

Convergence Accelerator Track E
Year 1 Review
Team Report
June 27, 2023

Phase II Award Number: 230479

Project Title: NSF Convergence Accelerator Track E: Backyard Buoys: Equipping Underserved Communities with Ocean Intelligence Platforms

Principal Investigator: Jan Newton

Lead Institution: University of Washington

Cohort Solicitation: NSF-20-565

Project Overview

Wave data can help save lives and protect livelihoods and resources. “Backyard Buoys” aims to get wave data into the hands of Indigenous communities in a way that increases the sense of ownership in ocean observations to serve the blue economy. We take advantage of existing, lower cost, user-friendly technology, provide co-designed applications for data input and dissemination, and enable sustained community-led stewardship of the wave buoys. Indigenous coastal communities, such as those from the Pacific Northwest (PNW), Alaska, and Pacific Islands, have depended on ocean resources over millennia and have stewarded their environment sustainably, but climate change is causing a more rapidly fluctuating and less predictable ocean. Access to ocean data is essential for these communities’ well-being, yet there is often insufficient financing and capacity available to purchase and sustain ocean observing technologies. The Backyard Buoys approach utilizes the power of local ownership and knowledge sharing to maintain ocean observations critical to the blue economy worldwide.

We bring together three groups: 1) a proven ocean float developer; 2) three U.S. Integrated Ocean Observing System (IOOS) Regional Associations (RAs), each with established, trusted relationships forged over decades with Indigenous and coastal communities and the demonstrated ability to provide tailored web applications that are intuitive and useful; and 3) Indigenous community partners to guide tool development and become lasting stewards of the technologies.

Project objectives will be achieved through co-design and co-development of Community Research Implementation and Stewardship Plans that ensure a successful launch and sustainability of the wave buoy systems. New online community engagement tools to allow others to replicate our process more easily will accelerate growth of the program. Additional innovations include: low-bandwidth data access tools to support decision-making and improve on-the-water safety; and integration of the Backyard Buoys wave data with regional data portals, providing community data in a broader context to support coastal resilience planning.

Intellectual Merit

The project serves two scientific aims. First, contribute to an increasing body of methodologies for co-design and democratization of ocean observing data, which can extend to other efforts worldwide. Integration of Indigenous Knowledge applied to address ocean sensing needs and data collection will enhance this knowledge base. We will publish an Ocean Best Practices document to describe the co-design and co-development process, including examples of community customizations. Second, create a new repository of hyper-local wave data that can be used by ocean modelers, coastal planners, and wave scientists for model optimization, adaptation planning, and large-scale scientific research to improve climatologies and predictions. Because of the affordability and small size, more floats can be deployed and sustained to provide critical wave information in high-use areas for communities. These data will be centrally archived providing data from previously unmonitored locations to U.S. national and global ocean observing efforts.

Broader Impacts

The project was co-designed with underserved communities to build capacity, complement and bridge Indigenous Knowledge, inform development of innovative technologies and techniques, and address goals of the UN Decade of Ocean Science for Sustainable Development to “promote a more targeted and effective information flow as well as innovative ways of conducting and using ocean science.” Proposed activities directly involve Indigenous communities throughout the project to broaden the ownership, capacity, and participation of Indigenous community members in the research planning, data collection, dissemination, and use of ocean observing data. Targeted in-person training will focus on key elements of capacity building requested by the partner communities. Regional education experts will develop educational materials for students utilizing their local Backyard Buoys wave buoy data. Involving students in the program builds community resilience by encouraging pursuit of STEM careers and becoming the next generation of stewards of the buoys.

Team

We have a geographically, academically, institutionally, and culturally diverse group of partners collaborating on all aspects of the Backyard Buoys program. The partnership will benefit the individual Indigenous communities that choose to deploy and steward the buoys, as well as the scientific modeling community and the RA stakeholders. Additional partnerships will continue to be added during Phase II implementation. As of the date of this report, we have six Indigenous partners that are funded, and six additional partners that are involved in all aspects of the project.

The core team is comprised of the Executive Directors from each of the IOOS RAs, all with extensive experience in leveraging partnerships for successful implementation of programs across their regions. Dr. Jan Newton (PI) has been the Director of the Northwest Association of Networked Ocean Observing Systems (NANOOS) since 2004, with a long history of tribal collaborations. Sheyna Wisdom (co-PI) has been the Director of the Alaska Ocean Observing System (AOOS) since 2021 and brings 20 years of environmental consulting experience, 15 of those in Alaska managing large-scale marine programs and working with Alaska Native partners. Melissa Iwamoto (co-PI) has been Director of the Pacific Islands Ocean Observing System (PacIOOS) since 2016 and has been collaborating with Pacific Island communities for over 20 years. Sebastien Boulay (co-PI) is the Director of South Seas Consulting Ltd, was Director of Business Development at Sofar Ocean and has been working on deploying marine technology with coastal communities for many years. The PI/co-PI team is augmented by the expertise of the other core team members. Dr. Roxanne Carini is the Deputy Director of NANOOS since 2022 and Senior Oceanographer at the Applied Physics Laboratory at the University of Washington. Dr. Jordan Watson is the Deputy Director of PacIOOS since 2022 with 25 years of marine science research expertise, 15 of which were focused on ecosystem modeling and environmental data assimilation. Duncan Mactavish is the project coordinator at Sofar Ocean. Duncan has been with the Sofar Ocean for two years and has a background in environmental engineering and coastal oceanography.

As the technology partner, **Sofar Ocean** provides the Spotter wave buoys and their underwater sensor platforms Smart Moorings, along with technical expertise during the various phases of the consultation and development of the community Research Implementation and Stewardship Plan (CRISP).

NANOOS Partners: In the PNW, the NANOOS team is partnered with two federally recognized coastal treaty tribes, **the Quileute Tribe** and the **Quinault Indian Nation**. Both tribes are long-time NANOOS Governing Council members. The **University of Washington** (UW) is developing the applications (apps) to make the Backyard Buoys wave data widely available to a broad range of users with varying degrees of technology and network capabilities

and will also support real time data ingestion and public access to wave data from deployed wave buoys through the NANOOS data portal known as the NANOOS Visualization System (NVS). **Western Washington University (WWU)** is developing undergraduate level PNW-specific educational modules using the wave buoy data over the project period.

AOOS Partners: The **Alaska Eskimo Whaling Commission (AEWC)** is the Alaska regional Indigenous partner with 11 whaling villages across the Arctic coast. The **Alaska Native Science and Engineering Program (ANSEP)** is the educational partner to provide opportunities to Alaska Native students (middle school to college level) across Alaska. The **University of Alaska Fairbanks (UAF)** is providing technical support, engagement, and outreach regarding the operation, deployment, and retrieval of Spotter wave buoys. **Axiom Data Science (Axiom)** serves as the data management team for AOOS and will support real time data ingestion and public access to wave data from deployed wave buoys through the AOOS Data Portal as part of this project. **Weston Solutions** was contracted as a project management firm with two highly qualified project managers (PM; Meghan Larson and Stacey Aughe), an environmental consulting firm in Anchorage, AK with extensive experience in managing complex programs, including working with Indigenous partners.

PacIOOS Partners: In the Pacific Islands, eight partners are collaborating with PacIOOS. The **Marshall Islands Conservation Society (MICS)** team is composed of local Marshallees and is a non-governmental, community-based organization dedicated to building awareness, support, and capacity for sustainable use of resources, conservation, and protection of biodiversity through the Reimaanlok process and Micronesia Challenge commitment. The **Ajeltake Community Development Association, Inc. (ACDA)** is a key partner of MICS and is the community that will be implementing the first CRISP in the Republic of Marshall Islands (RMI). As Backyard Buoys expanded to include historical and/or traditional weather patterns and impacts, MICS determined it was necessary to include **RMI Historic Preservation Office (HPO)**, as an expert on the subject matter in the RMI to guide them through the process. The **Marshall Islands Marine Resources Authority (MIMRA)** is involved in the project through participation and input in the local technical and governmental aspects for each community in the RMI. The **National Park Service of American Samoa (NPSA)** is the only U.S. National Park south of the equator and will continue to target Samoan communities and ocean users on the Manu'a Islands in American Samoa. The **Micronesian Conservation Trust (MCT)** is a key facilitating private corporation in the Federated States of Micronesia (FSM), RMI, Palau, Commonwealth of the Northern Mariana Islands (CNMI), and Guam. MCT will continue to engage with key ocean users and communities on Pohnpei, translating tools into Pohnpeian, to garner user input and help make connections with our other project partner in Pohnpei, the **Conservation Society of Pohnpei (CSP)**, a local non-governmental organization. To ensure that the ocean will feed Hawai'i's people for generations to come, **Conservation International Hawai'i (CI Hawai'i)** merges Indigenous Knowledge with Western science, conservation tools and strategies for changing how people and businesses value local, sustainable seafood.

Project Accomplishments Year 1

For Phase I, we established three teams that met regularly: 1) PI Management Team, 2) Core Team, and 3) Regional Teams. This process of regular meetings, synchronous work during the meetings, and asynchronous work using shared documents and meeting notes with assignments allowed the team spread across multiple time zones to meet all NSF deliverables, develop the community questionnaire, develop the low-fidelity prototypes, continue to cultivate the relationships with the Indigenous partners, and identify the new partners for Phase II.

For Phase II, we have implemented a similar, effective strategy. We established seven teams with regularly scheduled standing meetings, standardized meeting notes, a shared Google folder, and a project tracking tool managed by Weston Solutions.

- **NSF Curricula:** Three members of the program participated in the Stanford curriculum: Roxanne Carini of NANOOS, Sheyna Wisdom of AOOS, and Jordan Watson of PacLOOS. These members were responsible for all the required deliverables, including classroom participation and the presentations.
- **Core Team:** This core team (identified previously) meets weekly to work on milestones and deliverables, strategize on the project, and maintain collaboration. Since Nov 1, 2022, the core team has met 27 times.
- **Buoy Working Group:** This team meets monthly and includes project members working directly with the wave buoys and mooring. Since Dec 1, 2022, the team has met six times. All regions are close to initial deployment and have shared information on mooring design and lessons learned.
- **Permitting Working Group:** This sub-team of the Buoy Working Group was established so that permit applications were consistent across all three regions and for individual partners to have support from Weston Solutions, the project management firm who specializes in permitting. This team has met three times, but there have been numerous individual meetings on an as-needed basis.
- **Data Tools Working Group:** This team meets monthly and includes project members that are developing the web-based tools and ensuring that user feedback is incorporated. Since Dec 1, 2022, the team has met six times.
- **Education Working Group:** This team meets monthly and includes project members that are developing the education components. They have met seven times since Dec 1, 2022 and include WWU, ANSEP, CI Hawai'i, and other project members from each region.
- **Co-Design Working Group:** This team met monthly for four months to get to know each other but has postponed future meetings until after a few months of buoy operations. It is important to note that the Indigenous partners participate in all the other working groups.
- **All-Hands Meetings:** In addition to these smaller Working Groups, we hold quarterly all-hands meetings. We have held two meetings since Dec 1, 2022.

Our success relies on the diversity of the teams working simultaneously on the different aspects of this project. As highlighted previously, we have established teams who meet virtually and work asynchronously to meet the ambitious milestone schedule shown in Figure 1. This strategy has proven to be extremely effective as demonstrated in the summary of progress made in each of these teams.

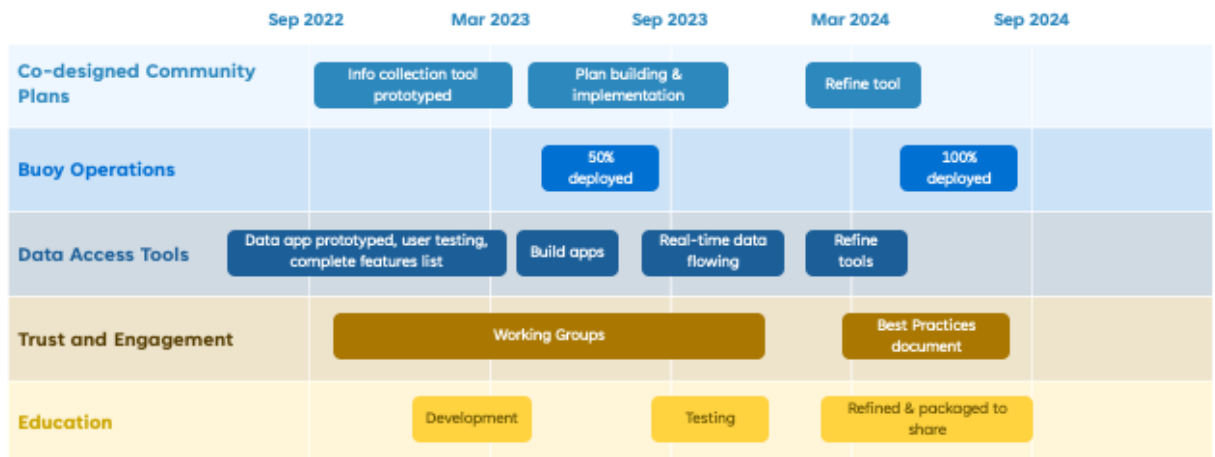


Figure 1. Backyard Buoy Milestones

I. Co-Designed Community Plans

CRISP Building Tool: The PacIOOS team has led the effort to put together the CRISP building tool (<https://www.surveymonkey.com/r/RM7R3G9>). This tool was designed by the core team and refined with input from our partners. The purpose of the tool is to obtain information for each community deploying buoys. The output will be a CRISP that can be used by anyone interested in participating in the project. We are currently working with our partners on their use of this tool.

Resources for Stewardship Plans: We have created and posted resources on the Backyard Buoys website that can be used for answering the CRISP tool questions (<http://www.pacioos.hawaii.edu/projects/backyard-buoys/#stewardship>). Resources currently on the site include: Backyard Buoys Permitting Plan, Spotter Mooring Guidelines, Spotter Product Documentation, Example Pre-Deployment Checklist and Schedule, Example Deployment Log, and Example Data Sharing Agreement Template. More resources will be added as lessons are learned for the first deployments.

Community questionnaire for Guam: While working with partners from Guam, the PacIOOS team developed a smaller version ([Guam tool](#)) to assist with preliminary local scoping. Seventeen applicants expressed that their top interest in a buoy was to improve safety, followed by supporting research, particularly around wave run-up and wave impacts. Respondents thought that local government and community organizations would be best situated to steward / maintain the buoys, especially given government resources for sustained support. All respondents expressed a desire for publicly available data through a web / smartphone app.

II. Buoy Operations

The buoy team has worked with each of the regional Indigenous partners to prepare for buoy deployment. This has included work for the permitting as well as the mooring design and deployment locations for the specific region.

Permitting: Weston Solutions and AOOS created a [Permitting Plan](#) for the overall project that identifies the Federal, state, and local permits required for each region. This plan is still not yet finalized, as we are still working with each of the coordinating entities. An update to the permitting was provided to NSF (Aurali Dade) on June 23 [Backyard Buoy Permit Update_062323.pdf](#).

The team worked to identify the primary Federal permit that could be used across all regions to fulfill National Environmental Policy Act (NEPA). Weston Solutions worked directly with the U.S. Army Corps of Engineers (USACE) and determined that buoy placement in waters of the U.S. would require a Section 10 or Section 404 permit. Through consultation with the USACE, they determined that buoy placement could be authorized under the 2021 [Nationwide 5 Permit - Scientific Instruments](#) (NWP5).

The USACE participated in Section 7 consultations during the process of issuing the 2021 NWP5; however, the agency requires submission of a Preconstruction Notification (PCN) in areas where Endangered Species Act (ESA)-listed species or designated critical habitat occur) on a case-by-case basis to assess the potential for effects on ESA protected resources. A PCN has been filed for each of the regions; we have not yet received authorization but are anticipating by early July.

Each region also must obtain authorization for State and local authorities as summarized below in Table 1 and the [Permitting Plan](#). We have provided maps from each of the regions of the proposed 2023 deployment locations (Figures 2-4).

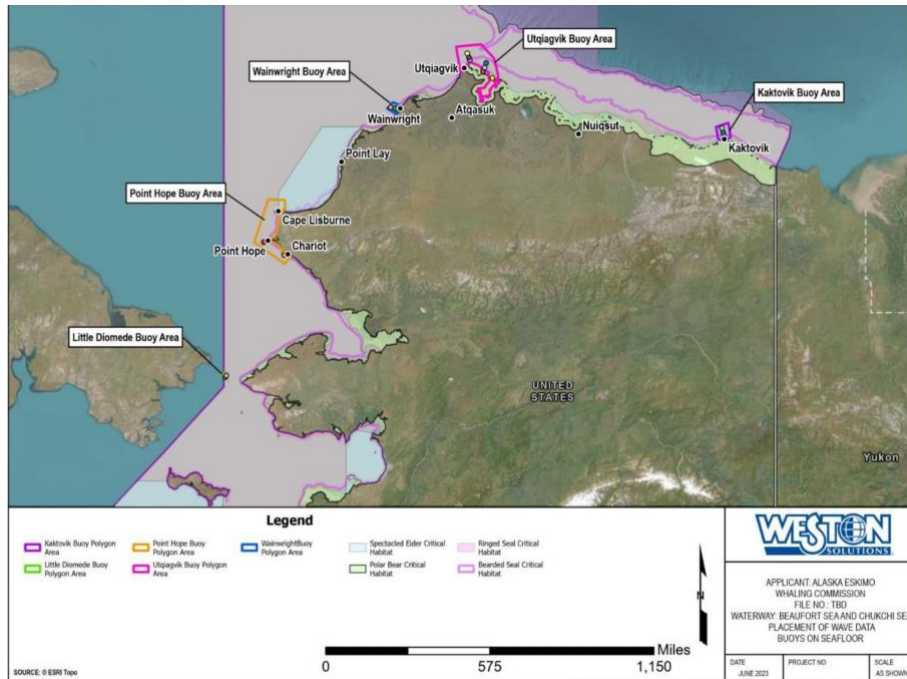


Figure 2. Map showing the five buoy regions including 18 buoys across the Arctic Alaskan coast for the Alaska Eskimo Whaling Commission.

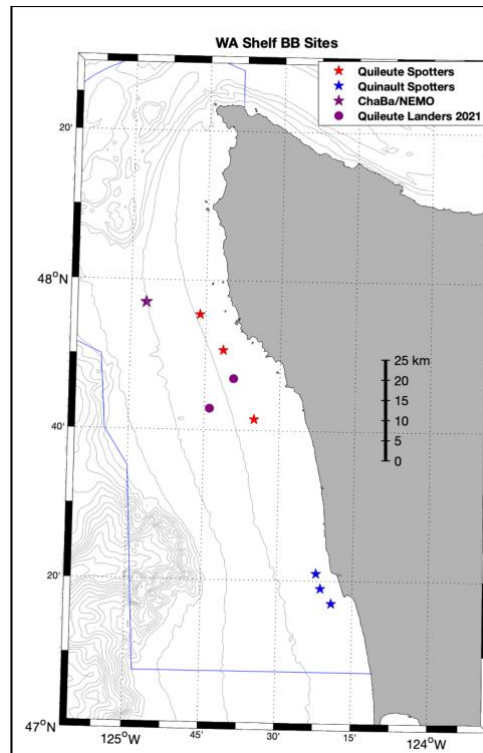


Figure 3. Map showing six buoy locations for the Quileute and Quinault partners off La Push, Washington.



Figure 4. Four general locations for which deployment preparations have begun in the Pacific region. Specific site locations and maps for each region are included in permitting documents.

First Test Deployment: Our first buoy was deployed by the Quileute Tribe on May 3, 2023 (Figure 5). This buoy will be out for a short deployment to test mooring design and data collection modes in the spring wave conditions off La Push, WA. Quileute Tribe fishers leaving La Push harbor must navigate wave conditions at the Quillayute River mouth and do not have a clear view of the wave conditions past James Island. Local implementation of the Backyard Buoys program will provide them with real-time wave data to support critical go/no-go decisions.

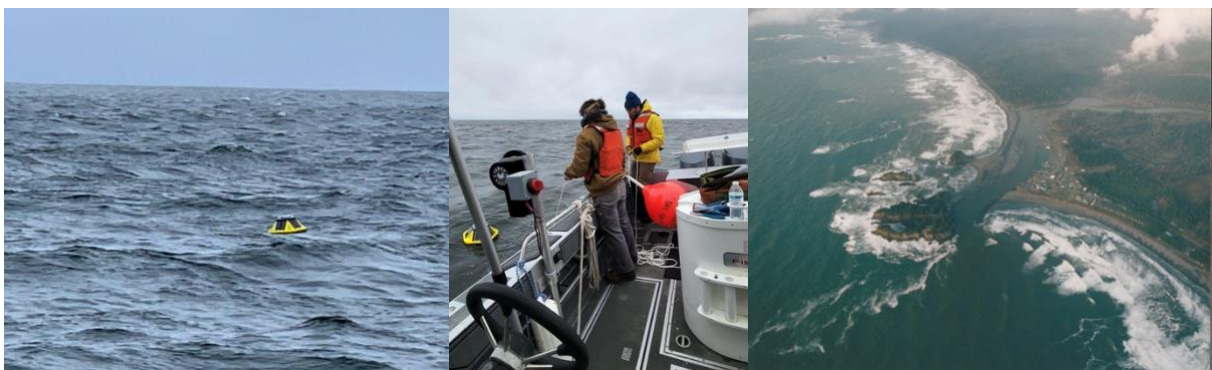


Figure 5 Left: Image of waters off of La Push, WA. Middle: Sofar Spotter buoy deployment off a Quileute Tribe vessel. Right: Spotter buoy in 34 m water about 2 miles off La Push, WA. Image credits: Left: US Coast Guard; middle and right: John Mickett (University of Washington) and Jennifer Hagen (Quileute Tribe).

Aqualink buoys in the Pacific Islands: To maximize community involvement and expand the spatial reach of Backyard Buoys, PacIOOS is seeking partnerships with participants of the Aqualink buoy program. This program deployed spotter buoys and smart moorings across the Pacific with a particular interest towards coral bleaching impacts. However, data access in this program is limited, and by integrating current Aqualink buoy deployments with the Backyard Buoys data services and community stewardship, PacIOOS seeks to amplify its reach in the region.

Buoy Deployments: As soon as permitting is complete, we anticipate up to 20 buoys will be deployed in summer of 2023. This first round of deployments will result in updates to the CRISP for each region, changes to mooring designs, and updates to our data tools.

III. Data Access Tools

The NANOOS team completed development of the [Backyard Buoy App prototype](#) in early 2023 (Figure 6). The development and refinement process included presentation of web app versions at each of the Working Group meetings, an All-Hands meeting, and with individual Indigenous partners to elicit feedback from a broad spectrum of project partners and implementers. Currently, the software team is beginning to build the smartphone app versions for iOS and Android and is securing AWS cloud server space to host and share the apps. They are also building the back-end data harvester that will communicate with the Sofar data service and a custom-built buoy log that community buoy team leads will use to notify the app that there's a new buoy in the water. Just like the web app prototype, the smartphone app will allow users to see summary data, time series, and set thresholds on wave height, wave period, and wind based on their safety ranges. The app also provides a place to add messages, so other on-the-water contextual information may be shared among users.

The data from the test deployment is currently viewable on the Sofar [Data Services & Marine Data Solutions](#) site for users. Once buoys are deployed, the data will be available on the individual RA sites ([AOOS Ocean Data Explorer](#), [PacIOOS Voyager](#), [NANOOS Explorer](#)).

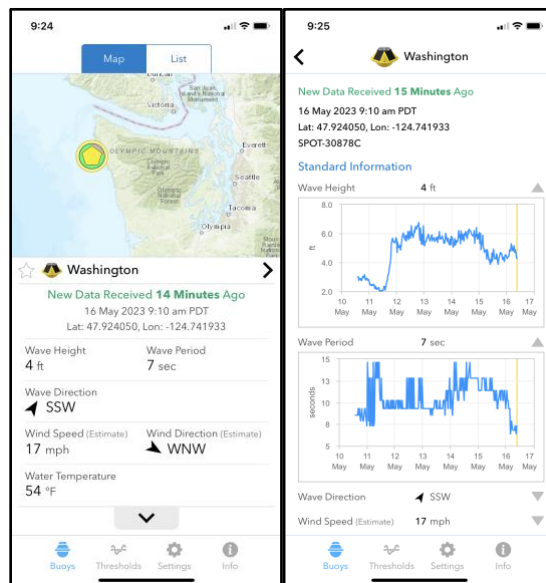


Figure 6. Left: Quileute Tribe test buoy on the map with summary data below. Right: Time series of wave height and period for the current week. Data shared with permission by Jennifer Hagen, Marine Biologist and Marine Policy Advisor for the Quileute Tribe.

IV. Education

Throughout Phase I, our Indigenous partners expressed the critical need to include an education component to Phase II so that the Backyard Buoys project can be sustained beyond Phase II funding. To address this urgent need, we included several educational partners from the three different regions to design a tailored curriculum that meets the needs of communities.

Pacific Northwest: In the PNW, Dr. Sam Kastner at WWU is working to create an undergraduate curriculum based on the Backyard Buoys project, technology, and data. “Waves and Tides” is listed as an upcoming winter quarter course for student enrollment. The syllabus has been created and the course material will be developed this summer.

Alaska: The Backyard Buoy team will be participating in the ANSEP Career Explorations opportunity in Juneau, AK in June to provide project exploration to Alaska middle school students. Career Explorations sessions include a five-day, academic, hands-on experience that emphasizes increasing knowledge and skills while re-engaging students with ANSEP. The Alaska team will also have a booth and activity at the Barrow Arctic Research Consortium Science Fair in August in Utqiagvik, AK.

Pacific Islands: Several different educational efforts are intended across the regions. PacIOOS has a liaison in American Samoa that has initiated conversations with local Department of Education teachers about how to connect the buoy program to high school curricula in marine science and physics. She plans to orient teachers in August 2023 during their annual orientation. She is also working with a teacher in the Teacher Education Division of the American Samoa Community College. During one of their courses, teachers create activities for their classes. The buoys and buoy data will provide excellent material for the teachers to work with.

Meanwhile, the NPSA has started using the Backyard Buoys discussions to frame larger education conversations around wave risks in the region, particularly in light of several recent drowning fatalities. Meanwhile, in Guam, University of Guam partners have begun to integrate the data from wave buoys into graduate education around physical oceanography.

Our education efforts in the Marshall Islands have been stalled due to staff turnover, but as of May 1, 2023, a new PacIOOS liaison is based at the College of the Marshall Islands (CMI) on Majuro. He plans to work with the Marshall Islands Conservation Society to engage CMI students in activities that utilize the wave buoy data.

Pan Regional: We had initially planned to have the whole Backyard Buoys team participate in the Indigenous Knowledge Summit in Honolulu in the summer of 2023 that is being coordinated by CI Hawai'i. There are a lot of potential synergies with our project and theirs. However, due to scheduling constraints with the primary intended audience of state-level natural resource managers, this event has been moved to the week of October 2, 2023. Unfortunately, this timing does not work for the Alaska Indigenous partners because that is in the middle of fall whale harvest timing. Therefore, Backyard Buoys is pivoting travel plans to instead have an all-hands meeting in early 2024. Several members of the Backyard Buoys team will also still attend the Indigenous Knowledge Summit hosted by CI Hawai'i.

Budget/financial overview

We have had a few challenges with the budget in Year 1. The effective date of the contract is Sep 1, 2022, but we did not receive the contract documents until mid-Nov 2022 and were not able to issue subawards until Dec 2022. Table 1 shows the allocations of the budget for year 1 and year-to-date expenses that have been invoiced.

Each region has had challenges but have been able to work through all the issues at this time. In Alaska, AEWC subcontracted UIC Science in the role of buoy coordinator. UIC Science is the village corporation in Utqiagvik that provides science logistics for the region. In the Pacific Islands, there have been challenges with staff turnover/hiring for engagement staff. In the PNW

and Pacific Islands regions, the main challenge is not with budget, but with timing of getting permits submitted within the project period.

Table 1. Budget allocations for the Backyard Buoys project

Institution	Year 1 budget	YTD expenses
University of Washington/NANOOS	\$1,179,888.35	\$32,469.87
AOOS	\$989,508.00	\$15,806.88
University of Hawaii/PacIOOS	\$709,242.00	\$8,593.59
Sofar Ocean	\$42,343.00	\$0
South Seas Consulting	\$30,377.00	\$3,930.00
Western Washington University	\$31,666.00	\$0
Total:	\$2,983,024.35	\$60,800.34

Sustainability Plan

Backyard Buoys’ non-profit business model will build community-driven wave data programs supported by a backbone of infrastructure from an existing federally-funded system. Our value proposition for Backyard Buoys communities, **our beneficiaries**, is to empower them to collect, steward, and use wave data that complements their existing knowledge and protects lives and livelihoods, leading to community autonomy over their wave buoy program. Our value proposition for Backyard Buoys **funders** is to serve the nation’s underserved communities and expand baseline wave data to study climate change impacts and coastal hazards in previously unmeasured areas, leading to more cost-effective and equitable delivery on their missions.

The startup funds from the NSF Phase I allowed us to build the right team and start our co-design process strong. NSF Phase II funding is the heavy investment we needed to launch the first three regional nodes of Backyard Buoys, get buoys in the water, and get their data into the hands of Indigenous communities. For the future, our per community cost estimated at \$16,000 is approachable enough for communities to self-fundraise or pursue small grants to join Backyard Buoys. Our long-term funding strategy is to request an annual line item of \$560,000 within the NOAA-IOOS budget request process, which comes through federal appropriations from Congress, to expand to all 11 RAs.

An important aspect of our sustainability is the U.S. IOOS Enterprise. IOOS is a national-regional partnership working to provide new tools and forecasts to improve safety, enhance the economy, and protect our environment. Integrated ocean information is available in near real time, as well as retrospectively. Easier and better access to this information is improving our ability to understand and predict coastal events - such as storms, wave heights, and sea level change. Backyard Buoys contributes to those mission areas by: Increasing wave data collection, geographic coverage, and availability for science and decision-making support and expanding support for particularly vulnerable and often underserved communities.

Backyard Buoys can succeed because there is precedence for our business model within the IOOS system. The IOOS program developed a similar model for nationwide [High Frequency Radar](#) system and as well as a [National Harmful Algal Bloom Observation Network](#), all of which are consistently Congressionally funded. The RAs will create a compelling request through NOAA-IOOS, armed with testimonials from constituents and a request of approximately \$560,000 increase per year to IOOS Regional Line (\$45M), which is a small ask for big payoff. Carl Gouldman, Director of US IOOS, shared “Backyard Buoys is creating momentum and demonstrating how our network can co-develop ocean knowledge with coastal communities to support decisions affecting lives every day. IOOS Regional Associations are perfectly situated to scale up this work and to take it to another level.”