

# Cooperative Institute for Marine and Atmospheric Research

Annual Report  
July 2022–June 2023

*Front cover: CIMAR divers often encounter vibrant giant clam (Tridacna) in and around the waters of American Samoa when conducting surveys on coral reef health (Photo credit: Daniela Escontrela)*

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# **Cooperative Institute for Marine and Atmospheric Research**

**Annual Report  
July 2022–June 2023**

<https://www.soest.hawaii.edu/cimar/>

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## The Cooperative Institute for Marine and Atmospheric Research (CIMAR)

CIMAR (<https://www.soest.hawaii.edu/cimar/>) is one of 16 National Oceanic and Atmospheric Administration (NOAA) Cooperative Institutes between NOAA facilities and academic research and training institutions nationwide. CIMAR's mission is to support research that is necessary for understanding and predicting environmental change in the Pacific Islands Region, for conserving and managing coastal and marine resources in island environments, notably the Hawaiian Islands and the U.S.-Affiliated Pacific Islands, and for supporting the region's economic, social, and environmental needs. Included in this report are projects under award number NA21NMF4320043. CIMAR seeks to:

- facilitate innovative collaborative research between scientists and engineers at NOAA and the University of Hawai'i;
- provide educational opportunities for basic and applied research in the Life and Earth Sciences at the undergraduate, graduate, and post-doctoral levels;
- advance interactions through the support of visiting scientists and post-doctoral scholars; and,
- promote the transition of research outcomes to operational products and services that benefit the Pacific Islands Region.



*Douglas S. Luther, PhD,  
Director*

CIMAR is located at the University of Hawai'i (UH), a research-intensive land-grant, Sea Grant, Space Grant and Sun Grant public institution that maintains a service mission to the State as well as to the Pacific Islands Region. CIMAR is a unit within the School of Ocean and Earth Science and Technology (SOEST), which has developed centers of excellence in marine, atmospheric, and earth science and technology that align well with the mission interests of NOAA. The University also provides capacity for social science research in several academic units. Adjacent to the UH campus is the independent, publicly funded East-West Center, which provides policy analysis and applied science across the Pacific Rim. CIMAR serves as a bridge to facilitate collaboration between NOAA in the Pacific Region and these academic research and educational units.

The principal NOAA Line Office for CIMAR is NOAA Fisheries, and CIMAR staff are integrated closely with its Pacific Islands Fisheries Science Center (PIFSC) at the Daniel K. Inouye Regional Center (IRC) at Ford Island, Pearl Harbor, O'ahu Island. The ~100 CIMAR staff within PIFSC are oceanographers, marine biologists, zoologists, geographers, coastal and environmental scientists, economists, fisheries scientists, sociologists, computer scientists, and engineers. The work with PIFSC is undertaken across 16 CIMAR projects encompassing coral reef monitoring and research, marine mammal and turtle research, human dimensions investigations and economics of fisheries, fisheries bycatch mitigation research, oceanic and reef ecosystems modeling, insular and pelagic fisheries stock assessment research, fisheries database management, and more.

CIMAR-supported scientists also interface with the NOAA National Weather Service (NWS), National Environmental Satellite, Data, and Information Service (NESDIS), and Office of Oceanic and Atmospheric Research (OAR) Line Offices, which support projects in the physics and chemistry focused research themes. Significant CIMAR supported programs active in these areas include the University of Hawai'i Sea Level Center (UHSLC), the UH Joint Archive for Shipboard acoustic Doppler current profiler (ADCP), and a partnership with the Pacific Islands Ocean Observing System (PacIOOS).

In response to a broadly advertised Notice of Funding Opportunity (NOAA-OAR-CIPO-2021-2006681), the University of Hawai'i submitted a proposal to NOAA in January 2021, to establish a new Cooperative Institute for the Pacific Islands Region. UH was awarded the new Cooperative Institute in June 2021. The new institute is named the Cooperative Institute for Marine and Atmospheric Research, replacing the prior institute named Joint Institute for Marine and Atmospheric Research. CIMAR officially began on October 1, 2021.



*Jeffrey Hare, PhD,  
Former Deputy Director  
for PIFSC Projects*

## Research Highlights

CIMAR research necessarily addresses one or more of eight themes, all aligned with the NOAA strategic plan and the University's Indo-Pacific mission. The themes are as follows: (1) ecological forecasting; (2) ecosystem monitoring; (3) ecosystem-based management; (4) protection and restoration of resources; (5) oceanographic monitoring and forecasting; (6) climate science and impacts; (7) air-sea interactions; and (8) tsunamis and other long-period ocean waves.

CIMAR's collaboration with the NOAA PIFSC drives the primary research and educational activities within the Institute. Here are some highlights that demonstrate the scope of CIMAR/PIFSC research in the theme areas of ecosystem monitoring, ecosystem-based management, and protection and restoration of resources.

### • Protection and Restoration of Resources

#### *Cetacean Research in the Pacific Islands Region*

Three distinct populations of false killer whales (*Pseudorca crassidens*) are found in the Hawaiian Archipelago, with one currently listed as endangered under the U.S. Endangered Species Act. These delphinids are known to interact with fishing activities throughout the archipelago, leading to whale mortality or injury at sometimes unsustainable rates. As a result, extensive survey efforts have focused on estimating the abundance of false killer whales. Acoustic monitoring has the potential to significantly enhance these abundance estimates, but the basic vocal behavior of the species needs to be understood first. Research led by CIMAR scientist Pina Gruden investigated the vocal behavior of false killer whales from the Hawaiian Archipelago, finding that acoustic subgroups of the species exhibited a diverse vocal behavior that varied between encounters. Some groups only produced echolocation clicks (29%), some only whistles (16%), and the majority produced both types of vocalizations (55%). Subgroups emitting both types of vocalizations were acoustically active for longer periods of time, increasing their availability for being detected and tracked with acoustic monitoring. This research aids in developing robust acoustic monitoring methods and in accounting for potential biases among subgroups for future acoustic-based abundance estimates.



Dr. Pina Gruden

Gruden P, Barkley YM and McCullough JLK (2023) Vocal behavior of false killer whale (*Pseudorca crassidens*) acoustic subgroups. *Front. Mar. Sci.* **10**:1147670. doi:10.3389/fmars.2023.1147670

After more than a century of intensive commercial whaling, monitoring sperm whale populations (*Physeter microcephalus*) is essential for guiding management decisions for their recovery. Understanding sperm whale distribution and habitat use is key and is typically based solely on surface visual observations. However, sperm whales are a deep-diving species that can spend at least 45 minutes foraging for prey hundreds of feet underwater. Thus, for the endangered sperm whale population in Hawaiian waters, CIMAR Researcher Dr. Yvonne Barkley led a study using both visual and passive acoustic data to develop species distribution models (SDMs) of sperm whale groups and their relationship with different environmental factors throughout the island chain. Sperm whales produce echolocation clicks that can be identified within the passive acoustic data. The click types were used to categorize foraging and non-foraging sperm whale groups, and assess the overall and within group spatial pattern in sperm whale distribution. Foraging groups were predicted primarily in the northwestern region of the archipelago between Laysan Island and Pearl and Hermes Reef as well as north of Maui and Hawai'i, in response to temperature at depth, surface chlorophyll, and location. Non-foraging groups were predicted to be more uniformly distributed throughout the archipelago in response to variation in sea surface height and location. Dr. Barkley's study furthers our understanding of Hawaiian sperm whale distribution patterns and contributes methods for building SDMs with visual and passive acoustic data that may be applied to other cetacean species.



Dr. Yvonne Barkley



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Barkley YM, Sakai T, Oleson EM and Franklin EC (2022) Examining distribution patterns of foraging and non-foraging sperm whales in Hawaiian waters using visual and passive acoustic data. *Front. Remote Sens.* **3**:940186. doi: 10.3389/frsen.2022.940186

- **Ecosystem-Based Management**

*Economics and Human Dimensions of Marine Ecosystems*

The Hawai'i longline fleet is a global leader in bycatch reduction and mitigation, but there is continual pressure to further reduce bycatch, particularly for protected species like false killer whales, sea turtles, sharks, and seabirds. Therefore, we interviewed 38 Hawai'i longline captains and crew about protected species bycatch to collect bycatch solutions from fishers and to discover if there were any social barriers that might prevent further reduction of bycatch. We found that the Hawai'i longline fleet could further reduce bycatch through enhanced fleet communication while at sea, relocation to avoid aggregations of protected species like false killer whales and sea turtles, and potentially through some innovative fisher-developed solutions. Our research emphasizes the importance of the human dimension and addressing social barriers in order to further reduce bycatch and accomplish ecosystem-based fisheries management goals.



Dr. Adam Ayers

Ayers, AL, and Leong, K (2022) Focusing on the human dimensions to reduce protected species bycatch. *Fish.Res.* **254**:106432. doi: 10.1016/j.fishres.2022.106432

The role of gender and gendering within fisheries is consistently understudied, contributing to the invisibilization—the erasure and marginalization—within fisheries research and subsequent management decisions of women and those whose gender is outside of the dominant binary model of gender. To understand how gender and gendering affects fishing practices, particularly with regard to the cultural values and meanings embedded within fisheries, CIMAR researcher Jonathan Fisk and his colleagues interviewed 28 women and fa'afafine in American Samoa about their fishing practices and how they more broadly relate and interact with the seas. The researchers found that intergenerational relationships were profoundly important for the perpetuation of fishing knowledges and practices, especially relationships between grandmothers and granddaughters and, conversely, that cultural subsistence in the form of locally caught fish plays a critical role in caring for elders. Furthermore, the cultural role of fisheries in regard to several social dynamics normally overlooked by fisheries research—domestic labor, art, and design—were emphasized by interviewees as having considerable cultural significance. This research highlights the need for more expansive engagements with gender in fisheries research in order to include more holistic tapestries of experiences, insights, and concerns within fisheries management considerations.



Jonathan Fisk

Fisk, J, Matagi, N and Kleiber D (2023) Gleaning the expanse: Gender and invisibilised dimensions of fisheries in American Samoa. *Women Fish. Info. Bull.* **37**:7-10.

- **Ecosystem Monitoring**

*National Coral Reef Monitoring Program—Pacific*

As part of the National Coral Reef Monitoring Program, CIMAR researchers survey coral reef communities at 34 U.S.-affiliated Pacific islands that span a range of oceanographic conditions as well as human habitation. Brittany Huntington and her colleagues used this long-term monitoring dataset to re-evaluate patterns reported for these islands in the early 2000s—in which reefs uninhabited by people were dominated by reef building taxa like coral and crustose coralline algae and, therefore, thought to be more resilient to climate change. Using contemporary data collected nearly two decades later, the team's analyses indicate this projection was not realized; reef builders no longer dominate the uninhabited islands in the U.S. tropical Pacific. Reef builder coverage now averages 26.9% ± 3.9 SE on uninhabited islands (compared to 45.18% in the early 2000s).

The researchers then asked whether ocean conditions influenced by climate change such as oceanic productivity, past sea surface temperatures (SST), or acute heat stress supersede the local impacts of human habitation on benthic cover. Indeed, variation in benthic cover was best explained not by human population densities, but by metrics of chlorophyll-a, SST, and herbivorous fish biomass. Interestingly, coral cover was positively correlated with daily variation in SST but negatively correlated with monthly variation, lending support to the idea that corals exposed to larger daily swings in temperature may fair better over time than those in more thermally stable environments.



Dr. Brittany Huntington

Huntington B, Vargas-Ángel B, Couch CS, Barkley HC and Abecassis M (2022) Oceanic productivity and high-frequency temperature variability—not human habitation—supports calcifier abundance on central Pacific coral reefs. *Front. Mar. Sci.* 9:1075972. doi: 10.3389/fmars.2022.1075972

#### *Life History and Population Assessment Research*

Reproductive characteristics of a fish stock provide important tools for assessing population health. Change in length-at-maturity (L50) is a potential indicator of exploited fish populations when consistent criteria are established for determining maturity. CIMAR Life History Biosampling Specialist Erin Reed led a research project exploring the effects that different data sources and maturity classification criteria have on the resulting length-at-maturity parameter using a data-limited study species in the main Hawaiian Islands, onaga (*Etelis coruscans*). Reed and coauthors found that the criteria a fisheries scientist uses to categorize whether a fish is immature or mature can have a significant impact on the resulting length-at-maturity estimate. An important finding was that as alternative maturity classifications deviate from traditional criteria, the estimated L50 parameter became smaller and smaller—indicating the strong effect of a maturity classification assignment. Overall, the study highlighted a knowledge gap in the field of fish reproductive biology, and provided robust analysis and in depth discussion of results with future implications for fish that have similar life history characteristics as onaga.



Erin Reed

Reed, EM, Brown-Peterson, NJ, DeMartini, EE and Andrews, AH (2023). Effects of data sources and biological criteria on length-at-maturity estimates and spawning periodicity of the commercially important Hawaiian snapper, *Etelis coruscans*. *Front. Mar. Sci.* 10:1102388. doi: 10.3389/fmars.2023.1102388

### **Transitioning to Products and Services—Examples**

A major focus for CIMAR researchers is to transition research outcomes to operational products and services and build datasets that benefit the Pacific Islands Region, NOAA, and other partner operations across all oceans. Many CIMAR projects contribute directly to PIFSC databases, specimen collections, software, models, and outreach and educational endeavors. Because CIMAR staff inhabit all of the research and operational programs in PIFSC, CIMAR will have contributed to nearly every product developed by the PIFSC programs. These CIMAR contributions include not only peer-reviewed scientific output and project technical reports, but also the following: data administration from every relevant Pacific Island and State of Hawai‘i fishery; processed satellite data; stock assessment model improvements and outputs; coral reef benthic habitat and fish assemblage information; oceanographic data; Hawaiian monk seal population dynamics data; marine turtle nesting data; marine turtle biological and ecological information; fish life history data; collected marine debris data; socioeconomic indicators and survey data; cetacean counts and identification data, etc.

- **Ensuring Sea Level Data Quality and Dissemination.** Researchers at the University of Hawai‘i Sea Level Center (UHSLC; <https://uhslc.soest.hawaii.edu>) continue to ensure that tide gauge data from nearly 500 stations maintained by 65 international agencies around the world (including 77 that are maintained by UHSLC) are collected, quality assessed, distributed, and archived for use in environmental monitoring and research applications related to climate. The UHSLC focuses on the stations that constitute the Intergovernmental Oceanographic

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Commission (IOC)/United National Educational, Scientific and Cultural Organization (UNESCO) Global Sea Level Observing System (GLOSS), and the Global Climate Observing System (GCOS). The UHSLC is a primary data center in GLOSS, curating and distributing two sea level gauge datasets: the Fast Delivery dataset and the Research Quality dataset. In addition, because vertical land motion monitoring is recommended by GLOSS/GCOS for the proper attribution of local sea level changes, the UHSLC maintains continuous global positioning system (GPS) receivers at 11 stations. During this fiscal year (FY), within CIMAR's tropical oceanography, meteorology and climate themes, UHSLC datasets were utilized directly in at least 41 peer-reviewed research articles (per Google Scholar), and in an additional 31 articles via the GESLA dataset, which is primarily composed of UHSLC data for locations in the Global South. UHSLC researchers were lead authors on the sea level section in the State of the Climate in 2022 report published in the summer of 2023 as a supplement to the *Bulletin of the American Meteorological Society*.

• **Empowering Ocean Users and Stakeholders.** CIMAR researchers and administrators make fundamental contributions to the success of the Pacific Islands Ocean Observing System (PacIOOS; <https://www.pacioos.hawaii.edu>) that empowers ocean users and stakeholders throughout the Pacific Islands by providing accurate and reliable coastal and ocean information, tools, and services that are easy to access and use. A variety of forecasts are made available to the public, including coastal inundation, wave, ocean, and atmospheric forecasts. As part of strategic planning, PacIOOS regularly organizes the collection of stakeholder comments articulating local and regional observing needs. PacIOOS continues to operate and maintain over 30 deployed buoys, sensors, and other instruments throughout the U.S. Pacific Islands. To supplement core funding support from the U.S. Integrated Ocean Observing System (IOOS), PacIOOS was awarded nearly \$1M in NOAA support from the Bipartisan Infrastructure Law to replace ageing observing assets, \$227,000 from the Office of Insular Affairs to improve atmospheric forecasting related to El Niño events in Guam and the Commonwealth of the Northern Mariana Islands (CNMI), and \$400,000 from the NOAA National Harmful Algal Bloom Observing Network to support a ciguatera information network. PacIOOS collaborated with two other regional associations to secure a Phase II cooperative agreement (\$5M) with the National Science Foundation for the Backyard Buoys project, which aims to equip underserved communities with ocean intelligence platforms while also serving as a demonstration of co-production. New data products this year include a western north Pacific regional ocean modeling system (ROMS) forecast and an atmospheric forecast for a similar regional grid, both of which include the Republic of Palau. Additional data layers were added to PacIOOS Voyager, enabling users to visualize and explore NOAA Environmental Sensitivity Indices and Marine Heatwaves. Regional engagement activities from the PacIOOS core team sought to identify data gaps and build relationships with stakeholders in Guam, the CNMI, and Palau. PacIOOS continued to work with IOOS partners from Alaska and the Pacific Northwest, as well as regional partners in American Samoa, the Republic of the Marshall Islands, and Guam to develop a network of community-stewarded wave buoys through the Backyard Buoys program. Continuous improvements are being made to PacIOOS' website (<https://www.pacioos.hawaii.edu>) and data visualization platform, PacIOOS Voyager (<http://www.pacioos.hawaii.edu/data/voyager/>), to provide free and easy access.

• **Short-term (6 Days) and Long-Term (Decades) Wave-driven Flooding Forecasts.** As sea level rises, swell wave-driven runup and coastal flooding are becoming a significant threat in many U.S. and international locations, especially as their growing frequency of occurrence will mark them as coastal hazards that are equivalent to moderate-sized tsunamis. A PacIOOS and CIMAR supported nonlinear, hydrodynamical model of swell wave transformations in shallow water was validated for accuracy with *in situ* data and implemented to provide spatially dependent, real-time run-up forecasts along West Maui. The 6-day forecast product was released on the PacIOOS web site in June 2021 (<https://www.pacioos.hawaii.edu/shoreline-category/runup-westmaui/>). The product has already had an impact among coastal agencies concerned with public safety and coastal erosion. A longer-term forecast product that includes climate-driven sea level rise scenarios, in conjunction with expected annually recurring swell wave events, was released in 2022 to provide government agencies and coastal communities with a tool to inform land and coastal use planning (<https://www.pacioos.hawaii.edu/shoreline/slr-westmaui/>).

• **Climate Research Support by the Asia-Pacific Data-Research Center (APDRC).** The activities of CIMAR staff at the APDRC (<http://apdrc.soest.hawaii.edu>) support climate research within the UH International Pacific Research Center (IPRC) for a broad spectrum of users throughout the region. APDRC meets critical regional needs by providing ocean, climate and ecosystem information, and also by generating relevant data products. APDRC is organized around three goals: provide integrated data server and management systems for climate data and products; develop and serve new climate-related products for research and applications users; and conduct climate research in support of the IPRC and NOAA research goals. APDRC hosts over 125 different data sets

from in situ platforms, satellites, and numerical models. The volume of data totals approximately 650 terabytes (TB) of redundantly stored data. For ease of access, APDRC maintains a suite of data transport and discovery servers. The APDRC will continue to support the World Meteorological Office (WMO) Regional Climate Center (RCC) for the Pacific Islands (known as RA-V) activities.

- ***Water Velocity Profiles Collected on All NOAA Fleet Vessels.*** The NOAA research vessel fleet employs acoustic Doppler current profilers (ADCPs) that aid a variety of NOAA programs and contribute to the global climatology of ocean current observations. CIMAR scientists at UH have a continuing NOAA mandate to maintain and upgrade the ADCP data acquisition and processing software, called the University of Hawai‘i Data Acquisition System (UHDAS), on 11 NOAA vessels, thereby maximizing the scientific value of the measurements during work at sea, and long into the future. CIMAR provides on-site upgrades and training, when possible, and remote consulting on UHDAS use and interpretation of acquired data, including immediate response to queries from at-sea ships. CIMAR staff established the NOAA-to-NOAA real-time data pipeline from two NOAA ships to the National Centers for Environmental Information (NCEI) so that observations from these vessels are available for researchers quickly and accurately. More ships will be added to this program in the future.

- ***Technical and Data Quality Control Contributions to the International Argo Project.*** At NOAA/PMEL, CIMAR staff continued working with U.S. and International Argo Project partners to improve the already highly successful Argo profiling observational float platform by conducting testing, deployment, and data/engineering evaluations of conventional ‘Core’ Argo floats, Deep Argo floats and Biogeochemical Argo floats. CIMAR staff also provide delayed-mode quality control of data from these three float classes for ocean climate change research.

- ***Coral Bleaching Database.*** Several databases are now available, including the American Samoa spatial data layers (hosted on the PacIOOS website) and the Hawaiian Islands 2019 Coral Bleaching database (hosted by NCEI). The Coral Bleaching database contains information on live coral cover and the extent and average severity of coral bleaching during the fall 2019 heat stress event, as well as taxa-specific metrics.

- ***Deep-sea Animal Identification.*** CIMAR continued to grow its deep-sea animal identification guide containing thousands of images that annotators use to identify the animals captured on submersible vehicle video. This guide, checked for accuracy from taxonomists from around the world, is now a standard for NOAA.

- ***Fishery Stock Assessment Tools.*** CIMAR researchers maintain, improve and disseminate the Automatic Differentiation Model Builder (ADMB), a free, open-source software package currently used by all NOAA Fishery Science Centers, as well as other U.S. and international institutions, to create fishery stock assessment tools. The project released ADMB-13.1 in December, 2022, which included improvements and fixes to the documentation, installation, testing, and source code. There were 841 downloads for all distributions of ADMB as of March 2023. Between 2011 and March, 2021, ADMB has been cited a total of 1763 times according to Google Scholar.

A user interface that links to the Agepro Calculation Engine was developed and is maintained by CIMAR project staff. This tool is widely used in stock assessments within NOAA and beyond.

## **Education, Dissemination and Outreach**

### ***Education***

- CIMAR devotes personnel time and funding for educational opportunities for K–12 students through to postgraduate research training.
- Under appropriate COVID-19 safety guidelines, researchers participate in: elementary, middle, and high school career and science day events; UH and community events; Waikiki Aquarium Family Night; Honolulu Seafood Festival; Hanauma Bay Education Lectures; teacher workshops; podcasts; fishing derbies; tables at community events; fisher forums; various expositions and conferences; and events at local hotels to educate tourists on ocean concerns. CIMAR staff also regularly teach courses or individual classes as expert researchers at various campuses in the UH system.
- CIMAR supports and facilitates the PIFSC Young Scientist Opportunity (PYSO) program that annually employs several undergraduate students. For the past few years, the program focused on developing local science undergraduates either from Hawai‘i or attending college in Hawai‘i. The PYSO is currently active with four young researchers hired into CIMAR to work in PIFSC alongside CIMAR and federal mentors on summer science projects.
- CIMAR staff help manage intern participant activities, including the NOAA Hollings Preparation Program at UH, which prepares undergraduates to be competitive applicants for the full NOAA Hollings Scholarship in their sophomore year of college. CIMAR and federal staff coordinated events for the students, including

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a meet-and-greet and cultural introduction, a public speaking and presentation skills workshop, a Hawai‘i graduate program information session, a NOAA career opportunities discussion, a service learning opportunity, and the annual Inouye Research Center Intern Symposium, which includes interns participating in a variety of national internship programs in all the local NOAA offices.

- Although many student activities were deferred during the pandemic, CIMAR projects regularly hire UH undergraduate students to work on various projects. A number of UH students also participate in projects as volunteers. CIMAR projects supported several graduate assistant students, primarily at UH, who are pursuing Masters and PhD degrees in oceanography, marine sciences, and social sciences.
- CIMAR programs support continuing education through the hiring of talented Postdoctoral Researchers. Research topics include: unraveling the links between El Niño Southern Oscillation (ENSO) and Hawai‘i rainfall (e.g., transition diversity and precursors, hydroclimate impacts of different ENSO types); and evolution of the internal tide, including its nonlinear byproducts, in environmental settings appropriate to Hawai‘i and specific mid-latitude locations.
- CIMAR researchers contribute to education and communication at UH by presenting talks at regular seminar series and teaching courses or individual classes as expert researchers at various campuses of the UH. Seminars presented by CIMAR and federal researchers at PIFSC are also web-streamed to interested researchers and students at UH.
- CIMAR staff regularly take advantage of training and professional development opportunities themselves, and the pandemic provided an alternative approach to professional improvement, with training and workshops held virtually and available around the nation. As employees of the Research Corporation of the University of Hawai‘i, CIMAR staff are afforded tuition reimbursement for a limited number of credits of educational training directly applicable to the individual’s job. Several CIMAR employees take advantage of this program each year.
- Former CIMAR staff members are frequently recruited into federal service, including leadership positions in PIFSC. Over 30 former CIMAR staff are currently serving as federal employees in PIFSC. Five CIMAR staff were recruited during this reporting period for federal employment with NOAA.

#### ***Dissemination and Outreach***

- Communication of research findings to the larger scientific community is fundamental to the progress of science. CIMAR staff regularly participate in national and international symposia, professional conferences, and subject-focused workshops. As a result of the pandemic, more events are being held in a virtual or hybrid environment, which enlarges the opportunities for scientific dialog through online presentations when travel to such events isn’t possible.
- Project scientific outputs, including research results, datasets and software tools, are disseminated in several ways, including: provided directly to co-located NOAA Sponsors as part of normal workflow at PIFSC; submitted to professional science print and online journals as contributions to the research literature; presented at professional scientific meetings and conferences; contributed as white papers to regional and international management organizations; and provided on open access websites and data repositories. Although several CIMAR projects started late during the reporting period, 16 CIMAR first author articles were published in peer-reviewed journals.
- CIMAR outreach activities are numerous and wide-ranging. CIMAR researchers contribute to science communication at UH by presenting talks at regular seminar series. Seminars presented by CIMAR and federal researchers at PIFSC are also web-streamed to interested researchers and students at UH.
- CIMAR leads or collaborates on numerous contributions to NOAA/NMFS/PIFSC blog postings, podcasts, story maps, and other web content.
- CIMAR staff meet with local and U.S. territorial government officials to communicate scientific endeavors within their jurisdictions.
- CIMAR researchers regularly meet with fishermen and fisheries observers in the Pacific Islands Region to discuss reporting requirements and instruct them on bycatch mitigation efforts for protected species.
- CIMAR staff create and distribute a quarterly newsletter for the Hawai‘i Community Tagging Program (<https://www.sharktagger.org/newsletters>).
- Staff participate in community and educational events to communicate information about CIMAR and NOAA missions, programs, and policies, and encourage the public to learn about and support healthy ocean ecosystems and marine science research. Activities included critter cam talks, University of Guam marine turtle

presentation, United Nations World Oceans Day, Hanauma Bay Science and Sustainability event, Kupu teacher externship event, Pacific Islands Interactive webinars at the Bishop Museum, monk seal webinar, and judging the Hawai‘i State Science Fair.

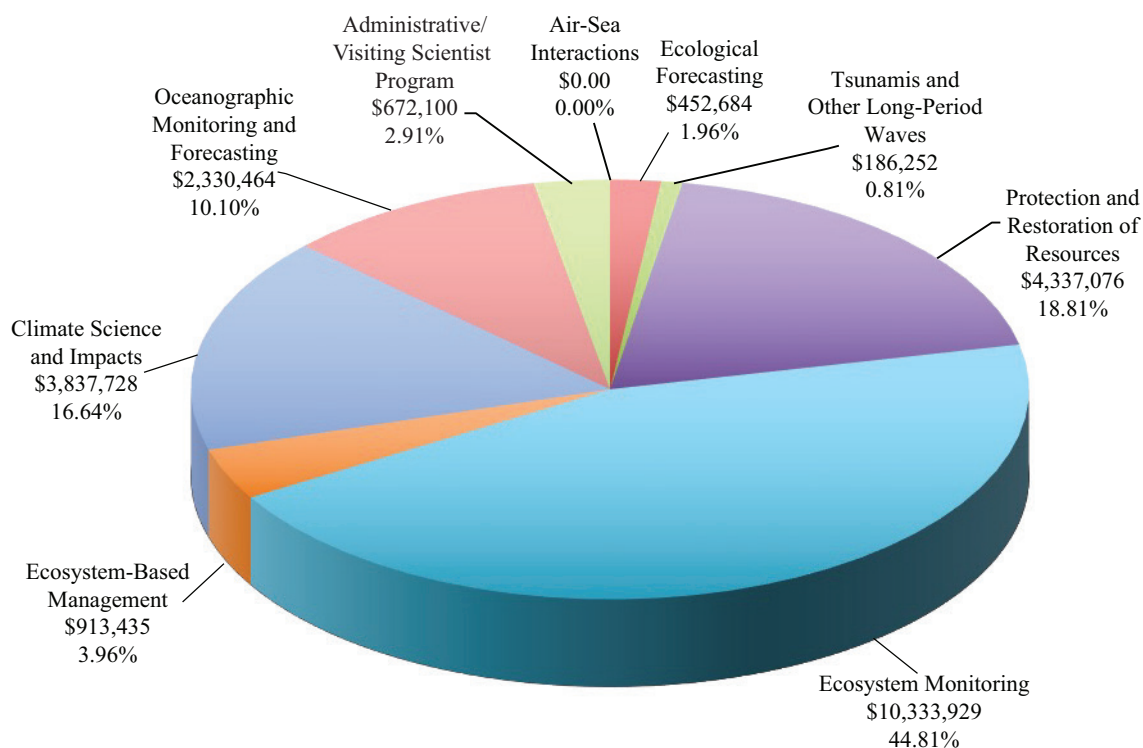
- CIMAR staff consistently contribute to NOAA/PIFSC web content such as feature stories, podcasts, science blogs, story maps, photographs, and videos.

The project descriptions on following pages provide vignettes of the significant roles that CIMAR plays as a Cooperative Institute linking the academic opportunities available at the University of Hawai‘i to NOAA’s concept of resilient ecosystems, communities, and economies.

### CIMAR Structure and Funding

The Director of CIMAR, Dr. Douglas S. Luther, is a Professor at the University of Hawai‘i at Mānoa and was appointed in 2017 through joint decisions by leaders of the University and NOAA. The Director reports to an Executive Board composed of University and NOAA officials. In the year covered by this report, the Director managed CIMAR activities with the assistance of Dr. Jeffrey Hare, Deputy Director for PIFSC Projects through February 15, 2023, and Mr. Kevin K. Higaki, Assistant Director for Administration, as well as Program Managers and faculty PIs. Mr. Higaki manages day-to-day operations through the administrative staff who are fully-supported by the Cooperative Agreement (NA21NMF4320043) and indirect cost funds. A Council of Fellows is available to provide advice to the Director on research opportunities and promotion of cooperation and scientific collaboration. The Fellows are drawn from both NOAA and the University of Hawai‘i. The following chart indicates how funds flowing through CIMAR are distributed according to the CIMAR research themes: (1) ecological forecasting; (2) ecosystem monitoring; (3) ecosystem-based management; (4) protection and restoration of resources; (5) oceanographic monitoring and forecasting; (6) climate science and impacts; (7) air-sea interactions; and (8) tsunamis and other long-period ocean waves.

**Distribution of NOAA Funding by Theme (FY 2022-2023)**



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# Accomplishments for Fiscal Year 2023

## Ecological Forecasting

*Research under this theme leads to improved forecasting of the frequency and magnitude of ecosystem processes within the Pacific Islands region. CIMAR facilitates research in development of open source fisheries ecosystems modeling tools (Auto-Differentiation Model Builder) and marine population dynamics and fisheries stock assessment models.*

### Open Source ADMB Project

**P.I.: Erik Franklin**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Jon Brodziak, Kristan Blackhart**

#### NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

#### Purpose of the Project

The general purpose of the Open Source Automatic Differentiation Model Builder (ADMB) Project is to maintain and improve the ADMB software package as free, open-source software. ADMB is currently used by all National Oceanic and Atmospheric Administration (NOAA) Fishery Science Centers to create stock assessment tools. Specifically, the project objectives aim to: (1) improve and maintain software installation and documentation so that end-users can successfully install and use the software on supported operating systems and compilers; (2) improve software quality by testing and fixing defects in the source code; (3) enhance the software with new features to use in model development, for faster run-times and to improve resource efficiency; (4) improve maintainability of the source code so that developers can successfully understand and enhance the software; (5) update source code to modern International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) C++ standards; and (6) port the source code to build on the new compilers and processors. The project maintains a long-term goal to outreach and support ADMB software through an active and committed group of users and developers located in laboratories and universities in the United States of America (USA) and around the world.

#### Progress during FY 2023

ADMB releases are the high priority task and main output of the project. Major releases, which typically include new features are released annually. Minor releases include fixes to the software. ADMB-13.1 is the latest minor version, which was released on December 22, 2022, which included improvements and fixes to the documentation, installation, testing, and source code. ADMB-13.0 is the latest major version that was released on August 8, 2022.

Highlights of development in ADMB features include the (1) development of the threaded funnel; (2) ADMB console display; (3) C/C++ Modular Interface; and (4) ISO/IEC C++ Standard Compliance. In addition, key changes for ADMB included support for arm64 processor and Microsoft Visual C++ 2022 and an issue resolution with compilers naming that include version (i.e., gcc-7). University of Hawai'i (UH)/Cooperative Institute for Marine and Atmospheric Research (CIMAR) staff collaborated with NOAA developers to improve the ADMB console display to be briefer and more user readable. Tweedie distributions (function: dtweedie) were added to ADMB based on a request from NOAA scientists. A modular interface for programing directly from C++ instead of using an ADMB template file was developed. There were 841 downloads for all distributions of ADMB as of March 2023.

## Ecosystem Monitoring

*Observing systems and data management are integral to this theme. Significant efforts are undertaken in CIMAR to monitor and assess reef ecosystems, fisheries habitat and stocks, endangered marine animals, and threats to marine ecosystems. CIMAR contributes to the National Marine Fisheries Service (NMFS) effort to continually monitor catch data from the fisheries industry across the Pacific Islands.*

### Ecosystem Structure and Function

**P.I.: Douglas S. Luther [CIMAR Project Lead: Justin Suca]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Ryan Rykaczewski**

#### **NOAA Goal(s):**

- Healthy Oceans
- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

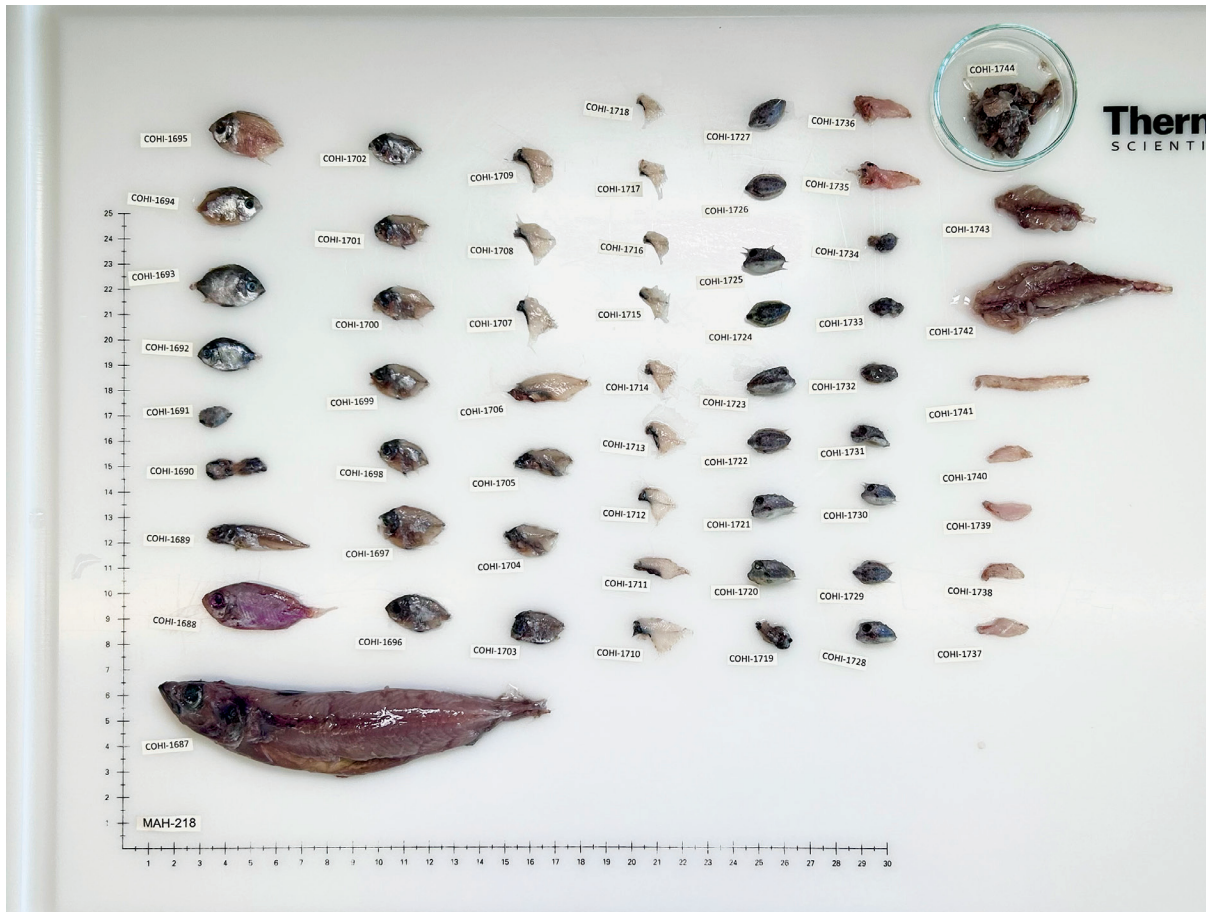
#### **Purpose of the Project**

This project conducts research to advance the understanding of the structure and function of the ecosystems in the waters surrounding the Hawaiian Archipelago, including the subtropical gyre. This work consists of multiple branches of analyses, including assessment of what constitutes essential fish habitat, investigations of the structure and function of pelagic ecosystems, support for NOAA provided satellite products, and an integrated ecosystem assessment of the Main Hawaiian Islands (MHI). Specific tasks include the analysis of lancetfish stomach contents to describe the spatial and temporal patterns of micronekton across the Central North Pacific to serve as a form of ecosystem monitoring. Stomach contents of mahi-mahi are collected from local fishers to understand how this species feeds in a region where coastal and pelagic habitats are in close proximity. Other avenues of research within this project include determining what constitutes habitat for coastal and pelagic fish taxa throughout the MHI using fishery-independent reef fish survey data and fishery dependent data sets (observer, logbook, and dealer records from the Hawai'i based longline fishery) in conjunction with oceanographic and human impact data to assess what drives trends in abundance and catch composition. These habitat assessments expand to understanding patterns in larval dispersal and larval habitat of these taxa, which collectively support ecosystem-based management. Work on this project also encompasses development of genetics and genomics techniques for ecosystem monitoring around Hawai'i—including stomach content metabarcoding and environmental DNA (eDNA)—and maintenance of satellite data products (OceanWatch) for oceanographic monitoring and forecasting.

#### **Progress during FY 2023**

Substantial progress was made this year on many aspects of the project, including the diet analysis of mahi-mahi from O'ahu, diet analysis of lancetfish, improved characterization of larval habitat of akule, 'ōpelu, and uku throughout Hawaiian waters, assessment of larval distributions and micronekton diets from the subtropical gyre, and characterization of the habitat of reef fishes in Hawai'i and the Marianas. Stomach content collections of mahi-mahi from local Hawai'i fishers ramped up significantly in this year, collecting 341 stomachs corresponding with the roll out of reward cards for fishers who contributed substantially and included media articles about the project. Lancetfish stomach content collections and stomach dissections continued in FY 2023 with ~200 stomachs dissected. The results from this and previous years dissections are currently being drafted into multiple manuscripts led by CIMAR employees and academic partners and were presented at the 2023 Tuna Conference. These analyses describe the spatial distribution and oceanographic drivers of micronekton from the stomach contents of lancetfish and an assessment of the prey of lancetfish prey, a project uniquely tractable due to the high-quality prey condition within lancetfish stomachs. This latter project (lancetfish prey-of-prey) is currently under review in a peer-reviewed journal.





Contents of a mahi-mahi stomach collected in 2023 and dissected by Nan Himmelsbach with many juvenile reef fishes, including juvenile butterflyfishes (*kīkākapu*), juvenile boxfishes (*makukana*), and a juvenile bigeye (*‘āweoweo*). Photo Credit: Nan Himmelsbach.

Essential fish habitat research in this year has largely focused on the early life stages of uku, including the submission of a report on the existing knowledge on larval and juvenile uku and presentation of the results at the 2022 Larval Fish Conference. This project served as the basis for multiple ongoing projects on uku larvae, including dispersal modeling of uku larvae throughout the MHI. This project focuses on larval dispersal models that describe the degree of inter-island connectivity of simulated uku larvae and physical drivers of this inter-annual variability. Mapping of adult essential fish habitat was also expanded this past year, with development of spatiotemporal distribution models for 16 resource species in Guam and the southern Mariana islands, including use of machine learning (ML) techniques to understand the drivers of their spatial distribution. Similar work using ML techniques has been developed for reef fish species throughout the MHI. Oceanographic processes continue to be updated and made broadly available through OceanWatch, including coordination of the 2023 OceanWatch meeting at the University of Hawai‘i at Mānoa. OceanWatch data were prominently featured in the 2022 Stock Assessment and Fishery Evaluation Reports of the Western Pacific Regional Fishery Management Council (WPRFMC), and CIMAR staff contributed to the development of those reports. Related work included an assessment of a local downscaled hydrographic model for estimating bottom temperatures over coral reef ecosystems by CIMAR staff. Lastly, genetic techniques for assessing patterns in eDNA and gut content metabarcoding were processed this year to understand the broader pelagic micronekton community. Multiple CIMAR staff worked on using genomics techniques to characterize these ecosystems and the trophic interactions of these taxa from the pelagic realm that is utilized by the Hawai‘i longline fishery. CIMAR staff contributed to the collections of bottomfish management unit species (BMUS) to power species-specific quantitative polymerase chain reaction (qPCR) study and generate whole mitogenome reference sequences for all locally-occurring snapper. This project generated 50



(above) *Hollardia goslinei*, also known as the Hawaiian Spikefish, a rare specimen discovered by Emily Contreras during lancetfish (*Alepisaurus ferox*) stomach dissections. This pelagic juvenile is the first specimen collected since the 1970's (and only the 9th globally), and will serve as the genetic voucher for the species and accessioned into the permanent collection at the National Museum of Natural History. Photo Credit: Emily Contreras.

(below) A lanternfish (*Myctophum* sp.) collected with the 2-meter ring net on the 2022 Bigeye Oceanography Cruise. Lanternfish represent a dominant component of the micronekton whose stomach contents were metabarcoded in the past year. The metabarcoding of gut contents from micronekton can feed into Pacific-wide ecosystem models. Photo Credit: Jonathan Whitney, Nan Himmelsbach, and Andrea Schmidt.



new gold-standard voucher specimens from ten snapper species (including uku and Deep 7) in Hawai‘i to be part of the National Museum of Natural History’s (NMNH) permanent reference collection. Tissues from vouchers are being used to generate whole mitogenome reference sequences via genome skimming and generate novel primers to support future bottomfish eDNA surveys. In addition, CIMAR staff supported generation of new voucher specimens of midwater fishes and squid for permanent curation at NMNH and barcode generation that will power metabarcoding projects in the region and worldwide.

## **Ecosystems Observations and Research Project**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Jeffrey Hare]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Ariel Jacobs**

**NOAA Goal(s):**

- Healthy Oceans
- Resilient Coastal Communities and Economies

### **Purpose of the Project**

The CIMAR Ecosystems Observations and Research Project (EORP) monitors and conducts research on ecosystems that involve marine species and resources of concern to NOAA in the Pacific Islands Region (PIR). The project activities enable scientists to provide advice to those charged with management of the resources as mandated by legislation. Current project activities include:

- Outreach and Education in the Pacific Islands
- Large Marine Ecosystem/Ecosystem-Based Fisheries Management Coordination

### **Progress during FY 2023**

*Outreach and Educational Activities.* The project Outreach and Education Coordinator (Coordinator), Ali Bayless Chene, participated in a variety of activities, including mentoring two high school students from Kamehameha School through a year-long internship program that resulted in an educational monk seal video series in ‘Ōlelo Hawai‘i. The Coordinator also attended multiple community events, including career fairs and public outreach events to communicate the work the Pacific Islands Fisheries Science Center (PIFSC) is doing across PIR. Multiple inter-island site visits to partner NOAA institutions resulted in collaboration and improvement of PIFSC research communication. She also participated in escorting visits to the Daniel K. Inouye Regional Center (IRC) by high school and middle school programs, participated as a judge at the Hawai‘i State Science Fair, and developed curriculum for middle and high school science classes. In addition, she shared presentations and outreach activities with university undergraduate students and worked on development and coordination of outreach plans for ongoing PIFSC and CIMAR research communication campaigns.

*PIFSC Young Scientist Opportunity (PYSO) and Other Internship Activities.* The Coordinator led every aspect of internship project development, advertisement, and recruitment for the PYSO internship program. Multiple CIMAR staff also took a leadership role in onboarding and training of incoming PYSO student researchers. The PYSO undergraduate student program is active with four young researchers, hired into CIMAR and mentored by CIMAR and federal research staff in PIFSC over the summer months. Over the past few years, the program has been focused on developing local science undergraduates either from Hawai‘i or attending college in Hawai‘i. The Coordinator also participated in the management of the Hollings Preparatory Program and other intern participant activities. CIMAR and federal staff coordinated several events for the students, including a meet-and-greet and cultural introduction, public speaking and presentation skills workshop, Hawai‘i graduate program information session, NOAA career opportunity discussion, a service-learning opportunity, and the annual IRC Intern Symposium, which includes interns participating in a variety of national internship programs in all the local NOAA offices. The four 2023 PYSO projects are:

- Project 1: Using eDNA to assess marine biodiversity in Hawai‘i
- Project 2: Transitioning the Hawaiian Monk Seal Biological Specimen Database



(above) IRC video premiere event of He Mo'olelo 'Iliokai (Story of the Hawaiian Monk Seal). The video series was created as part of a NOAA internship project led by Kamehameha High School students and through mentorship by Stacie Robinson (NOAA) and Ali Bayless Chene (CIMAR). Photo Credit: NOAA Fisheries.

(below) Ali Bayless at an outreach event at the Maui Ocean Center, sharing a whale and dolphin activity booth to learn how NOAA Fisheries studies marine mammals in the Pacific. Photo Credit: NOAA Fisheries.



- Project 3: PIFSC Research Cruise Operations Geographic Information System Dashboard: User Friendliness Phase
- Project 4: It's all about the plankton! Exploration of zooplankton communities in the North Pacific Ocean

## Electronic Monitoring and Bycatch Estimation in Fisheries

**P.I.: Douglas S. Luther [CIMAR Project Lead: Jeffrey Hare]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Keith Bigelow**

**NOAA Goal(s):**

- Healthy Oceans

### Purpose of the Project

The purpose of the Electronic Monitoring (EM) project is to conduct research in the Hawai'i longline fishery with the objective to advance EM capabilities in PIR. This will be done through continued efforts in Artificial Intelligence (AI) and ML research to automate catch detections in the fishery with more accurate detection models. The project will also continue EM protected species research by reviewing protected species interactions collected from EM data and continue working towards EM implementation in the region. This CIMAR project provides PIFSC with important research in emerging technologies with the goal of supplementing other collected fishery information for use in research and management towards the goal of maintaining a healthy ocean.

### Progress during FY 2023

The EM program continued to advance their AI research, with an additional contract with Deloitte to upgrade several aspects of the project's Google cloud platform environment to allow for faster training compute times and increasing the number images allowed per training. With these advancements and adding annotations to their image library, project staff trained a ML object detection model. This model was successful in detecting fish on deck and sea turtles in the water and on deck using 86,000 EM program annotations. Another objective was to research the feasibility of assessing post interaction mortality of protected species using collected EM data. During this year program staff reviewed protected species interactions for marine mammals and sea turtles gathered from EM data to determine what data could be collected for the assessment of post-release mortality, a data report is currently being drafted to summarize the projects findings.

Project staff presented EM project overview and research at several events during FY 2023 including the International Fisheries Observer and Monitoring Conference in Hobart, Australia; PIFSC Fisheries



*While checking on EM systems a vessel's dog stops to say hi to project staff Jennifer Stahl. Photo Credit: Joshua Tucker.*



*Electronic Monitoring project staff Jennifer Stahl (left) and Joshua Tucker (right) on top of a turret during a Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) offices tour, while attending the 10<sup>th</sup> International Fisheries Observer and Monitoring Conference in Hobart, Australia. Photo Credit: Joshua Tucker.*

Research and Monitoring Division bi-annual meeting; Electronic Technologies steering committee meeting; the False killer Whale Take Reduction Team Meeting; and PIFSC office tour for James Chang from Senator Brain Schatz’s office. During FY 2023, staff continued to collect EM disks from 20 volunteer vessels and performed maintenance on the EM systems. The EM data is used for AI development and review of protected species interactions.

## **Fisheries Monitoring Project**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Jeffrey Hare]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Jenny Suter**

### **NOAA Goal(s):**

- Healthy Oceans
- Resilient Coastal Communities and Economies

### **Purpose of the Project**

This project covers two areas of effort in the United States (U.S.) Pacific region, an area that includes the State of Hawai‘i and three U.S. territories: American Samoa, Commonwealth of the Northern Mariana Islands (CNMI), and Guam. The areas of effort are as follows:

1. Fisheries Monitoring—fisheries data management, electronic reporting (ER), software application development and data analysis for Western Pacific region fisheries in support of the Magnuson-Stevens Fishery Conservation Act; and
2. Western Pacific Fisheries Information Network (WPacFIN)—database and application systems development and technical support for fishery partner agencies and WPacFIN.

*Fisheries Monitoring.* This effort provides PIFSC with timely and accurate Fishery Ecosystem Plan logbook data for use in research and management. A focus of the work is outreach, training and education, and collaboration with federal partners, CIMAR staff, partner agencies, and the fishing industry through electronic reporting, data

management, software development and data analysis activities for the Hawai'i and American Samoa pelagic longline fleets, including a small number of California vessels. Additionally, Fisheries Monitoring provides the fishing industry with a contact point for feedback and information exchange with PIFSC fishery scientists and managers, and support for electronic data transmission of catch and effort data.

*WPacFIN.* This effort provides the best available fisheries monitoring data for research and sustainable management of fisheries in PIR. Both CIMAR staff and PIFSC federal staff comprise the WPacFIN team. CIMAR staff work with the State of Hawai'i and territory partner agency staff, contractors, fishers, and fish dealers to create and maintain databases and data systems, implement quality control measures, and manage and synthesize fishery-dependent monitoring data. CIMAR staff also provide technical support for the software applications that WPacFIN creates, deploys, and maintains. The collaboration enables PIFSC and partner agencies to collect and manage fisheries data, as well as produce timely reports using the best available fisheries data from each island area.

Both areas of effort contribute towards the goal of maintaining healthy oceans, which provides for resilient and economically sound communities.

### **Progress during FY 2023**

*Fisheries Monitoring.* From September 2021, ER became mandatory for all Hawai'i- and American Samoa-permitted longline vessels. As of September 2022, 90% of the Hawai'i-based fleet was electronically transmitting catch and effort data to PIFSC. Planning and preparations continued for American Samoa's fleet transition to ER and the CIMAR Scientific Information Associate continued to play a key role in the project as the resident expert in ER, tablet hardware and ELog-It software.

Since the start of 2022, the CIMAR Scientific Information Associate has led the regularly scheduled standing internal ER team meeting due to having a deep level of knowledge, skills, expertise and experience with ER, the tablets and the ELog-It software, both in the field and in the office, for the Hawai'i and the American Samoa fleets. In addition to providing expertise for the American Samoa ER deployment, the Scientific Information Associate coordinated with staff at the Pacific Islands Region Observer Program American Samoa Field Office to test ER transmission on American Samoa longline vessels and do outreach with vessel operators and owners. The American Samoa fleet roll-out for ER was planned for November 2022 and the remaining effort to transition the American Samoa fleet to ER moved to the CIMAR Territory Electronic Reporting Project when this project closed out.

Between July 2022 and September 2022, PIFSC received an average of 23 sets from California vessels and an average of 4701 sets from Hawai'i vessels. For paper logbooks sets collected, 248 paper logbook sets were from American Samoa vessels, 58 paper logbook sets were from California vessels and 629 paper logbook sets were from Hawai'i vessels. Of those, a total of 736 Fast-Track records were created, 616 records from electronic logs and 120 records from paper logbooks. The Fast-Track program monitors bigeye tuna and striped marlin. The data is used to forecast landing and predict possible closure dates for the Hawai'i-permitted longline bigeye tuna fishery and striped marlin landings are fast-tracked due to stock concerns.

To electronically report logbook data, vessel captains use an Android tablet to record and transmit encrypted catch and effort data via satellite from longline vessels to a PIFSC database. ELog-It is the software application running on the mobile device. Of the 148 permitted Hawai'i vessels, 132 vessels were provided with tablets. Issues with Vessel Monitoring Systems (VMS), which is used to transmit ER data, and contacting and training new and relief captains continued to be challenging, but the Hawai'i fleet was expected to have 100% participation in the ER program by February 2023.

Education, training and outreach with captains and the industry remained a top priority and a key component to the success of the program and CIMAR staff were instrumental in providing captain support, assisting with tablet and ELog-It issues, troubleshooting and providing captains with ongoing tablet training and refreshers. When working with captains and on the docks, the CIMAR ER team continued to maintain operating procedures and precautions consistent with Corona Virus Disease 2019 (COVID-19) guidelines as part of their daily routine.

Having ER in place confirmed the long-held assertion that ER, and the corresponding increase in accuracy, would greatly reduce labor requirements in the data management lifecycle of logbooks and also in downstream areas as well.

One tangible result as vessels transitioned to ER was a reduction in manually inputted logbook data. As more of the fleet adopted ER, the CIMAR data entry team correspondingly reduced in size due to retirements and separations. The need for manual keypunching and validation remains, but in a much smaller capacity, as the Hawai'i and American Samoa fleets complete their transitions from manual paper logbooks to electronic logbook

submission with significant increases in data accuracy. Manual preparation of logbooks for keypunching, data entry and verification will remain with CIMAR staff since all vessels carry paper logbooks as a backup in case of equipment failure or when the ER Team is unable to train new captains due to time constraints or scheduling conflicts; however, ER has substantially reduced the need to increase data entry staff.

The catch-to-dealer data integration, a downstream process, saw immediate and impactful gains with ER. The integration is the process of reviewing matches and researching mismatches between longline logbook data (catch) and data obtained from the Honolulu Fish Auction (dealer). As more and more of the fleet adopted ER and the accuracy of incoming data improved, the CIMAR Fisheries Specialist saw a drastic reduction in the hours needed to complete the regularly scheduled activity. The time needed for each integration run went from two weeks of time pre-ER to just a few hours of time once every other week.

*WPacFIN.* CIMAR project staff continued the work of modernizing fisheries information systems by transitioning databases and database applications from Visual FoxPro (VFP) to MySQL and creating web-based applications for Hawai‘i Division of Aquatic Resources (HDAR).

Visual FoxPro is a database system that reached end of life, and WPacFIN is in the latter stages of transitioning remaining HDAR VFP databases to MySQL, an open-source relational database management system using Structured Query Language (SQL) to query the database. Remaining VFP applications are being rewritten as web-based applications using Radzen, a rapid application development tool, and JavaScript, a programming language for the web.

In the three months this project was active, the CIMAR Data Applications Developer and CIMAR Data Program Manager continued to migrate VFP applications to the web for HDAR. Required documentation, development and testing continued to follow industry standard best practices to shorten development lifecycles while maintaining and deploying high quality software.

The main project for the current reporting period was to create viewers for the paper forms that HDAR uses for the Fisher Reporting and Dealer System web application. Two reports were identified as being the highest priority for development of a viewer, Net Trap Dive and Tuna Handline. Internal testing for Net Trap Dive Viewer and Tuna Handline Viewer were completed in August 2022 and September 2022, respectively, and the viewers were then deployed to HDAR for user acceptance testing. Go-live deployment for both viewers was moved to the CIMAR Territory Electronic Reporting Project when this project closed out.

Other projects that were completed:

- The CIMAR Computer Systems Specialist fulfilled four data requests for Hawai‘i and the territories. Data requests included boat-based expansions for BMUS for all three territories, a commercial purchase report for BMUS for all three territories, a commercial purchase and catch report for Kona crab for Hawai‘i, a boat-based creel survey report for Guam and a transshipment report for Guam.
- “Expansions” use an algorithm, which takes fishing survey data from specific locations and times then scales up those values to estimate the total catch across a broader range of interest, such as the total catch for an entire island over an entire year.
- WPacFIN continued to provide ongoing support to Hawai‘i and the territories for all system applications developed by WPacFIN.



*Nathan Chan, in the wheelhouse of a vessel docked at Pier 38, updating ELog-It, the application used to record Hawai‘i longline logbook data. Due to tight quarters and lack of space in a vessel’s wheelhouse, Nathan wears his backpack in the front to keep his belongings off the vessel’s busy work surfaces and prevent the pack from accidentally hitting anything in the bridge. Photo Credit: Frances Tong.*



## Life History and Population Assessment Research

P.I.: Douglas S. Luther [CIMAR Project Lead: Jeffrey Hare]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Sponsor: Michael P. Seki, Felipe Carvalho, T. Todd Jones

### NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

### Purpose of the Project

The Life History and Population Assessment Research project conducts innovative life-history research on federally managed coral reef, pelagic, and bottomfish species of commercial, ecological, and cultural value, with a geographic focus on the Pacific Islands under U.S. jurisdiction. The project's research generates life history parameters (age, growth rates and fecundity estimates) for management unit species (MUS) and provides these data to CIMAR and PIFSC stock assessment scientists to improve management advice for the conservation of marine fishery resources. The stock assessment scientists utilize these biological parameters and conduct research to assess the status of pelagic and coastal stocks and the impacts of harvesting, on these stocks according to the planned regional assessment schedule and facilitate regional management strategies.

### Progress during FY 2023

CIMAR Fish Life History Biosampling Specialist, Erin Reed, continued to make progress on an assessment of reproduction life history estimates (reproductive phase and length-at-maturity) for both sexes of *Etelis coruscans* from Guam and CNMI. An additional ~50 fish increased the Guam female-specific dataset to nearly ~230 individuals. Year-round sampling continues in both areas and currently the lag between getting the samples in the territory, shipping them to the U.S, and then processing by the John A. Burns School of Medicine has slowed



The Life History Program including CIMAR staff Erin Reed, spent two weeks in American Samoa working with the Department of Marine and Wildlife Resources to build capacity, share knowledge, and teach best data collection practices for life history data to their creel survey teams. Below is a compilation of all the training and outreach in the villages that the team executed over their two-week visit. Photo Credit: NOAA.

the assessment of histology slides for the necessary life history information to deliver to stock assessments. The maturity and likelihood of fish spawning are determined by data gathered from histology slides (confirmation of sex determination, maturity, reproductive phase, and cellular stage). Still, the project is near completion with Guam female histology to have a well-informed length-at-maturity estimate in the coming months. Additionally, the project will be able to make a combined Guam/CNMI region estimate for females to use as a preliminary length-at-maturity estimate if necessary while samples are still coming in. The project continues collection to fill size bin gaps for a representative sample of sex-specific lengths likely to determine length-at-maturity for both Guam and CNMI.

Erin was working on a draft manuscript available for review by program leader and FRMD director T. Todd Jones. This draft manuscript was the product from a pilot study to investigate the use of dendrochronology (tree-ring analysis) techniques to develop aquatic biochronologies for a commercially important reef fish *Naso unicornis* or the bluespine unicornfish, from CNMI. These biochronologies are used to assess biological responses (i.e., growth rate) to extrinsic variables such as sea surface temperature and climatic variability (i.e., El Niño Southern Oscillation, or ENSO) in the face of climate change. Otoliths from fishes were used to reconstruct past environmental conditions, identify thermal events, and thus assess how marine organisms may respond to a rapidly changing climate. Lastly, Erin participated in field surveys to monitor and manage data collection of life history data for stock assessments while building capacity with state agencies in American Samoa.

CIMAR Stock Assessment Scientist, Dr. Marc Nadon, finalized an extensive exploration of the data available in American Samoa to conduct next-generation stock assessment of data-limited bottomfishes, resulting in the publication of a NOAA Technical Memorandum. Following the publication of this report, Marc Nadon led the new benchmark stock assessment for 11 bottomfish species for American Samoa. The results from these assessments passed a review by independent experts in February 2023, held in Tutuila, and was presented at the latest Science and Statistical Committee and Fishery Council meetings in Honolulu and Tutuila, respectively. The results are being finalized in a tech memo that was published in July 2023.

## **National Coral Reef Monitoring Program—Pacific Project**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Brittany Huntington]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Jennifer Samson**

### **NOAA Goal(s)**

- Healthy Oceans

### **Purpose of the Project**

The CIMAR National Coral Reef Monitoring Project (NCRMP)-Pacific is a long-term monitoring project that assesses the status and temporal trends of coral reef ecosystems in the Hawaiian Islands, Mariana Islands, Pacific Remote Islands, American Samoa, and Guam. The overall objective is to inform management of coral reef ecosystems by providing high-quality scientific data on the health of coral reefs in the U.S. Pacific Islands. This project relies upon an integrated approach with CIMAR staff coordinating research alongside federal counterparts within the Ecosystem Sciences Division (ESD) across three research foci: (1) Fish Ecology and Monitoring; (2) Benthic Ecology and Monitoring; and (3) Oceanographic Climate Change Monitoring. Combining this wealth of biological data from the fish and benthic community, with habitat data, and oceanographic information provides a unique regional database for the U.S. Pacific. Long-term datasets of environmental and biological parameters provide a framework for assessing regional patterns in coral reef ecosystems and for ground truthing broad scale satellite and model outputs from NOAA, local agencies, and other partners.

### **Progress during FY 2023**

*2022 Post-Mission Demobilization, Data Processing, and Archive.* The NCRMP–Pacific project team has spent substantial time on demobilization and data management the months following the FY 2022 NCRMP field



*Mia Lamirand takes a photo with a group of visiting school children during an NCRMP outreach event on the docks of Pago Pago Harbor, American Samoa. Photo Credit: Max Sudnovsky (National Marine Sanctuary of American Samoa).*

mission to the Mariana Archipelago. CIMAR operations staff led gear offloading, cleaning, refurbishing, and storage. CIMAR science staff focused on processing instrument data, completing data entry, and executing quality control checks. Calcification accretion unit (CAU) processing is near completion (the last set of samples are now being processed). Water samples are awaiting analysis at NOAA Pacific Marine Environmental Laboratory (PMEL). Instrument data (subsurface temperature recorder [STR], conductivity temperature and depth [CTD], sonde, diel suite) were all processed and uploaded into the database, and are currently undergoing quality checks. CIMAR data management staff led the data archive efforts for the FY 2022 mission. By the end of this report period, the data staff will have fully processed and archived at National Centers for Environmental Information (NCEI) the stratified random Rapid Ecological Assessment survey data for reef fishes, coral demography, and benthic cover. The processing of several other datasets from the Oceanographic Climate Change Monitoring effort is actively underway.

*2023 Field Mission.* This year's Rainier Integrates Charting, Hydrography, and Reef Demographics (RICHARD) mission is again hosted aboard the NOAA Research Vessel (R/V) *Rainier*. As a joint mission, the cruise aims to meet numerous research goals that span coral reef ecosystem monitoring led by ESD staff to charting and mapping objectives led by NOAA's Office of Coast Survey. Highlights include: (1) the successful completion of the sole benthic leg where ESD divers counted over 25,000 coral colonies ranging in size 1 cm to over 6 m in diameter; (2) the successful deployment of soundtraps at Howland and Baker Islands to record the sounds of the reef; and (3) installation of numerous CAU and STR to measure reef growth over time and monitor seawater heat events.



*Benthic diver Corinne Amir collects data on coral reef health at Swains Island during the FY 2023 NCRMP Pacific RICHARD cruise. Photo Credit: Brittany Huntington.*

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## **National Coral Reef Monitoring Program—PacIOOS Support for Annual Refurbishment of MAPCO<sub>2</sub> Buoy at Class III Site in American Samoa**

**P.I.: Melissa Iwamoto**

**NOAA Office (of the primary technical contact): Coral Reef Conservation Program**

**NOAA Sponsor: Ian Enochs, Valerie Brown**

**NOAA Goal(s):**

- Healthy Oceans
- Climate Adaptation and Mitigation

### **Purpose of the Project**

This project is part of a larger proposal and collaboration with Dr. Enochs at NOAA-Atlantic Oceanographic and Meteorological Laboratory to support the long-term observations of carbonate chemistry at U.S.-affiliated coral reef sites; the proposed sites here are critical to understanding the impact of ocean acidification (OA) on coral ecosystems over time. This effort addresses NOAA's Ocean Acidification Program (OAP) requirements for *Monitoring of Ocean Chemistry* by building and maintaining the coral reef portion of the OA monitoring network. Incorporating an interdisciplinary approach, the project will collect, process, analyze, and steward continuous partial pressure of carbon dioxide (CO<sub>2</sub>) and potential of hydrogen (pH) data, as well as discrete biweekly dissolved inorganic carbon (DIC) and total alkalinity (TA) calibration/validation data, to document seawater carbonate chemistry at the National Coral Reef Monitoring Program Class III climate monitoring site in Fagatele Bay, American Samoa.

### **Progress during FY 2023**

The project was successful in accomplishing both scientific objectives: continuing to validate buoy measurements through discrete water sample analyses for DIC and TA and sustain carbonate system measurements onboard the moored autonomous partial pressure of carbon dioxide (MAPCO<sub>2</sub>) buoy system through conducting a recovery, calibration, and re-deployment of the Fagatele Bay MAPCO<sub>2</sub> buoy.

## **National Ocean Acidification Observing Network—O'ahu's Linked Kāne'ōhe Bay Observing Sites**

**P.I.: Christopher L. Sabine**

**NOAA Office (of the primary technical contact): Ocean Acidification Program**

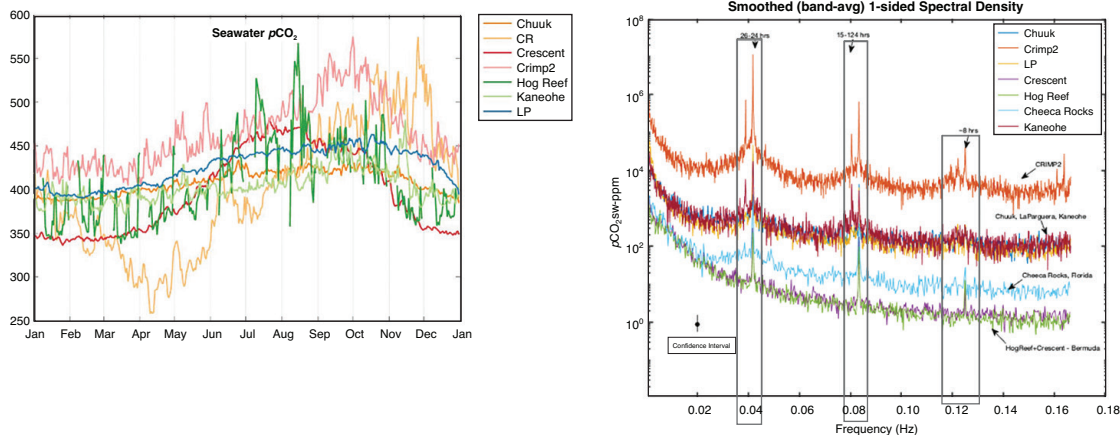
**NOAA Sponsor: Dwight Gledhill**

**NOAA Goal(s):**

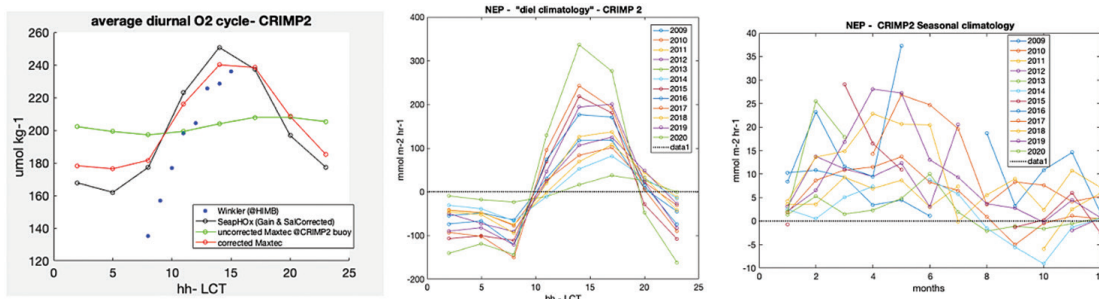
- Healthy Oceans
- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

### **Purpose of the Project**

In collaboration with NOAA's PMEL, this project aims to fulfill NOAA's OAP requirements of monitoring, analyzing, and modeling environmental change. The objective of this project is to maintain coral reef stations in the NOAA sustained observations portfolio as part of the National Ocean Acidification Observing Network (NOA-ON) and the Global Ocean Acidification Observing Network (GOA-ON). Through an interdisciplinary approach, the project will gather and analyze data on ocean acidification and seawater chemistry variations in Kāne'ōhe Bay. This will involve regular buoy refurbishment, instrument maintenance/support, and biweekly calibration/validation water sampling at specific sites within the bay. The collected data will be used to evaluate the drivers of CO<sub>2</sub> and net ecosystem calcification/net ecosystem production between the moorings, contributing



(left) Seawater partial pressure of carbon dioxide ( $pCO_2$  [ $\mu\text{atm}$ ]) for different MAPCO<sub>2</sub> located in coral reef areas in the Atlantic and Pacific. (right) Spectral analysis of the seawater  $pCO_2$  time-series at the different sites. Decomposing this time-series into its frequency components using Fourier Analysis can reveal information that may not be apparent from the time-domain representation alone.



Net Ecosystem Production at CRIMP-2 using changes in oxygen at diurnal and seasonal scales.

to understanding ocean acidification’s impacts on coral reef systems. Additionally, the project serves as a testbed for evaluating new sensors and approaches for assessing ocean acidification.

### Progress during FY 2023

Between July 2022 and June 2023, significant efforts were devoted to maintaining buoys, moorings, and instruments. The Kāne’ohe site, which experiences high swells throughout the year, particularly during winter storms, had its ten-year-old anchor replaced with a new one. In collaboration with PMEL, the UH team developed and implemented a new mooring design (four bungees instead of three) in July 2022 to reinforce the buoy’s resilience to storms. The team tackled common challenges associated with buoys and instrumentation, including calibration, maintenance, battery replacements, and data transmission. The mooring at the coral reef instrumented platform-2 (CRIMP-2) site was also replaced during this period, and instruments were sent to PMEL for calibration. The project continues to collect and analyze bottle samples for the subsequent laboratory determination of DIC and TA at two-week intervals (weather and sea conditions permitting). The project submitted a validation dataset through the end of 2022 to NCEI on March 2023, continuing the dataset submitted with Accession Number 0176671.

Furthermore, the CRIMP-2 site has served as a testbed for evaluating new instruments. Over the past year, the project conducted tests with two soundscapes sensors, a water quality buoy from DURO Sonde, a Sunburst submersible autonomous moored instrument for alkalinity (SAMI-alk), and a high-frequency SeaFET pH drifter, further advancing their understanding and capabilities in monitoring ocean acidification and its impacts on coral reef ecosystems.

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## Science Operations in the Pacific Islands Region

**P.I.: Douglas S. Luther [CIMAR Project Lead: Kyle Koyanagi]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Noriko Shoji**

### NOAA Goal(s)

- Healthy Oceans

### Purpose of the Project

This project's mission is to support analyses and evaluation of fishery independent data and collection methods for insular fish stocks in PIR; provide operational and logistical services to support PIFSC research missions and projects; promote the development of advanced and innovative survey and sampling technology and techniques; provide operational and logistical support for research infrastructure and aquaculture systems management; provide support to enhance fisheries research data management; and create products and tools that provide a mechanism for efficient access to fisheries data and information. Four project elements are included in the project description:

*Analysis and Evaluation of Fishery Independent Data, Habitat, and Collection Methods for PIFSC Research Missions and Activities.* As the effective management of limited fisheries resources becomes increasingly critical, improvements in data collection methodologies are required to expand the team's knowledge of target fish assemblage dynamics and supplement existing fisheries data sets. The Marine Optical Imagery (MOI) Team provides support for fishery-independent surveys of commercially important fish species, optical imagery and analysis technology advancement, and habitat evaluation, to enhance fisheries management through the analysis and evaluation of optical and acoustic data streams to support PIFSC's research activities throughout PIR.

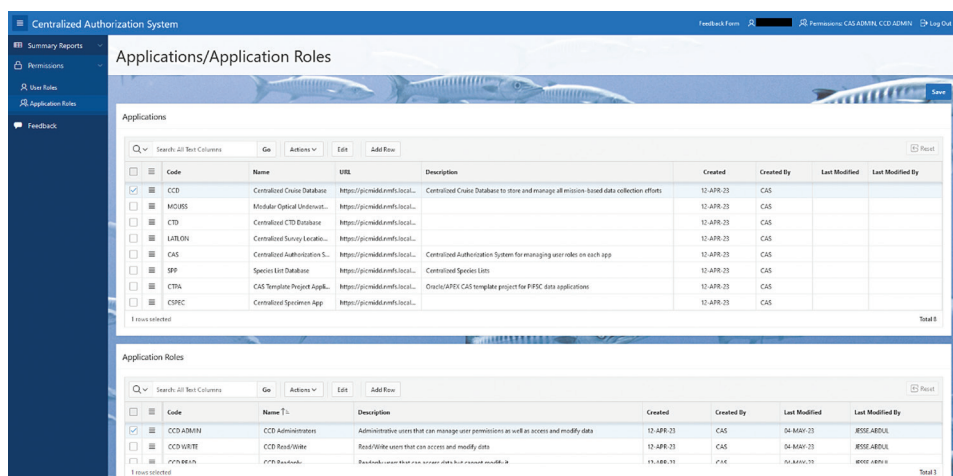
*Operations and Logistics Services to Support PIFSC Research Missions and Activities.* As scientific field campaigns become more complex with multi-faceted, multi-platform, multi-disciplinary, and technologically advanced endeavors, the responsibilities of scientists have grown such that dedicated and trained CIMAR staff to support planning and execution of desired science endeavors are necessary. Science operational staff direct research by collaborating with NOAA and CIMAR investigators to plan effective use and maintain operational readiness of equipment and resources and ensure operations are conducted safely and according to established policy. This model allows scientists to focus on their research objectives, while expert staff help plan, coordinate, and execute safe, effective, and efficient science operations.

*Advanced Technology, Marine Instrumentation, Design & Fabrication, Acquisition, and Infrastructure Support for PIFSC Research and Activities.* This project keeps abreast of emerging new technologies to enable PIFSC to remain on the cutting edge of fisheries research and innovatively uses existing technology to design and develop tools, equipment, marine instrumentation, and other physical products to enhance ecological data sampling efforts, which support the conservation and management of coastal and marine ecosystems in PIR. The project additionally provides day-to-day operational support for the PIFSC Marine Instrumentation Laboratories (MILs) and infrastructure support for the state-of-the-art PIFSC Marine Animal Recovery Facility (MARFAC), which provides an aquaculture environment suitable for maintaining the well-being and vitality of endangered Hawaiian monk seals, protected marine turtles, and various species of fish, algae, corals, and other marine life.

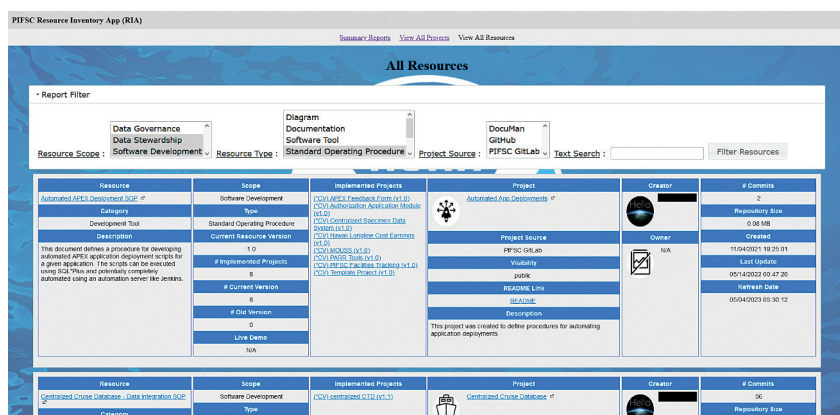
*Enhanced Fisheries Research Data Management to Support PIFSC Research Missions and Activities.* With the advancement of fisheries survey and sampling technology, larger volumes of data are produced making it critical to develop tools to collect, preserve, manage, and disseminate data streams. The Enhanced Fisheries Research Data Management Project continuously supports fishery and ecosystem research and data stewardship within PIR. The project provides software development and data stewardship support and services to researchers at the PIFSC to facilitate quality scientific research and resource management.

### Progress during FY 2023

*Analysis and Evaluation of Fishery Independent Data, Habitat, and Collection Methods for PIFSC Research Missions and Activities.* The MOI team fully comprised of CIMAR staff operating under the Analysis and



Screenshot from the Centralized Authorization System (CAS) app's Applications/Roles page that allows authorized administrators to manage applications and their associated roles. Sensitive information has been redacted.



Screenshot from the Resource Inventory App that provides a searchable interface to identify existing software and data resources to facilitate their reuse. Sensitive information has been redacted.

Evaluation of Fisheries Independent Data, Habitat, and Collection Methods for PIFSC Research Mission and Activities project supports PIFSC researchers and partners to maintain and improve fisheries image-based data streams. The MOI team completed the Modular Optical Underwater Survey System (MOUSS) video analysis for the 2022 Bottomfish Fishery Independent Survey in Hawai‘i (BFISH), resulting in a size-structured species abundance data product delivered to the Fisheries Research and Monitoring Division (FRMD) Stock Assessment Program (SAP). The video data set was additionally evaluated for dropped frame and camera recording issues, which led to updating an internal MOUSS Camera Error Report in 2023.

During the reporting period, the MOI team worked with the developer of the Video and Image Analytics for a Marine Environment (VIAME) open-source automated image analysis toolkit to determine if the software could be used to streamline and improve PIFSC video data analysis workflow. Efforts over the last year utilized a single frame high accuracy data set that was processed through the Wide Area Motion Imagery (WAMI) viewer software to interpolate and create new Deep 7 bottomfish annotations used to expand the data set refining the model to increasing its efficiency and accuracy. Continued effort will be needed to evaluate whether VIAME may prove useful for future analysis workflow.

The MOI team additionally evaluated photo annotations generated by the citizen scientist project OceanEYES (on the Zooniverse platform), which encourages the public to participate in the scientific process by reviewing images from its annual MOUSS BFISH surveys. Over the last year OceanEYES has had 6,935 new volunteers,





*Testing of a high-speed mini surface trawl designed and fabricated by the Marine and Applied Knowledge for Ecosystem Research Laboratory (MAKER Lab) on the Big Eye Tuna Research Mission aboard the NOAA R/V Oscar Elton Sette. Photo Credit: Johanna Wren.*

with a total of 17,348 volunteers who helped process images since the project began in September 2020. This year, OceanEYES has processed 86,347 images with public volunteers identifying a total of 1,298,351 fish. The OceanEYES project has included volunteers in more than 67 countries and from all age groups. Having such a high volume of annotations, with a wide range in user content knowledge, assessment of user accuracy was completed from the first version of the citizen science project, which used only one photo for the volunteers to base their fish identifications on. Completion of an assessment concluded that the addition of two sequential photos instead of one for the user would increase accuracy. The idea behind this was that the second photo could potentially track the fish into a more visible position or show movement in the substrate indicating that a fish was present. The use of the two sequential photos in the second version now has over one million classifications and will be compared to the first version to ascertain if accuracy was improved.

*Operations and Logistics Services to Support PIFSC Research Missions and Activities.* During the reporting period, the Science Operations Division (SOD) Survey & Operations Services CIMAR staff supported multiple PIFSC projects by providing logistical, operational and small boat support to all PIFSC Divisions. This year, CIMAR was heavily engaged in operations planning, mobilization, execution, and demobilization of SE-22-07 BFISH surveys aboard NOAA R/V *Oscar Elton Sette* and Pacific Islands Fisheries Group (PIFG) contract vessels. Missions aboard NOAA R/V *Oscar Elton Sette* also included Research and Development operations, which tested prototype lighting systems on MOUSS. CIMAR staff followed 2022 PIFG-MOUSS and the SE-22-07 BFISH missions with operational report-outs and post-mission debriefs. The 2022 survey effort was significantly greater compared to 2021, doubling the total MOUSS work to 200 grids surveyed (400 deployments), while the Temperature Depth Recorder (TDR) work again included the research fishing portion of the survey in addition to the MOUSS. The report-out reflected on the successes and challenges of the survey with recommendations to mitigate issues encountered.

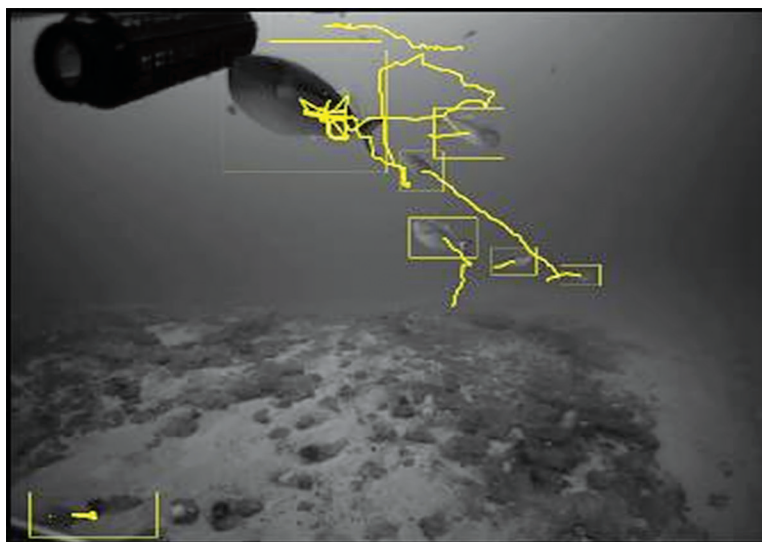
CIMAR staff additionally supported PIFSC research activities with vessel operations coordination for PIFSC Divisions, assisting in the management of small boat operations and assets. SOD CIMAR staff managed the Division's small boat and trailer maintenance and repairs, ensuring that these PIFSC assets met or exceeded NOAA Small Boat Program (SBP) safety standards, thereby minimizing safety risks and any loss of project operational days due to mechanical breakdowns. Annual Small Boat Evaluations (ASBEs) and Annual Trailer

Evaluations (ATEs) were performed on PIFSC assets by CIMAR staff to fulfill NOAA SBP requirements and to keep assets operational. CIMAR Staff served as the subject matter expert to outline custom modifications required to alter a new boat trailer and helped facilitate assembly (by supplying photos and measurements to the trailer vendor as needed). Staff also assembled, rigged, and outfitted a new 19-foot inflatable boat with twin engines, to replace an existing asset that is at the end of its lifecycle.

*Advanced Technology, Marine Instrumentation, Design & Fabrication, Acquisition, and Infrastructure Support for PIFSC Research and Activities.* The Marine and Applied Knowledge for Ecosystem Research Laboratory (MAKER Lab) team that operates under the Advanced Technology, Marine Instrumentation, Design & Fabrication, Acquisition, and Infrastructure Support for PIFSC Research and Activities project closely works with PIFSC Researchers to design and develop innovative tools, equipment, instruments and other physical products to enhance ecological data sampling efforts, which support the conservation and management of coastal and marine ecosystems in PIR.

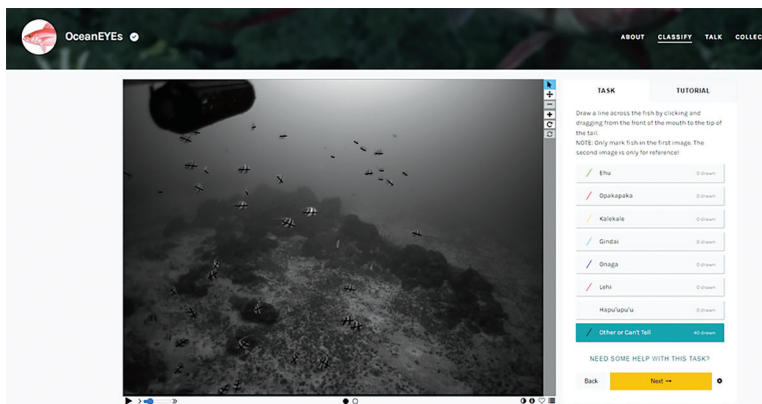
During the performance period CIMAR Staff in the MAKER Lab was able to support a number projects within PIFSC with their design and fabrication needs including the development of three battery banks with solar charging capability to support Hawaiian Monk Seal Research Program (HMSRP) field camp operations, design and production of new biopsy bolts to collect tissue samples for the Cetacean Research Program (CRP), and design and fabrication of railing fishing pole adapters to support the Life History Program (LHP) with its bottomfish sampling efforts. The project additionally worked with Pelagic Research Program researchers to design and fabricate a high-speed mini surface trawl, which will be used to support several projects including the collection of biological and anthropogenic samples in the neustonic layer, such as early life history stages of commercially-important fish species (e.g., bigeye tuna [*Thunnus obesus*]) and floating microplastic debris. CIMAR Staff were also essential in supporting ongoing in-house projects including the artificial lighting system to compliment the MOUSS, 360 camera systems, and the development of the next generation stereo camera system to support future BFISH survey efforts.

CIMAR staff supported facility and infrastructure maintenance and daily activity oversight for the MILs and the MARFAC. CIMAR staff conducted routine safety inspections, testing, maintenance, and troubleshooting of critical components including the recirculation, video camera, and Supervisory Control and Data Acquisition



(above) Screenshot from the VIAME software with annotation track lines on fish seen during a MOUSS camera deployment. Ingesting additional identified photos into the VIAME software will enhance model training.

(below) Screenshot showing lines drawn on non-target fish from the OceanEYES citizen science toggle workflow (Zooniverse.org). The OceanEYES platform allows the public to assist in scientific research to facilitate processing large data sets. <https://www.zooniverse.org/projects/benjamin-dot-richards/oceaneyes>



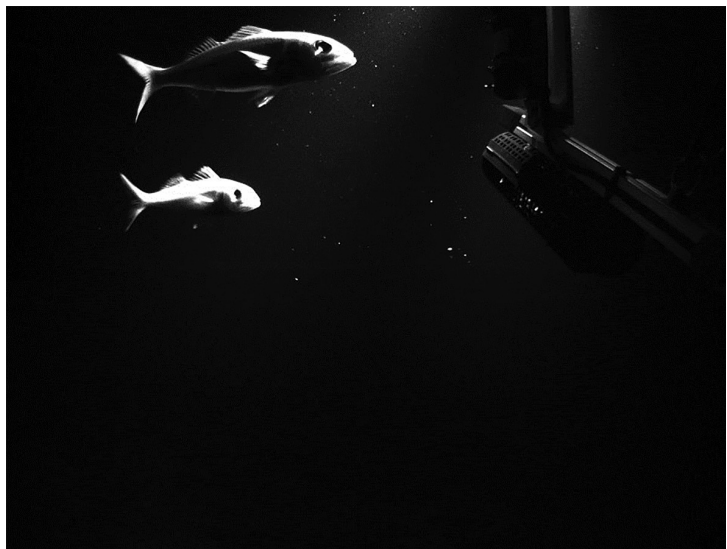
(SCADA) systems to maintain MARFAC operational readiness. During the performance period CIMAR staff were instrumental with the completion of the new Seal Beach tank facility and the installation, testing, and troubleshooting of a critical new SCADA program for the MARFAC. CIMAR staff additionally provided support to assist with four (4) monk seals housed in the new Seal Beach facility. Other NOAA projects supported were the MOUSS camera calibrations, Remotely Operated Vehicle (ROV) buoyancy and mobility testing, Seaglider (Autonomous Underwater Vehicle) ballasting and calibration testing, and HMSRP field camps.

*Enhanced Fisheries Research Data Management to Support PIFSC Research Missions and Activities.*

During the performance period CIMAR staff provided troubleshooting, consultation, and collaboration support to PIFSC for data processing and stewardship, database and application development, software development, and server administration to improve the functionality and quality of the data projects. Accomplishments were broad in scope including the development of ten software development best practices; three procedures that streamline the software development process including automated database testing and implementing template projects for new or existing data systems; six new or upgraded enterprise solutions that address software development and data stewardship needs including data archival tools and modules to perform authentication and authorization; and two new data systems implemented as containerized web applications that provide on-demand information about PIFSC data sets as well as existing PIFSC software and data resources to facilitate their reuse. CIMAR staff played an instrumental role leading the PIFSC Software Development Team (SDT), improving the quality of data stewardship through a variety of tactical software activities. The SDT identified shared software development and data stewardship needs including data system



Recovery of the MOUSS camera system with green led lights on R/V Oscar Elton Sette during the SE-22-07 Bottomfish cruise. Photo Credit: Christopher Demarke.



Screenshot capturing the illumination of a Deep 7 species, ehu (*Etelis carbunculus*) with the lighting system on the MOUSS during the SE-22-07 Bottomfish cruise (oprcode: 20220924\_220542, depth: 291m).



*Christopher Demarke at the Punahou Sustainability Fair outreach event displayed a 19' Safeboat and MOUSS unit and spoke to students about how it is used to collect optical imagery data on fish abundance. Photo Credit: Benjamin Richards.*

modernization, data sharing, and version control support. CIMAR staff served as technical experts on the Data Governance Implementation Team and made substantial contributions to the planning of a Data Governance Program for PIR. The project developed a comprehensive reporting system that retrieves information from the National Marine Fisheries Service (NMFS) metadata repository and generates separate custom reports for each PIFSC research division and program that clearly identify problematic metadata values for resolution.

The CIMAR project facilitated the integration of data holdings across divisions by developing a Centralized Authorization System (CAS) that centrally manages user access to multiple centralized data systems. The CAS was implemented in a Centralized Cruise Database, which is in the process of being integrated into two separate data systems to provide working examples of how to integrate these centralized data systems into new and existing data projects. The CIMAR project collaborated with ESD to identify additional centralized data systems that could be established to enable the integration of data within and across divisions to facilitate integrated analyses.

## **Sustaining Healthy Coastal Ecosystems Project**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Brittany Huntington]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Jennifer Samson**

**NOAA Goal(s)**

- Healthy Oceans

### **Purpose of the Project**

The CIMAR Sustaining Healthy Coastal Ecosystems (SHCE) project is a multi-disciplinary research endeavor, which seeks to monitor and assess the condition of coral reef ecosystems in MHI, the Northwestern Hawaiian Islands (NWHI), the Pacific Remote Island Areas, CNMI, American Samoa, and Guam. The overall project goal is to inform effective management by providing high-quality scientific data on the health and vitality of coral reefs and reef fish communities, including evaluating and reducing adverse impacts to coral reef ecosystems in the

U.S. Pacific Islands. These impacts include: (1) land-based sources of pollution (LBSP); (2) fishing impacts; and (3) climate impacts. Future goals include developing effective coral restoration and intervention strategies. This interdisciplinary, integrated approach to ecosystem monitoring requires coordinated research from the CIMAR staff in the NOAA National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Science Division (ESD).



Ariel Halperin gives a presentation on the lasting impacts of derelict fishing nets to coral reefs in the NWHI. Photo Credit: Ariel Halperin.

### Progress during FY 2023

*Bleaching Surveys.* The bleaching project is investigating the long-term impacts of the 2019 bleaching event in the Hawaiian Islands on coral recovery, demography, and three-dimensional (3D) reef structure. Using the Structure-from-Motion (SfM) imagery collected at sites during the 2019 bleaching surveys and resurveyed in 2020-2022, photomosaic models were generated and coral demographic (including bleaching metrics) were extracted. Data analysis is ongoing and the project is poised to meet all stated objectives by the end of 2023.

*LBSP Assessments in American Samoa.* The LBSP project aims to develop a coral reef baseline and monitoring strategy for Aūa, American Samoa (a priority watershed) from which the effectiveness of future management interventions in the watershed can be assessed. Aūa biological and water quality baseline surveys were completed from September 8–29, 2022. Benthic surveys were conducted at 18 shallow reef sites, and coral colony-level data gathered for size, taxonomic identity, and condition. Photo-quadrats and SfM optical data were collected for benthic composition and topographic complexity. CTD profiles and water samples were acquired at all sites. Water samples were measured for pH and alkalinity, and filtered for total suspended solids, dissolved and particulate nutrients, dissolved organic carbon, and chlorophyll-a. Finally, data were also collected to characterize non-coral bioindicators of LBSP, including benthic diatoms, macroinvertebrates, and benthic foraminifera. Data processing and quality assurance (QA)/quality control (QC) dominated much of this reporting period. Data analysis and report writing is currently underway. The final project objective—a larger regional analysis of LBSP drivers of coral reef benthic community structure across several watersheds in American Samoa—will not be completed due to COVID-19 delays in the Aūa field mission and the resignation of the lead CIMAR scientist (Dr. Vargas-Ángel) on this project in December 2022.



Candace Alagata collects coral data for carbonate budget analysis on a Self-Contained Underwater Breathing Apparatus (SCUBA) dive in the Marianas Islands. Photo Credit: Hannah Barkley.

*Structure from Motion (SfM) Research and Development.* CIMAR staff completed benthic annotations from SfM imagery for 100 benthic sites collected during the FY 2022 National Coral Reef Monitoring Program (NCRMP) mission to Guam and CNMI. CIMAR staff then led a comparative analysis between coral demographic data collected *in situ* by divers and those derived from SfM to assess any methodical bias in the transition to SfM. Coral vital rates analyses (i.e., growth, fission, and fusion of coral colonies over time) were completed in the summer. This dataset and subsequent analysis was delayed from the original proposal due to the effects of COVID-19 on the NCRMP expedition calendar.

*Coral Resilience.* CIMAR Coral Reef Researcher Dr. Courtney Couch’s paper exploring temporal patterns of juvenile coral density across the U.S.-affiliated islands and atoll in the central Pacific is currently in review at *Frontier in Marine Science*. Dr. Brittany Huntington (ESD Division Manager) published an analysis of the reef calcifiers across the U.S. Pacific—revisiting a previously established pattern of greater calcifier cover on uninhabited reefs. Using contemporary NCRMP data, Huntington and her co-authors found this pattern no longer detectable on U.S. Pacific reefs. CIMAR staff Ariel Halperin published a paper in *Marine Pollution Bulletin* on the lasting impact of derelict fishing net scars on shallow coral reefs in NWHI.

*Carbonate Budgets.* In FY 2023, the carbonate budgets team has processed pilot data from ten sites in Guam and CNMI collected during the 2022 NCRMP mission. Data analysis of these data are near completion. Once finalized, these results will be incorporated into a methods comparison to determine the best approach for conducting carbonate budgets as part of Pacific NCRMP. As field work and *in situ* methods testing for the Pacific Islands carbonate budget project was delayed six months due to COVID-19, the “Carbonate budget standard operating procedure” is delayed into early FY 2024.

*Fisheries Management and Herbivory.* The Marianas temporal trends project aims to integrate NCRMP and local coral reef monitoring data using down-scaled data at sub-island scales to assess the decadal responses of benthic and reef fish communities to warming events in the Mariana archipelago. The project team has completed its report on trends in benthic indicators and submitted the report to PIFSC editorial in the summer. The 2022 Kahekili Herbivore Fisheries Management Area report was also completed in this reporting period documenting temporal change in herbivore size and biomass as well as changes in the reef benthic community in this nearshore area.

## **Territory Electronic Reporting Project**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Jeffrey Hare]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Jenny Suter**

### **NOAA Goal(s)**

- Healthy Oceans
- Resilient Coastal Communities and Economies

### **Purpose of the Project**

This project’s effort focuses on the three U.S. territories in the Pacific region, American Samoa, CNMI, and Guam.

The primary component of this project is to create a suite of applications that can run on mobile devices, smartphones and tablets, primarily, as well as desktop and laptop computers to allow for commercial catch and effort data from fishers and fish sales data from vendors to be electronically reported with data going to PIFSC and WPacFIN. WPacFIN assists the territories with database and application systems development as well as providing technical support to fishery partner agencies.

The effort will also modernize fisheries information systems in the territories and move them from Visual FoxPro (VFP) applications to progressive web applications (PWA) for both agency office fishery applications and electronic reporting (ER) for fishers and vendors. The overarching plan is to develop a “Log It Suite” consisting of three modules: (1) “Catch It Log It,” to log and transmit catch and effort data; (2) “Sell It Log It,” to log and transmit sales data; and (3) Admin Portal for administrative and reporting activities.

Two smaller components of this project are as follows: (1) assist with planning and preparations for American Samoa's ER project for the longline fleet; and (2) provide ongoing technical support to Hawai'i and the territories for all system applications developed by WPacFIN.

Territory fisheries are regionally and culturally important commercial, recreational and subsistence fisheries. Reliable data on total removals and effort is needed to assist in the management of fishery species and maintaining healthy oceans, which provides for resilient and economically sound communities. With its inherent reach and scalability, ER will provide fisheries managers and stakeholders with access to higher quality and more timely data, which cannot be met currently with existing in-person data collection programs.

### **Progress during FY 2023**

The history of the territory ER project started with a pilot project created by WPRFMC 2019 for fishers in the territories to electronically self-report catch data via mobile devices. WPRFMC worked with an external software development contractor to develop a lightweight application, "Catch It Log It", to record and transmit catch and effort data to WPRFMC's Cloud server.

In November 2021, WPRFMC turned over the application to a different contractor team and WPacFIN to finish the development of the "Log It Suite". WPacFIN started work on "Sell It Log It" with the software contractor as the primary developer and CIMAR's role would be to produce artifacts and other work to support the project and software development needs.

"Sell It Log It" would be used by vendors to electronically record and submit commercial receipts for fish sales thereby replacing the VFP commercial receipt book application. This is the start of moving the territories off of VFP and modernizing their data collection and data management efforts. CIMAR staff contributed programming and software development expertise as well as exceptional knowledge and understanding of the territory datasets, workflows, dataflows, processes, VFP applications and territory technical needs.

Visual FoxPro is a database system that has reached end of life and WPacFIN is in the beginning stages of transitioning territory VFP databases to the Cloud and VFP applications to PWA, a new alternative for mobile development. PWAs are built using web technologies and can be installed and run on many different devices, all from one codebase. It has many advantages and benefits for the territories and partner agencies as well as for WPacFIN programmers and PIFSC scientists and researchers. PWA is also a good fit for the technical and mobile resources available to territory fishers, vendors, partner agencies and WPacFIN.

The Hawai'i and American Samoa longline fleets are transitioning from paper logbooks to electronic logbooks. After the Hawai'i roll-out was well underway, the focus turned to planning and preparing for the American Samoa fleet roll-out. The CIMAR Scientific Information Associate played a key role in the project as the resident expert in ER, tablet hardware and ELog-It software. During the seven months this project was active, the below was accomplished.

The CIMAR Computer Systems Specialist created five new VFP applications for the territories to run locally to fix database data automatically and on-demand. The applications not only fixed incoming and existing data, it also fixed 25 known data issues resulting in cleaner, more accurate and more reliable data. This project allowed the territories to maintain existing systems and data entry activities while "Sell It Log It" was in development. Planning for the project started in July 2022 with development starting in September 2022; work is ongoing as of January 2023. As of January 2023, this project continued under a different grant.

Additionally, the CIMAR Computer Systems Specialist worked on a number of VFP software fixes for the territories to continue to help partner agencies maintain and improve their data entry and data management activities while also participating in project and software development planning for "Sell It Log It".

For Guam, the Computer Systems Specialist fixed a calculation for multi-day fishing trips in the shore-based application and added Lunar Day to the boat-based and shore-based applications.

For CNMI, the Computer Systems Specialist updated the shore-based application to identify weekdays and weekends according to CNMI's Division of Fish and Wildlife (DFW) definition for fishery-dependent data. For the boat-based application, updates were made the user interface and database rules for the entry of employee shift times after midnight. For both the shore-based and boat-based applications, short names and species abbreviations were removed from the species dropdown list. In addition, the CIMAR Computer Systems Specialist assisted DFW staff with the digital imaging archive application. System files were clean up and the application was reinstalled.

For Hawai‘i, the Computer Systems Specialist updated the HDAR Fisher Reporting and Dealer System (FRDS) desktop app to add a Received Date field to the user interface. The Monthly Fishing Report screen did not have a field to record Received Date for incoming, manually entered paper reports. This was started and completed in December 2022.

As part of the HDAR project to migrate VFP to web-based applications, two major projects were completed for the FRDS web application by the CIMAR Data Applications Developer and CIMAR Data Program Manager: (1) all testing was completed for the Net Trap Dive and Tuna Handline Viewers and the viewers officially went live in December 2022; and (2) planning for the Monthly Fishing Report Editor, the next phase of development, began in October 2022, requirements and test cases were written and completed in November 2022, and reviewed by HDAR staff in December 2022. As of January 2023, this project continued under a different grant.

Other projects that were completed:

- The CIMAR Scientific Information Associate (Associate) provided technical support over telephone and by email from Hawai‘i to two federal staff (one ER team member) who were on site in American Samoa in November 2022. The federal staff were there to introduce and demonstrate the ER application to permit owners, captains and vessel operators. The application uses the vessel’s Vessel Monitoring System (VMS) to transmit ER data to PIFSC and the Associate coordinated requests to a VMS company to enable transmission from vessels. The Associate also monitored and confirmed receipt of ER test data at PIFSC. One tablet was successfully deployed. Additionally, as part of the ER program at PIFSC, the Associate continued to lead the regularly scheduled standing internal ER team meeting. As of January 2023, this project continued under a different grant.
- The CIMAR Computer Systems Specialist fulfilled three data requests for Hawai‘i: a catch report for precious corals, a catch report for Deep 7 Bottomfish and a commercial purchase report for Deep 7 Bottomfish.

WPacFIN continued to provide ongoing support to Hawai‘i and the territories for all system applications developed by WPacFIN.

## Ecosystem-Based Management

*Research under this theme focuses on facilitating an ecosystem approach to management in the Pacific Islands region. CIMAR research interests include investigations of the human dimensions of fisheries management, studies of the economic impacts from changes in fisheries, assessments of pelagic and insular fisheries stocks, and extensive public outreach and education efforts.*

### Economics and Human Dimensions of Marine Ecosystems

**P.I.: Douglas S. Luther [CIMAR Project Lead: Adam Ayers]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Justin Hospital**

**NOAA Goal(s):**

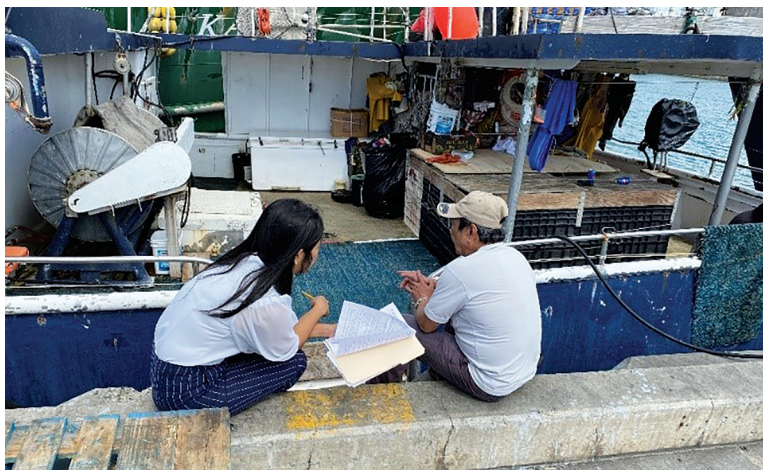
- Healthy Oceans
- Climate Adaptation and Mitigation
- Resilient Coastal Communities and Economies

#### **Purpose of the Project**

The CIMAR Economics and Human Dimensions of Marine Ecosystems project supports effective management of fisheries and marine ecosystems in the U.S. Pacific Islands region by conducting economic and human dimensions research through partnerships and collaborations with NOAA Fisheries, the University of Hawai‘i, and other relevant stakeholders. The project seeks to understand the role of human behavior in fisheries, to improve outreach and communications, and to contribute to the well-being of Pacific communities. This project is multifaceted and includes three project focus areas: (1) characterize fisheries, fishing communities, and social-ecological systems; (2) analyze and model dynamic relationships between fishing communities, governance processes, ecosystems,



and climate; and (3) enhance access and participation in science and management. Within each of these thematic areas, individual projects may include economic (trip-cost) data collection programs, economic impact analysis of key U.S. Pacific Island fisheries, assess changes in key economic indicators in fisheries, provide support for community social vulnerability or environmental justice indicators, conduct socioeconomic monitoring for resilient Pacific communities, conduct various cost-earnings studies, model fisheries trip-costs, utilize the burgeoning science of compliance to improve the one's understanding of sensitive and non-compliant fishery activities, evaluate interactions between specific bycatch species and small boat fisheries in a human dimension context, examine the allocative foundation for catch share management of commercial fisheries, assist with the modelling of climate change impacts on the economic viability of fishing, assist with modeling the effect of observers on fishing behaviors, understand and develop communication strategies with fishing communities, analyzing governance processes and compliance, integrate social/economic/cultural components into ecosystems models, and utilize advanced technologies to enhance data collection and analysis whenever feasible.



*CIMAR Temp Hire Longline Research Assistant and Translation specialist Kim-Dung Nguyen conducts a cost-earnings survey with a Hawai'i longline fishing vessel owner at Pier 38 in Honolulu, Hawai'i. Photo Credit: Adam Ayers.*

### Progress during FY 2023

*Characterize fisheries, fishing communities, and social-ecological systems.* Jonathan Fisk analyzed interviews conducted in American Samoa on the gendered dynamics of fisheries and published interview results in a manuscript. Fisk was a contributing author of a book section on mixed method approaches to study sociocultural ecosystem services. Fisk was also a lead author of a book chapter summarizing cultural ecosystem services frameworks to study the cultural dimensions of biocultural systems.

Adam Ayers led a research effort and drafted a publication (currently in PIFSC review) along with several CIMAR Socio-Ecological and Economic Systems co-authors, titled "Characterizing Hawai'i boat-based non-commercial fisheries to improve engagement." The publication characterized Hawai'i boat-based non-commercial fisheries by analyzing five recent social surveys, conducting and analyzing interviews with local and national engagement experts, examined boat-based non-commercial fisheries presence on multiple social media platforms, and developed recommendations to improve engagement.

Sarah Medoff and Adam Ayers, along with federal employee Justin Hospital, developed a draft 'report card' that summarizes important ecosystem and socioeconomic factors relevant to the main Hawaiian Islands uku fishery. The report card involved analyzing relationships between ecosystem and socioeconomic variables on participation and effort in the uku fishery. Crystal Dombrow completed an analysis of American Samoa Small Boat surveys and published a NOAA Administrative Report titled "Economic and social characteristics of the American Samoa small boat fishery: 2021."

*Analyze and model dynamic relationships between fishing communities, governance processes, ecosystems, and climate.* Sarah Medoff completed a manuscript titled "Estimating Relative Efficiency Gains from Industry Consolidation: A Case Study from the Hawai'i Longline Fishery" and submitted it to PIFSC review. In her manuscript, Medoff examined the efficiency gains from Hawai'i longline industry consolidation. Medoff also developed code to automate calculations of community social vulnerability indicators for Hawai'i communities and Tier 1 economic indicators for the Hawai'i Deep-7 bottomfish fishery.

Jonathan Fisk and Crystal Dombrow were contributing authors on a NOAA technical memorandum on ecosystem-based fisheries science in the region.

*Enhance access and participation in science and management.* Adam Ayers, along with federal colleague Beth Lumsden, completed 36 interviews of Hawai‘i community members to gather input on NOAA Fisheries draft Equity and Environmental Justice (EEJ) strategy. Ayers analyzed interview data and shared it with interviewees via a feedback report. The analysis was also submitted as part of NOAA Fisheries EEJ feedback for the region and nationally. The focus of the interviews was how to make NOAA fisheries science and management more equitable.

Jonathan Fisk was a contributing member of the Holomua Advisory network that assisted HDAR in their 30x30 initiative and collaborated with a sociocultural group to improve community-level resource monitoring efforts.

## Protection and Restoration of Resources

*This theme seeks to develop tools and approaches for protection and restoration of living marine resources, habitats, and ecosystems in the Pacific Islands region. CIMAR scientists work to protect, restore, and educate the public on endangered species of marine turtles, Hawaiian monk seals, and cetaceans. CIMAR works to protect and restore pelagic and insular fisheries through stock assessments, fisheries monitoring, and fisheries information exchange. CIMAR also conducts research and mitigation efforts on marine debris around the Pacific Islands.*

### Cetacean Research in the Pacific Islands Region

**PI: Douglas S. Luther [CIMAR Project Lead: Marie Hill]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Erin Oleson**

**NOAA Goal(s)**

- Healthy Oceans

#### Purpose of the Project

This project is charged with assessing the status of cetacean stocks within the U.S. Exclusive Economic Zone (EEZ) waters of PIR, which encompasses the EEZ around the entire Hawaiian Archipelago, Johnston Atoll, Kingman Reef and Palmyra Atoll, Baker and Howland Islands, Jarvis Island, American Samoa, Wake Island, Guam, and CNMI. At least thirty-four cetacean stocks occur in the Hawaiian EEZ alone, and many more exist in the other PIR EEZs, though most are largely unstudied. Assessment of cetacean stocks includes conducting inventories of species within each PIR EEZ, followed by evaluation of the structure of the stocks within each EEZ, the population status of each stock, and evaluation and mitigation of human impacts on cetacean stocks.

#### Progress during FY 2023

The Cetacean Research Program spent most of FY 2023 preparing for the upcoming five-month Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS, pronounced “high-seas”) scheduled to sail June 28 to December 5, 2023. HICEAS 2023 is similar to the previous three HICEAS surveys conducted in 2002, 2010, and 2017, such that it will use similar methodology across the same study area (U.S. waters surrounding the entire Hawaiian archipelago). The survey’s three major research objectives are: (1) visual observations, including photo-identification, biopsy sampling, and satellite tagging, to estimate cetacean abundance; (2) passive acoustic monitoring using towed hydrophone arrays and drifting recorders to detect, track, and record vocalizing cetaceans; and (3) ecosystem assessments, including seabird surveys, recording weather observations, plankton tows, and daily CTD measurements to provide habitat information. CIMAR staff (Marie Hill, Kym Yano, Erik Norris, and Yvonne Barkley) were involved in preparation efforts for HICEAS, which included repairs and improvements to survey gear and equipment, updating and streamlining the electronic data collection database, defining survey design and project operations, improving protocols and instructional documents, and developing a project website for the public to track survey progress.

CRP utilizes passive acoustics to study cetaceans and has a suite of instruments that are used for different purposes. Stationary devices called High-frequency Acoustic Recording Packages (HARPs) are deployed on the seafloor and used to assess year-round presence of cetaceans in remote locations where the project cannot survey regularly with a ship (e.g., Wake and Pagan Islands) or where there are long-term studies like off the Kona Coast of Hawai'i Island. During FY 2023 Erik Norris successfully replaced HARPs at Saipan, Kona, Pearl and Hermes Reef, and Wake and facilitated the recovery of the HARP at Pagan. Erik has also been collaborating with Scripps Institution of Oceanography (SIO) to convert HARP data loggers from Serial Advanced Technology Attachment (SATA) hard drives to secure digital (SD) cards. The SD systems use significantly less power, which has led to a cost saving by reducing the number of batteries needed to run the system. This has made it possible to simplify HARPs as they no longer need an additional pressure case devoted to batteries.

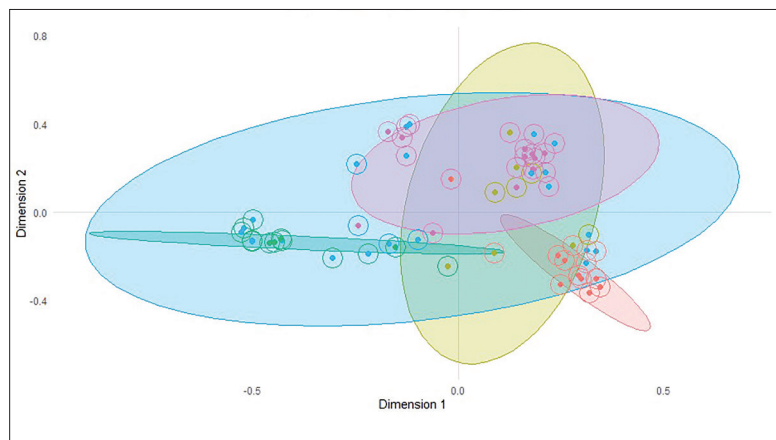
The project uses a modified version of the HARP to better understand the interaction of false killer whales (*Pseudorca crassidens*) and the longline fishing fleet. The CRP works in collaboration with the NOAA Fisheries Observer Program and longline vessel owners/captains to deploy longline HARPs (LLHARPs) by attaching them to fishing gear. During FY 2023, there were four deployments and recoveries of LLHARPs. The LLHARPs record sounds made by the fishing vessel, gear, and animals. Researchers hope to determine what sounds act as potential “dinner bell” cues for the animals leading to depredation events in which bait or catch are taken by the whales and sometimes results in the entanglement of animals in the gear. Understanding the timing and sources of the sound could lead to solutions to reduce or eliminate the interactions of the whales with the fishing gear.

The team is working toward using passive acoustics to estimate the density and abundance of cetaceans. At present, cetacean density and abundance estimates are based on visual survey data alone. The addition of acoustically localized groups could greatly improve abundance estimation by increasing the encounter rate (i.e., the number of detected groups). Dr. Pina Gruden has been working on the development of code for the automated tracking and localization of multiple acoustic sources from towed hydrophone array data; specifically false killer whale subgroups. During the past year she packaged the code, which was beta tested and adjusted based on the feedback, and another testing phase is about to commence. The developed framework was presented at the National Protected Species Assessment Workshop III (Gruden, Nosal, and Oleson, 2023). A direct application of part of this framework led to a publication that examined the vocal behavior of false killer whale subgroups



(above) Erik Norris assembles a HARP for deployment off Saipan. Photo credit: Yvonne Barkley.

(below) Proximity plot of acoustic classification results of the false killer whale populations. The colored dots are the true classification and the rings are the predicted classification. The following acronyms represent the different populations included in the analysis, MAC = Marianas, MHI = Main Hawaiian Island (endangered), NWHI = Northwestern Hawaiian Islands, PEL = Pelagic, UNK= False killer whales with unknown population.



(Gruden, Barkley & McCullough, 2023). The developed framework is species and platform agnostic, and thus applicable to other species and sensor configurations. Dr. Gruden used the developed framework and collaborated on multiple projects with other institutions. In collaboration with Southeast Fisheries Science Center, NOAA Fisheries, the developed code was used to track the endangered Rice's whales (*Balaenoptera ricei*) from an array of stationary sensors (Tenorio-Halle et al., 2023). In collaboration with SIO and the Hawaiian Islands Humpback Whale National Marine Sanctuary, the developed code is used to track singing humpback whales (*Megaptera novaeangliae*) from an array of vector sensors (Gruden et al., submitted).

In an effort to develop the use of passive acoustics for density estimation of marine mammals, the CRP has been contributing to the ACCURATE (ACoustic CUe RATES for passive acoustic density estimation, <https://accurate.st-andrews.ac.uk/>) Project. Dr. Yvonne Barkley and coauthors examined the variability in sperm whale (*Physeter macrocephalus*) click rates in Hawaiian waters using towed array data. They determined that click detection rates were significantly impacted by the type of sperm whale click compared to other factors, including spatiotemporal variables, the distance the whales were detected from the array, and the number of animals within the group. The implications of these results suggest that the click type should be considered when computing click rates for sperm whales in this region of the Pacific Ocean as they may significantly impact density estimates. A draft manuscript is currently under review by her coauthors and will be submitted to the *Journal of the Acoustical Society of America*.

There are three populations (management stocks) of false killer whales in Hawaiian waters (main Hawaiian Islands (endangered), NWHI, and Pelagic) that are currently identified using genetic and individual photo-identification data, which can be difficult to collect. Dr. Barkley began working on an analysis funded by a grant from the Cooperative Research Program to develop acoustic classifiers to identify the three populations using different call types from towed array data. An 'outgroup' population included false killer whale data from the Marianas. Preliminary models show promising results with some of the populations clustering tightly together (Figure 2). Acoustic data from the Marianas (MAC), NWHI, and the unknown false killer whale population all resulted in over 80% correct classification scores. Dr. Barkley and colleagues will perform a sensitivity analysis to determine the minimum amount of acoustic data that is required to achieve classification scores of 80% accuracy or higher. This information will help to better understand the limitations of the models and the data requirements for building the best possible acoustic classifier to distinguish each population. Once the acoustic classifier is optimized, it will be applied to classify acoustic encounters of unidentified dolphins as well as acoustic data of autonomous acoustic platforms to increase the sample size of false killer whale population data to inform and improve management strategies.

In collaboration with Oregon State University, the project uses SeaGliders to study cetaceans in the waters surrounding MHI. SeaGliders are autonomous underwater vehicles that move through the water by changing their buoyancy and communicate with satellites to transmit data and determine their global position. They collect environmental data using a CTD and passive acoustic data using a hydrophone and onboard recording device. Erik Norris assisted with two CRP SeaGlider missions in Hawai'i during FY 2023. The first began April 11, 2023 when the glider was deployed off the west side of O'ahu and initially traveled to Kaua'i. From Kaua'i, it traveled south along the windward sides of the islands and was recovered off the west side of the Hawai'i Island on June 5, 2023. The second SeaGlider was deployed on May 4, 2023 off the west side of O'ahu. It traveled south along the leeward sides of the islands and was also recovered on June 5 off the west side of Hawai'i Island. The second SeaGlider was equipped with a sperm whale click detector and was reporting near-realtime detections of sperm whales.

## **Fishing Impacts on Non-Target Species**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Melanie Hutchinson]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Keith Bigelow**

### **NOAA Goal(s)**

- Healthy Oceans
- Climate Adaptation and Mitigation
- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

## Purpose of the Project

The Fishery Impacts to Non-Target Species (FINTS) CIMAR project is focused on reducing the negative impacts of commercial tropical tuna fisheries on non-target species, with a concentration on oceanic sharks and protected species. The program conducts telemetry and physiological bycatch reduction research alongside commercial fishers in longline, purse seine and small-scale fisheries to quantify post-release survival rates to improve stock assessment parameters and to identify best handling and discard practices to reduce mortality of non-target and protected species. The project works closely with industry partners, fishers, managers and scientists across agencies and institutions in every ocean to conduct regional (ocean basin) habitat use and movement behavior studies to inform bycatch mitigation strategies and assist managers with effective conservation and management measures. FINTS specific objectives that were planned for the last fiscal year included the following.

1. Report on Species Distribution Models for key target and non-target MUS.
2. Report on fly-back trajectories of branchlines in Hawai'i longline fisheries.
3. Report on oceanic whitetip shark (OCS) longline capture characteristics using accelerometer data.
4. Conduct ongoing research and monitoring of association dynamics of oceanic whitetip and silky sharks around Fish Aggregating Devices in Hawai'i.

## Progress during FY 2023

Progress towards Objective 1 includes a workshop that was conducted in May of 2023 at the Inter-American Tropical Tuna Commission offices in La Jolla, California for staff to learn new algorithms for geolocation estimation and the generation of dispersal and connectivity estimates for stock assessment purposes. The project has expanded to include two large datasets that will make the species distribution models Pacific wide and so this project has been extended to next year.

Funding for Objective 2 was allocated to a different entity so this objective will not be met by this project.

The report on OCS longline capture characteristics identified under Objective 3 is complete, has been accepted for publication in the peer reviewed journal, *Animal Biotelemetry*. The report revealed that post-capture on a

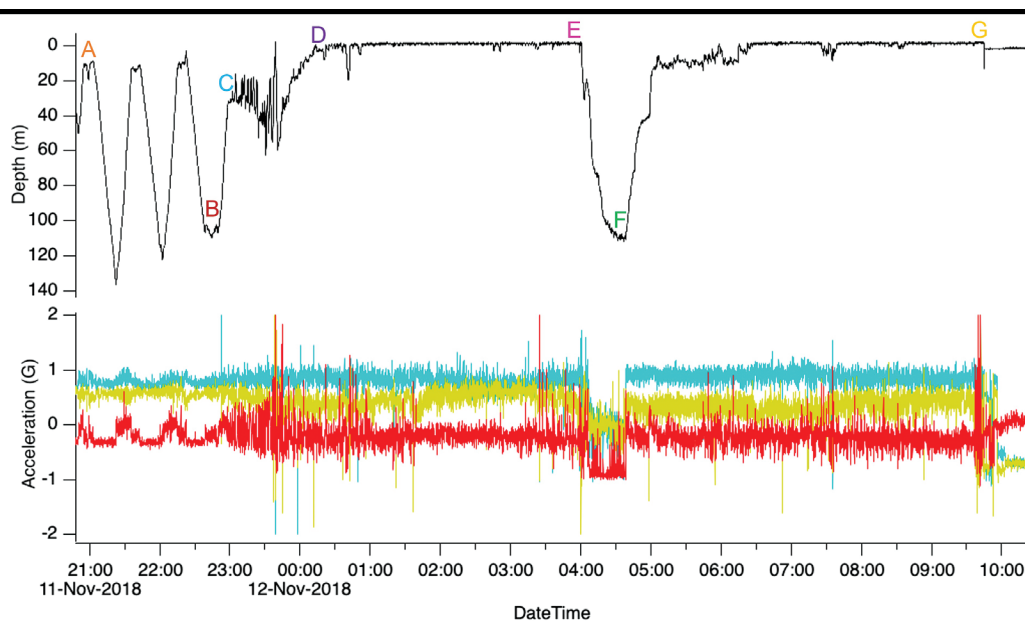


Fig. 1 A visual depiction of the oceanic whitetip shark's depth use (upper panel) and tri-axial acceleration (lower panel; teal; x-axis, gold; y-axis, red; z-axis) across an 18-hour period between 12-Nov-2018 12:10 and 13-Nov-2018 01:30 UTC pre and post hooking. Each letter represents a change in shark behavior across the capture process. Points A–B show normal yo-yo diving behavior. Near point C the shark likely gets hooked or first experiences the tension from the line if it was hooked during the ascent between points B and C. Between points C–D the shark fights actively against the gear and brings it towards the surface. Between points D–E the shark struggles on the line at the surface, then gradually sinks (times E–F) while on the line. The negative value of the z-axis acceleration (red) indicates the tag was dangling in a near vertical orientation. Between points F and G show when the shark is brought to the surface due to the tension from the haul of the longliner. Point H depicts the shark being handled near the vessel where it was recorded as dead on the line.

longline an OCS can fight against the gear for around five hours prior to succumbing to exhaustion and mortality (Fig. 1).

This project also made significant progress towards the goals of the Hawai‘i Community Tagging Program (HCTP: Objective 4), a large collaborative telemetry and outreach effort between CIMAR researchers, State of Hawai‘i’s Division of Aquatic Resources, PIFSC, NOAA’s Pacific Islands Regional Office, and local recreational and commercial fishers aimed at reducing mortality to the Endangered Species Act listed OCS. At present program participants deployed 319 tags on twelve different species of sharks including 138 tags on OCS and 70 on silky (FAL) sharks generating the largest telemetry dataset in existence for populations of OCS and FAL globally (Fig. 2). The data has thus far revealed that OCS and FAL exhibit some site fidelity to the Hawaiian Islands, particularly the Hawai‘i Island (for OCS) and O‘ahu (for FAL) with intermittent and short-term residency at fish aggregating devices (FADs) throughout the year (Fig. 3).

The program is ongoing, and regularly engages with program participants by providing frequent feedback on tag data, through quarterly newsletters and through their social media accounts. Participating fishers share their deterrent strategies with us during interviews that are published on the sharktagger.org website to inform community on non-lethal techniques to avoid protected species interactions and shark depredation of catch. The HCTP has suffered some major data losses over the last fiscal year, where eight FADs with acoustic receivers broke away and were lost, luckily, the project was able to recover five of them. Importantly, the program is finally wrapping up and has now

SPECIES	Acoustic (V16)	ID Tag	Satellite	Grand Total
Grey reef	0	3	0	3
Blacktip reef	0	6	0	6
Blue	0	7	5	12
Bigeye thresher	0	4	10	14
Bignose	0	5	1	6
Galapagos	0	9	0	9
Oceanic blacktip	0	1	0	1
Sandbar	1	24	4	29
Silky	36	12	22	70
Oceanic whitetip	57	34	47	138
Pelagic thresher	0	0	2	2
Shortfin mako	0	2	3	5
Tiger shark	0	3	0	3
Whitetip reef	0	5	0	5
<b>Total</b>	<b>95</b>	<b>128</b>	<b>96</b>	<b>319</b>

Fig. 2 Tag deployments, showing number of individuals tagged with acoustic, satellite and identification tags since the HCTP began in 2016.

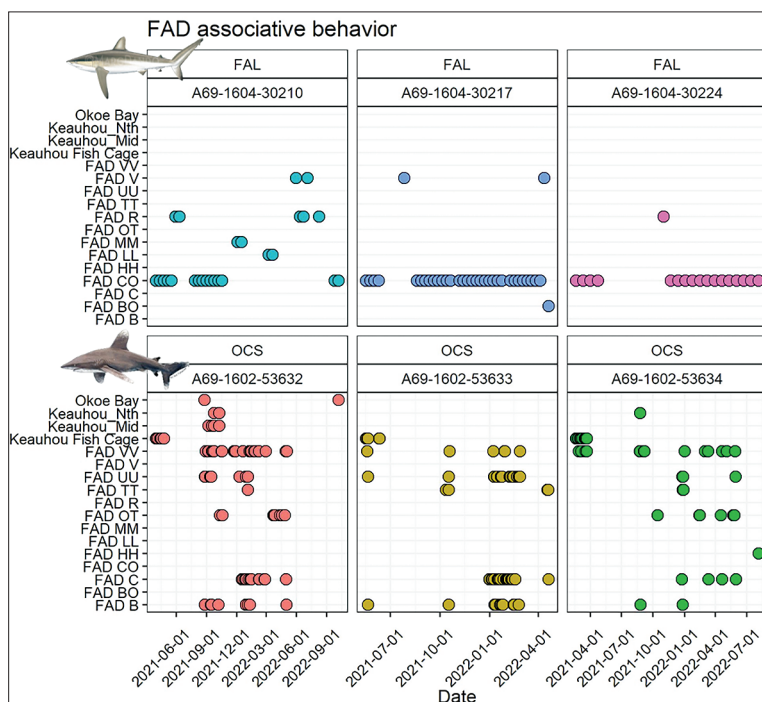


Fig. 3 Species-specific differences in FAD associative behavior between oceanic whitetip (OCS, bottom-row) and silky (FAL, top-row) sharks. FAL tend to stay at one FAD at a time, across days or weeks, compared with OCS who tend to roam between FADs.

deployed all their acoustic tags and satellite tags. These data will enable more accurate stock assessments and be crucial in the development of management plans for commercially impacted species. The conventional ID tags will provide estimates of fishery interaction rates for mark-recapture studies, to improve life history parameters and recreate historical mortality indices. This project engaged over 200 participants from all Hawaiian Islands to understand the nature and frequency of interactions with the species and to gauge how outreach and education for conservation may be most effective. The goals and objectives set out for the year were achieved. The next steps are to allow the tags to generate data and monitor transmissions, begin data analysis and writing.

In addition, the HCTP recruited a Masters student, Abigail Campbell who, for her thesis, focused specifically on the photo identification component of the HCTP. This component included establishment and maintenance of a large photo identification library to better understand OCS demographics and fishery interactions in the region. From the analysis of over 2000 images of OCS between 2006 and 2023 the project identified 176 females and 89 males with 46 confirmed resights. The sex ratio of males and females identified was approximately 2:1. While pregnancy could not be definitively confirmed, thirty-one females (17.6%) were recorded with mating scars, and fifty-one (28.9%) had particularly distended abdomens and were recorded as potentially pregnant. Seventy-four (25%) individuals were recorded as having evidence of a prior fishery interaction, particularly interactions with gear remaining on the body. The information obtained from this study can help to provide necessary baseline information regarding the population demographics, residency and fishery interactions of *C. longimanus* around the MHI to help inform conservation and management efforts for this protected species.

## **Hawaiian Monk Seal Papahānaumokuākea Marine National Monument Research Project**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Lizabeth Kashinsky]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Michelle Barbieri**

### **NOAA Goal(s)**

- Healthy Oceans

### **Purpose of the Project**

CIMAR's Hawaiian Monk Seal Papahānaumokuākea Marine National Monument Research Project supplements research and recovery activities on protected species population biology, ecology, and anthropogenic influences. This CIMAR project provides seasonal support for the Protected Species Division (PSD) Hawaiian Monk Seal Research Program (HMSRP) Assessment and Recovery Camps (ARCs), which are the foundation of NOAA's Hawaiian monk seal research and recovery efforts in the Papahānaumokuākea Marine National Monument (PMNM) and are a priority action for the Hawaiian Monk Seal Recovery Plan. Season field staff are typically deployed to remote field camps in the PMNM annually to conduct population monitoring, critical for stock assessment, and undertake numerous activities to aid in the recovery of the species. The project augments year-round activities of the HMSRP.

### **Progress during FY 2023**

At the beginning of the reporting period, remote field camps were already established at five of the six major reproductive sites in the Northwestern Hawaiian Islands (NWHI) at Lalo (French Frigate Shoals), Kamole (Laysan), Kapou (Lisianski), Manawai (Pearl and Hermes), and Holaniku (Kure Atoll). Fifteen CIMAR field staff at these five sites gathered data on the number of pups born, number that survived to weaning, number marked and tagged, number of older animals identified, inter-atoll movements, causes of mortality, and other key demographic variables. Teams also performed a variety of survival enhancing activities such as disentangling seals, administering antibiotics to compromised seals, vaccinating seals against morbillivirus, identifying and capturing animals in need of rehabilitation, and collecting marine debris dangerous to wildlife. The field team at Lalo also freed wildlife entrapped in disintegrating infrastructure at Tern Island and translocated weaned pups away from areas with historic high shark predation at Lalo. On July 15, the field team at Manawai was evacuated to ensure



*CIMAR field staff take a break from setting up their summer field camp on Tern Island at Lalo, French Frigate Shoals, on May, 2023 (Work conducted under Permit No. PMNM-2023-001). Photo Credit: Hope Ronco.*

their safety during a historic large south swell. The Papahānaumokuākea Marine Debris Program cruise-chartered vessel *Imua* was already on site and were able to safely retrieve the team and deliver them to Kuaihelani (Midway Atoll). After the evacuation, the team performed similar research and enhancement activities at Kuaihelani, which hosts the sixth major monk seal subpopulation in the PMNM. Throughout the duration of the 2022 field season, field teams at all sites also supported research by other groups within PIFSC by tagging and monitoring sea turtles in collaboration with PIFSC's Marine Turtle Biology and Assessment Program (MTBAP). CIMAR staff also conducted a variety of conservation and research activities in collaboration with the U.S. Fish and Wildlife Service and other partners such as deploying acoustic recorders at Lalo and Manawai, assisting with sea level rise research at Lalo, and staging marine debris for pickup by Papahānaumokuākea Marine Debris Program cruises. Surveys of Nihoa and Mokumanamana (Necker) also were conducted during the NOAA R/V *Oscar Elton Sette* cruise SE-22-06, which departed Honolulu on August 6 to retrieve field teams in two stages. During the cruise, compromised young seals were collected and field staff assisted with supportive care during their transport to The Marine Mammal Center's Ke Kai Ola. Additionally, a rehabilitated weaned pup collected earlier was released at her natal site at Kamole and CIMAR staff continued to monitor her until they were retrieved from their field site. All field camp personnel, supplies, equipment, and data were collected from all sites by the final leg of the cruise when it returned to Honolulu on September 2.

In 2023, HMSRP began a new framework to maximize scientific value and recovery actions within a shortened NWHI field season with the hopes of creating efficiencies in both staff bandwidth and budget by alternating years of the more typical three to five-month Assessment and Recovery Camps at all five sites with in between years of ARC Light seasons in which field efforts at most sites will be concentrated within a single research cruise of approximately one month. In early 2023, three seasonal field assistants were hired to participate as a four-person field team led by CIMAR Biological Research Associate Jonathan Schneiderman for a five-month deployment at Lalo. The team began training on March 13 and additional layers of complexity were added to this major undertaking due to the need to operate safely during the COVID-19 pandemic. Field staff received training including data collection and animal handling techniques, zoonotic disease, necropsy and specimen collection





*CIMAR field team lead Paige Mino conducting a seal survey at Kuaihelani (Midway) (Work conducted under NMFS Permit No. 22677 and PMNM-2022-002). Photo Credit: Meagan Selvig.*

techniques, communication, biosecurity, a three-day National Outdoor Leadership Wilderness First Aid course, and small boat operations. During the training period, field staff also prepared necessary supplies and equipment, including scientific gear, living supplies, and inventoried, shopped for, and packed food and medications (e.g., over the counter and prescription drugs, and first aid supplies) to last the duration of the field season. Project funds were used to purchase communication training, food and medical supplies, as well as the establishment of a contract with Hawai'i Emergency Physicians Associated. This contract allows around the clock medical consultation for field staff as needed throughout the deployment. Field staff deployed on the NOAA-chartered vessel *Kahana II* on May 15 after close to a week delay because of the detection of a highly invasive ant species (yellow crazy ant) on the vessel. Due to the potential for introducing this species to Lalo, which could result in devastating impacts on the ecosystem, several eradication/mitigation measures and authorizations were necessary before the field team was able to depart. On board the vessel were two monk seals that had been collected in 2022 and had been undergoing rehabilitation at The Marine Mammal Center's Ke Kai Ola over the past several months.

The team arrived at Lalo on May 17, and along with a sea turtle research team, established a remote research station the following day. Field staff began conducting research and recovery activities on May 24. To date, they established wildlife entrapment barriers, released and began monitoring the two rehabilitated seals, conducted surveys, tagged seals, and documented mom and nursing pup pairs and seal injuries.

## Hawaiian Monk Seal Research and Recovery Project

**P.I.: Douglas S. Luther [CIMAR Project Lead: Lizabeth Kashinsky]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Michelle Barbieri**

### NOAA Goal(s)

- Healthy Oceans

### Purpose of the Project

The CIMAR Hawaiian Monk Seal Research and Recovery Program, in collaboration with NOAA’s Pacific Islands Fisheries Science Center (PIFSC) Protected Species Division (PSD) Hawaiian Monk Seal Research Program (HMSRP), conducts research and recovery activities on the Hawaiian monk seal (HMS; *Neomonachus schauinslandi*), the most endangered marine mammal occurring entirely within U.S. jurisdiction. In 2022, the estimated total population was 1,605 (with 95 percent confidence that the true number is between 1,512 and 1,743) with about 75 percent of the seals occurring in NWHI at six highly studied sites where abundance had previously declined by two thirds since the late 1950s. The remaining 25 percent of HMSs occur in the main Hawaiian Islands (MHI). After decades of declining numbers, the number of monk seals has increased on average by two percent per year since 2013—a slow but steady rise over a full decade. Research and recovery activities are critical to understanding and reversing the historic population decline. CIMAR project staff play a crucial role in supporting the deployment and recovery of annual research camps in the NWHI, as well as participate in research and recovery activities in the MHI, such as population and assessment surveys and stranding response activities.



*CIMAR Hawaiian Monk Seal Program Associate Tracy Mercer records data after a Hawaiian monk seal flipper tagging procedure on Moloka’i with a NOAA biologist (NMFS Permit No. 22677). Photo Credit: Mark Sullivan.*

### Progress during FY 2023

Project staff supported demobilization efforts for the 2022 PSD recovery cruise and supported deployed field staff from afar during the latter half of the 2022 and beginning of the 2023 field seasons to ensure the goals of team safety, population monitoring, and recovery activities to save seals were met. Paige Mino, a field camp team lead during the 2022 field season, was hired in a short term CIMAR position at the end of the 2022 field season to fulfill a crucial role needed to ensure the success of HMSRP’s field camp logistical operations.

Christy Kozama took over the role as the program’s primary logistics role when she was hired as the project’s Logistics/Research Technician in October. Her former Biological Research Associate position was filled in early 2023 by former field camp team lead Jonathan Schneiderman. In 2023, HMSRP piloted a new framework to maximize scientific value and recovery actions within a shortened NWHI field season with the hopes of creating efficiencies in both staff bandwidth and budget by alternating years of full seasons of three to five-month

Assessment and Recovery Camps (ARC) and ARC Light seasons in which field efforts at most sites will be concentrated within a single research cruise of approximately one month. Thus, for the 2023 field season, only one field site (Lalo, or French Frigate Shoals) was staffed with a team expected to deploy for the full duration of the field season.

Project staff were essential to the preparation for the 2023 field season, including the recruitment and hiring of three monk seal field camp assistants. CIMAR staff participated in annual reviews of program field protocols and trained field personnel in conducting field activities. They also procured, tested, and packed field supplies and equipment and provided other logistical support to deploy the camps for a five-month deployment to Lalo. Project staff also participated in the planning and preparation for a one-month long ARC Light cruise, which departed in mid-August, including gear and equipment preparation for short camps at three field sites and hiring two temporary hire field assistants.

In addition to providing support for field camp deployments, CIMAR staff flipper tagged, vaccinated, and bleach marked weaned pups on O‘ahu and Moloka‘i. In August 2022 and May 2023, staff participated in the capture and translocations of newly weaned pups from their birthplace at Kaimana beach to less populated areas. CIMAR staff were directly involved in the decision making and planning for the translocations and led and participated in the capture, tagging, instrumentation and release of these seals. Tracy Mercer and Mark Sullivan planned and led a multiagency seal survey trip to Moloka‘i where they trained partners on seal biology and behavior, bleach marking, tagging, and handling. CIMAR staff continued to work closely with agency partners to facilitate data collection, monk seal monitoring, bleach marking and flipper tagging of individual seals. Staff trained partners in seal handling and response to help build capacity in the MHI and worked with Navy biologists to coordinate monk seal surveys of Ni‘ihau. They also coordinated and participated in field responses to seals of concern in the MHI. University of Hawai‘i graduate student Kirby Parnell was hired in a temporary hire position in May to assist with MHI field work and acoustical projects. Project intermittent hire veterinarians Drs. Ednee Yoshioka and Meghan Barrett provided veterinary care to monk seals and stranded sea turtles, including participation in stranding responses, the transport of a seal via U.S. Coast Guard from Kona to O‘ahu, and veterinary support prior to release. Veterinarians assisted with seal processing, tagging, and release of translocated seals and traveled to The Marine Mammal Center’s Ke Kai Ola in Kona to provide veterinary support on hospitalized seals. Mark Sullivan led tours and trained staff on the use of a seal holding and gear wash down area at the IRC Marine Animal Rehabilitation Facility. The holding area was built to address veterinary needs, operational requirements, environmental compliance issues, and safety concerns related to the captive care of seals and mobilization/demobilization of field efforts. The holding area was first utilized as a temporary holding area for the Kaimana beach pup translocation in August and has greatly increased the ability to support monk seals during all phases of medical procedures, as well as ensure strict quarantine protocols are adhered to during field camp gear washing.



*CIMAR and NOAA federal staff perform a dry run of a Hawaiian monk seal intake procedure in a new seal holding facility on O‘ahu in March, 2023. Photo Credit: Mark Sullivan.*

## Marine Turtle Recovery in the Pacific Islands Region

**P.I.: Douglas S. Luther [CIMAR Project Lead: Lizabeth Kashinsky]**

**NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center**

**NOAA Sponsor: Michael P. Seki, Summer Martin**

### **NOAA Goal(s):**

- Healthy Oceans

### **Purpose of the Project**

CIMAR collaborates with NOAA's Pacific Islands Fisheries Science Center (PIFSC) Marine Turtle Biology and Assessment Program (MTBAP) in the following areas.

*Population assessment.* CIMAR conducts marine turtle in-water and nesting surveys throughout the Pacific Islands Region (PIR) aiding in analyses of population abundance and trends, and participating in Section 7 analyses, Biological Opinions, and Status Review Teams, including critical habitat.

*Climate research.* CIMAR develops, conducts, and analyzes climate-based data/research on sea level rise, climate projections of temperature and its associated effects on hatching sex-ratios and embryonic death, as well as foraging habitat degradation. These studies take place throughout PIR and foreign Exclusive Economic Zones with marine turtles important to U.S. commerce and recovery.

*Fisheries interactions.* CIMAR contributes to fishery bycatch reduction and/or mitigation through international collaborations to quantify bycatch rates, reduce and mitigate bycatch, conduct studies on post-interaction mortality, and analyze data on pelagic ecology and movements of turtles in oceanic habitats. CIMAR conducts observer training of agency personnel in the collection of marine turtle data during commercial longline fishing operations.

*Biology and ecology.* CIMAR conducts basic investigations of the biology, life history, ecology, and physiology of marine turtles.

*Stranding and salvage.* CIMAR contributes to the marine turtle stranding and salvage network for research, rescue, rehabilitation, and return to the wild. This involves the collection of long-term time series datasets, including health assessments, and the development of reports, manuscripts, and maps derived from stranding data.

*Data and sample management.* CIMAR staff enter and validate data for the MTBAP data and photo databases; organize, preserve, store, and ship samples; and train and use Freezerworks for stranding and sample database management.

*Provide assistance to collaborative PIFSC Programs.* The Protected Species Division of PIFSC also conducts research and recovery efforts with the Hawaiian Monk Seal Research Program and the Cetacean Research Program, and CIMAR staff assist these programs with stranding responses, necropsies, and rehabilitative care.

### **Progress during FY 2023**

Multiple project core objectives were accomplished by CIMAR staff, including captive sea turtle care and rehabilitation, biological sample collection and management of biological samples, participation in field capture of marine turtles, research on the general biology, life history, and ecology of sea turtles in coastal marine habitats and on nesting beaches, as well as participation in the planning, preparation, and data analysis and reporting of previous nesting field work conducted at Lalo (French Frigate Shoals) within the Papahānaumokuākea Marine National Monument (PMNM). Three University of Hawai'i at Mānoa Marine Option Program student assistants participated in stranding response and rehabilitation for sea turtles on O'ahu as well as assisted with program needs including data entry and conducting and assisting with necropsies, while three UH Hilo undergraduate students continued to support MTBAP's stranding response mission on Hawai'i Island. Student assistant Brittany Clemans worked with MTBAP staff last summer on the citizen science project Honu Count. Honu Count is a project where members of the public can report sea turtles with visible shell-etching identifications to help monitor population abundance and foraging/migration trends. Brittany helped develop a new website providing information on the project, as well as a new online survey format to make reporting more accurate and accessible to the public. Marylou Staman mentored a Pacific Islands Young Scientist Opportunity (PYSO) intern, Nicole



*CIMAR's Marylou Staman conducts a survey with local partners to find green sea turtle tracks at Muliava (Rose Atoll), American Samoa. Research conducted under USFWS Permit #TE-72088A-3. Photo Credit: Shawn Murakawa.*

Simpson, in the summer of 2022. The PYSO project was intended to increase MTBAP's capacity for live, in-field data entry for the PMNM nesting project. Because current transcribing efforts take up to a year to complete, the development of this more efficient, tablet-based method to streamline data entry will be quite impactful, as it will allow MTBAP to analyze data and produce products in a more timely manner. Marylou Staman also traveled to American Samoa November 3–14, 2022 to assist with MTBAP's annual green sea turtle nesting rapid assessment project at Muliava (Rose Atoll). Marylou and student assistant Brittany Clemans traveled to Colombia to attend the 41st International Sea Turtle Symposium where they presented posters about Hawaiian green sea turtle research.

At the beginning of the reporting period, Alexandra "Alex" Reininger and two seasonal field staff (Andrew Glinsky and Jamie Stoll) were already deployed at Lalo for the 2022 field season. The field team conducted research and recovery activities, including nesting and basking surveys, deploying satellite telemetry tags and nest temperature data loggers, and mitigating wildlife entrapment hazards. Staff were retrieved from Lalo on the NOAA R/V *Oscar Sette* and returned from the field on September 2. Two student assistant positions were converted to temporary hire positions so they could deploy on the cruise, along with Marylou Staman, to assist with the retrieval of field staff, gear, and equipment. Marylou also served in the role of Cruise Operations Lead and Chief Scientist on two legs of the cruise. In early March 2023, Alex Reininger and two seasonal field staff (Andrew Glinsky and Shelbie Ishimaru) began training in preparation for a five-month deployment to Lalo for the 2023 field season. Additional layers of complexity were added to this major undertaking due to the need to operate safely during the COVID-19 pandemic. During the training period, field staff prepared necessary supplies and equipment, including scientific gear, living supplies, and inventorying and packing food and medications (e.g., over the counter and prescription drugs, and first aid supplies) to last the duration of the field season. Project



CIMAR's Alex Reiningger performs a green sea turtle nest excavation on Tern Island, Lalo, PMNM, while Jamie Stoll records the nest success data and Andrew Glinsky inspects a straggler hatchling prior to release. Research conducted under USFWS Permit #TE-72088A-3 and PMNM PMNM-2022-001. Photo Credit: Alex Reiningger.

funds were used to cover costs for communication training, National Outdoor Leadership School Wilderness First Aid training, food and medical supplies, clothing to maintain PMNM biosecurity protocols, as well as the establishment of a contract with Hawai'i Emergency Physicians Associated in order to provide remote medical consultation for field staff as needed throughout the deployment. Prior to deployment, CIMAR staff participated in an annual review of program field protocols and trained field personnel in conducting field activities. This included training on data collection and animal handling techniques, zoonotic disease, necropsy and specimen collection techniques, communication, biosecurity, and small boat operations. Field staff deployed on the NOAA-chartered vessel *Kahana II* on May 15 after close to a week delay because of the detection of a highly invasive ant species (yellow crazy ant) on the vessel. Due to the potential for introducing this species to Lalo, which could result in devastating impacts on the ecosystem, several eradication/mitigation measures and authorizations were necessary before the field team was able to depart. The team arrived at Lalo on May 17, and along with a monk seal research team, established a remote research station the following day. Field staff began conducting research and recovery activities on May 24. To date, they established wildlife entrapment barriers and began conducting daytime basking and nighttime nesting surveys. Project staff in Honolulu supported deployed field staff from afar to assure that the research and safety goals for both 2022 and 2023 field seasons were met.

## Pacific Islands Deep-Sea Coral and Sponge Initiative

P.I.: Douglas S. Luther [CIMAR Project Lead: Jeffrey Drazen]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Sponsor: Michael P. Seki, Frank Parrish

### NOAA Goal(s)

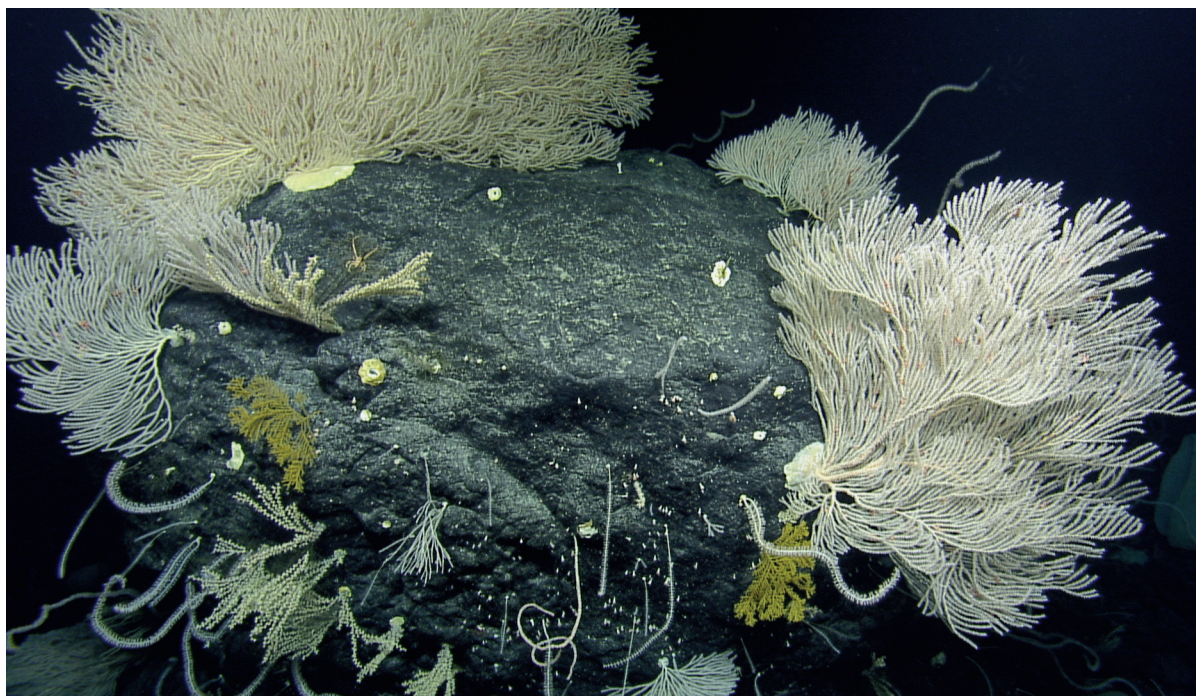
- Healthy Oceans

### Purpose of the Project

This project seeks to advance NOAA's Deep-Sea Coral Research and Technology Program (DSCRTP) priorities and gather information on the diversity and abundance of deep-sea coral and sponge communities in the U.S. Exclusive Economic Zone (EEZ) to improve the management of these important resources. The project focuses on extracting, compiling, and synthesizing deep-sea coral and sponge video data from Remotely Operated Vehicle (ROV) or manned submersible surveys in the Pacific. The goal is to produce detailed records of animal observations, including the taxonomic identification, location, and oceanographic data for incorporation into the DSCRTP national database in order to improve one's understanding of the conditions that promote the formation of deep-sea coral and sponge communities.

### Progress during FY 2023

This project continued to provide the DSCRTP with animal records and images for their national database (<https://deepseacoraldata.noaa.gov/>). The annotation protocol involved creating records of deep-sea corals, sponges, fishes, and associated fauna captured on the dive video. Supplemental information documented for these records includes sizes, counts, substrate and habitat data, and comments regarding the identification or

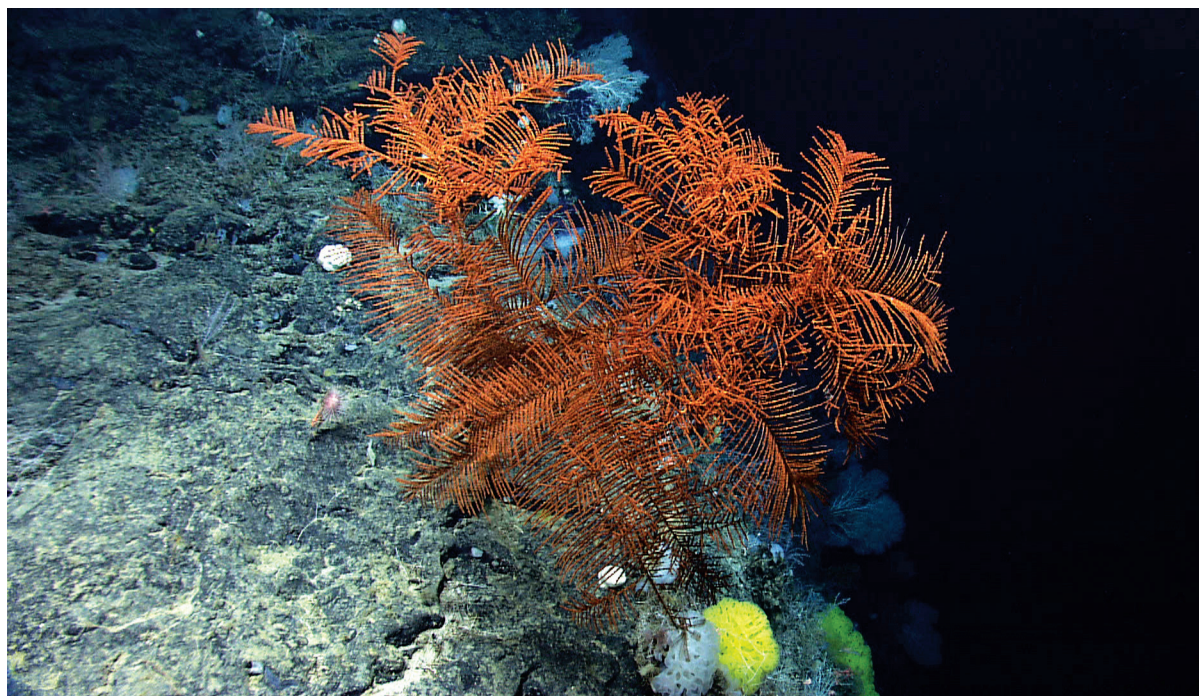


*A garden of large primnoid fans, bamboo whips, and golden Stauroopathes corals inhabiting a boulder. Animals observed by the ROV Hercules operated by the E/V Nautilus during dive NA134 H1889 on Don Quixote seamount at 1815 m depth. Photo Credit: Ocean Exploration Trust.*



*(above) A close-up view of the pink coral, Hemicorallium, feeding polyps with an associate anemone. Observed at 2,599 m depth on the northwestern flank of the main edifice of the Atlantis II Seamounts. Image captured by the ROV Deep Discoverer operated by the NOAA Okeanos Explorer during EX1404L2 Dive 07. Photo Credit: NOAA Office of Exploration and Research.*

*(below) The majestic black coral, Telopathes magnus, accompanied by yellow Hertwigia falcifera sponges. Image captured by the ROV Deep Discoverer operated by the NOAA ship Okeanos Explorer while exploring Gonsold Seamount at 1963 m depth. EX1404L3Dive08. Photo Credit: NOAA Office of Exploration and Research.*





occurrence. CIMAR staff used the Video Annotation and Reference System (VARS) software for annotating, then merged the annotations with available location and oceanographic data, reviewed the records for quality control, and formatted them for inclusion into the DSCRTP's database.

During this reporting period, the team generated records and images to the DSCRTP from Okeanos Explorer ROV dives conducted in 2013 and 2014 in the North Atlantic (EX1304, EX1404), dives in the Discoverer seamount range in the PMNM (NA134) and are halfway through dives on the Lili'uokalani ridge in PMNM (NA138). In total the project submitted data for 58 dives representing 71,252 individual video annotations. Furthermore, the staff focused on updating the VARS software and transitioning QA/QC processes from manual checks to code-based reports.

These updates and code generating activities will also facilitate integration of a significant number of historical (back to ~2007) Hawai'i Undersea Research Laboratory annotations into the DSCRTP database.

## **Papahānaumokuākea Marine National Monument Monitoring and Research**

**P.I.: Douglas S. Luther [CIMAR Project Lead: Brian Hauk and Chelsie Counsell]**

**NOAA Office (of the primary technical contact): National Ocean Service**

**NOAA Sponsor: Randall Kosaki**

**NOAA Goal(s):**

- Healthy Oceans

### **Purpose of the Project**

The CIMAR Papahānaumokuākea Marine National Monument (PMNM) Monitoring and Research project conducts primary research and monitoring activities to characterize the spatial distribution and composition of marine ecosystems within the PMNM and other partner NOAA Marine Sanctuary sites. By investigating spatial and temporal trends in the PMNM marine ecosystems, this research can inform strategies to better manage and protect PMNM resources from anthropogenic and natural threats. As part of this, the project directly supports the Resource Protection Program through support for hull inspections, monitoring invasive species, and efforts for other marine resource threats. Research and monitoring activities utilize small boats, SCUBA gear, technical diving gear (including closed-circuit rebreathers, CCR), ROVs, unmanned aircraft systems (UAS), remote sensing technologies, and other scientific equipment to collect data on the marine ecosystems of primarily NWHI during research expeditions. Subsequent specimen processing, data analyses, and scientific publication are based out of PMNM's offices at the NOAA Inouye Regional Center in Honolulu, as well as in the Multi-Scale Environmental Graphics and Analysis (MEGA) Lab at the University of Hawai'i at Hilo. The objective of this research is to advise management and policy decisions in order to conserve, protect, and enhance the biodiversity of the PMNM.

### **Progress during FY 2023**

In the past few years, the team has gotten smaller and had turnover through staffing changes. In May 2023, the project brought in a new Science Operations Technician and a new Research Supervisor. In May and June, time has been dedicated to training these two new team members on NOAA diving, small boat, and research method protocols. The project's new Research Supervisor obtained Active NOAA Diver as well as NOAA Coxswain for PMNM small boats status, and has completed the Hawai'i Employers Council's supervisory training series. Building the team's capacity is critical to fulfill the project's research and monitoring priorities for this summer and future years.

*Coral Reef Monitoring.* CIMAR personnel organized and prepared for a Reef Assessment and Monitoring Program research expedition scheduled for Summer 2023. CIMAR was supporting this expedition with personnel working as the chief scientist and as technician support. In preparation, partnerships were utilized with MEGA, PIFSC, and HDAR. Research gear was prepared and packed. CIMAR personnel organized and led a week-long training session for partners in support of effective data collection on the expedition. This cruise was canceled by NOAA Office of Marine and Aviation Operations (OMAO) due to maintenance issues with the ship.

In July 2022, CIMAR staff supported an expedition to Kuaihelani (Midway Atoll). As part of this expedition, they opportunistically surveyed reefs for coral health and observed low levels of coral bleaching as well as a

high prevalence of dead coral on shallow coral reefs. CIMAR staff helped conduct surveys to investigate the abundance and distribution of invasive algae on coral reefs around Kuaihelani including at forereef and inner atoll/lagoon sites. The team found *Chondria tumulosa* to be abundant, but not forming the thick 3D mats that were observed at Manawai (Pearl and Hermes). This invasive alga was observed over growing corals as well as in more cryptic locations, e.g., the underside of rocks and interwoven into floating mats of other algal species. The project also observed *Acanthophora spicifera*, a new alien alga record for Kuaihelani for which a manuscript is pending. *Hypnea cervicornis* was also discovered forming large aggregations that can be observed as dark areas in satellite imagery.

*Characterization of Mesophotic Coral Ecosystems (MCEs).* The team has been working with partners to develop an effective CCR-based survey plan to characterize the mesophotic reefs in American Samoa. This has included technical meetings and support of Standard Operating Procedure (SOP) development with partners at the Bishop Museum and the National Marine Sanctuary of American Samoa. To support this research on upcoming expeditions, CIMAR personnel worked to rebuild CCR capacity within the PMNM project through proficiency dives, practice of rescue skills, and small boat support training operations.

*Underwater 3D Photogrammetry Research.* CIMAR personnel continued processing 3D models and analyzing 3D reef structure and benthic cover data from previous expeditions. The team also prepared research manuscripts based on these results. During the Fall 2022 and Spring 2023 semesters, CIMAR personnel mentored a NOAA Educational Partnership Program with Minority Serving Institutions scholar on topics related to underwater 3D photogrammetry research.

*Remote Sensing Applications.* Satellite imagery was accessed and processed to identify sites of potential interest for the July 2022 Kuaihelani expedition. Similarly, areas with potential algal growth at Manawai were identified using satellite imagery. CIMAR staff worked with partners at the University of Hawai‘i to develop an SOP for underwater use of a spectrometer to better characterize the reflectance of invasive and native algae across a depth gradient. These data will be collected and used to inform future remote sensing efforts for algal growth in PMNM.

The Papahānaumokuākea Remote Observation Group conducted UAS proficiency flights and submitted the required NOAA paperwork to keep their UAS program active. CIMAR staff represented the program’s NOAA Line Office in the Uncrewed Marine Systems (UMS) working group to help develop an UMS Manual, and reviewed proposals for a NOAA OMAO request for proposals for Uncrewed Systems. The project also led efforts to submit a proposal for UMS funding for work within PMNM.

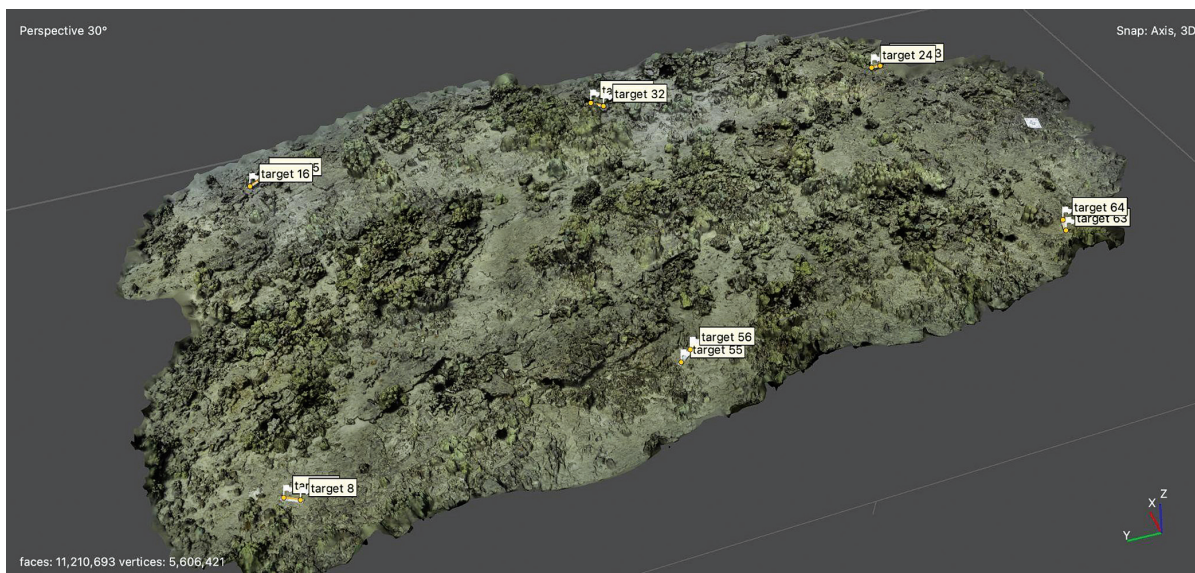
*Resource Protection.* CIMAR personnel conducted major updates on the PMNM vessel notification system database to streamline weekly and annual reporting processes. In addition, the team developed R scripts to quickly visualize vessel traffic in the PMNM to support future reporting and analyses.

CIMAR staff assisted with vessel hull inspection surveys and alien species risk assessment reports required for permitted vessel entry into PMNM. Staff also participated in an alien octocoral working group to address a new species found within Pearl Harbor. The occurrence and potential spread of this species around O‘ahu could have future ramifications for protecting resources in PMNM.

CIMAR personnel supported a July 2022 expedition to Kuaihelani focused on better understanding invasive algae, e.g., *C. tumulosa*, on the coral reefs at this atoll. To better understand the ecosystem dynamics and population



CIMAR staff utilize a Pulse amplitude fluorometer machine to access photosynthesis in *C. tumulosa* fragments after a lethality trial during a July 2022 expedition to Kuaihelani. Photo Credit: Brian Hauk.



CIMAR staff increasing the capacity for coral reef surveys through training on underwater photogrammetry (May 2023). Underwater photogrammetry allows for 3D reconstruction of coral reef habitat in high resolution and subsequent quantitative analyses of reef structure and benthic cover.

connectivity of *C. tumulosa*, the project collected samples for a population genetics analysis, microbiome surveys, stable isotope composition, associated meiofaunal communities, and examination for reproductive structures. CIMAR staff also supported collection and processing of samples for eDNA, oceanographic characterization of the atoll, and coral health. As part of this expedition, the team conducted lethality trials to test the effectiveness of desiccation, freezing, bleach, betadine, freshwater, borax, and green clean pro as biosecurity treatments for items that were in contact with *C. tumulosa*. This information was critical to management to guide the development of best management practices and to better understand the novel species’ life history aspects of this ecological invasion.

*Maritime Archeology*. Nothing to report for this objective during this project period.

## Oceanographic Monitoring and Forecasting

*Research under this theme is associated with the collection and analysis of physical, biological, and chemical observations across the equatorial regions of the Pacific Ocean to yield important information on large-scale ocean dynamics and variability. CIMAR hosts the University of Hawai’i Sea Level Center (UHSLC), which maintains a coordinated network of tide gauge stations and provides sea level data for the oceanographic and climate communities. CIMAR is also home for the Pacific Islands Ocean Observing System (PacIOOS), which is one of 11 regional centers coordinating oceanographic observational data.*

### Improving Ocean Current Measurements for Research: Maximizing Contributions from the NOAA Fleet

**P.I.:** Julia Hummon

**NOAA Office (of the primary technical contact):** Office of Marine and Aviation Operations

**NOAA Sponsor:** Solomon Tadele, Don Jones

**NOAA Goal(s)**

- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

## Purpose of the Project

The University of Hawai‘i Currents Group is engaged in a long-term project to foster global ocean current measurements for research into ocean circulation, its variability on a broad range of temporal and spatial scales, and its relation to ocean biogeochemistry and climate. An important source of these measurements is the NOAA research fleet, equipped with shipboard acoustic Doppler current profilers (ADCPs) and high-precision navigation and orientation sensors. The team develops, deploys, and uses software systems and procedures for routinely acquiring, monitoring, processing, and serving ADCP data. The project objective is to improve and apply techniques to the NOAA fleet, thereby maximizing the scientific value of the measurements during work at sea, and long into the future.

This involves working with NOAA to get high-quality data at the start, and to make it as discoverable and easy to use as possible, long after it is acquired.

## Progress during FY 2023

In FY 2023 the project continued active monitoring of the University of Hawai‘i Data Acquisition System (UHDAS) on 11 NOAA ships. Earlier in the year, the obsolete spare UHDAS server aboard R/V *Ron Brown* was replaced with a newer machine. Staff also replaced the UHDAS server on R/V *Gordon Gunter* after a motherboard failure following a long drydock period. Another UHDAS server was built and sent to R/V *Thomas Jefferson*, and is currently awaiting installation aboard the ship. The project expects to round out UHDAS installations on all 12 of the suitably equipped NOAA ships this year.

In December 2022, Toby Martin attended the annual NOAA Survey Tech training and gave an hour presentation. In March 2023 he retired, leaving Andrew Frambach well-trained to replace him. UHDAS servers are due for an upgrade; in April 2023, the team formally selected a candidate Dell server and are awaiting the acquisition of two such servers for testing.

There was significant development on the NOAA to NOAA pipeline this year, leading to a formal rolling, daily submission and accession of ADCP data to NCEI starting in March 2023. In total, the project submitted over 88 cruise bundles thus far from NOAA ships R/V *Nancy Foster* and R/V *Bell Shimada*, and continue to work through a large backlog of cruises on those ships.

## University of Hawai‘i Sea Level Center

**P.I.: Philip Thompson**

**NOAA Office (of the primary technical contact): Office of Oceanic and Atmospheric Research/  
Global Ocean Monitoring and Observing Program**

**NOAA Sponsor: David Legler**

### NOAA Goal(s)

- Climate Adaptation and Mitigation
- Resilient Coastal Communities and Economies

## Purpose of the Project

The purpose of the University of Hawai‘i Sea Level Center (UHSLC) project is to ensure that tide-gauge data from around the world are collected, quality assessed, distributed, and archived for use in monitoring and research applications related to climate, oceanography, ocean engineering, and geophysics. While UHSLC assembles time series from many tide-gauge stations, the primary focus is the set of stations that constitute the Intergovernmental Oceanographic Commission (IOC)/United Nations Educational, Scientific, and Cultural Organization (UNESCO) Global Sea Level Observing System (GLOSS) and the Global Climate Observing System (GCOS). The GLOSS and GCOS networks cover most major oceanic islands and island chains, with a subset of available continental coastal stations distributed evenly around the margins of ocean basins. The UHSLC fulfills this purpose via two parallel and complementary activities. First, the UHSLC is a primary data center in the international GLOSS system, curating and distributing two tide gauge datasets: the Fast Delivery dataset—which provides preliminary, quality-assured, hourly and daily tide gauge data within four to six weeks of collection—and the Research

Quality dataset—which is an archive of hourly and daily tide gauge data that underwent a complete quality assessment within one year of collection. The Research Quality database is maintained in collaboration with the National Centers for Environmental Information, which involves acquiring tide gauge data from nearly 500 tide gauge stations maintained by 65 international agencies. Second, UHSLC technicians and data analysts collaborate directly with international partners to maintain 77 tide gauge stations that are essential for the sea level and tsunami observing efforts. In addition, vertical land motion monitoring is recommended at all GLOSS and GCOS stations for the proper attribution of local sea level changes, and for this purpose, the UHSLC maintains continuous Global Positioning System (GPS) receivers at 11 stations. UHSLC involvement ensures that research-quality and near-real-time monitoring datasets are available from otherwise sparsely sampled areas of the global ocean, and that developing nations have access to training, technical support, and data processing services as needed.

### Progress during FY 2023

Data management objectives for FY 2023 were met, as the Fast Delivery and Research Quality databases were updated and expanded to accommodate new data and stations. These datasets are essential to global research efforts in oceanography, geodesy, and climate change. During FY 2023, UHSLC datasets were utilized directly in at least 41 peer-reviewed articles (per Google Scholar) and in an additional 31 articles via the Global Extreme Sea Level Analysis dataset, which is primarily composed of UHSLC data for locations in the Global South. The project continued efforts to improve and modernize data flow and data-processing software within the center, including development of added capabilities to ingest data from non-UHSLC stations into the quality-control pipeline and automating procedures for aggregating data for year-end review. Tide gauge network and station maintenance objectives were reorganized during FY 2023 to accommodate the installation of four new tide gauges in American Samoa to support sea-level rise and tsunami monitoring. These new gauges



(above) New UHSLC tide gauge in the village of 'Au'asi on Tutuila Island, American Samoa. Photo Credit: Jason Klem.

(below) New UHSLC tide gauge on Ofu, part of the remote Manu'a Islands of American Samoa. Photo Credit: Jason Klem.



required two site visits per station (one for initial scouting and one for installation), as well as significant effort for station design and permitting. In addition, technicians made maintenance visits to six stations (La Libertad, Quepos, Yap, Chuuk, Saipan, and Palau). UHSLC technicians and engineers either visited or remotely assisted with five additional stations to support the global tide gauge network.

UHSLC researchers participated in multiple research projects leading to peer-reviewed articles in FY 2023, including published papers on statistical forecasts of seasonal high-tide flooding, the benefits of assimilating altimetry into seasonal forecasts of the ocean, and causes of increased high-tide flooding since 1950. With funding from Center for Operational Oceanographic Products and Services (CO-OPS) through CIMAR, significant progress was made on an assessment of the accuracy and utility of a 40-year high-resolution water-level reanalysis produced by NOAA. UHSLC researchers were also the lead authors on the sea-level section in the “State of the Climate in 2022” published in *Bulletin of the American Meteorological Society* during Summer 2023. Collaboration is a key component of UHSLC research goals, and staff collaborated with researchers outside the center on a variety of efforts related to oceanography and climate, including multiple successful proposals to NOAA programs.

## Utilization of Glider Observations for Environmental Prediction in Different Climate Regimes

**P.I.: Douglas S. Luther**

**NOAA Office (of the primary technical contact): Pacific Marine Environmental Laboratory**

**NOAA Sponsor: William S. Kessler**

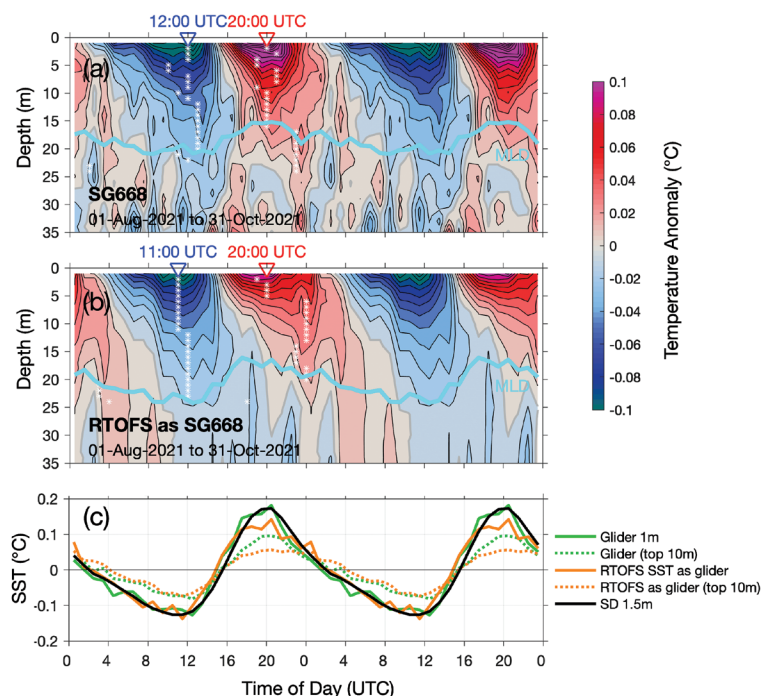
**NOAA Goal(s)**

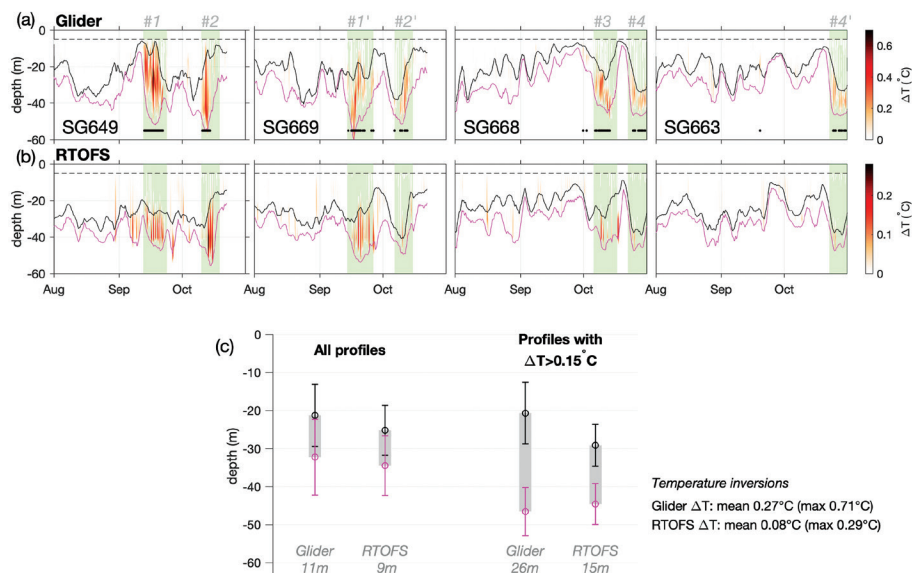
- Climate Adaptation and Mitigation

### Purpose of the Project

Gliders are an effective, sustainable, and low-cost technology for monitoring currents, temperature, and salinity in remote regions where other technologies would be difficult to implement. Gliders can also provide high-resolution *in situ* sampling, complementary to data collected through shipboard, moored buoy and satellite observations, and other autonomous technologies. While gliders were deployed in many parts of the world ocean, their observations were analyzed mainly within individual regions. A comparison of their impact on environmental

Vertical sections of the mean diurnal cycle in temperature from (a) glider SG668 south of Puerto Rico, and (b) Real-Time Ocean Forecast System (RTOFS) sampled as the glider. The mean diurnal cycle is computed as the hourly average of the anomaly from the daily mean, then averaged for the period August-October 2021. White stars mark the time of minimum and maximum temperature anomaly by depth. The cyan line shows the mean diurnal cycle of the mixed layer depth, the depth at which the potential density has increased compared to the surface by a threshold equivalent to 0.3°C decrease in temperature at constant salinity. (c) Mean diurnal cycles of surface temperature from the glider (at 1m and top 10 m), from RTOFS sampled as the glider (SST and top 10 m), and from the saildrone (1.5 m).





Comparison of upper ocean structure between glider (row [a]) and RTOFS sampled as the glider (row [b]) for 4 glider missions near Puerto Rico from 2021 (labeled SG649, SG669, SG668 and SG663). Each panel shows the mixed layer depth (black line), the thermocline depth (magenta line), and barrier layer, the distance between the two lines. The color represents the temperature departure from its surface value, where only positive values (temperature inversions) were plotted. Four periods of strong temperature inversions ( $T > 0.15^{\circ}\text{C}$ ) are highlighted in green and numbered 1 to 4 (prime is used when the same location has been sampled simultaneously by a 2nd glider). Panel (c) shows the mean mixed layer depth (black), thermocline depth (magenta), and barrier layer thickness (grey shading and grey label at the bottom) for RTOFS and the glider, computed separately for all profiles and only during strong temperature inversions. RTOFS has deeper mixed layer, and tends to underestimate the magnitude of temperature inversion and barrier layer thickness, especially in the presence of strong temperature inversion.

predictions in different climate regimes, and the added value as they combine with other techniques, is in order. To examine oceanic and atmospheric processes associated with regional impacts of climate variability and change, the project proposes to evaluate the use of glider observations in three climate settings: (1) to monitor the low-latitude western boundary current in the southwest Pacific; (2) to test the strategy of paired gliders with uncrewed surface vehicle observations to improve the storm-forecasting capabilities of coupled models; and (3) to complement moored buoys and shipboard observations with high-resolution *in-situ* data to study the physical processes affecting the variability of shelf-basin and Pacific-Arctic exchanges. In all three instances, the focus is on understanding the oceanic and atmospheric processes associated with regional climate on various temporal scales.

### Progress during FY 2023

The Global Real-Time Ocean Forecast System (RTOFS) of the National Centers for Environmental Prediction (NCEP), is one of the models providing initial ocean conditions for operational storm forecasting. Biases in simulated ocean conditions can negatively impact the surface ocean response and result in errors in storm intensity forecasts. The combination of paired glider-saildrone measurements, including upper ocean ADCP currents, provide a valuable *in situ* basis to evaluate and better understand the reasons for model biases and further improve model performance. During the past fiscal year, glider and Argo profiles were used to demonstrate a cold bias in RTOFS sea surface temperature that persists over the upper ocean and is associated with deeper mixed layer and weaker stratification. Additionally, the model tends to underestimate, or miss, the presence of barrier layers where a halocline separates warmer subsurface from colder surface waters. Using one-dimensional mixing model initialized with either Argo or model (RTOFS) profiles the team demonstrated that these differences in upper ocean conditions lead to substantially different sea surface temperature (SST) evolution under storm conditions. This is consistent with the direct observations collected when a saildrone intercepted Hurricane Sam in 2021 and revealed surface ocean warming under the eyewall of the storm. This warming was not present in the forecast models but can be consequential for storm intensity prediction. The project’s analysis attributes this flaw to the lack of temperature inversions in the upper ocean initial conditions provided by RTOFS (Chiodi et al. 2023).

## Climate Science and Impacts

*Oceanic and atmospheric processes drive global and regional climate, and climate change and impacts are associated with changes in these processes as well. Under this theme, CIMAR collaborates in research efforts with the International Pacific Research Center (IPRC) in SOEST, and hosts the Pacific El Nino Southern Oscillation (ENSO) Applications Center (PEAC).*

### **Atmospheric Gases in the Remote Pacific Marine Free Troposphere Measured in Hawai'i**

**P.I.: Douglas S. Luther**

**NOAA Office (of the primary technical contact): Earth System Research Laboratories/Mauna Loa Observatory**

**NOAA Sponsor: Brian Vasel [Darryl T. Kuniyuki]**

#### **NOAA Goal(s)**

- Healthy Oceans
- Weather-Ready Nation
- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

#### **Purpose of the Project**

The project collects and analyzes semi-continuous high altitude (11,144 feet) measurements of elemental mercury (Hg<sub>0</sub>), gaseous oxidized mercury (GOM), and particulate-bound mercury (PBM) at the Mauna Loa Observatory, Hawai'i. The objectives of this task will be to accumulate a long-term record of ambient Hg<sub>0</sub>, GOM, and PBM chemistry to: (1) support atmospheric mercury chemistry research; (2) establish a baseline mercury measurement station; (3) investigate the long-range transport of mercury from South East Asia across the Pacific; and (4) deploy and evaluate improved methodologies for accurate measurements of atmospheric mercury species. In addition to this primary task, other data are measured and collected which may elucidate the transport and transformation mechanisms of atmospheric mercury. This includes measurements of atmospheric aerosols, ozone, sulfur dioxide, carbon monoxide, elemental carbon, and meteorological variables. All of the data are to be organized and archived in a database. The mercury data are publicly available and are archived at the National Atmospheric Deposition Program (NADP): <https://nadp.slh.wisc.edu/networks/atmospheric-mercury-network/>.

#### **Progress during FY 2023**

From July 1 to approximately November 28, 2022, all objectives of the monitoring program were on track to completion. However, the summit eruption of the Mauna Loa volcano at the end of November 2022 disabled operations at the Mauna Loa Observatory. Lava flows blocked the access road from the Saddle Highway to the observatory, and halted electrical power at the observatory. While some progress has been made to install solar panels and battery backups to run low-power instruments, the mercury instrumentation was turned off and remained unpowered as of June 22, 2023.



## Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center (IPRC)

**P.I.: Niklas Schneider**

**NOAA Office (of the primary technical contact): National Environmental Satellite, Data, and Information Service/National Climatic Data Center**

**NOAA Sponsor: Howard Diamond**

### NOAA Goal(s)

- Weather-Ready Nation
- Climate Adaptation and Mitigation
- Resilient Coastal Communities and Economies

### Purpose of the Project

This project is a continuation of activities at the Asia-Pacific Data-Research Center (APDRC) in support of climate research within the International Pacific Research Center (IPRC) at the University of Hawai‘i. The project’s primary goal is to meet critical regional needs for ocean, climate and ecosystem information. The APDRC does this through local support of climate research activities but also by generating relevant data products for a broad spectrum of users throughout the Asia-Pacific region. The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and to provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community, and the public. The APDRC is organized around three main goals: (1) providing integrated data server and management systems for climate data and products; (2) developing and serving new climate-related products for research and applications users; and (3) conducting climate research in support of the IPRC and NOAA research goals.

### Progress during FY 2023

This past year, the award was used entirely to support the efforts of a software engineer (S. DeCarlo) at roughly 75% FTE. DeCarlo continued to maintain the APDRC’s suite of data transport and discovery servers, including Open-source Project for a Network Data Access Protocol (OPeNDAP)-based Thematic Real-time Environmental Distributed Data Services (THREDDS) Distributed Ocean Data Systems (DODS) Server (TDS), Grid Analysis and Display System (GrADS) DODS Server (GDS) and (DAPPER), a Data Access Protocol Live Access Server (LAS); and DCHART, a Data Access Protocol viewer. Due to restrictions in funding, no new servers were added this year.

The APDRC hosts over 125 different data sets from *in situ* platforms, satellites, and numerical models. Together, these data amount to approximately 650 terabytes (TB). This volume increases each year due to regular updates to continuing time-series (e.g., satellite platforms and models that continually provide data). These include satellite products Atmospheric Infrared Sounder (AIRS) and Moderate Resolution Imaging Spectro-radiometer (MODIS), and reanalysis products Global Ocean Data Assimilation System (GODAS) and Ensemble 4 of the Enhanced Data Assimilation and Climate Prediction model (EN4). The operational ocean model output from Hybrid Coordinate Ocean Model (HYCOM; 245TB), high-resolution ocean model hindcast from the Ocean Model for the Earth Simulator (OFES; 76TB); coupled model output from Intergovernmental Panel on Climate Change (IPCC) runs, Coupled Model Intercomparison Project Phase 5 (CMIP-5; 76TB); and output from the NCEP operational Coupled Forecast System, version 2 (CFSv2; 17TB) continue to be the most popular requests. Maintenance of the data servers is the minimal level of support, but keeping data sets up-to-date is also a priority. This second activity can sometimes require a great deal of time and effort as data sets often change.

The APDRC intends to continue support for the World Meteorological Office (WMO) Regional Climate Center (RCC) for the Pacific Islands (known as Regional Alliance Five; RA-V) activities but these were minimal this past year. This was due in part to a reduction in staff.

## Increased Logistical Support for Dissertations Symposium in Chemical Oceanography (DISCO) XXVIII and Physical Oceanography Dissertations Symposium (PODS) XXII

**P.I.: Christopher L. Sabine**

**NOAA Office (of the primary technical contact): Oceanic and Atmospheric Research/Global Ocean Monitoring and Observing**

**NOAA Sponsor: Kathy Tedesco**

### NOAA Goal(s)

- Healthy Oceans
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

### Purpose of the Project

This grant is to organize and provide on-site logistics for the Dissertations Symposium in Chemical Oceanography (DISCO) XXVIII and the Physical Oceanography Dissertations Symposium (PODS) XII in October 2022.

### Progress during FY 2023

DISCO XXVIII and PODS XII symposia were held in Kailua-Kona, Hawai'i from October 16-20, 2022. The senior guest speakers, Dr. Angelicque White of the University of Hawai'i, and Dr. Allan Clarke, emeritus, Florida State University gave their plenary addresses on the opening day of the meeting to an audience consisting of DISCO and PODS participants. The 25 DISCO and 25 PODS participants represented 30 U.S. and eight international institutions. Each participant gave a 30-minute presentation on their dissertation research. The presentations were also broadcast live, over Zoom, for those few participants could not attend in person. One presentation was made remotely (via Zoom) from a participant that could not attend in person. Those that were present also participated in joint sessions, to discuss various topics concerning ocean science careers. Program managers also gave introductions to their agencies (both in person and remotely, via Zoom), as well as short talks on proposal writing and review, and planning and executing a research cruise. These Zoom presentations are linked to the project's websites.



(above) Group photo of DISCO XXVIII participants. Credit: Charla Thompson.

(below) Group photo of PODS XII participants. Credit: Charla Thompson.



## Profiling CTD Float Array Implementation and Ocean Climate Research

PI: Douglas S. Luther

NOAA Office (of the primary technical contact): Pacific Marine Environmental Laboratory

NOAA Sponsor: Gary Matlock

### NOAA Goal(s):

- Healthy Oceans
- Weather-Ready Nation
- Climate Adaptation and Mitigation
- Resilient Coastal Communities and Economies

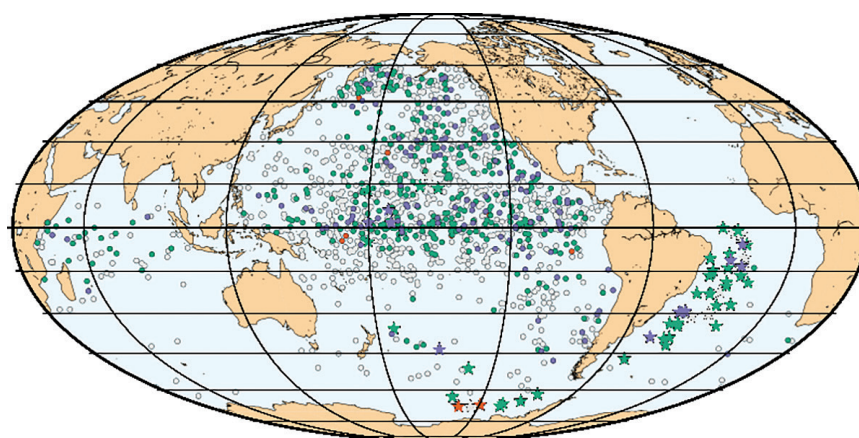
### Purpose of the Project

CIMAR works with U.S. and International Argo Project partners, especially NOAA/PMEL, on aspects of the Argo Program. The first objective involves Core, Deep, and Biogeochemical Argo float testing, deployment, and data/engineering evaluation. The second objective involves delayed-mode quality control of Argo float data and ocean climate research using data from these floats and other sources.

### Progress during FY 2023

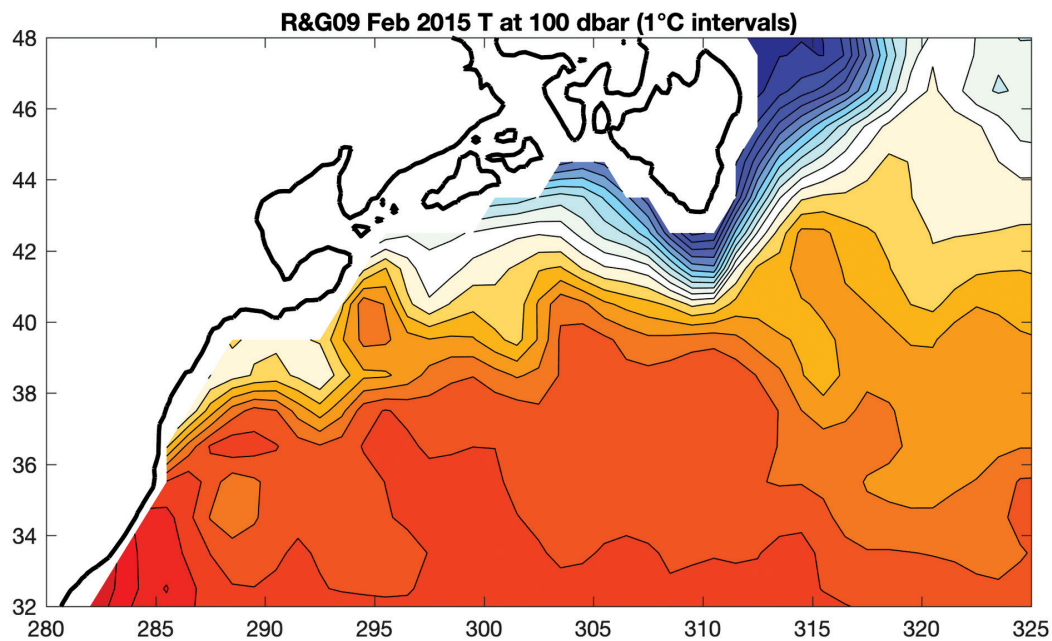
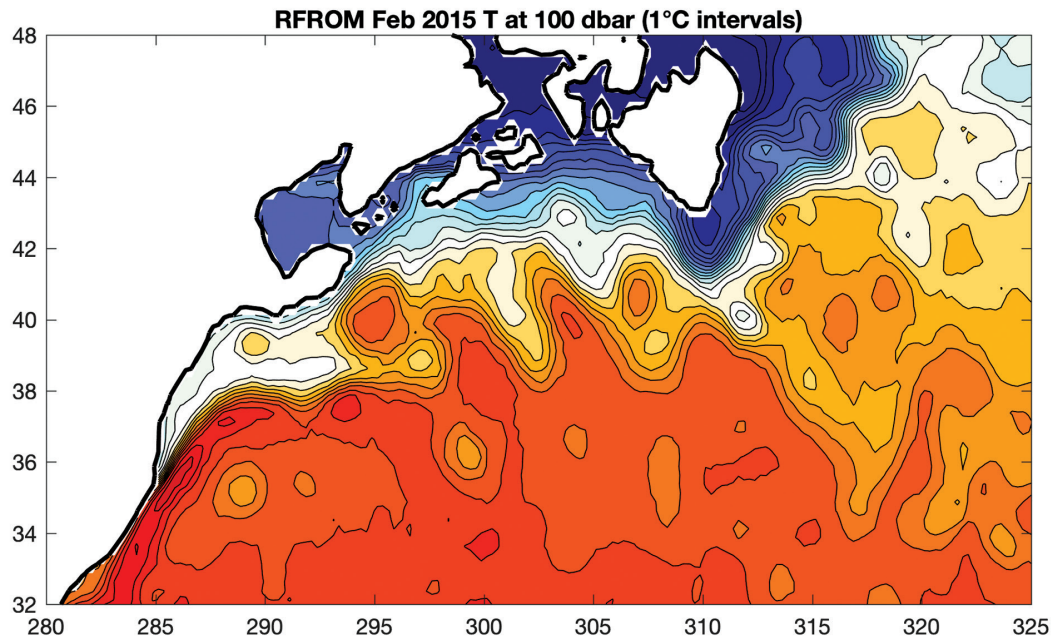
At the PMEL float lab Dr. Elizabeth Steffen continued to test floats, monitor float performance, diagnose and coordinate repairs of problems discovered with the floats, and work with the manufacturers to resolve problems. She also arranged for Core, Deep, and Biogeochemical Argo float deployments and notified the national and international databases of those deployments. She continued working on testing protocols for Biogeochemical Argo floats as well. She traveled to load and test floats on ships and train deployers.

Dr. John Lyman continued to perform scientific analyses of Argo and other data, contributing to two sections (Ocean Heat Content and Salinity) for the Global Oceans chapter of the annual “State of the Climate 2022” report published as a special supplement to the *Bulletin of the American Meteorological Society*, two other published scientific publications using Argo data, and some publications in progress as well. He finished development for new maps of ocean heat content using machine learning algorithms, dubbed Random Forest Regression Ocean Maps (RFROM; <https://www.pmel.noaa.gov/rfrom/>). He continued piloting of Deep Argo floats and continued to work with other members of the PMEL float group on Deep Argo Information Technology infrastructure. He performed some scientific delayed-mode quality control on PMEL Argo float profile data.



All Argo Float locations as of 2023-05-25

Recent locations of PMEL conventional and Deep Argo floats, for which Dr. Elizabeth Steffen performs the logistics, testing, and much of the monitoring, with Dr. John Lyman piloting the Deep Argo floats. As of May 26, 2023, conventional Argo floats reporting in the past 30 days (green and blue circles) numbered 473, and deep Argo floats (green and blue stars) numbered 46.



Comparison of temperature at 100 decibars for March 2015 in the western North Atlantic contoured at 1°C intervals for the new RFROM (<https://www.pmel.noaa.gov/rfrom/>) product (top panel) versus the Roemmich and Gilson (2009; [https://sio-argo.ucsd.edu/RG\\_Climatology.html](https://sio-argo.ucsd.edu/RG_Climatology.html)) Argo Climatology (bottom panel). The 100-m isobath is shown by the thick black line in both panels. The RFROM map has higher horizontal (and temporal) resolution, extends into shallower water, and better resolves feature such as eddies and the warm core of the Gulf Stream.

## Air-Sea Interactions

*SOEST is uniquely qualified for geophysical research in tropical regimes, and the Department of Atmospheric Sciences provides world-class research in the areas covered under this theme. In addition to facilitating IPRC and Department of Atmospheric Sciences research, CIMAR hosts NOAA National Weather Service fellowship programs in the SOEST academic departments.*

Nothing to report for this period.

## Tsunamis and Other Long-Period Ocean Waves

*CIMAR efforts in tsunami detection include development of monitoring systems for the Indian Ocean. Further collaboration in this theme is affected through interactions with the UHSLC.*

### Tsunami Research and Modeling

**P.I.: Douglas S. Luther**

**NOAA Office (of the primary technical contact): Pacific Marine Environmental Laboratory**

**NOAA Sponsor: Gary Matlock**

**NOAA Goal(s):**

- Weather-Ready Nation
- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

### Purpose of the Project

The goal of the project is an earthquake scenario-based tsunami hazard assessment for Majuro Atoll (Republic of the Marshall Islands), Chuuk, Yap and Pohnpei (Federated States of Micronesia).

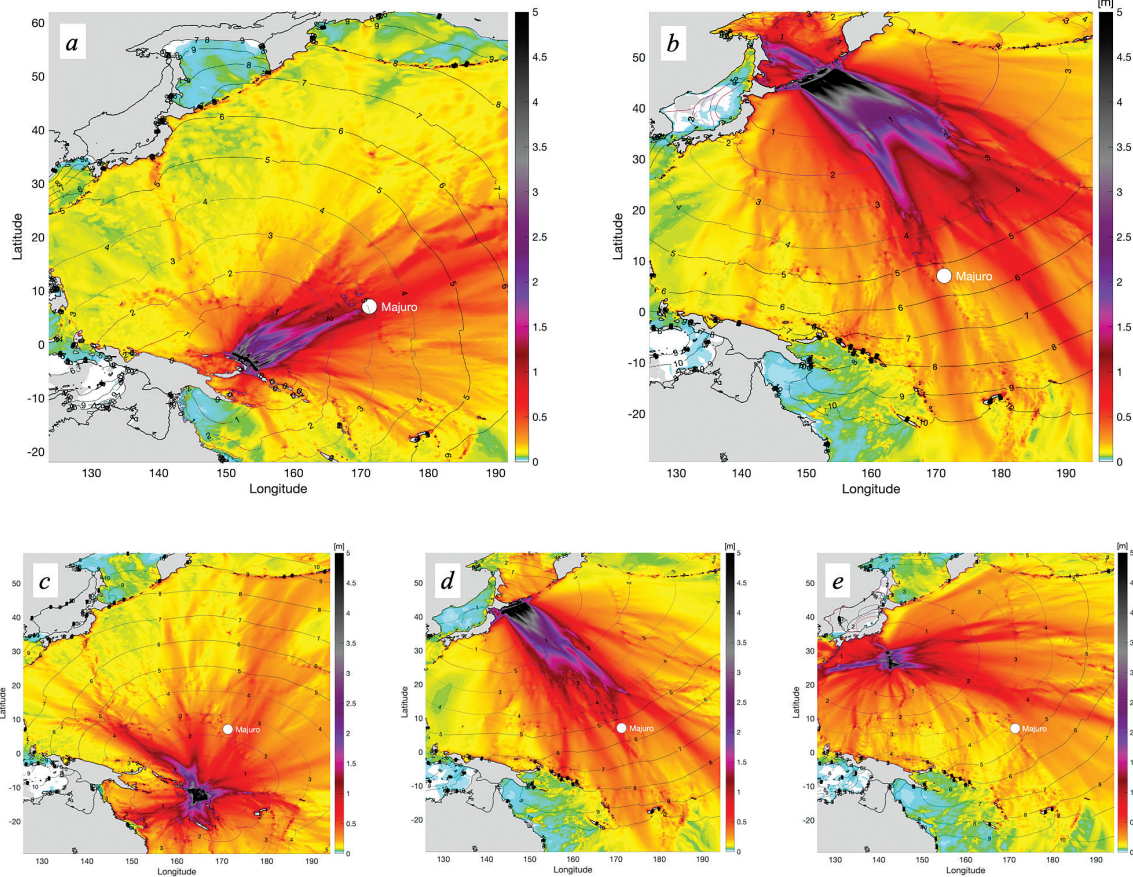
### Progress during FY 2023

With the historic cases in mind, a sensitivity study was conducted using the NOAA Tsunami Forecast Propagation Database to model tsunami impact on optimized grids along the coastline of Majuro Atoll (Republic of the Marshall Islands), Chuuk, Yap and Pohnpei (Federated States of Micronesia) from tsunami originating from 77 discrete earthquake sources. The results helped to identify the most potentially hazardous sources for each location of interest originated from different subduction zones along the Pacific Ring of Fire.

The five most hazardous sources found during the sensitivity testing were selected to determine their impact in Majuro using the available high-resolution Digital Elevation Model (DEM; 10 m) and calculation grid. The non-linear shallow water wave inundation model Digital Elevation Model Hyperbolic Systems and Efficient Algorithms (HySEA) was used to determine travel, arrival and duration times, maximum wave amplitudes, tsunami heights, flow depths, inundation, current speeds and attenuations. Time series were generated for specific locations. The results of this study are used for tsunami evacuation mapping and planning for Majuro.

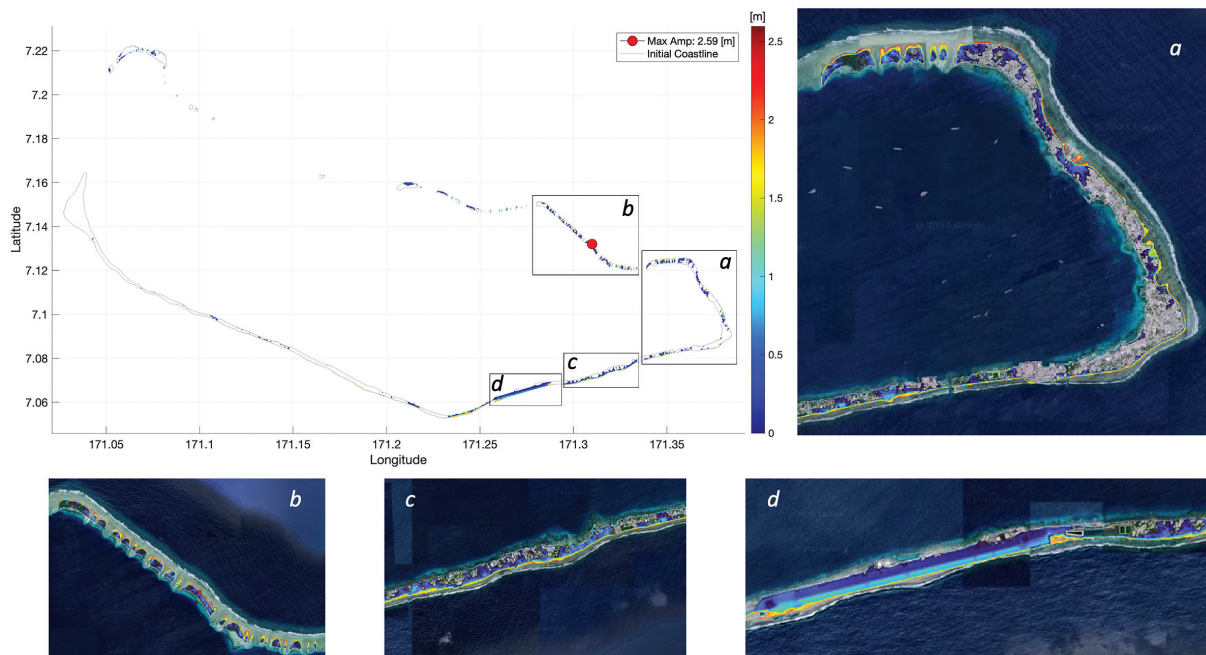
The non-linear shallow water wave inundation model Method of Splitting Tsunami (MOST) was used to determine travel and arrival times, maximum wave amplitudes in deep ocean for Yap and Chuuk using the best available resolution DEM. The method of amplification factors was used to find the tsunami heights at the shoreline and based on them – the merged tsunami hazard maps were built. The results can serve as preliminary for tsunami evacuation mapping and planning for Yap and Chuuk until better resolution DEM becomes available.

The tsunami inundation modeling for Pohnpei is ongoing. The high-resolution DEM reproducing the fringing reef around the island was created using available bathymetry (General Bathymetric Chart of the Oceans; GEBCO 2022 + Allen Coral Atlas + Digital Atlas of Micronesia) and topography data (Forest and Buildings removed Copernicus DEM; FABDEM V1-2).



(above) Source location, arrival times, and maximum wave amplitudes in deep ocean for the largest sources: a) Manus, b) Kuril, c) South Solomon-New Hebrides, d) Kuril-Japan, e) Izu-Bonin.

(below) Maximum flow depth for the Manus source with the areas of major concern highlighted: a) DUD; b) from Arniel to Enigu Islands; c) Raiirik Island; d) Amata Kabua International Airport.



## Tsunami Research and Modeling—United Forecast System (UFS)

P.I.: Douglas S. Luther

NOAA Office (of the primary technical contact): Pacific Marine Environmental Laboratory

NOAA Sponsor: Gary Matlock

NOAA Goal(s):

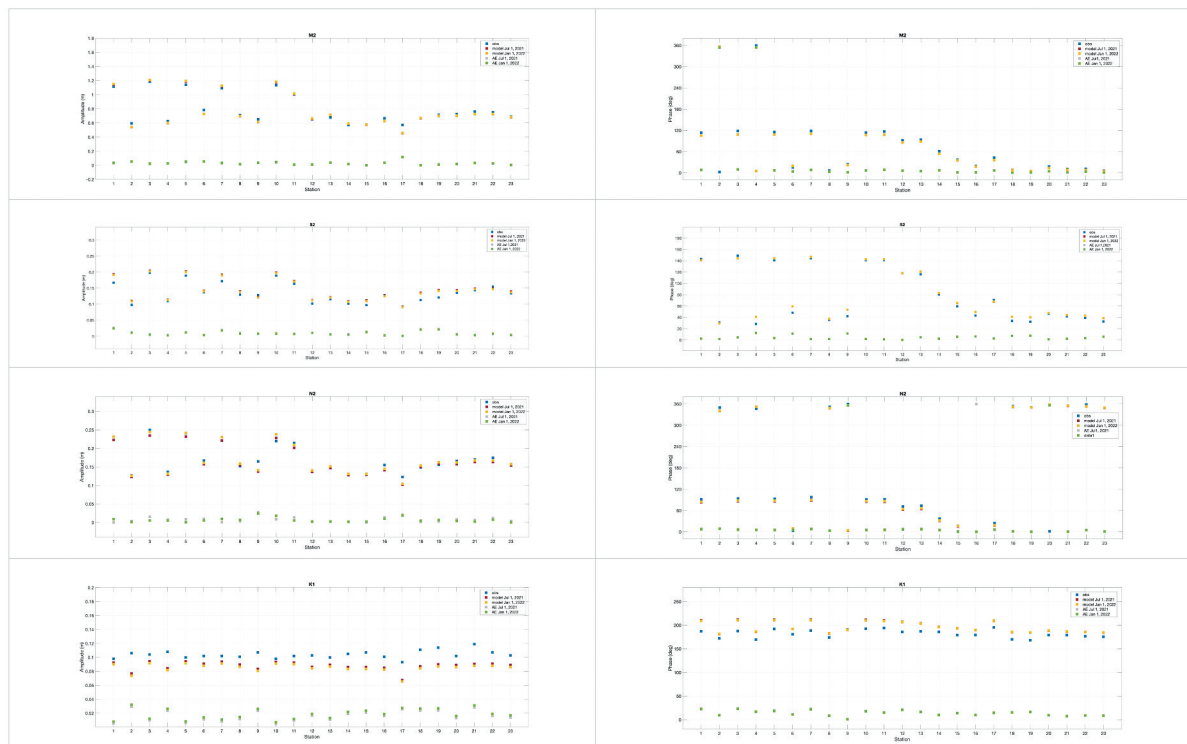
- Weather-Ready Nation
- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

### Purpose of the Project

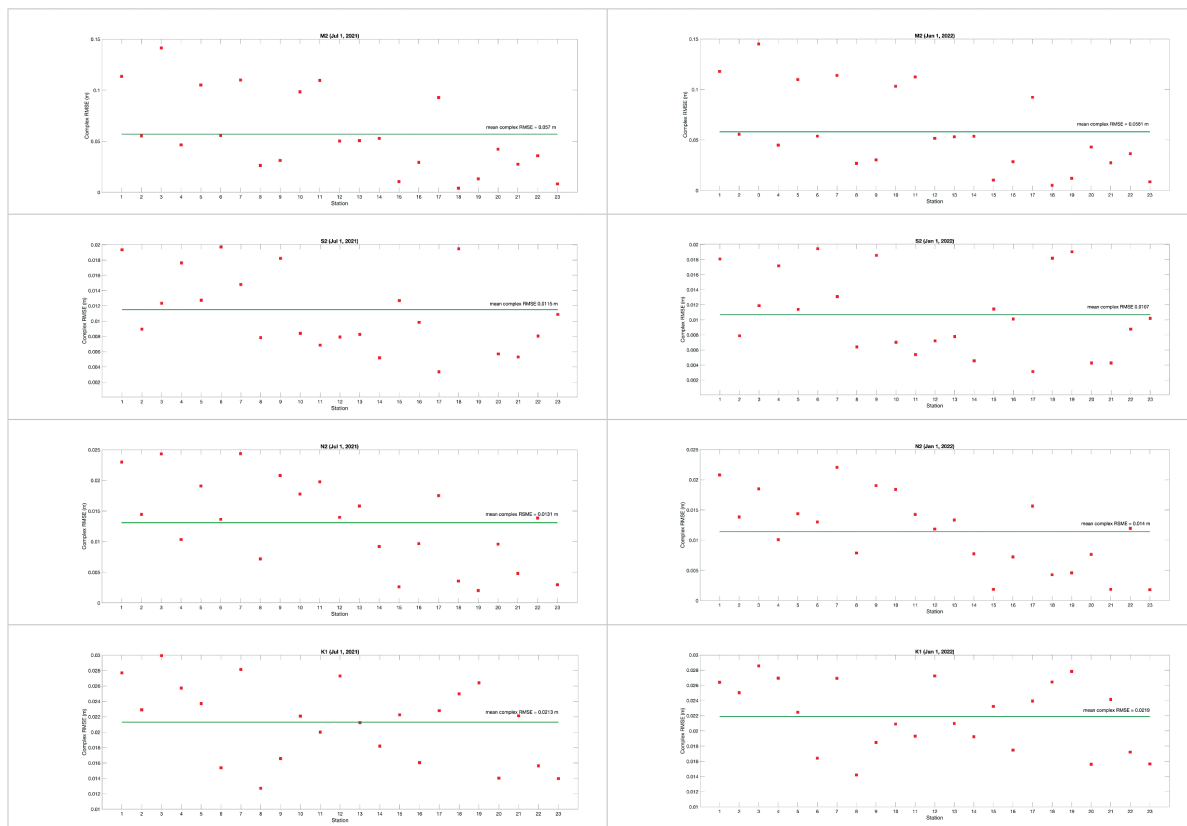
The goal of the project is the Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) evaluation testing as a potential candidate for the United Forecast System (UFS). The UFS is a proposed community-based, coupled comprehensive Earth modeling system that is designed to incorporate National Ocean Service (NOS) oceanographic forecast model core(s) into a simplified NOAA modeling suite. This simplification is intended to reduce the footprint of the number of NOAA models and thus reduce development, operations, and maintenance. The SCHISM and Finite-Volume Coastal Ocean Models (FVCOMs) were selected for further evaluation as potential candidates.

### Progress during FY 2023

For the evaluation process, SCHISM was applied to the New York City area and skill assessments with observations were performed. The high-resolution unstructured mesh was generated to conform to the complex coastline geometry and bathymetry and to increase the modeling accuracy. The testing was performed for two 90-day time periods. As the first phase of testing the water level model simulations and observations comparison



*M2, S2, N2 and K1 amplitudes and phases observed vs calculated with the corresponding AE at 23 NOS/CO-OPS stations for two hindcast periods.*



M2, S2, N2 and K1 constituents' Complex RMSE and mean Complex RMSE at 23 NOS/CO-OPS stations for both hindcast periods.

at 23 NOS/CO-OPS stations around New York Harbor was conducted. It includes major constituents (M2, S2, N2, and K1) evaluation and errors estimations (Absolute Error [AE], Root Mean Square Error [RMSE], Complex RMSE). The evaluation computation and related collaboration took place on Texas Advanced Computing Center's Frontera supercomputer. The model performs very well and the resulting mean Complex RMSE is below 6 cm for M2, ~ 1 cm for S2 and N2, and ~ 2 cm for K1.



# CIMAR Publications

Journal Articles and Books					
Author(s) Names	Publication Year	Title	Published In (Journal Name, volume and page number)	Article DOI	Project Title
Alvarado, E., F. Cabrera, M. Paiano, J. Fumo, H. Spalding, C. Smith, J. Leonard, K. Lopes, R. Kosaki, A. Sherwood	2022	Unveiling mesophotic diversity in Hawai'i: two new species in the genera <i>Halopeltis</i> and <i>Leptofaucha</i> (Rhodomeniales, Rhodophyta)	Algae, 37(4), 249-264	<a href="https://doi.org/10.4490/algae.2022.37.10.31">https://doi.org/10.4490/algae.2022.37.10.31</a>	Papahānaumokuākea Marine National Monument Monitoring and Research
Asbury M., N.M.D. Schiettekatte, C.S. Couch, T.A. Oliver, J.H.R. Burns, J.S. Madin	2023	Geological age and environments shape reef habitat structure	Global Ecology and Biogeography, 32(7), 1230-1240	<a href="https://doi.org/10.1111/geb.13691">https://doi.org/10.1111/geb.13691</a>	National Coral Reef Monitoring Program - Pacific Project
Ayers, A., K. Leong	2022	Focusing on the human dimensions to reduce protected species bycatch	Fisheries Research, 254, 106432	<a href="https://doi.org/10.1016/j.fishres.2022.106432">https://doi.org/10.1016/j.fishres.2022.106432</a>	Economics and Human Dimensions of Marine Ecosystems
Barkley H.C., T.A. Oliver, A.A. Halperin, N.V. Pomeroy, J.N. Smith, R.M. Weible, C.W. Young, C.S. Couch, R.E. Brainard, J.C. Samson	2022	Coral reef carbonate accretion rates track stable gradients in seawater carbonate chemistry across the U.S. Pacific Islands.	Frontiers in Marine Science, 9, 991685	<a href="https://doi.org/10.3389/fmars.2022.991685">https://doi.org/10.3389/fmars.2022.991685</a>	National Coral Reef Monitoring Program - Pacific Project
Barkley, Y.M., T. Sakai, E.M. Oleson, E.C. Franklin	2022	Examining distribution patterns of foraging and non-foraging sperm whales in Hawaiian waters using visual and passive acoustic data	Frontiers in Remote Sensing, 3, 940186	<a href="https://doi.org/10.3389/frsen.2022.940186">https://doi.org/10.3389/frsen.2022.940186</a>	Cetacean Research in the Pacific Islands Region
Chidong, Z., G.R. Foltz, A. Chiodi, C. Mordy, C. Edwards, C. Meinig, D. Zhang, E. Mazza, E. Cokelet, E.F. Burger, F. Bringas, G. Goni, H. Hristova, H.S. Kim, J. Trinanés, J. Zhang, K. Bailey, K. O'Brien, M. Morales-Caez, N. Lawrence-Slavas, R. Jenkins, S.S. Chen, X. Chen	2023	Hurricane observations by uncrewed systems	Bulletin of the American Meteorological Society	<a href="https://doi.org/10.1175/BAMS-D-21-0327.1">https://doi.org/10.1175/BAMS-D-21-0327.1</a>	Utilization of Glider Observations for Environmental Prediction in Different Climate Regimes
Chiodi, A.M., H. Hristova, G.R. Foltz, J.A. Zhang, C. Mordy, C. Edwards, C. Zhang, C. Meinig, D. Zhang, E. Mazza, E. Cokelet, E. Burger, F. Bringas, G. Goni, H-S. Kim, J. Trinanés, K. Bailey, K. O'Brien, M. Morales-Caez, N. Lawrence-Slavas, S. Chen, X. Chen	In Review	Surface ocean warming in the core of Hurricane Sam and its representation in forecast models	Geophysical Research Letters		Utilization of Glider Observations for Environmental Prediction in Different Climate Regimes
Fisk, J., N. Matagi, D. Kleiber	2023	Gleaning the expanse: Gender and invisibilised dimensions of fisheries in American Samoa	Women in Fisheries Information Bulletin, 37, 7-10		Economics and Human Dimensions of Marine Ecosystems
Gruden, P., Y.M. Barkley, J.L.K. McCullough	2023	Vocal behavior of false killer whale ( <i>Pseudorca crassidens</i> ) acoustic subgroups	Frontiers in Marine Science 10, 1147670	<a href="https://doi.org/10.3389/fmars.2023.1147670">https://doi.org/10.3389/fmars.2023.1147670</a>	Cetacean Research in the Pacific Islands Region
Halperin, A.A., F. Lichowski, J. Morioka, K. O'Brien, R. Suka, B. Huntington	2023	Coral cover remains suppressed three years after derelict net removal in a remote shallow water coral reef ecosystem	Marine Pollution Bulletin, 188, 114703	<a href="https://doi.org/10.1016/j.marpolbul.2023.114703">https://doi.org/10.1016/j.marpolbul.2023.114703</a>	Sustaining Healthy Coastal Ecosystems Project
Hersh, T.A., S. Gero, L. Rendell, M. Cantor, L. Weigart, M. Amano, S.M. Dawson, E. Slooten, C.M. Johnson, I. Kerr, R. Payne, A. Rogan, R. Antunes, O. Andrews, E.L. Ferguson, C.A. Hom-Weaver, T.F. Norris, Y.M. Barkley, K.P. Merkens, E.M. Oleson, T. Doniol-Valeroze, J.F. Pilkington, J. Gordon, M. Fernandes, M. Guerra, L. Hickmott, H. Whitehead	2022	Evidence from sperm whale clans of symbolic marking in non-human cultures	Proceedings of the National Academy of Sciences. 119(37), e2201692119	<a href="https://doi.org/10.1073/pnas.2201692119">https://doi.org/10.1073/pnas.2201692119</a>	Cetacean Research in the Pacific Islands Region
Hirsh, H.K., T.A. Oliver, H.C. Barkley, J.L.K. Wren, S.G. Monismith, D.P. Manzello, I.C. Enochs	2023	Predicting coral reef carbonate chemistry through statistical modeling: Constraining nearshore residence time around Guam	Aquatic Geochemistry, 29, 73-94	<a href="https://doi.org/10.1007/s10498-023-09411-6">https://doi.org/10.1007/s10498-023-09411-6</a>	Sustaining Healthy Coastal Ecosystems Project
Huntington, B., B. Vargas-Ángel, C.S. Couch, H.C. Barkley, M. Abeccasis	2022	Oceanic productivity and high-frequency temperature variability—not human habitation—supports calcifier abundance on central Pacific coral reefs	Frontiers in Marine Science, 9, 1075972	<a href="https://doi.org/10.3389/fmars.2022.1075972">https://doi.org/10.3389/fmars.2022.1075972</a>	Sustaining Healthy Coastal Ecosystems Project
Hutchinson, M.R., M.E. Scott, R.B. Bauer, J.A. Anderson, D. Coffey, K.N. Holland, C.G. Meyer, M. Royer	2023	Habitat use and movement patterns of adult male and juvenile scalloped hammerhead sharks, <i>Sphyrna lewini</i> , throughout the Hawaiian archipelago.	Endangered Species Research	<a href="https://doi.org/10.3354/esr01267">https://doi.org/10.3354/esr01267</a>	Fishing Impacts on Non-Target Species
Johnson, G.C., J. Reagan, J.M. Lyman, T. Boyer, C. Schmid, R. Locarnini	2022	Salinity	Bulletin of the American Meteorological Society, 103(8), S157-S162	<a href="https://doi.org/10.1175/BAMS-D-22-0072.1">https://doi.org/10.1175/BAMS-D-22-0072.1</a>	Profiling CTD Float Array Implementation and Ocean Climate Research
Johnson, G.C., J.M. Lyman, T. Boyer, L. Cheng, J. Gilson, M. Ishii, R.E. Killick, S.G. Purkey	2022	Ocean heat content	Bulletin of the American Meteorological Society, 103(8), S153-S157	<a href="https://doi.org/10.1175/BAMS-D-22-0072.1">https://doi.org/10.1175/BAMS-D-22-0072.1</a>	Profiling CTD Float Array Implementation and Ocean Climate Research
Kauaoo, F., T. Miura, J. Martinez, K. Lopes, F. Amidon, J. Torres-Pérez, H. Spalding, T. Williams, K. So, E. Sachs, R. Kosaki	2023	Using commercial high-resolution satellite imagery to monitor a nuisance macroalga in the largest marine protected area in the USA	Coral Reefs, 42, 253-259	<a href="https://doi.org/10.1007/s00338-022-02336-6">https://doi.org/10.1007/s00338-022-02336-6</a>	Papahānaumokuākea Marine National Monument Monitoring and Research
Lyman, J.M., G.C. Johnson	2023	Global high-resolution random forest regression maps of ocean heat content anomalies using in situ and satellite data	Journal of Atmospheric and Oceanic Technology, 40, 575-586	<a href="https://doi.org/10.1175/JTECH-D-22-0058.1">https://doi.org/10.1175/JTECH-D-22-0058.1</a>	Profiling CTD Float Array Implementation and Ocean Climate Research

Widlansky, M.J., X. Long, M.A. Balmaseda, C.M. Spillman, G. Smith, H. Zuo, Y. Yin, O. Alves, A. Kumar	2023	Quantifying the benefits of altimetry assimilation in seasonal forecasts of the upper ocean	Journal of Geophysical Research-Oceans, 128(5), e2022JC019342	<a href="https://doi.org/10.1029/2022JC019342">https://doi.org/10.1029/2022JC019342</a>	University of Hawai'i Sea Level Center
Medoff, S., J. Lynham, J. Raynor	2022	Spillover benefits from the world's largest fully protected MPA	Science, 378, 6617, 313-316	<a href="https://doi.org/10.1126/science.abn0098">https://doi.org/10.1126/science.abn0098</a>	Economics and Human Dimensions of Marine Ecosystems
Peng, L., J. Walden, K. Leong, G. DePiper, C. Speir, S. Blake, K. Norman, S. Kasperski, M. Weijerman, K. Oleson	2023	Identifying social thresholds and measuring social achievement in social-ecological systems: A cross-regional comparison of fisheries in the United States	Marine Policy, 152, June 2023, 105595	<a href="https://doi.org/10.1016/j.marpol.2023.105595">https://doi.org/10.1016/j.marpol.2023.105595</a>	Economics and Human Dimensions of Marine Ecosystems
Pezner, A.K., T.A. Courtney, H.C. Barkley, W-C. Chou, H-C. Chu, S.M. Clements, T. Cyronak, M.D. DeGrandpre, S.A.H. Kekuwa, D.I. Kline, Y-B. Liang, T.R. Martz, S. Mitarai, H.N. Page, M.S. Rintoul, J.E. Smith, K. Soong, Y. Takeshita, M. Tresguerres, Y. Wei, K.K. Yates, A. Andersson	2023	Increasing hypoxia on global coral reefs under ocean warming	Nature Climate Change, 13, 403-409	<a href="https://doi.org/10.1038/s41558-023-01619-2">https://doi.org/10.1038/s41558-023-01619-2</a>	Sustaining Healthy Coastal Ecosystems Project
Reed, E., N.J. Brown-Peterson, E. DeMartini, et al.	2023	Effects of data sources and biological criteria on length-at-maturity estimates and spawning periodicity of the commercially important Hawaiian snapper, <i>Etelis coruscans</i>	Frontiers in Marine Science, 10, 1102388	<a href="https://doi.org/10.3389/fmars.2023.1102388">https://doi.org/10.3389/fmars.2023.1102388</a>	Life History and Population Assessment Research
Scott, M.E., M. Royer, M.R. Hutchinson	2023	Time of death—behavioral responses of an oceanic whitetip shark, <i>Carcharhinus longimanus</i> , to capture by a longline fishing vessel	Animal Biotelemetry	<a href="https://doi.org/10.1186/s40317-023-00346-x">https://doi.org/10.1186/s40317-023-00346-x</a>	Fishing Impacts on Non-Target Species
Stahl, J.P., J. Tucker, L. Hawn, A. Bradford	2023	Electronic monitoring video expands opportunities for determining post-release condition of protected species following fisheries interactions	Kennelly, S.J. (ed.), Proceedings of the 10th International Fisheries Observer and Monitoring Conference, p. 246-249		Electronic Monitoring and Bycatch Estimation in Fisheries
Thompson, P.R.	2023	GESLA Version 3: A major update to the global higher-frequency sea-level dataset	Geoscience Data Journal	<a href="https://doi.org/10.1002/gdj3.174">https://doi.org/10.1002/gdj3.174</a>	University of Hawai'i Sea Level Center
Thompson, P.R., M.J. Widlansky	2023	A novel statistical approach to predict seasonal high tide flooding	Frontiers in Marine Science, 9, 1073792	<a href="https://doi.org/10.3389/fmars.2022.1073792">https://doi.org/10.3389/fmars.2022.1073792</a>	University of Hawai'i Sea Level Center
Thompson, P.R., M.J. Widlansky, E. Leuliette, D.P. Chambers, W. Sweet, B.D. Hamlington, S. Jevrejeva, M.A. Merrifield, G.T. Mitchum, R.S. Nerem	2023	Sea level variability and change	Bulletin of the American Meteorological Society, 103, S143-S192	<a href="https://doi.org/10.1175/BAMS-D-22-0072.1">https://doi.org/10.1175/BAMS-D-22-0072.1</a>	University of Hawai'i Sea Level Center
von Schuckman, K., G.C. Johnson, J.M. Lyman, et al.	2023	Heat stored in the Earth system 1960-2020: where does the energy go?	Earth System Science Data, 15, 1675-1709	<a href="https://doi.org/10.5194/essd-15-1675-2023">https://doi.org/10.5194/essd-15-1675-2023</a>	Profiling CTD Float Array Implementation and Ocean Climate Research

**Reports**

Author(s) Names	Publication Year	Title	Published In (Journal Name, volume and page number)	Article DOI	Project Title
Amir, C., T. Oliver, M. Lamirand, C. Couch	2023	Measuring coral vital rates using TagLab semi-automatic coral segmentation and temporal linking across fixed sites: standard operating procedures and time savings estimates	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-139, 32 p	<a href="https://doi.org/10.25923/s2ym-tn10">https://doi.org/10.25923/s2ym-tn10</a>	Sustaining Healthy Coastal Ecosystems Project
Ayers, A., K. Leong, J. Hospital, C. Tam, R. Morioka	2023	2022 American Samoa Fisher Observations Data Summary and Analysis.	PIFSC Data Report	<a href="https://doi.org/10.25923/vwj1-3z88">https://doi.org/10.25923/vwj1-3z88</a>	Economics and Human Dimensions of Marine Ecosystems
Ayers, A., K. Leong, J. Hospital, C. Tam, R. Morioka	2023	2022 Guam and CNMI Fisher Observations Data Summary and Analysis	PIFSC Data Report	<a href="https://doi.org/10.25923/fxkk-9p79">https://doi.org/10.25923/fxkk-9p79</a>	Economics and Human Dimensions of Marine Ecosystems
Ayers, A., K. Leong, J. Hospital, C. Tam, R. Morioka	2023	2022 Hawai'i Fisher Observations Data Summary and Analysis	PIFSC Data Report	<a href="https://doi.org/10.25923/qv15-dm14">https://doi.org/10.25923/qv15-dm14</a>	Economics and Human Dimensions of Marine Ecosystems
Dombrow, C., J. Hospital	2023	Economic and social characteristics of the American Sāmoa small boat fishery: 2021	NOAA Administrative Report	<a href="https://doi.org/10.25923/hqca-xs29">https://doi.org/10.25923/hqca-xs29</a>	Economics and Human Dimensions of Marine Ecosystems
Ehrenberg, J., M. Winston, T.A. Oliver, C.S. Couch	2022	Development of a semi-automated coral bleaching classifier in CoralNet: A summary of standard separating procedures and report of results	NOAA Technical Memorandum NMFS PIFSC, 133	<a href="https://doi.org/10.25923/d0re-9y93">https://doi.org/10.25923/d0re-9y93</a>	Sustaining Healthy Coastal Ecosystems Project
Gaos, A.R., D. Johnson, S. Ishimaru, Y.M. Barkley, C.D. Allen, S.L. Martin	2022	Sea turtle tagging in the naval base Guam area	Final Report prepared for the U.S. Naval Base Guam, Apra Harbor, Guam, by NOAA Fisheries, Pacific Islands Fisheries Science Center, Protected Species Division, Marine Turtle Biology and Assessment Program, Honolulu, Hawaii, under Interagency Agreement, 45 p		Cetacean Research in the Pacific Islands Region
Gove, J., J.A. Maynard, J. Lecky, D.P. Tracey, M.E. Allen, G.P. Asner, E. Conklin, C.S. Couch, K. Hum, R.J. Ingram, T.L. Kindinger, K. Leong, K.L.L. Oleson, E.K. Towle, R. van Hoooidonk, G.J. Williams, J. Hospital	2022	2022 Ecosystem Status Report for Hawai'i	PIFSC Special Publication, SP-23-01, 91 p	<a href="https://doi.org/10.25923/r53p-fn97">https://doi.org/10.25923/r53p-fn97</a>	National Coral Reef Monitoring Program - Pacific Project
Kindinger, T.	2023	Kabekili Herbivore Fisheries Management Area: 2022 Results	PIFSC Internal Report, IR-23-07, 2 p		Sustaining Healthy Coastal Ecosystems Project

Knor, L., M. Meléndez, N. Howins, D. Boeman, E. Lechner, E.H. De Carlo, C.L. Sabine	2022	Dissolved inorganic carbon, total alkalinity, water temperature and salinity collected from surface discrete observations using coulometer, alkalinity titrator and other instruments from the coral reef MPCO2 buoys at Ala Wai, CRIMP-2, Kaneohe, and Kilo Nalu from 2016-01-08 to 2020-12-20	NOAA National Centers for Environmental Information, Dataset	<a href="https://doi.org/10.25921/pe6v-qg74">https://doi.org/10.25921/pe6v-qg74</a>	National Ocean Acidification Observing Network - O'ahu's Linked Kāne'ohe Bay Observing Sites
Knor, L., M. Meléndez, N. Howins, D. Boeman, E. Lechner, E.H. De Carlo, C.L. Sabine	2022	Dissolved inorganic carbon, total alkalinity, water temperature and salinity collected from surface discrete observations using coulometer, alkalinity titrator and other instruments from the coral reef MPCO2 buoys at Ala Wai, CRIMP-2, Kaneohe, and Kilo Nalu from 2016-01-08 to 2020-12-20	NOAA National Centers for Environmental Information, Dataset	<a href="https://doi.org/10.25921/pe6v-qg74">https://doi.org/10.25921/pe6v-qg74</a>	National Ocean Acidification Observing Network - O'ahu's Linked Kāne'ohe Bay Observing Sites
McMillan, C.J., J.K.B. Ford, T. Cheeseman, J. Calambokidis, K. Audley, C. Birdsall, J.K. Byington, J. Currie, J.D. Darling, J. De Weerd, N. Doe, T. Doniol-Valcroze, K. Dracott, R. Finn, A. Frisch-Jordán, C. Gabriele, B. Goodwin, J. Hildering, M. Jones, E. Lyman, M. Malleson, P. Martinez Loustalot, A.A. Pack, E. Quintana-Rizzo, N. Ransome, T.J.H. Shaw, S. Stack, J. Urbán Ramirez, J. Wray, B.M. Wright, K.M. Yano	2023	Spatial patterns in the migratory destinations of humpback whales ( <i>Megaptera novaeangliae</i> ) encountered in Canadian Pacific waters, based on photo-identification data and ocean basin-wide collaboration	Canadian Technical Report of Fisheries and Aquatic Sciences, 3519	<a href="https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41096150.pdf">https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41096150.pdf</a>	Cetacean Research in the Pacific Islands Region
Mukai, G.N.M., D.R. Kobayashi, M.R. Hutchinson, M.E. Scott, J. Stahl, J. Giddens, M. Nelson	2022	Pacific Islands vulnerability assessment shark species narrative	PIFSC Data Report, DR-22-019	<a href="https://doi.org/10.25923/bjg8-ze76">https://doi.org/10.25923/bjg8-ze76</a>	Fishing Impacts on Non-Target Species
Parke, M., B. Lumsden, I. Biedron, R. Rykaczewski, P. Woodworth-Jefcoats, J. Wren, K. Tanaka, R. Ahrens, J. Ruzicka, J. O'Malley, M. Trianni, E. Oleson, M. Barbieri, C. Allen, A. Bradford, S. Robinson, A. Gaos, K. Leong, J. Fisk, J. Gove, J. Whitney, C. Dombrow	2023	Ecosystem-based fisheries (EBF) science in a data-limited region	U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC, 141, 37 p	<a href="https://doi.org/10.25923/2acc-eb81">https://doi.org/10.25923/2acc-eb81</a>	Economics and Human Dimensions of Marine Ecosystems
<b>Conference and Workshop Proceedings</b>					
<b>Author(s) Names</b>	<b>Publication Year</b>	<b>Title</b>	<b>Published In (Journal Name, volume and page number)</b>	<b>Article DOI</b>	<b>Project Title</b>
Barkley, Y.M., T. Sakai, E.M. Oleson, E.C. Franklin	2022	Examining distribution patterns of foraging and non-foraging sperm whales in Hawaiian waters	24th Biennial Conference on the Biology of Marine Mammals		Cetacean Research in the Pacific Islands Region
Barkley, Y.M., T. Sakai, E.M. Oleson, E.C. Franklin	2023	Modeling sperm whale distribution using visual and passive acoustic data	National Protected Species Assessment Workshop III, Miami, FL, USA, 28-30 March		Cetacean Research in the Pacific Islands Region
Gruden, P., E.M. Nosal, E.M. Oleson	2023	Acoustic localization of false killer whale ( <i>Pseudorca crassidens</i> ) subgroups in the Hawaiian archipelago	National Protected Species Assessment Workshop III, Miami, FL, USA, 28-30 March		Cetacean Research in the Pacific Islands Region
Gruden, P., Y. Barkley, J.L. McCullough	2022	Insights into acoustic behavior of false killer whales	The Journal of the Acoustical Society of America, 151, A74		Cetacean Research in the Pacific Islands Region
Nakachi, A., K. Leong, K. Oleson	2023	Social value mapping kuleana to place	Pathways 2023 Conference		Economics and Human Dimensions of Marine Ecosystems
Nakachi, A., K. Leong, K. Oleson	2023	Social value mapping kuleana to place	EcoSummit 2023 Conference		Economics and Human Dimensions of Marine Ecosystems
Sannikova, N., C. Moore, C. von Hillebrandt-Andrade, et al.	2022	Modeling tsunami inundation for hazard assessment of Barbados	AGU Fall Meeting 2022, held in Chicago, IL, 12-16 December 2022, id. NH22C-0447		Tsunami Research and Modeling
Sannikova, N., Y. Wei, V. Titov	2023	Coastal ocean SCHISM model evaluation	CICOES Symposium, held in Seattle, WA, 13-14 June, 2023		Tsunami Research and Modeling-United Forecast System
Stahl, J.P., J. Tucker	2023	Electronic monitoring video expands opportunities for making determinations of post release condition of protected species	10th International Fisheries Observer and Monitoring Conference		Electronic Monitoring and Bycatch Estimation in Fisheries
Tenorio-Halle, L., P. Gruden, H. Frouin-Mouy, A. Debich, A. Cook, L. Garrison, E.M. Nosal, E.M. Oleson, M. Soldevilla	2023	Passive acoustic localization and tracking of Rice's whales ( <i>Balaenoptera ricei</i> ) in the northeastern Gulf of Mexico.	The Journal of the Acoustical Society of America, 153, A184		Cetacean Research in the Pacific Islands Region
Tucker, J., J.P. Stahl	2023	Artificial Intelligence (AI) models developed from electronic monitoring video automate detection of catch in the Hawaii longline fisheries	10th International Fisheries Observer and Monitoring Conference		Electronic Monitoring and Bycatch Estimation in Fisheries
<b>Presentations</b>					
<b>Author(s) Names</b>	<b>Publication Year</b>	<b>Title</b>	<b>Published In (Journal Name, volume and page number)</b>	<b>Article DOI</b>	<b>Project Title</b>
Ayers, A., J. Hospital, S. Medoff, C. Dombrow, K. Kamikawa, S. Sakuma	2023	Characterizing non-commercial boat-based fishing communities in Hawai'i to improve engagement	World Recreational Fishing Conference 10. Keeping Pace in a Dynamic and Challenging World with Changing Fisheries		Economics and Human Dimensions of Marine Ecosystems
Briggs, E., T. Martz, C. Sabine, M. Meléndez, A. Morris	2022	Ph and total alkalinity sensor for in-situ monitoring of aqueous CO2 system	2022 OCB Summer Workshop		National Ocean Acidification Observing Network - O'ahu's Linked Kāne'ohe Bay Observing Sites

Fisk, J.	2023	Environmental Justice & Governance	Cultural Evolution Society's Cultural Evolution + Natural Resource Management Working Group	Economics and Human Dimensions of Marine Ecosystems
Meléndez, M., C. Sabine	2022	An inter-island comparison of net ecosystem response to ocean acidification	UH Marine Geology & Geochemistry Oceanography Graduate Student (COGS) Symposium	National Ocean Acidification Observing Network - O'ahu's Linked Kāne'ohe Bay Observing Sites
Nakachi, A., K. Leong, K. Oleson	2023	Spatially representing social values in West Hawai'i	IEA 2023 Face to Face	Economics and Human Dimensions of Marine Ecosystems
Ferg, L., J. Walden, K. Leong, G. DePiper, C. Speir, S. Blake, K. Norman, S. Kasperski, M. Weijerman, K. Oleson	2023	Identifying social thresholds and measuring social achievement in social-ecological systems	Society for Applied Anthropology Meeting (April 2, 2023)	Economics and Human Dimensions of Marine Ecosystems
Reed, E.	2023	Fish life history biosampling best practices	American Samoa Shore Based Training and Research	Life History and Population Assessment Research
Reed, E.	2022	From the field to the sea: Fish life history research with a NOAA affiliated scientist	University of Guam POETS Talks	Life History and Population Assessment Research
Reed, E., N.J. Brown-Peterson, E. DeMartini, et al.	2023	Effects of data sources and biological criteria for length-at-maturity estimates in a data-limited species	NOAA NSAW/MARVLS Workshop	Life History and Population Assessment Research
Sannikova, N., C. Moore	2022	Barbados tsunami modeling and hazard assessment	Tsunami Evacuation Mapping Workshop, held in Bridgetown, Barbados, 8-12 August 2022	Tsunami Research and Modeling
Sannikova, N., C. Moore	2023	Modeling tsunami inundation for hazard assessment of Majuro (Marshall Islands), Yap, Chuuk and Pohnpei (Federated States of Micronesia)	Tsunami Ready Meeting, held in Seattle, WA, 23 February 2023	Tsunami Research and Modeling
Sannikova, N., C. Moore	2023	Modeling tsunami inundation for hazard assessment of Majuro (Marshall Islands), Yap, Chuuk and Pohnpei (Federated States of Micronesia)	ITIC Training, held in Honolulu, HI, 3 April 2023	Tsunami Research and Modeling
Sannikova, N., Y. Wei, V. Titov	2023	UFS CAT SCHISM model evaluation (Phase 1 tide simulation)	Unstructured Mesh Generation for SCHISM Model Report, held remotely, 15 February, 2023	Tsunami Research and Modeling-United Forecast System
Sannikova, N., Y. Wei, V. Titov	2023	UFS CAT SCHISM model evaluation (Phase 1 tide simulation)	Phase 1 wrap up project report, held remotely, 17 May, 2023	Tsunami Research and Modeling-United Forecast System
Scott, M.E., M.R. Hutchinson	2023	Assessing effects of leader material and trailing gear on non-target species	73rd Annual Tuna Conference, Lake Arrowhead, Los Angeles	Fishing Impacts on Non-Target Species
Scott, M.E., M.R. Hutchinson	2022	Assessing effects of leader material and trailing gear on non-target species	Presented to the Scientific and Statistical Committee of the 190th Meeting of the Western Pacific Regional Fishery Management Council, Hawaii, USA	Fishing Impacts on Non-Target Species
Stahl, J.P.	2022	Electronic Monitoring (EM) expands opportunity for detecting and making determinations of post-release condition of cetaceans in Hawaii longline fisheries	False Killer Whale Take Reduction Team Meeting	Electronic Monitoring and Bycatch Estimation in Fisheries
Stahl, J.P.	2023	Hawaii Longline Electronic Monitoring (EM) Program	FRMD Bi-Annual Meeting	Electronic Monitoring and Bycatch Estimation in Fisheries
Stahl, J.P., J. Tucker	2022	Hawaii Longline Electronic Monitoring (EM) Program	Electronic Technologies (ET) Steering Committee Meeting	Electronic Monitoring and Bycatch Estimation in Fisheries
Tucker, J., J.P. Stahl	2023	Hawaii Longline Electronic Monitoring (EM) Program	Senator's staff PIFSC office tour	Electronic Monitoring and Bycatch Estimation in Fisheries

## Publication Summary

The table below shows the total count of publications for the reporting period categorized by CIMAR Lead Author, NOAA Lead Author, or Other Lead Author and whether it was peer-reviewed or non-peer reviewed.

		FY 22	FY 23
Peer Reviewed	<b>CIMAR Lead Author</b>	2	17
	NOAA Lead Author	3	7
	Other Lead Author	0	8
Non Peer-Reviewed	<b>CIMAR Lead Author</b>	5	37
	NOAA Lead Author	6	5
	Other Lead Author	0	7

## Appendix I List of Acronyms

3D	Three-Dimensional
ACCURATE	ACoustic CUe RATE
ADCP	Acoustic Doppler Current Profiler
ADMB	Automatic Differentiation Model Builder
AE	Absolute Error
AI	Artificial Intelligence
AIRS	Atmospheric Infrared Sounder
APDRC	Asia-Pacific Data Research Center
ARC	Assessment and Recovery Camps
ASBE	Annual Small Boat Evaluation
ATE	Annual Trailer Evaluation
BFISH	Bottomfish Fishery-Independent Survey in Hawai‘i
BMUS	Bottomfish Management Unit Species
CAS	Centralized Authorization System
CAU	Calcification Accretion Units
CCR	Closed-Circuit Rebreathers
CFSv2	Coupled Forecast System, version 2
CIMAR	Cooperative Institute for Marine and Atmospheric Research
CIPIR	Cooperative Institute for the Pacific Islands Region
CM	Centimeter
CMIP-5	Coupled Model Intercomparison Project Phase 5
CNMI	Commonwealth of the Northern Mariana Islands
CO-OPS	Center for Operational Oceanographic Products and Services
CO <sub>2</sub>	Carbon Dioxide
COVID-19	Corona Virus Disease 2019
CRIMP-2	Coral reef instrumented platform-2
CRP	Cetacean Research Program
CTD	Conductivity Temperature and Depth
DAPPER	Data Access Protocol server
DCHART	Web-based server for display of in situ and gridded data sets
DEM	Digital Elevation Model
DFW	Division of Fish and Wildlife
DIC	Dissolved inorganic carbon
DISCO	Dissertations Symposium in Chemical Oceanography
DNA	Deoxyribonucleic Acid
DODS	Distributed Ocean Data Systems
DSCRTP	Deep Sea Coral Research and Technology Program
eDNA	Environmental Deoxyribonucleic Acid

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EEJ	Equity and Environmental Justice
EEZ	Exclusive Economic Zone
EM	Electronic Monitoring
EN4	Ensemble 4 of the Enhanced Data Assimilation and Climate Prediction model
ENSO	El Niño Southern Oscillation
EORP	Ecosystems Observations and Research Program
ER	Electronic Reporting
ESD	Ecosystem Sciences Division
ET	Electronic Technologies
E/V	Exploration Vessel
FABDEM	Forest and Buildings removed Copernicus DEM
FAD	Fish Aggregating Device
FAL	Silky sharks
FINTS	Fishery Impacts to Non-Target Species
FRDS	Fisher Reporting and Dealer System
FRMD	Fisheries Research and Monitoring Division
FVCOMS	Finite-Volume Coastal Ocean Model
FY	Fiscal Year
GCOS	Global Climate Observing System
GDS	GrADS DODS Server
GEBCO	General Bathymetric Chart of the Oceans
GLOSS	Global Sea Level Observing System
GOA-ON	Global Ocean Acidification Observing Network
GODAS	Global Ocean Data Assimilation System
GOM	Gaseous oxidized mercury
GPS	Global Positioning System
GrADS	Grid Analysis and Display System
HARP	High-frequency Acoustic Recording Package
HCTP	Hawai'i Community Tagging Program
HDAR	Hawai'i Division of Aquatic Resources
Hg0	Elemental Mercury
HICEAS	Hawaiian Islands Cetacean and Ecosystem Assessment Survey
HMS	Hawaiian Monk Seal
HMSRP	Hawaiian Monk Seal Research Program
HYCOM	Hybrid Coordinate Ocean Model
HySEA	Hyperbolic Systems and Efficient Algorithms
IEC	International Electrotechnical Commission
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center

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IRC	Daniel K. Inouye Regional Center
ISO	International Organization for Standardization
IT	Information Technology
LAS	Live Access Server
LBSP	Land-Based Sources of Pollution
LHP	Life History Program
LLHARP	Longline High-frequency Acoustic Recording Package
MAC	Marianas
MAKER Lab	Marine and Applied Knowledge for Ecosystem Research Laboratory
MAPCO <sub>2</sub>	Moored autonomous partial pressure of CO <sub>2</sub>
MARFAC	Marine Animal Recovery Facility
MEGA	Multi-Scale Environmental Graphics and Analysis
MHI	Main Hawaiian Islands
MIL	Marine Instrumentation Laboratory
ML	Machine Learning
MLO	Mauna Loa Observatory
MODIS	Moderate Resolution Imaging Spectro-radiometer
MOI	Marine Optical Imagery
MOST	Method of Splitting Tsunami
MOUSS	Modular Underwater Stereoscopic System
MTBAP	Marine Turtle Biology and Assessment Program
MUS	Management Unit Species
N2N	NOAA to NOAA
NADP	National Atmospheric Deposition Program
NCEI	National Centers for Environmental Information
NCEP	National Centers for Environmental Prediction
NCRMP	National Coral Reef Monitoring Program
NMFS	National Marine Fisheries Service
NMNH	National Museum of Natural History
NOA-ON	National Ocean Acidification Observing Network
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWHI	Northwestern Hawaiian Islands
OA	Ocean acidification
OAP	Ocean Acidification Program
OCS	Oceanic whitetip shark
OFES	Ocean General Circulation Model for the Earth Simulator
OMAO	Office of Marine and Aviation Operations
OPeNDAP	Open-source Project for a Network Data Access Protocol
PacIOOS	Pacific Islands Ocean Observing System



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pCO <sub>2</sub>	Partial pressure of carbon dioxide
PEAC	Pacific ENSO Applications Climate Center
PGM	Particulate-bound mercury
pH	Potential of hydrogen
PIFG	Pacific Island Fisheries Group
PIFSC	Pacific Islands Fisheries Science Center
PIR	Pacific Islands Region
PMEL	Pacific Marine Environmental Laboratory
PMNM	Papahānaumokuākea Marine National Monument
PODS	Physical Oceanography Dissertations Symposium
PSD	Protected Species Division
PWA	Progressive Web Applications
PYSO	PIFSC Young Scientist Opportunity
QA	Quality Assurance
QC	Quality Control
qPCR	Quantitative Polymerase Chain Reaction
RA-V	Regional Alliance Five (Pacific Islands)
RCC	Regional Climate Center
REA	Rapid Ecological Assessment
RFROM	Random Forest Regression Ocean Maps
RICHARD	Rainier Integrates Charting, Hydrography, and Reef Demographics
RMSE	Root Mean Square Error
ROV	Remotely Operated Vehicle
RTOFS	Real-Time Ocean Forecast System
R/V	Research Vessel
SATA	Serial Advanced Technology Attachment
SAMI-alk	Submersible Autonomous Moored Instrument for alkalinity
SAP	Stock Assessment Program
SBP	Small Boat Program
SCADA	Supervisory Control and Data Acquisition
SCHISM	Semi-implicit Cross-scale Hydroscience Integrated System
SCUBA	Self-Contained Underwater Breathing Apparatus
SD	Secure Digital
SDT	Software Development Team
SfM	Structure-from-Motion
SHCE	Sustaining Healthy Coastal Ecosystems
SIO	Scripps Institution of Oceanography
SOD	Science Operations Division
SOEST	School of Ocean and Earth Science and Technology
SOP	Standard Operating Procedure

SQL	Structured Query Language
SST	Sea Surface Temperature
TA	Total alkalinity
TB	Terabyte
TDR	Temperature Depth Recorder
TDS	THREDDS DODS Server
THREDDS	Thematic Real-time Environmental Distributed Data Services
UAS	Unmanned Aircraft Systems
UFS	United Forecast System
UH	University of Hawai'i
UHDAS	University of Hawai'i Data Acquisition System
UHSLC	University of Hawai'i Sea Level Center
UMS	Uncrewed Marine Systems
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USA	United States of America
VARs	Video Annotation and Reference System
VFP	Visual FoxPro
VIAME	Video and Image Analytics for a Marine Environment
VMS	Vessel Monitoring System
WAMI	Wide Area Motion Imagery
WMO	World Meteorological Office
WPacFIN	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Regional Fishery Management Council

## Appendix II List of Awards and Related Amendment Numbers

COOPERATIVE INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH (CIMAR)

COOPERATIVE AGREEMENT NO. NA21NMF4320043

List of Projects described in the Annual Report for the period: July 1, 2022–June 30, 2023

<b>Title</b>	<b>NOAA Technical Lead/Sponsor</b>	<b>Amendment Number(s)</b>
Atmospheric Gases in the Remote Pacific Marine Free Troposphere Measured in Hawaii	Brian Vasel	43, 73
Cetacean Research in the Pacific Islands Region	Charles Littnan	8, 51
Economics and Human Dimensions of Marine Ecosystems	Charles Littnan	18, 49
Ecosystem Structure and Function	Charles Littnan	20, 56
Ecosystems Observations and Research Project	Charles Littnan	21, 27, 45
Electronic Monitoring and Bycatch Estimation in Fisheries	Charles Littnan	22, 62
Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center (IPRC)	Howard Diamond	2, 40
Fisheries Monitoring Project	Charles Littnan	24
Fishing Impacts on Non-Target Species	Charles Littnan	6
Hawaiian Monk Seal PMNM Research Project	Charles Littnan	10, 31, 61, 70
Hawaiian Monk Seal Research and Recovery Project	Charles Littnan	5, 30, 58, 68
Improving Ocean Current Measurements for Research: Maximizing Contributions from the NOAA Fleet	Solomon Tadele	23, 47
Increased Logistical Support for Dissertations Symposium in Chemical Oceanography (DISCO) XXVIII and Physical Oceanography Dissertations Symposium (PODS) XXII	David Legler	35
Life History and Population Assessment Research	Charles Littnan	12, 38, 44
Marine Turtle Recovery in the Pacific Islands Region	Charles Littnan	14, 29, 52, 69
National Coral Reef Monitoring Program - Pacific Project	Charles Littnan	15, 59
National Coral Reef Monitoring Program - PacIOOS Support for Annual Refurbishment of M <sub>Ap</sub> CO <sub>2</sub> Buoy at Class III Site in American Samoa	Ian Enochs	1, 39, 64
National Ocean Acidification Observing Network - O'ahu's Linked Kāne'ohe Bay Observing Sites	Dwight Gledhill	3, 53, 54
Open Source ADMB Project	Jon Brodziak	9, 42
Pacific Islands Deep-Sea Coral and Sponge Initiative	Charles Littnan	13, 37
Papahānaumokuākea Marine National Monument Monitoring and Research	Randall Kosaki	19, 60
Profiling CTD Float Array Implementation and Ocean Climate Research	Gary Matlock	17, 34
Science Operations in the Pacific Islands Region	Charles Littnan	11, 26, 36, 46, 66, 71
Sustaining Healthy Coastal Ecosystems Project	Charles Littnan	16, 48
Territory Electronic Reporting Project	Charles Littnan	7, 57, 65
Tsunami Research and Modeling	Gary Matlock	28, 32, 67
Tsunami Research and Modeling - United Forecast System (UFS)	Gary Matlock	55
University of Hawaii Sea Level Center	David Legler	63
Utilization of Glider Observations for Environmental Prediction in Different Climate Regimes	Gary Matlock	4, 41

## Appendix III Visiting Scientists

DATE	NAME/AFFILIATION	PURPOSE OF VISIT
11/06/22 - 11/10/22	Abigail Campbell Candidate for Masters of Science Northeastern University Three Seas Program Boston, MA	To present original research on Oceanic whitetip shark population demographics and fishery interactions using photo-identification around Hawai‘i in support of the Hawai‘i Community Tagging Program at the 2022 Australian Society for Fish Biology Conference.

## Appendix IV Workshops, Meetings and Seminars

**Electronic monitoring video expands opportunities for making determinations of post-release condition of protected species**

**March 9, 2023, 10<sup>th</sup> International Fisheries Observer and Monitoring Conference, Hobart, Australia**

Jennifer Stahl, Fisheries Monitoring & ByCatch Research Associate, CIMAR Pacific Islands Fisheries Science Center

**Artificial Intelligence (AI) models developed from electronic monitoring video automate detection of catch in the Hawai'i longline fisheries**

**March 9, 2023, 10<sup>th</sup> International Fisheries Observer and Monitoring Conference, Hobart, Australia**

Joshua Tucker, Fisheries Electronic Monitoring Research Associate, CIMAR Pacific Islands Fisheries Science Center

**Honu Count: Using shell-etchings and community science to track and monitor the Central North Pacific green sea turtle population**

**March 22–23, 2023, 41<sup>st</sup> International Sea Turtle Symposium, Cartagena, Colombia**

Brittany Clemans, Student Assistant, CIMAR Pacific Islands Fisheries Science Center

**East Island, 5 years later: Shifts in key demographic parameters for Hawaiian green sea turtles (honu) following the loss of their primary nesting island**

**March 22–23, 2023, 41<sup>st</sup> International Sea Turtle Symposium, Cartagena, Colombia**

Marylou Staman, Marine Science Coordinator, CIMAR Pacific Islands Fisheries Science Center

**Modeling sperm whale distribution using visual and passive acoustic data**

**March 29, 2023, NOAA Protected Species Assessment Workshop III, Miami, FL**

Yvonne Barkley, PhD, Cetacean Acoustic Researcher, CIMAR Pacific Islands Fisheries Science Center

**Acoustic localization of false killer whale (*Pseudorca crassidens*) subgroups in the Hawaiian archipelago**

**March 29, 2023, NOAA Protected Species Assessment Workshop III, Miami, FL**

Pina Gruden, PhD, Cetacean Acoustic Researcher, CIMAR University of Hawai'i at Mānoa

**When will it flood next month? A new statistical model to predict daily high tide flooding**

**April 26, 2023, Joint IPRC-CIMAR Climate Seminar, University of Hawai'i at Mānoa, Honolulu, HI**

Greg Dusek, PhD, Senior Scientist, NOAA National Ocean Service

**Dissertations Symposium in Chemical Oceanography (DISCO) XXVIII**

**October 16–20, 2022, Courtyard King Kamehameha Beach Hotel, Kailua-Kona, HI**

Lydia Babcock-Adams, Daniel Clements, Fei Da, Hannah Dawson, Shannon Doherty, Yuanxu Dong, Sarah Douglas, Maria Figueroa, Kalina Grabb, Mohammed Hashim, Hope Ianiri, Robert Izett, Colette Kelly, Irina Koester, Susanna Michael, Jule Middleton, Linqun Mu, Jiwoon Park, Jaclyn Pittman, Lorenza Raimondi, Hojong Seo, Rachel Thomas, Nicole Travis, Tatiana Williford, Stephanie Wilson

**Physical Oceanography Dissertations Symposium (PODS) XII**

**October 16–20, 2022, Courtyard King Kamehameha Beach Hotel, Kailua-Kona, HI**

Caitlin Amos, Russell Arnott, Christine Baker, Samuel Brenner, Houraa Daher, Charly de Marez, Henri Drake, Elizabeth Ellson, Helena Frazão, Madelaine Gamble Rosevear, Maria Gastelu Barcena, Isabelle Giddy Nunes da Costa, Fraser Goldsworth, Manuel Gutierrez-Villanueva, Suneil Iyer, Margaret Lindeman, Josué Martínez Moreno, Theresa Morrison, Astrid Pacini, Channing Prend, Charles Turner, Young (Paul) Yi, Ken Zhao, Yixi Zheng, Xiaohui Zhou

## Appendix V CIMAR Personnel

Information as of June 30, 2023

Category	Number	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	15	0	0	0	0	15
Visiting Scientist	0	0	0	0	0	0
Postdoctoral Fellow	3	0	0	0	0	3
Research Support Staff	70	2	1	42	19	6
Administrative	8	0	0	7	1	0
Total (≥ 50% support)	96	2	1	49	20	24
Undergraduate Students	6	6	0	0	0	0
Graduate Students	11	0	0	7	4	0
Employees that receive < 50% NOAA Funding (not including students)	6	0	0	1	2	3
Located at Lab (including name of Lab)	1 - ESRL 81 - PIFSC 5 - PMEL 4 - PMNM					
Obtained NOAA employment within the last year	5					

## **Appendix VI Awards**

### **Jesse Abdul**

- 2022 RCUH Outstanding Employee of the Year, Honorable Mention, Researcher/Project Manager

### **Brittany Clemans**

- Nominee for 2023 Student Employee of the Year

## **Appendix VII Graduates**

Nothing to report for this period.



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## Appendix VIII List of Progress Reports for Associated Awards

The following associated awards progress reports can be found under their respective award numbers in Grants Online.

Award#: NA22NMF4050043

Title: Cooperative Institute for Marine and Atmospheric Research (CIMAR) – Parallel Award

Principal Investigator: Dr. Douglas Luther

Award# NA23NMF4050054I

Title: BIL – Baseline Sea Level Climatologies and Coastal Flood Monitoring and Reporting

Principal Investigator: Dr. Philip Thompson



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*Back cover: A beautiful table coral (Acropora hyacinthis) graces the foreground of the reef in American Samoa while a CIMAR diver counts corals in the background (Photo credit: Mia Lamirand)*

# Cooperative Institute for Marine and Atmospheric Research

