

Performance Progress Report
Enhancing and Sustaining the Pacific Islands Ocean Observing System (PacIOOS)
Cooperative Agreement # NA16NOS0120024
Performance Period: December 1, 2016 through May 31, 2017

Submitted June 2017 by:
Chris Ostrander, School of Ocean and Earth Science and Technology,
University of Hawai'i at Manoa

This report covers activities conducted during the second six 6-month performance period of this award. PacIOOS' estimated operating budget for the performance year is \$2,757,500.

1.0 Progress and Accomplishments

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

***Status:** Ongoing. Keeping all 14 wave buoys managed by PacIOOS operational continued to be a challenge 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. We believe a large vessel struck Barber's Point buoy, and we are still attempting to recover it. Kaumalapau (Lāna'i) was caught by a Young Brothers towline and dragged to Moloka'i. This buoy has been recovered and will be repaired and redeployed. Additional unplanned operations this reporting period included redeploying Aunu'u (American Samoa), Kāne'ohē WETS, and Waimea wave buoys.*

Swap Waimea, Kāne'ohē Bay, and Kāne'ohē WETS wave buoys; Original completion date: February 2017

***Status:** Complete. Waimea redeploy – January 2017; Kāne'ohē Bay – March 2017; Kāne'ohē WETS – March 2017. Two of these had to be redeploys, and not swaps as planned.*

Swap Hilo and Ritidian wave buoys; Original completion date for buoy swaps: May 2017

***Status:** Partially Complete. Ritidian complete – April 2017; Hilo – delayed due to limited staff and partner resources. Expected swap date is now early June 2017.*

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

***Status:** Ongoing. New, dynamic plots for Combined Wave Observations and Forecast are now available on the PacIOOS website. Spectral wave information from NOAA's WaveWatch III global wave model output is used to display different predicted wave components of the mixed sea. The 7-day forecast data refreshes every 6 hours and wave observations are updated in 30 minute intervals. Users can zoom into the timespan of interest (e.g., 1, 3, or 7 days) and hover over the graph to obtain values for significant wave height, direction, and peak period of the different wave events.*

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

Status: Ongoing. PacIOOS currently has 6 near shore sensors operational in Hawai‘i (5 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. The PacIOOS Water Quality Sensor Partnership Program (WQSPP) continues to be popular with partners and the PacIOOS Governing Council. The program currently has one sensor still deployed in Pohnpei (FSM) measuring water quality at a spawning aggregation site for 3 species of groupers, and the other one went to Palmyra during this reporting period to support a U.S. Fish and Wildlife coral rehabilitation study. Because of the popularity of the WQSPP, it would be nice to have another sensor to commit to this program, however funds are not currently available for this.

Collection of validation samples at the MAPCO2 (Kāne‘ohe) buoy twice a month, conditions permitting, and conduct analysis of total alkalinity (TA) and dissolved inorganic carbon (DIC). Original completion date: Ongoing

Status: Ongoing. During this reporting period, De Carlo’s group published one peer-reviewed journal contribution, has three manuscripts under review and made three presentations at the recent (Feb 2017) biennial Aquatic Sciences Meeting in Honolulu, HI.

Kāne‘ohe water quality buoy operating and data online; Original completion date: Ongoing

Status: Ongoing. Data are available on the PMEL website, IPACOA data portal, and the PacIOOS Voyager.

Hilo Bay water quality buoy operational and data online; Original completion date: Ongoing

Status: Ongoing. Data from the Hilo Bay WQB were used in a publication (Alizadeh and Kavianpour. 2015. Development of wavelet-ANN models to predict water quality parameters in Hilo Bay, Pacific Ocean. Marine Pollution Bulletin 98:171-178), leading to a collaboration and potential future publications. Poster presentation including PacIOOS water quality buoy data at the Association for the Sciences of Limnology and Oceanography (ASLO) Aquatic Sciences Meeting.

Deploy Pelekane water quality buoy; Original completion date: February 2017

Status: Delayed. We have obtained the nationwide permit for the buoy deployment from USACE, and the team is now working on the community impacts questions by the USCG for the PATON application. There are questions from the USCG about the visual impact of the buoy. While we hoped to resolve these during this reporting period, the meeting with the community was delayed until June 2017. Expected deployment is now late 2017.

Water quality data and products online; Original completion date: Ongoing

Status: Ongoing. Dynamic graphs and map viewers on PacIOOS' website provide a quick way to check PacIOOS' 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 85-89% uptime during this reporting period. Focus has been on operations and maintenance of 7 HFR stations on O'ahu and Hawai'i Island. Additional antennae were deployed at the Kapolei site, bringing the site from 8 to 16 antennae, increasing the resolution from 7-8 degree to 3-4 degree. Access to this site has become difficult due to a change of ownership of the Kapolei refinery, and interrupted paths of administrative communication. Changes in management at three other places where we have long range WiFi communication relays has also resulted in intermittent data uploads. 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 and 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. Many of the outdoor equipment (cables, antennas) at the HFR sites are aging (Koko Head is 8 years old), and will soon need repairs. 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' website provide a quick way to check PacIOOS' latest observations and forecasts.

High-water level forecasts available online; 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. High water levels around Hawai'i were top news stories in the islands during the month of April and May 2017. The April level surpassed Hawai'i's 112-year-old record.

Harbor surge forecasts available online; Original completion date: Ongoing

Status: Ongoing. The scientific basis for the PacIOOS Harbor Surge Forecast in Hale'iwa Harbor was codified by Assaf Azouri upon the successful defense and submission in December 2016, of his dissertation (Azouri, 2016) for the degree of Doctor of Philosophy in Oceanography. This work, supported by PacIOOS funding, advanced our understanding of the importance of coastally-trapped infragravity modes in the variability of sea level and currents within harbors. The work produced the empirical information required to establish the Harbor Surge Forecast. In addition, Azouri's work revealed phenomena relevant to another PacIOOS product (Wave Run-up Forecast), such as the small scale of alongshore variability in the several processes that contribute to wave run-up and inundation along the wave-exposed coasts of Hawai'i. Azouri is currently preparing several manuscripts for publication on both his scientific and operational accomplishments.

Azouri, Assaf, 2016: Observations, Forecast, and Modeling of 0.5-200 Min Infragravity Oscillations in Haleiwa Harbor Region, Hawai'i. Ph.D. Dissertation, U. of Hawai'i at Manoa, December, 2016.

Wave run-up forecasts available online; Original completion date: Ongoing

***Status:** Ongoing. Submitted proposals outside of IOOS to expand locations of wave run-up forecasts within the region. Continuously refining forecasts with user feedback and collaborating with partners to obtain on-the-ground validation during predicted events. A combination of the highest astronomical tides of the year ("King Tides"), global sea level rise, delayed sea level effects from the 2014-2016 El Niño, Pacific-wide climate and sea level variability, and localized eddies have caused record-breaking sea level heights in Hawai'i. Flooding and wave inundation have occurred in many parts of the state at the end of April and May, in particular when large swell events coincide.*

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

***Status:** Ongoing. Significant activities intended to improve the accuracy, reliability and public comprehension of the Coastal Hazards group's products were completed, including the following:*

- Code for the generation of all of the Coastal Hazards products was migrated to the new PacIOOS server, which also provided the opportunity to overhaul many code components to improve reliability, access and archiving of the products;*
- Revised text and new video tutorials succinctly explaining the Wave Run-up Forecast and Six-Day High Sea Level Forecast forecast tools are now available on the PacIOOS website. These allow for improved comprehension of the products; and*
- Improvements to the product graphics and email-based alerts.*

Two efforts were initiated to further improve our understanding of the environmental conditions affecting our ability to accurately forecast short-term sea level variability, wave runup and/or harbor surges. The first is a drone-based effort to quantify short-term (hours to days) variability of beach faces. The changing beach profile affects the reach of the waves during high surf conditions. This effort also extends and complements existing long-term studies of at-risk shorelines by revealing the impacts of individual swell events on beach faces in relation to intermittent beach profile surveys intended to reveal long-term erosion or accretion.

The other new effort is the development of highly flexible and user-friendly tidal analysis software in the Python language. This project extends the ideas implemented in the Super-Tide technique built under PacIOOS for the sea level forecast products. The software is at the stage where it can do analyses using a broad set of linear tidal constituents, including creation of the equilibrium tide time series for the station. Current focus is on production of the user interface and spectral representation of the analyzed tide.

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 are currently being rolled out and tested within the PacIOOS operational system. 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 will come out of the water in June, and in a pilot cooperation program with Iolani school, students will process those data and compare with the model to perform validation. The PacIOOS team will do other validation tests as well. As part of these efforts, Dr. Grieg Steward, a UH researcher, is collecting water samples and 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.

The ROMS team also worked with partners at NOAA CRED to develop a model of a portion of the Northwestern Hawaiian Islands to examine the physical flow across coral reefs. This work has become a draft for publication.

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. Plume model relies on real-time water quality data, ROMS ocean model, and SWAN wave model. Visual impact is significant after severe rain events. Hawai'i Surf News Network and the Waikīkī Rough Water Swim both posted the plume forecast on their websites.

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

Status: Ongoing. During the reporting period, 8 additional Scout tags were deployed (7 on tiger sharks, 1 on hammerhead shark). These tags are capable of providing near real-time oceanographic profiles. As an example to illustrate this point, one of the tagged sharks (160379) has provided over 70 profiles over the 5-month period since it was tagged. Reception of these data is significantly enhanced by transmissions being detected and relayed via land-based receivers. 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. Near-real time availability of tracking data via the ATN DAC is projected to occur in the very near future.

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

***Status:** Ongoing. During the reporting period an additional unit was deployed above Makakilo, O‘ahu, which greatly increased the coverage area of the array. In addition, permission was secured to deploy another unit on private land on the island of Lāna‘i. This installation will occur in the near future.*

Integration of biological data into PacIOOS data management system; Original completion date: February 2017

***Status:** Delayed. Early this reporting period, PacIOOS successfully worked with partners to develop a joint job position funded by PacIOOS and JIMAR (for the Pacific Islands Fisheries Science Center) and advertised the position. We are still in the process of trying to fill the job opening. Estimated start date for this effort is now fall-winter 2017.*

Convene Governing Council Executive Committee meeting; Original completion date: April 2017

***Status:** Complete. April 2017. Members of the PacIOOS Governing Council (GC) Executive Committee met in Tumon Bay, Guam. Committee members, IOOS Director Carl Gouldman, and PacIOOS staff reviewed program updates and discussed the future outlook. The focus of the meeting was to further develop a new Strategic Plan for PacIOOS. Based on the strategic framework approved by the Governing Council in the fall, the Executive Committee addressed objectives and actions in more detail. Meeting attendees also participated in site visits at the National Weather Service Weather Forecast Office in Guam, University of Guam Marine Lab, and Masso and Pago Bay watersheds to better understand local needs and challenges.*

Outreach with stakeholders on Hawai‘i Island about location for former Kiholo water quality buoy; Original completion date: November 2016

***Status:** Delayed. Focus for the Hawai‘i Island water quality has been to get the Pelekane water quality buoy permitted and deployed. There is an anticipated change in staffing at UH Hilo, which is also delaying this effort until there is more certainty of options for a researcher to take on the former Kiholo water quality buoy. Estimated completion date is currently unknown.*

Internal PacIOOS Evaluation; Original completion date: February 2017

***Status:** Complete. The internal PacIOOS evaluation is used to provide an objective review of what is going well and what needs more attention within the program. The results were presented to the PacIOOS Governing Council Executive Committee in April 2017, and were one of the key drivers of the FY17 budget discussion with the committee.*

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 200 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 1,745 recipients receive monthly updates.*
- *Increased public awareness and interest in PacIOOS with targeted, engaging press releases to announce the redeployment of the PacIOOS wave buoy in American Samoa, and record-breaking sea levels in Hawai‘i.*
- *Article published in Master Mariners Magazine (December 2016) and in the Waikīkī Aquarium quarterly magazine, “Kilo I‘a” (March 2017).*
- *Publication of 10-Year Anniversary brochure to summarize PacIOOS’ development over the past decade.*
- *Continue to produce updated and relevant flyers and materials for workshops, conferences, partner meetings, and general outreach; transfer existing flyers to match new branding.*
- *Increased number of web stories to share PacIOOS updates; highlight new and existing tools as “featured item” on the website to draw users’ attention.*
- *During this reporting period, the PacIOOS website was visited by over 56K users and had more than 132K 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 1,290 likes; Twitter following increased by 20% from the last reporting period to 300 followers.*
- *Popular posts included the PacIOOS wave buoy redeployment off Waimea, announcement of the Friends of PacIOOS, PacIOOS data management job opportunity, release of new combined wave observation/forecast plots, redeployment of the PacIOOS wave buoy in American Samoa, record-breaking sea levels in Hawai‘i (April & May), release of new tiger shark tracks.*

Outreach and Education Efforts

- *Participated in outreach and educational events, including Mauka to Makai community event, Hawai‘i Ocean Sciences Bowl, and Career Day at Wilson Elementary.*
- *Continued 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.*
- *Continued 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 continued to mentor undergraduate college students and high school students to support the near shore sensor program. Activities this reporting period include providing a volunteer opportunity for a high school student from Mid-Pacific*

Institute; mentoring a minority, undergraduate engineering student (who helped to maintain the PacIOOS sensors); mentoring an undergraduate geology student from DePauw University during Winter Term; helping develop a 9th grade science course at Iolani School; and helping develop education units for high school science course for Kamehameha Schools.

- In order to increase student involvement in our PacIOOS Coastal Hazards activities, a short presentation of the beach survey project was produced for the Global Environmental Sciences senior student thesis seminar in the Dept. of Oceanography. One student in the process of drafting his thesis proposal showed great interest. He will focus on the image processing and Digital Elevation Model work, with a thesis goal of producing a time series of beach morphology using photogrammetry.*
- Finally, the Coastal Hazards team continues to provide guidance and assistance to stakeholders, the public and interested students. The team provided guidance to a graduate student in Australia working on projected future sea level rise involving the Micronesian Megapode that occur and nest in the Rock Islands, Palau. The team also provided links to data and assistance for a UH Hilo graduate student working on fishpond response to sea level rise.*

Stakeholder and Partner Engagement

- Met with stakeholders on Hawai‘i Island to identify possible synergies for collaboration, and to discuss placement of the former Kiholo water quality buoy. Partners provided input on who to meet with to further discuss the value of the buoy and potential issues.*
- Met with stakeholders on Guam, Saipan, and Palau to discuss ongoing projects and learn about issues and needs in this part of the PacIOOS region.*
- Presented to Engineers and Architects of Hawai‘i to introduce the PacIOOS program.*
- Participated in the He‘eia Science to Management Symposium to engage with community members, resources managers, and scientists. He‘eia is the newest of NOAA’s National Estuarine Research Reserves.*
- Participated in the Hawai‘i Sea Level Rise Vulnerability & Adaptation Workshop.*
- Attended Pacific Risk Management ‘Ohana (PRiMO) Conference to engage with partners from across the Pacific Islands region.*
- Partnering with Ocean Tipping Points Project to develop project page and to ingest all data sets to enable public access to data.*
- Continued collaboration with the Hawai‘i Office for Coastal and Conservation Lands and the UH Coastal Geology Group to address needs of the Hawai‘i Interagency Climate Adaptation Committee.*
- Continue to participate on the NOAA Pacific Island Regional Team (PIRT), NOAA Sentinel Site Program, NOAA Pacific Regional Outreach Group (PROG), NOAA Offshore Aquaculture Group, one NOAA American Samoa, NOAA Habitat Blueprint Program, and State of Hawai‘i Ocean Resources Management Plan (ORMP) Working Group.*

Participate in IOOS Federal Advisory Committee Meeting; Original completion date: April 2017

Status: Complete. April 2017. Chris Ostrander participated in the FAC meeting in Washington, D.C.

Maintenance of ship-based detection of tsunamis network; Original completion date: Ongoing

Status: Ongoing.

Network operations: Continued to maintain the network. Equipment was removed from Matson vessel, Manoa, due to dry dock scheduling. It will be replaced in July when the ship returns to active duty. The UH vessel, Kaimikai o Kanaloa, was added to the network, and there are plans to equip the NOAA vessel, Hiialakai, with equipment and add it to the network once it returns to dock in Honolulu in July.

Real-time display: Continued to improve the real-time data analysis and display package, and the beta version of this is complete. Archiving a low-pass filtered and 1-minute decimated version of the data streams has greatly increased the update and response speed of the interface.

Data Completeness Analysis: Preliminary analysis of the data streams indicates that the satellite communications link is an area that could be improved to increase the robustness of the system. "Shadow" areas where coverage is absent or weak reduce network completeness, and occasional "drop-outs" for some ships on some azimuths also introduce periods of lower quality data.

Real-time analysis and event detection: Successfully produced automated predictions of tsunami sea-surface displacements at ship locations for several large earthquakes during this period. Although none of these events produced significant tsunamis that could be detected in the open ocean, they allowed the team to refine its operational approach.

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 million. PacIOOS wave buoys accounted for over 3.2 million data requests and over 4.3 million RSS requests through NDBC during this reporting period.*
- *Over 3,000 unique visitors (via direct external access to our servers) accessed more than 990,000 pages in our servers and transferred over 245 GB of data.*
- *PacIOOS secured additional funding from multiple sources, including UH SOEST, HNEI, ONR, University of Guam EPSCoR, and other NOAA offices (OCM, OAP, NWS).*
- *PacIOOS now offers observation data from two weather stations. Air temperature, wind speed and direction, rainfall, and other variables are collected in real-time on Moku o Lo'e (Coconut Island) in Kāne'ohe Bay, O'ahu. The latest hourly readings and previous measurements are available in our dynamic graphs online. For the Republic of Palau, PacIOOS is serving a nine-year observation record from Rock Islands Southern Lagoon in Koror State. Located within the UNESCO World Heritage Site, measurements recorded by*

the automatic weather station include (amongst others) air temperature, wind speed and direction, rainfall, and humidity. All data can be viewed online or downloaded through our data services.

- *PacIOOS Voyager migrated to a new server behind the scenes.*
- *New partner data sets were added to the PacIOOS Voyager, including higher resolution NOAA Coral Reef Watch products and higher resolution NCEP GFS weather forecast.*
- *Continued discussions with Pacific Islands Regional Planning Body (RPB) on potential partnership with PacIOOS providing the data management backbone for the RPB.*
- *PacIOOS management and a PacIOOS co-investigator are participating on the IOOS HFR working group. Ongoing.*
- *PacIOOS participated in combined IOOS Spring and IOOS DMAC meeting in Washington, D.C. (March 2017).*
- *Continued participation in the IOOS Association.*
- *Strategic Planning efforts are continuing to update the 5-year PacIOOS Strategic Plan.*

2.0 Scope of Work

No changes to the project scope of work are anticipated.

3.0 Personnel and Organizational Structure

There were no changes to organizational structure during this reporting period.

- *Personnel Changes: Job opening for Marshall Islands Coastal Management Agent was posted, which includes duties of PacIOOS RMI liaison.*

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 March 31, 2017, through Grants Online. That report showed total receipts of \$1,662,624.10

As of May 31, 2017, internal budget tracking shows expenditures of \$2,085,890.60 representing a draw down of 75% of the Federal funding for this award.