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Atmospheric Research
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Annual Report for Fiscal Year 2021 For Cooperative Agreement NA16NMF4320058 Performance Period July 1, 2020–June 30, 2021

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Front cover: The NOAA PIFSC/JIMAR Marine Debris team works to remove a large derelict fishing net from Midway Atoll within the Papahānaumokuākea Marine National Monument (Photo credit: Steven Gnam/NOAA/JIMAR)

Wave image on pages 1, 3, 31, 39, 57, 63, 69, 73, 79, and 87 courtesy of freePNGimg.com.

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Introduction—Fundamentals of the Cooperative Institute

The Joint Institute for Marine and Atmospheric Research (JIMAR) manages the Cooperative Institute for the Pacific Islands Region (CIPIR), one of 19 National Oceanic and Atmospheric Administration (NOAA) Cooperative Institutes between NOAA facilities and academic research and training institutions nationwide. JIMAR’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 NA16NMF4320058. JIMAR seeks to:

- facilitate innovative collaborative research between scientists 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.

JIMAR is located at the University of Hawai‘i (UH), a research-intensive land grant, Sea Grant and Space Grant public institution that maintains a service mission to the State as well as to the Pacific Islands Region. JIMAR 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 sciences that align well with the mission interests of NOAA. The University also provides capacity for social science research via 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. JIMAR 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 JIMAR is the National Marine Fisheries Service (NMFS) and JIMAR 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, Oahu Island. Other JIMAR staff work collaboratively in the NOAA Papahānaumokuākea Marine National Monument (PMNM) division under the Office of National Marine Sanctuaries (ONMS) in the IRC. The ~100 JIMAR scientists within PIFSC and PMNM are oceanographers, marine biologists, zoologists, geographers, coastal and environmental scientists, economists, fisheries scientists, sociologists, computer scientists, and engineers. The work with PIFSC and PMNM is undertaken across 20 JIMAR 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.

JIMAR-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 research themes of equatorial oceanography, climate research and impacts, tropical meteorology, and tsunamis and other long-period ocean waves. Significant JIMAR supported programs active in these areas include the University of Hawai‘i Sea Level Center (UHSLC), 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 will be named the Cooperative Institute for Marine and Atmospheric Research (CIMAR) and will pursue augmentation



*Douglas S. Luther, PhD,
Director*



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

of JIMAR activities without reduction of its current capabilities. CIMAR officially begins on October 1, 2021, while JIMAR activities will be phased out or transferred to CIMAR during FY 2022.

Research Highlights

JIMAR 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) ecosystem forecasting; (2) ecosystem monitoring; (3) ecosystem-based management; (4) protection and restoration of resources; (5) equatorial oceanography; (6) climate research and impacts; (7) tropical meteorology; and (8) tsunamis and other long-period waves.

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

- **Monitoring Coral Populations.** As threats to coral reefs increase in severity and frequency, researchers are looking for ways to increase monitoring scale and efficiency. Scientists are now exploring the use of 3D technology such as photogrammetry, also called Structure-from-Motion (SfM), to collect imagery that can be analyzed later and significantly reduce dive time underwater. In a new study developed for the NOAA National Coral Reef Monitoring Program (Couch et al., 2021), JIMAR scientists at PIFSC, led by JIMAR Supervisory Coral Reef Researcher Dr. Courtney Couch, compared data from standard in-water visual coral surveys to data generated from SfM for the first time to test the differences between the methods for the same reef areas. Couch and her team found that the majority of the tested metrics did not vary between methods. However, there were some exceptions for metrics including coral partial mortality, coral bleaching prevalence, and the juvenile density of a specific coral genera. Overall, this study suggests that SfM imagery may revolutionize the way we monitor coral reefs in the future.



Dr. Courtney Couch

- Couch, C., T.A. Oliver, R. Suka, M. Lamirand, M. Asbury, C. Amir, B. Vargas-Angel, M. Winston, B. Huntington, F. Lichowski, A. Halperin, A. Gray, J. Garriques, and J. Samson, 2021: Comparing coral colony surveys from in-water observations and Structure-from-Motion imagery shows low methodological bias. *Front. Mar. Sci.* <https://doi.org/10.3389/fmars.2021.647943>.

- **Sociopolitical Perspectives of Fisher-Shark Interactions.** Fisheries science and management often fail to account for stakeholder conflicts and sociopolitical inequities. A team led by JIMAR Fisheries Social Research Specialist, Mia Iwane, engaged fishers to examine the sociopolitical dimensions of fisher-shark interactions in pursuit of more holistic problem framings and solutions. Interviews with Hawai'i small boat fishers and observations of a community-based shark-tagging project elicited insights into fisher perspective, socioeconomic landscapes, stakeholder relationships, and power dynamics. The investigators found that economic cost and sharks as fishing competitors frame the fisher-shark interactions superficially. Deeper conflicts include fishers' poor perceptions of management legitimacy, degraded relationships with researchers and managers, threatened fisher identities, and poor enforcement capacity. These layered problem framings limit the effectiveness of singular approaches, such as regulation to mitigate fisher-shark interactions, and require multi-pronged solutions attentive to engagement processes and stakeholder relationships. The team documented the potential for fisher-researcher collaboration, knowledge exchange, and transparent communication to advance collective understanding of sharks and shark-handling strategies, shift fisher behavior, and reduce shark mortality. A sociopolitical approach to problem solving may yield greater collective benefits to fisheries stakeholders and sharks, with applications to managing complex social-ecological systems more broadly.



Mia Iwane

• Iwane, M.A, K.M. Leong, M. Vaughan, and K.L.L. Oleson, 2021: When a shark is more than a shark: A sociopolitical problem-solving approach to fisher-shark interactions. *Front. Conserv. Sci.* <https://doi.org/10.3389/fcosc.2021.669105>.

- **Surveying Reef Biodiversity with DNA Metabarcoding.** DNA metabarcoding is redefining coral biodiversity surveys as a molecular method to identify organisms through DNA extraction from a homogenized community using barcode reference libraries. The paucity of marine invertebrate barcodes within these libraries raises questions on the accuracy of species identifications using this technique for complex marine invertebrate communities. JIMAR Marine Ecosystems Research Project Specialist, Dr. Molly Timmers, and others evaluated the performance of DNA metabarcoding in detecting sponges from a complex community established on Autonomous Reef Monitoring Structures (ARMS). After two years, the number of sponges identified on the ARMS by a taxonomist using morphology and DNA barcodes were compared with the number of species detected from metabarcoding a homogenized subsample of the multi-phyta community on the ARMS. While the study found DNA metabarcoding adequately captures richness overall and at the sponge class level, it uncovered technical and biological constraints associated with order-level identifications. With over 75% of the sponges in the study found to be new species to the DNA reference database, and with the growing movement to use genetics to characterize biodiversity, there is a need for empirical performance tests to improve the utility of metabarcoding.



Dr. Molly Timmers

- Timmers, M.A, J. Vincente, M. Webb, C.P. Jury, and R.J. Toonen, 2020: Spinging up diversity: Evaluating metabarcoding performance for a taxonomically challenging phylum within a complex cryptobenthic community. *Environmental DNA*, <https://doi.org/10.1002/edn3.163>.

- **Relating Fish Populations to Coral Reef Architectural Complexity.** Structure-from-Motion photogrammetric techniques allow for time-efficient collection of habitat data in the field, which can accompany ecological data on reef fish populations. JIMAR Ecological Research Statistician, Dr. Atsuko Fukunaga, led a team that applied the techniques to a fish monitoring program in the Northwestern Hawaiian Islands (NWHI) and investigated associations between the reef habitats and fish assemblages. The structure of fish assemblage and number of species were, in general, positively associated with the architectural complexity of reef habitats. Higher levels of architectural complexity supported greater numbers of herbivores, piscivores and corallivores. Composition of benthic organisms was, however, important only for the distribution of corallivores, likely due to the reliance of dominant coral-feeding fishes in the NWHI on specific corals (e.g., *Acropora* and *Pocillopora*) as their food source. This study highlights the importance of the architectural complexity of coral reefs to the structure of fish assemblages in the NWHI and emphasizes the importance of accounting for its effects when assessing the status of the reef fish populations.



Dr. Atsuko Fukunaga

- Fukunaga, A., R.K. Kosaki, K.H. Pascoe, and J.H.R. Burns, 2020: Fish assemblage structure in the Northwestern Hawaiian Islands is associated with the architectural complexity of coral-reef habitats. *Diversity*, <https://doi.org/10.3390/d12110430>.

- **Improving Fishing Practices to Promote Shark Bycatch Survivability.** As shark bycatch rates in commercial fisheries continue to push some populations towards endangerment, efforts to reduce the impacts of commercial fishing are paramount. One such effort led by JIMAR Science Program Manager for the Fisheries Research and Monitoring Division at PIFSC, Dr. Melanie Hutchinson, recently published a report quantifying the post release survival rates of five species of pelagic shark including the Endangered Species Act (ESA) listed oceanic whitetip shark captured in U.S. Pacific longline fisheries (Hutchinson et al., 2021). This study also identified handling and release methods that will improve post release survival rates for discarded sharks and quantified the effects of gear configurations (leader materials) on oceanic whitetip shark mortality rates. The results and shark conservation recommendations from this study were influential to the Western Pacific

Regional Fisheries Management Council’s decision to ban wire leaders in U.S. tuna fisheries and implement handling and release method regulations for bycaught sharks. In U.S. longline fisheries, 98% of all sharks are discarded and these new regulations will greatly improve post release survivorship and reduce overall mortality for Pacific pelagic shark populations. These regulatory actions by the U.S. will also be carried forward to the international regional fisheries management organizations for improving conservation and management measures for shark populations.

- Hutchinson, M., Siders, Z., Stahl, J., Bigelow, K. 2021. Quantitative estimates of post-release survival rates of sharks captured in Pacific tuna longline fisheries reveal handling and discard practices that improve survivorship. NOAA PIFSC Data Report DR-21-001. <https://doi.org/10.25923/0m3c-2577>.



Dr. Melanie Hutchinson

Transitioning to Products and Services—Examples

A major focus for JIMAR 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 JIMAR projects contribute directly to PIFSC databases, specimen collections, software, models, and outreach and educational endeavors. Because JIMAR staff inhabit all of the research and operational programs in PIFSC, JIMAR will have contributed to nearly every product developed by the PIFSC programs. These JIMAR contributions include not only peer-reviewed scientific output and project technical reports, but also include: 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.

- ***Ensuring Sea Level Data Quality and Dissemination.*** Researchers at the University of Hawai‘i Sea Level Center (UHSLC) continue to ensure that tide gauge data from nearly 500 stations maintained by 65 international agencies around the world (including more than 80 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 IOC/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 GPS receivers at 11 stations. During this FY, within JIMAR’s tropical oceanography, meteorology and climate themes, UHSLC datasets were utilized in 61 peer-reviewed research articles, two books, two government agency reports, and three academic theses. UHSLC researchers were lead authors on the sea level section in the State of the Climate in 2020 report published this summer as a supplement to the Bulletin of the American Meteorological Society.
- ***Empowering Ocean Users and Stakeholders.*** JIMAR researchers and administrators make fundamental contributions to the success of the Pacific Islands Ocean Observing System (PacIOOS) 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 PacIOOS’ strategic planning, PacIOOS collected more than 370 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. During this reporting period, outside funding was secured to expand the network of wave buoys in the Freely Associated States (Republic of Palau, Federated States of Micronesia, and Republic of Marshall Islands).
- ***Short-term (6 Days) Wave-driven Flooding Forecasts.*** As sea level rises, swell wave-driven run up and coastal flooding are becoming a significant issue 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 JIMAR supported nonlinear, hydrodynamical model of swell wave transformations

in shallow water has been validated for accuracy with in situ data and implemented to provide spatially dependent run-up forecasts along West Maui. The product was released on the PacIOOS web site in June 2021. The product has already had an impact among coastal agencies concerned with public safety and coastal erosion, and is being used to investigate how the spatial patterns of flooding will change in the coming decades given various sea level rise scenarios.

- ***Building Ocean Observation Capacity and Dissemination.*** PacIOOS closely works with state and federal agencies, non-profit organizations, academic institutions, and other partners to make coastal and oceanographic data publicly available. After receiving initial certification in 2015, the Integrated Ocean Observing System (IOOS) recertified PacIOOS as a Regional Information Coordination Entity, which means PacIOOS provides high-quality observations that meet National-level standards. Continuous improvements are being made to PacIOOS' website (<http://pacioos.org>) and data visualization platform, PacIOOS Voyager (<http://pacioos.org/voyager>), to provide free and easy access. During this reporting period, regular maintenance of observing assets, such as wave buoys and water quality sensors, had to be conducted in accordance with COVID-19 pandemic safety guidelines. As part of the Water Quality Sensor Partnership Program (WQSPP), PacIOOS supported the Maui Nui Marine Resource Council by loaning a nearshore sensor to assist with ongoing watershed monitoring efforts. Data from previous WQSPP projects have been analyzed and outreach materials are now publicly available. With the idea of using “Sharks as Oceanographers”, a new generation of tags has been deployed on multiple tiger sharks in Hawai‘i to track their locations and also record environmental data.
- ***Climate Research Support by the Asia-Pacific Data-Research Center (APDRC).*** The activities of JIMAR staff at the APDRC 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 450 TB of redundantly stored data. For ease of access, APDRC maintains a suite of data transport and discovery servers.
- ***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. JIMAR scientists at UH now maintain and upgrade the ADCP data acquisition and processing software, called the University of Hawai‘i Data Acquisition System (UHDAS), on all 11 NOAA vessels. JIMAR 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. This year, due to the pandemic, remote upgrades were performed for two installations and one training session (“UHDAS for operations”) for NOAA officers was conducted via videoconference. JIMAR staff is working with NOAA to establish the NOAA-to-NOAA real-time data pipeline from the ships to the National Centers for Environmental Information (NCEI) so observations will be available for researchers quickly and accurately.
- ***Technical and Data QC Contributions to the International Argo Project.*** At NOAA/PMEL, JIMAR staff continued working with U.S. and International Argo Project partners to improve the already highly successful Argo profiling observational float platform by conducting: (i) testing, deployment, and data/engineering evaluation of conventional Argo floats and the newer Deep Argo float; and (ii) delayed-mode quality control of conventional and Deep Argo float data 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 percentage and average bleaching severity, as well as taxa-specific metrics.
- ***Deep-sea Animal Identification.*** JIMAR developed a 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.*** The JIMAR Stock Assessment Research Program created several software tools that are now widely available. The PRToolbox was developed and used to generate the bycatch estimates for 25 species of shark, 6 species of rays, and 64 species of bony fish for the years 2017–2019 in the Hawaiian deep-set fishery.

JIMAR 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-12.3 in March 2021 that fixed defects, added new features, and provided improved documentation for the software. Since 2011, ADMB has been cited a total of 1763 times according to Google Scholar with 190 citations in 2020 and 20 citations as of March 2021.

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

Education and Outreach

• *Education*

JIMAR devotes personnel time and funding for educational opportunities for K–12 students through to postgraduate research training.

This year, due to safety protocols established after the onset of the COVID-19 pandemic, JIMAR researchers participated virtually in elementary, middle and high school career and science day events, rather than in person. Subject areas included the following: cetacean research; protection of Hawaiian monk seals; marine turtle biology and ecology; coral reef ecosystem health and vitality; fish and fisheries research; shark and other bycatch mortality; and marine debris impacts on our environment.

The PIFSC Young Scientist Opportunity (PYSO) Summer Intern Program is a primary educational initiative sponsored by JIMAR. The PYSO is a collaborative program between PIFSC and JIMAR that offers several qualified undergraduate students from across the nation the opportunity to acquire professional research experience and training during the summer under the mentorship of selected PIFSC and JIMAR researchers at PIFSC. PYSO was successfully established for the summer of 2021, after a one-year pandemic pause. Four university undergraduate student interns, recruited in a competitive national process, are being hosted virtually. Argo floats prepared by JIMAR staff at NOAA/PMEL are deployed regularly by undergraduate college students from the SSV *Robert C. Seamans* of the Sea Education Association and occasionally by cadets from the TS *Golden Bear* of the California Maritime Academy. These deployments involve students in a global ocean observing system, which both institutions value.

Although many student activities have been deferred due to the pandemic, JIMAR projects regularly hire University of Hawai‘i undergraduate students to work on projects as paid workers. Other UH undergraduates participate in projects as volunteers.

JIMAR projects supported 12 Graduate Assistants during this reporting period, primarily at the University of Hawai‘i. All are pursuing Masters or PhD degrees in oceanography, marine sciences, or social sciences. Their research includes such topics as the kinematics and dynamics of short- and long-period gravity waves that periodically produce coastal flooding along West Maui; and the effects of environmental influences (e.g., ENSO; Madden-Julian Oscillation; low-level vorticity; relative humidity) on the characteristics of central and eastern Pacific cyclones.

JIMAR programs support continuing education through the hiring of talented Postdoctoral Researchers. Their research includes such topics as: unraveling the links between El Niño Southern Oscillation (ENSO) and Hawai‘i rainfall, e.g., transition diversity and precursors, and hydroclimate impacts of different ENSO types; and the evolution of the internal tide, including its nonlinear byproducts, in environmental settings appropriate to Hawai‘i and specific mid-latitude locations.

JIMAR 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 in the UH system. Seminars presented by JIMAR and federal researchers at PIFSC are also web-streamed to interested researchers and students at UH.

JIMAR 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, JIMAR staff are afforded tuition reimbursement for a limited number of credits of educational training directly applicable to the individual’s job. Several JIMAR employees take advantage of this program each year. Former JIMAR staff members are frequently recruited into federal service, including leadership positions in PIFSC. Over 30 former JIMAR staff are currently serving as federal employees in PIFSC. Eleven JIMAR staff were recruited during this reporting period for federal employment with NOAA.

• **Outreach**

JIMAR staff contribute to NOAA/NMFS/PIFSC blog postings and provide other web content including feature stories, podcasts, science blogs, story maps, photographs, and videos. They also coordinate and conduct ‘newsroom’ sessions each month in the PIFSC to harmonize science communications, education, and outreach messaging for scientists in PIFSC.

JIMAR staff participated in community and educational events to communicate information about JIMAR and NOAA missions, programs, and policies and encourage the public to learn about and support healthy ocean ecosystems and marine science research. These activities included: the Hawai‘i Seafood Month webinar; 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 Bishop Museum; monk seal webinar; Hawai‘i State Science Fair judging; Hawai‘i Conservation Conference; Daniel K. Inouye Regional Center Summer Intern Symposium; NOAA Discovery Day at Kapolei Library; Marine Educator’s Night; Career Fair at UH Mānoa; Hawai‘i Fish & Dive Expo; various high school career fairs; Earth Day events; Waikiki Aquarium events; and World Ocean Day.

JIMAR researchers regularly meet with fishermen and fisheries observers in the Pacific Islands Region to discuss and promote bycatch mitigation efforts for protected species. JIMAR staff also create and distribute a quarterly newsletter for the Hawai‘i Community Tagging Program (<https://www.sharktagger.org/newsletters>). JIMAR staff working in the SocioEconomics project collaborated with federal staff to develop a short outreach video to summarize relevant fieldwork with local fishing communities and to demonstrate the multi-faceted value of fishing.

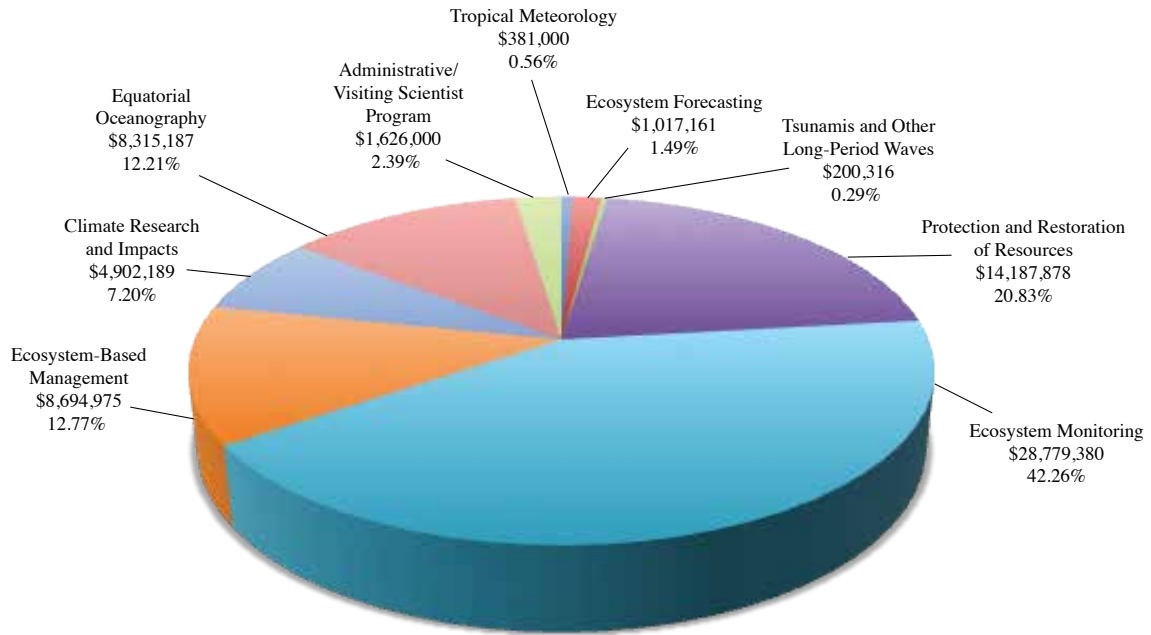
JIMAR staff meet with local and U.S. territorial government officials to communicate scientific endeavors within their jurisdictions. For example, tours can be conducted on NOAA ships while in port in American Samoa, Guam, or Saipan as part of reef monitoring activities, and JIMAR staff often escort local school children, government officials, and the general public to view the vessel and interact with the scientists, when permitted by pandemic safety protocols.

JIMAR staff continue to be highly productive, despite the COVID-19 pandemic. The project descriptions on following pages will provide a better glimpse of the significant roles that JIMAR 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.

JIMAR Structure and Funding

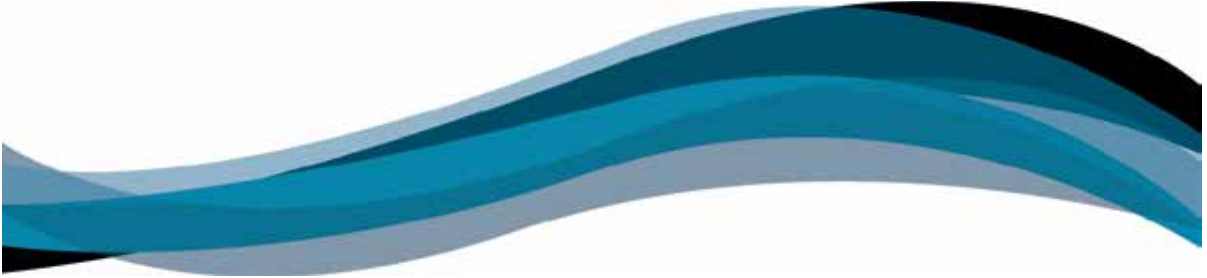
The Director of JIMAR, Dr. Douglas S. Luther, is a Professor at the University of Hawai‘i at Mānoa and is appointed through joint decisions by leaders of the University and NOAA. The Director reports to an Executive Board composed of University and NOAA officials. The Director manages JIMAR activities with the assistance of Dr. Jeffrey Hare, Deputy Director for PIFSC Projects, and Mr. Kevin K. Higaki, Assistant Director for Administration, as well as Program Managers and faculty PI/Directors. Mr. Higaki manages day-to-day operations through the administrative staff that are fully supported by the Cooperative Agreement and returned indirect cost funds. A Council of Fellows advises the Director on research opportunities and promotes 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 JIMAR are distributed according to the JIMAR research themes: (1) ecosystem forecasting; (2) ecosystem monitoring; (3) ecosystem-based management; (4) protection and restoration of resources; (5) equatorial oceanography; (6) climate research and impacts; (7) tropical meteorology; and (8) tsunamis and other long-period waves.

Distribution of NOAA Funding by Theme (FY 2017–2021)



Accomplishments for Fiscal Year 2021

Ecosystem Forecasting



Ecosystem Forecasting

Research under this theme leads to improved forecasting of the frequency and magnitude of ecosystem processes within the Pacific Islands region. JIMAR 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

PI.: Erik Franklin

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

NOAA Sponsor: Jon Brodziak

NOAA Goal(s):

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

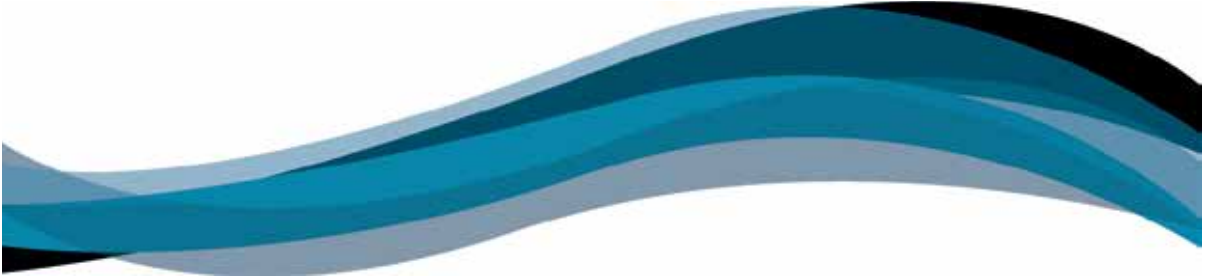
Purpose of the Project

The general purpose of the Automatic Differentiation Model Builder (ADMB) Open Source Project is to maintain and improve the AD Model Builder 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 aims 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 ISO/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 U.S.A. and around the world.

Progress during FY 2021

The project released ADMB-12.2 in July 2020 and ADMB-12.3 in March 2021. Both releases had defects fixed, new features added and improved documentation for the software. Some of the notable fixes to the software include a more robust input text file reader for various line ending formats, reverted back to faster version of vector pooling, improved and simplified build system, improvements to the adnuts feature, and much improved software testing. The new features added include the capability to do single Newton steps using the inverse Hessian (by Cole Monnahan, NOAA), the `hessian_phase()` to check if the hessian is being computed, able to still call `FINAL_SECTION` even if hessian is not positive definite and added new options in the ADMB scripts. A new feature of ADMB was developed with multi-processor support. It is still very experimental and will need user and developer testing before merging with the main branch. The multi-processor branch will produce major changes to internal ADMB class data types. Installation procedure documentation was updated. Documentation for ADMB functions were added or edited for improvement. The International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) C++14 standard is now the default for building and running ADMB programs. The previous ISO/IEC C++11 will still be supported when possible for older compilers. The Developers Workshop 2020 was canceled in Copenhagen, Denmark due to the global pandemic. A virtual workshop was discussed by the ADMB Foundation members as an alternative, but was deemed unfeasible for many participants because of the large difference in time zones. The ADMB Foundation decided to delay the workshop. The software is used by science centers, researchers, and scientists from NOAA, U.S.A. and around the world. Since 2011, ADMB was cited a total of 1763 times according to Google Scholar with 226 citations in 2019 and 20 citations as of March 2021.

Ecosystem Monitoring



Ecosystem Monitoring

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

Ecosystem Structure and Function

PI.: Douglas S. Luther [JIMAR 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, Phoebe Woodworth-Jefcoats

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

This project conducts research to advance the understanding of the structure and function of an important marine ecosystem, the subtropical gyre. This work includes a range of approaches for deepening the understanding of this ecosystem; particularly how trophic structure is impacted by climate variability and change. One component of the project consists in processing and analyzing a time-series of lancetfish stomach contents collected by observers in the Hawai‘i-based longline fishery to develop an index of the pelagic micronekton community to describe the spatial and temporal patterns of micronekton across the Central North Pacific (CNP). An additional aspect of the project examines fishery dependent data sets (observer, logbook, and dealer records from the Hawai‘i based longline fishery) in conjunction with oceanographic data to assess spatiotemporal trends in catch composition and to identify drivers of this change. Ecosystem modeling approaches are also used to evaluate changes in ecosystem structure and function as well as the vulnerability of species to climate change.



Figure 1. Lancetfish (*Alepisaurus ferox*) larvae pulled from the stomach of a larger lancetfish. Photo Credit: Emily Contreras.

Progress during FY 2021

Longnose lancetfish (*Alepisaurus ferox*) are the most commonly caught by-catch species in Hawai‘i’s Longline Fishery, which mainly targets tuna and swordfish. Due to their slow digestion of prey, lancetfish act as biological samplers by providing researchers with a better idea of deep-living prey communities in the middle of the food web. During the year, JIMAR Research Associate Emily Contreras dissected around 50 lancetfish stomachs to document contents- identifying prey to species level when possible, conserving rare or unknown samples, and working with experts to identify cephalopods and fish. All prey items are entered into the lancetfish database,



Figure 2. Four millimeter larval Akule (*Selar crumenophthalmus*). Photo Credit: Emily Contreras.

in which a data summary report will be provided in the coming months.

The JIMAR West Hawai'i Integrated Ecosystem Assessment (IEA) project coordinates with the project to conduct plankton tows off West Hawai'i to assess ecosystem status through monitoring of indicators. Plankton samples caught off West Hawai'i from 1998-2018 were sorted by JIMAR project staff, identifying larval fish (as small as 1mm) to species, using experts to identify or by relying on DNA barcoding to confirm ecologically important species (for example, flying fish, triggerfish, jacks, and goatfish). Plastics from samples were also photographed, weighed and analyzed by ImageJ, a processing program. Project technicians also created a guide with about a hundred Hawaiian fish species, which will aid new staff in confirming identifications. Furthermore, a manuscript is being developed to highlight the habitat use of larval bigeye scad (*Selar crumenophthalmus*) and mackerel scad (*Decapterus macarellus*) from the West Hawai'i time series. Bigeye and mackerel scads represent the largest and arguably the most important inshore fisheries in Hawai'i for as long as the islands have been inhabited. Along with noting new characteristics for the morphological identification of the two species, the manuscript is focused on time of collection which will be compared to known spawning times and spatial distribution, giving the first record of these larval species found in these preferred habitats.



Figure 3. One of the most common prey items found in lancetfish stomachs: deep-sea hatchetfish (*Sternoptyx* sp.). Photo Credit: Emily Contreras.

Ecosystems Observations and Research Program: Research Support Project

P.I.: Douglas S. Luther [JIMAR 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, Tia Brown

NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The JIMAR Ecosystems Observations and Research Program (EORP) monitors and conducts research on ecosystems that involve marine species and resources of concern to NOAA in the Pacific Islands Region. The project activities enable scientists to provide advice to those charged with management of the resources as mandated by legislation (e.g., Reauthorized Magnuson Stevens Act, Marine Mammals Protection Act, Endangered Species Act, etc.). Current project activities include:

- Aquaculture Systems Management,
- Fisheries and Ecosystems Data Support in the Pacific Islands,
- Outreach and Education in the Pacific Islands,
- Large Marine Ecosystem (LME) / Ecosystem-Based Fisheries Management (EBFM) Coordination, and Genomics as a Tool for Fisheries Stock Assessment and Ecosystem Based Fisheries Management

Progress during FY 2021

Aquaculture System Management. Led by Aaron Moriwake, the project provides system operation and oversight for the Marine Animal Recovery Facility (MARFAC) on Ford Island to support research of marine species of concern to the Pacific Island Region. This includes working closely with federal and University partners in coordinating, developing, modifying, and maintaining the captive care facility for research, culture, and rehabilitation for marine species.

With limited access to the Daniel K. Inouye Regional Center (IRC) and MARFAC due to the pandemic, JIMAR staff employed a modified two days/week exercise program to ensure the recirculation systems remain operational for animals housed at the facility. Other support activities included troubleshooting and resolving maintenance issues that arose, modifying the systems to improve efficiency, service system components, assisting in an exercise program to keep government vehicles operational, and conducting quarterly safety assessments for MARFAC. During this time, JIMAR staff assisted in designing a new monk seal enclosure for an Asset Management Program proposal using Sketchup software, which developed a new Smartsheet database to document maintenance issues and solutions, wrote up a standard operating procedure (SOP) for the new Turtle Beach system, and revised the SOP for the other turtle systems.

Within the reporting period, JIMAR staff provided support for one rehabilitating turtles, which included system preparation, maintenance, and monitoring 24/7 via video cameras and the Supervisory Control and Data Acquisition system. Also, JIMAR staff provided support for the Modular Optical Underwater Survey System camera calibration and coordinated schedules for use of MARFAC including for the 2021 field camp preparation.

Pacific Islands Region Fisheries Science Outreach and Education. Led by Ali Bayless, the objectives of this JIMAR effort are to plan, develop and implement an effective outreach and education program via a partnership between JIMAR and Pacific Islands Fisheries Science Center (PIFSC). JIMAR staff serve as resource, advisor, and point of contact for outreach and education activities for JIMAR, PIFSC, and Pacific Islands Regional Office (PIRO) outreach and communications staff, across all divisions and programs. This project directly supports the JIMAR aim of sustainable balances between the forces of coastal development and the goals of conservation/preservation through scientific and public outreach and education.

The project delivers scientific outreach and education products, programs, and services including community events, educational opportunities, career fairs, Science Camp, PIFSC Young Scientist Opportunity (PYSO), and printed and online products. The past year was drastically impacted by the change in operations due to the pandemic, so efforts shifted completely online, with virtual outreach and education products.

Outreach and Educational Activities. Staff participated in community and educational events to communicate information about JIMAR and NOAA missions, programs, and policies and encourage the public to learn about and support healthy ocean ecosystems and marine science research. Activities included:

- October Hawai'i Seafood Month webinar
- Monk seal critter cam talk at Kapolei High School
- University of Guam marine turtle presentation
- United Nations World Oceans Day

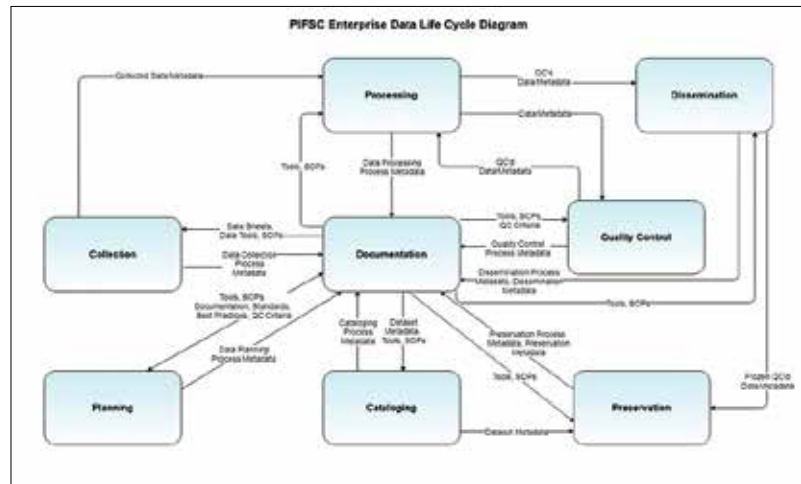


Figure 1. Diagram of the PIFSC Enterprise Data Lifecycle showing the interactions between each of the different lifecycle phases.

- Hanauma Bay Science and Sustainability event
- Kupu teacher externship event
- NOAA Live! Pacific Islands Interactive webinars at Bishop Museum
- NOAA Live! Monk seal webinar
- 2021 Hawai‘i State Science Fair judging
- World Oceans Day

PIFSC Young Scientist Opportunity (PYSO). The PYSO internship program is up and running again this year after a cancelled last year. Four interns will be hosted virtually this summer. Projects include:

- Hawaiian Green Sea Turtle Research Integrating Climate Projections into a Population Model;
- Creating a Data Visualization Module of Bigeye Catch Data for a Fisheries Online Data Dashboard;
- Time Series Tuesday: Sharing the Fruits of Long-term Monitoring Efforts; and
- Biogeographic Waifs & Vagrants in the Hawai‘i Recreational Fishing Community

Web Content. Web content includes feature stories, science blogs, story maps, photographs and videos with JIMAR staff consistently contributing to the content.

A. Feature Stories

- What can global commercial fisheries transitioning to rights-based management learn from Hawai‘i?
- Hawaiian monk seal translocation project improves survival
- Scientists develop annual forecast for the Hawai‘i bigeye fishery
- Cooperative research allows for continuation of the annual bottomfish survey in Hawai‘i
- NOAA partnering with citizen scientists to help count “Deep 7” bottomfish in Hawai‘i
- 2020 Northwestern Hawaiian Islands green turtle and Hawaiian monk seal field season highlights: Celebrating partners!
- Scientists provide comprehensive information for two culturally and commercially valuable coral reef fishes
- New study reveals most impactful threats to main Hawaiian Islands monk seals
- Researchers use aerial images and artificial intelligence (AI) for the first time to map coral across the Main Hawaiian Islands
- Citizen scientists help NOAA research reproduction of Hawaiian monk seals
- Hidden world just below the surface: Surface slicks are pelagic nurseries for diverse ocean fauna
- A new web portal lets you see where Hawaiian monk seals travel
- NOAA researcher uses sound as a tool to help quantify snappers in Hawai‘i and prevent overfishing
- Looking and listening for whales and dolphins around the Mariana Archipelago

B. Program Web Content

- Fisheries Research and Monitoring Division Ecosystems Based Fisheries Management page
- Using advanced technology to measure impacts of ghost nets on coral reefs
- Hawai‘i Community Tagging Program Newsletter: September 2020
- Hawai‘i Small Boat Survey 2021 Facebook post
- Hawai‘i Community Tagging Program Newsletter: January 2021
- Hawai‘i Community Tagging Program Newsletter: April 2021
- PIFSC-PIRO bottomfish video project

C. Citizen Science Project

- Zooniverse Bottomfish Citizen Science Project

D. Blogs

- Destination Known - Punahele’s safe return home from Lalo
- Keepin’ it reel: When your catch of the day is not what you expected
- Rehabilitated endangered Hawaiian monk seals back in the wild
- What’s in a name? Choosing names for new fish species from the Mariana Archipelago

E. Podcasts

- Pohaku Chronicles #5, monk seal podcast
- Aquadocs podcast interview

F. Story Maps

- HI Atlantis ecosystem model story map
- October Hawai‘i Seafood Month
- Hidden world just below the surface: Surface slicks are pelagic nurseries for diverse ocean fauna
- Mariana Islands acoustic cetacean survey story map

Large Marine Ecosystem/Ecosystem-Based Fisheries Management Coordination. Led by Taylor Souza, Ecosystem-based Fisheries Management (EBFM) provides a holistic approach to looking at ecosystems to balance ecological and human well being. With investment in EBFM, defining Large Marine Ecosystems (LMEs) for the Pacific Islands Region (PIR) will lay a foundation for scientists, managers, and other stakeholders to more effectively implement EBFM. LMEs are highly productive, extensive ocean areas with distinct ecological characteristics relative to bathymetry, hydrography, biological productivity, and trophically linked populations. Ecologically significant, LMEs are the world's most productive areas of the ocean, where a large portion of the world's fish catch is taken, contributing goods and services to the global economy. LMEs harbor high levels of biodiversity and provide important ecosystem services as global centers for fisheries, marine tourism, shipping, energy production, and other sectors, but they also host the majority of ocean pollution and coastal habitat alteration. In turn, they provide ecologically defined areas for stakeholder engagement, understanding root causes for impacts, and initiating sectoral changes and can be used in an ecosystem approach toward assessment, management, recovery, and sustainability of marine resources.

The Insular Pacific-Hawaiian area is the only LME currently defined in the central and western U.S. Pacific Ocean. PIFSC began working in 2019 to characterize the Izu-Bonin Mariana Arc System as a "Marianas LME" and have developed baseline information on the key components for assessment: oceanography and productivity, ecology and fisheries, ecosystem health, threats, and impacts, governance, and socioeconomics. The designation of the Marianas as an LME will provide an enhanced ecosystem wide perspective to assist managers and stakeholders in making informed decisions.

The JIMAR LME Research Technician worked with federal partners to draft the Marianas LME document. In addition, JIMAR project staff is in process of creating a subsequent Executive Summary and Technical Memorandum to support the effort. JIMAR reached out to PIFSC experts in a range of disciplines for comprehensive review, input, and contribution to the document. This included new authors to the Oceanography, Fisheries, and Ecology sections and refinement of the document with an end goal of publication. Presentations, a poster, relevant figures, and an informational document were also generated to gain inputs and to socialize this effort with partners and scientists, which has now been extended to local experts in the Marianas region.

Fisheries and Ecosystems Data Support in the Pacific Islands. Led by Jesse Abdul, this JIMAR effort continuously supports fishery and ecosystem research and data management within the Pacific Islands Region. The overall objective is to provide database development, data management, and data application development support and services to scientists at PIFSC to facilitate quality scientific research and resource management. During the year, JIMAR staff provided data processing, database development, application development, data management, server administration, troubleshooting, consultations, collaborations, and the development of SOPs. JIMAR staff led the PIFSC Software Development Team (SDT), which meets, on a regular basis to improve the quality of data management through a variety of tactical software activities. A new initiative within the Team provides opportunity to present new ideas and innovations in the framework of data management improvement, including a PIFSC enterprise Data Lifecycle (DLC) diagram developed by JIMAR staff.

Due to workplace interruptions caused by the pandemic, the project focused on maintaining and improving the existing SDT instead of attempting to create a new functional data group. Activities during the reporting period included:

- Development and documentation of standards and best practices for data integration, version control, database development, and application development including:
 - standards and best practices to improve the security and efficiency of custom software solutions and to help ensure the integrity of the data;
 - data tools and procedures to address a formal phase of the DLC;
 - extensive updates for an existing Data Validation Module (DVM) framework to formally address the Quality Control phase of the DLC for a given Oracle scientific database, fulfilling a PIFSC milestone.
- Integrated upgraded DVM into multiple existing software projects to ensure the framework fulfills its intended purpose;
- Developed customized software to fulfill requirements defined by the National Centers for Environmental Information (NCEI) for a large volume data archival pilot project to help address the preservation phase of the DLC that can be utilized by any PIFSC data project;
- Developed automated testing procedures for multiple data systems to help ensure the quality of software development projects and streamline the development process;

- Developed custom data solutions for a new Life History Program data system that formally address multiple phases of the DLC;
- Integrated existing custom PIFSC data solutions to leverage resource investments, identify additional needs, and improve the functionality of the solutions;
- Developed enterprise software tools and procedures to fulfill NOAA GitHub requirements and enable the publishing of PIFSC code projects to facilitate data transparency and reproducibility;
- Established the PIFSC GitHub organization and published three enterprise software projects developed by JIMAR to enable public access and contributions.

The project also identified opportunities for collaboration between PIFSC divisions/programs to: provision test database and application servers to facilitate continued use of the test platforms; facilitate public access of scientific data sets; and identify opportunities to implement enterprise data solutions. JIMAR staff also played roles in the NOAA Environmental Data Management (EDM) Workshop in presenting information about strategies, projects, and accomplishments and contributed to the national and regional data governance planning process.

Genomics as a Tool for Fisheries Stock Assessment and Ecosystem Based Fisheries Management. Led by Evan Barba and Mykle Hoban, genomics work offers the promise of filling gaps in the understanding of species abundance and/or improving data collection in areas where traditional survey methods are not optimal. Environmental DNA (eDNA) analysis for species abundance is transformative in that the technologies have the potential to be both less expensive and less time intensive than traditional surveys by ship.

Current eDNA methods to identify and quantify species of interest include quantitative polymerase chain reaction (qPCR) and metabarcoding. Both techniques can be performed on filtered water samples, where the filter traps cells present in the water, followed by extraction of nucleic acid from the filter. qPCR is a technique that targets a single species of interest by PCR amplification of a unique DNA sequence, usually a species-specific mitochondrial gene segment. The technique is suited for both presence/absence determinations and quantification of the number of genome equivalents (i.e., corresponding to the number of cells) present in the sample.

Another tool used to analyze eDNA is metabarcoding, which is a rapid method of biodiversity assessment combining DNA-based identification and high throughput DNA sequencing. Metabarcoding uses universal PCR primers to mass-amplify DNA from eDNA, resulting in a collection of PCR fragments called DNA barcodes. The barcodes are then sequenced using next generation high throughput sequencing, resulting in DNA sequences representative of the species present in the water sample. Metabarcoding is useful for determination of what species were represented in the sample, but the methods to reliably quantify abundance of a given species in that sample require further development including species-specific calibration.

JIMAR staff engaged in research focused on assessing the feasibility and performance of eDNA analysis, particularly in relation to Hawaiian bottomfish fisheries. The aim is toward assessment of how eDNA in the water reflected fish biomass captured during simultaneous video deployments, as well as establishment of a spatial detection field via depth stratified sampling. All benchwork for the eDNA analysis including DNA extraction, primer design and optimization, as well as amplification and preparation for sequencing on the MiSeq platform was completed during the project year. Quantitative PCR analysis was also conducted using species-specific primers for *opakapaka*, however these results indicated that there was not enough DNA present for these specific primers to quantify detection. Staff are also engaged in the bioinformatic data analysis process, where preliminary results indicate variability rates in both detection and read abundance which indicate the a lack of sensitivity for incorporation as an index of abundance to inform stock assessment. Additional sequence data is expected to either confirm preliminary results or allow the statistical power to make further inference. JIMAR is preparing the results for dissemination in either a journal article or technical memo early in the next project year.

Another goal for the JIMAR genomics work is to DNA barcode every species of Hawaiian fish. One of the main weak points for DNA metabarcoding is the paucity of known barcodes in the database, as there are several glaring absences of barcodes for common endemic Hawaiian fish species. Over the last year, JIMAR and PIFSC have partnered with the Smithsonian, NOAA, the Bishop Museum, and Scripps Institution of Oceanography to identify ways to fill out barcode lists for other localities and taxa. In addition, rather than sequencing targeted loci, the project will sequence the entire mitogenome, which covers all currently used barcoding loci. A software tool was developed which can be used to identify gaps in the barcode record, and which allows researchers to adjust their approach based on which sequences have valid associated voucher specimens and whether they have been collected in the waters of interest. Using this tool, species lists are being developed to send to natural history collections, which could assist to fill the gaps. In addition, there are several large-scale (384 species) sequencing

runs in progress, and bioinformatic analysis has begun on some preliminary mitogenome data. The goal is to ultimately complete the barcode record for Hawaiian fishes at identified loci and to distribute the software tool, which should allow other groups to develop their own barcoding strategies.

Ecosystems Observations and Research Program: Science Operations Project

PI.: Douglas S. Luther [JIMAR 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 provide high quality and effective logistical, operational, and technical project support and to 'lead the standard' in safety and training for the Pacific Islands Fisheries Science Center's (PIFSC) research activities in the Pacific Islands Region (PIR). The five project elements that follow detail the full project description.

Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. In the Pacific Islands Region, commercial fish stocks are comprised of reef fish, bottomfish, and pelagic species. The use of sampling technologies can greatly aid in the study of these commercially exploited species, as each set of gears can be customized to survey species-specific depths, habitat types, and spatial scales. As the effective management of fisheries resources becomes more critical, advancements in data collection methodologies expand the knowledge of target fish assemblage dynamics and supplement current fisheries datasets. Currently, photo and video recordings from camera systems make up the bulk of the incoming fishery-independent survey data. These recordings require processing of fish counts, fish lengths, and habitat data for use in fisheries studies. The JIMAR Analysis and Evaluation Team generate the fish assemblage data products from optical data streams through annotation of photo and/or video. As camera survey technologies continue to be developed, there will be a continuing need for evaluation of new technology and standardization of fisheries data products across survey platforms from photo and/or video analysis.

Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. As scientific field campaigns become more complex with multi-faceted, multi-platform, multi-disciplinary, and technologically advanced endeavors,



(top) Figure 1. Modular Optical Underwater Survey System (MOUSS) image capturing two 'Deep 7' Hawai'i bottomfish species: opakapaka (*Pristipomoides filamentosus*) and lehi (*Aphareus rutilans*).

Figure 2. Three hundred sixty-degree cameras showing a group (X=9) of opakapaka (*Pristipomoides filamentosus*).

the responsibilities of scientists have grown such that dedicated and trained JIMAR staff to support planning and execution of desired science endeavors are necessary. Science operational staff direct research by collaborating with JIMAR investigators to plan the effective use of equipment and resources and to 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 Survey and Sampling Technology Development. Keeping abreast of emerging new technology and maintaining current survey and sampling technological assets are vital to keeping JIMAR and PIFSC on the cutting edge of fisheries research. Dedicated staff coordinate with researchers in different disciplines to provide a broader perspective to ascertain the survey and sampling technology needs and priorities. This centralized model allows technology to be assessed for availability and effectiveness for multiple users. Survey and sampling technology development on a broad scale at PIFSC is essential to fostering collaborations, maximizing utilization of technology assets, providing opportunities for cost sharing and for cross-training staff for a wider range of expertise, and allowing Principal Investigators to focus on their research while still integrating the newest most cost effective methods of data collection.

Geospatial Products. The need for better access to collected data is an ongoing concern for data users both internal and external to PIFSC. The need to access, create and compile geospatial data is critical for the planning of research programs and publication of results. Unfortunately, access to the data and associated tools is not universally available. While some PIFSC programs have well-developed Geographic Information System (GIS) capabilities and databases, others have staff with limited skills and resources to meet all demands related to accessing, processing and displaying spatial data. As a centralized resource, the JIMAR Geospatial Products Team (GPT) seeks to provide access to high-quality data, tools and resources that would not otherwise be available.

Marine National Monuments of the Pacific. This project addresses the need to expand centralized resources to continue the development of products and tools that create effective ways to access, compile, and package Marine National Monuments of the Pacific data streams for planning of research programs, publishing of results, and supporting outreach and education activities and materials. The project aids in facilitating collaboration with federal, state, local, and academic partners and coordinating NOAA scientific research within the Marianas Trench, Pacific Remote Islands, and Rose Atoll Marine National Monuments. To encourage collaboration, the project is working on a variety of ways to make data and products readily available. The Monuments Photo Library Project aims to engage and inspire, by providing easy access to a repository of photos to researchers and the general public. This project works to collaborate with different programs within NOAA Fisheries to provide assistance with collecting archived photos and selecting the best images, cataloging, and updating metadata records for photos in preparation for data entry into Monuments Photo Library Interface.



Figure 3. Screenshot from the Wide Area Motion Imagery (WAMI) software viewer, showing annotation bounding boxes (rectangles) of Deep 7 bottomfish. Center pink bounding box: hapu'upu'u (*Hyporthodius quernus*). Yellow bounding boxes: opakapaka (*Pristipomoides filamentosus*).



Figure 4. Calibrating Modular Optical Underwater Survey System (MOUSS) prior to 2021 Bottomfish Fishery-Independent Survey in Hawai'i (BFISH) operations. Photo Credit: Kyle Koyanagi.

Progress during FY 2021

Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. Although the ongoing coronavirus pandemic led to the cancellation of the 2020 Bottomfish Fishery-Independent Survey in Hawai'i (BFISH) SE-20-07 aboard NOAA Ship *Oscar Elton Sette*, Modular Optical Underwater Survey System (MOUSS) surveys were continued by the Pacific Islands Fisheries Group (PIFG) cooperative research vessel, *Ao Shibi IV*, sampling 47 locations around Oahu and Penguin Bank in October 2020 collecting 96 videos. During the reporting period, JIMAR completed video analysis for the 2020 BFISH, delivering the size-structured species abundance data product to the Fisheries Research and Monitoring Division (FRMD) Stock Assessment Program (SAP). Video analysis on archived data was also conducted for the SE-12-02 American Samoa mission which utilized the Baited Remote Underwater Video Station (BRUVS) video camera system, with the resulting target species abundance data product delivered to the Life History Program (LHP) in September 2020. There were a total of 108 camera drops collected during that mission. Annotations identified how often target species were spotted by the BRUVS camera system. The final data product will be used to determine the feasibility of conducting future BRUVS surveys for fishery-independent indices of abundance for the three shallow water Bottomfish Management Unit Species (BMUS).

Directional camera systems are commonly being used to estimate fish populations under the assumption that estimates relate to their true abundance. To better understand the effectiveness of directional camera systems like the MOUSS (82-degree field of view) and the potential for them to underestimate or overestimate fish population due to individual fish going uncounted or being double counted, JIMAR staff on the Video Analysis Team additionally led efforts on the MOUSS-360 comparison study including videos from three surveys: SE-18-06 (55 paired videos), SE-19-04 (51 paired videos), and SE-19-06 (79 paired videos), for a total of 185 paired MOUSS-360 videos. Paired videos from additional surveys were necessary to ensure a sufficient number of annotatable videos with fish present for pairwise comparisons were obtained. Video analysis for this study was completed with a technical report showing no significant differences between bottomfish estimates from the 360-degree cameras versus the directional MOUSS camera system.

JIMAR supported preliminary testing, evaluation, and training of the Video and Image Analytics for Marine Environment (VIAME) open-source automated image analysis toolkit to determine if this software could be used to streamline and improve video data analysis workflow. Initial training used the Wide Area Motion Imagery (WAMI) viewer software to interpolate and create new Hawai'i 'Deep 7' bottomfish annotations from videos, which were previously annotated manually. Rapid Model Generation (VIAME based iterative query refinement or IQR) results indicate that significantly more iterative training would be needed to determine whether VIAME might prove useful for bottomfish analysis workflow. During the telework period, the VIAME operating software was converted from Linux to Windows to make user interface more practical.

JIMAR played an integral part in the advancement of the OceanEYES Citizen Science Project. To increase public engagement OceanEYES, hosted on the Zooniverse platform, was launched in September 2020. The project allows public participation to help process images from the PIFSC MOUSS during the Bottomfish Fishery-Independent Survey in Hawai'i. Volunteers complete classifications on images by identifying 'Deep 7' species and marking their location on the photo. These annotated pictures can then be used to train advanced artificial



Figure 5. Science Operations staff conducting boat operator training and overboard victim recovery in preparation for upcoming 2021 field operations. Photo Credit: Kyle Koyanagi.



Figure 6. JIMAR Insular Fisheries Research Associate, Christopher Demarke (white shirt), supporting the Bottomfish Fishery-Independent Survey in Hawai'i (BFISH) project by conducting Modular Optical Underwater Survey System (MOUSS) training and equipment support for Pacific Islands Fisheries Group (PIFG) cooperative fishing vessel crew. Photo Credit: Clay Tam.

intelligence (AI) tools (like VIAME) to look at different ways of counting fish from video, thereby reducing staff annotation times and providing additional abundance data to the stock assessment.

Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. During the reporting period, JIMAR supported a large portion of PIFSC missions and projects by providing logistical, operational and small boat support to all PIFSC Divisions. Because the pandemic poses serious threats to staff health, safety precautions and restrictions were implemented within the University of Hawai'i and NOAA, which significantly impacted PIFSC research activities and operations. As the pandemic continued to evolve, there was a pressing need for JIMAR operational staff to re-think and develop innovative solutions to continue operational support and progress within the parameters of mitigating policies and best practices.

For the 2020 BFISH Project, JIMAR operational staff played pivotal support roles in operational planning, logistics, instrument and equipment preparation, and training.

Operational staff spent countless hours developing BFISH operational and COVID-19 risk mitigation plans that met or exceeded policy and guidelines from the various authorities including UH/JIMAR and NOAA. The pandemic ultimately led to the cancellation of the fall BFISH cruise aboard NOAA Ship *Oscar Elton Sette*, SE-20-07. To continue progress, the fieldwork portion of this project was shifted fully to the Pacific Islands Fisheries Group (PIFG) cooperative fishing vessels. JIMAR continued support for the project providing technical and logistical support and modified distance learning/training to accommodate COVID-19 policies and best practices. As a result, the PIFSC Stock Assessment Program obtained valuable 2020 BFISH MOUSS data collected through the PIFSC/PIFG collaboration.

This data set contributed significantly to the stock assessment and correlative policies and regulations of the Hawai'i 'Deep 7' commercial bottomfish species. Due to the success of the 2020 PIFSC/PIFG collaborative effort, expansion of the fleet of commercial fishing boats capable of performing MOUSS operations continues in 2021, thus advancing the long-term goal of completing all fishery-independent data collection (Cooperative Research Fishing and MOUSS video) with commercial fishing vessels.

JIMAR Science Operations Division (SOD) staff also provided support as small boat Vessel Operations Coordinators (VOCs) and managed small boat operations and assets for two PIFSC Divisions. Staff also managed small boat maintenance and repairs to ensure that PIFSC small boat assets met or exceeded NOAA Small Boat Program safety standards to minimize safety risks and the loss of project operational days due to mechanical breakdowns. Pandemic restrictions eventually cancelled the coordinated Annual Small Boat Evaluations (ASBE) normally held in November in which SOD JIMAR plays a leading role in small boat and safety equipment inventory and inspections. Therefore, a delayed, modified collaborative effort was conducted in January 2021 where staff supported other PIFSC divisions with ASBE reviews, with a staggered as needed approach, to support critical inventory and inspections needed in time for the restart of a FY 2021 field season. Additionally, because SOD recently hired a number of new small boat operators and because existing SOD small boat operators' currency and certifications were lapsed, JIMAR VOCs collaborated with small boat instructors and supported small boat training and Personal Qualification Standards (PQS) for SOD small boat assets and personnel, working through the challenges and restrictions placed on training by engaging in a combination of virtual training sessions and staggered practical exercises with minimal crew aboard.

This year, SOD JIMAR supported the SE-21-02 Mariana Archipelago Cetacean Survey, the MP-21-05 Marine Debris Removal Project, and preparations for the 2021 Hawaiian Monk Seal Research Program (HMSRP) field camps with small boat improvements, maintenance, repairs and inspections, and virtual training courses in inflatable boat repair/maintenance, outboard maintenance and repairs, and basic marine electrical concepts. In addition to project field support, JIMAR provided technical operational support with the development and review of Project Instructions and Mission Plans, Statements of Work (SOWs) for small boat asset purchases, modifications, and repairs, Return to Onsite Work (RTOW) documents, and JIMAR Small Boat activity requests. JIMAR staff played pivotal roles with assisting PIFSC researchers with outlining safe and effective research activities that met or exceeded JIMAR and NOAA safety standards.

Advanced Survey and Sampling Technology Development. Although the MOUSS is now considered 'operationalized', the Survey and Sampling Technology Development Project (SSTP) staff still play a critical role in maintenance and troubleshooting of the MOUSS. Following the cancellation of SE-20-07 portion of the Fall 2020 BFISH, surveys were continued through the efforts of PIFG cooperative fishing vessels. MOUSS videos collected during the mission were monitored for dropped frame and camera recording issues, with 12% of total videos experiencing issues. From this 12% of videos, 2% were from dropped frames, and 10% were due to one particular Digital Video Recorder (DVR), which did not record. Typically a MOUSS Pi device is used during NOAA ship missions to ensure the cameras are working properly prior to deployment. Because this year was impacted by the pandemic and PIFSC staff were unable to imbed on the PIFG vessels, the MOUSS Pi was not used in order to facilitate a simplified deployment protocol. These camera errors did not affect the bottomfish data output (i.e., fish abundance estimates and length measurements). However, to mitigate issues on future missions, JIMAR collaborated with technical contractors to troubleshoot and identify the cause for MOUSS dropped frames. Hardware inspections on all camera connection points were conducted, and all worn or suspect hardware components were replaced. Camera firmware was updated with the latest version, designed to better deal with brief loss of Precision Time Protocol (PTP) synchronization, which could contribute to the large gap issues in some cases. Additionally, the MOUSS DVR software was updated to avoid restarting when a brief loss of camera connectivity is detected, bringing down the lost data time down from 5-9 minutes to just seventeen seconds. Together these changes will help to minimize the former large gap issue such that it should have no effect on the final data output. MOUSS systems have additionally been upgraded to increase ease of use and store more imagery for an expanded survey and longer field season in 2021. To increase MOUSS DVR data storage capacity for the upcoming 2021 PIFG-MOUSS survey, MOUSS DVRs were upgraded from 512 GB Solid State Drives (SSD) to much larger 4 TB SSDs with the capacity to record an entire survey's worth of image data with no need to delete files to clear up space. Additionally, a modified data download Standard Operating Procedure (SOP) using Windows OS and "drag and drop" data copying methods was developed by SSTP JIMAR staff to simplify data back-ups for the PIFG contractors.

Because the MOUSS stereo-camera system has already been in operation since 2016, the development of a new stereo-camera system is critical to remain on the cutting edge of fisheries survey technology. During this performance period JIMAR began work to develop an in-house stereo camera system with two distinct software approaches. One approach is based on the Flir machine vision Software Development Kit (SDK) written in Python, and the other incorporates the Robot Operating System (ROS) to use multiple camera manufacturers. Different hardware platforms are also being developed. There was also testing of whether existing hardware

will accept the new software and several other single board computers. Flir Blackfly S cameras continue to be evaluated to determine U.S.A.bility in underwater imagery acquisition. Cost comparison, size, ease of use, and power consumption are all factors that will determine what hardware is selected. Continued lab and field testing are planned for the upcoming year.

The successes in the design and fabrication component of the Survey and Sampling Technology Project gave way this year to the launch of the Marine and Applied Knowledge for Ecosystem Research (MAKER) Laboratory. JIMAR staff in the MAKER Lab use basic design, fabrication, electrical, and mechanical services to support PIFSC researchers to find innovative ways to meet their survey and sampling needs. Researchers know what samples and data they would like to collect. The MAKER Lab closely works with PIFSC Researchers to carefully outline their survey and sampling requirements to design and fabricate equipment and instruments to collect repeatable and reliable data transforming their vision into reality. During the performance period COVID-19 restrictions delayed or canceled many lab and field research activities hindering project progress. Despite these challenges the MAKER Lab was still able to support a number projects within PIFSC with their design and fabrication needs including the design and fabrication of the Turtle Restraint Device (TURD), re-design and fabrication of a new 6' Isaac-Kidd Midwater Trawl, design and fabrication of custom in line Bottomfishing Temperature Depth Recorder (TDR) LAT 1400 /1800 brackets, and design and fabrication of a custom underwater dual laser seafloor distance gauge. In addition to such support requests, the MAKER Lab continued to support ongoing PIFSC 2021 goals through the continued development of an artificial lighting system to compliment the MOUSS and 360 camera systems and the conversion of storage shed into a battery storage and solar charging station.

Geospatial Products and Marine National Monuments of the Pacific. Due to staff vacancies, progress on these projects is on hold pending new recruitment action.

National Ocean Acidification Observing Network – Oahu NCRMP Class III

P.I.: Christopher 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

This project uses an autonomous buoy in Kaneohe Bay, Oahu, HI to measure carbon dioxide (CO₂) in the atmosphere and dissolved in seawater as well as a variety of other environmental parameters that are necessary to understand the biogeochemistry of the ocean carbon cycle and ocean acidification (OA). One of the objectives is to resolve local from basin-scale drivers of the inorganic carbon system in coastal waters. The study will also logistically support reef studies conducted by colleagues at other institutions and be part of larger national and international efforts under the auspices of NOAA and the Global Ocean Acidification Observing Network (GOA-ON). Nearly ten years of high-temporal resolution data from the project's buoys around Oahu are now beginning to reveal trends of increased CO₂ in coastal waters that will continue, and could further exacerbate the



Figure 1. Site location map of MAPCO₂ buoys in Hawai'i [Drupp et al., 2013] b) the CRIMP-2 and Kaneohe sites, c) and d) locations of other MAPCO₂ buoys in Hawai'i.

impact of ocean acidification on valuable reef systems. Ocean acidification could significantly affect the fishing industry and tourism (through degradation of beaches and reefs), both major components of Hawai'i's economy. The project's work can help resource managers understand how the chemistry of Hawaiian coastal waters is changing over time and the implications for coastal services.

Progress during FY 2021

Lead PI, Dr. Sabine oversaw the mooring maintenance and validation sample collection and analysis. The activities remain largely the same as described in the prior annual reports. The project continues to support the broader agency (NOAA/PMEL, NOAA/OAP) based efforts to develop technologies to monitor coastal processes, with emphasis on the inorganic carbon system (CO₂-carbonic acid system) and ocean acidification (OA). The coral reef instrumented platform-2 (CRIMP-2) buoy is a National Coral Reef Monitoring Program (NCRMP) Class III (climate level) observing station, one of two in the Pacific, and is an important asset supporting the goals of the National and global OA observing efforts. The project continues to collect and analyze bottle samples for the subsequent laboratory determination of dissolved inorganic carbon (DIC) and total alkalinity (TA) at two-week intervals (weather and sea conditions permitting). The project also conducts short term high intensity sampling experiments in conjunction with projects undertaken by academic and agency colleagues whose objectives are: 1) to derive a better understanding of processes driving coral reef metabolism near the project's fixed MAPCO₂ buoy sites, 2) to develop and test new technology permitting precise and accurate automated measurement of two of the four CO₂-carbonic acid system (with PMEL, UHM and SIO colleagues) and, 3) to continue the long standing high frequency time-series pCO₂ (12th year) observations on a coral reef environment.

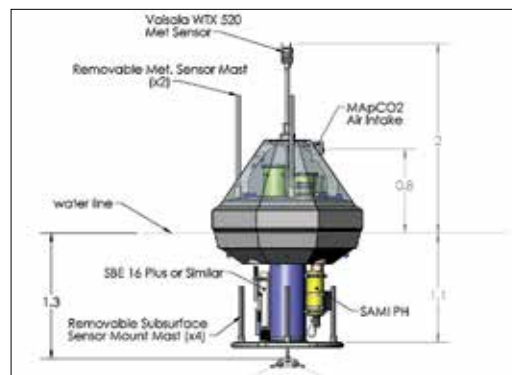


Figure 2. Illustration of the configuration of a MAPCO₂ mooring, with MAPCO₂ system imbedded in the buoy. The Conductivity Temperature and Depth (CTD) and pH sensors are secured on the outside of the buoy below the waterline (note: met sensor is not included in Hawai'i moorings).

NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)

PI.: Douglas S. Luther [JIMAR 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 JIMAR National Coral Reef Monitoring Program (NCRMP) Pacific Reef Assessment and Monitoring Project is a multi-disciplinary research endeavor, which seeks to monitor and assess the condition of coral reef ecosystems in the main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), the Pacific Remote Island Areas (PRIA), the Commonwealth of Northern Mariana Islands (CNMI), American Samoa, and Guam. JIMAR NCRMP Project supports the NOAA Pacific NCRMP project. The overall project objective is to inform effective management by providing high-quality scientific data on the health and vitality of coral reefs in the U.S. Pacific Islands. This interdisciplinary, integrated approach to ecosystem monitoring requires coordinated research from the JIMAR staff in the NOAA National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) across three research focuses: Fish Ecology and Monitoring, Benthic Ecology and Monitoring, and Ocean and Climate Change (OCC). NOAA continues to rely on the expertise of JIMAR personnel who are instrumental to completing the Pacific NCRMP efforts in support of the national NCRMP program.



Figure 1. New benthic divers surface after a first successful training dive to learn NCRMP-Pacific survey methods. Photo Credit: James Barlow.

Progress during FY 2021

Field Mission. The FY 2021 research cruise to the Marianas Islands was canceled due to the pandemic. In lieu of this cruise, the project focused this fiscal year's field efforts to training in preparation for a FY 2022 field mission. During the year, training efforts began, including NOAA scientific diver training for new JIMAR personnel, Motorboat Operation Course Certification to train additional small boat coxswains, and NCRMP Rapid Ecological Assessment (REA) survey method training for both reef fish and benthic communities.

In addition to training, the project has refined sampling methods to improve subsequent NCRMP – Pacific research cruises. For example, the Ocean and Climate Change (OCC) Team is aiming to trial, test, and train the survey team on in water Carbonate Budget data collection methods to ensure greatest efficiency during upcoming NCRMP cruises. This work addresses multiple priority activities defined within the core climate pillar of the NOAA Coral Reef Conservation Program (CRCP) and supports jurisdictional research needs. The activity further supports the development of a resilience-focused assessment model for coral reefs. The OCC team conducts water sampling, deployment of their diel suite in Kaneohe Bay and Kewalo, and subsurface temperature recorders at the seven OCC NCRMP sites established around the island of Oahu.

The Benthic Team focused their methodology improvements on the geolocation of Structure-from-Motion digital imagery collection to improve the ability of the research team to re-image the exact same plot of reef with higher accuracy. Diving occurs at the same seven OCC sites that are already established around Oahu to improve the team's ability to assess change in coral colonies over time with greater accuracy.

The Fish Team's diving operations support the development of a resilience-focused assessment model for coral reef ecosystems (PIFSC/ESD priority). This activity collects benthic, fish, and oceanographic data at established

NCRMP fixed sites allowing the team to examine resilience and investigate how coral reef associated organisms and processes interact. Specifically, fish divers are conducting Stationary Point Count fish surveys and collect benthic imagery (photo quadrats and Structure-from-Motion) at sites randomly distributed across a survey area centered upon each fixed site. The benthic and OCC teams established these fixed sites to monitor temporal oceanographic conditions, carbonate budgets, coral bleaching, and coral demography. Fish survey areas are sufficiently large enough to characterize the fish community associated with each fixed site.

Data archive for FY 2021. The cancelation of the Marianas NCRMP cruise offered a window of opportunity for the Data Services team to catch up on datasets awaiting archive as well as complete an overhaul of the database system holding all OCC NCRMP datasets. The team has or will be completing outstanding archive for all 2019 Hawaiian Archipelago NCRMP datasets this spring. In addition, the team has completed overdue archive needs for Conductivity Temperature and Depth (CTD) data and Autonomous Reef Monitoring Structures (ARMS) data from 2017, 2018 and 2019 NCRMP cruises, and Calcification and Accretion Unit (CAU) data from 2018. The team also fixed errors in REA benthic datasets and OCC water sampling dataset (as far back as 2013) that were previously submitted to the federal data archive. By the end of this fiscal year, the only outstanding NCRMP dataset awaiting federal archive will be the 2019 CAU dataset; processing these samples in the laboratory was delayed in 2020 and early 2021 due to pandemic closure of the Daniel K. Inouye Regional Center (IRC).

To address data integrity issues with the OCC data streams, the Data Services Team completed migrating the data from a Microsoft Access database to Oracle and developing an Oracle Application Express tool to channelize the entry of this data with appropriate validations. The result of this massive effort is improved data accuracy and integrity of existing OCC data streams.



Figure 2. New benthic divers practicing NCRMP-Pacific survey methods. Photo Credit: Morgan Winston.

Ocean Remote Sensing

P.I.: Douglas S. Luther [JIMAR 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, Ryan Rykaczewski

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

This JIMAR project distributes a suite of reprocessed, delayed and near real-time satellite oceanographic data products to the scientific community, management and conservation agencies, and the general public through web-based services. These datasets include sea surface temperature, dynamic sea surface topography and geostrophic currents, surface winds, and ocean color products, such as chlorophyll-a concentration, photosynthetically

available radiation (PAR), diffuse attenuation coefficient at 490 nm (K_d490). The products are served at various temporal (daily, weekly, monthly) and spatial scales (regional or global). The project also works with local, regional, and international users to explore and foster new partnership opportunities and develop a suite of climate indicators for research purposes.

Progress during FY 2021

The project has been paused due to the departure of staff and the subsequent pandemic.

On-site Support for OA Mooring Test-beds: Evaluating and Expanding New Carbon Technologies to Subsurface Habitats

PI.: Christopher 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

The NOAA/PMEL Carbon Group has been augmenting and expanding high-frequency observations on moorings to provide valuable information for better understanding natural variability in inorganic carbon chemistry over daily to inter-annual cycles. The current NOAA ocean acidification (OA) mooring network consists of 35 moorings in coral, coastal, and open ocean environments which host a standardized suite of surface sensors measuring air and seawater partial pressure of CO_2 ($p\text{CO}_2$), pH, temperature (T), salinity (S), dissolved oxygen (DO), fluorescence, and turbidity at all sites. Although OA is primarily driven by uptake of CO_2 from the atmosphere, many coastal and estuarine processes that affect water chemistry and the interpretation of coastal OA are manifested in subsurface waters. Furthermore, many of the most sensitive organisms (e.g. corals, shellfish) are benthic and respond primarily to subsurface water chemistry. The objective of this project is to provide on-site support at existing Hawai'i MAPCO₂ buoy sites for the evaluation of the best carbon system technologies to deploy in the subsurface, to demonstrate the utility of these enhanced observations on the moorings, and to make recommendations on how advanced technologies can be incorporated into the overall OA program. On-site support includes in addition to the deployment and servicing of benthic instruments, the carrying out of analyses of water samples in the project's laboratory at UH Mānoa.

Progress during FY 2021

Multiple sensor deployments have been conducted at the CRIMP2 site over the past few years. The primary focus of this effort has been to work with Sunburst Sensors and NOAA/PMEL to evaluate the Submersible Autonomous Moored Instrument for alkalinity (SAMI-Alk) sensor, but there have been challenges with getting this sensor to work reliably. The project has also been working with Dr. E. Briggs and Dr. T. Martz to test a novel combined pH and Total Alkalinity sensor at CRIMP2. A deployment of both sensors early in the year failed to produce useful data from either system. The sensors were returned to the manufacturers for repairs, and then redeployed in February 2021. After two weeks the sensors were briefly recovered to determine that they were working. After seeing that both had data, they were redeployed for another month. The systems have now been recovered and the data are being processed.

Pacific Fisheries Monitoring Program

PI.: Douglas S. Luther [JIMAR Project Lead: Frances Tong]

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

This project provides the Pacific Islands Fisheries Science Center (PIFSC) with timely and accurate Fishery Ecosystem Plan (FEP) logbook data and other fishery information for use in research and management towards the goal of maintaining a healthy ocean, which provides for a resilient and economically sound community. The main focus of the work is the daily monitoring of the Hawai‘i and American Samoa pelagic longline fleets, along with four California vessels, which are presently and increasingly subject to international management at a species level. The project provides the fishing industry a contact point for feedback and information exchange with PIFSC fishery scientists and managers.

Progress during FY 2021

Fisheries Monitoring. JIMAR staff continue to provide timely high-level support to fishery monitoring activities by providing high quality fisheries data to NMFS, PIFSC, and other JIMAR projects.

Staff collect and receive the following: 1) federal longline logbooks; 2) federal non-longline logbooks; and 3) Pacific tuna fishery purse seine fleet data forms. Data is run through a quality control process, entered into the system via data entry applications, processed and then loaded into databases.

The general Hawai‘i-permitted longline fleet-wide quarterly reports are completed forty-five days after the end of the quarter. As of June 2021, staff collected and processed 11,258 paper logbook set forms from Hawai‘i, 829 paper set forms from American Samoa and 273 paper set forms from California. While the COVID-19 pandemic negatively impacted paper logbook data entry, the project caught up with its three-month backlog during FY 2021.

The Electronic Reporting (ER) team, comprised of JIMAR and PIFSC staff, continued its activities; however, deployment progress was negatively impacted by the pandemic. There was a seven-month pause in tablet deployments with deployments resuming when the virus threat lessened and safety protocols were put in place.

A proposed rule change will make it mandatory for the Hawai‘i-permitted and American Samoa-permitted longline fleet to submit catch logs electronically. At the close of FY 2021, tablets have been installed on 106



Figure 1. Nathan Chan on board a vessel preparing an electronic reporting tablet for a training session with a captain. Nathan is wearing his backpack in the front to keep his belongings off of the vessel's surfaces. Photo Credit: Walter Machado.

vessels, which is 73% of the longline fleet. The tablets run “Elog-It”, an Android application that enables longline captains to securely record and submit their logbook data electronically in real time directly to the PIFSC longline database. During FY 2021, 532 e-log trips with approximately 7,120 fishing set and haul forms were successfully transmitted by fishing captains and received at PIFSC. An ER specialist is working with the PIRO American Samoa Observer Field Office to begin testing ER in the American Samoa fleet.

Captains have expressed satisfaction with the ER application’s simple and user-friendly interface. They have also found that using the electronic application to log catch data is faster than filling out paper logsheets. Feedback and suggestions are continually compiled and will be considered for future application updates.

Complete adoption of ER will greatly improve the timeliness of data availability for Regional Fishery Management Organization (RFMO) reporting, scientists and researchers, and forecasting fishing area closures. Implementing ER has reduced the time and labor required to manually enter or keypunch the fisheries data by JIMAR staff.

Staff now allocate a portion of their time and efforts to supporting the ER effort: outreach; tablet maintenance and inventory; dock-side, front-facing technical support to captains and vessel owners; software support, code updates and testing for tablets; and creation and maintenance of training videos and written user and administration guides.

Many vessel captains in Honolulu do not speak English as their primary language and a large percentage of them speak Vietnamese. A JIMAR ER specialist worked with a Western Pacific Fishery Council-contracted Vietnamese language translator to train these captains on how to use Elog-It.

The Fast-Track program for selected species also continued into FY 2021 for bigeye tuna and striped marlin. Fast-track information is used to forecast landings, predict possible closure dates of the Hawai’i-permitted longline bigeye tuna fishery, and anticipate when the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) annual quota will be reached. Striped marlin landings are fast-tracked due to stock concerns.

Tallies are compiled weekly or as necessary as the quota gets taken. Additional quality control procedures and cross checks of relevant databases are implemented as needed to continually validate and improve the results, quality and timeliness of the product. Crosschecks involve a matching program that compares the longline logbook tuna counts to sales records from dealer data. The fisheries observer data are reconciled with Hawai’i longline logbook data.

The paper logbook scanning and archiving project is ongoing.

Electronic Monitoring. Electronic Monitoring (EM) continues to be managed entirely by JIMAR staff. In FY 2021, the EM program had the objective to execute a catch handling study to address gaps in EM detection with discarded species such as sharks. As a prerequisite for this study, 20 new EM systems needed to be installed on Hawai’i longline vessels as old EM systems were near the end of their functionality. New EM system installations were delayed by the pandemic and required approval by NOAA of a service agreement for each volunteer vessel. New EM system installations began in February 2021 and as of May 24, 2021, 19 of 20 installations have been completed by the subcontractor. The catch handling study is expected to begin in June 2021.



Figure 2. Walter Machado at Pier 38 testing the connection between the electronic reporting tablet and a vessel’s VMS system. Photo Credit: Nathan Chan.

A data report was published that compared the detection accuracy between three video review speeds. The results indicate that video can be sped up to 8x speed for video review, which is a cost savings to current monitoring methods of reviewing video in real-time. In addition, this study determined that protected species could reliably be detected in EM footage as reviewers were unknowingly given video selected with protected species interactions to review.

The project is working to determine the potential for post-interaction mortality rates to be determined from EM for protected species. These data could be used to ensure the fishery does not exceed the number of allowable protected species interactions and are currently only collected on trips with at-sea observers. If these determinations can be successfully performed using EM, then these data could be collected for 100% of protected species interactions in the Hawai'i-based longline fisheries.

For this project, JIMAR collaborated with protected species experts to summarize six marine mammal and 23 sea turtle interactions that were recorded in EM footage. The summaries included information on what criteria could be assessed that are needed to determine likelihood of post release mortality and what modifications to EM systems, handling, or fishing gear might be explored to better assess the likelihood of post release mortality of protected species. In addition, EM staff met with the PIFSC Science Operations Division to brainstorm ideas for obtaining and/or creating models of sea turtles and false killer whales for laboratory and field simulations to determine what modifications to EM camera and/or fishing gear could improve the assessment of the likelihood of post interaction mortality.

During the year, staff collected a limited number of EM disks from vessels due to safety concerns related to the pandemic. With the near completion of new EM installations and reduced virus threats, JIMAR staff has begun collecting EM data again. JIMAR staff will perform all system maintenance for these new installations.

JIMAR staff collaborated with Pacific Islands Region (PIR), Hawai'i Longline Association, Western Pacific Regional Fishery Management Council (WPRFMC), Ecological Modeling Services, and Pelagic Ecosystems Research Group to use EM to evaluate bird interaction mitigation devices (tori lines) to minimize bird catches during longline setting. This study was summarized in a journal article in *Reviews of Fish Biology and Fisheries*.

Staff continued to work on annotation of images and streamlining workflow for automatic annotation of images. These images were added to the AI library for training the automatic detection of fish and protected species from EM footage.



Figure 3. Joshua Tucker, JIMAR Electronic Monitoring team member, checking on the operation of the newly installed electronic monitoring system after a hard drive change. The hard drive is the box mounted on the ceiling behind Joshua. Photo Credit: Joshua Tucker.

Pacific Islands Territorial Science Initiative

P.I.: Douglas S. Luther [JIMAR Project Lead: Frances Tong]

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

NOAA Sponsor: Michael P. Seki, Timothy T. Jones

NOAA Goal(s)

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The overarching objective of the JIMAR Pacific Islands Territorial Science Initiative (TSI) project is to improve the volume and quality control of catch data from the fisheries of the U.S. Pacific territories of Guam, American

Samoa, and the Commonwealth of the Northern Mariana Islands (CNMI). Insufficient data collection and quality control in the territories has resulted in a paucity of fisheries information to guide management actions mandated by the Magnuson-Stevens Act and other federal law. The small size and modest budgets of territorial governments, relatively low commercial value of the diverse and small-scale fisheries, and limited physical presence of NMFS staff in these islands detract from the efficacy of data collection programs. Thus, there is a need to improve the amount and detail of fisheries monitoring data collected from the territories along with improving quality control, in order to enable fisheries scientists to conduct more accurate stock assessments. The TSI project collaborates with several other JIMAR projects and PIFSC programs to promote better communication with management agencies in the territories, establish and improve protocols for fisheries monitoring and sampling, and develop tools for data expansion and summary analyses.

Progress during FY 2021

JIMAR project staff worked with other JIMAR and federal staff at PIFSC to complete a draft NOAA Technical Memorandum summarizing the implementation of, data from, and expansion of territory creel surveys. This includes sections detailing the organization of the expansion code, a step-by-step walk-through of the expansion calculations, and analyses of the sensitivity of expansion results to two central assumptions. The document will contribute to an upcoming external review of the creel survey expansion algorithm by the Center of Independent Experts (CIE). This fulfills the objectives for this task and represents an expanded contribution by the staff member than previously expected.

Project staff also made significant progress on a simulation model to compare the effectiveness of low-cost fishery monitoring and management plans. Finer details of the project plan were updated from the previous year and no longer include a Bayesian data integration model to aggregate data from multiple surveys, instead

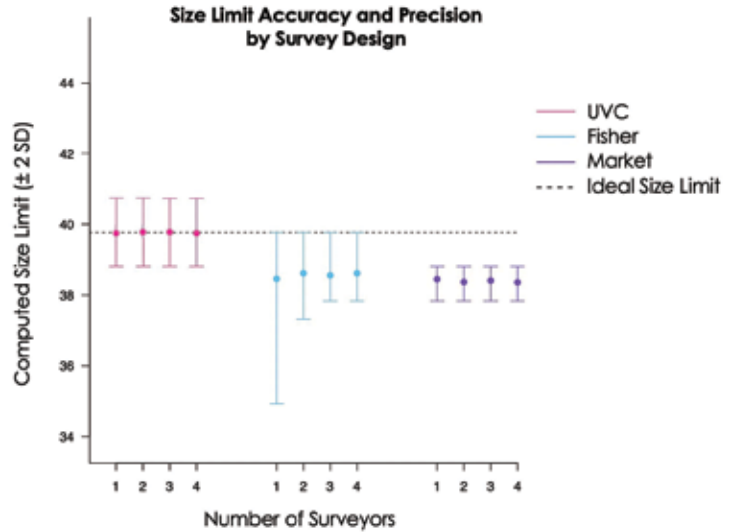


Figure 1. The bias and precision of size limit estimates from three survey types, as a function of survey effort. Underwater visual censuses (UVC) provide an unbiased estimate of the desired size limit, but with lower precision and typically higher survey costs than a market-based survey. Both UVC and market-based surveys collect sufficient data with a single surveyor and do not exhibit increased precision with additional survey effort.

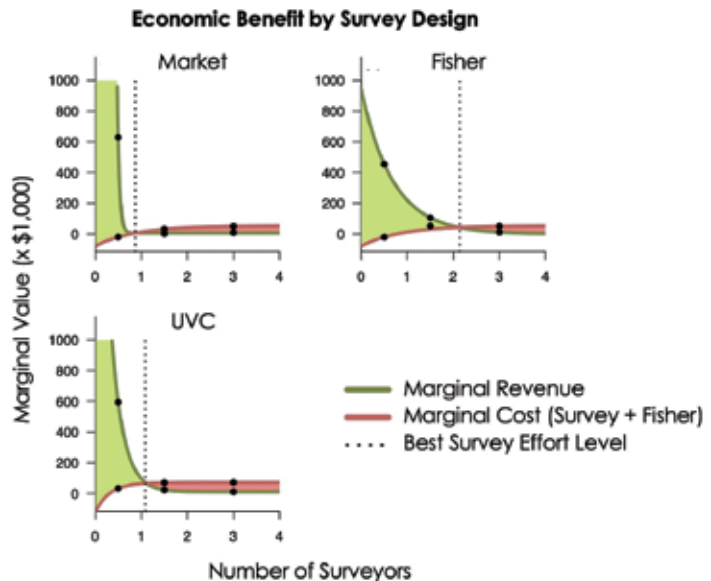


Figure 2. The economic benefit provided to fisheries managed by three survey types, as a function of survey effort. Both UVC and market-based surveys provide maximal benefit with about one surveyor, while fisher-based surveys require two surveys. The absolute economic benefit is greatest with a market-based survey employing a single surveyor.

opting to combine the surveys through an existing stock assessment method. Further simulation model changes were made to increase realism. Results were presented at the 2021 University of Hawai‘i’s Albert L. Tester Memorial Symposium to compare the quantity and quality of data from three survey types, and furthermore how these differences influence the economic performance of the fisheries when management is simulated under each survey type. A related manuscript is still in progress.

Pacific Tuna Fishery Data Management

PI.: Douglas S. Luther [JIMAR Project Lead: Frances Tong]

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

This JIMAR project seeks to develop improved data management tools to preserve and provide scientific and management access to purse seine tuna fishery data obtained by U.S. flagged vessels licensed under the South Pacific Tuna Treaty (SPTT). This important data set is of high value to tuna stock assessment scientists, tuna fisheries monitoring, fisheries managers and policy makers. JIMAR develops contemporary tools to enable access to these data and a system for sustained data management. The project coordinates with several NOAA National Marine Fisheries Service offices to effect the development of the data management system and also collaborates with several Pacific Islands Fisheries Science Center (PIFSC) research projects and the Pacific Islands Regional Office (PIRO) for subsequent access and analysis functions and to meet monitoring and reporting requirements.

Progress during FY 2021

The project set a goal to finalize development and implementation of quality control criteria for data collected under SPTT. Early in the reporting period, all JIMAR activity was completed to address the quality, accuracy, and completeness of the data.

The project established a goal to develop new database schemas, data tools, and procedures for managing additional SPTT data streams, and all work was finalized early in the reporting period.

The remainder of the project activity was centered on quality control and quality assurance for the data streams. The project coordinated with the JIMAR Western Pacific Fisheries Information Network project and the JIMAR Pacific Fisheries Monitoring Program project to complete all relevant activity.

Sustaining Healthy Coastal Ecosystems

PI.: Douglas S. Luther [JIMAR 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
- Resilient Coastal Communities and Economies

Purpose of the Project

The JIMAR Sustaining Healthy Coastal Ecosystems (SCHE) project is a multi-disciplinary research endeavor that seeks to monitor and assess the condition of coral reef ecosystems in the main Hawaiian Islands, Northwestern

Hawaiian Islands, Pacific Remote Island Areas, Commonwealth of the Northern Mariana Islands (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 JIMAR staff in the NOAA National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Science Division (ESD).

Progress during FY 2021

Bleaching Surveys. In collaboration with the Hawai'i Coral Bleaching Collaborative (HCBC), JIMAR scientists in NOAA's ESD joined a multi-institution effort to document the extent and severity of coral bleaching in the main Hawaiian Islands. The goal was to lay the groundwork for tracking coral response and recovery through time by rapidly assessing bleaching stress in as many of Hawai'i's coral reefs as possible. Through this dataset the aim is to learn about which factors enhance coral resilience to bleaching, identify where coral appear most susceptible to bleaching, and inform active intervention and emerging restoration methods to help maintain Hawai'i's corals into the future. The JIMAR Coral Bleaching Analyst has completed a rigorous analysis of spatial bleaching patterns and the factors driving those patterns in order to guide management actions to benefit coral resilience to future bleaching events. These findings were presented to the HCBC in April 2021 and are currently being incorporated into a manuscript for peer-review.

Pacific Remote Islands Marine National Monument (PRIMNM) Report and Workshops. In FY 2021, JIMAR staff completed an analysis summarizing bleaching impacts on the benthic and reef fish community at Jarvis Island as well as potential management implications of these results and submitted their findings to the journal *Coral Reefs* (in review). JIMAR staff shared analytical outputs with the PRIMNM management team and are contributing to ongoing efforts to develop an effective Monument Management Plan for the PRIMNM. In addition, printed copies of comprehensive report entitled 'Coral Reef Ecosystem Monitoring Report for the Pacific Remote Islands Marine National Monument: 2000-2017' were disseminated to jurisdictional partners in the U.S. Pacific Islands, Pacific Islands Regional Office, and to other natural resource agencies.

LBSP efforts in American Samoa. Two NOAA technical reports were completed providing a summary of key findings for work completed in 2015 and 2020 to assess the status and trends of the benthic coral reef communities in Vatia Bay and Faga'alu Bay, American Samoa. Collectively, these data offer a contrast between the 2015 baseline assessment and the subsequent 2020 status survey, and examine how benthic and coral community response variables differed across factors of year (2015 and 2020) and reef stratum. JIMAR focused the analyses exclusively at detecting measurable change but not attribution. A forthcoming analysis of the Vatia reef biological monitoring data set will attempt to couple the measurable physical and biological gradients to better discriminate and ascribe change over space and time.

Structure from Motion (SfM) Research and Development. A NOAA technical report was completed in FY 2021 providing a comparative analysis of SfM generated demographic data vs. in situ demographic data, the strength and weaknesses of each method an analysis of costs under different survey methods, and recommendations for operationalizing SfM during Pacific National Coral Reef Monitoring Program (NCRMP) surveys. This technical report served as the foundation for a more in-depth, peer-reviewed analysis that is currently accepted to the journal *Frontiers in Marine Science*.



Figure 1. Hawai'i Coral Bleaching Collaborative Meeting sharing results from analyses of spatio-temporal trends in coral bleaching in the Hawaiian Islands. Photo Credit: Morgan Winston.

Reef Resilience: Downscaling to Inform Management. The first report on downscaling reef resilience in the Main Hawaiian Islands was completed applying a quantitative examination of existing sub-island scale benthic data, using fish, invertebrate, and environmental data sets to improve understanding of drivers of spatio-temporal trends. This effort is next step in developing the Pacific Islands Fisheries Science Center method of statistically down-scaling the Pacific NCRMP datasets to optimally address questions of reef resilience to better guide efforts in resilience-based-management. In particular, JIMAR continues to add to contiguous clustering, and applying a nuanced temporal model of ecological change, correlated to coral bleaching-relevant heat stress. JIMAR identified high and low performing zones for each of five resilience-relevant ecological metrics, and highlighted consistent performance across multi-metric aggregations. Specifically, the regions of N. Lanai, S.E. Molokai, and N. Kohala show consistent, multi-metric resistance and recovery, and are worthy of further process-based investigations.



Figure 2. Reef fishes enjoying the no-take status of the Kahekili Herbivore Fisheries Management Area. Photo Credit: Tye Kindinger.

Fisheries Management. In the spring of 2021, fish scientists from ESD completed five days of reef assessments inside the Kahekili Herbivore Fisheries Management Area (HFMA) in Maui, in close partnership with the Hawai‘i Department of Aquatic Resources. The team surveyed 83 sites across six different types of hard-bottom habitat. At each site, the following data were collected along a 25-m belt transect: (1) quantity, species, and estimated sizes of all fishes, (2) quantity and species of urchins, and (3) digital still photographs (one per meter) to characterize benthic-community cover. This dataset is part of a long-term monitoring effort to evaluate the efficacy of no-take marine reserve protection to directly improve fish biomass and indirectly benefit the benthic reef community. Lessons learned from the Kahekili HFMA directly inform the State of Hawai‘i’s “30 by 30” effort to protect thirty percent of state waters by the year 2030.

Territorial Biosampling

PI.: Douglas S. Luther [JIMAR 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, Joseph O’Malley

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Territorial Biosampling project conducts life-history research on federally managed coral reef fish and bottomfish species of commercial, ecological, and cultural value, with a geographic focus on the Pacific Islands under U.S. jurisdiction. The project endeavors to generate life history parameters for species of interest and management unit species (MUS) and provides these data to stock assessment scientists and to those charged with the management of marine fishery resources as mandated by legislation. Additionally, the project strives for a more comprehensive understanding of the influence of biophysical and anthropogenic forces on fish life histories (e.g., climate change and fishing). This project works to elucidate the spatial and temporal trends of these relationships to better predict the impacts they may have on harvested fish demographics with changing future ocean conditions.

(top right) Figure 1. Uncle Roy Morioka with his catch from a research fishing trip during the 2020 Bottomfish Fishery-Independent Survey in Hawai'i (BFISH). Fish caught from this trip resulted in life history sample donations for JIMAR staff's research on the reproductive characteristics of the Hawaiian deep-water snapper, *Etelis coruscans*, in the MHI. Photo Credit: Crew of Renee NV.

Figure 2. Marvin Lum with the new state record for Onaga; a 94 cm and 34 lb, 3 oz female. This fish was a rare opportunity to obtain life history information from such a large female. Some of her parts were donated to science and used for JIMAR staff's research on the reproductive characteristics of the Hawaiian deep-water snapper, *Etelis coruscans*, in the MHI. Photo Credit: Kevin Desilva.

Progress during FY 2021

Plans for the year focused on delivering research products describing life-history strategies of several commercially harvested species including a coral reef fish species, territory Management Unit Species (MUS), and deep-water snappers from U.S. Pacific Islands. A NOAA administrative report documenting the reproductive characteristics of a Hawaiian deep-water snapper (*Etelis coruscans*) in the Main Hawaiian Islands (MHI; which is also a territorial MUS) is now available for use in upcoming stock assessments (Reed et al., 2021). In this same report, alternative length-at-maturity methods based on the maturity classification of data were included and discussed. The continuation and expansion of a collaborative sampling effort from dedicated commercial fishers, continued for *E. coruscans* in the MHI during COVID-19 with necessary modifications made to sampling protocols for safety. Once lab facilities re-opened at PIFSC, the remaining lab work for a spatial variability in the age, growth, and reproduction of Bluefin trevally (*C. melampyus*) in the Commonwealth of Northern Mariana Islands (CNMI) was completed. The delay in access to lab facilities also paused the drafting of the manuscript until FY 2022. Additionally, JIMAR project staff are leading a new collaboration among the University of Melbourne, University of Guam and PIFSC personnel in which staff are exploring the spatial and temporal variability in fish growth rates using dendrochronology techniques on a coral reef species and a territorial MUS in CNMI, (*N. unicornis* and *P. zonatus*).

During the year, other major accomplishments included; JIMAR project staff participating in and contributing expertise to several virtual workshops including the NOAA PIFSC 4th Annual Collaborative



Climate Change Workshop, the NOAA National Maturity Assessment and Reproductive Variability in Life Stages (MARVLS) Virtual Histology Workshop, and the NOAA PIFSC Ecosystem Based Fisheries Management Workshop. Additionally, staff took a training course from NOAA OceanWatch Operations to build skills utilizing remotely sensed environmental data, extracting satellite data using web services and coding in R. The course also taught techniques on assessing appropriate content for analysis, and in mapping satellite data.

There have been some major setbacks to the program due to the COVID-19 pandemic including the cancellation of a PIFSC Life History Program (LHP) research cruise to CNMI. Additionally, two shore-based research trips to America Samoa working with local fishers were planned and canceled due to the pandemic. Despite these challenges, JIMAR staff have continued to work with territorial partners and PIFSC scientists to acquire and produce life history information in support of U.S. Pacific Islands and territorial needs.

West Hawai'i Integrated Ecosystem Assessment

P.I.: Douglas S. Luther [JIMAR 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, Jamison Gove

NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The JIMAR West Hawai'i Integrated Ecosystem Assessment (IEA) project aims to produce robust scientific information that directly supports current and future resource management concerns in West Hawai'i. This area is home to a diverse group of species including ornamental fish, lush coral reefs, sea turtles, cetaceans and manta rays. The region all supports myriad ecosystem services important to the community, including eco-tourism, an aquaculture industry, and recreational and aquarium fisheries. The balance of these human activities with the natural processes helps to sustain ecosystem health in this productive region.

Goals of this JIMAR project include understanding oceanographic processes that support local ecosystem productivity, assessing key food-web linkages across multiple trophic levels, and quantifying human activities, both on land and in the ocean, that impact marine ecosystem structure and function.

Progress during FY 2021

The JIMAR West Hawai'i IEA continued efforts related to scientific information synthesis, manuscript development, and the dissemination of research findings from recent JIMAR-led field efforts. These efforts included continued research on ocean processes which drive trophic dynamics and govern larval fish survivorship, which have produced novel and widely publicized results recently published in the prestigious journal *Nature Scientific Reports*. The research findings demonstrate that surface slicks, a common coastal convergence feature, provide nursery habitat for diverse marine larvae, including over a hundred species of commercially and ecologically important fishes. The findings support the notion that late-larval fishes actively select surface slick habitats to capitalize on concentrations of diverse prey and shelter. By providing these survival advantages, surface slicks enhance larval supply and replenishment of adult populations from coral reef, epipelagic, and deep-water ecosystems. Taken collectively, these findings suggest that slicks play a critically important role in enhancing ecosystem productivity in tropical marine ecosystems.

The publication is currently in the top 1% of research articles tracked in terms of media attention with numerous international and local news outlets, science blogs, and social media outlets highlighting this groundbreaking research led by JIMAR scientists.

This past year was also focused on piloting the use of genomics in support of ecosystem-based fisheries management (EBFM). Specifically, the project led a shore-based field mission to develop, test, and employ advanced genomic methods, specifically environmental DNA (eDNA), to assess marine biodiversity in West Hawai'i. The focus of these efforts is on nearshore marine biodiversity, including assessing the important drivers and their

relative contribution to spatial variation in marine species. The utilization of eDNA is expected to provide a more robust assessment of marine biodiversity and underpin the implementation of EBFM. This approach will likely become a powerful complement to traditional surveys and play a critical role in monitoring health and diversity of complex marine ecosystems. The project is a collaboration with multiple government agencies (the State of Hawai‘i, PIFSC, PIRO), universities (Arizona State University, Scripps Institution of Oceanography, University of Hawai‘i) and non-governmental organizations (The Nature Conservancy, Conservation International).

Western Pacific Fisheries Information Network (WPacFIN)

P.I.: Douglas S. Luther [JIMAR Project Lead: Frances Tong]

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

NOAA Sponsor: Michael P. Seki, Timothy T. Jones

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The objective of JIMAR’s Western Pacific Fisheries Information Network (WPacFIN) project is to provide the best available fisheries monitoring data for research and sustainable management of fisheries in the Pacific Islands Region. WPacFIN partners with agencies in Hawai‘i, American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI) and Guam. JIMAR and Pacific Islands Fisheries Science Center (PIFSC) federal staff work with island agency staff, contractors, fishers and fish dealers to create data systems to implement quality control measures and synthesize fishery-dependent monitoring data. This technical support enables PIFSC and partner agencies to produce timely reports of the best available fisheries data from each island area.

Progress during FY 2021

JIMAR project staff continued the work of modernizing fisheries information systems by transitioning databases and database applications from Visual FoxPro (VFP) to MySQL, a relational database, and C#, a programming language used to create applications, for WPacFIN Central and all partner agencies.

The transition from VFP to MySQL involves designing databases in MySQL, importing data from VFP databases to the new MySQL databases then rewriting VFP data applications to MySQL/C# applications. The Hawai‘i effort for the Hawai‘i Division of Aquatic Resources (HDAR), which house State of Hawai‘i commercial fisheries data, has been ongoing and is expected to be completed Summer 2022. The effort for American Samoa, CNMI and Guam (“the Territories”) is expected to start Summer 2021.

HDAR’s Fisher Reporting and Dealer System (FRDS) database was completed July 2020 and met the goal of consolidating all historical and current data into one place. The FRDS application was updated to use the new MySQL database as well as output annual catch data and annual purchase data to continue the WPacFIN Hawai‘i dealer data integration process.

In FY 2020, as the shift to modernize fisheries data access and reporting continued, the team identified a need for a user-friendly, web-based self-service reporting tool. Research yielded a software application called “Metabase.” After a period of testing, the WPacFIN team stood up an installation at PIFSC in November 2020 then set up HDAR’s installation in January 2021. The application will reduce report development costs as well as provide a means for HDAR staff to perform their own data discovery, create ad-hoc queries and write reports. WPacFIN JIMAR programmers also write and share report code to HDAR’s Metabase installation for HDAR staff to run on their datasets. With the November HDAR rollout, WPacFIN programmers included several canned reports for HDAR to use with FRDS and other Hawai‘i datasets.

In May 2021, WPacFIN programmers began researching and testing the use of rapid application development (RAD) tools to shorten development time for application development in preparation for the FY 2022 Hawai‘i application rewrites and future territory application rewrites. This retooling does not eliminate or replace C# programming but instead, augments the development process by allowing the RAD tool to produce much of the general user interface code.

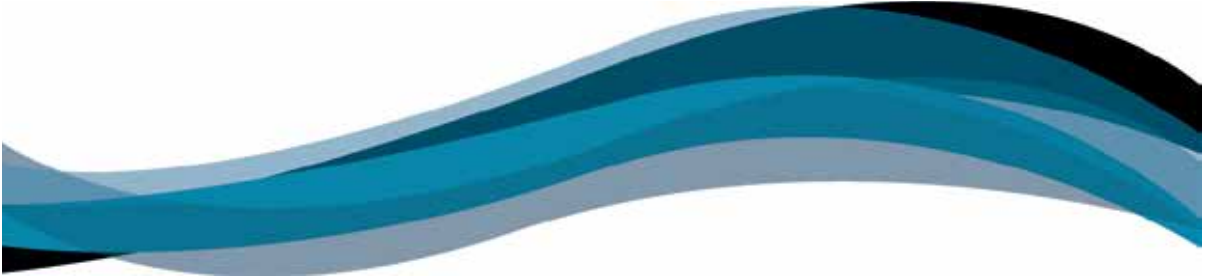
The responsibilities of importing and validating commercial dealer data was transferred to HDAR with JIMAR project staff continuing the catch-to-dealer data integration, the process which matches catch data to dealer (sales) data. The application matches longline catch data and HDAR fishing reports with their associated dealer sales records. Approximately 98% to 99% of longline and 50% to 60% of HDAR catch reports are matched to their corresponding dealer sales. After automated matching, a JIMAR Fisheries Monitoring Database Technician manually researches and addresses the discrepancies.

JIMAR project staff continue to provide technical support and training for WPacFIN-produced applications for HDAR. Throughout the year, JIMAR staff also complete data requests and participate in the annual SAFE Report project by programming, conducting code reviews, creating or updating documentation and producing final reports for Hawai'i and the territories that are submitted to the Western Pacific Regional Fishery Management Council (WPRFMC).

All work was developed and implemented by Western Pacific Fisheries Information Network (WPacFIN) using Structured Query Language (SQL) and C# in a MySQL environment.

JIMAR project staff include a Data Applications Developer who has progressive web applications (PWA), database, C# and JavaScript programming skills to help with the Hawai'i effort and start development for the territory effort. The JIMAR Data Applications Developer also has support responsibilities for the territory creel survey datasets and maintenance of the territory data applications.

Ecosystem-Based Management



Ecosystem-Based Management

Research under this theme focuses on facilitating an ecosystem approach to management in the Pacific Islands region. JIMAR 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.

Marine Debris Mitigation Project

PI.: Douglas S. Luther [JIMAR Project Lead: James Morioka]

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 JIMAR Marine Debris Mitigation project is a research and management endeavor, which focuses on derelict fishing gear removal within the U.S. Pacific Islands, including the Northwestern Hawaiian Islands (NWHI) within the Papahānaumokuākea Marine National Monument (PMNM) and the main Hawaiian Islands. The overall project objective is to reduce the impact of derelict fishing gear and other sources of marine debris on the health and vitality of coral reefs and critical shoreline habitats. Many of the islands and shallow water environments in the U.S. Pacific Islands are important habitats for rare species such as the threatened Green turtle and the endangered Hawaiian monk seal, as well as millions of seabirds that breed, nest, and feed in these areas. This project supports episodic large-scale marine debris removal missions which require coordinated efforts from the JIMAR staff in the NOAA Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) along with support from numerous partner agencies to execute the removal of derelict fishing gear from these remote islands and atolls. Outcomes of the project will include improving the quality of shallow coral reef systems and shorelines—critical habitat for numerous marine and avian species—through the removal and proper disposal of derelict fishing gear from these environments.

Progress during FY 2021

Two marine debris removal missions were completed during this reporting period. The Fall 2020 marine debris removal mission at French Frigate Shoals in the NWHI was completed between 19 October 2020–5 November 2020 (nineteen days-at-sea). The Papahānaumokuākea Marine Debris Project (PMDP) led this collaborative project with volunteer participation from two JIMAR staff from ESD, along with partners from the U.S. Fish and Wildlife Service. In total, this project removed over 82,000 lbs of debris from Tern Island at French Frigate Shoals. Project staff assisted in flipper-tagging seven weaned Hawaiian monk seal pups, and conducted eleven daily monk seal and turtle surveys around Tern Island.

The Spring 2021 marine debris removal mission in the NWHI was completed between 30 March 2021–20 April 2021 (22 days-at-sea) on board the *M/V Imua*. The project team included three JIMAR staff from ESD, along with partners from State of Hawai‘i’s Department of Land and Natural Resources (DLNR) and Division of Forestry and Wildlife (DOFAW), U.S. Fish and Wildlife Service, and PMDP. In total, this project removed 94,302 lbs. of marine debris from the shorelines of French Frigate Shoals, Laysan Island, Lisianski Island, Midway Atoll, and Kure Atoll. In addition, the team deployed a High-frequency Acoustic Recording Package (HARP) and collected observational data on monk seals and sea turtles for the PIFSC Hawaiian Monk Seal Research Program (HMSRP) and Marine Turtle Biological Assessment Program (MTBAP).



(above) Figure 1. An endangered Hawaiian monk seal (female) is entangled in a derelict fishing net at Lisianski Island. This monk seal was disentangled by the JIMAR project team. Photo Credit: Matthew Chauvin.

Figure 2. The JIMAR/NOAA Marine Debris Team sails home from the Northwestern Hawaiian Islands within Papahānaumokuākea Marine National Monument after a successful 22-day cruise where they removed over 94,000 pounds of marine debris. Photo Credit: David Golden.



Socioeconomics of Western Pacific Fisheries

PI: Douglas S. Luther [JIMAR 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 Adaptations and Mitigation
- Resilient Coastal Communities and Economies

Purpose of the Project

The purpose of this JIMAR project is to support effective fishery and associated ecosystem management by conducting socioeconomic research in the U.S. Pacific Islands Region, which includes Hawai'i, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). Collecting and analyzing key fisheries-related economic and sociocultural data, and monitoring vital socioeconomic indicators allows managers to make better informed decisions about regulations that govern fisheries and ecosystems under a changing climate.

Progress during FY 2021

The projects listed below were planned for FY 2021 and updates are provided for each of them.

Assistance to the National Community Social Vulnerability Indicators work plan. JIMAR staff conducted a literature review, developed a framework, and an interview guide to assess fishing communities in the main Hawaiian Islands that may be vulnerable based upon their reliance on climate-vulnerable species. Due to the pandemic, fieldwork was not conducted in FY 2021 but is tentatively planned for 2022 to complete this work.

Conduct socioeconomic monitoring for resilient communities in the Pacific. JIMAR staff assisted in the development of a non-species specific framework to better understand fishing community vulnerability to climate change.

Conduct a cost-earnings study of Hawai'i longline fleet. The pandemic forced a postponement of fieldwork to collect cost-earnings data from the Hawai'i longline fleet in FY 2021, but work is tentatively scheduled for the coming year. Paperwork Reduction Act (PRA) was approved and preparations for fieldwork were completed, including retaining translation services and translating the cost-earnings survey into Vietnamese.

Conduct a cost-earnings study of Hawai'i small-boat fisheries. Cost-earnings data is currently being collected for the Hawai'i small boat fleet. Once completed, JIMAR will help analyze the survey data and assist with writing the cost-earnings report.

Incorporating socioeconomic data throughout stock assessments process. JIMAR staff conducted fieldwork with Uku fishers throughout the main Hawaiian Islands via telephone, and collated secondary/archival socioeconomic data. These data will be analyzed and presented in a report. JIMAR staff also conducted interviews about the bottomfish stock assessment process in Hawai'i to inform a multi-stakeholder process in Guam regarding their bottomfish stock assessment process.

Analyze governance processes, institutions, and compliance to improve Western Pacific fisheries management. JIMAR staff developed a manuscript titled "Understanding the human dimension to reduce protected species bycatch" and submitted it for peer reviewed publication in an academic journal. This manuscript is based upon the same interview dataset with Hawai'i longline fishers conducted in FY 2019 that resulted in a NOAA administrative report published in November 2020.



Figure 1. Due to COVID-19 restrictions, Mia Iwane [top right] and Adam Ayers [middle right] attended a Conservation Conflict Transformation training administered by Conflict Resolution expert Francine Madden over Zoom. Photo Credit: Mia Iwane.

Examine climate change impacts to Hawai'i fisheries and fishing community adaptive capacity. Fieldwork for this project was delayed due to the pandemic, but it will be conducted in the coming year. An analysis of Pacific Islands Vulnerability Assessment (PIVA) Community Social Vulnerability Indicators (CSVI) datasets will provide insights into which factors influence the adaptive capacity of fishing communities in the Main Hawaiian Islands. This information will be summarized in a technical report.

Integrate social, economic, and cultural components into submodule for Main Hawaiian Islands Atlantis Ecosystem Model. JIMAR staff developed an analytical approach to assess and predict regime shifts and tipping points compatible with existing human dimensions datasets in Hawai'i. This approach and analysis will be summarized in a draft manuscript intended for peer-reviewed publication.

Incorporate spatially explicit sociocultural values in the West Hawai'i IEA. JIMAR staff conducted virtual workshops to collect individual and community perspectives. This data collection will allow creation of a framework that can describe and categorize individual/community-level emotional connections to coastal and marine environments in the West Hawai'i IEA.

Additional Projects

Exploratory analysis of economic contributions of the U.S. purse seine fishery. JIMAR staff collected and analyzed data for the U.S. purse seine fishery operating in multiple geographies (American Samoa, United States, elsewhere across the Pacific). The contributions of American Purse Seine fisheries will be summarized in an internal report that will also describe data gaps and future research needs.

Adaptation of Pacific Island Regional fisheries to COVID-19. JIMAR staff assisted with fieldwork interviews conducted virtually or over the telephone with fishers and fishing related businesses across the U.S. Pacific Islands region. These interviews supported two reports on COVID-19 impacts to Pacific Island fisheries.

Hawai'i Seafood Market Analysis. JIMAR staff revised and updated R code to automate Hawai'i seafood trade data analysis. The coding and data analysis is being used to update a manuscript previously drafted by JIMAR staff.

ESD-PIRO Quarterly Coordination. JIMAR staff served as co-coordinator to discuss pressing/relevant science updates or management needs.

Stock Assessment Research Program

P.I.: Douglas S. Luther [JIMAR 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, Felipe Carvalho

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Stock Assessment Program (SAP) project supports continuing stock assessment research on pelagic (e.g., billfishes, sharks, tuna, etc.) and coastal (e.g., bottomfish and reef fish) management unit species (MUS) according to a schedule determined by resource users, stakeholders and managers. The objective of this project is to provide required support to assess the status of pelagic and coastal stocks and the impact of harvesting on these stocks. For pelagic species, the project explores the utility of integrated stock assessment models to improve the ability to understand and predict the status of stocks and impacts of exploitation. For coastal species, the project explores methods of Catch Per Unit Effort (CPUE) standardization to improve assessments through the inclusion of more precise abundance indices, habitat information, and spatio-temporal information, as well as the development of an efficient fishery-independent sampling design, and the development of length-based stock assessment techniques. Of particular interest is the coordinated effort on bottomfish habitat characterization and integration of these data into stock assessments. Databases, software tools, and modeling approaches are also in development to facilitate future analyses. Including software tools to automate the estimation of hundreds of bycatch species from the Western Pacific longline fisheries, including over 20 protected species. The goal is to

turn existing estimation code into user-friendly tools, perhaps in the form of a Graphic User Interface (GUI), that a less technical person can use with minimal guidance from PIFSC bycatch estimation scientists. Implementation of such a tool will improve the ability for PIFSC to meet all bycatch estimation deadlines and result in more scientific staff time to focus on unique, management-driven protected species questions that arise from circumstance. The interdisciplinary nature of this project is a step toward building stronger capacity for effective marine resource stewardship, and collaborations between JIMAR, PIFSC, PIRO and resource management agencies.

Progress during FY 2021

Research goals for FY 2021 focused on meeting the stock assessment schedule, developing a toolkit to improve bycatch estimations for the Hawai'i deep-set and American Samoa tuna longline fisheries, to continue support for existing SAP tools and to develop a smart phone application to inform resource users on spawning periods of marketable fish species. This year work on the upcoming stock assessment of territorial bottomfish species in American Samoa was started. The first step was generating a tech memo

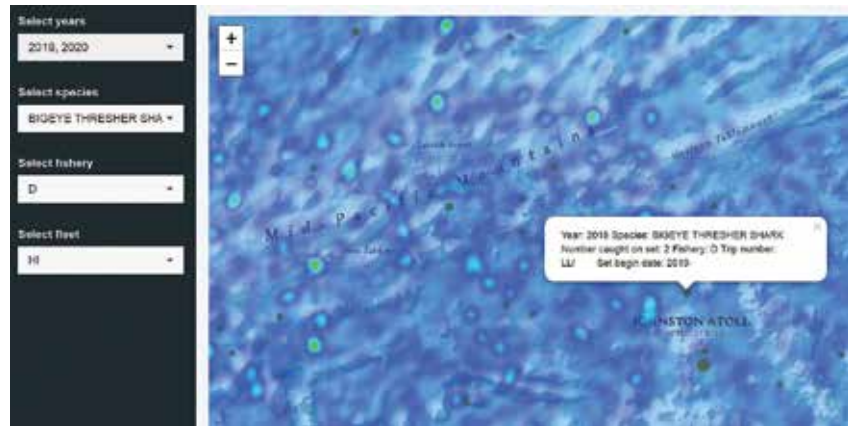
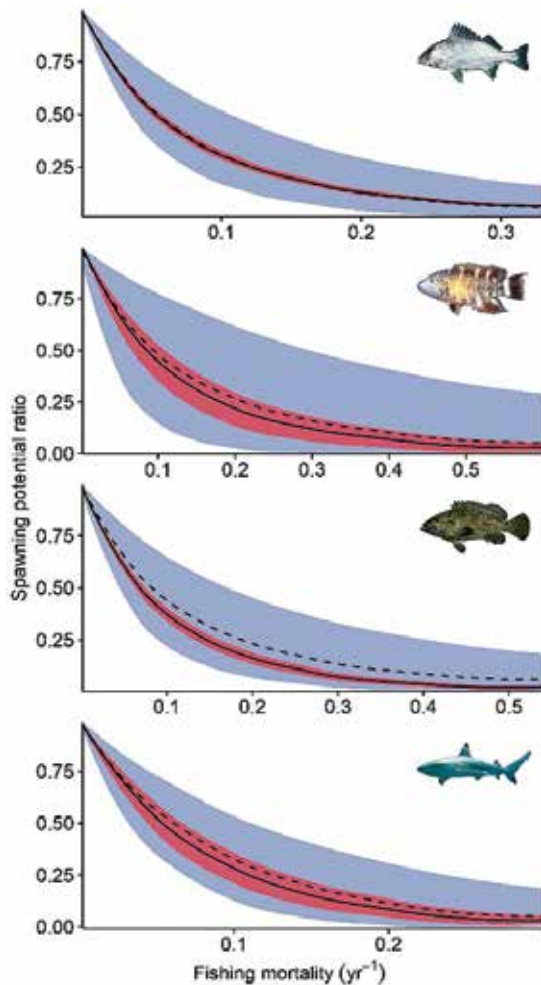


Figure 1. A screenshot of the beta version of the PRToolkit mapping tool. This demonstrates the interactive map (scrollable, can be zoomed in/out, etc.), which has a heat map of logbook data, and observer sets denoted by the green circles. Clicking on the green circles produces a popup with information regarding the set. The dropdowns on the left allow the user to parse through bycatch by year, species, fishery, and fleet.

on the data available in American Samoa for bottomfish assessments. This work is nearing completion and will be published early in the next fiscal year. These assessments will be helped by the publication of a JIMAR scientific paper extending a meta-analytical tool to generate life history parameters for data-limited species. This paper is undergoing final edits and will be published at the end of 2021.

Progress towards the generation of the 2020 bycatch estimates was seriously impacted by the pandemic. The NOAA Observer Program struggled to place observers on the Hawaiian deep-set longline fishery, and the program was unable to meet the randomly generated systematic sample over a two-month period. The project collaborators spent approximately two months of their time focusing on generating statistically sound estimates for the bycatch during this period. Multiple techniques were attempted, with the earlier attempts being discarded after the results appeared to be inflicted with bias. With the software tools developed in this project, the deep-set estimates would normally take less than a week to complete. Despite these setbacks, progress was substantial towards several other bycatch estimation toolkit goals including:

1. Four new estimation techniques were written into R code to process the American Samoa bycatch data. The automation has not been completed for this, as the American Samoa estimation procedures are being evaluated to handle the decreasing number of trips and permit owners in the fishery. For example, in 2020 there was only a single observed trip, and the estimation methodology needed to change to account for such a small sample size. Determining the future estimation routines for American Samoa has taken the back-burner as the bycatch estimation team is focusing on generating bycatch estimates for the 2020 Hawaiian fisheries, which has been complicated by the effects of pandemic, including a two month gap in the observer program's systematic sampling routine.
2. Software tools to separate bycatch for the marine mammals in American Samoa have been developed, but automating the marine mammal bycatch estimation routines has not been completed due to the potential for changing methodology and 2020 estimation challenges mentioned above.
3. Software tools to automate reporting for bycatch estimates for marine mammals in the Hawaiian longline deep-set and shallow-set fisheries have been completed. This tool has not yet been expanded to the shallow-



(above left) Figure 2. Spawning potential ratio at different fishing mortality rates for four species, using either published life history parameters (red area) or the new meta-analytical approach developed by JIMAR researchers at PIFSC (blue area). The meta-analytical approach is used when life history parameters for a given species are unavailable.

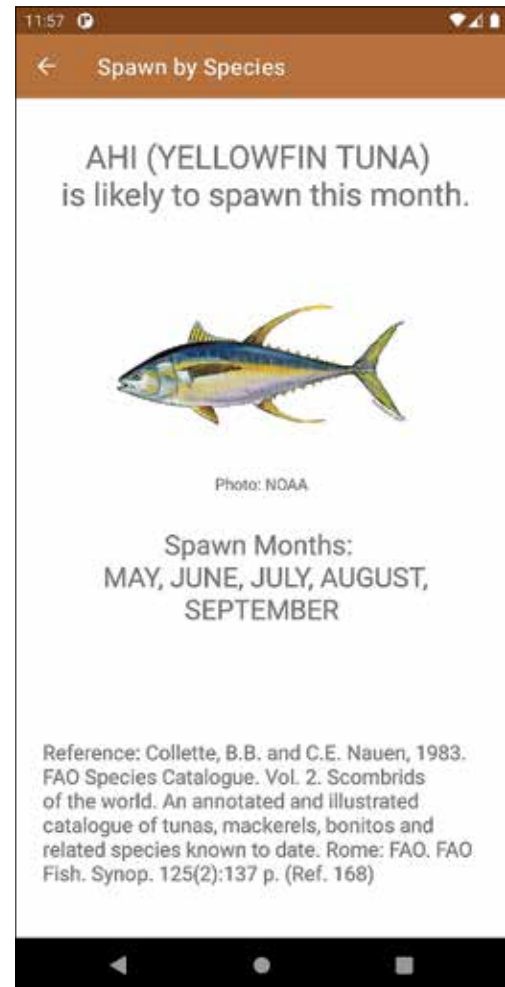


Figure 3. Screenshot of Malamalama android app displaying the spawning likelihood for ahi or yellowfin tuna (*Thunnus albacares*) during October. Below is species picture, including author source, ahi-yellowfin tuna spawn months, and spawning month cycle references.

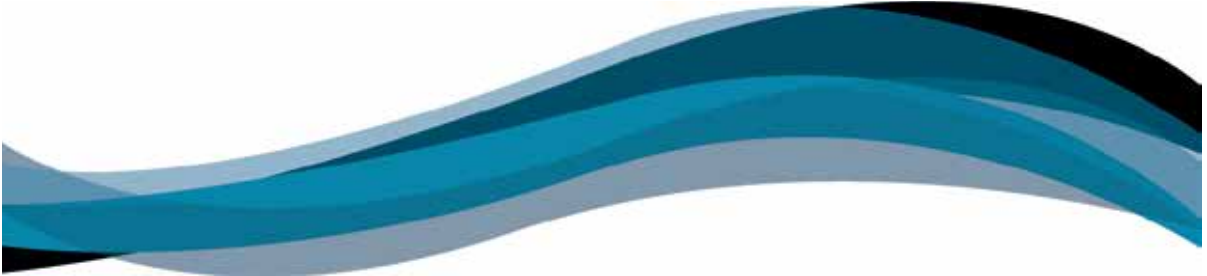
set fishery, although the 2020 bycatch estimates, which have been greatly slowed by the pandemic, have taken precedence over the reporting automation.

4. The software tools to report bycatch estimates for seabird and turtle species in the Inter-American Tropical Tuna Commission (IATTC) convention area and the total fishing grounds in the Hawaiian longline deep-set and shallow-set fisheries have been completed.
5. The documentation for the software tools has started, and it is approximately 20% complete. This task has been slowed by prioritization of other tasks, including the pandemic-affected 2020 bycatch estimation calculations and desire by PIFSC leadership to develop a version of the Protected Resources Toolbox (PRToolbox) graphical user interface to the council.
6. The beta version of the PRToolbox mapping tool is approximately 90% complete, and it is on track for release in FY 2021. The data to demonstrate it will use placeholder data to avoid confidentiality and simply demonstrate the capabilities of the mapping tool to other science centers.

The project also created an application called *Malamalama* to inform the public about the spawning months of main Hawaiian Islands fish and shellfish captured and sold locally. The development of this app was an ongoing partnership with PIFSC leadership, scientists and the Kohala Center, and led by JIMAR SAP project staff. This product is based on an informational poster, ‘*Spawning Guide for the Leeward Coast of Hawai‘i Island*’ published by the Kohala Center. The core features to inform users of spawning months was developed by JIMAR project staff, and includes Native Hawaiian moon cycles and fishing pono practices. The JIMAR developer worked with a representative from the Kohala Center to test application and transfer the app and code to their organization during this year. The Kohala Center will be responsible for public release of *Malamalama* app.

This project has also created a publicly accessible SAP Github site where project products, datasets, assessments and reports are available. JIMAR project staff maintain this site with updates, in-depth descriptions of stock assessments, software tools and documentation. JIMAR SAP staff also worked on the release of an Age Structured Projection Model (AGEPRO) bugfix update during this period. Currently, a new AGEPRO project began, focusing on refactoring graphical user interface and data object code written by JIMAR project staff developer. It will also include the age-structured projections published in the 2020 Uku assessment.

Protection and Restoration of Resources



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. JIMAR scientists work to protect, restore, and educate the public on endangered species of marine turtles, Hawaiian monk seals, and cetaceans. JIMAR works to protect and restore pelagic and insular fisheries through stock assessments, fisheries monitoring, and fisheries information exchange. JIMAR also conducts research and mitigation efforts on marine debris around the Pacific Islands.

Cetacean Research Program

PI: Douglas S. Luther [JIMAR 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

The JIMAR Cetacean Research Program (CRP) project is charged with assessing the status of cetacean stocks within the U.S. Exclusive Economic Zone (EEZ) waters of the Pacific Islands Region (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 the Commonwealth of the Northern Mariana Islands (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 2021

Vessel Surveys. Chronic disturbances to the daily behavioral patterns of spinner dolphins have caused concern for the long-term health and status of the main Hawaiian Islands stocks. NOAA Fisheries' Pacific Islands Regional Office has proposed a 50-yard approach rule to mitigate the disturbance to the dolphins. In collaboration with the Hawai'i Institute of Marine Biology's (HIMB) Marine Mammal Research Program, JIMAR CRP staff conducted a pilot project of small-boat line-transect abundance surveys for spinner dolphins in the nearshore waters of Oahu in October-November 2021. The data will help NOAA Fisheries to better understand the present status of spinner dolphin stocks in Hawai'i. Delays due to the pandemic pushed the planned summertime surveys to October. Weather conditions limited the project to four days on the water. The survey team completed 105 survey lines out of the 298 planned (35%). There were four spinner dolphin sightings during which approximately 1,700 photos were collected for photo-ID. Additional surveys are planned for the summer of 2022.

The Pacific Marine Assessment Program for Protected Species (PacMAPPS) is a partnership among federal agencies; Bureau of Ocean Energy Management (BOEM), NOAA Fisheries (Alaska, Northwest, Pacific Islands, and Southwest Fisheries Science Centers), U.S. Navy, and U.S. Fish and Wildlife Service (USFWS); to conduct surveys to assess the abundance of multiple species and their ecosystem. The annual rotation of PacMAPPS surveys began in 2017 with the summer/fall Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) and has continued since with California Current Ecosystem Survey (CCES) off the U.S. west coast in 2018 and Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS) in 2020. During May-July 2021, JIMAR led a visual and passive acoustic ship-based survey aboard the NOAA R/V *Oscar Elton Sette* within the combined EEZ around Guam and the Commonwealth of the Northern Mariana Islands (CNMI) as part of the PacMAPPS plan. The data collected during the Mariana Archipelago Cetacean Survey (MACS) will complement ongoing efforts by NOAA to conduct comprehensive marine mammal, seabird, and



Figure 1. Spinner dolphins were encountered in Kaneohe Bay during line-transect abundance surveys around Oahu in November 2020. Photo credit: Marie Hill.

ecosystem surveys in U.S. waters in the Pacific every three to six years to estimate the abundance of protected species populations, develop spatial models of species distributions, and monitor status and trends. The data will also be used to support environmental planning processes for the Navy under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA).

Passive Acoustics Research. Towed hydrophone arrays are a standard approach for the passive acoustic monitoring of cetacean species during shipboard research surveys. Towed array data are used to track and localize cetacean groups to assist visual observers and can also be used to estimate perpendicular distance estimates, a key parameter in abundance estimation. However, current two-dimensional (2D) localization methods are not optimized for deep-diving cetaceans, such as sperm whales, and can lead to biased distance estimates. Recently, JIMAR staff and coauthors developed a new model-based localization approach for towed array data to improve the localization of deep divers by accounting for animal depth, the effects of sound propagation, and other sources of error not previously incorporated. They demonstrated how estimating sperm whale locations and distances could be affected by several factors, including a whale's depth, distance, and movement. Three-dimensional probability surfaces (i.e., ambiguity volumes) provided a visualization of the model-based approach results and allowed for the comparison of 2D localization results. Overall, the model-based approach provided more robust localization results compared to the 2D method.

The model-based localization method was applied to towed array acoustic data of sperm whales collected within the Hawaiian Exclusive Economic Zone (EEZ) to incorporate additional location information into species distribution models. Previous species distribution models for the Hawaiian sperm whale population included only visual sighting data and predicted a broad increase in sperm whale density towards the northwest portion of the Hawaiian EEZ. The addition of towed array acoustic data generated models predicting finer-scale distribution patterns of sperm whales, with higher densities generally predicted between Laysan Island and Pearl and Hermes



Figure 2. An autonomous acoustic recorder drifts off of Alamagan during the 2021 Mariana Archipelago Cetacean Survey. Photo credit: Marie Hill.

Atoll as well as areas north of Maui and Hawai'i. Furthermore, the types of echolocation clicks identified in the towed array data were used to build species distribution models for foraging and non-foraging sperm whales providing information more directly related to their ecology. This analysis developed a framework to incorporate towed array and sighting data into species distribution models and is a step towards gaining a more complete understanding of sperm whale distribution patterns in the Hawaiian EEZ.

Recently, a JIMAR Postdoctoral Researcher (Dr. Yvonne Barkley) began a research project to estimate sperm whale cue rate from towed array data, another parameter necessary for achieving acoustic density estimation. With ample towed array data available, JIMAR will examine sperm whale encounters that are both acoustically detected and sighted by visual observers. Ultimately, the goal will be to develop a statistical relationship between the number of clicks produced during an encounter with the number of individuals estimated by the visual observers to better understand the rate at which sperm whale vocalize. This information is important for improving the accuracy of acoustic density and abundance estimates.

JIMAR also has a Postdoctoral Researcher (Dr. Pina Gruden) is working on a project that aims to automate acoustic tracking of multiple false killer whale (*Pseudorca crassidens*) groups. False killer whales are known to interact with fisheries within the Hawaiian Archipelago, leading to whale mortality or injury, sometimes at unsustainable rates. To assess the impact of this bycatch to the population it is critical to determine the false killer whale abundance. Common abundance estimation methods, using visual line-transect surveys, are complicated by a number of biases and uncertainties specific to this species, and the inclusion of the passive acoustic monitoring could improve abundance estimates. In order to effectively incorporate passive acoustic monitoring, automated methods for processing acoustic data are needed.

Currently, the bearings to the vocalizing animals obtained from the towed hydrophone array are manually tracked to obtain the animal(s) position(s). This manual process is extremely time consuming and subjective, as the results vary greatly between different analysts. In addition, the bearings are typically derived based on either

whistles or echolocation clicks. However, the groups of false killer whales can have a diverse vocal behavior, with some groups only whistling, some echo locating, and some producing both. Moreover, it can be especially difficult to resolve multiple animals or groups, especially when swimming closely. Recently, a new automated approach was developed, based on the Probability Hypothesis Density filters, to track multiple groups of animals based on their bearings. Compared to the current manual process, this approach speeds up the analysis significantly (from hours/weeks per encounter to minutes), and eliminates the subjectivity of the manual analysis. This new approach incorporates information from both whistles and echolocation clicks, and allows more detailed information to be extracted from a given acoustic encounter.

In 2017, the CRP began integrating drifting acoustic recorders into shipboard surveys. The Drifting Acoustic Spar Buoy Recorders (DASBRs) are deployed from the ship and are left to drift with the currents for days to weeks. In 2018, a network of eight DASBRs were deployed on the west side of the Mariana Archipelago with the goal of examining the distribution and habitat use of beaked whales and *Kogia* spp. in this region using passive acoustic monitoring. Using measurements from concurrent CTD casts and satellite-derived oceanographic data, CRP found a latitudinal shift in the distribution of beaked whale species related to oceanographic conditions. The detection rate of the target species on the DASBRs was substantially higher in the region north of 15.5°N than for those occurring farther south. The differences in the oceanographic characteristics between the northern and southern regions may impact foraging opportunities and therefore affect the distribution of these cetacean species.

High-frequency Acoustic Recording Packages (HARPs) are an integral part of the CRP's passive acoustic monitoring program. CRP uses two different types of HARPs: one moored to the ocean floor for long-term recording (six to twelve months); and another attached to longline gear for the period of the soak (five to twenty hours). Moored HARPs are used to better understand cetacean presence and temporal patterns in remote locations, where regular visual surveys are not possible. In addition, they are used to monitor ocean ambient noise at various sites to assess differences in order to understand the potential effects on cetacean populations. Sites currently maintained by the CRP include Kona off the west side Hawai'i Island, Pearl and Hermes Reef in the Papahānaumokuākea Marine National Monument, Saipan and Pagan Islands in the CNMI, and Wake Island in the CNP. Of note for this year, the HARPs at Saipan, Pagan, and Wake were exchanged after several years and new data are being collected. Due to logistical difficulties the HARP off Saipan had not been exchanged in two years and the HARPs off Pagan and Wake had not been exchanged in over three years.

The longline HARPs are used to better understand the interactions between cetaceans and the gear of commercial longline fishing boats. This project is carried out with the assistance of NOAA Fisheries' Observer Program and voluntary fishing vessels from the Hawai'i longline fleet. This project slowed considerably due to the pandemic. However, efforts have been made to ramp up the project/deployments as restrictions ease and access is regained to the fleet. Additionally, the project has been expanded to provide in-air recorders to the vessels that take longline HARPs. Previous analysis has shown that some vessels make a noise when recovering gear that attracts cetaceans. By providing the in-air recorder and longline HARP further analysis can be done to better understand interactions between the longline vessels and cetaceans, and it may be possible to modify gear or operations to reduce interactions that lead to serious injury or death of the whales and potential closure of the fishery.

Fishing Impacts on Non-target Species

P.I.: Douglas S. Luther [JIMAR 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

Purpose of the Project

The JIMAR Fishery Impacts to Non-Target Species (FINS) 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

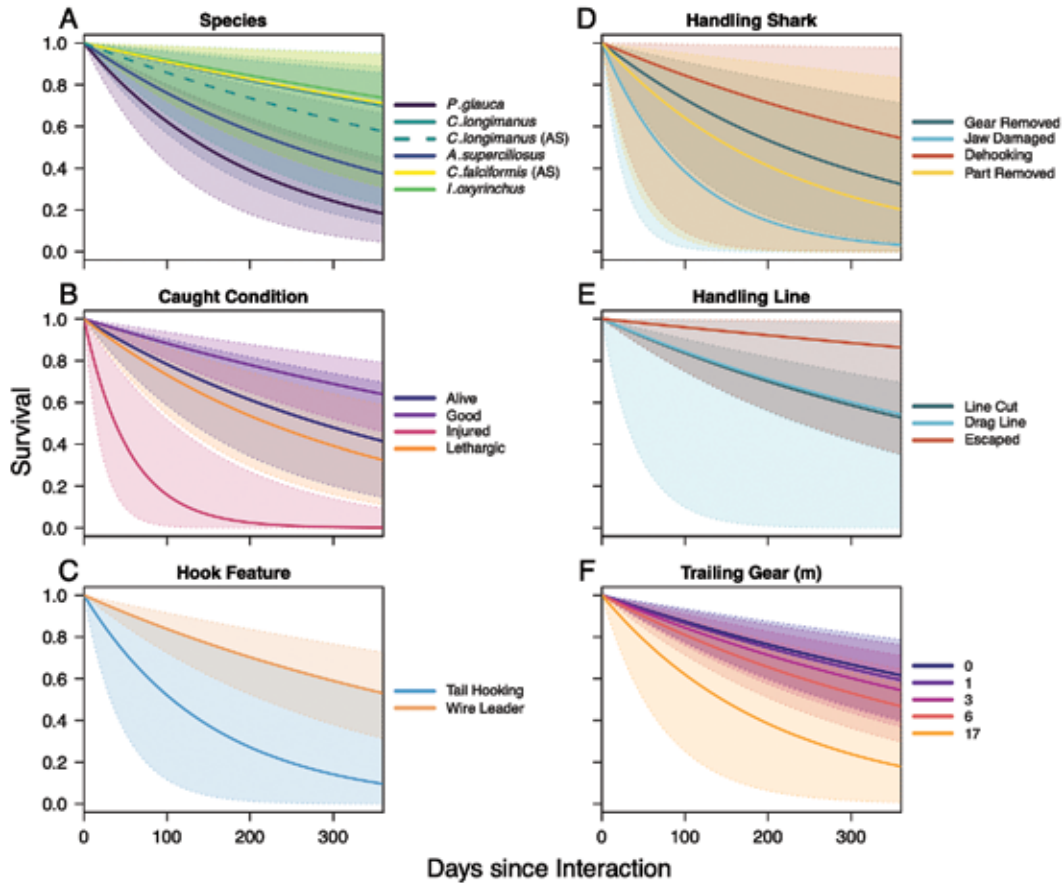


Figure 1. Bayesian survival curves determined from the shark post release survival tagging data in the U.S. Pacific longline fisheries. Bayesian survival curves of the mean fishing interaction conditions for 1 to 360 days since the interaction occurred: for each species (A), by caught condition (B), by hook feature (C), by handling condition involving the shark (D), handling condition involving the line (E), and by length of trailing gear (F) from 1 to 360 days since interaction. For B and D-F, the baseline hazard rate, h_0 , was the mean across species and tag deployment periods while all other conditions were assumed to be at their respective mean. In (C), the baseline hazard rate was the mean across all species tagged for the wire leader. For tail hooking the baseline hazard is the mean across *A. superciliosus* (BTH) only. These rates help provide managers and stock assessment scientists with estimations of mortality and evidence for improving post release survival rates with gear configuration, handling and discard practice regulatory amendments.

fishers in longline, purse seine and small-scale fisheries to quantify post-release survival rates, improve stock assessment parameters and to identify best handling and discard practices to reduce mortality. 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. FINS specific objectives during the last fiscal year included:

- Quantify post release survival rates of shark bycatch in longline fisheries
- Elucidate the effects of handling on post-release survival rates of shark bycatch in longline fisheries
- Identify strategies to reduce mortality to the threatened oceanic whitetip shark

Progress during FY 2021

During FY 2021 this project generated a data report (Hutchinson et al. 2021) quantifying post release survival (PRS) rates of five shark bycatch species captured in the Hawai‘i and American Samoa tuna longline fisheries. The report used a Bayesian analytical approach on telemetry and observer datasets that allowed the project to generate PRS rates for the most common capture and release scenarios occurring in the fisheries. The PRS rates



Figure 2. Oceanic whitetip shark photo taken near Kona, Hawai'i and submitted to the Hawai'i Community Tagging Program's (HCTP) photo identification library. This photo of a shark tagged previously by HCTP fishers provides further evidence of regional residency, updates details on demographics of OCS in the region, and helps researchers track OCS interactions and gear retention. Photo Credit: Deron Verbeck.

are now available for stock assessments and for determining post release fate of an ESA listed shark species. The report also generated PRS rates under a variety of handling and discard methods that are utilized in the fisheries. The analyses revealed that most sharks are released with large quantities of trailing gear and that reducing the amount of trailing gear significantly improved PRS. Additionally, the project was able to determine the impacts of leader material (wire versus monofilament) on PRS and found the use of wire leaders reduced PRS. The report was presented to the Science and Statistical Committee, the Pelagic Plan Team and Oceanic Whitetip Working Group for the Western Pacific Regional Fishery Management Council (WPRFMC). The WPRFMC has since created a management measure to ban wire leaders in the Hawai'i deep-set (tuna target) longline fishery. The WPRFMC is also generating shark bycatch handling regulations based on the recommendations in the report. Results revealed that leaving sharks in the water and cutting away as much trailing gear as possible significantly improved PRS for all species of sharks that were tagged in the study. The WPRFMC has also requested the U.S. State Department compose a letter to the international Regional Fisheries Management Organizations (RFMO), requesting all fishing nations that impact overfished populations implement handling and discard method regulations based on the results and recommendations from this study. The PRS study has been slightly delayed to pandemic restrictions preventing observers from going to sea. The study relies on observers for the deployment of tags during commercial trips and there are still a few more tags (N=18) that need to be deployed. The project anticipates completion during the next fiscal year.

This project also made significant progress towards the goals of the Hawai'i Community Tagging Program (HCTP), a large collaborative telemetry and outreach effort between JIMAR researchers, State of Hawai'i's Division of Aquatic Resources (DAR), PIFSC, PIRO and local recreational and commercial fishers aimed at reducing mortality to the ESA listed oceanic whitetip sharks (OCS). OCS are temporally resident at anchored fish aggregating devices (FADs) and are also often found in association with pilot whales around Hawai'i. As such, OCS are often captured incidentally by recreational and commercial troll fishers targeting tuna and billfish around the anchored FAD array. In this fishery OCS have been implicated as a major contributor to shark depredation rates and are considered a nuisance by local fishermen. As a result of these interactions some fishers may kill OCS depredating their catch. The HCTP endeavors to work with fishers to educate the community on the conservation status of OCS and other pelagic sharks, deploy electronic tags to elucidate habitat use and movement behavior,

generate estimates of depredation rates in the small-scale fisheries and to come up with practical and non-lethal strategies for deterring sharks from fishing gear. At present, program participants have deployed over 200 tags on twelve different species of sharks including 81 tags on OCS, generating the largest telemetry dataset in existence for an OCS population. The data has thus far revealed that OCS do exhibit some site fidelity to the Hawaiian Islands with intermittent and short-term residency at FADs. The program is ongoing and despite restrictions on travel and gathering in person due to COVID-19 the project was able to engage with program participants remotely by providing regular feedback on tag data and through quarterly newsletters. Participating fishers share their deterrent strategies during interviews published on the sharktagger.org website to inform the community on non-lethal techniques to avoid protected species interactions and shark depredation of catch. The HCTP has suffered some major data losses due to FAD hardware malfunctions, pandemic restrictions on travel and diving to service the receivers stationed on FADs with hardware issues. Over the last fiscal year several FADs with acoustic receivers broke away and were lost. The losses generate gaps in receiver coverage and impede the understanding of FAD association dynamics. The project has generated new partnerships to expand the receiver array and to assist with array maintenance to hopefully mitigate losses in the future.

Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support

PI.: Douglas S. Luther [JIMAR 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

JIMAR's Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support project, in collaboration with the NOAA Pacific Islands Fisheries Science Center Protected Species Division, conducts studies on the Hawaiian monk seal (*Neomonachus schauinslandi*), the most endangered marine mammal occurring entirely within U.S. jurisdiction. The Northwestern Hawaiian Islands (NWHI) Research Seasonal Support project conducted monk seal population assessment, health and disease, survival enhancement, foraging, and behavioral research, as well as standard enhancement activities. Research and enhancement activities are conducted primarily in the NWHI to augment year-round program activities in the Main Hawaiian Islands (MHI). JIMAR field staff and volunteers are deployed on a seasonal basis at up to five main breeding sites and conduct field studies opportunistically at Midway Atoll, Mokumanamana, Nihoa, Niihau, and within the MHI. Field research activities include visual and photographic monitoring, tagging, pelage bleach marking, health screening, necropsies, specimen collection, and vocalization and foraging studies. Field staff also participate in translocation and other recovery actions including hazing or removal of aggressive male seals, shark predation mitigation and deterrence, entrapment surveys, behavioral modification, vaccination research, disentanglement, reuniting mother-pup pairs, abscess treatment, marine debris removal, inter- and intra-atoll translocation, evaluation and capture of seals for rehabilitation, and feeding and soft release of rehabilitated seals. JIMAR field staff also provided assistance to other programs and agencies, including activities such as conducting insect, plant, and Laysan duck surveys, monitoring for invasive species, and collecting sea turtle nesting data.

Progress during FY 2021

A total of ten paid staff and six volunteers were selected to participate in the 2020 field season, which commenced in the previous project period (February 2020). Initially, field personnel participated in securing and packing food stores and training to conduct field activities. Due to the global pandemic, the training period was shifted to online training only in mid-March and the deployment cruise and field season were ultimately canceled. Despite the challenges and cancellation of the field season, field staff and volunteers made valuable contributions to the



(above) Figure 1. JIMAR staff conducting boating operation off of Oahu in preparation for the 2021 NWHI Field Camp season. Photo Credit: Hope Ronco.

Figure 2. JIMAR Research and Logistics Technician food shops for the 2021 NWHI Field Camp season. Photo Credit: Hope Ronco.

program throughout the duration of their terms. They created new protocols and training modules including protocols for biosecurity and boating maintenance and kayaking operations. Hard copy data sheets were converted to electronic form and an electronic database for field camp inventory to organize and track all of the gear and supplies for remote research was developed. The new database is expected to result in quite impactful increased efficiencies and new protocols will help us uphold safety and the strict biosecurity and safety protocols. The team also helped us to catch up on backlogs of important data, which has positioned the program to be well prepared for the 2021 field season.

Preparations for the 2021 field season include the hiring of 5 field technicians to lead camps at five of the six major reproductive sites in the NWHI at French Frigate Shoals (FFS), Laysan Island, Lisianski Island, Pearl and Hermes Reef (PHR), and Kure Atoll. Additionally, nine field camp assistants were hired to assist technicians with field research and recovery activities in 2021. The training period began in late May, and



due to the pandemic, training activities have been adapted to a hybrid of in-person and virtual in order to minimize exposure. Training activities include wilderness first aid, field data collection and animal handling techniques, as well as training for a collaborative project with UH Sea Grant and University of Hawai'i Hilo called Huli'ia, a traditional tool to aid in natural resource management. Field personnel participated in securing and packing food stores and assist with the loading of the deployment vessel *Kahana II*. The deployment is expected to take place after the project period ends.

Hawaiian Monk Seal Research Program

PI.: Douglas S. Luther [JIMAR 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 JIMAR Hawaiian Monk Seal Research Program (HMSRP), in collaboration with the NOAA Pacific Islands Fisheries Science Center Protected Species Division, conducts research on the Hawaiian monk seal (HMS; *Neomonachus schauinslandi*), the most endangered marine mammal occurring entirely within U.S. jurisdiction. There are approximately 1,400 monk seals remaining, the majority of which occur at the six highly studied sites in the Northwestern Hawaiian Islands (NWHI) where abundance is estimated to have declined by two thirds since the late 1950s. Apparent stability or population growth in the NWHI in recent years substantially influences overall trends, and the average growth rate of the overall population has been approximately 2% per year since 2013.

The program conducts research designed to promote sound conservation and management of the species by characterizing natural and anthropogenic factors that may impede population recovery. Research focuses on connections between population biology, foraging ecology, individual health, and environmental and oceanographic parameters in the North Pacific. JIMAR staff develop, test, and implement tools to assist in recovering the species.

Progress during FY 2020

Accomplishments during FY 2021 included population monitoring and assessment, survival enhancement activities, foraging ecology characterization, health and disease evaluation, and behavioral research.

Due to pandemic restrictions, limited field activities were conducted by HMSRP JIMAR staff during the project period. JIMAR staff played a crucial role in planning possible scenarios to deploy adapted NWHI field efforts, but the NWHI field season was ultimately canceled in July 2021.

However, robust data are routinely obtained from seal sightings in the MHI, which are received from the public via a NOAA hotline and greatly supported by agency partners and volunteer networks throughout the region. Despite limitations associated with the pandemic, sufficient data were collected by MHI partners throughout the year to allow for standard analyses to be conducted. JIMAR staff worked closely with agency partners to facilitate data collection, monk seal monitoring and bleach marking of individual seals. Staff held virtual trainings and kept in close communications with partners to ensure compliance with federal permits and the flow of monk seal information.

JIMAR staff were heavily involved in the development of NOAA RTOW risk assessment protocols for specific work related tasks, such as NWHI field camp preparations at the IRC and field work activities in the MHI. These protocols enabled the HMSRP to participate in mission critical activities such as the transport of compromised seals into rehabilitative care in Kona, stranding response to seals of concern, bleach marking of individual seals for population tracking, and flipper tagging of weaned pups for long term identification. During the reporting period, and working within the restrictions of the pandemic, JIMAR staff were able to successfully flipper tag and bleach mark several weaned pups on Oahu. JIMAR staff also coordinated and participated in field response to



(above) Figure 1. HMSRP staff tagging a weaned pup on Oahu in November 2020 (work conducted under NMFS Permit No. 22677). Photo Credit: Gayle Matsuda.

Figure 2. The release of two rehabilitated yearling seals at Midway in August 2020 (work conducted under NMFS Permit No. 19786). Photo Credit: Hope Ronco.



seals of concern on Oahu. In August of 2020, JIMAR staff successfully coordinated and participated in the release of four rehabilitated juvenile seals from Ke Kai Ola Monk Seal Hospital on Hawai'i Island to Midway Atoll in the NWHI.

JIMAR staff played a crucial role in preparation for the 2021 field research camps in the NWHI. A JIMAR Biological Research Technician was hired in January 2021 to work year round with the program and four technicians and nine assistants were recruited and hired to participate in the 2021 field research camps. Field staff began training in late May and early June. Program staff reviewed and revised protocols, and trained field personnel in conducting field activities. They also procured, tested, and packed field supplies and equipment, and provided other logistical support necessary to deploy the camps. Due to the pandemic precautions, all training was converted to a hybrid of virtual and in person training and the deployment cruise is due to depart on July 10. Careful considerations have been made and risk assessments to mitigate COVID-19 risks have been undertaken, and JIMAR staff have played a crucial role in evaluating and mitigating those risks from packing, in person training, and field and emergency response activities.

Additional accomplishments by the project include overseeing the design and development of a specialized "squeeze" cage for handling monk seals. Preparation of data reports and large data sets at the request of agency partners. Program staff continued to improve and refine data collection in the MHI by creating and implementing

new platforms for data collection and import. JIMAR staff are also working with outside partners to create a digital web-based photo catalog of seals on Oahu with the potential to expand the catalog to all MHI seals in the future. A monk seal program staff member also led a team tasked with developing a proposal to obtain capital improvement funding to address veterinary needs, operational requirements, environmental compliance issues, and safety concerns related to the captive care of the endangered Hawaiian Monk Seal and the mobilization/demobilization of field efforts supporting species recovery efforts. This project was intended to repurpose an underutilized area in the sea water system facility at NOAA's Daniel K. Inouye Regional Center to provide for a near ground level secure enclosure.

Marine Turtle Recovery in the Pacific Islands Region

PI.: Douglas S. Luther [JIMAR 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

The research conducted by the Pacific Islands Fisheries Science Center (PIFSC) Marine Turtle Biology and Assessment Program (MTBAP) includes nine discrete elements, which are mirrored in this JIMAR project: 1) research to reduce or mitigate high-seas and coastal fishery by-catch of sea turtles; 2) research on the general biology, life history and ecology of sea turtles in coastal marine habitats and nesting beaches; 3) monitoring of sea turtle population trends for stock assessments; 4) simulation modeling of long term sea turtle datasets to better understand population dynamics; 5) assist with health assessments and disease investigations; 6) administration of a sea turtle stranding and salvage network for research and live turtle rehabilitation; 7) educational outreach to the public focused on sea turtle research results; 8) maintenance of efficient and secure storage, management, and retrieval of sea turtle research data; and 9) training of observers learning to conduct the collection of sea turtle data aboard commercial longline fishing vessels.



Figure 1. JIMAR field staff Lindsey Bull (R) and Brittany Clemans (L) pause while on a green sea turtle basking survey on Tern Island, Lalo (French Frigate Shoals) at the beginning of the 2021 field season deployment [Conservation and Management Permit PMNM-2021-00, NMFS Permit No. 21260 for research activities on sea turtles, and U.S. Fish and Wildlife Service recovery permit No. TE-72088A-3 issued under section 10(a)(1)(A) of the Endangered Species Act (ESA), 16 U.S.C. 1531 et seq]. Photo Credit: Lindsey Bull.

Progress during FY 2021

Multiple MTBAP core objectives were accomplished by JIMAR staff, including: (1) captive sea turtle care and rehabilitation, (2) necropsy of dead turtles, biological sample collection, and management of biological samples, (3) educational outreach, (4) participation in field capture of marine turtles on Oahu, (5) research on the general biology, life history, and ecology of sea turtles in coastal marine habitats and on nesting beaches, (6) as well as participation in the planning, preparation, and data analysis/reporting of previous nesting field work conducted at French Frigate Shoals (FFS), Northwestern Hawaiian Islands (NWHI).

Although the 2020 field season was canceled due to the coronavirus pandemic, field staff provided valuable contributions to the project. They packed and prepared equipment and supplies for the 2021 field season. Field staff also developed a photo database and trained Artificial Intelligence facial recognition software. During the mandatory telework period the field researchers created Standard Operating Procedures (SOPs), templates for annual reports, and training modules, which are valuable products for MTBAP efficiency and effectiveness. The team also helped the program catch up on backlogs of important data and worked with USFWS and Malama Na Honu to conduct nest excavations. It turned out to be a record high season of nest observations on Oahu.

In March 2021, two JIMAR seasonal field staff were deployed to FFS and will remain there for the duration of the project period. Prior to deployment, JIMAR staff and partners conducted training in data collection, wilderness first aid, and emergency communications to prepare for the 2021 field season. In May, an additional seasonal field camp assistant began training in Honolulu and will deploy on the chartered *Kahana II* in early July.

JIMAR staff collated decades of satellite tag deployment data and uploaded it to the animal telemetry network (ATN) to comply with federal policy on public availability of data. In addition, JIMAR staff conducted sea turtle endocrinology research for investigation of sex, sex ratio, capture stress, and reproductive related questions.

Two UH Marine Option Program (MOP) Student Assistants, and a Student Assistant from the Hawai'i Pacific University (HPU) participated in stranding responses and rehabilitation for sea turtles on Oahu, while four UH Student Assistants continued to support MTBAP's mission in on the Islands of Hawai'i and Maui.

The Oahu-based JIMAR staff and students were instrumental in helping tag and/or evaluate 53 green sea turtles (including outfitting six with satellite transmitters) on the North Shore during spring basking surveys.



Figure 2. JIMAR researcher Marylou Staman holds up a juvenile green sea turtle with fibropapillomatosis (FP) tumors during Spring 2021 basking surveys on the North Shore of Oahu [NMFS Permit No. 21260 for research activities on sea turtles and U.S. Fish and Wildlife Service recovery permit No. TE-72088A-3 issued under section 10(a)(1)(A) of the Endangered Species Act (ESA), 16 U.S.C. 1531 et seq]. Photo Credit: Jan Willem Staman.

Pacific Islands Deep Sea Coral and Sponge Initiative

PI.: Douglas S. Luther [JIMAR 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 JIMAR 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. Pacific Islands 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 the understanding of the conditions that promote the formation of deep-sea coral and sponge communities. This project fits under the JIMAR theses of Ecosystem Monitoring and Ecosystem-Based Management.

Progress during FY 2021

This JIMAR project continued to provide the DSCRTP with animal records and images for their national database (<https://deepseacoraldata.noaa.gov/>). The annotation protocol involves 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 occurrence. JIMAR staff used the Video Annotation and Reference System (VARS) software for annotation, 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 submitted records and images to the DSCRTP from nineteen ROV dives conducted in 2019. Eight dives were from a cruise to American Samoa aboard the *E/V Nautilus* (cruise NA112), which documented the presence of high-density coral and sponge communities in some locations. More than 27,000 animals were identified and counted, including corals and sponges, from over 7400 individual annotations. Images from these dives were provided to the National Marine Sanctuary of American Samoa Office. Eleven dives were from a cruise to the Emperor Seamounts aboard the *R/V Falkor* (cruise FK190726). More than 41,000 animals were identified and counted, including corals and sponges, from over 7600 individual annotations. Abundances were particularly high on the surveyed portions



Figure 1. Large Paragorgia arborea bubblegum corals with basket stars perched on top and surrounded by Echinid urchins. Suiko seamount of the northern Emperor seamounts, 1495 m. Copyright Schmidt Ocean Institute. Photo taken by the Science team of the R/V Falkor Cruise FK190726.

of Godaigo and Jingu seamounts. Finally, the team also annotated another seventeen ROV dives collected from 2007-2011 in the Papahānaumokuākea Marine National Monument aboard the *R/V Ka'imikai-O-Kanaloa*. The resulting 6500 annotations documented over 13,000 individual animals. These records are being reviewed for quality control in preparation for submission to the DSCRTP.

During the report period, JIMAR staff created slides from video frame grabs of *in situ* animal observations for cruise EX1905 aboard the *R/V Okeanos Explorer* and received feedback on animal identifications from taxonomist experts from images and/or examination of collected specimens. The resulting animal guide has been provided to NOAA personnel for an upcoming cruise back to this region in Summer 2021. Annotation of the twelve dives from this cruise is ongoing.

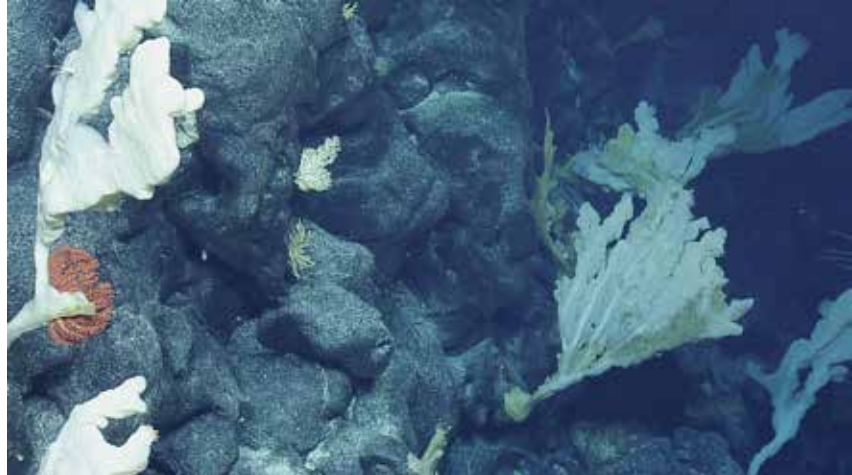


Figure 2. A grove of Tretopleura sponge fans with a Novodinia sea star and Eumunida crab commensals. Enallopsammia rostrata dot the rock face between the sponges. Rose Atoll at a depth of 752 m. Copyright Ocean Exploration Trust, Inc. Photo taken by the ROV team of the Nautilus Exploration Program Cruise ID NA112.

Papahānaumokuākea Marine National Monument Monitoring and Research

P.I.: Douglas S. Luther [JIMAR Project Lead: Brian Hauk]

NOAA Office (of the primary technical contact): National Ocean Service/Office of National Marine Sanctuaries

NOAA Sponsor: Randall Kosaki

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

The 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. This research also serves to better manage and protect PMNM resources from anthropogenic and natural threats through the PMNM Resource Protection Program. Research and monitoring activities utilize self-contained underwater breathing apparatus (SCUBA) gear, technical diving gear (including closed-circuit rebreathers), remotely operated vehicles (ROV), small boats, remote sensing technologies and other scientific equipment to collect data on the marine ecosystems of primarily the Northwestern Hawaiian Islands (NWHI) during research cruises. Subsequent specimen processing, data analyses, and scientific publication are based out of PMNM's offices at the NOAA Daniel K. Inouye Regional Center in Honolulu. The objective of this characterization is to advise management and policy decisions in order to conserve, protect and enhance the biodiversity of the PMNM.

Progress during FY 2021

The primary objectives of the JIMAR PMNM project are: Coral Reef Monitoring, Characterization of Mesophotic Coral Ecosystems, Quantification of Benthic Habitats, PMNM Resource Protection, Maritime Archeology and Remote Sensing.

Coral Reef Monitoring. JIMAR analyzed the structure of reef fish assemblages in the NWHI in relation to the structural complexity and benthic composition of the reefs. This work utilized data from in-situ fish visual surveys in the NWHI and corresponding three-dimensional (3D) reconstructions of the sites to extract the structural data and benthic composition. The results of the analysis revealed patterns specific to trophic categories, and the effects of the structural complexity on each trophic category were dependent on spatial scales. The staff prepared a manuscript as the first author to report these findings, and it was published in the journal *Diversity*.

JIMAR took a lead on quantitative analyses of damages to an iconic coral reef called Rapture Reef at Lalo (French Frigate Shoals) caused by Hurricane Walaka in 2018 and co-authored a manuscript with collaborators from University of Hawai'i at Hilo, comparing the 3D structural complexity of the Rapture Reef before and after the hurricane. The manuscript has been accepted for publication in the journal *Scientific Reports* and is currently in press.

JIMAR digitized orthophotomosaics from the NOAA weather buoy grounding site at Kapou (Lisianski Island), classifying the damage to the coral reef caused by the grounding into separate categories. The staff analyzed the data, considering 3D surface areas provided by the substrata and/or benthic features, and completed an initial draft report. The assessment showed the primary cause of coral mortality at the site was abrasion from the chain of the weather buoy's mooring system. The final report is scheduled to be completed in September 2021.

Characterization of Mesophotic Coral Ecosystems. JIMAR staff mentored a NOAA José E. Serrano Educational Partnership Program scholar to extract benthic data from the 3D reconstructions of mesophotic coral reefs. The primary task of this internship was to digitize the orthophotomosaics generated from the 3D reconstructions, allowing for subsequent quantitative analysis of 3D surface areas provided by different benthic organisms/features of mesophotic coral ecosystems. Due to the time-consuming nature of the task, all digitization is still in process, and the staff continued digitizing the remaining orthophotomosaics.

Quantification of Benthic Habitats. JIMAR staff examined 3D and 2.5-dimensional habitat metrics using simulated surfaces and coral colonies in order to identify different behaviors and properties of each metric. This work revealed specific habitat metrics that are suited to capture the structural complexity of different coral species or benthic features, thereby providing the foundation for future ecological analyses of coral reefs involving habitat structure. The staff prepared a manuscript as the first author to report the results of this work, and it was published in the journal *Remote Sensing*.

Resource Protection. JIMAR staff reduced or mitigated resource threats by working inside the ecosystem management framework established for the PMNM. These cross-cutting solutions require that staff work within the realms of the policy/permitting system, field operations, research, and education/outreach programs in order to achieve the overarching goal of minimizing risks to natural resources by anthropogenic influences and safeguarding the human presence in the Monument associated with conservation and research activities or innocent vessel passage. JIMAR staff facilitate all aspects of vessel compliance for entrance and passage through PMNM. Personnel monitored vessel notification phone lines and email communications to track innocent passage and emergency transits through PMNM and provided weekly summaries to enforcement partners at NOAA's Office of Law Enforcement (OLE) and the United States Coast Guard (USCG). JIMAR staff coordinated Vessel Monitoring Systems (VMS) installation and transmission verification with permittees and OLE to ensure permit compliance. Additionally, staff conducted several vessel alien species risk assessments during the year utilizing snorkel equipment, ROVs, photographic documentation and husbandry records to quantify the risk of alien species introductions as part of the permitting process for entry to the PMNM. Project staff also coordinated rodent inspection results to permit coordinators of co-trustee agencies. These processes help to protect the ecosystems of the NWHI, which are noted for their low abundances of alien species. Staff worked with Monument co-trustee partners to

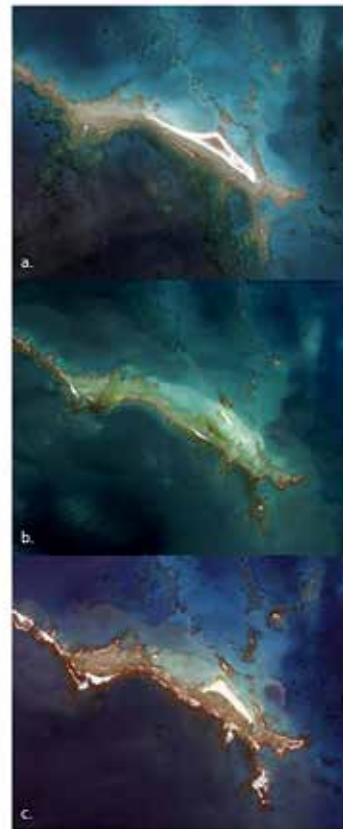


Figure 1. Figure produced for the State of the Monument Report 2020 showing East Island recovery after Hurricane Walaka.

standardize vessel survey methods to further increase capacity and conducted joint survey operations to better manage non-indigenous species archipelago wide. The project has been networking with managers in New Zealand to improve risk analysis and vessel profiling techniques to further assist with alien species prevention and management. JIMAR has created a new PMNM Alien Species Database to track all known non-indigenous species found within the PMNM and are currently working with partners to expand this database to include an archipelago wide species list and spatial distribution maps. Staff published this species checklist in the 2020 State of the Monument Report to make it readily available to the public. Project staff reviewed several PMNM access permits to ensure applicants' activities do not harm any PMNM resources and comply with resource protection objectives. JIMAR also represented PMNM at



Figure 2. JIMAR staff getting manufacturer UAS training. Photo credit: Jason Leonard.

both the Office of National Marine Sanctuaries (ONMS) site-wide and PMNM Co-Trustee Resource Protection Working Groups to better align resource protection objectives across all of ONMS and to develop best management practices (BMPs) and standard operating procedures for permitted activities to be adopted and implemented by the Monument Management Board. Additionally, the project represented the PMNM office at several other multi-agency/co-trustee working groups and coordinated response partnerships (e.g. Logistics Working Group; Alien Aquatic Organism Task Force; Hawai'i Invasive Species Council; Hawai'i Ocean Safety Team; USCG Area Committee; Western Regional Panel; Large Whale Entanglement Group and Marine Debris partners) to ensure the PMNM's resources are protected in the event of a ship grounding, oil spill or other natural/anthropogenic disturbance such as the loss of thousands of shipping containers which occurred during this fiscal year.

JIMAR assisted with the logistical actions required to remove the National Weather Service (NWS) buoy from Lisianski and are currently working on a summary report to quantify damaged resources. Staff have also been heavily involved in invasive alga research at Pearl and Hermes Reef and are working to develop new BMPs to allow continued operations in affected areas.

JIMAR participated in virtual Large Whale Entanglement refresher training for whale disentanglement across Oahu and personnel have been providing small boat operation and logistical support for SANCTsound by deploying/recovering Ecological Acoustic Recording (EAR) devices. SANCTsound entails deploying and retrieving these EARs in the PMNM and Hawaiian Islands Humpback Whale National Marine Sanctuary in order to better understand marine mammal communications and attempt to monitor the environment for other acoustic signals like vessel activity.

Remote Sensing. Remote sensing as a discipline is multifaceted with a wide range of data and data products. JIMAR staff have led in the development of this additional capacity at PMNM and created a working remote sensing group referred to as PMNM Collaborative Laboratory (CoLab). Staff utilize satellite imagery for a multitude of resource monitoring and protection projects. One of these projects included a quantified analysis of the five (5) major sandy islets of Lalo (French Frigate Shoals), including East Island. This data was published in the 2020 State of the Monument Report to make it readily available to the public. Satellite imagery has also

(right top) Figure 3. Images of coral and fish abundance at Rapture Reef (a) pre (September 2017) and (b) post Hurricane Walaka (July 2019). Pascoe KH, Fukunaga A, Kosaki RK, Burns JHR. 2021. 3D assessment of a coral reef at Lalo Atoll reveals varying responses of habitat metrics following a catastrophic hurricane. In press, Scientific Reports.

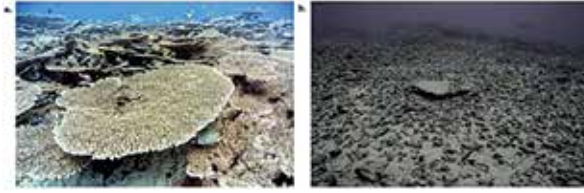
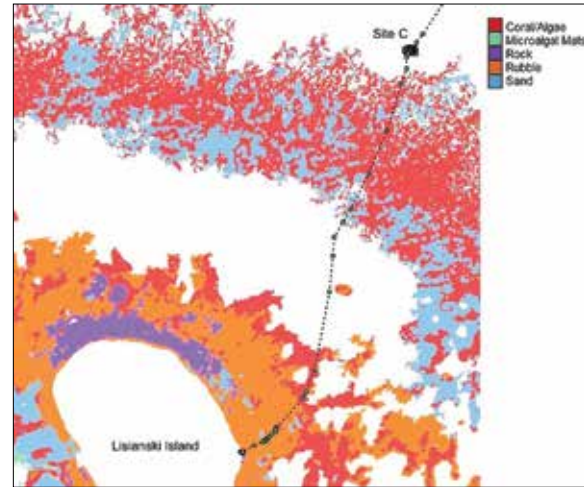


Figure 4. Path of the weather buoy overlaid on Allen Coral Atlas' Benthic Map (<https://allencoralatlas.org>), showing the potential benthic classes where the buoy system crossed. The green dots show hourly locations of the weather buoy as it approached the shoreline of Kapou (Lisianski Island).



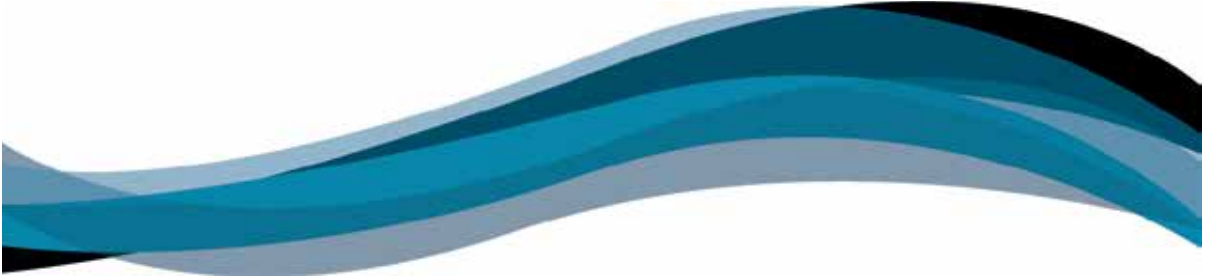
been used to investigate potential threats from derelict fishing containers caused by multiple cargo spillages by ships during the 2020-21 winter season, which will be investigated on the upcoming research expeditions.

In order to build internal capacity at PMNM, JIMAR staff were selected to the prestigious National Atmospheric and Space Administration (NASA) DEVELOP program designed to build the capacity of applied sciences. This ten week program created a Google Earth Engine application focusing on the oceanographic parameters surrounding Manawai (Pearl and Hermes) that will be publicly accessible in early 2022.

JIMAR staff endeavored to participate in Uncrewed Aerial Systems (UAS) capability during the year. This increased capacity benefits PMNM by adding another method of data collection for protected resources. This UAS project supported by the Office of Restoration and Remediation has three main priorities: rapid response to maritime incidents and damage assessments, coral reef ecosystem monitoring, and marine mammal entanglement response. Field work will begin in July 2021.

Maritime Archeology. No efforts have been made towards Maritime Archaeology in FY 2021.

Equatorial Oceanography



Equatorial Oceanography

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. JIMAR 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. JIMAR is also home for the Pacific Islands Ocean Observing System (PacIOOS), which is one of 11 regional centers coordinating oceanographic observational data.

Observation and Dynamics of Oceanic Variability in the Solomon Sea

PI.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock, William S. Kessler

NOAA Goal(s)

- Climate Adaptation and Mitigation

Purpose of the Project

The equatorward boundary current in the Solomon Sea is the primary pathway by which waters from the subtropical South Pacific reach the equatorial zone. It is thus a crucial pathway of the ocean circulation that supports interannual to decadal climate variability in the Pacific and enables the long term “memory” carried by the ocean. Underwater gliders are used to make 12-16 transects each year crossing the Sea to build a time series of flow variability. Analysis of this now 11-year time series is determining how and why transport and water properties vary, how these affect and are affected by the El Niño/Southern Oscillation (ENSO) and decadal variability. This project's objective is to produce, study, and publicly distribute value-added products that would enable wider use of the data by the team and others. This would include modelers, model developers and ENSO/climate analysts, and provide an ongoing description of this boundary current system interacting with the basin-scale circulation. The result would foster improved modeling of this key piece of the tropical Pacific climate system, and provide a basis for the study of this variability.

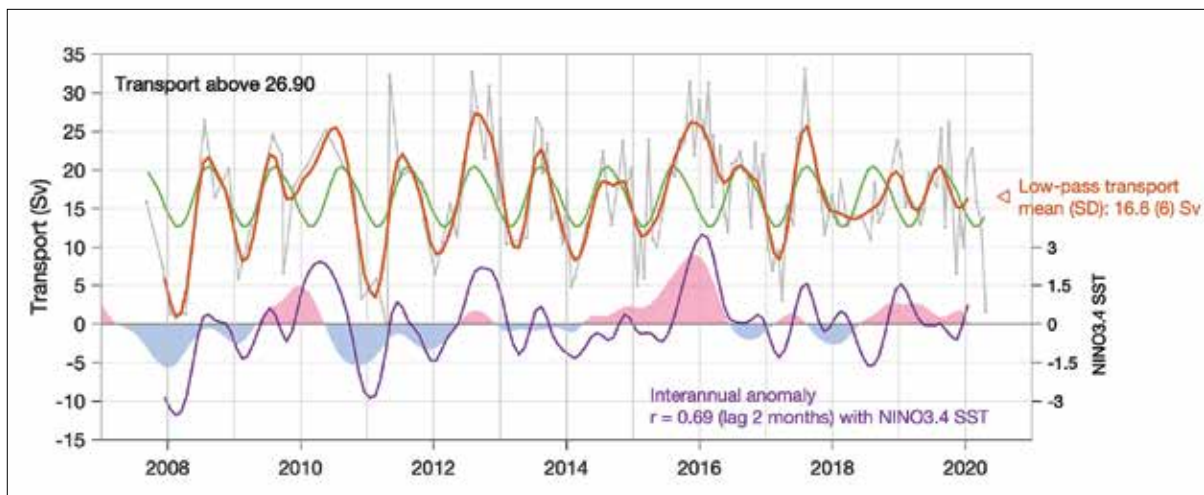


Figure 1. Time series of total transport above sigma-theta 26.9 (about 500m deep in the Solomon Sea), showing: mission-by-mission values (gray line and dots), low-frequency (sum of annual+interannual; red line), average annual cycle (green line), interannual anomalies (purple line at bottom, overlaid on Niño3.4 SST shading).

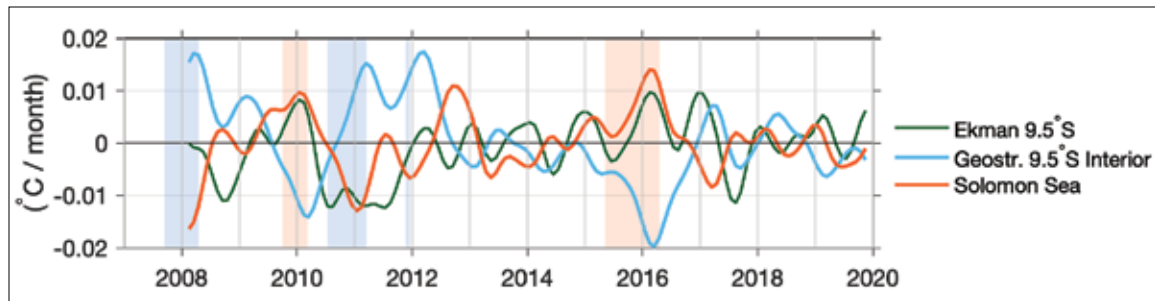


Figure 2. Influence of Solomon Sea temperature advection on the tropical strip 9.5°S to 9.5°N, computed using the method by Lee et al. (2004). As expected, the Solomon Sea term (red) is highly anti-correlated with the geostrophic flow to its east (blue). During La Niña (blue shaded time periods), meridional geostrophic currents across the wide interior are strongly inward, warming the tropical box and increasing equatorial heat content, while Solomon Sea inflow is weak, forming an anomalous cooling term. During El Niño (red shaded time periods), the interior drains the equatorial region, removing warm water, while the role of the western boundary is to replace it with a slight lag.

Progress during FY 2021

Due to the COVID-19 pandemic glider operations in the Solomon Sea were suspended. No new data were collected which will result in at least 20 month gap in the 11-year time series. The project's focus was instead on producing delayed-mode, user friendly products to enable and foster collaborations with modelers and model developers. The project produced a dataset containing a climatology of Solomon Sea currents and water properties, in the final stages of being distributed publicly through a website. The irregular tracks of gliders and their high-resolution sampling that measures the tides, which are a substantial source of noise, are both barriers to wider use of glider data; the project employed methods to filter these and produce clean fields that are more directly comparable to basin models and other products. The project also initiated collaborations with several modeling groups with the goal to study the downstream consequence of the mass and heat transport through the Solomon Sea.

Optimizing Routine Ocean Current Measurements by the NOAA Fleet: (OMAO FY 2020-2021)

PI.: Eric Firing

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

NOAA Sponsor: Solomon Tadele

NOAA Goal(s)

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

Purpose of the Project

The NOAA research fleet includes many ships with acoustic Doppler current profilers (ADCPs). These instruments have the potential to aid a wide variety of NOAA programs using the ships, and to contribute to the global climatology of ocean current measurements; but without suitable data acquisition and processing software installed, and used routinely, this potential is not realized. The purpose of this project is to continue to apply our software and expertise to the NOAA fleet, continuing the installations, maintenance, and consulting that we began during the original five years of funding. In addition, the project is working with NOAA to establish the data pipeline from the ship to NCEI so that the observations are available for future researchers.

Progress during FY 2021

The project is now in year 7 and remains on track: the team has installed and maintained the University of Hawai'i Data Acquisition System (UHDAS) on all 11 NOAA ships with ADCPs ready to run. Establishment of a

fully standardized “NOAA to NOAA” (N2N) data pipeline for getting all data submitted to the National Centers for Environmental Information has progressed, but more slowly than anticipated.

An important component of the team’s work involves interfacing with a wide range of NOAA personnel, and providing training. Typically this involves travel for meetings, workshops, and ship visits, but this was restricted during FY 2021. In place of ship visits, remote upgrades were performed for two installations. One training session (“UHDAS for operations”) for NOAA officers was conducted via video conference.

University of Hawai‘i Sea Level Center

P.I.: Philip Thompson

NOAA Office (of the primary technical contact): Climate Program Office

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 have undergone a complete quality assessment within 1 year of collection. The Research Quality database is maintained in collaboration with the National Oceanographic Data Center, and toward this purpose, the UHSLC acquires 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 more than 80 high-profile water level 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 eleven 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 2021

Data management objectives for FY 2021 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 2020, UHSLC datasets were utilized in 61 peer-reviewed research articles, two books, two governmental agency reports, and three academic theses. The project continued efforts to improve and modernize data flow within the center. New quality-control routines applied via a modern graphical user interface are now in daily operation, increasing the efficiency of the data processing team. The project’s new Station Explorer tool for exploring the climatology of mean sea level and sea level extremes is now operational (<https://uhslc.soest.hawaii.edu/stations/?stn=007#climatology>), which enables users to place recent sea level extremes into historical context and relate sea level events to what is expected during any given time of the year. Tide gauge network and station maintenance objectives were not met during FY 2020 due



Figure 1. Photo of the new UHSLC tide gauge installed on Chuuk, Federated States of Micronesia. This gauge was installed via remote collaboration during the COVID-19 pandemic with colleagues at the Korea-South Pacific Ocean Research Center on Chuuk. Photo Credit: Korea-South Pacific Ocean Research Center (KSORC).

to travel restrictions imposed by the COVID-19 pandemic. The lone site visit was to Johnston Island in May 2021 aboard a Fish and Wildlife vessel to perform maintenance to the tide gauge and install a new cGPS station. Despite being unable to travel, UHSLC technicians and engineers worked with local contacts near problematic stations to fix issues remotely, when possible, as well as arranging for a brand-new station installation by colleagues at the Korea-South Pacific Ocean Research Center on Chuuk, Federated States of Micronesia (FSM). The new Chuuk station was assembled and tested at the UHSLC, then disassembled and shipped to Chuuk with detailed assembly and installation instructions. The installation occurred during FY 2021 with remote assistance from the UHSLC technicians. UHSLC technicians and engineers continued to make progress on a variety of other endeavors during the travel hiatus: testing new radar sensors for inclusion in future installations, testing Iridium-capable data loggers for low-power installations, development of software for streaming data from Iridium to Global Telecommunication System (GTS), development of in-house station monitoring tools for rapid detection of battery problems, and others. The rebuilt GPS station on Johnston Island met the objective of one new GPS installation during FY 2021. All GPS/GNSS data from UHSLC stations were provided to the GLOSS Tide Gauge Benchmark Monitoring Project (TIGA) data center.

UHSLC researchers participated in multiple research projects leading to peer-reviewed articles in FY 2020, including published papers on projections of high-tide flooding in the United States; increases in sea level variability related to ocean warming; the dynamics of hemispheric asymmetry in Pacific sea-level trends; and a skill of assessment of seasonal sea-level forecasts in an ensemble of models. UHSLC researchers were also the lead authors on the sea level section in the “State of Climate in 2020” Report to be published later this summer. Collaboration is a key component of UHSLC research goals, and the project collaborated with researchers outside the center on a variety of efforts related to oceanography and climate, including papers on ENSO-driven extremes and the relationship between current and future Pacific sea-level trends.

University of Hawai‘i Sea Level Center cGPS

P.I.: Philip Thompson, James Foster

NOAA Office (of the primary technical contact): Climate Program Office

NOAA Sponsor: Emily Smith

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

Vertical land movements can significantly alter the rates of sea-level rise expected from the sole climatic contributions of ocean thermal expansion and land-based ice melting, possibly magnifying the impacts of sea-level rise on the coast. This motion can be determined through continuous measurements of the Global Navigation Satellite System (GNSS) at tide-gauge sites, and GNSS sites are required for all tide-gauge stations within the Global Sea-level Observing System Core Network (GCN). This project will install, maintain, and handle the data flow from GNSS sites at GCN tide gauge operated by the University of Hawai‘i Sea Level Center (UHSLC).

Progress during FY 2021

The project goals for 2021 were to maintain current data flow, perform one new GNSS site installation at a tide-gauge, and make three maintenance visits. COVID-19 has restricted the project’s ability to travel to perform some of the planned maintenance, and instead the team focused on maintenance tasks achievable within current travel restrictions. The team replaced the GNSS receiver and communications system for site **HNLC** at the Honolulu Tide Gauge. The project arranged manual downloads from the GNSS sites at Wake (**WQSL**) and Midway (**MQSI**) islands, where the project’s installed communications have failed due to issues with an internet firewall. The team continues to work with the United States Geological Survey (USGS) and Pacific Tsunami Warning Center to diagnose and resolve that issue. The project identified a firmware issue with the GNSS receiver, **TEPC**, on Tern Island. The team diagnosed the problem with the manufacturer and arranged for a replacement receiver to be installed in July.

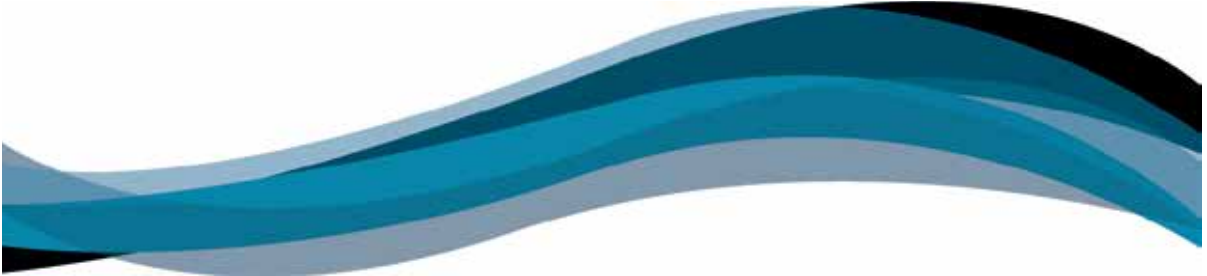
The new station installation was at Johnston Atoll, completed on May 24, 2021. The site has a Xeos Resolute GNSS receiver, with a Trimble Choke Ring antenna and is using a U.S. Department of Defense (DoD) Iridium SIM for the communications. The GNSS antenna was included in the regular tide gauge benchmark network leveling, and the team is now receiving hourly data files.

The project established a real time stream from the GNSS receiver on the UH Mānoa campus to the UHSLC NTRIP Caster to provide the real time correction data for real-time kinematic GNSS surveys of tidal flooding areas.



Figure 1. Sunset view of the new Global Navigation Satellite System (GNSS) site “JSTN” installed on Johnston Atoll on May 24th 2021 as part of the effort to install GNSS sites at all tide-gauge stations within the Global Sea-level Observing System Core Network. The photo shows the GNSS antenna at the bottom left. To the right of it are the instrument box, the Iridium satellite communications antenna, the solar panel (next to two unused bollards), and the tide gauge. The GNSS provides high-accuracy vertical positions and velocities in the global reference frame. The GNSS antenna is surveyed as part of the tide gauge leveling network, and the vertical offset between it and the tide gauge reference level is precisely measured. Photo credit: Jason Klem.

Climate Research and Impacts



Climate Research 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, JIMAR collaborates in research efforts with the International Pacific Research Center (IPRC) in SOEST, and hosts the Pacific El Niño Southern Oscillation (ENSO) Applications Center (PEAC).

Analysis of Vulnerability of Military Installations in the Pacific Basin to Coastal Flooding

P.I.: Mark A. Merrifield

NOAA Office (of the primary technical contact): National Environmental Satellite, Data, and Information Service, National Centers for Environmental Information

NOAA Sponsor: John J. Marra

NOAA Goal(s):

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

Purpose of the Project

The purpose of the project is to advance the practical application of statistical and other analytical techniques that can be used to assess the vulnerability of built and natural environments to the impacts of coastal flooding in a changing climate. The results will advance the practical applications of coastal flooding analysis, and will lead to an improved understanding of which components of DoD facilities and infrastructure are potentially vulnerable to coastal flooding and how they could be affected, as well as how species and ecosystems associated with DoD lands and waters will respond in a changing climate. They will be amenable to incorporation into site and region-specific tools and models to inform decision and policy making. The results will have broad interest within the region and the nation. In summary, the project will: (i) enhance the historical diagnosis of site-specific still water level patterns and trends; (ii) explore techniques that can be used to support regional analysis to address poor spatial coverage of tide gauge (TG) records; (iii) extend the diagnosis and prognosis of extreme water level patterns and trends by applying it total water levels; and (iv) address gaps that exist in the types of assets as well as the measures used to evaluate impacts of coastal flooding in all its forms to assets on an individual basis and in aggregate under different climate change scenarios.

Progress during FY 2021

The Pacific Disaster Center (PDC) has the results from the extreme-value assessments and is currently readying the accessibility of the data in GIS format through their DisasterAWARE platform. This should be completed by July-August 2021.

The Regional Frequency Analysis (RFA) for the Pacific Region (OCONUS) manuscript was published in *Frontiers in Marine Science*. The RFA for the Continental U.S. (CONUS) methodology and results will be included in the NOAA 2021 SLR Taskforce Report.

The project completed the mixed distributions analysis that model lesser extremes at seven TGs with differing characteristics (continental vs. island, west coast of CONUS vs. east coast of CONUS, or tropical-cyclone (TC) dominated areas vs. areas not dominated by TCs). The manuscript for this analysis will be completed by September 2021.

The project is in the process of completing an exemplar application of the Level 1 impact analysis at the installation-level coastal flooding vulnerability assessment at Naval Amphibious Base-Coronado (NABC). At this time, the analysis of installations on the Bay side of NABC has been completed. However, there has been a minor setback to the Ocean side installations due to a minor bug in the production of runoff and excursion values

along ocean-side transects (another Cooperative Institute is producing the values and the project will have them by the end of June 2021).

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

PI.: Douglas S. Luther

NOAA Office (of the primary technical contact): Earth System Research Laboratory/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

Collection of atmospheric mercury speciation data. The project collects and analyzes semi-continuous high altitude (11,144 feet) measurements of elemental mercury (Hg⁰), reactive gaseous mercury (RGM), and particulate mercury (Hg^P) at the Mauna Loa Observatory (MLO), Hawai'i. The objectives of this task will be to accumulate a long-term record of ambient Hg⁰, RGM, and Hg^P chemistry to (i) support atmospheric mercury chemistry research, (ii) establish a baseline mercury measurement station, (iii) investigate the long range transport of mercury from South East Asia across the Pacific, and (iv) 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, elemental carbon, and meteorological variables. All of the data are to be organized and archived in a database.

Progress during FY 2021

Due to the COVID-19 pandemic, NOAA has halted all official travel and little progress has been made beyond routine monitoring operations. The PI has been unable to travel to MLO to effect instrument calibration, maintenance, or repair and has instead relied on MLO staff to perform these duties.

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

PI.: 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: providing integrated data server and management systems for climate data and products; developing and serving new climate-related products for research and applications users; and conducting climate research in support of the IPRC and NOAA research goals.

Progress during FY 2021

The APDRC maintains a wide suite of data transport and discovery servers including: Open-source Project for a Network Data Access (OPeNDAP)-based Thematic Real-time Environmental Distributed Data Services (THREDDS) Distributed Ocean Data System (DODS) Server (TDS); Grid Analysis and Display System (GrADS) DODS Server (GDS); and Data Access Protocol server (DAPPER); a Live Access Server (LAS); and a web-based server for display on in situ and gridded data sets (DCHART). These servers continue to be maintained. Due to restrictions in funding, no new servers were added this year.

At present the APDRC hosts over 125 different data sets from *in situ* platforms, satellites, and numerical models. Together, these data amount to approximately 450TB. New additions in the past year and have included updated reanalysis from the European Center for Medium-range Weather Forecasts (ECMWF), the ERA-5 dataset. NASA/Goddard Space Flight Center (GSFC) model output from Modern-Era Retrospective analysis for Research and Applications-2 (MERRA-2) was also added. Updates were made to many datasets as new data were made available. 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) (215TB); 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 (CMIP-5; 76TB); and output from the National Centers for Environmental Prediction (NCEP) operational coupled climate model (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 RA-V) activities but these were minimal this past year. In part, this was due to a reduction in staff. The APDRC web programmer left the prior year, and there were insufficient funds to rehire this position. There is a proposal under consideration now for helping in this regard.

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

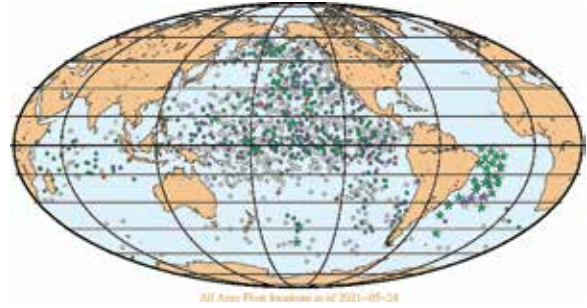
Purpose of the Project

JIMAR works with U.S. and International Argo Project partners, especially NOAA/PMEL, on three aspects of the Argo Program. The first objective involves conventional Argo float testing, deployment, and data/engineering evaluation. The second objective involves Deep Argo float testing, deployment, and data/engineering evaluation.

The third objective involves delayed-mode quality control of conventional and Deep Argo float data and ocean climate research using data from these floats and other sources.

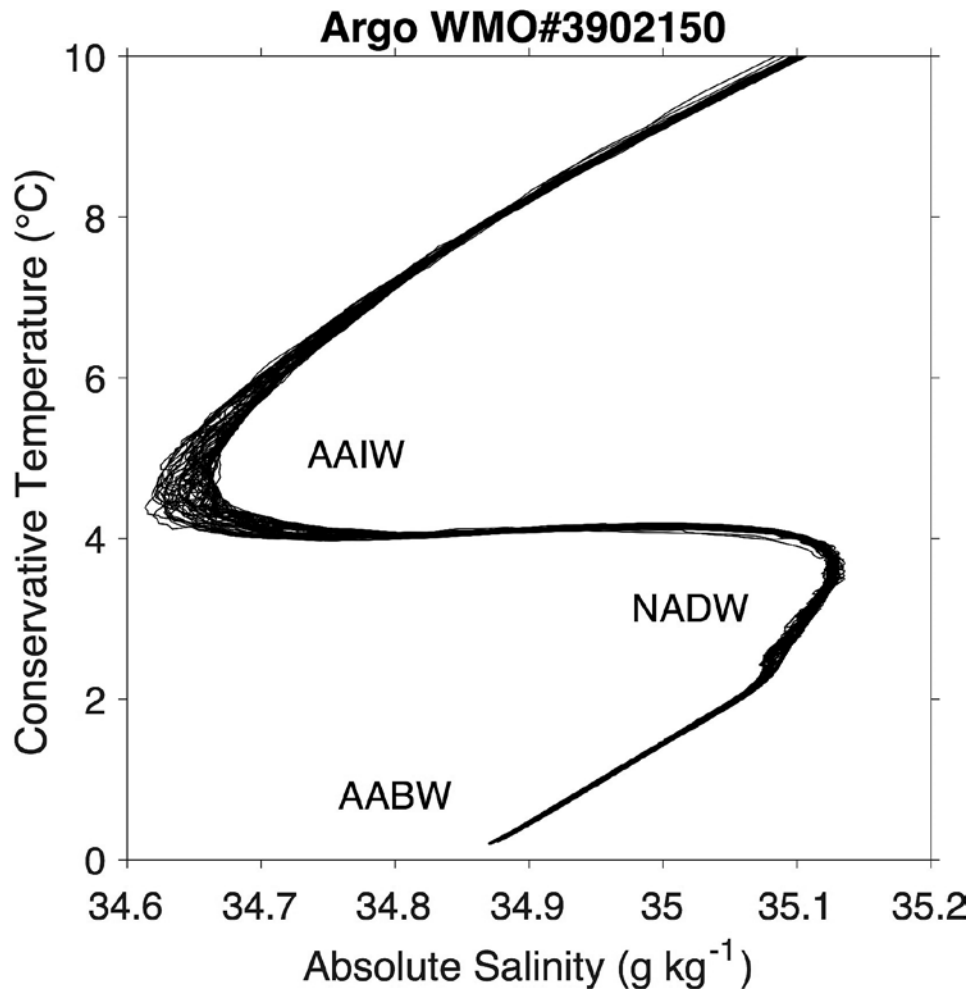
Progress during FY 2021

At the PMEL float lab Dr. Elizabeth Steffen and Ms. Chanelle Cadot continued to test floats, monitor float performance (Fig. 1), diagnose and coordinate repairs of problems discovered with the floats, and work with the manufacturer to resolve problems. They also arranged for many Core Argo float deployments along with several Deep Argo float deployments and notified the national and international databases of those deployments.



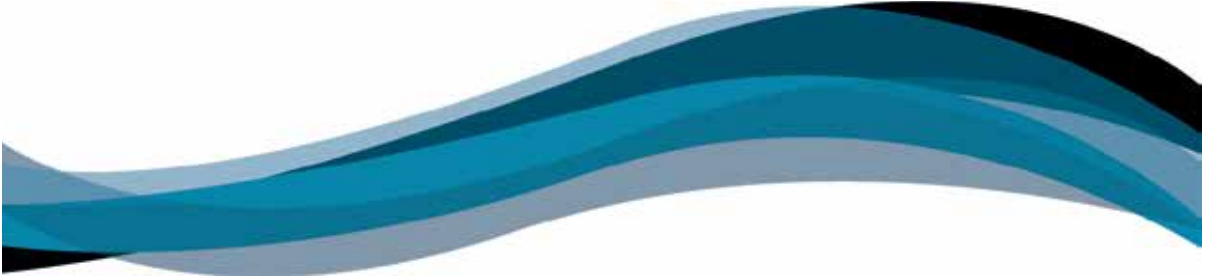
(above right) Figure 1. Recent locations of PMEL conventional and Deep Argo floats, for which Dr. Elizabeth Steffen and Ms. Chanelle Cadot perform the logistics, testing, and much of the monitoring. As of 24 May 2021, conventional Argo floats reporting in the past thirty days (green and blue circles) numbered 475, and deep Argo floats (green and blue stars) numbered 31.

Figure 2. Plot of Absolute salinity vs. conservative temperature data as reported from Deep Argo float WMO#3902150, revealing the sub-thermocline water masses in the Brazil Basin: Cold and fresh Antarctic Bottom Water (AABW) spreading northwards in the abyss, with warmer and saltier North Atlantic Deep Water (NADW) spreading southwards above it, and fresher Antarctic Intermediate Water (AAIW) spreading northwards still higher in the water column.



Cadot and Steffen also contributed to one scientific publication using Deep Argo data from the Brazil Basin (e.g., Fig. 2). 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 report published as a special supplement to the Bulletin of the American Meteorological Society as well as six other scientific publications using Argo data. He also worked with other members of the group on Deep Argo IT infrastructure and performed scientific delayed-mode quality control on data from substantial numbers of PMEL Argo float profiles. While work was slowed somewhat by warranted safety precautions in response to the COVID-19 global pandemic, and what work could be done from home was, stated goals were met.

Tropical Meteorology



Tropical Meteorology

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, JIMAR hosts NOAA National Weather Service fellowship programs in the SOEST academic departments.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

ENSO Diversity and Improving the Prediction Skill of Rainfall in Hawai'i and the Pacific Islands

Xiao Luo, IPRC Assistant Researcher

Purpose of the Research

This research has two primary objectives: 1) investigate Hawai'i rainfall variability and unravel the links between ENSO and variability in Hawai'i rainfall; and 2) investigate ENSO transition diversity, especially focusing on La Niña events, detect robust ENSO transition precursors, and examine boreal summer hydroclimate impacts of different ENSO event types.

Progress during FY 2021

For the first objective, the project performed trend analysis and spectral analysis for the Hawai'i rainfall index for the dry season, wet season, and annual total and understand the secular change of Hawai'i rainfall and the major modes of variability. The project found that statewide Hawai'i summer rainfall (HSR) variability exhibits two distinct regimes: quasi-biennial (QB, ~2 years) and interdecadal (~30–40 years). The QB variation is linked to alternating occurrences of the Western North Pacific (WNP) cyclone and anticyclone in successive years, which is modulated by the intrinsic El Niño-Southern Oscillation biennial variability and involves a positive feedback between atmospheric Rossby waves and underlying sea surface temperature (SST) anomalies. The interdecadal variation of HSR is largely modulated by the Pacific Decadal Oscillation through affecting upstream

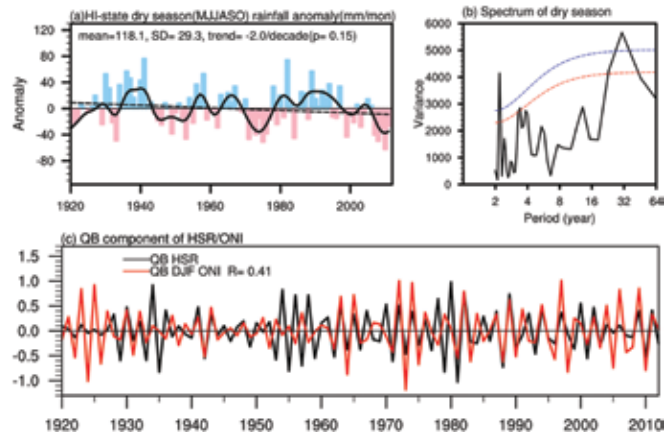
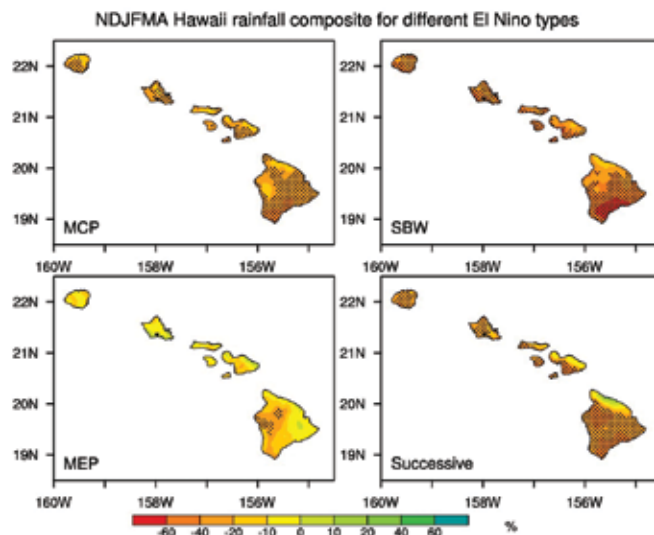


Figure 1. The time series and spectrum of statewide Hawai'i summer rainfall (HSR) anomalies from 1920–2012. (a) The time series of HSR (color bar) and its interdecadal component (>7 years period component, black solid line). The black dashed line indicates the linear trend in HSR during 1920–2012. (b) The power spectrum of HSR, the blue (red) dashed line indicates the 95% (90%) confidence bounds. (c) The quasi-biennial component of the normalized HSR and the quasi-biennial component of Oceanic Niño Index (ONI) from December to the next February.

(right) Figure 2. Composite Hawai'i summer anomaly percentage during four types of El Niño events. (a) Moderate central Pacific (b) strong basin-wide (c) Moderate eastern Pacific (d) Successive El Niño events.



low-level humidity that affects topographic rainfall. The first objective was accomplished with one peer-reviewed research paper published in *Geophysical Research Letters*. This first description of the major physical drivers of summer rainfall variability provides key information for seasonal rainfall prediction in Hawai‘i.

For the second objective, the project performed a composite analysis on dry (Summer) season rainfall associated with different types of ENSO. The results show that Hawai‘i summer rainfall exhibit distinctive features during different types of ENSO events. Extended research needs to be further conducted to understand the associated physical mechanism.

Future Research Plans

- Understand the physical mechanism for the relationship between different types of ENSO and Hawai‘i summer rainfall.
- Based on the physical understanding of the precursor-predictand relationship and use the detected precursors to establish prediction models for rainfall in Hawai‘i and Pacific Islands. Estimate the independent prediction skill and rainfall predictability over Hawai‘i and Pacific Islands.

Publications

Luo, X., B. Wang, A. Frazier, and T.W. Giambelluca, 2020. Distinguishing variability regimes of Hawaiian summer rainfall: quasi-biennial and interdecadal Oscillations, *Geophys. Res. Lett.*, Vol. 47, Iss. 23, doi:10.1029/2020GL091260.

Cluster Analysis of Eastern and Central North Pacific Tropical Cyclones and the Influences of ENSO and MJO

Haley Okun, JIMAR Graduate Student

Purpose of the Research

The aim of this study is to gain a better understanding of regional tropical cyclone (TC) activity over the Central North Pacific (CNP) and Eastern North Pacific (ENP). This is achieved by using a mixture Gaussian model

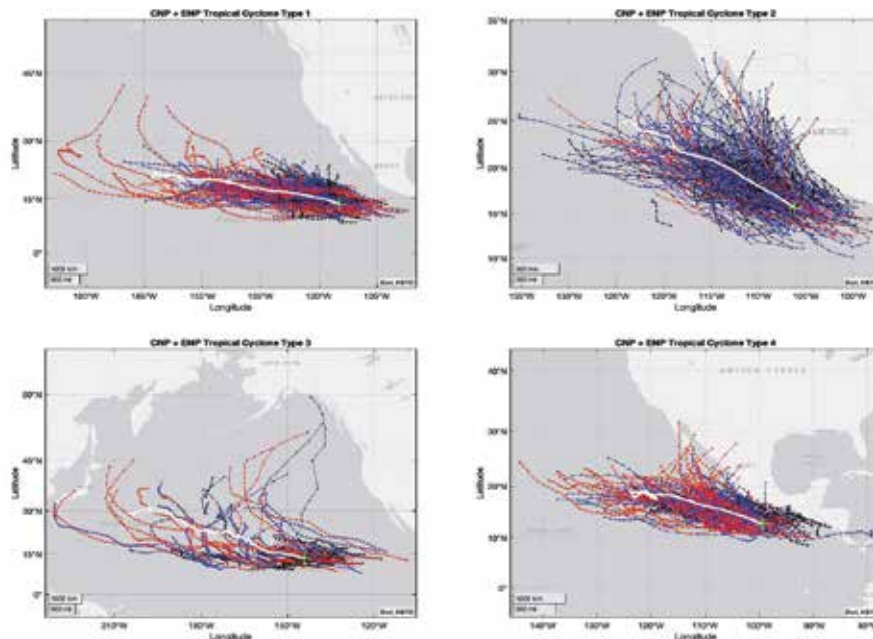


Figure 1. Type 1, 2, 3, and 4 TCs. Black plots indicate TS, blue are hurricanes, and red is major HU. The white cross indicates the average genesis location, and the white line is the mean TC track.

and Expectation-Maximization (EM) algorithm to cluster TCs into different track types. Once all the storms are divided into distinct track types, their characteristics are examined to determine patterns in intensity, lifetime, frequency, accumulated cyclone energy (ACE), and translation speed. Finally, the environmental influences, such as El Niño Southern Oscillation (ENSO), Madden-Julian Oscillation (MJO), low level vorticity, and relative humidity, are considered to explain the occurrence of each track type. Overall, track typing of TCs can allow for a better understanding of TC frequency, paths, and intensity in the CNP and ENP.

	Type 1	Type 2	Type 3	Type 4
Avg. Lifetime (days)	5.44	3.79	6.01	5.63
Avg. MWS (knots)	73.81	70.07	76.31	87.51
Avg. ACE (knots ²)	9.29	5.53	10.98	11.21
Avg. Intensity (knots ² /day)	1.34	1.25	1.39	1.72
Avg. Translation Speed (km/hr)	16.72	15.49	18.24	14.08
Avg. Genesis Location	13.6°N, 114.8°W	15.7°N, 106.2°W	13.5°N, 144.2°W	12.7°N, 99.4°W

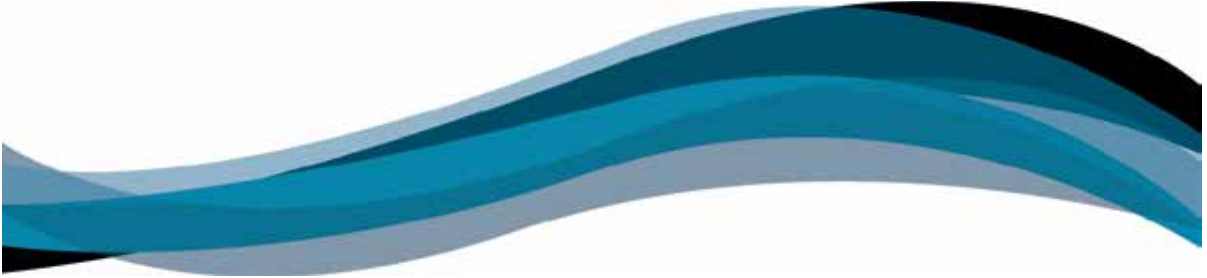
Figure 2. Summary of TC characteristics, sorted by type.

Progress during FY 2021

During 2021, all the TCs in the ENP and CNP from 1966–2019 were track typed. Of the 821 storms, they can be sorted into four distinct track types. The main conclusion that can be drawn from this study is that storms that follow the track of Type 1 or 3, especially in El Niño years, are more likely to impact Hawai‘i. On the other hand, storms with a genesis around the origins of Type 2 or Type 4 are unlikely to even reach the CNP, let alone influence Hawai‘i. The benefits of track TCs are twofold. Firstly, it allows for a better fundamental understanding of TC activity over the CNP and ENP. Secondly, track typing provides an opportunity for improved and more detailed forecasting.

Type 1 storms are mainly straight-line movers, with few curving tracks. These storms only make landfall over Hawai‘i but are also the most likely to propagate into the CNP. Type 2 is the most populous track type, with storms that parallel the Mexican coast. They form a majority in neutral ENSO years and in September, the peak of hurricane season. This storm track has the northern most genesis location and the shortest lifetime. Type 3 storms have the western most average genesis location, actually located in the CNP. Of the four track types, these are the most likely to propagate into the WNP as the environmental conditions are most favorable across the entire basin with warmer SSTA. Type 4 storms are a mix of straight movers and recurving storms, but they have a genesis location much closer to Mexico than Type 1 storms. These storms have the highest intensity, and also are the most likely to make landfall along Central America. This combination of stronger storms is contained to the ENP, so it poses no risk to Hawai‘i, but is a major threat to those living in Mexico.

Tsunamis and Other Long-Period Ocean Waves



Tsunamis and Other Long-Period Ocean Waves

JIMAR 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.

Archive of Rapidly Sampled Hawaiian Sea Level

P.I.: Douglas S. Luther

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

NOAA Sponsor: Michael P. Seki

NOAA Goal(s)

- Weather-Ready Nation
- Resilient Coastal Communities and Economies

Purpose of the Project

The Archive of Rapidly Sampled Hawaiian Sea Level (ARSHSL) is intended to provide an Internet-accessible, public database of rapidly-sampled ($\Delta t \leq 6$ minutes) sea level observations from Hawaiian coastal sea level gauges previously or currently maintained by the National Ocean Service (NOS) and Pacific Tsunami Warning Center (PTWC). The main objective of ARSHSL, originally established by NOAA in 1997, is to ensure a consistent repository for rapidly-sampled sea level in the Hawaiian Islands for the study of tsunamis and related infra-gravity wave signals (including coastal-trapped waves and harbor oscillations) at periods of 2–120 minutes. The archive has been maintained with funding by JIMAR. Sea level (SL) data from two-thirds of the Hawaiian gauges that are accessed are not generally available to the public or research communities; that is, the data are not prepared and offered to the public by the agency (PTWC) responsible for maintaining the gauges because these activities are not part of the mission of that agency. Therefore, this data archiving and dissemination activity is intended to provide as complete a dataset as possible of sea level fluctuations on the coasts of the Hawaiian Islands for current and future research and practical applications. Past applications of the archived data ranged from hydrogeology to gravity wave studies to dock design. Predominant users in the past year focused on infragravity waves at periods of 2-120 minutes in support of the NOAA-funded development and maintenance of high-spatial-resolution numerical models of coastal run-up nowcasts and forecasts along the west coast of Maui (now online at <http://www.pacioos.hawaii.edu/shoreline-category/runup-westmaui/>). A long-term objective of this program is to achieve harbor surge forecasts and coastal run-up forecasts in other Hawaiian harbors or along other coasts, respectively, using the archived high-temporal-resolution sea level data in ARSHSL to validate empirical or numerical models. Such forecasts are disseminated on the PacIOOS website as they are established (<http://www.pacioos.hawaii.edu/shoreline-category/harborsurge/> and <http://www.pacioos.hawaii.edu/shoreline-category/runup/>).

Progress during FY 2021

The acquisition, processing and formatting of the 6-minute SL observations has continued throughout the fiscal period for the six NOS gauges in Hawai'i. This record is current through April 2021. As part of the expansion of NOAA's Tides and Currents product, the one-minute tsunami sea level gauge data was brought into their repository system and made available online. This NOAA update included halting the ftp repository of one-minute data the project has been accessing for ARSHSL. The project has not converted the record acquisition machinery to the new system yet. The one-minute data in the ARSHSL repository is current up to May 2020. Some of the automated scripts have been idled until the project converts to the new data portal.

Also per the plans for this past year, the ARSHSL has been maintained on the World Wide Web (<http://ilikai.soest.hawaii.edu/arshsl/techrept/arshsl.html>) by M. Guiles and D. Luther, in collaboration with the NOAA-funded U.H. Sea Level Center (P. Thompson, Director).

Tsunami Research and Modeling

PI.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock

NOAA Goal(s):

- Resilient Coastal Communities and Economies

Purpose of the Project

In general terms this project is concerned with improving the accuracy and timeliness of tsunami forecasts issued by NOAA's Tsunami Warning Centers. In that respect, the project's main objective is to conduct research and apply science to the development of new tools and systems that can be used by the TWCs. In addition, to activities in forecast research, the project is also concerned with the development of Tsunami Hazard Assessment Analysis from both a deterministic and probabilistic approaches and with a number of activities related to outreach and capacity building, particularly in the area of tsunami modeling.

Progress during FY 2021

A parametric study to investigate the influence of source aspect ratio on the decay rate of the generated tsunami waves was initiated during the previous reporting period. This study was concluded in 2021 and findings were reported and published as a research article in *Geosciences*. (This objective was established in the previous reporting period and has been completed in 2021, as anticipated).

Dr. Sannikova's assistance was requested for a different project dealing with the use of real-time, Global Navigation Satellite Systems (GNSS) to address the problem of near-field tsunami forecasting.

Dr. Sannikova's contributions to the GNSS project have been focused on evaluating the accuracy of tsunami forecasts based on Deep-ocean Assessment and Reporting of Tsunamis (DART) data inversion with that obtained using GNSS data. Her contribution to the project has been and continues to be key for the completion of a NASA/NOAA funded effort to expedite tsunami forecast computation.

In addition, Dr. Sannikova has presented her work at the fall meeting of the American Geophysical Union (AGU) and the Seismological Society of America meeting with a poster and an oral presentation respectively.

University of Hawai'i Sea Level Center—Tsunami Research

PI.: Philip Tho

NOAA Office (of the primary technical contact): NOAA Tsunami Program

NOAA Sponsor: Michael Angove

NOAA Goal(s):

- Resilient Coastal Communities and Economies

Purpose of the Project

The University of Hawai'i Sea Level Center (UHSLC) maintains nine water level stations in the Caribbean Sea and eleven water level stations in the Pacific Ocean in support of regional tsunami warning and sea level monitoring. The Caribbean portion of the project was developed in collaboration with the Puerto Rico Seismic Network (PRSN). UHSLC oversees the operation of the stations and provides ongoing technical support, data processing, and quality assessment services. The Pacific portion of the project is primarily focused on the maintenance of tsunami water level stations previously maintained by the Pacific Tsunami Warning Center (PTWC). UHSLC involvement ensures that the water level stations remain operational and transmitting real-time, high-frequency data while also complying with global sea level observing system requirements for oceanographic and climate research.

Progress during FY 2021

Travel restrictions imposed in response to the COVID-19 pandemic prevented planned maintenance visits to tsunami tide gauge stations during FY 2021. Instead, the project focused on efforts for the NOAA/NWS Tsunami Warning Program on collaborating with the PTWC on updating and expanding the PTWC network of stations around the state of Hawai'i. UHSLC technicians visited ten locations and helped to make numerous upgrades to PTWC stations, as well as providing training to PTWC staff on new equipment and sensors.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

West Maui Wave Runup Forecasts

Camilla Tognacchini, JIMAR Graduate Student

Purpose of the Research

The main objectives of this research are: (1) acquire nearshore observations of wave heights and currents along the West Maui coastline, (2) analyze the collected data to identify and quantify the components that contribute to wave induced runup as a function of position along the West Maui coastline, (3) compare the analyses of the collected data to analyses of wave heights and currents from a hydrodynamical model, in order to accredit that model for the provision of wave-driven run-up forecasts for this domain, and (4) employ the model to explore the detailed spatial distribution of swell energy and its interaction products - infragravity wave energy and setup - along the West Maui coastline.

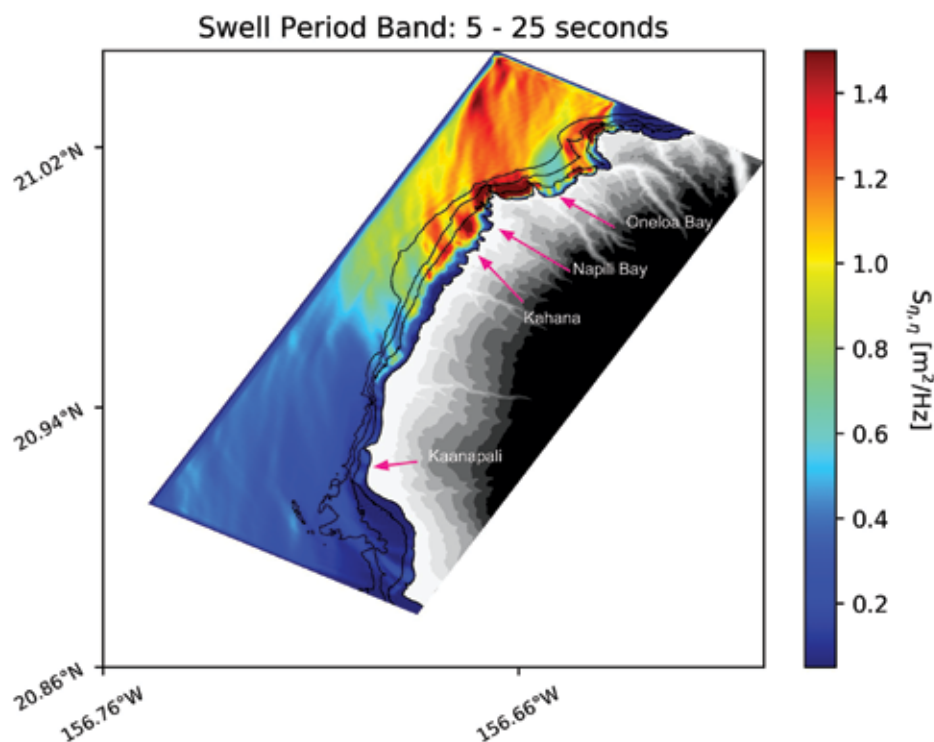


Figure 1. Map of model domain 1 (Lahaina to Honolulu, West Maui), showing the spatial distribution of power spectral density (PSD) in the swell period band (5-25 seconds) for a simulation of the north swell event on December 7, 2019 19:00-23:00 UTC. The plot shows the average band integrated PSD from five consecutive hourly simulations of 120 minutes each. Black contour lines show depths of 10, 20 and 30 meters.

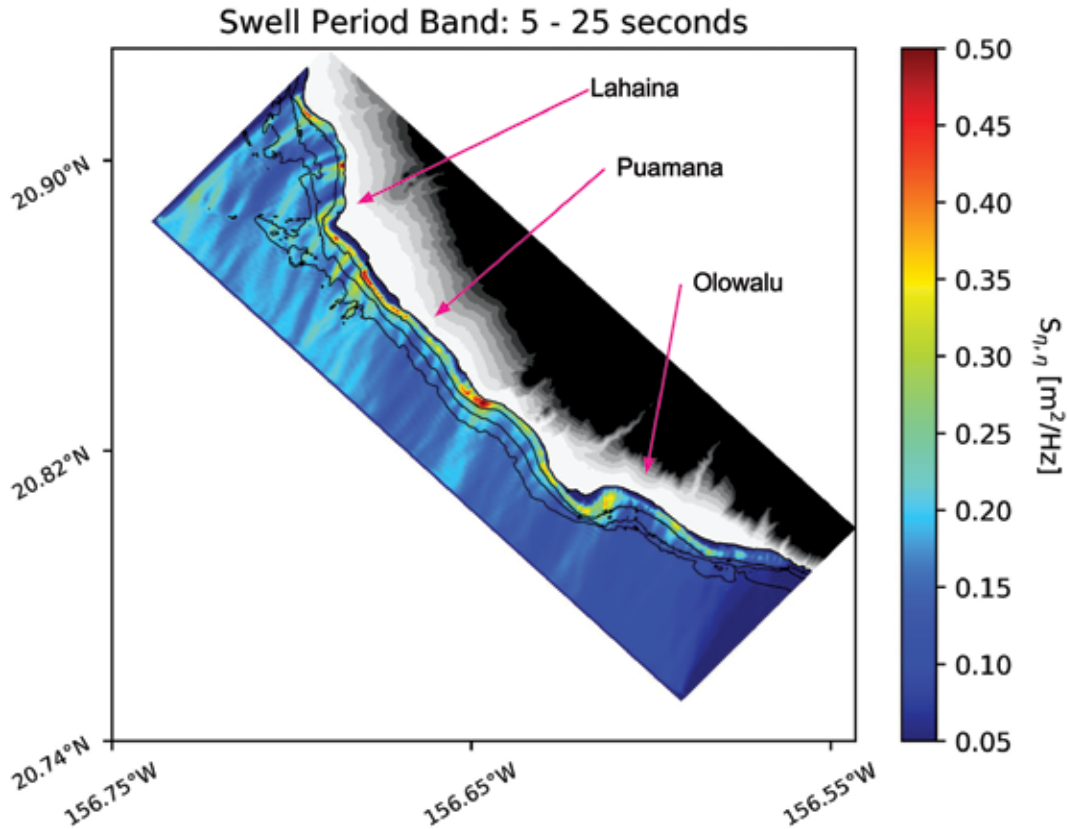


Figure 2. Map of model domain 2 (Ukumehame to Lahaina, West Maui), showing the spatial distribution of power spectral density (PSD) in the swell period band (5-25 seconds) for the simulation of the south swell event on July 14–15, 2019 22:00–2:00 UTC. The plot shows the average band integrated PSD from five consecutive hourly simulations of 120 minutes each. Black contour lines show depths of 10, 20 and 30 meters. Ecosystem Monitoring

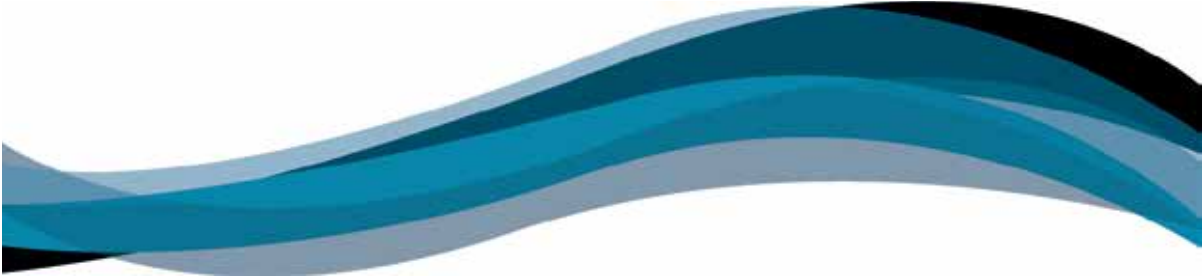
Progress during FY 2021

To meet the objective (1) the field program was concluded in FY 2020, as planned. Fifteen pressure gauges were recovered on a field trip on October 20–30, 2020. The new records provided new opportunities for data analysis, and were first subjected to a quality control process. The wave height observations have been analyzed to identify and quantify the components of sea level variability that contribute to wave runup in different regions of West Maui to meet objective (2). With the support of a NOAA coastal resilience grant, a two-dimensional phase-resolving nearshore gravity wave model was set up by collaborators on a grid wrapping around the West Maui coast. Methods and techniques for model accuracy validation were established and applied to the model output, validating the model for use for runup forecasts for the two domains (1= north and 2 = south), to meet objective (3). Examples of swell wave energy for a modeled North swell event for domain 1 and a South swell event for domain 2 are provided in Figures 1 and 2 respectively, showing distinct “fingers” of energy caused by refraction into West Maui from both swell directions. Analyses of the modeled swell simulations are ongoing to meet objective (4).

Future Research Plans

In FY 2021, a master’s thesis and a manuscript for publication will be finished and Ms. Tognacchini will start the PhD program at UH with Dr. Luther. Her research will focus on understanding infragravity wave forcing mechanisms and dynamics in different coastlines as well as in the open ocean. The work described here will be presented at the AGU Ocean Sciences conference taking place February 2022 in Honolulu, HI.

JIMAR Publications



JIMAR Publications

Journal Articles and Books					
Author(s) Names	Publication Date	Title	Published In (Journal Name, volume and page number)	Citation No. or hyperlink	Project Title
Baker, J.D., M.M. Barbieri, T.C. Johanos, C.L. Littnan, J.L. Bohlander, A.C. Kaufman, A.L. Harting, S.C. Farry, C.H. Yoshinaga	8/3/20	Conservation translocations of Hawaiian monk seals: accounting for variability in body condition improves evaluation of translocation efficacy	Anim. Conserv., 24, 206–216	http://dx.doi.org/10.1111/acv.12622	Hawaiian Monk Seal Research Program
Brown, J.R., M. Lengaigne, B.R. Lintner, M.J. Widlansky, K. van der Wiel, C. Dutheil, B.K. Linsley, A.J. Matthews, J. Renwick	8/18/20	South Pacific convergence zone dynamics, variability and impacts in a changing climate	Nat. Rev. Earth Environ., 1, 530–543	doi:43017-020-0078-2	University of Hawai'i Sea Level Center
Couch, C., T. Oliver, R. Suka, M. Lamirand, M. Asbury, C. Amir, B. Vargas-Angel, M. Winston, B. Huntington, F. Lichowski, A. Halperin, A. Gray, J. Garriques, R. Boland, N. Pomeroy, J. Samson	5/28/21	Comparing coral colony surveys from in-water observations and structure-from-motion imagery shows low methodological bias	Front. Mar. Sci., 8, 647943	doi: 10.3389/fmars.2021.647943/abstract	Sustaining Healthy Coastal Ecosystems
Durden, J.M., M. Putts, S. Bingo, A.B. Leitner, J.C. Drazen, A. Gooday, D.O.B. Jones, T. Washburn, C.R. Smith	5/24/21	Megaafaunal ecology of the western Clarion Clipperton Zone	Front. Mar. Sci., 8, 671062	doi: 10.3389/fmars.2021.671062	Pacific Islands Deep Sea Coral and Sponge Initiative
Erickson, K., M.O. Nadon	6/20/21	An extension of the stepwise stochastic simulation approach for estimating distributions of missing values of life history parameters for sharks, groupers, and other taxa	Fish. Bull., 119(1), 77–92	doi: 10.7755/FB.119.1.9	Stock Assessment Research Program
Fukunaga, A., J.H.R. Burns	8/19/20	Metrics of coral reef structural complexity extracted from 3D mesh models and digital elevation models	Rem. Sens., 12, 2676	https://doi.org/10.3390/rs12172676	Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., R.K. Kosaki, K.H. Pascoe, J.H.R. Burns	11/15/20	Fish assemblage structure in the northwestern Hawaiian Islands is associated with the architectural complexity of coral-reef habitats	Diversity, 12, 430	https://doi.org/10.3390/d12110430	Papahānaumokuākea Marine National Monument Monitoring and Research
Gilman, E., M. Chaloupka, A. Ishizaki, M. Carnes, H. Naholowaa, C. Brady, S. Ellgen, E. Kingma	5/12/21	Tori lines mitigate seabird bycatch in pelagic longline fisheries	Rev. Fish Biol. Fisheries, 31, 653–666	https://doi.org/10.1007/s11160-021-09659-7	Pacific Fisheries Monitoring Program
Hamlington, B.D., T. Frederikse, P.R. Thompson, J.K. Willis, R.S. Nerem, J.T. Fasullo	12/22/20	Past, present, and future Pacific sea-level change	Earth's Future, 8, e2020EF001839	doi: 10.1029/2020EF001839	University of Hawai'i Sea Level Center
Harting, A.L., M.M. Barbieri, J.D. Baker, T.A. Mercer, T.C. Johanos, S.J. Robinson, C.L. Littnan, K.M. Colegrove, D.S. Rotstein	9/15/20	Population-level impacts of natural and anthropogenic causes-of-death for Hawaiian monk seals in the main Hawaiian Islands	Mar. Mamm. Sci., 37, 235–250	https://onlinelibrary.wiley.com/doi/full/10.1111/mms.12742	Hawaiian Monk Seal Research Program
Holbrook, N.J., D.C. Claar, A.J. Hobday, K.L. McInnes, E.C.J. Oliver, A. Sen Gupta, M.J. Widlansky, X. Zhang	10/23/20	ENSO-driven ocean extremes and their ecosystem impacts	McPhaden, M.J., A. Samtoso, W. Cai (eds.), El Niño Southern Oscillation in a Changing Climate, Wiley, AGU Geophysical Monogr. Ser. 253, p. 409–428	doi: 10.1002/9781119548164.ch18	University of Hawai'i Sea Level Center
Iwane, M.A., K.M. Leong, M. Vaughan, K.L. Oleson	5/7/21	When a shark is more than a shark: A sociopolitical problem-solving approach to fisher-shark interactions	Front. Conserv. Sci., 2, 1–18	https://doi.org/10.3389/fcsc.2021.669105	Socioeconomics of Western Pacific Fisheries

Johnson, G.C., J.M. Lyman	7/13/20	Warming trends increasingly dominate global ocean	Nat. Clim. Change, 10, 757–761	doi: 10.1038/s41558-020-0822-0	Profiling CTD Float Array Implementation and Ocean Climate Research
Johnson, G.C., C. Cadot, J.H. Lyman, E.L. Steffen, K.E. McTaggart	8/30/20	Antarctic bottom water warming in the Brazil basin: 1990s through 2020, from WOCE to Deep Argo	Geophys. Res. Lett., 47, e2020GL089191	doi: 10.1029/2020GL089191	Profiling CTD Float Array Implementation and Ocean Climate Research
Johnson, G.C., J. Reagan, J.M. Lyman, T. Boyer, C. Schmid, R. Locarnini	8/12/20	Salinity [in “State of the Climate in 2019”]	Bull. Amer. Meteor. Soc., 101(8), S144	doi: 10.1175/2020BAMSStateoftheClimate.1	Profiling CTD Float Array Implementation and Ocean Climate Research
Johnson, G.C., et al. [J.M. Lyman]	8/12/20	Ocean heat content [in “State of the Climate in 2019”]	Bull. Amer. Meteor. Soc., 101(8), S140–S144	https://doi.org/10.1175/BAMS-D-21-0083.1	Profiling CTD Float Array Implementation and Ocean Climate Research
Kumar, P., B. Hamlington, S.-H. Cheon, W. Han, P. Thompson	9/22/20	20th century multivariate Indian Ocean regional sea level reconstruction	J. Geophys. Res.–Oceans, 125, e2020JC016270	doi: 10.1029/2020JC016270	University of Hawai‘i Sea Level Center
Loeb, N.G., G.C. Johnson, T.J. Thorsen, J.M. Lyman, F.G. Rose, S. Kato	6/15/21	Satellite and ocean data reveal marked increase in Earth’s heating rate	Geophys. Res. Lett., 48, e2021GL093047	doi: 10.1029/2021GL093047	Profiling CTD Float Array Implementation and Ocean Climate Research
Long, X., et al. [M.J. Widlansky, P.R. Thompson]	5/20/21	Seasonal forecasting skill of sea level anomalies in a multi-model prediction framework	J. Geophys. Res.–Oceans, 126, e2020JC017060	doi: 10.1029/2020JC017060	University of Hawai‘i Sea Level Center
Lovenduski, N.S., N.C. Swart, A.J. Sutton, J.C. Fyfe, G.A. McKinley, C.L. Sabine, N.L. Williams	2/1/21	The ocean carbon response to COVID-related emissions reductions	Geophys. Res. Lett., 48(6), e2020GL092263	doi: 10.1029/2020GL092263	National Ocean Acidification Observing Network - Oahu NCRMP Class III
McCullough, J.L.K., J. Wren, E.M. Oleson, A.N. Allen, Z.A. Siders, E.S. Norris	5/28/21	An acoustic survey of beaked whales and Kogia spp. in the Mariana Archipelago using drifting recorders	Front. Mar. Sci., 8, 664292	doi: 10.3389/fmars.2021.664292	Cetacean Research Program
Pascoe, K.H., A. Fukunaga, R.K. Kosaki, J.H.R. Burns	6/8/21	3D assessment of a coral reef at Lalo Atoll reveals varying responses of habitat metrics following a catastrophic hurricane	Sci. Rep., 11, 12050	https://doi.org/10.1038/s41598-021-91509-4	Papahānaumokuākea Marine National Monument Monitoring and Research
Robinson, S.J., A.L. Harting, T.A. Mercer, T.C. Johanos, J.D. Baker, C.L. Littnan	11/23/20	Sighting patterns reveal unobserved pupping events to revise reproductive rate estimates for Hawaiian monk seals in the main Hawaiian Islands	Mar. Mamm. Sci., 37, 420–432	https://onlinelibrary.wiley.com/doi/full/10.1111/mms.12761	Hawaiian Monk Seal Research Program
Sannikova, N.K., H. Segur, D. Arcas	4/16/21	Influence of tsunami aspect ratio on near and far-field tsunami amplitude	Geosci., 11(4), 178	https://doi.org/10.3390/geosciences11040178	Tsunami Research and Modeling
Scannell, H.A., G.C. Johnson, L. Thompson, J.M. Lyman, S.C. Riser	11/16/20	Subsurface evolution and persistence of marine heatwaves in the northeast Pacific	Geophys. Res. Lett., 47, e2020GL090548	doi: 10.1029/2020GL090548	Profiling CTD Float Array Implementation and Ocean Climate Research
Schloesser, F., P.R. Thompson, C.G. Piecuch	3/2/21	Meridional asymmetry in recent decadal sea-level trends in the subtropical Pacific Ocean	Geophys. Res. Lett., 48, e2020GL091959	doi: 10.1029/2020GL091959	University of Hawai‘i Sea Level Center
Sweet, W.V., A.S. Genz, J. Obeyseker, J.J. Marra	10/23/20	A regional frequency analysis of tide gauges to assess Pacific coast flood risk	Front. Mar. Sci., 7, 1–15	https://doi.org/10.3389/fmars.2020.581769	Analysis of the Vulnerability of Military Installations in the Pacific Basin to Coastal Flooding
Thompson, P.R., et al. [M.J. Widlansky]	8/1/20	Sea level variability and change [in “State of the Climate in 2019”]	Bull. Amer. Meteor. Soc., 101(8), S153–S156	doi: 10.1175/2020BAMSStateoftheClimate.1	University of Hawai‘i Sea Level Center
Thompson, P.R., et al. [M.J. Widlansky]	6/21/21	Rapid increases and extreme months in projections of United States high-tide flooding	Nat. Clim. Chang., 11, 584–590	https://doi.org/10.1038/s41558-021-01077-8	University of Hawai‘i Sea Level Center
Timmers, M., J. Vicente, M. Webb, C. Jury, R. Toonen	11/20/20	Sponging up diversity: Evaluating metabarcoding performance for a taxonomically challenging phylum within a complex cryptobenthic community	Environ. DNA	https://doi.org/10.1002/edn3.163	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
von Schuckmann, et al. [J. Lyman]	9/7/20	Heat stored in the Earth system: Where does the energy go?	Earth Syst. Sci. Data, 12, 2013–2041	doi: 10.1029/2020GL089191	Profiling CTD Float Array Implementation and Ocean Climate Research

Weijerman, M., Z. Oyafuso, K. Leong, K. Oleson, M. Winston	11/24/20	Supporting ecosystem-based fisheries management in meeting multiple objectives for sustainable use of coral reef ecosystems	ICES J. Mar. Sci., fsaa194	https://doi.org/10.1093/icesjms/fsaa194	Sustaining Healthy Coastal Ecosystems
Whitney, J.L., J.M. Gove, M.A. McManus, K.A. Smith, J. Lecky, P. Neubauer, J.E. Phipps, E.A. Contreras, D.R. Kobayashi, G.P. Asner	2/4/21	Surface slicks are pelagic nurseries for diverse ocean fauna	Sci. Rep., 11(1), 3197	doi: 10.1038/s41598-021-81407-0	West Hawaii Integrated Ecosystem Assessment
Wicksten, M.K., S. Bingo	3/1/21	Platymaia Miers, 1885 (Decapoda: Brachyura: Inachidae) can swim	J. Crustacean Biol., 41(1), ruaa090	https://doi.org/10.1093/jebiol/ruaa090	Pacific Islands Deep Sea Coral and Sponge Initiative
Widlansky, M.J., X. Long, F. Schloesser	8/20/20	Increase in sea level variability with ocean warming associated with the nonlinear thermal expansion of seawater	Commun. Earth Environ., 1, 9	https://doi.org/10.1038/s43247-020-0008-8	University of Hawai'i Sea Level Center
Winter, K.B., et al.	8/1/20	Collaborative research to inform adaptive comanagement: a framework for the He'eia National Estuarine Research Reserve	Ecol. Soc., 25(4), 15	https://doi.org/10.5751/ES-11895-250415	On-site Support for OA Mooring Test-beds: Evaluating and Expanding New Carbon Technologies to Subsurface Habitats
Wong, A.P.S., et al. [J.M. Lyman]	9/15/20	Argo data 1999–2019: Two million temperature-salinity profiles and subsurface velocity observations from a global array of profiling floats	Front. Mar. Sci., 7, 700	doi: 10.3389/fmars.2020.00700	Profiling CTD Float Array Implementation and Ocean Climate Research

Reports

Author(s) Names	Publication Date	Title	Published In (Journal Name, volume and page number)	Citation No. or hyperlink	Project Title
Aricò, S., et al.	5/1/21	Integrated ocean carbon research: A summary of ocean carbon research, and vision of coordinated ocean carbon research and observations for the next decade	IOC Technical Series 158, R. Wanninkhof, C. Sabine, and S. Aricò (eds.), Intergovernmental Oceanographic Commission, UNESCO-IOC, Paris, France, 46 pp, doi: 10.25607/h0gj-pq41	doi: 10.25607/h0gj-pq41	National Ocean Acidification Observing Network - Oahu NCRMP Class III
Asher J., A. Rollo, D. Miller-Green, B. Richards	4/21/21	Insights from “Deep 7” bottomfish abundance comparisons between uni- and multi-directional camera systems, Pacific Islands Fisheries Science Center	PIFSC Internal Report, IR-21-005, 16 p	IR-21-005	Ecosystem Observations and Research Program: Science Operations Project
Ayers, A., K. Leong	11/18/20	Stories of conservation success: results of interviews with Hawai'i longliners	NOAA Administrative Report, H-20-11, 1-43	https://doi.org/10.25923/6bnn-m598	Socioeconomics of Western Pacific Fisheries
Couch, C., R. Suka, T. Oliver, M. Lamirand, M. Asbury, C. Amir, B. Vargas-Angel, M. Winston, B. Huntington, F. Lichowski, A. Halperin, A. Gray, J. Garriques, R. Boland, N. Pomeroy, J. Samson	1/4/21	Comparing coral demographic surveys from in situ observations and structure-from-motion imagery shows low methodological bias	PIFSC Administrative Report, H-21-01	https://doi.org/10.25923/307k-fk90	Sustaining Healthy Coastal Ecosystems
Hill, M.C., A.L. Bradford, E.M. Oleson	7/1/20	Preliminary mark-recapture abundance estimates of humpback whales on a breeding area in the Mariana Archipelago	PIFSC Administrative Report, H-20-07, 18 p.	https://doi.org/10.25923/v3fd-yf59	Cetacean Research Program
Hill, M.C., E.M. Oleson, A.L. Bradford, K.K. Martien, D. Steel, S. Baker	9/1/20	Assessing cetacean populations in the Mariana Archipelago: A summary of data and analyses arising from Pacific Islands Fisheries Science Center surveys from 2010 to 2019	NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-108, 98 p.	https://doi.org/10.25923/wrye-6h14	Cetacean Research Program

Hutchinson, M., Z. Siders, J. Stahl, K. Bigelow	3/15/21	Quantitative estimates of post-release survival rates of sharks captured in Pacific tuna longline fisheries reveal handling and discard practices that improve survivorship	NOAA Data Report DR-2021-001	https://doi.org/10.25923/0m3c-2577	Fishing Impacts on Non-Target Species
Iwane, M., K.M. Leong, D. Kleiber	2/1/21	Non-commercial fishing in policy, practice, and culture: Insights from the Papahānaumokuākea Marine National Monument	NOAA Technical Memorandum NMFS-PIFSC-114, 1-43	https://doi.org/10.25923/r365-2f47	Socioeconomics of Western Pacific Fisheries
Iwane, M.A., K. Leong	12/1/20	Socioeconomic context for fisher-shark interactions in the Marianas	NOAA Administrative Report, H-20-13, 1-48	https://doi.org/10.25923/9wat-a254	Socioeconomics of Western Pacific Fisheries
McCracken, M., B. Cooper	12/30/20	Estimation of bycatch with bony fish, sharks, and rays in the 2017, 2018, and 2019 Hawaii permitted deep-set longline fishery	PIFSC Data Report; DR-20-023	https://doi.org/10.25923/n97k-wh55	Stock Assessment Research Program
McCracken, M., B. Cooper	8/21/20	Assessment of incidental interactions with marine mammals in the Hawaii longline deep and shallow set fisheries from 2015 through 2019	PIFSC Data Report; DR-20-024	https://doi.org/10.25923/m55s-ea18	Stock Assessment Research Program
McCullough, J.L.K., E.M. Olson, J. Barlow, A.N. Allen, K. Merckens	4/1/21	An acoustic survey in the main Hawaiian Islands using drifting recorders	NOAA Admin Report H-21-04, 20 p.	https://doi.org/10.25923/rzzz-0v38	Cetacean Research Program
Oliver T., H. Barkley, C. Couch, T. Kindinger, I. Williams	7/1/20	Downscaling ecological trends from the spatially randomized datasets of the National Coral Reef Monitoring Program	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-106	https://doi.org/10.25923/2fef-8r42	Sustaining Healthy Coastal Ecosystems
Parke, M., et al. [M. Putts, V. Moriwake, S. Bingo]	3/1/21	Deep-Sea Coral Research and Technology Program: Pacific Islands deep-sea coral and sponge initiative final report	NOAA Technical Memorandum NMFS-PIFSC-117	https://doi.org/10.25923/j6vh-ca45	Pacific Islands Deep Sea Coral and Sponge Initiative
Reed, E., N.J. Brown-Peterson, E.E. DeMartini, A.H. Andrews	4/26/21	Reproductive characteristics of longtailed red snapper (onaga, <i>Etelis coruscans</i>) in the main Hawaiian Islands	PIFSC Administrative Report	https://doi.org/10.25923/gy4t-vx60	Territorial Biosampling
Stahl J., M. Carnes	9/18/20	Detection Accuracy in the Hawai'i Longline Electronic Monitoring Program with Comparisons between Three Video Review Speeds.	PIFSC Data Report DR-20-012.	https://doi.org/10.25923/n1gq-m468	Pacific Fisheries Monitoring Program
Vargas-Angel, B., B. Huntington	9/1/20	Status and trends assessment for land-based sources of pollution impacts on benthic reef communities in Faga'alu Bay, American Samoa	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-109	https://doi.org/10.25923/0gvj-zm69	Sustaining Healthy Coastal Ecosystems
Vargas-Angel, B., B. Huntington	11/25/20	Status and trends assessment of benthic coral reef communities in Vatia Bay, American Samoa, 2015-2020	PIFSC Data Report, DR-20-020	https://doi.org/10.25923/r7dd-wg50	Sustaining Healthy Coastal Ecosystems
Yano, K.M., E.M. Oleson, J.L.K. McCullough, M.C. Hill, A.E. Henry	11/30/20	Cetacean and seabird data collected during the Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January–March 2020	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p.	https://doi.org/10.25923/ehfg-dp78	Cetacean Research Program

Conference and Workshop Proceedings

Author(s) Names	Publication Date	Title	Published In (Journal Name, volume and page number)	Citation No. or hyperlink	Project Title
Iwane, M., K. Leong, K. Oleson, M. Vaughan	3/22/21	Accounting for layered problem definitions in shark and fisheries management	81st Annual Meeting of the Society of Applied Anthropology		Socioeconomics of Western Pacific Fisheries

Kessler, W.S., M. Wei, H.G. Hristova	12/14/20	Glider estimates and model diagnoses of low-latitude western boundary current temperature advection into the Pacific equatorial strip	AGU Fall Meeting 2020, OS039-03	https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/699901	Observation and Dynamics of Oceanic Variability in the Solomon Sea
Presentations					
Author(s) Names	Publication Date	Title	Published In (Journal Name, volume and page number)	Citation No. or hyperlink	Project Title
Abdul, J.	8/18/20	PIFSC data strategies to empower scientists	2020 NOAA Environmental Data Management Workshop		Ecosystem Observations and Research Program: Research Support Project
Ayers, A., K. Leong	12/3/20	Stories of conservation success: results of interviews with Hawai'i longliners	184th Meeting of the Western Pacific Regional Fishery Management Council		Socioeconomics of Western Pacific Fisheries
Barkley, Y.M.	2/17/21	New developments for passive acoustic monitoring of sperm whales in Hawaiian waters	National Marine Sanctuary Webinar Series		Cetacean Research Program
Barkley, Y.M.	12/4/20	Characterizing patterns in endangered cetacean populations in the Hawaiian Archipelago using passive acoustic data	UH Manoa, Marine Biology Dissertation Defense		Cetacean Research Program
Drazen, J.C., V. Moriwake, C. Kelley	9/1/20	Discovering deepwater habitats and species	National Fish and Wildlife Foundation Projects Communications Webinar		Pacific Islands Deep Sea Coral and Sponge Initiative
Ingram, R., K. Leong, A. Nakachi, A. Adams	9/3/20	Monitoring cultural ecosystem services with place-based indicators in west Hawai'i	27th Hawai'i Conservation Conference, Ola Ka Aina Momona Managing for Abundance		Socioeconomics of Western Pacific Fisheries
Iwane, M.	3/22/21	Social science and stock assessment: Understanding engagement challenges and opportunities	Ecosystem-Based Fisheries Management Workshop, Fishing Communities		Socioeconomics of Western Pacific Fisheries
Iwane, M., K. Leong	3/16/21	Socioeconomic context for fisher-shark interactions in the Marianas	139th Scientific and Statistical Committee Meeting, Western Pacific Regional Fisheries Management Council		Socioeconomics of Western Pacific Fisheries
Iwane, M., K. Leong	3/24/21	Socioeconomic context for fisher-shark interactions in the Marianas	185th Meeting of the Western Pacific Regional Fishery Management Council		Socioeconomics of Western Pacific Fisheries
Long, X., et al. [M.J. Widlansky, P.R. Thompson]	12/15/20	Seasonal forecasting of sea level anomalies in a multi-model prediction framework	AGU Fall Meeting		University of Hawai'i Sea Level Center
Mercer, T.A.	3/18/21	Deviations from national guidelines for monk seal serious injury determination	2021 Pacific Scientific Review Group Meeting		Hawaiian Monk Seal Research Program
Mercer, T.A.	3/23/21	Main Hawaiian Islands Monk Seal Population Overview	7th Regional Pacific Islands Marine Animal Response Network Meeting		Hawaiian Monk Seal Research Program
Mercer, T.A.	3/23/21	Hawaiian Monk Seal Research Program overview and stranding response	7th Regional Pacific Islands Marine Animal Response Network Meeting		Hawaiian Monk Seal Research Program
Nakachi, A., K. Leong, K. Oleson	9/2/20	Developing methods to spatially represent social values in Hawai'i	27th Hawai'i Conservation Conference, Ola Ka Aina Momona Managing for Abundance		Socioeconomics of Western Pacific Fisheries
Perng, L., K. Oleson, M. Weijerman, K. Leong	9/1/20	Social tipping points in marine resource-dependent Hawaiian coastal communities	27th Hawai'i Conservation Conference, Ola Ka Aina Momona Managing for Abundance		Socioeconomics of Western Pacific Fisheries
Reed, E., B. Schumacher, M. Sabatar	10/13/20	Identifying relationships with climate or the environment in the Mariana Archipelago using fish otoliths	4th Annual Collaborative Climate Science Workshop	https://doi.org/10.25923/ezac-hk23	Territorial Biosampling

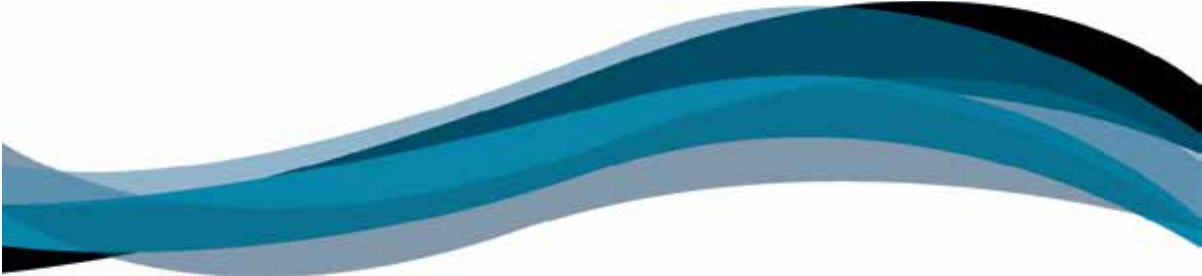
Sannikova, N.K., H. Segur, D. Arcas	12/1/20	Tsunami amplitude decay on source aspect ratio investigation	American Geophysical Union Annual Meeting	https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/754430	Tsunami Research and Modeling
Sannikova, N.K., Y. Wei, D. Arcas, K. Kwong, A. Williamson, D. Melgar	4/20/21	Rapid GNSS source and DART inversion models comparison along the Cascadia Subduction Zone	Seismological Society of America	https://www.seismosoc.org/wp-content/uploads/2021/03/SSA-2021-Program-for-SRL.pdf	Tsunami Research and Modeling
Staman, M., et al.	9/2/20	Status and trends of Honu, or green sea turtles (<i>Chelonia mydas</i>), in the Papahānaumokuākea Marine National Monument	Hawai'i Conservation Conference		Marine Turtle Recovery in the Pacific Islands Region
Widlansky, M.J., N. Komar, P.R. Thompson, G. Dusek, W.V. Sweet, K. Hagemann	7/15/20	Visualizing the climatology and extremes of coastal water levels	Modeling, Prediction, and Sensor Networks for Coastal Flooding in the U.S. East Coast, Coastal Solutions Workshop		University of Hawai'i Sea Level Center
Widlansky, M.J., X. Long, F. Schloesser	12/15/20	Increase in sea level variability with ocean warming associated with the nonlinear thermal expansion of seawater	Treading water: Understanding Sea Level Rise and connections to coastal flooding and impacts, AGU Fall Meeting		University of Hawai'i Sea Level Center

Publication Summary

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

		FY 18	FY 19	FY 20	FY 21
Peer Reviewed	JIMAR Lead Author	18	15	18	15
	NOAA Lead Author	3	5	6	9
	Other Lead Author	15	17	24	15
Non Peer-Reviewed	JIMAR Lead Author	52	41	46	29
	NOAA Lead Author	6	4	9	5
	Other Lead Author	3	6	12	6

Appendices



Appendix I List of Acronyms

2D	Two-Dimensional
3D	Three-Dimensional
AABW	Antarctic Bottom Water
AAIW	Antarctic Intermediate Water
ACE	Accumulated Cyclone Energy
AD	Automatic Differentiation
ADCP	Acoustic Doppler Current Profiler
ADMB	Automatic Differentiation Model Builder
AGEPRO	Age Structured Projection Model
AGU	American Geophysical Union
AI	Artificial Intelligence
AIRS	Atmospheric Infrared Sounder
APDRC	Asia-Pacific Data Research Center
ARMS	Autonomous Reef Monitoring Structures
ARSHSL	Archive of Rapidly-Sampled Hawaiian Sea Level
ASBE	Annual Small Boat Evaluation
ATN	Animal Telemetry Network
BFISH	Bottomfish Fishery-Independent Survey in Hawai'i
BMP	Best management practice
BOEM	Bureau of Ocean Energy Management
BMUS	Bottomfish Management Unit Species
BRUVS	Baited Remote Underwater Video Station
CAU	Calcification and Accretion Units
CFSv2	Coupled Forecast System, version 2
cGPS	Co-located Global Positioning System
CIE	Center of Independent Experts
CIMAR	Cooperative Institute for Marine and Atmospheric Research
CIPIR	Cooperative Institute for the Pacific Islands Region
CMIP-5	Coupled Model Intercomparison Project Phase 5
CNMI	Commonwealth of the Northern Mariana Islands
CNP	Central North Pacific
CoLab	Collaborative Laboratories
CONUS	Continental United States

COVID-19	Corona Virus Disease 2019
CPUE	Catch Per Unit Effort
CRCP	Coral Reef Conservation Program
CRIMP-2	Coral reef instrumented platform -2
CRP	Cetacean Research Program
CSVI	Community Social Vulnerability Indicators
CTD	Conductivity Temperature and Depth
DAPPER	Data Access Protocol server
DAR	State of Hawai'i Division of Aquatic Resources
DART	Deep-ocean Assessment and Reporting of Tsunamis
DASBR	Drifting Acoustic Spar Buoy Recorder
DCHART	Web-based server for display of in situ and gridded data sets
DIC	Dissolved inorganic carbon
DLC	Data Lifecycle
DLNR	Department of Land and Natural Resources
DNA	Deoxyribonucleic Acid
DoD	Department of Defense (U.S.)
DODS	Distributed Ocean Data System
DOFAW	Division of Forestry and Wildlife
DSCRTP	Deep Sea Coral Research and Technology Program
DVM	Data Validation Module
DVR	Digital Video Recorder
EAR	Ecological Acoustic Recorder
EBFM	Ecosystem-Based Fisheries Management
ECMWF	European Center for Medium-Range Weather Forecasts
EDM	Environmental Data Management
eDNA	Environmental Deoxyribonucleic Acid
EEZ	Exclusive Economic Zone
EM	Electronic Monitoring
EN4	Ensemble 4 of the Enhanced Data Assimilation and Climate Prediction model
ENP	Eastern North Pacific
ENSO	El Niño Southern Oscillation
EORP	Ecosystems Observations and Research Program
ER	Electronic Reporting
ESA	Endangered Species Act

ESD	Ecosystem Sciences Division
E/V	Exploration Vessel
FAD	Fish Aggregation Device
FEP	Fishery Ecosystem Plan
FFS	French Frigate Shoals
FINS	Fishery Impacts to Non-Target Species project
FP	Fibropapillomatosis
FRDS	Fisher Reporting and Dealer System
FRMD	Fisheries Research and Monitoring Division
FRS	Fisher Reporting System
FSM	Federated States of Micronesia
FY	Fiscal Year
GCN	Global Sea-level Observing System Core Network
GCOS	Global Climate Observing System
GDS	GrADS DODS Server
GIS	Geographic Information System
GLOSS	Global Sea Level Observing System
GNSS	Global Navigation Satellite System
GOA-ON	Global Ocean Acidification Observing Network
GODAS	Global Ocean Data Assimilation System
GPS	Global Positioning System
GPT	Geospatial Products Team
GrADS	Grid Analysis and Display System
GSFC	Goddard Space Flight Center
GTS	Global Telecommunication System
GUI	Graphic User Interface
HARP	High-frequency Acoustic Recording Package
HCBC	Hawai'i Coral Bleaching Collaborative
HCTP	Hawai'i Community Tagging Program
HDAR	Hawai'i Division of Aquatic Resources
HFMA	Herbivore Fisheries Management Area
Hg0	Elemental Mercury
HgP	Particulate Mercury
HICEAS	Hawaiian Islands Cetacean and Ecosystem Assessment Survey
HIMB	Hawai'i Institute of Marine Biology

HMS	Hawaiian Monk Seal
HMSRP	Hawaiian Monk Seal Research Program
HPU	Hawai'i Pacific University
HSR	Hawai'i Summer Rainfall
HYCOM	Hybrid Coordinate Ocean Model
IATTC	Inter-American Tropical Tuna Commission
IEA	Integrated Ecosystem Assessment
IEC	International Electrotechnical Commission
IOC	Intergovernmental Oceanographic Commission
IOOS	Integrated Ocean Observing System
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
IQR	Iterative Query Refinement
IRC	Daniel K. Inouye Regional Center
ISO	International Organization for Standardization
ISSF	International Seafood Sustainability Foundation
IT	Information Technology
JIMAR	Joint Institute for Marine and Atmospheric Research
Kd490	Diffuse Attenuation Coefficient at 490 nm
LAS	Live Access Server
LBSP	Land Based Sources of Pollutions
LHP	Life History Program
LME	Large Marine Ecosystem
MAKER Lab	Marine and Applied Knowledge for Ecosystem Research Laboratory
MAPCO2	Moored autonomous partial pressure of CO2
MARFAC	Marine Animal Recovery Facility
MARVLS	Maturity Assessment and Reproductive Variability in Life Stages
MCMC	Markov Chain Monte Carlo
MERRA-2	Modern-Era Retrospective analysis for Research and Applications-2
MHI	Main Hawaiian Islands
MJO	Madden-Julian Oscillation
MLO	Mauna Loa Observatory
MMPA	Marine Mammal Protection Act
MODIS	Moderate Resolution Imaging Spectro-radiometer
MOP	Marine Option Program

MOUSS	Modular Underwater Stereoscopic System
MTBAP	Marine Turtle Biology and Assessment Program
MUS	Management Unit Species
N2N	NOAA to NOAA
NABC	Naval Amphibious Base – Coronado
NADW	North Atlantic Deep Water
NASA	National Atmospheric and Space Administration
NCEI	National Centers for Environmental Information
NCEP	National Centers for Environmental Prediction
NCRMP	National Coral Reef Monitoring Program
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWHI	Northwestern Hawaiian Islands
NWS	National Weather Service
OA	Ocean acidification
OAP	Ocean Acidification Program (NOAA office)
OAR	Oceanic and Atmospheric Research
OCC	Ocean and Climate Change
OCONUS	Outside of the Continental United States
OCS	Oceanic whitetip shark (FAO 3 alpha code)
OFES/AFES/CFES	Ocean/Atmosphere/Coupled model For the Earth Simulator
OLE	Office of Law Enforcement
ONMS	Office of National Marine Sanctuaries
OPeNDAP	Open-source Project for a Network Data Access Protocol
PacIOOS	Pacific Islands Ocean Observing System
PacMAPPS	Pacific Marine Assessment Program for Protected Species
PAR	Photosynthetically Available Radiation
PDC	Pacific Disaster Center
PEAC	Pacific ENSO Applications Climate Center
PHR	Pearl and Hermes Reef
PIFG	Pacific Island Fisheries Group
PIFSC	Pacific Islands Fisheries Science Center
PIR	Pacific Islands Region

PIRO	Pacific Islands Regional Office
PIVA	Pacific Island Vulnerability Assessment
PMDP	Papahānaumokuākea Marine Debris Project
PMEL	Pacific Marine Environmental Laboratory
PMNM	Papahānaumokuākea Marine National Monument
PQS	Personal Qualification Standards
PRA	Paperwork Reduction Act
PRIMNM	Pacific Remote Islands Marine National Monument
PRS	Post release survival
PRSN	Puerto Rico Seismic Network
PRTtoolbox	Protected Resources Toolbox
PSD	Power spectral density
PTP	Precision Time Protocol
PTWC	Pacific Tsunami Warning Center
PWA	Progressive Web Applications
PYSO	PIFSC Young Scientist Opportunity
QB	Quasi-biennial
RAD	Rapid Application Development
RAMP	Reef Assessment and Monitoring Program
RA-V	Regional Alliance Five (Pacific Islands)
RCC	Regional Climate Center
REA	Rapid Ecological Assessment
RFA	Regional Frequency Analysis
RFMO	Regional Fishery Management Organization
RGM	Reactive Gaseous Mercury
ROS	Robot Operating System
ROV	Remotely Operated Vehicle
RTOW	Return to Onsite Work
R/V	Research Vessel
SAMI-alk	Submersible Autonomous Moored Instrument for alkalinity
SAP	Stock Assessment Program
SCHE	Sustaining Healthy Coastal Ecosystems
SCUBA	Self-Contained Underwater Breathing Apparatus
SDK	Software Development Kit
SDT	Software Development Team

SfM	Structure-from-Motion
SL	Sea level
SLR	Sea level rise
SOD	Science Operations Division
SOEST	School of Ocean and Earth Science and Technology
SOP	Standard Operating Procedure
SOW	Statements of Work
SPTT	South Pacific Tuna Treaty
SQL	Structured Query Language
SSD	Solid State Drives
SST	Sea Surface Temperature
SSTP	Survey and Sampling Technologies Program
SSV	Sailing School Vessel
TA	Total alkalinity
TB	Terabyte
TC	Tropical cyclone
TDR	Temperature Depth Recorder
TG	Tide gauge
THREDDS	Thematic Real-time Environmental Distributed Data Services
TIGA	Tide Gauge Benchmark Monitoring Project
TS	Training Ship
TSI	Territorial Science Initiative
TURD	Turtle Restraint Device
UAS	Uncrewed Aerial Systems
UH	University of Hawai‘i
UHDAS	University of Hawai‘i Data Acquisition System
UHM	University of Hawai‘i at Mānoa
UHSLC	University of Hawai‘i Sea Level Center
UNESCO	United Nations Educational, Scientific and Cultural Organization
U.S.	United States
U.S.A.	United States of America
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UVS	Underwater Visual Census

VARs	Video Annotation and Reference System
VFP	Visual Fox Pro
VIAME	Video and Image Analytics for Marine Environment
VMS	Vessel Monitoring Systems
VOC	Vessel Operations Coordinator
WAMI	Wide Area Motion Imagery
WCPFC	Western and Central Pacific Fisheries Commission
WMO	World Meteorological Office
WNP	Western North Pacific
WPacFIN	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Regional Fishery Management Council
WQSPP	Water Quality Sensor Partnership Program

Appendix II List of Awards and Related Amendment Numbers

**JOINT INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH (JIMAR)
COOPERATIVE AGREEMENT NO. NA16NMF4320058
List of Projects described in the Annual Report for the period: July 1, 2020-June 30, 2021**

Title	NOAA Technical Lead/Sponsor	Amendment Number(s)
Analysis of the Vulnerability of Military Installations in the Pacific Basin to Coastal Flooding	John Marra	31, 64, 109, 160
Atmospheric Gases in the Remote Pacific Marine Free Troposphere Measured in Hawaii	Brian Vasel	19, 39, 42, 94, 161, 184
Cetacean Research Program	Michael Seki	8, 80, 117, 141, 171, 192, 208
Ecosystem Structure and Function	Michael Seki	10, 77, 124, 139, 179, 194
Ecosystems Observations and Research Program: Research Support Project	Michael Seki	37, 81, 113, 155, 174
Ecosystem Observations and Research Program: Science Operations Project	Michael Seki	34, 71, 112, 128, 130, 154, 175, 200, 207
Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center (IPRC)	Howard Diamond	1, 43, 96, 135, 173
Fishing Impacts on Non-Target Species	Michael Seki	24, 40, 41, 56, 114, 146, 199
Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support	Michael Seki	38, 60, 118, 147, 169, 186, 211
Hawaiian Monk Seal Research Program	Michael Seki	7, 65, 121, 142, 170, 204
Marine Debris Mitigation Project	Michael Seki	100, 165, 183

Marine Turtle Recovery in the Pacific Islands Region	Michael Seki	12, 68, 115, 144, 168, 185
National Ocean Acidification Observing Network—Oahu NCRMP Class III	Dwight Gledhill	137, 176
NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)	Michael Seki	123, 157, 187
Observation and Dynamics of Oceanic Variability in the Solomon Sea	Gary Matlock	163, 196, 202, 206
Ocean Remote Sensing	Michael Seki	25, 63, 107, 151
On-site Support for OA Mooring Test-beds: Evaluating and Expanding New Carbon Technologies to Subsurface Habitats	Dwight Gledhill	138, 177
Open Source ADMB Project	Michael Seki	33, 74, 106, 159, 178
Optimizing Routine Ocean Current Measurements by the NOAA Fleet: (OMAO FY2020–2021)	Solomon Tadele	36, 53, 126, 164, 181
Pacific Fisheries Monitoring Program	Michael Seki	15, 66, 101, 150, 198, 205
Pacific Islands Deep Sea Coral and Sponge Initiative	Michael Seki	17, 76, 97, 162, 172, 193
Pacific Islands Territorial Science Initiative (PITSI)	Michael Seki	4, 54, 102, 158
Pacific Tuna Fishery Data Management	Michael Seki	13, 79, 120
Papahānaumokuākea Marine National Monument Monitoring and Research	Randall Kosaki	9, 70, 122, 145, 188
Profiling CTD Float Array Implementation and Ocean Climate Research	Gary Matlock	32, 55, 89, 131, 180

Socioeconomics of Western Pacific Fisheries	Michael Seki	20, 67, 116, 149, 190
Stock Assessment Research Program	Michael Seki	21, 69, 119, 143, 197, 210
Sustaining Healthy Coastal Ecosystems	Michael Seki	35, 78, 108, 111, 156, 191
Territorial Biosampling	Michael Seki	14, 72, 105, 148
Tsunami Research and Modeling	Gary Matlock	46, 133, 203
University of Hawai'i Sea Level Center	David Legler	22, 59, 82, 85, 91, 132, 166, 182, 201
West Hawai'i Integrated Ecosystem Assessment	Michael Seki	11, 62, 110, 140, 189
Western Pacific Fisheries Information Network (WPacFIN)	Michael Seki	30, 48, 104, 153, 209

Appendix III Visiting Scientists

Nothing to report for this period.

Appendix IV Workshops, Meetings and Seminars

- **New Developments of Passive Acoustic Monitoring for Sperm Whales in Hawaiian Waters**
February 17, 2021, OneNOAA Science Seminar Series, NOAA Office of National Marine Sanctuaries
Yvonne Barkley, Cetacean Acoustics Researcher, JIMAR Pacific Islands Fisheries Science Center
- **Sea Turtles in the Main Hawaiian Islands—Biology, Research, and Conservation**
September 17, 2020, Hanauma Bay Weekly Virtual Seminar
Christina Copenrath, Field and Laboratory Research Associate, JIMAR Pacific Islands Fisheries Science Center
- **Working with Industry to Improve Post-release Survival of Sharks Incidentally Captured in Commercial Fisheries**
July 23, 2020, Hanauma Bay Weekly Virtual Seminar
Melanie Hutchinson, Science Program Manager, JIMAR Pacific Islands Fisheries Science Center
- **Pearl and Hermes Reef: Seal Paradise or Peril?**
October 15, 2020, Hanauma Bay Weekly Virtual Seminar
Hope Ronco, Research/Logistics Technician, JIMAR Pacific Islands Fisheries Science Center

Appendix V JIMAR Personnel

Information as of June 30, 2021

Category	Number	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	18	0	0	0	0	18
Visiting Scientist	0	0	0	0	0	0
Postdoctoral Fellow	0	0	0	0	0	0
Research Support Staff	92	3	2	56	28	3
Administrative	11	0	0	9	1	1
Total ($\geq 50\%$ support)	121	3	2	65	29	22
Undergraduate Students	6	6	0	0	0	0
Graduate Students	12	0	0	7	5	0
Employees that receive < 50% NOAA Funding (not including students)	5	0	0	1	1	3
Located at Lab (including name of Lab)	1 - ESRL 100 - PIFSC 5 - PMEL 3 - PMNM					
Obtained NOAA employment within the last year	11					

Appendix VI Awards

Lizbeth Kashinsky

- 2020 PIFSC Team Member of the Year, Professional/Scientific/Technical

Brooke Olenski

- 2020 PIFSC Team Member of the Year, Professional/Scientific/Technical

Hope Ronco

- 2020 RCUH Outstanding Employees of the Year, 2nd Place, Project Support Staff Category

Appendix VII Graduates

Yvonne Barkley, Ph.D., Marine Biology, University of Hawai‘i at Mānoa, December 2020, “Characterizing patterns in endangered cetacean populations in the Hawaiian Archipelago using passive acoustic data”

Sarah Medoff, Ph.D., Economics, University of Hawai‘i at Mānoa, “Essays examining Hawai‘i’s longline fishery”

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#: NA18NMF4320334

Title: 2018 Cetacean Density and Acoustic Analyses in the Hawaiian Islands

Principal Investigator: Dr. Douglas Luther

Award#: NA17OAR4310110

Title: Multi-model Seasonal Sea Level Forecasts for the U.S. Coast

Principal Investigator: Dr. Mark Merrifield