems across Hawai'i. Users can download data layers in various formats, find metadata, and explore all layers in an interactive map viewer. The project pages also offer information about the Hawai'i case study, its value, project findings, and partners involved in the study.*
- *Participated on the NOAA Pacific Island Regional Team (PIRT), NOAA Sentinel Site Program, NOAA Pacific Regional Outreach Group (PROG), one NOAA American Samoa, and State of Hawai'i Ocean Resources Management Plan (ORMP) Working Group.*

- *Continued collaboration with the Hawai‘i Office for Coastal and Conservation Lands and the UH Coastal Geology Group to address needs of what is now called the Hawai‘i Climate Commission.*
- *Partnering with NOAA Habitat Blueprint team for West Hawai‘i to wrap up project page to inform the public on the efforts in the priority area and to enable access to related data.*
- *Continued discussions with Pacific Islands Regional Planning Body (RPB) on potential partnership with PacIOOS providing the data management backbone for the RPB.*
- *PacIOOS participated in IOOS Association Directors meeting in Washington, D.C. (June 2017).*
- *PacIOOS participated in IOOS Fall Meeting in Seattle, WA (September 2017).*
- *Strategic Planning efforts are continuing to update the 5-year PacIOOS Strategic Framework and PacIOOS Operational Plan.*

2.0 Scope of Work

No changes to the project scope of work are anticipated.

3.0 Personnel and Organizational Structure

Ms. Melissa Iwamoto became Principal Investigator for PacIOOS on July 1, 2017. The former PI, Mr. Chris Ostrander, moved to a position outside the PacIOOS region in August 2017. In addition, Dr. Margaret McManus is now overseeing the PacIOOS wave buoy operations, and Dr. Steven Colbert is overseeing the PacIOOS water quality buoys on Hawai‘i Island.

PacIOOS held 2017 elections in July-September 2017 to fill 6 seats on the PacIOOS Governing Council. New PacIOOS Governing Council Members include representatives from The Nature Conservancy (Hawai‘i Program); State of Hawai‘i Office of Planning, Coastal Zone Management Program; and the U.S. Army Corps of Engineers. Re-elected members include representatives from Pacific Disaster Center; State of Hawai‘i Department of Transportation, Harbors Division; and Mālama Maunaloa. Dr. Brian Taylor, Dean of the School of Ocean and Earth Science and Technology at the University of Hawai‘i at Mānoa, is now chair of the PacIOOS Governing Council.

PacIOOS added two new MOA partners during this reporting period: The Nature Conservancy’s Hawai‘i Program and the State of Hawai‘i Department of Land and Natural Resources, Division of Aquatic Resources. The total number of MOA Signatories is now 56.

4.0 Budget Analysis

Spending for this award is on track with projected program expenditures. The University of Hawai‘i Office of Research Services submitted a semi-annual financial report for the period ending September 30, 2017, through Grants Online. That report showed total receipts of \$2,659,005.08.

As of December 4, 2017, internal budget tracking shows expenditures of \$3,180,230.88 representing a draw down of 62.5% of the Federal funding for this award.

**Performance Progress Report Addendum
(covering December 2016 – November 2017, unless otherwise stated)**

Education and Outreach Inventory

The Education and Outreach Inventory has been updated with PacIOOS activities. Please see the Google Doc for responses.

https://docs.google.com/a/noaa.gov/spreadsheets/d/1gjQiCa_cf1IGUNZPSoS4OG5CAKSXW_ejCFEVjLEOZHE/edit?usp=sharing

Data Management, Products, and Services

The PacIOOS data management group (DMG) ensures the data collected by PacIOOS are stored and accessible to users via standard services. Progress and challenges toward addressing each data management requirement are described below. See PacIOOS Data Management System (DMS) Plan (2016) for details.

1. Open Data Sharing

PacIOOS adheres to the NOAA Data Sharing Procedural Directive. All real-time and near real-time data managed by PacIOOS are freely available through open services, without delay or restriction. Avenues for accessing the data are available through the PacIOOS website: <http://www.pacioos.hawaii.edu/data-access/servers/>. Geospatial data are served via GeoServer and OpenLayers. PacIOOS does not restrict access to any data it collects or serves. Metadata are provided for all data, and data are machine-readable.

2. Data management planning and coordination

PacIOOS ensures local data storage and is working with NCEI for permanent archiving of data. PacIOOS routinely updates our data management plan, which was also part of our successful certification package. The PacIOOS DMG enables activities within PacIOOS modeling groups. PacIOOS continuously strives to make improvements to the system to ensure that regional DAC maintenance is stable, reliable, and efficient. Funding is always a challenge when planning for long-term operations and maintenance, including of a DMAC system. Additional funding sources outside of IOOS are continuously being pursued in order to ensure continuity and stability of the DAC.

PacIOOS supports data management coordination by participating in the operations, maintenance, and evolution of the national DMAC subsystem, including attending annual meetings and joining webinars and conference calls throughout the year. PacIOOS actively participates in cross-regional data management policy and implementation plan development, when invited to do so. PacIOOS is willing to participate in national data management committees and forums.

3. Provision of data to the Global Telecommunication System (GTS)

PacIOOS does not actively send data to the GTS. However, data that go through the functional DACs (e.g., data from the PacIOOS wave buoys) are sent by the DAC to the GTS when appropriate. WMO numbers will be sought for the remaining observing

platforms (near shore sensors (NSS) and water quality buoys (WQB)). A request has been made for our example WQB data set, and we are awaiting word from NOAA.

4. Data access services

All PacIOOS data are made available via data access services, and all are registered in the IOOS Catalog. 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. 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. 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.

5. Catalog registration

All PacIOOS data have complete and accurate metadata. These metadata are provided in a web accessible folder (WAF) that is read by various catalog services, including the IOOS catalog service.

6. Common data formats

PacIOOS offers data in IOOS-approved common data formats, including but not limited to, NetCDF, flat IEEE binary, ASCII, CSV, HDF, GRIB, and GIS formats. Our format is consistent with the NCEI netCDF templates.

7. Metadata standards

PacIOOS data sets conform to the Federal Geographic Data Committee (FGDC) and/or ISO 19115. A python-based PacIOOS web catalog service (pyCSW) provides access to all metadata with query capabilities. All our metadata are in a WAF and catalog service.

8. Storage and archiving

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. In addition, all PacIOOS data are replicated across mirrored RAID systems. PacIOOS is currently working with NCEI to ensure archiving of PacIOOS data. We have set up a process to provide data to NCEI via a WAF. ERDDAP is used to aggregate the daily files into archive files. An initial test has been successful, and we are now waiting for all metadata vocabularies (particularly for QC flags) and for WMO numbers (see 3 above) before proceeding with the other WQB and NSS data. Storage and archiving of data that go through a functional DAC from PacIOOS are handled by each respective functional DAC.

9. Ontologies, vocabularies, common identifiers

The PacIOOS DM sub-system 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). The vocabularies used for geophysical data adhere to the netCDF Climate and Forecast (CF) conventions. Biological data use the IOOS Biology Standard that is based on Darwin Core.

10. Consideration for Long-term Operations

PacIOOS aims to maintain and enhance a system that will persist long-term. Changes to the IOOS DMAC policies and procedures, such as QARTOD updates, will be incorporated as necessary. While PacIOOS has implemented, and will continue to implement automation in the system (through programming, etc.) as much as possible, there will also be a need for experienced, knowledgeable personnel. Federal requirements, software, stakeholder needs, etc. are always changing, and automation cannot always appropriately accommodate such evolutions. Funding, therefore, is always a key consideration when planning for short- or long-term activities. PacIOOS' strategic goals moving forward, therefore, include the need to diversify and expand funding and leveraged resources to create a resilient and robust financial foundation. Additional funding sources outside of IOOS are continuously being pursued in order to ensure continuity and stability of the DAC. This is an ongoing challenge.

Observing Assets

1. RA Observing Asset Inventory

Please see the attached Observing Asset Inventory spreadsheet for PacIOOS.

2. HFR Operations and Maintenance progress

Please see the attached spreadsheet for an annual update on HFR expenditures. Also, please see the attached annual update on HFR assets and staffing.

3. Annual Glider Days Inventory

Please see the attached Annual Glider Days Inventory spreadsheet.