JIMAR

Annual Report for Fiscal Year 2019

For Cooperative Agreement NA16NMF4320058

Douglas S. Luther, PhD
Director

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Performance Period July 1, 2018–June 30, 2019

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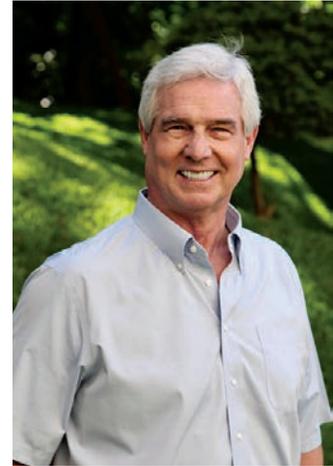
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Introduction

The Joint Institute for Marine and Atmospheric Research (JIMAR) manages the Cooperative Institute for the Pacific Islands Region (CIPIR), one of 16 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 Hawaii;
- provide educational opportunities for basic and applied research in the Life and Earth Sciences at the undergraduate, graduate, and post-doctoral levels;
- advance interactions through the support of visiting scientists and post-doctoral scholars; and,
- promote the transition of research outcomes to operational products and services that benefit the Pacific Islands Region.

Douglas S. Luther, PhD, Director

JIMAR is located at the University of Hawaii (UH), a research-intensive land-grant and Sea Grant 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 several 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 engagements between NOAA in the Pacific Region and these academic research 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. The ~100 JIMAR scientists within PIFSC are oceanographers, marine biologists, zoologists, geographers, coastal and environmental scientists, economists, fisheries scientists, sociologists, computer scientists, and engineers. The work with PIFSC is undertaken across ~23 JIMAR projects encompassing coral reef

Jeffrey Hare, PhD, Deputy Director for PIFSC Projects

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 interact 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 a number of projects in the research themes of equatorial oceanography, climate research and impacts, tropical meteorology, and tsunamis and other long-period ocean waves. JIMAR programs active in these areas include the University of Hawaii Sea Level Center (UHSLC), the Pacific El Niño Southern Oscillation (ENSO) Applications Climate (PEAC) Center, and a partnership with the Pacific Islands Ocean Observing System (PacIOOS).

Research

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

- Genetic analyses of nuclear DNA are a primary tool for investigating mating systems in marine turtles. Studies over the past two decades demonstrate that polyandry (i.e., females mating with multiple males) is common in marine turtles, but polygyny (i.e., males mating with multiple females) has rarely been reported. JIMAR Marine Ecological Researcher Alexander Gaos led an investigation of the mating structure of critically endangered hawksbill turtles in one of the largest rookeries in the eastern Pacific Ocean (Gaos et al., 2018). Based on genetic sampling of females and hatchlings from multiple clutches during a single nesting season, they reconstructed the paternal genotypes for known male turtles and found the highest polygyny level reported to date for marine turtles. The relatively high level of polygyny suggests limited numbers of sexually mature males at the site and could indicate polygynous mating strategies may compensate for potential ongoing feminization in marine turtle populations.

- Hematology and serum chemistry reference intervals (RI's) have been previously established for the endangered Hawaiian monk seal as an imperative measure for health assessments. Monitoring the health of the wild population depends upon RI's, which are context specific, so JIMAR Veterinary Lab Associate Angie Kaufman and colleagues developed RI's using fresh samples (not frozen) from wild monk seals (Kaufman et al., 2018). Blood samples were analyzed by a single veterinary diagnostic laboratory within 24 hours of collection from apparently healthy, wild seals during research activities, and the RI's were determined based on the analytical steps outlined by the American Society for Veterinary Clinical Pathology. These comprehensive hematology and serum chemistry RI's will enable more consistent and systematic interpretation of results which will guide ongoing individual and population-level health assessment and decision-making research and recovery activities for the Hawaiian monk seals.

- Long-term ecological monitoring of reef fish often requires simultaneous collection of data on benthic habitats to account for the effects of these variables on fish assemblage structure. Photogrammetric techniques, such as Structure-from-Motion photogrammetry, allow for three-dimensional (3D) reconstruction of coral reefs that can facilitate characterization of benthic habitat structure in high resolution. In a study led by JIMAR Ecological Research Statistician Atsuko Fukunaga, various measures of structural complexity extracted from the 3D reconstruction of reef habitat in the Northwestern Hawaiian Islands were generally highly correlated with one another, but not with curvature measures, indicating the importance of treating these measures separately when characterizing the benthic habitat (Fukunaga et al., 2019). Fractal dimension that combined structural information from different spatial scales (1 to 64 cm in this study) was the most robust measure of complexity among all those examined. Further investigations into characterization of coral reef habitats should focus on obtaining metrics at relevant spatial scales that are complementary to fractal dimension.

- A study led by JIMAR Fisheries Economic Specialist Emily Rollins developed several single- and multi-region input-output models using economic data from a survey of charter fishing operations in the state of Hawaii (Rollins et al., 2019). This industry accounted for nearly $50M of sales and supported over 850 jobs in 2011. County scale and state level models were built to observe regional effects, and the state model is linked to secondary mainland regions to observe external economic effects, which has relevance due to Hawaii's dependence on mainland supplies. The relatively novel multi-region approach allowed the team to observe spillover effects (effects occurring in the secondary regions in response to a demand in the study region) and feedback effects (further effects that occur in the study region as a result of purchasing goods and services by the secondary regions). The results from this multi-region model method are informative and broad reaching as they capture the spillover and feedback effects that would otherwise be lost as leakages.

- To expand understanding of short-finned pilot whale ecology, JIMAR Cetacean Research Program Supervisor Marie Hill led research within the Mariana Archipelago to investigate individual associations, movements, spatial use, and dive behavior of short-finned pilot whales. The team collected genetic, photo identification,

and satellite tag data to identify 191 distinctive individuals. A preliminary social network diagram of photo cataloged individuals revealed a main cluster of 82% of individuals, and kernel density estimates for tagged short-finned pilot whales were used to identify areas with the highest probability of use (10% probability density contour), core area (50%) and home range (95%). Satellite tag data suggest some individuals are island associated year-round. Data from location dive tags demonstrated that short-finned pilot whales dive more often to intermediate depths at twilight and night, suggesting they may target prey foraging on the deep scattering layer as it migrates to and from the surface (Hill et al., 2018).

- In tropical tuna purse seine fisheries in the Pacific Ocean, juvenile silky sharks comprise a large proportion of the total elasmobranch bycatch, but there is growing recognition of declines in their population and a need for international conservation. In a study led by JIMAR Science Program Manager Melanie Hutchinson, the movement behavior of juvenile silky sharks was investigated using pop-up satellite archival tags placed on sharks captured during chartered research cruises on a commercial tuna purse seine fishing vessel in the western and central Pacific Ocean and on sharks captured using pelagic longlines in the eastern tropical Pacific (Hutchinson, et al., 2019). Tag data revealed that silky sharks spend nearly 100% of their time in the shallow, warm waters of the mixed layer, which overlaps, with the preferred habitat of the primary target tuna species, indicating they are vulnerable to capture in both purse seine and longline fisheries. Their movement paths also cross adjacent national jurisdictions and international waters, highlighting the need for international collaborations in the implementation of conservation measures.

- The oceans are warming and coral reefs are bleaching with increased frequency and severity, but in the central equatorial Pacific, some of the most productive reefs regularly experience extreme heat associated with El Niño. A study led by JIMAR Supervisory Coral Reef Ecological Oceanographer Hannah Barkley used skeletal signatures preserved in Jarvis Island corals to evaluate responses to multiple successive heatwaves since 1960. By tracking skeletal stress band formation from 1960 through the 2015-16 El Niño, which killed 95% of Jarvis corals, they found occurrence of eight severe (>30% bleaching) and two moderate (<30% bleaching) events, each coinciding with El Niño (Barkley et al. 2018). While the frequency and severity of bleaching did not increase over this time period, 2015–16 was unprecedented in magnitude. The trajectory of recovery of this historically resilient ecosystem will provide critical insights into the potential for coral reef resilience in a warming world.

Transitioning to Products and Services

A major focus for JIMAR researchers is to transition research outcomes to operational products and services and to 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 and gray literature scientific output, but also data administration from every relevant Pacific Island and State of Hawaii fishery, processed satellite data, stock assessment model improvements and outputs, coral reef benthic habitat and fish assemblage information, oceanographic data, Hawaiian monk seal population dynamics data, marine turtle nesting data, marine turtle biological and ecological information, fish life history data, collected marine debris data, socioeconomic indicators and survey data, cetacean counts and identification data, etc.

Regional and global sea level change studies by JIMAR researchers at the UHSLC have yielded assessments and forecast tools of high sea level events up to six months in advance in the Pacific Islands region. Using new dynamical and statistical modeling techniques, the UHSLC has been able to provide notice of flooding threats weeks to months in advance and assisted the NWS with the issuance of public warnings. The seasonal sea level forecasting assessments established for the Pacific Islands are being extended to all U.S. coastlines under a NOAA-funded Modeling, Analysis, Predictions, and Projections (MAPP) project led by JIMAR researcher Matthew Widlansky. The coastal high water level forecasts are being conducted by a NOAA task team that also considers forecasts for marine living resources.

In addition to transitioning their research accomplishments, the UHSLC scientists continue to ensure that tide gauge data from nearly 500 stations around the world, more than 80 of which are maintained by UHSLC, are collected, quality assessed, distributed, and archived for use in monitoring and research applications related to climate, oceanography, ocean engineering, and geophysics. 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, as 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. Within JIMAR's tropical oceanography, meteorology and climate themes, UHSLC datasets were utilized in 47 peer-reviewed research articles, three governmental agency reports, and two academic theses during FY 2019. UHSLC researchers were lead authors on the sea level section in the State of the Climate in 2018 report published in September, 2019, as a supplement to the Bulletin of the American Meteorological Society. As well, Dr. John Lyman, in the JIMAR Argo team at NOAA's Pacific Marine Environmental Laboratory (PMEL), contributed analyses of ocean state variables using Argo and other data for the Global Oceans chapter of the State of the Climate in 2018 report.

JIMAR researchers and administrators make fundamental contributions to the success of the PacIOOS, which empowers ocean users and stakeholders at many Pacific islands by providing accurate and reliable coastal and ocean information, tools, and services that are easy to access and use, and are often incorporated in NWS forecasts. PacIOOS continues to operate and maintain over 30 deployed buoys and sensor suites (variously measuring temperature, salinity, turbidity, chlorophyll, CO_2, etc.) across the U.S. Pacific Islands, allowing resource managers and community groups to collect accurate nearshore water quality measurements to support monitoring efforts. PacIOOS' wave buoys in Hawaii and in the Mariana Islands recorded record-breaking wave heights during typhoons, hurricanes, and other storm systems this past year. A variety of forecasts are made available to the public, including coastal inundation, wave, ocean, and atmospheric forecasts. For the development of a new wave run-up forecast for West Maui, instruments were deployed to gather pressure, current, and wave data; and community training workshops were held to help with the validation of the forecast through photo documentation. PacIOOS closely works with state and federal agencies, non-profit organizations, academic institutions, and other partners to make coastal and oceanographic data publicly available at the PacIOOS website (https://pacioos. org) and data visualization platform, *PacIOOS Voyager* (https://pacioos.org/voyager). PacIOOS supports local organizations to make 'citizen scientists' data available on PacIOOS Voyager, such as the *Hui O Ka Wai Ola* water quality data and the King Tides Project. PacIOOS staff led or contributed to multiple publications associated with the OceanObs'19 conference in September, 2019.

The NOAA research fleet includes 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 maintain and upgrade the ADCP data acquisition and processing software, called UHDAS, on NOAA vessels and will install UHDAS on two new NOAA vessels this year. The staff provide training and consulting on UHDAS usage and interpretation of acquired data, and are working with NOAA to establish the data pipeline from the ships to the National Centers for Environmental Information so observations are available to researchers as quickly and correctly as possible.

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-12.0 binaries and source in 2017 that have been downloaded 2725 times. A planned 2018 release was delayed through this year to focus on a key feature for multiple CPU deployment. The version control repository recorded a total of 637 changes and fixes to the software from the previous release ADMB-12.0. Since 2011, ADMB has been cited 1388 times (via Google Scholar) with 250 citations in 2018 and 106 citations as of June 2019.

At NOAA/PMEL, JIMAR staff are working with U.S. and International Argo Project partners to improve the already highly successful Argo observational float platform: (i) testing, deployment, and data/engineering evaluation of conventional Argo floats; (ii) testing, deployment, and data/engineering evaluation of the newer Deep Argo float; and, (iii) delayed-mode quality control of conventional and Deep Argo float data for ocean climate change research.

Outreach and Education

JIMAR devotes personnel time and funding for educational opportunities for K-12 students through to postgraduate research training. The PIFSC Young Scientist Opportunity (PYSO) Summer Intern Program is one of the educational events sponsored by JIMAR. The PYSO is a collaborative program between PIFSC and JIMAR that offers 3-4 qualified undergraduate students from across the nation the opportunity to acquire

professional research experience and training on summer science projects under the mentorship of selected PIFSC and JIMAR researchers at PIFSC. JIMAR projects also regularly hire University of Hawaii undergraduate students to work on projects as paid workers. Other UH undergraduates participate in projects as volunteers.

JIMAR projects supported 12 Graduate Assistant students during this reporting period, primarily at the University of Hawaii. All are pursuing Masters or PhD degrees in oceanography, marine sciences, and social sciences. JIMAR is also supporting UH graduate student Paige Okamura's efforts to translate Hawaiian newspaper articles from the 1800's that are of environmental and geophysical relevance. Progress of her work can be found in the tropical meteorology section of this report.

Given its remote locale, JIMAR has been funding a Visiting Scientist Program that provides an important mechanism to engage with experts from around the world. JIMAR also sponsors trips by JIMAR researchers to international conferences and workshops.

To educate and engage the general public, JIMAR staff continually engage in numerous outreach activities. JIMAR staff participate in UH and community events, such as the biennial SOEST Open House, the annual Waikiki Aquarium Family Night, Honolulu Seafood Festival, Hawaii Fish and Dive Expo, the weekly Hanauma Bay Education Lecture Series, and local fishing derbies, manning tables at events in the community, various expositions and conferences, events at local hotels to educate tourists on ocean concerns, fishermen forums and workshops, etc.

JIMAR staff participate in elementary, middle, and high school career and science day events, provide hands-on training for volunteers on observing and handling marine turtles and other protected species, facilitated and coordinated the 2019 NOAA Fisheries Teacher Workshop, contribute to NOAA/NMFS/PIFSC blog postings and provide other web content, conduct and facilitate tours of the Inouye Regional Center facilities for VIPs and other visitors, and coordinate and conduct 'newsroom' sessions each month in the PIFSC to harmonize science communications, education, and outreach messaging for scientists in PIFSC.

JIMAR researchers regularly meet with fishermen and fisheries observers in the Pacific Islands Region to discuss and educate bycatch mitigation efforts for protected species. JIMAR staff also meet with local and U.S. territorial government officials to communicate scientific endeavors within their jurisdictions. Tours were conducted on the NOAA Ship *Hi'ialakai* while in port in American Samoa as part of reef monitoring activities, and JIMAR staff escorted local school children, government officials, and the general public to view the vessel and interact with the scientists.

During the 2018 marine debris mitigation effort, JIMAR staff member Kevin O'Brien was extensively interviewed for the CBS News program '60 Minutes' (aired on January 3, 2019). Eleven million viewers watched the segment that focused on the problem of plastics in the oceans. Several other interviews were conducted for various print media for the same project and the local news media and school children were invited to the Inouye Regional Center in November 2018 to view and sort through the extensive marine debris brought back to Honolulu from Midway and other islands and atolls in the Northwestern Hawaiian Islands.

JIMAR researcher Jonathan Whitney collaborated with a photographer to document larval fish interactions with plastics in surface slicks during a 2018 field mission off the Kona coast of the Island of Hawaii. The resulting photographs were featured in an article published in the May 2019 issue of National Geographic magazine.
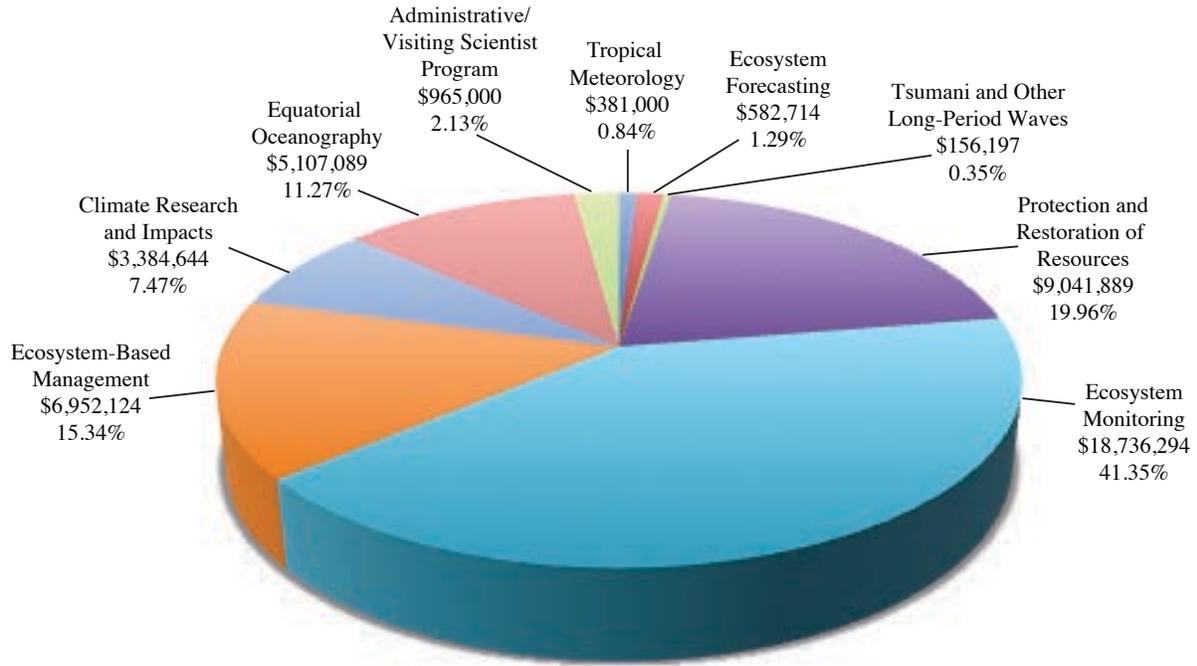
It has been a busy and productive year for JIMAR. The project descriptions on following pages will provide a better glimpse of the significant roles that JIMAR plays as a Cooperative Institute linking the academic opportunities available at the University of Hawaii to NOAA's concept of resilient ecosystems, communities, and economies.

JIMAR Structure and Funding

The Director of JIMAR, Dr. Douglas S. Luther, is a regular member of the University of Hawaii faculty 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 day-to-day operations through the administrative staff (fully-supported by the Cooperative Agreement and returned indirect cost funds), Program Managers and faculty PI/Directors. 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 Hawaii.

The following chart indicates how funds flowing through JIMAR are distributed according to the JIMAR research themes listed in the Research section above.

Distribution of NOAA Funding by Theme

Administrative/
Visiting Scientist
Program
$965,000
2.13%

Tropical
Meteorology
$381,000
0.84%

Ecosystem
Forecasting
$582,714
1.29%

Tsumani and Other
Long-Period Waves
$156,197
0.35%

Equatorial
Oceanography
$5,107,089
11.27%

Climate Research
and Impacts
$3,384,644
7.47%

Protection and
Restoration of
Resources
$9,041,889
19.96%

Ecosystem-Based
Management
$6,952,124
15.34%

Ecosystem
Monitoring
$18,736,294
41.35%

Accomplishments for Fiscal Year 2019

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

P.I.: John R. Sibert

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

NOAA Sponsor: Michael P. Seki

NOAA Goal(s):

- 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 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 NOAA Fishery Science Centers to create stock assessment tools. Specifically, the project aims to: 1) improve and maintain software installation and manuals for end users; 2) improve software quality and more fully apply the ADMB coding standard; 3) enhance the software with new features to improve run time efficiency and model development; 4) improve long-term maintainability of the source code; and 5) upgrade previous generation C++ coding standards to modern C++ coding standards. The project maintains a long term goal to support the ADMB software through an active and committed group of users and developers located in laboratories and universities around the USA and the world.

Progress during FY 2019

The main objective of the ADMB Open Source project is to regularly maintain and improve the AD Model Builder software. Developers will make available a yearly software release that may include bug fixes, improvements and possible new features. As of June 2019, the ADMB-12.0 binaries and source distribution released in 2017 have been downloaded 2725 times. The planned 2018 release was delayed to 2019 to focus on a key feature for multiple CPU development. Development of the feature will continue during the next fiscal year. The version control repository recorded a total of 637 changes and fixes to the software from the previous release ADMB-12.0. The ADMB software is used by NOAA science centers and researchers and scientists worldwide. Since 2011, ADMB has been cited a total of 1388 times according to Google Scholar with 250 citations in 2018 and 106 citations as of June 2019.

Research Support for PMEL Earth-Ocean Interactions Program (EOI), Ecosystems Fisheries-Oceanography Coordinated Investigations Program (Eco-FOCI), and Carbon Research Program

P.I.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock

NOAA Goal(s):

- Climate Adaptation and Mitigation

Purpose of the Project

The purpose of this project is to provide research and laboratory support for the following PMEL research programs: Earth-Oceans Interactions Program (EOI); Ecosystems Fisheries-Oceanography Coordinated Investigations Program (Eco-FOCI); and the Carbon Research Program.

Progress during FY 2019

Variability of the ocean circulation in the Alaska Gyre is one of the factors influencing the rich ecosystem in the Gulf of Alaska. Improved understanding of the variability in the Alaska Gyre structure and transport and its place in the larger picture of North Pacific global climate modes, such as the Pacific Decadal Oscillation (PDO), is therefore of prime concern given its biologic and economic implications.

During the final months of the project Hristina Hristova finalized the manuscript on the interannual variability and trends of the Gulf of Alaska circulation. The manuscript was accepted for publication in the *Journal of Geophysical Research*. (Hristova, H.G., C. Ladd, and P.J. Stabeno, accepted. Variability and trends of the Alaska Gyre from Argo and satellite altimetry, *Journal of Geophysical Research*).

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

Biogeochemical Modeling at the University of Hawaii: Simulating the Marine Ecosystem and the Ocean Carbon Cycle of the Main Hawaiian Islands and Kaneohe Bay

**Lisa Hahn-Woernle, JIMAR Postdoctoral Researcher**

Purpose of the Research

The main objectives of this research are to: 1) develop a coupled physical and biogeochemical modeling capability at the University of Hawaii; 2) configure this coupled model for different regimes (Antarctica and Hawaii), and for different scales, main Hawaiian Islands (4 km) and Kaneohe Bay (100 m); and 3) test the model configurations to various available observations.

Progress during FY 2019

Significant progress was made during FY 2019. The Regional Ocean Modeling System (ROMS) hydrodynamic physical ocean model was successfully coupled to the NOAA Geophysical Fluid Dynamics Laboratory Carbon Ocean And Lower Trophics (COBALT) geochemical model and configured for three different cases: a fjord on the Western Antarctic Peninsula; the main Hawaiian Islands; and Kaneohe Bay. This involved extensive analysis of various data to define fields at the open boundaries, initial state of the ocean, and seasonal forcing fields.

As an example, for the main Hawaiian Islands, a coupled simulation of the period 2010–2017 was recently completed. The physical forcing was provided by a decadal state-estimate reanalysis of the ocean physics based on the NOAA PacIOOS Hawaiian Island Ocean Forecast. Biogeochemical boundary conditions were provided by NOAA collaborator Dr. Charles Stock. Figure 1 provides insight into spatial resolution of the model and the strong response of the ecosystem to the ocean physics. Initial model results exhibit promising agreements of numerous
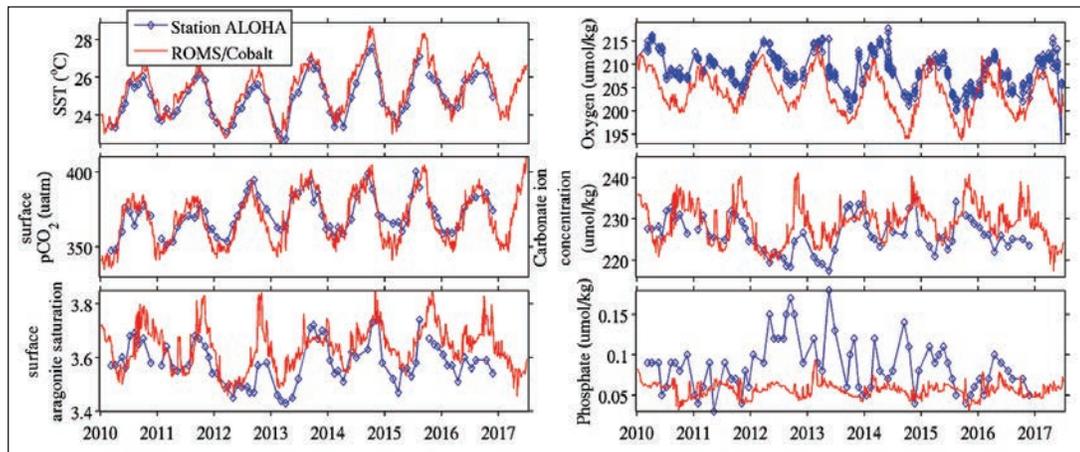
(above) Figure 1. Snapshot of the simulated average chlorophyll concentration [µg kg⁻¹] over the upper 100 m during fall 2016 based on the coupled physical and biogeochemical model of the main Hawaiian Islands.

(right) Figure 2. Comparison of surface parameters simulated with the coupled model (red) to Station ALOHA observations (blue).

biogeochemical parameters simulated by the coupled model and observations at Station ALOHA (A Long-term Oligotrophic Habitat Assessment; Fig. 2). Comparing simulated surface variables to observations from Station ALOHA reveals that the coupled physical and biogeochemical model can successfully reproduce the annual cycle of important carbon-cycle parameters.
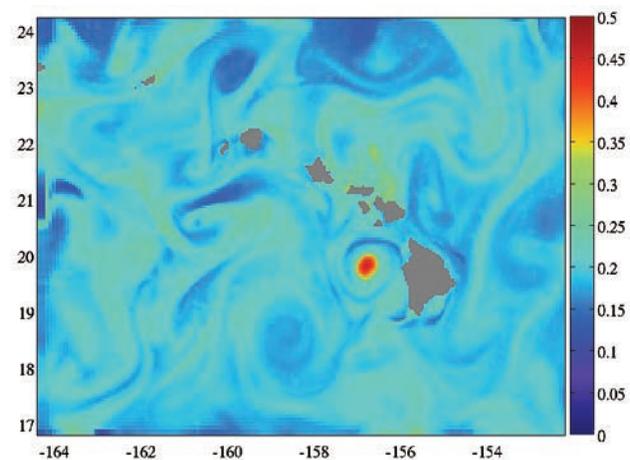
Future Research Plans

The oceanic circulation around the main Hawaiian Islands is subject to substantial meso- and submesoscale activity. Dr. Tobias Friedrich of PacIOOS will continue working with the Hawaiian Island model to explore how these processes affect the marine ecosystem and the ocean's carbon cycle around the main Hawaiian Islands and in Kaneohe Bay. Through close collaboration with the Center for Microbial Oceanography: Research and Education (C-MORE), the Hawaii Institute of Marine Biology (HIMB) and other partner researchers, this work will elucidate the role of eddies, hurricanes/tropical storms, and volcanic eruptions in driving primary productivity and in controlling carbon cycle parameters. Future simulations will also be conducted to study the characteristics of ocean acidification in Hawaiian waters for the 21st century.

Dr. Lindsay Veazey, a researcher in UH Oceanography professor Dr. Brian Powell's laboratory, will use the coupled physical and biogeochemical model of Kaneohe Bay to gain new insight about the drivers of the abnormally high larval recruitment event observed across Hawaii during 2013–2014. The unique subdivision into six plankton types in the ecosystem model is expected to provide further insight into the lower trophic levels that support important herbivorous fish populations that are established in the culturally significant fishponds around the bay.

Presentation

- Hahn-Woernle, L., Ecosystem physics of a WAP Fjord: A modeling study of key controlling factors. Department of Oceanography Seminar, University of Hawaii at Manoa, March 28, 2019.

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.

Data Validation at the Hawaii MAPCO2 Buoy Network in Support of a Test-Bed for Technology Development

P.I.: Eric Heinen De Carlo

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

NOAA Sponsor: Gary Matlock

NOAA Goal(s):

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

Purpose of the Project

The primary objective of this project is to carry out expanded field sampling for inorganic carbon parameters in the water column of tropical coral reefs, particularly concurrent with the deployment of new technology by project research partners, and carry out laboratory-based data validation analyses that were previously not possible with the limited resources provided by other funding agencies supporting the project's Ocean Acidification (OA) research. This project also directly supports recent efforts to operate a NCRMP Class III station at the CRIMP-2 buoy location.

Progress during FY 2019

The project continued to support broad agency (NOAA/PMEL, NOAA/OAP) based efforts to develop technologies to monitor coastal processes, with emphasis on the inorganic carbon system (CO_2-carbonic acid system) and ocean acidification (OA). The CRIMP-2 buoy is an NCRMP Class III (climate level) observing station, one of two in the Pacific, and an important asset supporting the goals of the national and global OA observing efforts. The project continued 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). Sampling takes place at four NOAA (PMEL, OAP and Sea Grant) supported MAP-CO2 buoys that are deployed on coral reefs around the island of Oahu, Hawaii. The project also conducted short term high intensity sampling experiments in conjunction with projects undertaken by academic and agency colleagues whose objectives are to: 1) derive a better understanding of processes driving coral reef metabolism near the fixed MAP-CO2 buoy sites; 2) develop and test new technology permitting precise and accurate automated measurement of two of the four CO_2-carbonic acid system (with PMEL and SIO colleagues); and 3) continue the long standing high frequency time-series pCO_2 (11th year) observations on a coral reef environment. Project researchers also participated in NSF and OAP sponsored inter-laboratory comparisons (for inorganic carbon system parameters) conducted by Dr. Andrew Dickson of SIO. The group typically obtains excellent ratings of these analyses that are conducted by a graduate student sponsored by a NOAA/UH Sea Grant project.

Ecosystem Structure and Function

P.I.: Douglas S. Luther [JIMAR Project Lead: Melanie Abecassis]

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 further advance understanding of the structure and function of an important marine ecosystem, the subtropical gyre. This work includes a range of approaches to increase understanding of this ecosystem, in particular, how trophic structure is impacted by climate variability and change. One component of the project consists of processing and analyzing a time-series of lancetfish stomach contents collected by observers in the Hawaii-based longline fishery to develop an index of the pelagic micronekton community. This index is then used to describe the spatial and temporal patterns of micronekton across the central North Pacific. Another component of the project examines fishery dependent data sets (observer, logbook, and dealer records from the Hawaii based longline fishery) in conjunction with oceanographic data to assess spatiotemporal trends in catch composition and 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.

Progress during FY 2019

   The longnose lancetfish (*Alepisaurus ferox*) is a midtrophic, mesopelagic predator found circumglobally at tropical and subtropical latitudes and is known mostly from reports of incidental catch in tuna and swordfish longline fisheries. Lancetfish appear to store food in their stomach for extended periods with minimal digestion, allowing for detailed prey identification. During the year, a University of Hawaii (UH) JIMAR graduate assistant documented the contents of about 350 lancetfish stomachs, identified prey items to the species level, documented unknown species, and worked with experts in the field to identify cephalopod and fish species by providing them with valuable samples. All diet data was entered into a dedicated database and is being correlated with environmental variables in the central north Pacific to determine spatial and temporal patterns.

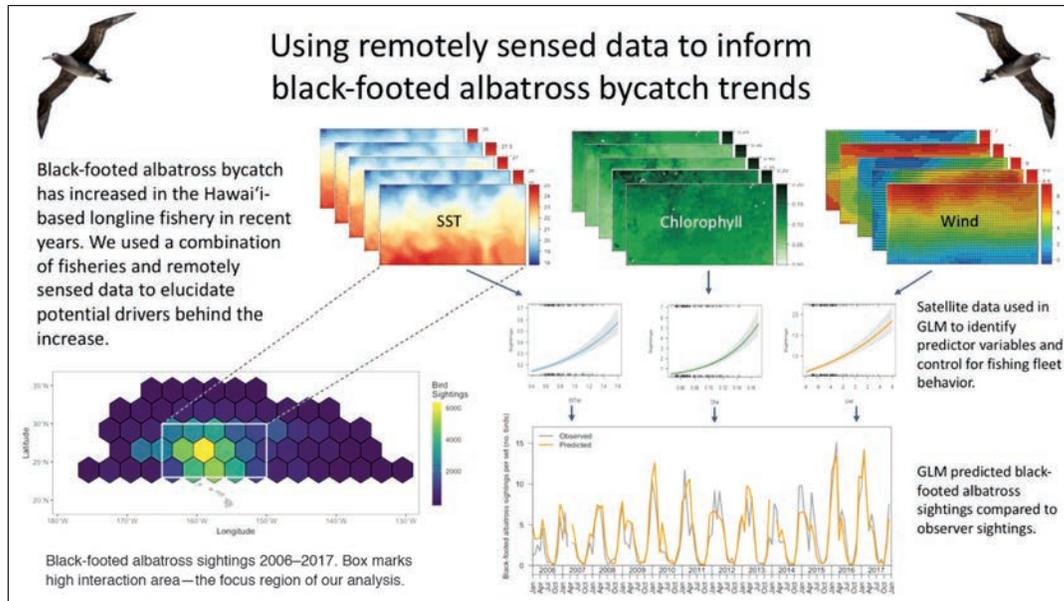*Figure 1. Image of lancetfish being measured in the lab.*

Figure 2. Approach used to investigate trends in black-footed albatross bycatch.

Interactions between black-footed albatross and the Hawaii deep-set longline fishery (HDLL) increased three fold over the period 2015 through 2017 compared with the previous eight years (2006–2014). JIMAR project researchers investigated the factors behind the increased interactions and discovered that the increase in black-footed albatross sightings (used as a proxy for interactions) with the HDLL in 2016–2018 was due to a positive Pacific Decadal Oscillation (PDO) and El Niño. The increase in interactions is likely due to one or two reasons: an increased overlap between the black-footed albatross foraging grounds and the HDLL fishing grounds; and the black-footed albatross taking advantage of stronger and more southward displaced westerly winds, thus changing their transit to feeding grounds through the HDLL fishing grounds and not to the north of them as is the norm. This finding was supported by GPS tracking data that showed that black-footed albatrosses spent 42% more time south of 30°N during positive PDO phase years compared to negative PDO phase years. After finalizing this analysis JIMAR Research Analyst Dr. Johanna Wren presented the results at a seabird mitigation workshop convened by the regional fishing council in Sept. 2018. A manuscript was submitted and is under review.

Dr. Wren analyzed networks of fish species interactions in the longline fishery and ran analyzed simulations of larval dispersal in different types of mesoscale eddies (cyclonic and anticyclonic, linear and non-linear) around the Hawaiian Archipelago. She co-authored a manuscript of these results that was recently submitted for review. She also worked on particle simulations of diel vertical migration to identify potential habitat for insular false killer whales (*Pseudorca*), a protected species interacting with the longline fishery.

JIMAR Climate Vulnerability Analyst Dr. Jonatha Giddens coordinated efforts for the Pacific Islands Vulnerability Analysis project. She compiled profiles for all 83 fish and invertebrate species as well as the vulnerability narratives from 30 different experts in a manuscript entitled, "Assessing the vulnerability of marine life to climate change in the Pacific Region" which was submitted for review.

Finally, an assessment of eddy activity in the Hawaiian Archipelago region was conducted using an eddy characterization algorithm. Eddies are obtained from a simulation with the Massachusetts Institute of Technology general circulation model (MITgcm) that was completed in the prior year. The analysis showed that spatially, eddy births are more frequent: 1) along the nearshore (for cyclones) and offshore (for anticyclones) corridors on the windward side of the main Hawaiian Islands; 2) in the islands' leeward region with distributions of cyclones and anticyclones that resemble the dipole structures of wind stress curl; and 3) in zonal bands of both eddy polarities west and north of the islands. Temporally, high eddy activities occurred in the spring. There is a meridional distribution of eddy lifespans that increases northward. Cyclones are more abundant, longer-lived, smaller, and more nonlinear. Reef fish spawning locations in Hawaii coincide with the regions of high eddy activity, with nonlinear eddies responsible for high larval retention.

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, Evan Howell

NOAA Goal(s):

• Healthy Oceans

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: Environmental Data Management; Large Marine Ecosystem/ Ecosystem-Based Fisheries Management Coordination; Aquaculture Systems Management; and Outreach and Education.

Environmental Data Management to Support Fisheries and Ecosystem Research. This JIMAR effort continuously supports fishery and ecosystem research and data management within the Western and Central Pacific Ocean (WCPO) region. The overall objective of this project is to provide JIMAR database development, data management, and data application development support and services to scientists and resource managers at the Pacific Islands Fisheries Science Center (PIFSC) to facilitate quality scientific research and resource management.

Large Marine Ecosystem/Ecosystem–Based Fisheries Management Coordination. Over 30 years ago, NOAA developed the Large Marine Ecosystem (LME) concept as a model to implement ecosystems approaches to assessing, managing, recovering, and sustaining resources and environments. LME's are relatively large areas of ocean space adjacent to land masses where biological primary productivity is nominally higher than open ocean regions. The extended Hawaiian Archipelago comprises one of the identified LME's and is the primary emphasis zone for JIMAR and PIFSC research.

In 2016, the NOAA National Marine Fisheries Service (NMFS) formally established a commitment to Ecosystem–based Fisheries Management (EBFM). EBFM essentially determines a holistic approach to meet fisheries conservation and management mandates by balancing ecological well-being and human well-being through good governance. Fisheries management has historically focused on management of a single species or complex, but EBFM establishes ecosystem considerations synthesized across diverse disciplines and data streams. Effective implementation of an ecosystem approach requires that scientists and managers continuously communicate and share data on the ecosystems of the Pacific Islands Region (PIR). Because many of the threats to coastal ecosystems are land-based or the result of activities occurring shoreward of the U.S. Exclusive Economic Zone (EEZ), collaboration with the State of Hawaii, U.S. Territories of the Pacific, and other key partners is integral to successfully advancing EBFM across the PIR. These exchanges require focused coordination, which JIMAR provides across federal, state, and territorial science and management programs.

PIFSC coordinated with federal partners to compile the EBFM Implementation Plan for the Pacific Islands Region (2018–2022). The plan serves as the operating document to progress toward EBFM in the near and longer term for the PIR and initially within the Hawaiian Archipelago LME.

Aquaculture Systems Management. The Aquaculture System Management project provides system management for the Seawater System (SWS) facility 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.

Pacific Islands Region Fisheries Science Outreach and Education. The objectives of this JIMAR effort are to plan, develop and implement an effective outreach and education program via a partnership between JIMAR and PIFSC. JIMAR staff serves 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
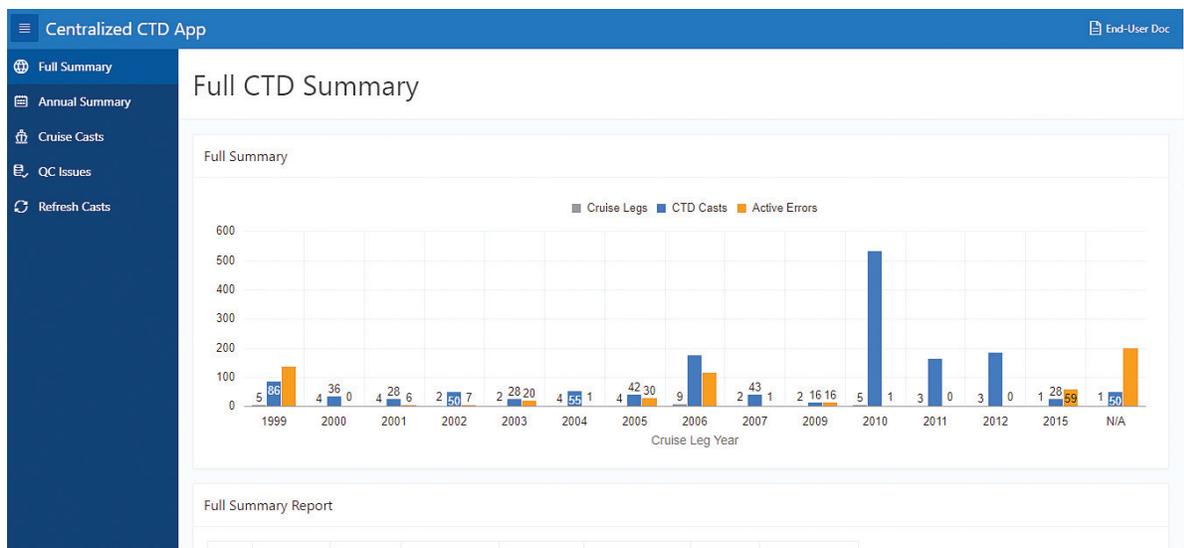
Figure 1. Screenshot from the current version of the CTD data system's web application showing the summary report chart of all research cruise legs grouped by year.

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.

Progress during FY 2019

Enhanced Environmental Data Management to Support Fisheries and Ecosystem Research. Led by Jesse Abdul, the project provided data management and application development support and guidance to the Ecosystem Sciences Division (ESD), Science Operations Division (SOD), and Fisheries Research and Monitoring Division (FRMD) for multiple data projects throughout the year. This included reviews and feedback to facilitate projects, performing setup and troubleshooting, developing software solutions, and compiling documentation. The project facilitated PIFSC and PIRO compliance with the NOAA Public Access to Research Results (PARR) requirement by providing support and guidance to data staff and maintaining the tools and procedures to enable public access to their scientific data sets. JIMAR staff helped to ensure the goal of 100% PARR compliance during the three-year PARR project.

The project formed the Software Development Team (SDT) and led biweekly meetings with representatives from each PIFSC division to discuss common data needs, collaboration opportunities, and reviewed and recommended software standards, best practices, tools, and procedures to improve the quality of scientific data management.

Another accomplished project goal was identifying collaboration opportunities between divisions on data projects was another goal for the project year. Throughout the year the project collaborated with the ESD data management staff on data projects that could improve the quality of their data management. JIMAR staff recommended multiple software modules and procedures to ESD and performed extensive software development to upgrade an existing software module and deploy it for field testing during the 2019 field season. The project also collaborated with the FRMD to develop a generalized approach to making non-confidential fishery data summaries securely available from the enterprise database, and plans to discuss this topic with the SDT. The project proposed several software standards and best practices for PIFSC to the SDT, which regularly collaborated in the review and feedback process.

Prior to the start of the year, the project established a goal to provide support and guidance for the integration of data holdings across divisions to increase the usability of the data. JIMAR developed a prototype Centralized Cruise Database (CCD) to manage all PIFSC cruise information and this system will allow all research divisions to integrate their scientific data with the cruise database. An initial working prototype of a centralized Conductivity, Temperature, Depth (CTD) database will enable the management of all CTD data collected by PIFSC. JIMAR integrated the CCD into the CTD database and provided it as an example of integrating data across databases.
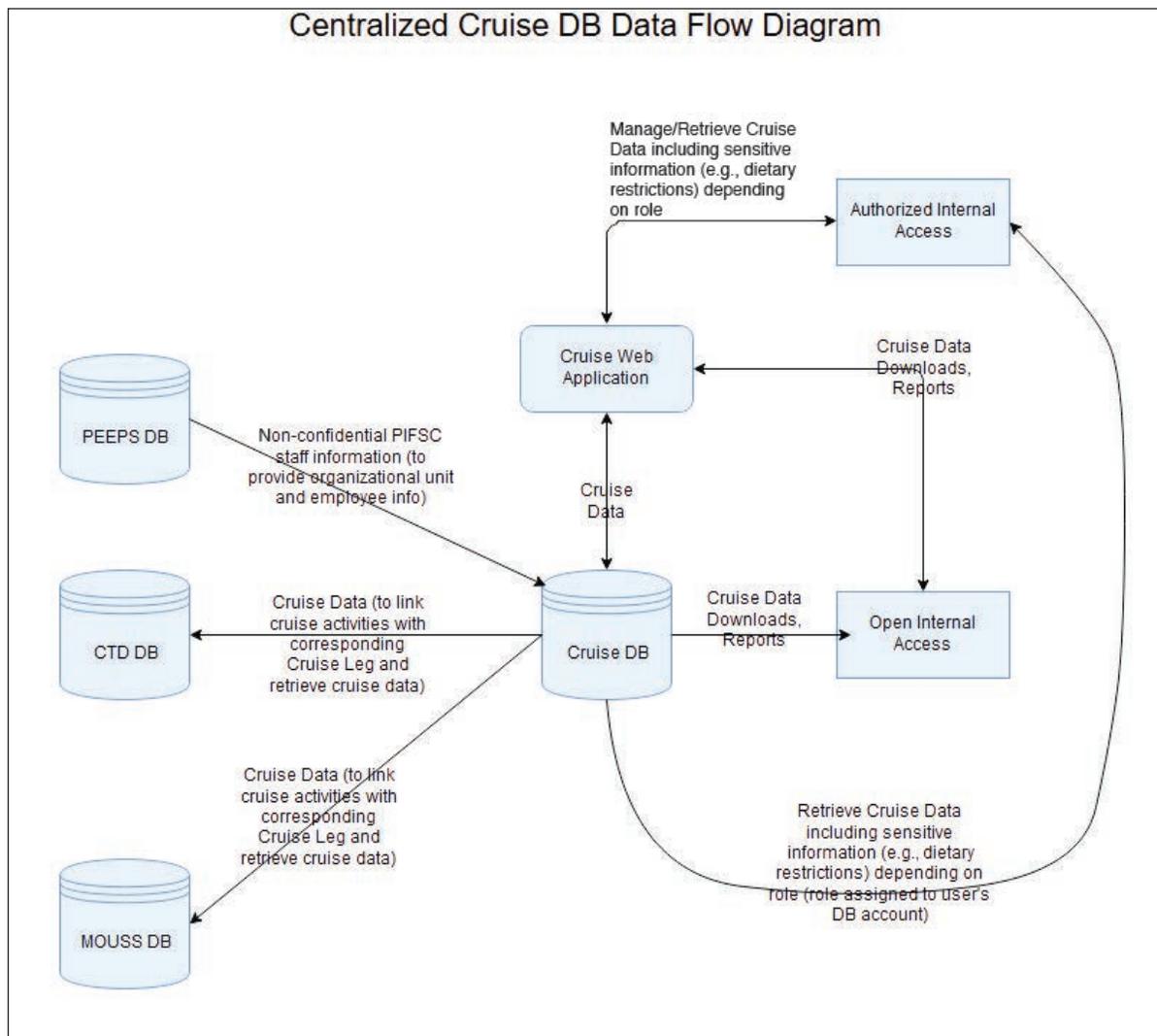
Figure 2. Formal data flow diagram for the current version of the CCD showing how it relates to other enterprise database schemas.

The project also developed a Data Integration standard operating procedure (SOP) that can be used by any PIFSC division to easily define the relationship between their scientific data and the CCD using a code template. This SOP will be developed further to define how to integrate any two enterprise databases within the project year.

The project developed multiple draft data standards and best practices throughout the year in the areas of application development, database development, and technical documentation. A formal review and feedback process was undertaken for seven software standards/best practices with the SDT and submitted to the PIFSC Data Governance Council (DGC) for organization-wide adoption; an additional three software standards are currently in the review process with the SDT. The project drafted multiple SOPs throughout the year for deploying end-user applications, requesting Oracle resources, automating backend testing, integrating data, and guiding software development by contractors. Various SOPs were developed for the Modular Optical Underwater Survey System (MOUSS) data operations that were compiled during the 2018 MOUSS research cruise. Two proposed SOPs were submitted to the SDT, one of which was reviewed and submitted to the DGC to date. The Data Integration SOP addresses the integration phase of the data life cycle. Throughout the reporting period JIMAR developed and updated multiple data tools including a shared database utility package and a flexible automated backend testing method that will be presented to the SDT. The project completed the first phase of the CTD data standardization project fulfilling a PIFSC milestone. The JIMAR project developed a data model, a flexible automated data

Figure 3. Local middle school educators participate in the 2019 NOAA Fisheries Teacher Workshop at the Inouye Regional Center.

import module, data quality control (QC) criteria, a web application for visualizing and downloading CTD data, and extensive documentation on the different aspects of the data system. The current CTD data system formally addresses the data collection and assurance phases of the data life cycle. The project began developing the technical specifications and data model for the CCD in preparation for developing a fully featured data system. JIMAR also integrated software standards and best practices developed over time by the SOD Data Team into all data projects.

Large Marine Ecosystem / Ecosystem-Based Fisheries Management Coordination. Led by Megan Asher, the JIMAR staff worked with the PIFSC Director's Office and a Pathways Intern student to research, define, and develop a draft document LME for the Mariana Archipelago. Existing information was used to define ecological, cultural, socioeconomic, and politically significant information relative to the archipelago. For a workshop held in July 2018, presentations and an informational document were developed to gain inputs on initiating the process. Efforts were also undertaken to present staff findings to partners and scientists of the Western Pacific Regional Fishery Management Council's Scientific Steering Committee and at other scientific meetings.

As information continues to be collated, valuable management and scientific inputs are being requested from the NOAA Pacific Islands Regional Office, PIFSC and JIMAR staff. In particular, the project continues seeking inputs in order to reveal where there are gaps in the layers of important ecosystem information and shape efforts in creating a valuable resource for stakeholders. Given the value tied to key partner engagement, the project plans to reach out to additional stakeholders as the document continues to move forward.

Aquaculture System Management. Led by Aaron Moriwake, JIMAR staff implemented a weekly exercise program and a year-round maintenance schedule to ensure system readiness for incoming animals (monk seal, turtle, fish, and multi-purpose) in the four distinct units. JIMAR staff trained turtle, monk seal, and SWS staff on system operations and coordinated daily activities within the SWS yard. Other support included troubleshooting and resolving maintenance issues, designing and making improvements to the facility, updating protocols, and conducting monthly safety assessments for the SWS facility. The project also archived records on repair, maintenance, and replacement of equipment in a shared Google document.

Within the reporting period, JIMAR provided support for thirteen turtles and several tests of equipment for PIFSC researchers. When animals are housed at the SWS facility, JIMAR staff provide 24/7 emergency support through email/text alarm alerts, and remote access control of cameras and the Supervisory Control and Data Acquisition (SCADA) system.

Pacific Islands Region Fisheries Science Outreach and Education. Led by Ali Bayless, the project produced 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.

Outreach and educational activities. Staff participated in community and educational events to communicate information about JIMAR and NOAA's missions, programs, and policies and encourage the public to learn about and support healthy ocean ecosystems and marine science research. Outreach events included opportunities to provide career guidance for students and inspire the next generation of marine scientists. In the past year, the project participated in the following events: Hawaii Conservation Conference; Inouye Regional Center Summer Intern Symposium; NOAA Discovery Day at Kapolei Library (Oahu); Marine Educator's Night; Career Fair at UH Mānoa; Hawaii Fish and Dive Expo; Moanalua High School Career Fair; Sacred Hearts Science Symposium for Girls; UH Marine Option Program visit to IRC; NOAA Teacher Workshop; Molokai Earth Day; Mauka to Makai Waikiki Aquarium Earth Day; Waipahu High School's Marine Science Career Presentation; North Shore Oceanfest; and World Ocean's Day.

2019 NOAA Fisheries Teacher Workshop. In March 2019, a group of middle school science teachers participated in an all-day teacher workshop at the NOAA Pacific Islands Region facility, the first of its kind. The workshop was a joint effort between the PIFSC and the PIRO. The hands-on activities included a fish dissection, a demonstration of how scientists determine the sex of a sea turtle using hormones, and an advanced technology show-and-tell. The teacher workshop was a great opportunity for teachers to learn first-hand about the exciting research NOAA Fisheries conducts and how NOAA Fisheries research helps to shape important management decisions. It's hoped that the inquisitive instructors will take what they learned at the workshop back to the classroom and inspire the next generation of conservation scientists and policy makers.

PIFSC Young Scientist Opportunity (PYSO). PYSO is a highly successful collaborative program coordinated by PIFSC and JIMAR that offers qualified undergraduate college science student participants professional scientific research experience and formal training opportunities tailored to meet their educational and professional goals and interests. In 2018, the PYSO program hired four highly-qualified undergraduate students to participate in summer research with JIMAR and federal staff at PIFSC. The 2018 PYSO students and field of research are described below.

- Isabelle Cunitz from the University of Oklahoma worked with the Advanced Technologies Program to design and implement the addition of artificial lighting to the Modular Optical Underwater Survey System stereo-camera apparatus.
- Maegha Lanka from Duke University worked with the PIFSC Cetacean Research Program to identify fin whale song recorded by High-Frequency Acoustic Recording Packages (HARP) in order to collect spatial and temporal occurrence data for this species.
- Mia Melamed from the University of Hawaii at Manoa worked with JIMAR's Rhonda Suka and Annette DesRochers using Structure from Motion software to create photomosaics to help refine efficiency of underwater data collection and processing on land.
- Dalton Solbrig from the University of Hawaii at Manoa worked on spatial and temporal analysis of fish larvae and plastics in slicks off the coast of Kona, Hawaii with the West Hawaii Integrated Ecosystems Assessment project.

Outreach and Science Communications. Newsroom sessions were established to develop and coordinate science communications, education, and outreach opportunities for research expeditions, scientific publications, and projects with staff from all PIFSC and JIMAR programs, PIRO, and external project partners.

Web Content. During the year, JIMAR contributed to numerous web postings including the following.

- Story Maps: 2018 Marine Debris Removal and Assessment in the Northwestern Hawaiian Islands
- Partnering to Protect Monk Seals and Sea Turtles in the Northwestern Hawaiian Islands
- Communicating Science in Saipan
- Passive Acoustics in the Pacific Islands

- Students on a QUEST (Quantitative Underwater Ecological Surveying Techniques) to Learn Underwater Surveying Techniques in American Samoa
- Observations of Fish, Birds, and Life at Sea in the Pacific Islands
- Interview with John Henderson of NOAA's Hawaiian Monk Seal Research Program
- Notes from Nihoa, A NOAA Seal Team Goes Airborne for a Critical Science Mission, Science and Stewardship in the Northwestern Hawaiian Islands
- Field Biologists Return from the Northwestern Hawaiian Islands
- Estimating the Number of Endangered False Killer Whales in the Main Hawaiian Islands
- Honu Count 2018: Help Us Find Numbered Sea Turtles in Hawaii
- Lessons Learned from Hawaiian Monk Seal Kahulu (RJ16)
- Seabird Sighting at Sea: Not Just Another Brown Booby
- Old Friends in New Places: Cetacean Research in the Western Pacific
- Photo Journal: Whales and Dolphins in the Marianas
- Saving Seals in the Northwestern Hawaiian Islands During Hurricane Season
- Survey to Track Whales and Dolphins in the Mariana Archipelago
- Motherload: The Story of a Fertile Turtle in the Hawaiian Islands
- #MIHumpbacks: The U.S. Coast Guard Sector Guam is Always Ready, Checking the Ocean's Pulse with Plankton
- From the Barracks to the Berth: An Army Veteran's Experiences Aboard a NOAA Ship
- Scientists Monitor Coral Reef Ecosystems Throughout the Hawaiian Archipelago
- Reef Resilience Through Herbivore Management Areas
- Fishermen and Scientists Work Together to Reduce Shark Bycatch in Hawaii.

Ecosystems Observations and Research Program: Science Operations Project

P.I.: 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 effective logistical, operational, and technical project support and lead the standard in safety and training for the Pacific Islands Fisheries Science Center's (PIFSC) research activities in the Pacific Islands Region (PIR). Five project elements are described below.

Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. In the PIR, commercial fish stocks are made up 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 gear can be customized to survey species-specific depths, habitat types, and spatial scales. As effective management of fisheries resources becomes more critical, advancements in data collection methodologies expands knowledge of target fish assemblage dynamics and supplement current fisheries data sets. 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. And as camera survey technologies continue to be developed, there will be a continuing need to evaluate new technology and standardize 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, the responsibilities of PIFSC scientists have grown such

Figure 1. NOAA-JIMAR small boat team conducting Modular Optical Underwater Survey System (MOUSS) operations during the Bottomfish Fishery-Independent Survey-Hawaii (BFISH) 2018. The North Kohala coast, Hawaii Island, is in the background.

that dedicated trained JIMAR staff is necessary to support planning and execution of desired science endeavors. Science operational staff directs research by collaborating with JIMAR investigators to plan the effective use of equipment and resources and ensure operations are conducted safely and according to established policy. This model allows the scientists to focus on their research objectives, while expert staff helps plan, coordinate, and execute safe and effective 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 staying on the cutting edge of fisheries research. Coordination between dedicated JIMAR staff and researchers of different disciplines provide a broader perspective in ascertaining survey and sampling technology needs and priorities. This centralized model allows technology to be assessed for availability and effectiveness for multiple users. The need for survey and sampling technology development on a broader scale at PIFSC is essential to fostering collaboration and maximizing utilization of technology assets. It provides opportunities for cost sharing and cross training to gain a wider range of expertise. This also allows scientists to focus on their research while still integrating the newest most cost effective way of data collection.

Geospatial Products. The need for improved 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 planning research programs and publishing 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 yet must still meet all requests related to accessing, processing and displaying spatial data. The JIMAR Geospatial Products Team (GPT) is a centralized resource providing 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 for continued development of products and tools that create effective ways to access, compile, and package Marine National Monuments of the Pacific data streams. These data streams are essential for planning research programs, publishing results, and supporting outreach and education activities and materials. The project helps facilitate collaboration with federal, state, local, and academic partners and coordinate NOAA scientific research within the Marianas Trench, Pacific Remote Islands, and Rose Atoll Marine National Monuments. To encourage
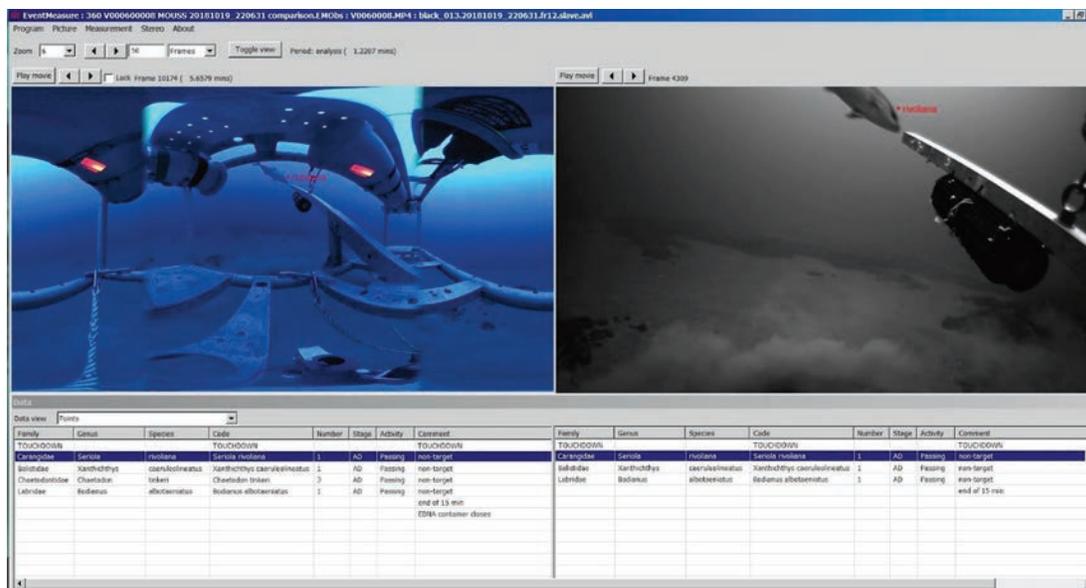
Figure 2. Three hundred sixty degree camera view (left) vs. MOUSS camera view (right) of the same fish.

collaboration, the project is working on a variety of ways to make data and products more readily available. By providing easy access to its repository of photos, The Monuments Photo Library Project aims to engage and inspire researchers and the general public. This project collaborates with different programs within the National Marine Fisheries Service (NMFS) to provide assistance with collecting archived photos, selecting the best images, cataloging, and updating metadata records for photos in preparation for data entry into Monuments Photo Library Interface.

Progress during FY 2019

Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. During the reporting period, JIMAR staff on the Analysis and Evaluation Team supported the Modular Optical Underwater Survey System (MOUSS), a stereo-video survey tool that provides non-extractive size-structured relative abundance estimates of fish species in their natural habitat. MOUSS surveys were conducted aboard NOAA Ship *Oscar Elton Sette* and an additional research fishing vessel, F/V *Ao Shibi IV* operated by the Pacific Islands Fisheries Group (PIFG). Analysis of the 2018 Bottomfish Fishery Independent Survey-Hawaii (BFISH) videos (308 total) was completed and the resulting size-structured species abundance data product was delivered to the Fisheries Research and Monitoring Division's (FRMD) Stock Assessment Program (SAP) in February 2019. During these analyses, a camera issue was identified in which 17% of the videos exhibited ~9 minutes of dropped frames. These dropped frames consistently affected only one of the paired stereo-cameras, so fish abundance estimates for stock assessments were unaffected; however length measurements were not possible for nine bottomfish out of 120 possible measurements. Ongoing analysis and troubleshooting tests are currently being conducted to troubleshoot the dropped frame issue and ensure it will not impact future bottomfish surveys. Directional camera systems are commonly 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 under or overestimate fish population due to fish going uncounted or double counted, JIMAR Survey and Sampling Technology Program (SSTP) staff began a preliminary MOUSS-360 video comparison study during the 2018 MHI bottomfish survey. This study utilizes off the shelf 360 cameras to capture a 360-degree "snapshot" view of the underwater environment. A total of 25 paired MOUSS-360 videos were successfully analyzed and early results suggest that a small percentage of bottomfish may currently go uncounted with the MOUSS system alone. Further paired MOUSS-360 comparison surveys will be conducted to allow for robust statistical analysis of MOUSS accuracy and extrapolating potential effects on resulting bottomfish abundance estimates.
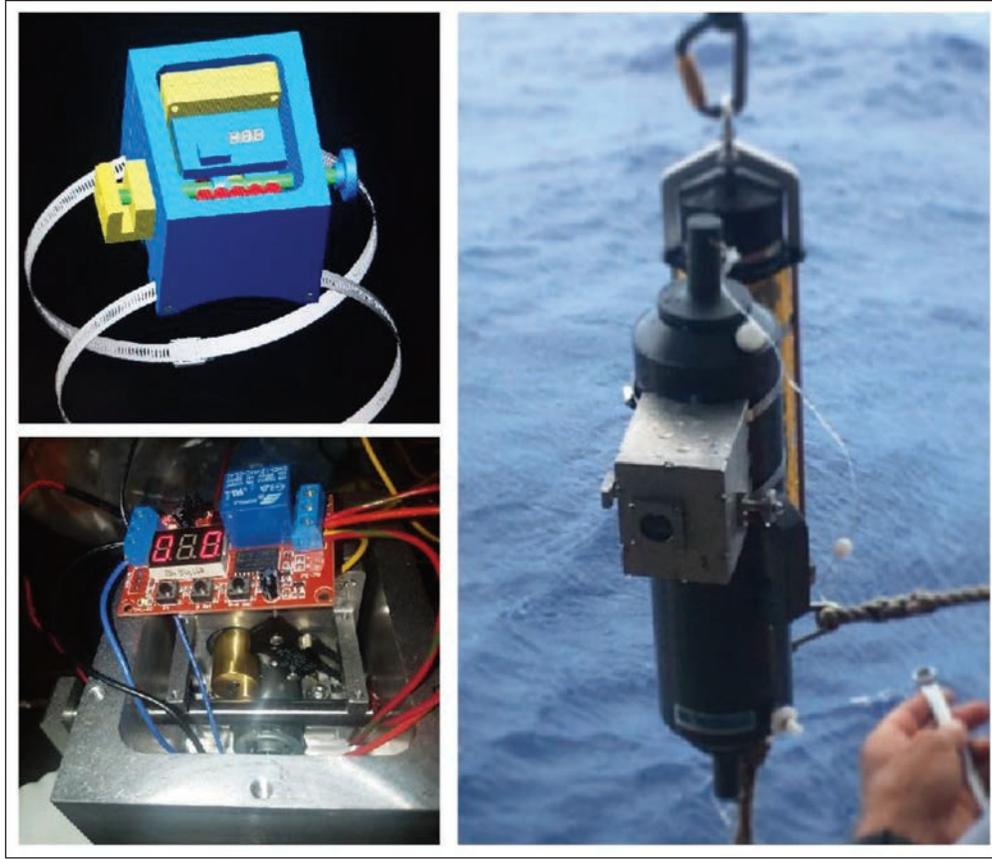
Figure 3. A custom designed and fabricated eDNA Niskin bottle release for collecting water samples at a depth of ~250 msw in association with DropCam Instrument Package rigging (DCIP). Top left: release design concept. Bottom left: electronics fabrication. Right: shown attached to the acoustic release of the DCIP after successful implementation in the field.

Historical analysis of MOUSS video has shown survey depth limitations due to lack of ambient light at increasing depths beyond 250 meters. To potentially increase the MOUSS operational survey depth limit to incorporate bottomfish species that extend below the 250 meter threshold, JIMAR SSTP staff partnered with the University of Hawaii's (UH) Hawaii Institute of Marine Biology (HIMB) to conduct experimental trials to test the feasibility and effectiveness of using Dual-frequency Identification Sonar (DIDSON) "acoustic camera" technology as a potential compliment to current MOUSS bottomfish surveys. The results of this MOUSS-DIDSON comparison study showed that the DIDSON was unable to identify fish taxonomically and had a "blind spot" with no fish visible from 0 to 1–1.5 m directly in front of the unit, making it unsuitable for PIFSC survey requirements. Currently there are no plans to continue further MOUSS-DIDSON comparison testing and preliminary results were summarized in an internal technical report.

Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. During the reporting period, JIMAR staff supported a large portion of PIFSC missions and projects by providing logistical, operational, small boat, laboratory, and dive research support to all PIFSC Divisions. On ship-based projects SE-18-02, SE-18-06, and SE-19-04 the JIMAR Field Operations team members played pivotal project leadership roles and made significant contributions to the successful completion of mission objectives. During these missions, JIMAR staff held the Operations Lead role and provided leadership, expertise, and support for executing MOUSS deployment/recovery operations in the Main Hawaiian Islands (MHI) and for Life History data collection efforts in the Commonwealth of the Northern Mariana Islands (CNMI) and MHI. The PIFSC Stock Assessment Program's (SAP) 2018 Bottomfish Fishery Independent Survey-Hawaii (BFISH) received MOUSS video-data collected by JIMAR staff during SE-18-06 and during the follow-on PIFSC/PIFG collaboration, which utilized MOUSS equipment deployed from commercial fishing vessels. These data contribute significantly to the

stock assessment and correlative policies and regulations of the Hawaii 'Deep 7' commercially viable bottomfish species. The success of the PIFSC/PIFG collaborative effort contributed to an expansion of commercial fishing boats capable of performing MOUSS operations thus advancing the goal of eventually 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. The second regionally coordinated Annual Small Boat Evaluation (ASBE) effort was held November 2018 and was instrumental in getting the Protected Species Division's (PSD) Hawaiian Monk Seal Research Program (HMSRP) and Marine Turtle Biology and Assessment Program (MTBAP) prepared for their 2019 field camps in the Northwestern Hawaiian Islands. Support provided by project staff included small boat improvements, maintenance and repairs, and training courses in outboard motor troubleshooting and inflatable

Figure 4. Jeremy Taylor and Chris Demarke conducting final systems check of DABR+ prior to testing.

boat repair/maintenance. JIMAR science operations staff also served as subject matter experts in the detailed technical review of the design and fabrication of two new PIFSC small boat assets by providing input and expertise acquired from over a decade of operating and repairing similar assets already existing onsite.

The JIMAR Dive and Laboratory Research Manager supported the day-to-day operations and training at the Inouye Regional Center Dive Center and laboratories. The manager assisted with reviewing and assessing research dive plans as well as equipment support. Over the last year the manager played a critical role in acquiring and operationalizing a new Nitrox compressor system essential to upcoming dive operations aboard the NOAA Ship *Rainier* (which is new to Hawaiian waters) for the Hawaiian Archipelago Reef Assessment and Monitoring Program (HARAMP). The manager was also responsible for developing an Annual Laboratory Safety Refresher training module and maintaining the IRC Laboratory Chemical Hygiene Plan, which significantly improved user competence and compliance with laboratory safety best practices.

Advanced Survey and Sampling Technology Development. During the reporting period, JIMAR staff supported the SSTP in a variety of field and laboratory capabilities to support the work of PIFSC researchers requiring development, evaluation, fabrication, and maintenance of in-situ instrumentation and monitoring systems in the PIR. JIMAR staff served as technical leads for science operations and collaborated with participating researchers to fulfill their project technical requirements. Over the last year, the SSTP had three major accomplishments including further development of the use of 360-degree cameras during ship-based MOUSS DropCam Instrument Package (DCIP) surveys. DCIP frames were modified to house both MOUSS and 360-camera technologies, allowing side-by-side comparison to gain a better understanding of fish interactions with survey equipment. Preliminary analysis showed that a small percentage of fish seen only by the 360-degree cameras are uncounted in the directional MOUSS camera surveys; further comparison surveys will be conducted to determine the accuracy and effectiveness of MOUSS fish surveys.

SSTP also supported the Cetaceans Research Program (CRP) with the fabrication of an additional five Drifting Acoustic Spar Buoy Recorders (DASBR) housings and arrays for the CRP mission aboard NOAA Ship *Oscar Elton Sette* in April 2019 (SE-19-01). DASBRs are free-floating acoustic recorders designed to mitigate background noises that are associated with towed array systems and detect species that tend to shy away from ships and other activities that create a noisy environment. SSTP also designed and fabricated a new DASBR+ prototype equipped with a battery bank with solar charging and power management system, AIS tracking, and a low light LED flasher avoidance system. All the data pulled from deployed DASBRs during the mission were of high quality and confirmed a successful design and construction of the new DASBRs.

With Environmental Deoxyribonucleic Acid (eDNA) sampling and analysis now a PIFSC scientific priority, JIMAR SSTP staff played an integral role with the PIFSC Life History Program (LHP) by taking a concept and turning it into reality. A versatile seawater collection and filtration system was built for subsequent eDNA analysis in an effort to assess select bottomfish species abundance and compare it with MOUSS camera estimates. A timed-release eDNA Niskin bottle capable of being deployed down to 250+ meters of seawater was fabricated and successfully tested on

Figure 5. JIMAR customized eDNA sample bottle (with sample) being recovered by crewmembers of NOAA Ship Oscar Elton Sette *as part of a DropCam Instrument Package (DCIP) deployed during the Bottomfish Fishery-Independent Survey-Hawaii (BFISH) 2018.*

NOAA Ship *Oscar Elton Sette* during the BFISH, SE-18-06 and SE-19-04 cruises, thus providing eDNA samples across depth profiles and with various sampling methods.

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

Main Hawaiian Islands Commercial Fisheries Fast Track Data Project

P.I.: Douglas S. Luther [JIMAR Project Lead: Kimberlee Harding]

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

NOAA Sponsor: Michael P. Seki, Beth Lumsden

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The Main Hawaiian Islands (MHI) Commercial Fisheries Fast Track Data Project is an ongoing JIMAR project that began in September 2007. The primary objective of the project is to improve the accuracy of data collection, timely reporting, and improve processing methods for the State of Hawaii's commercial fisheries and fish dealer data, including the Deep 7 bottomfish fishery that is managed by a federal Annual Catch Limit (ACL).

The ACL is set by the Western Pacific Regional Fishery Management Council (WPRFMC) in the State of Hawaii to manage sustainable harvest of the Deep 7 bottomfish species caught in the main Hawaiian Islands. Near real-time monitoring is needed to close the fishery before the ACL is reached, without exceeding this limit, so data collection and processing must be fast-tracked to provide timely and accurate landings information to assist in the monitoring and management of this fishery. The Deep 7 complex is comprised of six eteline snappers and an endemic grouper, known locally as onaga (*Etelis coruscans*), ehu (*Etelis carbunculus*), opakapaka (*Pristipomoides filamentosus*), kalekale (*Pristipomoides sieboldii*), gindai (*Pristipomoides zonatus*), lehi (*Aphareus rutilans*), and hapuupuu (*Hyporthodus quernus*).

Hawaii Revised Statutes require commercial fishers to submit their monthly fishing reports within ten days following the month in which marine life was taken. The Department of Land and Natural Resources (DLNR) Hawaii Division of Aquatic Resources (HDAR) implemented a new Administrative Rule on September 1, 2011, requiring commercial fishermen who catch Deep 7 species to submit trip reports within five days of their trip
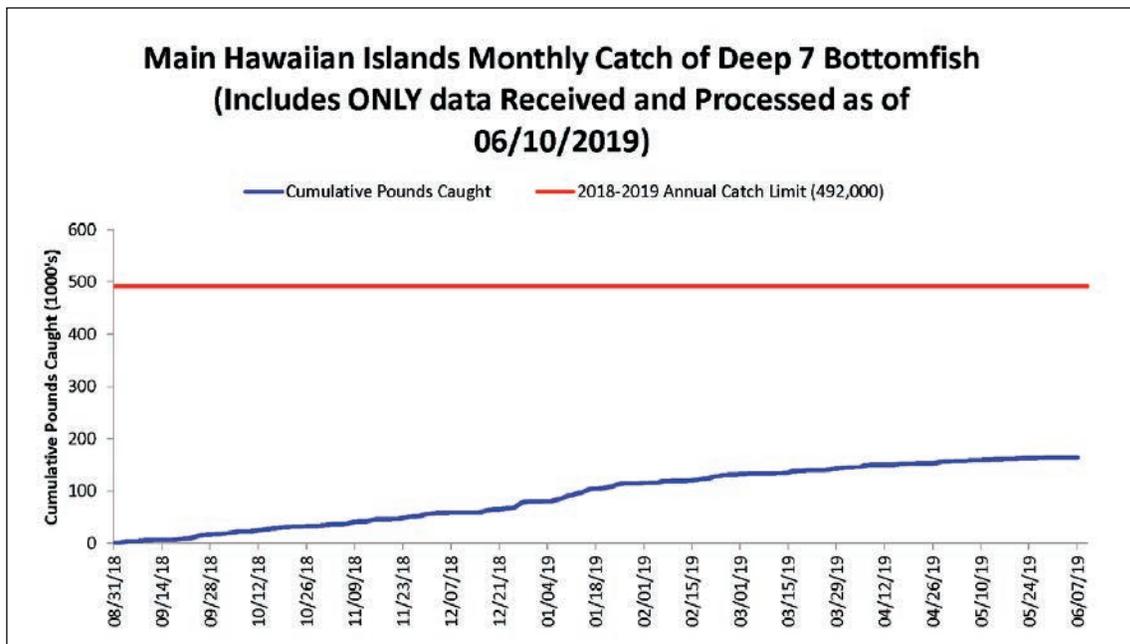

Figure 1. Accumulated pounds for the MHI Deep 7 bottomfish fishery during for the 2018–2019 federal fishing year (163,906 lbs or 33.3% of the ACL of 492,000 lbs).

end date. JIMAR staff work in collaboration with DLNR-HDAR to fast-track Deep 7 bottomfish fishing and dealer data in order to successfully monitor the fishery. The fishing year for the Deep 7 bottomfish fishery opens annually on September 1st and closes either when the total landings are predicted to reach the ACL or on August 31st (whichever occurs first).

Progress during FY 2019

JIMAR staff successfully fast-tracked data processing of the Main Hawaiian Islands commercial catch and dealer reports, including the Deep 7 bottomfish fishery that is managed by a federal ACL, with the 2018–2019 fishing year (ending August 31, 2019) at 392,000 pounds with a 40% risk of overfishing for all of the Deep 7 species.

DLNR-HDAR launched the new Online Commercial Marine Dealer Reporting System (ODRS) in July 2017. In June 2018, HDAR received the first prototype for the public interface webpage and began the testing phase. The website will allow commercial marine dealers to report their commercial marine purchase reports online instead of submitting paper or emailed reports. JIMAR staff is providing support for the design and development of the ODRS website.

JIMAR staff began using the new HDAR Fishing and Dealer Report System. The full conversion of the obsolete Visual FoxPro (VFP) based database to a MySQL database will be completed during the summer 2019. The Oracle database was converted to a MySQL database and the administrative applications were written and developed by Western Pacific Fisheries Information Network (WPacFIN).

JIMAR staff supported HDAR staff with the administrative rule change to repeal four of the twelve Bottomfish Restricted Fishing Areas (BRFAs). JIMAR staff created outreach materials for new reporting requirements. The JIMAR supervisor used GIS to create digital and paper maps for fishers use to ensure accurate reporting, and a digital mobile app for use in the field. The BRFAs will open July 1, 2019.

NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)

P.I.: 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, Russell Brainard

NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The JIMAR National Coral Reef Monitoring Program (NCRMP) Pacific Reef Assessment and Monitoring Program (RAMP) project is a multi-disciplinary research endeavor 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 RAMP project, which in turn supports the National Coral Reef Monitoring Program (NCRMP). The overall project goal 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 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. NOAA continues to rely on the expertise of JIMAR personnel who are instrumental in completing the Pacific RAMP efforts in support of the larger national NCRMP program.

Figure 1. JIMAR reef fish survey diver encountering a reef shark.

Progress during FY 2019

Field Mission Planning, Execution, and Documentation. The American Samoa RAMP (ASRAMP) cruise was completed in mid-August 2018 and included fish, benthic, and ocean and climate monitoring surveys of the American Samoa region and the Pacific Remote Islands Marine National Monument (PRIMNM). The "2018 NOAA-ESD American Samoa and Pacific Remote Islands Marine National Monument Reef Assessment and Monitoring Cruise (ASRAMP) Project Report" was published in February 2019. The Hawaiian Islands Reef Assessment and Monitoring Program (HARAMP) cruise planning was completed in the spring of 2019. The field mission is currently underway throughout the summer of 2019 with the first of four planned legs completed.

Figure 2. R/V Hiialakai *departs Kingman Reef for home (Honolulu, HI) in August 2018.*

A pilot study to evaluate the potential for Structure-from-Motion photogrammetry techniques to yield efficient collection and extraction of benthic coral community data is currently underway.

Data Processing and Archive. ASRAMP Phase I data, which does not require post-collection processing, was migrated into the Ecosystem Sciences Division (ESD) databases and successfully submitted to the Coral Reef Information System (CoRIS) and National Center for Environmental Information (NCEI) archives to meet Coral Reef Conservation Program (CRCP) and PIFSC Public Access to Research Results (PARR) requirements for data accessibility. Benthic coral observations, fish observations, rugosity (measures of underwater terrain and sea urchin abundance), and benthic and climate site image datasets were all submitted to the National Center for Environmental Information (NCEI) on or before March 31, 2019. ASRAMP Phase II data processing, where data requires laboratory analysis and/or post-processing, is currently underway. Specifically, water sample processing and benthic image scoring were completed and Calcification Accretion Unit (CAU) processing is underway. These datasets still require in-depth quality-control and will be migrated to the archive in September 2019. Datasets from the 2017 Marianas Archipelago Reef Assessment and Monitoring Program (MARAMP) research cruises underwent final quality-control and were submitted for archive to CoRIS and NCEI by June 1, 2019.

Data Products. Templates for data summary briefs were developed for each of the three main research foci. Completed briefs were published for fish, benthic, and ocean and climate for ASRAMP 2018. In addition, two standard operating procedures defining the methods used during RAMP missions were published during this fiscal year: one describing benthic methods and the other describing towed-diver methods.

Ocean Remote Sensing

P.I.: Douglas S. Luther [JIMAR Project Lead: Melanie Abecassis]

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

NOAA Sponsor: Michael P. Seki, Evan Howell

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 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), and diffuse attenuation coefficient at 490 nm (Kd490). These products are available 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 2019

In addition to maintaining all databases and servers and servicing data to OceanWatch-Central Pacific (OWCP) users, the project continued its collaboration with the Pacific Islands Ocean Observing System (PacIOOS). OWCP data is regularly updated on the PacIOOS Voyager website.

The project set up a new data processing server allowing for increased processing speed and use of the latest tools and libraries. All data processing code was rewritten in Python so that all data streams are in the same language and data flow. A code versioning system was implemented in Git.

OWCP also developed training materials for a three day course on ocean satellite data. Lectures were adapted and updated from CoastWatch training materials. R scripts, tutorials, and an ArcGIS training module were also developed and made available online on the OWCP website. The course was conducted at PIFSC in October 2018 with 22 participants from PIFSC and UH in attendance. A course feedback survey was subsequently distributed and all respondents stated the course was useful or very useful. An ArcGIS workshop organized in April 2019 was attended by 16 PIFSC staff.
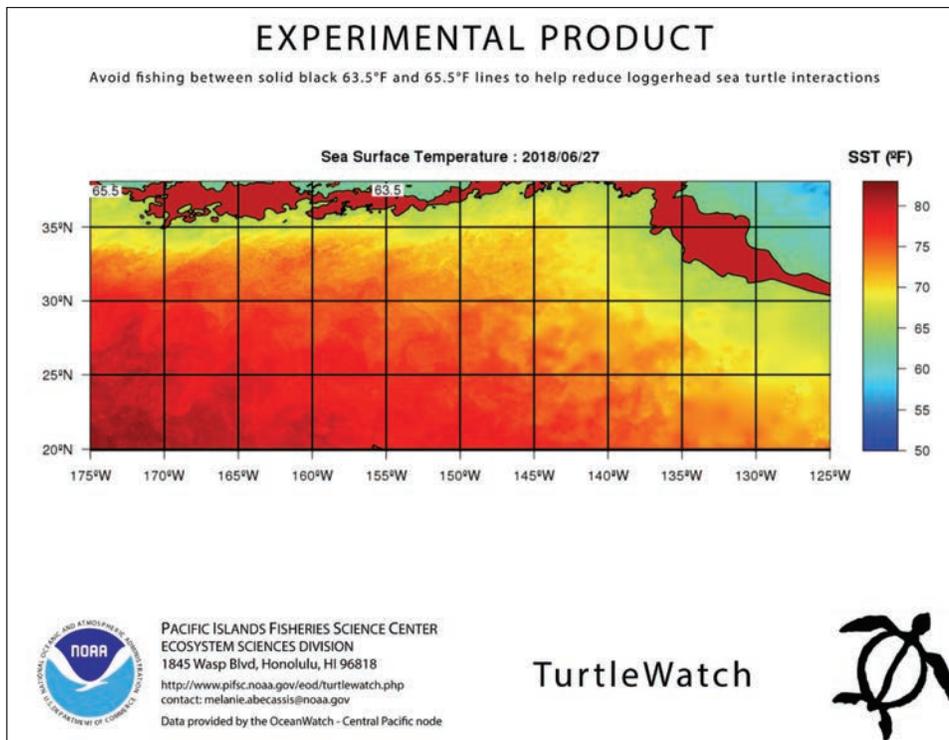
Figure 1. Example of the daily TurtleWatch product.

The JIMAR OceanWatch Researcher/Manager, Dr. Melanie Abecassis, continued to assist the regional fishing council and Pacific Islands Regional Office (PIRO) by investigating recent increases in loggerhead interactions in the shallow-set longline fishery and providing the TurtleWatch product to longline fishermen. TurtleWatch provides daily maps of sea surface temperatures that display a range of temperatures identified as the zone to avoid in order to reduce turtle interactions. She also participated on the steering committee of a new Ecosystem-Based Fisheries Management project aimed at estimating risk contours of interactions in the longline fishery. Dr. Abecassis presented a poster about OceanWatch and gave a talk at the NOAA booth at the December 2018 AGU meeting held in Washington, D.C.

Pacific Fisheries Monitoring Program

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, Keith Bigelow

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

This JIMAR project works to provide 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 Hawaii and American Samoa pelagic longline fleets, along with two California vessels, which are presently and increasingly subject to international

Figure 1. Photo of the JIMAR Electronic Monitoring Team, Jennifer Stahl and Matthew Carnes, attending the Hawaii Fish Auction Tour at the Honolulu Fish Auction located in the Commercial Fishing Village on Pier 38.

management at a species level. The project provides PIFSC and the fishing industry a contact point for feedback and information exchange with fishery scientists and managers.

Progress during FY 2019

The JIMAR staff continued to provide timely high-level support to fishery monitoring activities by providing high quality fisheries data to NMFS, PIFSC, and other JIMAR projects. The initial task of key punching the logbook data is the responsibility of JIMAR staff and the amount of data has been steadily increasing each year as longline fishing activities have increased. The Fast-Track program for selected species also continued into FY 2019.

Fast-tracking procedures implemented to monitor Hawaii's bigeye tuna (BET) landings require additional effort especially with the increased activity of fishing vessels. The fast-tracking information is used in forecasting landings to predict possible closure dates of the Hawaii-permitted longline BET fishery if the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) annual quota is predicted to be reached. Fast track monitoring also encompasses striped marlin landings due to stock concerns.

The JIMAR staff was cross-trained to cover the multiple facets of fast track duties. The fast-tracking requirement increased the daily workload and 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. The cross-checks involve a matching program that compares the longline logbook tuna counts to sales records from dealer data. The fisheries observer data are reconciled with Hawaii longline logbook data.

In 2017, JIMAR added electronic monitoring (EM) capabilities to the project and tested the use of mounted video monitoring on longline vessels to compare actual catch to logbooks and simultaneous on board observer data. Electronic monitoring continues to be pioneered by JIMAR staff, and in December, JIMAR was solely tasked with implementing the EM project. JIMAR EM staff assumed the duties of system maintenance and installation as well as software design and programmatic direction to serve PIFSC. In March, EM staff finished annotating over 40,000 images to help train machine learning on how to identify fish using convolutional neural networks. An additional staff member was hired in March to help with the growing responsibilities of the program which include: EM system data management; communication with vessel crew and captains; and reporting and research to improve EM systems. EM staff also completed a technical memorandum, "Evaluation of Electronic Monitoring Pre-implementation in the Hawaii-based Longline Fisheries", that demonstrates EM capabilities in the Hawaii longline fisheries.

The Electronic Reporting (ER) team, comprised of JIMAR and PIFSC staff, completed work with a developer on ELog-It, an Android application that enables longline captains to securely submit their longline logbook data electronically in real-time. The application was extensively tested by JIMAR team members and volunteer captains at sea before its official release in August 2018. The team also completed work with a second contractor on a backend application to download, decrypt, format, and process the incoming ER data to be compatible with current operating procedures.

The team deployed tablets installed with ELog-It on 40 vessels, about 28% of the fleet. One hundred forty trips with approximately 1,800 fishing set and haul forms were successfully transmitted by fishing captains and received at PIFSC. Captains expressed satisfaction with the ER application's simple and user-friendly interface. They also discovered that using the electronic application to complete electronic logs is faster than filling out paper log sheets. Feedback and suggestions are continually compiled and will be considered for future application updates.

Adoption of ER will greatly improve the timeliness of data availability for Regional Fishery Management Organization (RFMO) reporting, forecasting fishing area closures, and use by scientists and researchers. Implementing ER will decrease the time and labor required to manually enter or keypunch the fisheries data by JIMAR staff. These resources can be allocated to support the growing ER program and address other data needs.

The general Hawaii-permitted longline fleet-wide quarterly reports are completed 45 days after the end of the quarter. As of May 2019, staff collected and processed 17,400 logbook set forms from Hawaii, 1,500 set forms from American Samoa, and 70 set forms from California.

The paper logbook scanning and archiving project is ongoing.

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, Beth Lumsden

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 laws. 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 National Marine Fisheries Service (NMFS) staff in these islands all 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 Pacific Islands Fisheries Science Center (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 2019

The project Territorial Fisheries Data Specialist and Territorial Fisheries Associate participated in a workshop hosted by the Hawaii State Department of Land and Natural Resources (DLNR) in Honolulu, Hawaii, to identify appropriate fishery surveys for Hawaii and the U.S. Pacific territories that can be certified by the NOAA Fisheries Marine Recreational Information Program. The Territorial Fisheries Data Specialist presented information on

Figure 1. Fourteenth Annual Marianas Underwater Fishing Federation Spearfishing Challenge, August 11, 2018. JIMAR staff (Christine Laurent, left; Anna Regis, right) assisted in the registration of participants.

Guam surveys and pilot studies and by the end of the workshop measures were identified for the territories to seek certification.

The Territorial Fisheries Data Specialist assisted with adaptations to the existing R expansion algorithms for territory creel surveys, including additional data products and updates to algorithms used when survey data is limited. Staff began updating an existing Atlantis Ecosystem Model for Guam coral reefs to better reflect natural ecosystem dynamics and allow the simulation of fishing activity. Project staff also worked on a neutral landscape model to analyze the bias and precision of different types of fishery and ecosystem surveys.

The JIMAR Territorial Fisheries Associate on Guam contributed 50 surveys to the Guam Division of Aquatic and Wildlife Resources (DAWR) creel survey program, performed quality control on all creel data, and assisted with database issues. The Associate also produced several quarterly outreach brochures, updated the freshwater and saltwater sets of "Fish on Guam" factsheets and created a new set of fish factsheets for the freshwater reservoir, all for use on Guam. In addition to the brochures, the following were also created and subsequently updated as needed.

- Guam Fisheries Data Collection—created February 2018
- Guam Fish Records—July 2018 (updated from time to time)
- Guam Seasonal Fishes—created October 2018

The JIMAR Fisheries Database Assistant keypunched all of the catch and co-op commercial receipt data, scanned in the creel surveys to a document management system, and performed quality checks of the entered data.

The Territorial Fisheries Data Specialist produced a report for Guam DAWR summarizing the results of the Guam pilot study, including suggestions to improve the creel survey. A draft creel survey manual for CNMI Division of Fish and Wildlife (DFW) was completed, pending review by the creel survey supervisor. However, a draft creel survey manual for American Samoa Department of Marine and Wildlife Resources (DMWR) could not be completed due to insufficient time and resources.

In total, these accomplishments fulfilled the objectives established for the reporting period with the one exception being the American Samoa DMWR the draft creel survey manual.
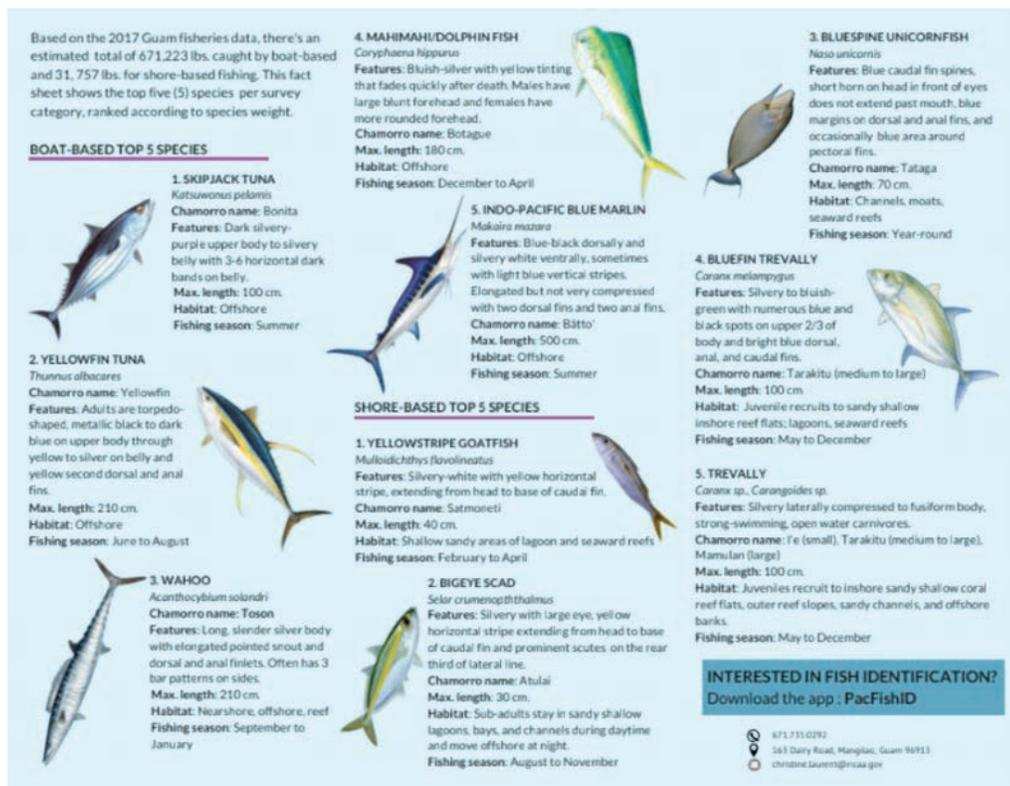
(top) Figure 2. Brochure, "Common Fishes Caught on Guam"—trifold page 1.
(bottom) Figure 3. Brochure, "Common Fishes Caught on Guam"—trifold page 2.

Guam Fish Records

Pelagic and Bottomfish
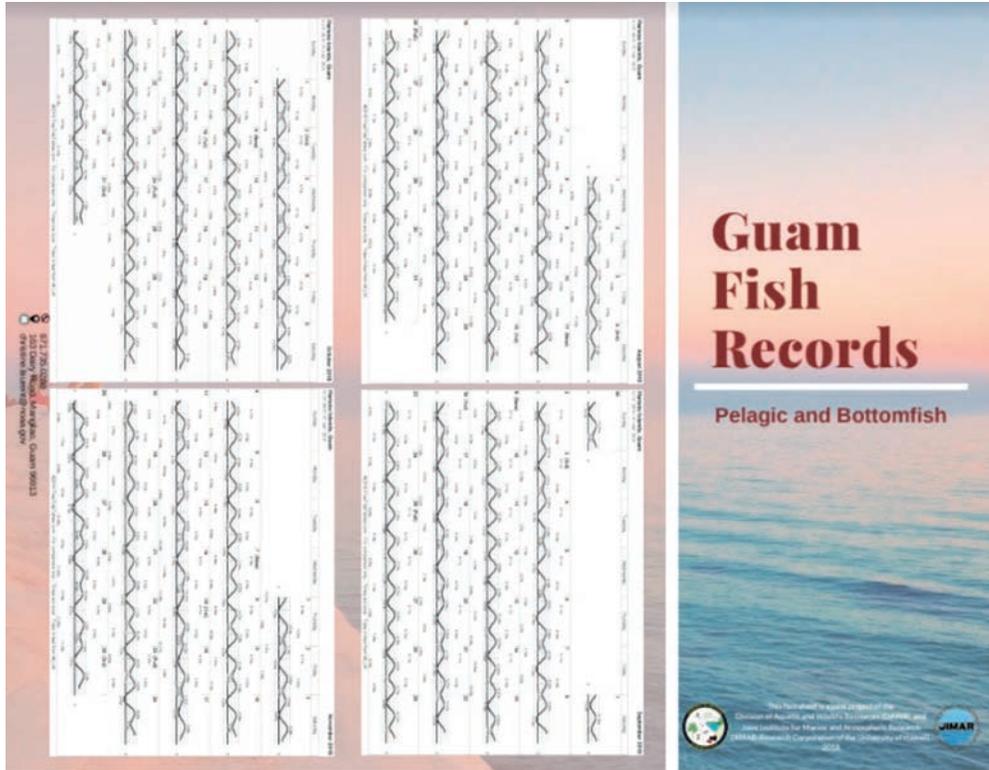
Introduction

This fact sheet shows a summary of record for pelagic and bottomfish caught on Guam. The data is based on records from Guam Fishing and Boating Association (1963), DAWR creel surveys (1982 to present), and Marianas International Fishing Derby statistics (1969-2018).

Pelagic

The following are top 5 species caught offshore. Table 1 shows the heaviest catch for other pelagic fishes commonly caught on Guam.

Bonita
Katsuwonus pelamis
23 lbs. 12 oz (2015)

Yellowfin tuna
Thunnus albacares
149 lbs. 3 oz (1979)

Wahoo
Acanthocybium solandri
80 lbs. (1966)

Mahimahi/Dolphin fish
Coryphaena hippurus
69 lbs. (1963)

Indo-Pacific Blue Marlin
Makaira mazara
1,153 lbs. (1969)

Table 1. List of record catch for other pelagic fishes caught on Guam (1966-2018).

Common Name	Scientific Name	Record Catch (lbs)	Year Caught
Blackfin barracuda	Sphyraena genie	41	1995
Great barracuda	Sphyraena barracuda	27	1997
Kawakawa	Euthynnus affinis	21	2003
Leatherback	Scomberoides lysan	4	1995
Rainbow runner	Elagatis bipinnulata	20	2015
Sailfish	Istiophorus platypterus	125	1966

The bigeye scad is an oceanic fish that may be caught both offshore and inshore.

Atulai
Selar crumenophthalmus
2 lbs. (1984)

Deepwater Bottomfishes

Deepwater bottomfishes are only caught offshore. The following are top 5 deepwater bottomfishes caught on Guam. Table 2 shows the heaviest catch for other bottomfishes.

Onaga
Etelis coruscans
39 lbs. 5 oz (2012)

Lehi
Aphareus rutilans
29 lbs. 5 oz (2019)

Ehu
Etelis carbunculus
42 lbs. 14 oz (2018)

Yellow-banded grouper
Cephalopholis igarashiensis
7 lbs. 4 oz (2010)

Gindai
Pristipomoides zonatus
5 lbs. 15 oz (2008)

Table 2. List of record catch for other deepwater bottomfishes caught on Guam (1982-2018).

Common Name	Scientific Name	Record Catch (lbs)	Year Caught
Blueline gindai	Pristipomoides argyrogrammicus	4	2016
Yellowtail kalikali	Pristipomoides auricilla	8	2008
Pink opakapaka	Pristipomoides filamentosus	11	1994
Opakapaka	Pristipomoides flavipinnis	14	1998
Other	Ruvettus pretiosus	68	2017
Pink grouper	Saloptia powelli	6	2010
Greater amberjack	Seriola dumerli	38	1987

Shallow to Deepwater Bottomfishes

Most bottomfishes that live on shallow to deepwater may be caught both offshore and inshore. The following are top 5 species commonly caught under this category.

Redgill emperor
Lethrinus rubrioperculatus
Offshore: 7 lbs. 14 oz (1996)
Inshore: 1 lb. 15 oz (2016)

Longnose emperor
Lethrinus olivaceus
Offshore: 15 lbs. 2 oz (2004)
Inshore: 10 lbs. 10 oz (1994)

Red snapper
Lutjanus bohar
Offshore:34 lbs. 3 oz (1988)
Inshore: 19 lbs. 14 oz (2007)

Yellow spotted trevally
Carangoides orthogrammus
Offshore: 15 lbs. 1 oz (1985)
Inshore: 4 lbs. 14 oz (1987)

Dogtooth tuna
Gymnosarda unicolor
Offshore: 170 lbs. (2018)
Inshore: 4 lbs. 6 oz (2006)

Table 3. List of record catch for other shallow to deepwater bottomfishes caught on Guam (1982-2018).

Common Name	Scientific Name	Boat-based Record Catch (lbs)	Year Caught	Shore-based Record Catch (lbs)	Year Caught
Black jack	Caranx lugubris	24	2001	7.5	2007
Blacksaddle grouper	Epinephelus howlandi	2	2005	3	2014
Black lipped grouper	Epinephelus fasciatus	1	1989	2.5	2014
Bluelined snapper	Lutjanus kasmira	1	1988	1.7	2005
Camoflauge grouper	Epinephelus polyphekadion	5	2004	4	2003
Highfin grouper	Epinephelus maculatus	3	1988	1.25	2007
Jobfish	Aprion virescens	43	1985	6.25	2002
White-margined lyretail grouper	Variola albimarginata	8	1999	Not caught	NA
Tomato grouper	Cephalopholis sonnerati	16	2014	Not caught	NA

The white-margined lyretail grouper and Tomato grouper, also known as Gådao mattingan or Buelli, are only caught offshore.

(top) Figure 4. Brochure, "Guam Fish Records"—trifold page 1.
(bottom) Figure 5. Brochure, "Guam Fish Records"—trifold page 2.

Pacific Tuna Fishery Data Management

P.I.: Douglas S. Luther [JIMAR Project Lead: Jesse Abdul]

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 objective of this project is 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 (NMFS) offices to effect the development of the data management system and also collaborates with several Pacific Islands Fisheries Science Center (PIFSC) programs and the Pacific Islands Regional Office (PIRO) divisions for subsequent access and analysis functions and to meet monitoring and reporting requirements.

Progress during FY 2019

The project continued to develop and implement data quality control (QC) criteria for data collected under SPTT, such as data QC criteria to identify violations of fish aggregation device closure rules.

The project continued ongoing data management activities to ensure quality, accuracy, and completeness of the data received. JIMAR staff entered all received regional purse seine log sheets (RPL), unloading and transshipment log sheets (UL), final out turn receipts (FOT), and sampling forms into the enterprise database using the existing data management applications and maintained the various reference lists used in the SPTT database throughout the year. The project evaluated the defined data QC checks on a regular basis for the RPL, UL, FOT, and sampling data streams and resolved data issues to maintain the quality of the data used for reports and data analysis.
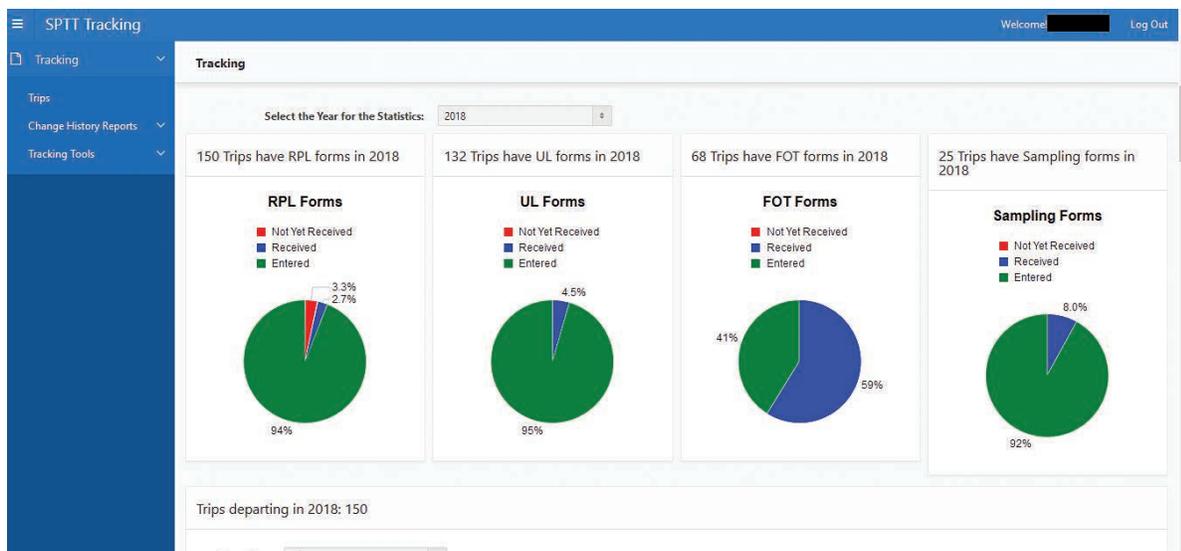

Figure 1. Screenshot of the tracking application that the project reviewed and provided feedback on, which is currently under development by a contractor.

The project established a goal to develop new database schemas, data tools, and procedures for managing additional SPTT data streams. JIMAR staff worked with PIRO and PIFSC staff to provide and document feedback to inform software development decisions on a document and workflow tracking application that is currently under development by a PIFSC contractor. The project imported tracking data in spreadsheet format into the Oracle database so the data could be used when testing the tracking application. The project also performed formal testing on the tracking application and provided feedback to the developer to help facilitate the software development lifecycle.

An additional goal was to facilitate the development and implementation of automated data loading processes for electronically reported SPTT data. The project collaborated with Fisheries Research and Monitoring Division (FRMD) data staff to define software requirements for a contractor to develop the electronic data loading process based on the data provider's technical specifications and the existing PIFSC SPTT data model. JIMAR developed an initial version of the electronic reporting data model and provided that to the contractor for implementation. Technical documents were drafted for mapping the data between the two systems and project staff participated in regularly scheduled meetings with the contractor and FRMD data staff to facilitate progress and address any issues. The data loading application has progressed and is still under development.

The project traveled to the Southwest Fisheries Science Center in July 2018 to meet with data staff to develop a process to import the historical SPTT data to PIFSC. JIMAR staff completed migrating a subset of the historical reference data to PIFSC and migrated historical scanned portable document format files to PIFSC.

Sustaining Healthy Coastal Ecosystems

P.I.: 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, Russell Brainard

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 (MHI), Northwestern Hawaiian Islands (NWHI), Pacific Remote Island Areas (PRIA), Commonwealth of Northern Mariana Islands (CNMI), American Samoa, and Guam. The project objective is to support 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; 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 NMFS Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Science Division (ESD). Project goals accomplished during the reporting period are described below.

Progress during FY 2019

Manuscripts and Reports. Several recently completed manuscripts focused on improving understanding of coral reef ecosystems through interdisciplinary assessment, long-term monitoring, and applied research across the Pacific. The first manuscript explores the scope of herbivore management and its contribution to coral reef persistence in the Main Hawaiian Islands. The manuscript was submitted to the PIFSC editorial review in April 2019 and is intended for submission to *Frontiers in Marine Science*. Topics covered include impacts of algae on coral growth, mortality and replenishment, and evidence from previous Marine Protected Area (MPA) studies. Major conclusions include that while herbivore management has frequently not been effective at increasing coral resilience, there are examples in which it has been highly effective. And while herbivore management will not

Figure 1. Coral reefs of Baker Island; one of the 40 islands and atolls surveyed as part of the National Coral Reef Monitoring Program Pacific Reef Assessment and Monitoring Program.

benefit all coral reefs, it is relatively straightforward to identify situations in which this form of management is most likely to be effective.

The second manuscript focuses on leveraging satellite and in-situ temperature data to generate better metrics of coral thermal stress at depth. This manuscript presents novel methods and concludes that: 1) researchers do not see any evidence of depth refuge from heat stress; and 2) satellite-only observations significantly underestimate in situ stress. The current draft is under review by co-authors and will be submitted to *Nature Communications* once finalized.

A third manuscript reports on the widespread coral mortality at Jarvis Island in the aftermath of the 2015–2016 super-El Niño warming event. Hard coral cover declined from 18.9% in April 2015 (pre-bleaching) to 0.3% in May 2016 (post-bleaching), representing a catastrophic decline of over 98%. This manuscript was accepted to the journal *Coral Reefs*.

Lastly, the Annual Reef Fish report was submitted to PIFSC Editorial Services for review. It describes and compares the National Coral Reef Monitoring Program fish data collected during the 2018 Reef Assessment and Monitoring Cruise in American Samoa and the Pacific Remote Islands Marine National Monument (PRIMNM).

PRIMNM Monitoring Report and Workshops. In FY 2019, significant progress was made on the comprehensive report entitled 'Coral Reef Ecosystem Monitoring Report for the Pacific Remote Islands Marine National Monument: 2000–2017'. The report presents data and analyses of integrated, interdisciplinary ecosystem observations conducted as part of the Pacific RAMP between 2000–2017. The report includes individual chapters for the following atolls and islands: Palmyra, Johnston, Kingman and Wake Atolls; and Howland, Baker, and Jarvis Islands. Each chapter provides information on the following: historical background; benthic habitat mapping and characterization; oceanographic conditions and variability; status and trends of benthic community structure; fish community structure; species of concern; marine debris; and ecosystem integration. In addition, the report includes a chapter comparing coral reef ecosystems among the different islands and atolls of the PRIMNM with those of the other U.S.-affiliated Pacific Islands. Completion of the entire report is expected in fall 2019.

In an effort to better support PIRO's on-going development of Monument Management Plans for the Pacific Remote Islands Marine National Monument, the project completed a series of information-sharing workshops to discuss and answer questions about the analyses and information provided in the Coral Reef Ecosystem

Monitoring Report for the PRIMNM with one workshop held per island chapter. A final workshop on region-wide integration will be held in September 2019.

Public Access to Research Results (PARR) Compliance. Considerable progress was made in FY 2019 to meet PIFSC goal of 100% PARR compliance for ESD datasets by the July 1, 2019 deadline. This effort led to substantial improvements in data integrity (i.e., accuracy) and metadata records.

Research Analyses. As a first step to improving understanding of reef resilience, the project is currently working on a NOAA technical memo that describes a statistical technique to downscale NCRMP-RAMP data to the finest spatial resolution possible while maintaining robust statistical trends over time. Project staff will convene relevant expertise to develop a consensus statistical methodology so that temporal patterns can be more clearly described at the fine spatial scales requested by reef managers.

Figure 2. JIMAR divers install a diurnal suite of instruments to monitor various ocean and climate variables that influence coral reef ecosystems.

A monitoring report written for the National Marine Sanctuary of American Samoa is near completion. It presents an analysis that compares ASRAMP cruise data collected during the expeditions completed in 2015 and 2018. This report also focuses on the data streams collected in the Sanctuary Management Areas. ESD JIMAR personnel will work with the Sanctuary's Science Coordinator to allow for feedback. The report is expected to be completed in September 2019.

Research and development for applying Structure-from-Motion (SfM) technology to benthic reef surveys is currently underway. The survey design for SfM benthic assessments during NCRMP-RAMP cruises was implemented and efforts to build capacity within ESD to analyze the collected imagery are ongoing. Staff led a workshop in winter 2018–19 to train ESD staff in photomosaic image collection and processing methods used to generate 3D models and extract coral demographic data. A pilot study of SfM surveys around Oahu was completed and is awaiting statistical analyses to identify strengths and limitations for future photomosaic surveys.

Lastly, JIMAR's Dr. Hannah Barkely is leading the process to create a vision plan for future ESD ocean and climate change research. Her team is evaluating all ocean and climate data streams to determine scope and scale of ongoing research efforts. These analyses will be used to create a plan for future Ecosystem Science Division (ESD) climate research priorities.

Territorial Biosampling

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, Joseph O'Malley

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

The JIMAR Territorial Biosampling project conducts both fundamental and innovative 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

Figure 1. JIMAR Life History Fish Biosampling Specialist Erin Reed (second from left) leads her small group in fish dissection at the NOAA Pacific Island Fisheries Science Center Teacher Workshop, Oahu, HI.

parameters for species of interest and provides these data 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. 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.

Progress during FY 2019

Research activities resulted in the data compilation, analysis, and writing of a draft manuscript to document age, growth, and maturation of two goatfish species from Saipan, Commonwealth of the Northern Mariana Islands (in

Figure 2. JIMAR Life History Fish Biosampling Specialist Erin Reed (middle image) leads fish reproduction biology outreach efforts for the 2019 Fishers Forum, Oahu HI.

NOAA internal review). Project staff led efforts to construct preliminary data analysis and advance sample design by describing the reproduction characteristics of a deep-water snapper from the Main Hawaiian Islands, which is also found in the U.S. Territories. JIMAR staff worked temporarily with the University of Southern Mississippi Marine Lab to advance skillsets in histology from a world renowned expert in fish reproduction biology, and a collaboration to investigate life history parameters of deep-water snappers resulted from the visit. In addition, staff continued to manage the internal database of the Life History Program. This year, the project provided a comprehensive internal review of Guam coral reef fish species via public outreach documents. Project staff was also integral in the success of two field operations this year. First, JIMAR provided crucial personnel assistance for small boat sampling activities on the federally funded MOUSS Bottomfish cruise SE-18-06, Main Hawaiian Islands. Secondly, project staff was the Data Lead aboard the Life History Program's cruise SE-19-04 and also participated in small boat sampling operations for deep-water snappers in the MHI.

West Hawaii 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

Purpose of the Project

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

Progress during FY 2019

The JIMAR West Hawaii IEA project continued to focus on building relationships with Hawaii State, Federal and non-governmental agencies and engaging local community organizations to understand management and community needs in the region. These diverse relationships resulted in numerous contributions that are highly supportive and complementary to management efforts. For example, the recently released West Hawaii Integrated Ecosystem Assessment Ecosystem Status Report represents a collaborative and multidisciplinary effort that compiles 30 ecosystem indicators that track the status of the region's marine ecosystem. Indicators include climate and oceanic drivers of ecosystem change, the states of ecological communities, and the activities and relationships between people and marine resources in West Hawaii. Additionally, the West Hawaii IEA recently released an assessment on the vulnerability of coral reefs in the area to climate change. This effort combines state-of-the-art climate model output with up-to-date ecological information of coral reefs to assess the vulnerability of this important ecosystem to warming ocean temperatures. These efforts will directly support resource management and policy decision making in West Hawaii.

A multitude of JIMAR-led research efforts continued as part of the West Hawaii IEA project over the past year. Research focused on larval fish and surface slicks (narrow, meandering lines along the surface ocean) produced surprising and ecologically important results. The areas within and around slicks aggregate floating material and attract organisms in areas where food resources are otherwise sparse and dispersed, functioning as biological oases and contributing to the recruitment and retention of early life history stages of fishes. JIMAR researchers also discovered these areas are densely populated with plastics, shedding light on a previously unknown concern for larval fish survival in West Hawaii.

JIMAR scientists also devoted considerable efforts into science communication to distill the complexities of West Hawaii IEA research into a more tangible format that the general public can more readily understand.
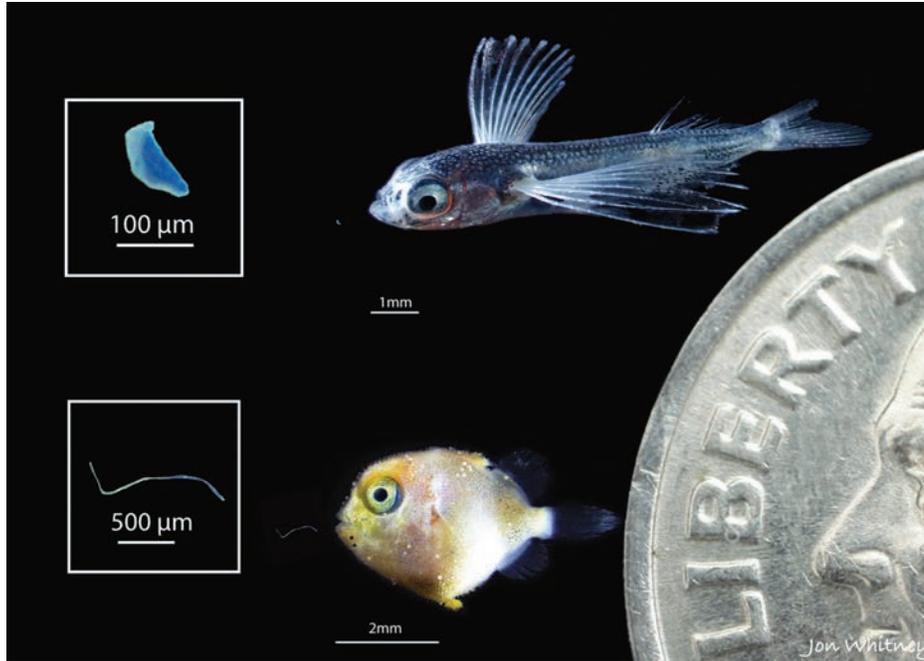
Examples include the West Hawaii IEA website (https://www.integratedecosystemassessment.noaa.gov/regions/), which provides thorough summaries and information on each of the projects and publications led by the West Hawaii IEA. Similarly, as part of their Planet or Plastic campaign to raise awareness about the global plastic waste crises, *National Geographic* recently published in their magazine an article featuring research led by JIMAR scientists on surface slicks and the accumulation of microplastics in larval fish nurseries. The article contains striking photographs of larval fish and plastics that JIMAR scientists collected in plankton samples off of West Hawaii in 2018.

(top) Figure 1. Larval fishes found with ingested microplastics as part of West Hawaii IEA larval fish project. (Top) larval flyingfish (Parexocoetus brachypterus) *with a ~100 µm fragment of blue polystyrene, and (bottom) larval triggerfish* (Balistidae) *with a ~1 mm long blue plastic fiber found in their stomachs. Dime shown for scale (image courtesy of Jonathan Whitney).*

(left) Figure 2. Photograph of larval fish and plastics collected in surface plankton tow off of West Hawaii during 2018 field mission. In this sample, a blue plastic bag has begun to disintegrate. Two gnarled rope ends from a fishing net are collecting algae and other organisms. A striped mahimahi larva (center right), just under two inches long, turns away from the rope; an inch-long triggerfish (upper left), about 10 weeks old and almost of an age to head back to the reef, noses up to a triangular shard of white plastic (photo courtesy of David Liittschwager, National Geographic).

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, Beth Lumsden

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 Guam, the Commonwealth of the Northern Mariana Islands (CNMI), Hawaii, and American Samoa. JIMAR and Pacific Islands Fisheries Science Center (PIFSC) federal staff work with island agency staff, contractors, fishermen, and fish dealers to create data systems that 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 2019

JIMAR project staff continued converting the Visual FoxPro (VFP) database applications to MySQL and C# for WPacFIN Central and all partner agencies. Data summaries for reports to the Western Pacific Regional Fishery Management Council were completed in MySQL. A C# interface was created for the Territorial Pelagics Plan Team module.

The project made progress on the new WPacFIN website and supported completion of Phase I and II user queries by providing non-confidential species and gear-based data views and catch-per-unit-effort data views for service on the web.

Figure 1. Annual Kids Fishing Derby, July 07, 2018. JIMAR staff assisted in the registration, measurement of fish catch, and distribution of awards to kids at Asan Park, Guam.

(above) Figure 2. 23rd Annual Guam Marianas International Fishing Derby, August 25–26, 2018. JIMAR staff assisted in the registration of participants, updating the tally board, and awarding prizes during the Awards night.

(below) Figure 3. Haanen Familias—A Day at the Reef, January 26, 2019. JIMAR staff distributed fish posters, pamphlets, and brochures to kids and their families at the Guam Museum.

Project staff completed metadata documentation for all VFP data collections for Hawaii, American Samoa, Guam, and CNMI. Annual and semi-annual summary reports were submitted to Regional Fishery Management Organizations (RFMOs) and the NMFS "Fisheries of the United States" (FUS) publication. A publication "Fishery Statistics of the Western Pacific" is still planned for completion.

Hawaii Information Consortium (HIC) data was made compatible with the State of Hawaii Division of Aquatic Resources (DAR) MySQL database directly through MySQL adjustments without the need for a separate C# interface. However, a C# interface still needs to be created to allow users to perform data summaries.

The following list of project accomplishments satisfy most of the objectives established for the fiscal year, with the exception of one publication and those related to the Hawaii DAR database.

WPacFIN project staff completed: 1) import module for United Fishing Agency (UFA) using C# as the front end and MySQL database; 2) review of all documentation and code for accuracy for the Territorial Pelagic Plan Team; 3) WPacFIN web portal for Fishery Statistics of the Western Pacific (maintained by WPacFIN and went live in November 2018); 4) Annual Summary report documentation for Hawaii and the territories; 5) code review for the Annual Summary reports; and 6) Document Image Archival System (DIAS) viewer for DAR and WPacFIN.

The project staff also migrated: 1) VFP aquarium data entry form to C# as the front end interface and MySQL as the database; and 2) old WPacFIN website to the new intranet in 2018 with new standard format.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

Effects of Elevated pCO2 and Temperature on Reef Biodiversity Using Autonomous Reef Monitoring Structures

Molly Timmers, JIMAR Graduate Student

Purpose of the Research

The goal of this project is to improve understanding of the effects of ocean acidification and warming on coral reef communities by examining responses of entire suites of reef organisms recruiting to Autonomous Reef Monitoring Structures (ARMS) in benthic mesocosms. For the past two years, ARMS units have been soaking within a fully factorial design that consists of four treatments of low and high temperature and pCO2 levels. Twenty-four ARMS units (six per treatment) were removed on a bimonthly basis to be photographed and analyzed to examine recruitment and community structure across treatments. Upon completion of the experiment, the ARMS units under went DNA barcoding and metabarcoding to examine treatment effects on biodiversity. This project is the first to investigate the effects of elevated temperature and pCO2 on reef biodiversity and emergent ecosystem processes across a multiannual scale and should result in a transformative advance of conceptual and empirical understanding of how marine ecosystems respond to rapid environmental change.

Progress during FY 2019

Funding from JIMAR provided partial support of Timmers through September 2018. It supported her work to wrap up the two-year mesocosm experiment and complete the DNA barcoding of 200 plus organisms and the DNA metabarcoding lab work for all 24 ARMS units. Sequences that were submitted to UH for DNA barcoding and to UC Riverside for metabarcoding were returned January 2019, analyzed in the spring, and preliminary results were presented at the 44th Annual Albert L. Tester Memorial Symposium, University of Hawaii at Manoa campus, April 10–12, 2019.

Future Research Plans

The goal is to publish the results from both the metabarcoding data examining biodiversity and community structure of the end time point and the image analyses data examining recruitment and community structure analyses over 17 collection time points during the course of the two-year experiment.

(above) Figure 1. Image of an ARMS plate from the heated treatment dominated by the sponge, Plakortis halichondroides.

(below) Figure 2. Mesocosm set up at the Hawaii Institute of Marine Biology.

Presentations

- Timmers, M. A. Crypofauna coral reef diversity in the tropical Pacific. Haunama Bay Seminar Series, Honolulu, HI, September 2018. https://www.youtube.com/watch?v=JtafBiq-9P0&t=21s.
- Timmers, M. A., et al. Effects of elevated pCO2 and temperature of coral reef cryptofauna biodiversity and community composition. 44th Annual Albert T. Tester Symposium, Honolulu, HI, April 2019.

Ecosystem Impacts of Surface Slicks in West Hawaii

Jonathan Whitney, JIMAR Postdoctoral Researcher

Purpose of the Research

This study is investigating the ecological and physical oceanographic properties of surface slicks, their importance for larval fish and overall relevance for local ecosystem dynamics in the West Hawaii region. The areas within and around slicks aggregate floating material and attract organisms in areas where food resources are otherwise sparse and dispersed, functioning as biological oases and contributing to the recruitment and retention of early life history stages of fishes. Despite this potential ecological importance, very little is known with respect to the underlying physical mechanisms, ecological relevance, ephemerality, and motility of surface slicks in the region.

The overarching goals of this project are to examine the spatial and temporal variability in larval distribution and abundance in relation to specific oceanographic features (slicks) in order to identify the environmental conditions that drive that variability and ultimately use that knowledge to develop indicators to improve stock and ecosystem assessments.

Progress during FY 2019

In July 2018, Whitney organized and led a successful shore-based field mission to West Hawaii for which he received a JIMAR Performance Award. During the mission the research team completed 11 days of on-water surveys, conducted 336 plankton tows and wrapped up the three-year sampling effort. In March, they completed processing and quality assurance of all 985 plankton tows collected over the three-year period. This represented a major milestone for the project. Whitney made significant progress analyzing and synthesizing the project's comprehensive three-year dataset and recently completed the second draft of a manuscript describing the surface slicks as critical nursery habitat for larval fish; this manuscript will be submitted to *Nature Ecology and Evolution* in August. He also made significant progress synthesizing data and analyzing results for a follow-up manuscript

Figure 1. *Larval mahi-mahi* (Coryphaena hippurus) *collected in surface slick off West Hawaii during JIMAR-supported 2018 field mission.*

Figure 2. Pelagic juvenile rough triggerfish (Canthidermis maculata) *collected in surface slick off West Hawaii during JIMAR-supported 2018 field mission.*

that will assess spatial patterns of larval fish communities in West Hawaii. In addition, he worked extensively with Katie Smith on the analysis of the physical oceanography aspect of the slick study and produced a manuscript currently in revision to be submitted to *Continental Shelf Research* in August. This year, the research team conducted dissections of almost 700 larval fishes to look for evidence of plastic ingestion. They discovered the first evidence of plastic ingestion of coral reef fish larvae along with other pelagic species. Furthermore, the team completed processing and analysis of plastic accumulation in surface slicks which included image analysis of more than 100,000 plastic pieces sorted from plankton samples. Whitney and Jamie Gove co-led the production of a manuscript, which is under review in the *Proceedings of the National Academy of Sciences*.

Future research plans

Whitney will continue analyzing the extensive amounts of biological and physical data collected during previous expeditions to the region. These efforts will be synthesized into a number of peer-reviewed journal articles and outreach material, highlighting novel findings and key insights on food-web dynamics necessary to support ecosystem-based management in the region. The team has one manuscript in review and two manuscripts in preparation on surface slicks in West Hawaii.

The team will continue processing and assembling a 20-year (1998–2019) time series of neustonic ichthyoplankton collections from West Hawaii in order to assess inter-annual variation in larval abundance and distribution. Next they will assemble data from historical collections with ichthyoplankton and zooplankton surveys from their three recent research cruises that provide high-resolution biophysical coupled sampling of more than 150 slicks sampled across three seasons to assess intra-annual variation in larval dynamics. They will then analyze both ichthyoplankton data sets individually and comparatively to assess patterns of change in abundance, distribution, and assemblages of key species.

Presentation

Whitney, J. L., et al., West Hawaii ichthyoplankton project: Exploring a unique ecosystem and their impact on larval fish ecology. Symposium on Science in Support of Archipelagic Management, Honolulu, Hawaii, November 20, 2018.

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

P.I.: 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 Marine Debris Mitigation project is a research and management endeavor that focuses on derelict fishing gear removal within the U.S. Pacific Islands including the Northwestern Hawaiian Islands within the Papahānaumokuākea Marine National Monument and the main Hawaiian Islands. The overall project goal 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.
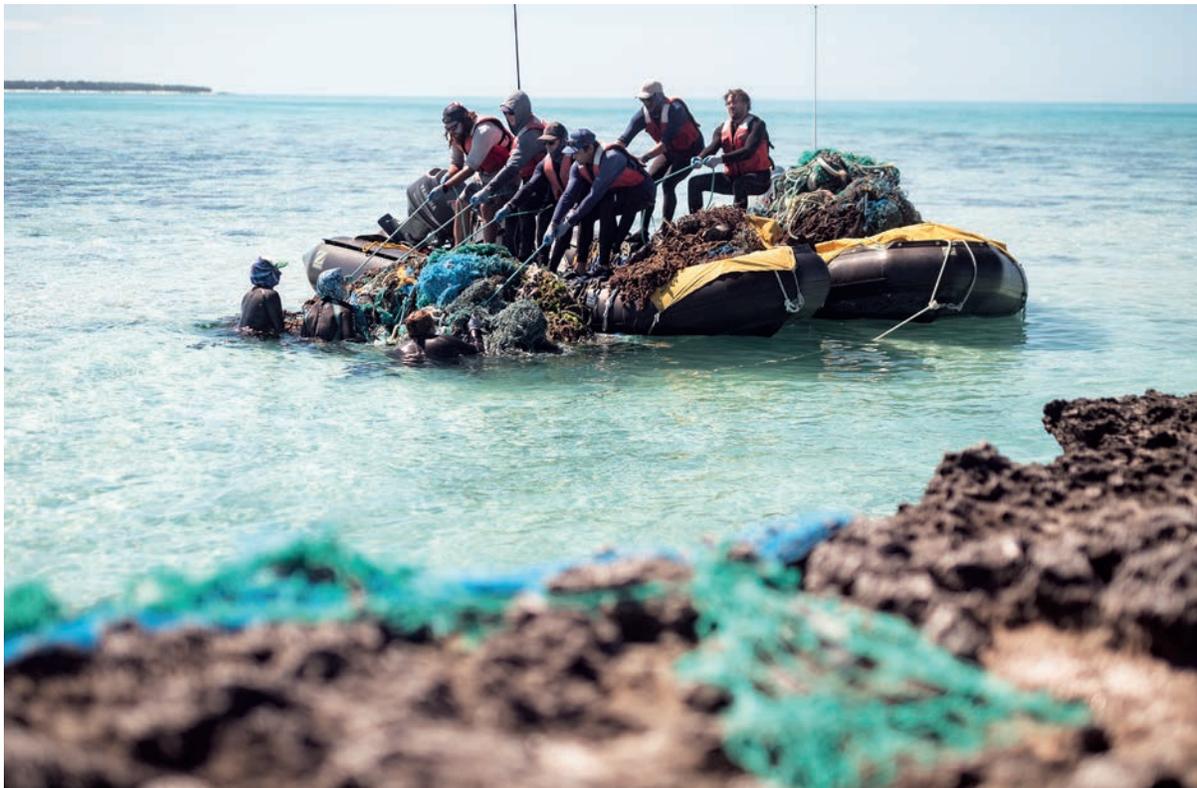

Figure 1. Marine debris team works to haul in a large net.
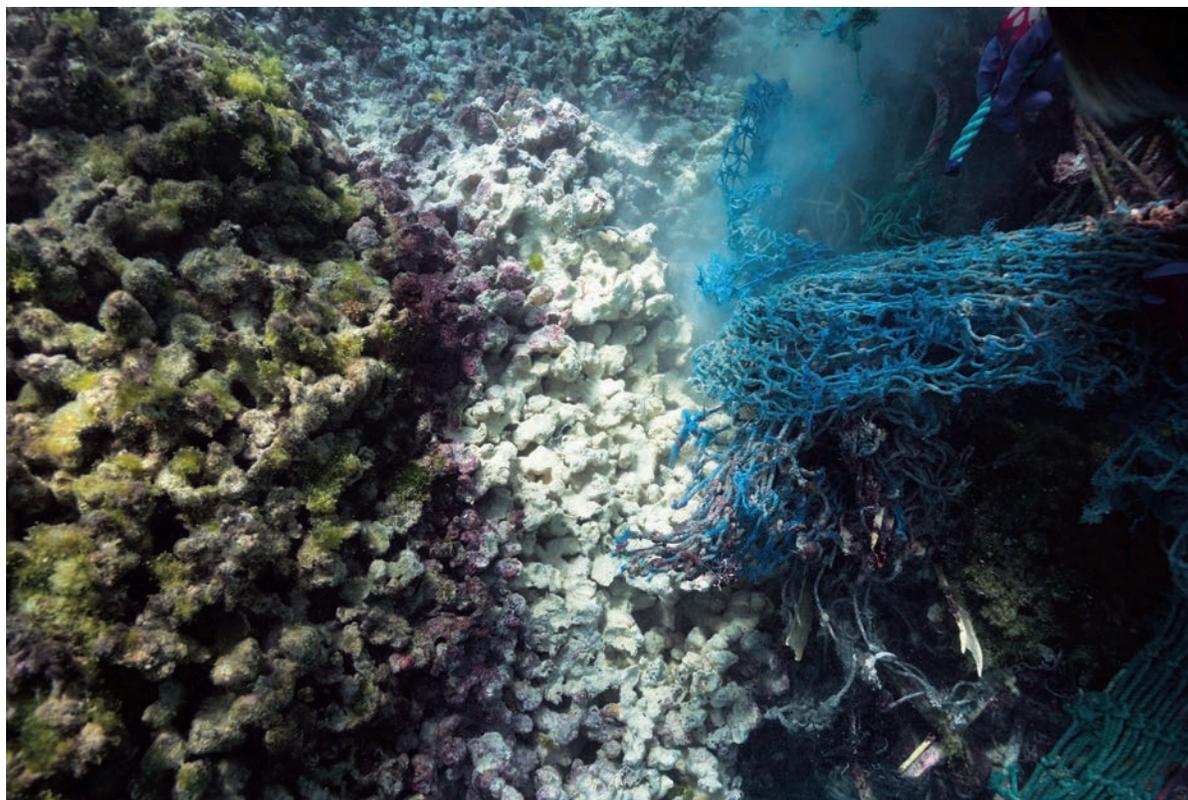
Figure 2. Harmful impacts of derelict fishing nets on a coral reef in the Northwestern Hawaiian Islands.

This project supports episodic marine debris removal missions (every three years) to remove derelict fishing gear from these remote islands and atolls. The JIMAR staff in the NOAA NMFS Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) coordinates these missions with support from numerous partner agencies including the U.S. Fish and Wildlife Service, NOAA Office of National Marine Sanctuaries, NOAA Office of Response and Restoration, NOAA Office of Marine and Aviation Operations, and NOAA Marine Debris Programs. 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 2019

Marine Debris Removal Field Mission and Data Collection. A team of 19 marine debris staff executed a marine debris removal and research mission from September 19–October 30, 2018. External resources supported staffing and field work execution while project resources supported post-cruise analysis, data management, and outreach efforts.

Outreach and Community Engagement. During the project period, the JIMAR/NOAA PIFSC Marine Debris Project conducted several outreach events, interviews, and presentations to relay the mission and successful completion of the 2018 field mission to the Northwestern Hawaiian Islands (NWHI). Outreach efforts directly reached 906 people.

Data Stewardship. JIMAR staff made concerted efforts to improve the integrity of the archived data developed by this project. Improvements included streamlining data storage within the Oracle database to reduce redundancy or unused fields, correcting inaccurate data, modifying existing fields, and improving overall organization. Land debris data entry fields were expanded and standardized to more accurately reflect the wide variety of debris types encountered. Finally, the two datasets (in-water debris and shoreline land debris) were submitted to the NOAA archive to meet Public Access to Research Results (PARR) requirements for the June 1, 2019 deadline.

Socioeconomics of Western Pacific Fisheries

PI: Douglas S. Luther [JIMAR Project Lead: Hing Ling Chan]

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):

• Resilient Coastal Communities and Economies

Purpose of the Project

This JIMAR project supports effective fishery and associated ecosystem management through fisheries socioeconomic data collection and socioeconomics research in Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). It is essential to collect fishery economic data and sociocultural information and monitor changes in key socioeconomic indicators for fisheries in the U.S. Pacific Islands due to the significant contribution of the fishery sector to the local economies and communities and due to constant changes in fishery management and regulations.

Progress during FY 2019

The project successfully supported socioeconomic database management of the Hawaii longline fishery and American Samoa longline fishery and continued data collection and monitoring activities in the American Samoa, Guam, and CNMI small-boat fisheries. A NOAA technical memorandum tracking the economic performance indicators of small boat fisheries in the three island areas was published.

Project activities accomplished during FY 2019 are described below by sub-project.

• Project staff assisted with the National Community Social Vulnerability Indicators work plan by submitting updated social indicators to NOAA headquarters, which then published updates on its website.

• To conduct socioeconomic monitoring for resilient communities in the Pacific, an assessment was developed for socio-economic data and indicators to determine connectivity with existing biophysical data and improve their usefulness for resource management in the U.S. Pacific islands. An online survey was launched in May 2019 and four focus group analyses were completed. In addition, JIMAR staff co-facilitated a regional socioeconomic monitoring strategic planning meeting in Pohnpei in August 2018 with the Pacific Islands Managed and Protected Areas Community (PIMPAC) and partners from Guam, CNMI, Republic of the Marshall Islands, Federated States of Micronesia, and Palau. This was followed by a regional socioeconomic monitoring training and socioeconomic assessment that JIMAR staff co-led in Nahtik, Pohnpei in September 2018, and in Tamil, Yap during January 2019. JIMAR staff also provided on-going social scientific support to the PIMPAC program evaluation and multiple socioeconomic monitoring initiatives in Hawaii, including the Community-Based Subsistence Fishing Areas, Hawaii Division of Aquatic Resources 30x30 project, Conservation International's community-based marine resource monitoring in Hawaii, and the Maui Nui Network with eleven communities in Maui, Lanai, and Molokai. Two manuscripts and a PIFSC special publication were published from this work and four additional manuscripts were developed and submitted to journals.

• The project conducted an analysis to model longline fisheries trip costs in Hawaii and American Samoa and a draft manuscript is near completion.

• For a cost-earnings study of the CNMI and Guam small boat fisheries, the field work was completed and data entry is ongoing. The next step is to prepare data analysis for technical report.

• A draft NOAA Technical Memo was completed for the project to survey the 2018 Hawaii pelagic fishing tournament.

• A pilot project entitled "Fisher behavior and protected species interactions in Hawaii and American Samoa longline fisheries" was implemented that focuses on the science of compliance to improve understanding of sensitive/non-compliant fishery activities. In the fall of 2019 project staff will collect social and behavioral data related to protected species interactions. This project required extensive planning and was slightly delayed due to the federal government shutdown. The next steps are to collect data, perform data analysis, and prepare a report.

Figure 1. Postcards and information sheets for the 2019 Hawaii Diving and Snorkeling Survey laid out on a NOAA table at the 2018 Hawaii Fish and Dive Expo. JIMAR staff Emily Rollins attended this event in order to promote the survey.

- The project to evaluate interactions between oceanic whitetip sharks and West Hawaii small-scale fisheries in a human dimension context resulted in a master thesis for Ms. Mia Iwane of the University of Hawaii. Results were shared with research participants, academic, and management communities at a public meeting, fisheries workshop, professional conference, and at Ms. Iwane's thesis defense held at the University. A NOAA technical memorandum will be submitted to PIFSC editorial in FY 2019.
- A manuscript is in development to examine allocative foundations for catch share management of the Hawaii longline industry.
- A preliminary analysis was conducted for the project to assist with modeling the impact of climate change on the economic viability of fishing for tuna and billfish. A first draft of the research report was submitted to the Department of Economics at UH Manoa.
- For the West Hawaii Integrated Ecosystem Assessment (IEA) project, JIMAR staff developed a project framework and methodology to gather indicators of cultural ecosystem services and human well-being for the West Hawaii IEA. A literature review was conducted and an interview guide was developed. JIMAR staff interviewed 31 participants and transcription of the interviews is underway. The next steps are to perform data analysis and report writing.
- A project to integrate social, economic, and cultural components into a submodule for the Main Hawaiian Islands Atlantis Ecosystem Model was delayed pending recruitment of a researcher.

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, Joseph O'Malley

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

JIMAR staff conducts and supports the stock assessment of bottomfish, coral reef fishes, and crustaceans in the Pacific Islands Region (PIR). Researchers on this project also conduct collaborative assessments of pelagic fish stocks in the western Pacific Ocean together with scientists from Japan, Taiwan, Canada, Korea, China, Mexico, the Inter-American Tropical Tuna Commission (IATTC), and the Secretariat of the Pacific Community (SPC). These assessments are conducted under the auspices of the International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean (ISC). Priority is given to marlins, swordfish, and oceanic sharks species (blue, oceanic whitetip, silky, mako, and thresher sharks) in the North and Central Pacific Ocean. The primary objective of these investigations is to provide quantitative information that meets defined standards of scientific rigor and satisfies management requirements for the sustainable exploitation of these resources.

Progress during FY 2019

For the insular assessment work, JIMAR researchers continued developing the surplus-production model R package called Just Another Bayesian Biomass Assessment (JABBA), published a 100 page NOAA technical memo on reef fish stock assessments for the island of Guam, and created several fisheries tools available as R
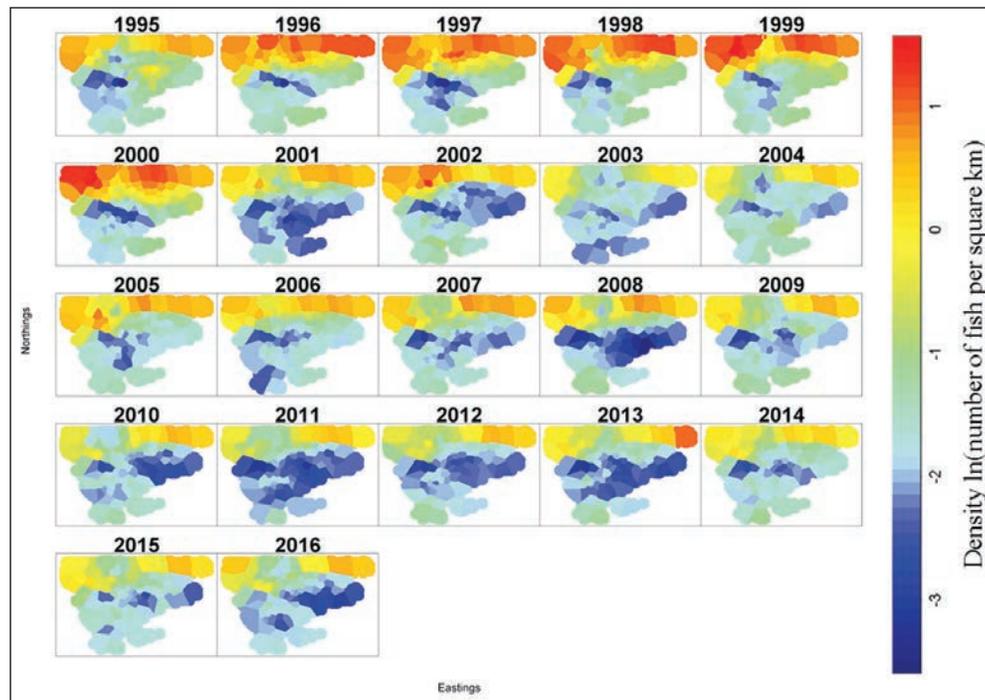
Figure 1. Distribution of swordfish density by year from the Hawaii-based longline fishery from a Vector Autoregressive Spatio-Temporal (VAST) model. Units are ln (number of fish per square km).
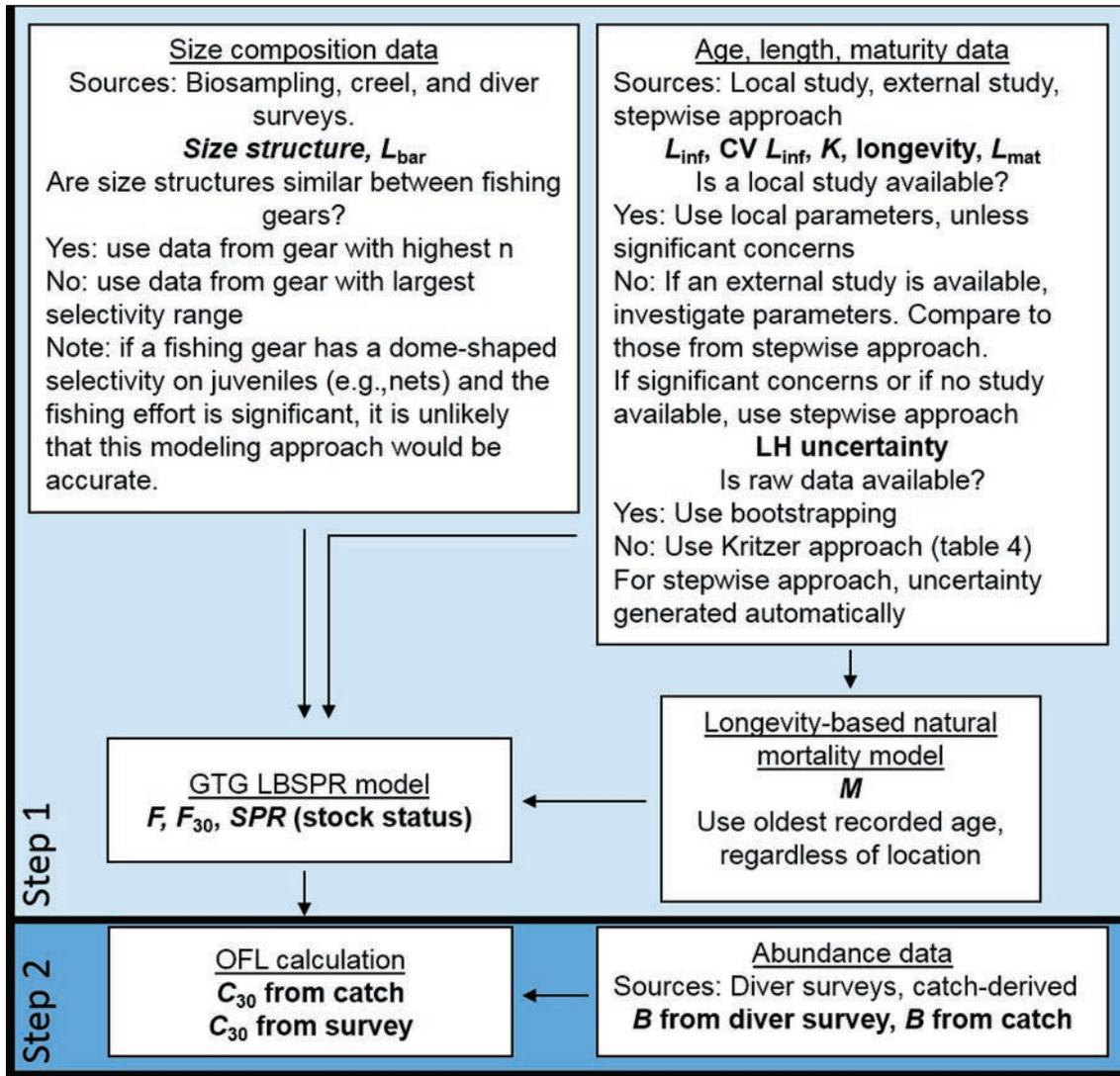
Figure 2. Overall approach and decision points used to calculate stock status using SPR and, for some species, calculate overfishing limits (OFL) in the Guam reef fish stock assessment.

packages, StepwiseLH (generates life history parameters) and TMB.LBSPR (implements a length-based stock assessment model using Template Model Builder). The Kona crab stock assessment was completed and made public. Work was started on the uku (*Aprion virescens*) stock assessment as data processing and catch-per-unit-effort standardization were finalized. For the assessment the JIMAR staff plan to use the advanced Stock Synthesis model. For the pelagic assessment work, JIMAR researchers collaborated with scientists from other NOAA line offices and international fisheries agencies and universities to address research problems in pelagic fisheries. The North Pacific striped marlin assessment was successfully completed in collaboration with federal staff and scientists from Taiwan and Japan. An analysis of assumptions used in marlin and swordfish stock assessments was undertaken in collaboration with scientists from Taiwan and South Africa and a publication detailing this work is currently under review. Project staff is also collaborating with PIFSC federal staff in preparing a manuscript on spatio-temporal dynamics of swordfish caught in the Hawaiian fishery and developing research goals for bigeye tuna.

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 34 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 2019

During the past year, the CRP conducted two shipboard surveys, two small-boat surveys and began a collaborative Unmanned Aerial System (UAS) project with the University of Hawaii's Marine Mammal Research Program.

In July 2018, the CRP conducted the Mariana Archipelago Cetacean Survey (MACS), which was a 24-day survey effort aboard the NOAA Ship *Oscar Elton Sette* to study cetaceans in the waters of Mariana

Figure 1. Erik Norris prepares a High-frequency Acoustic Recording Package (HARP) for deployment.

Archipelago. The MACS study area focused on pelagic waters extending west from the archipelago out to the West Mariana Ridge and from Guam in the south to Pagan in the north. MACS focused on the deployment and recovery of Drifting Acoustic Spar Buoy Recorders (DASBRs) with the intent of collecting passive acoustic

Figure 2. Members of the Cetacean Research Program conduct a small-boat survey around Pagan during the 2018 Mariana Archipelago Cetacean Survey (MACS).

data for estimating the distribution and density of beaked whales and other cetaceans. JIMAR assisted with the deployment of eight DASBR units over the course of the 24-day effort and let the instruments drift with the current for several days. In addition to the DASBR research, the group conducted visual and towed hydrophone array observations for cetaceans and recovered and re-deployed HARPs (High-frequency Acoustic Recording Packages) off Saipan, Tinian, and Pagan. There were 64 cetacean visual sightings of thirteen species, including: spinner (*Stenella longirostris*), pantropical spotted (*S. attenuata*), striped (*S. coeruleoalba*), rough-toothed (*Steno bredanensis*), bottlenose (*Tursiops truncatus*), and Risso's (*Grampus griseus*) dolphins; melon-headed (*Peponocephala electra*), pygmy killer (*Feresa attenuata*), short-finned pilot (*Globicephala macrorhynchus*), and sperm (*Physeter macrocephalus*) whales; Cuvier's beaked whales (*Ziphius cavirostris*), dwarf sperm whales (*Kogia sima*), and Bryde's whales (*Balaenoptera edeni*); and groups of dolphins and whales that could not be identified to species. Photographic documentation commenced during most sightings, resulting in more than 6,600 individual or species identification photos. Biopsy sampling was attempted during twelve sightings, which resulted in 20 biopsy samples collected from pantropical spotted and bottlenose dolphins, melon-headed, short-finned pilot, and Bryde's whales. A total of 94 acoustic encounters were identified in real-time using the automated detectors, including acoustic detections during 30 visual sightings. In addition to those groups seen by the visual team, the passive acoustic team encountered four groups of false killer whales, seven groups of sperm whales, five groups of Blainville's beaked whales, two groups of Cuvier's beaked whales, one group of Longman's beaked whales, and 45 groups of unidentified dolphins.

Since 2010, the CRP has been conducting visual surveys for cetaceans in the waters surrounding Guam and CNMI as part of an ongoing effort to develop a record of cetacean occurrence in the region. During August– September 2018, non-systematic visual surveys for cetaceans were conducted from small vessels off Saipan, Tinian, Aguijan, and Guam. A total of 1,168 km of trackline was surveyed on fourteen days during which 20 cetacean groups were encountered including: spinner, pantropical spotted, and bottlenose dolphins; short-finned pilot and sperm whales. A total of 6,437 photos and 33 biopsy samples were collected from all five species.

Five satellite tags were deployed on short-finned pilot whales. In January 2019, non-systematic surveys were conducted off Saipan and the surrounding area. There were a total of 12 encounters with four cetacean species including humpback whale (*Megaptera novaeangliae*), rough-toothed dolphin, bottlenose dolphin, and spinner dolphin. A total of 377 photos were collected. Fluke images were collected from three humpback whales.

In March 2019, the CRP began a collaborative project with the University of Hawaii Marine Mammal Program. The purpose of the project is to validate body measurements of marine mammals obtained via aerial photogrammetry using UAS along with hands-on physical measurements obtained of captive animals. This research will help obtain robust demographic and health measurements of free-ranging populations of dolphins and whales.

Effects of Nitrogen Sources and Plankton Food-Web Dynamics on Habitat Quality for the Larvae of Atlantic Bluefin Tuna in the Gulf of Mexico

P.I.: Karen E. Selph

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

NOAA Sponsor: John Lamkin

NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The Gulf of Mexico (GoM) is one of the most economically important marine regions in the U.S. Exclusive Economic Zone (EEZ). The country's largest recreational fisheries occur in the GoM, targeting a multitude of species including bluefin, skipjack and yellowfin tuna, billfish, mahi mahi, coastal pelagics, snappers and groupers. Atlantic bluefin tuna (ABT) and other highly migratory species spawn in the GoM but are distributed as adults throughout the northern Atlantic Ocean, including the EEZs of many European, American and African nations. Despite various management measures, the western ABT stock is considered to be over exploited. Current stock assessments for the GoM require better ecosystem understanding to effectively evaluate how bottom-up processes limit or enhance ABT recruitment. The objective of this proposal is to elucidate the underlying mechanisms that link variability in nitrogen sources and food-web fluxes in the GoM to habitat quality, feeding, growth and survival for ABT larvae.

Figure 1. NOAA Ship Nancy Foster *in the Gulf of Mexico, May 2018.*

Figure 2. NOAA Ship Nancy Foster *in dry dock, Pascagoula, MS, May 2018.*

Progress during FY 2019

In May 2018, the project completed the second of two cruises in the GoM aboard the NOAA vessel *Nancy Foster*. During FY 2019, 498 samples collected from this expedition were processed and analyzed for flow cytometry data to determine phytoplankton and bacteria abundance. The project PIs participated in a one day workshop on 24 Feb 2019 (New Orleans, LA); PI Selph participated remotely. The project PIs also presented results at a March 2019 meeting at the Centro Oceanografico de Canarias (Tenerife) attended by scientists from the Istituto Espanol de Oceanografia. These latter colleagues are involved in studying the same tuna species in the Mediterranean and joint publications for several of the data sets are currently being prepared.

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

Shark bycatch in commercial fisheries on the high seas and in local Hawaii fisheries targeting tuna and billfish contribute significantly to population declines of pelagic species across whole ocean basins. In the Pacific Ocean, both silky (*Carcharhinus falciformis)* and oceanic whitetip (*C. longimanus*) sharks have been assessed
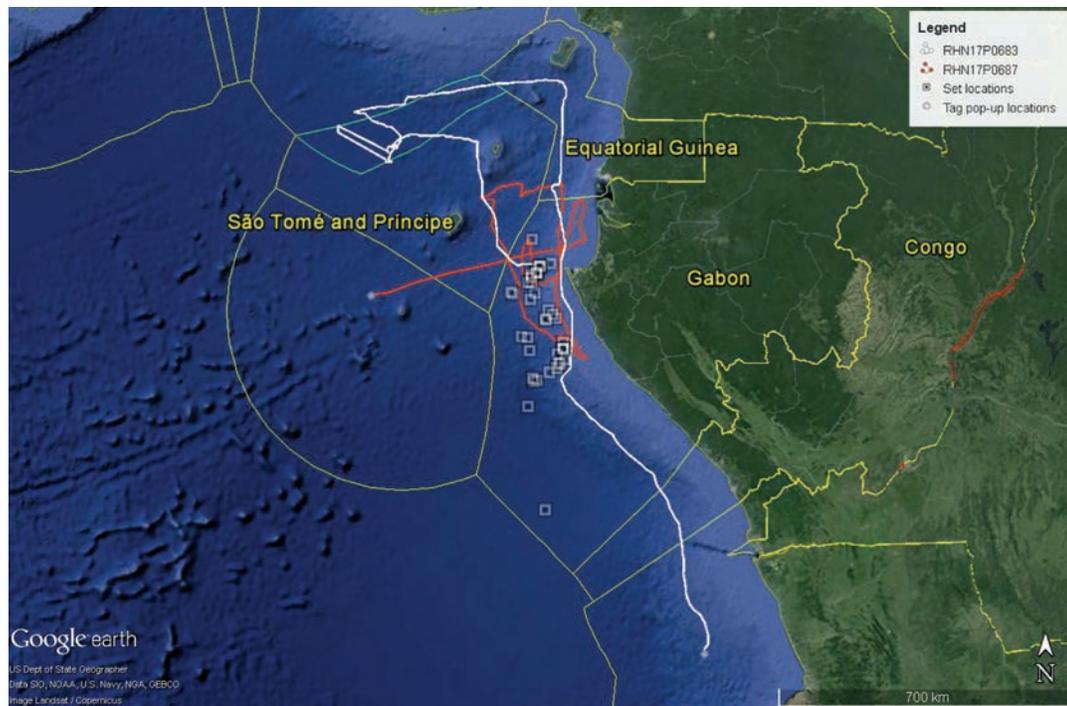
Figure 1. Tracks generated by two whale sharks to estimate post release survival using best handling practices after release from encirclement by the purse seine vessel, Pacific Star.

as overfished and overfishing for both species is currently occurring. Furthermore, oceanic whitetip sharks are now listed under the U.S. Endangered Species Act as threatened with extinction. In this JIMAR project several research objectives aimed at reducing mortality for sharks during incidental interactions with commercial fishers, are being carried out.

Project research objectives include: 1) quantify post release mortality rates of sharks discarded in the Hawaii tuna and American Samoa longline fisheries; 2) identify best handling practices for improving survivorship of sharks discarded in longline fisheries; 3) understand oceanic whitetip shark Fish Aggregating Device (FAD) association, habitat use and movement behavior around Hawaii; and 4) support community engagement to reduce mortality to oceanic whitetip sharks in small scale tuna fisheries around Hawaii.

Progress during FY 2019

During the reporting period, JIMAR project staff completed a four year tagging effort aimed at quantifying post release mortality rates of four species of sharks discarded in longline fisheries. Over the course of the study a total of 159 satellite linked pop-off archival tags (PATs) were deployed on incidentally caught sharks. Project staff participated in a workshop with post release mortality experts to analyze and prepare several data sets (including the project's data set) for presentation at the 15th Regular Session of the Scientific Committee, Western and Central Pacific Fisheries Commission (WCPFC), in August 2019. This report will be distributed to relevant agencies and user groups and is also being used to advise an International Seafood Sustainability Foundation (ISSF) lead project on creating an illustrated shark best handling practices guide that will be made available in several languages. In addition, a hook configuration dissolution study was completed. This one year study will inform managers on corrosion rates and breaking/bending strengths for different hooks that are used in U.S. commercial fisheries. These data will also facilitate management recommendations for the False Killer Whale Take Reduction Team. The report will be available as a WCPFC Scientific Committee Information Paper. In collaboration with the Pacific Islands Regional Office Observer Program (PIROP), gear trials testing catch rates of target and non-target species on test monofilament gear versus normal tuna wire leader gear were initiated on a longline vessel with three of the four funded trips completed to date.

Figure 2. Male blue shark tagged with a survival PAT by Hawaii Community Tagging Program member Deron Verbech.

JIMAR project staff also expanded the scope of the ongoing Hawaii community tagging program to include tagging of other species such as silky sharks. A large identification tagging program was developed, similar to what other NMFS science centers have done. Project staff created identification tags, set up a phone reporting line and website, database, tagging materials, and a newsletter for broad dissemination. The newsletter contains information about the tagging program, progress to date, and a shark identification guide. These data assist in outreach endeavors and generate baseline interaction information and population demographics for several species.

Project staff also worked with ISSF and an international team of researchers aboard a purse seine vessel to assess the efficacy of best handling recommendations for removing whale sharks, mobula ray, and silky sharks from purse seine gear. JIMAR staff served as the chief scientist during a commercial fishing trip and conducted several tagging experiments and fishing experiments on reducing mortality to incidental elasmobranchs. Results from this cruise are in preparation for presentation to the 2019 WCPFC Scientific Committee meeting and will undergo peer review in the coming months. The results from this cruise and previous cruises were published in the ISSF compendium of research activities through 2018, resulting in two manuscripts that are currently under review.

Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support

P.I.: 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, Charles Littnan

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

JIMAR's Hawaiian Monk Seal Research Program (HMSRP), in collaboration with the NOAA Pacific Islands Fisheries Science Center Protected Species Division (PIFSC PSD), 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 implements 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). Field staff and volunteers are deployed on a seasonal basis at up to five main breeding sites and conduct field studies opportunistically at

Figure 1. *JIMAR staff Hope Ronco photographing seals on Nihoa for identification purposes (work conducted under NMFS Permit No. 16632 and PMNM-19-012).*

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. Field staff also provided assistance to other programs and agencies, including activities such as establishing and maintaining marine debris plots, conducting insect, plant, and Laysan duck surveys, monitoring for invasive species, and collecting sea turtle nesting data.

Progress during FY 2019

Field camps were already established 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 when the reporting period commenced on July 1, 2018. Field teams, consisting of ten JIMAR staff and four University of Hawaii volunteers, conducted Hawaiian monk seal population research and enhancement activities, including gathering data on the number of pups born, number that survived to weaning, number marked, number of older animals identified, inter-atoll movements, causes of mortality, and other key demographic variables. Survival enhancement activities included vaccinating seals against morbillivirus, disentangling seals, reuniting mom/pup pairs that had been separated during the nursing period, freeing seals and other wildlife entrapped in disintegrating infrastructure at Tern Island, translocating weaned pups away from areas with high shark predation, fishing for predatory sharks, abscess treatment, and identifying and capturing animals in need of rehabilitation and de-worming. Monk seal field teams supported other PIFSC researchers by continuing a debris accumulation study in collaboration with the Coral Reef Ecosystem Program, and tagging and monitoring turtles in collaboration with the Marine Turtle Biology and Assessment Program. While deployed, they also conducted a variety of conservation activities in collaboration with the U.S. Fish and Wildlife Service (USFWS), including entrapment surveys and mitigation and rat detection surveys at FFS, Laysan duck surveys at Laysan Island, and *Verbesina* eradication efforts at North Island, PHR. Short term field efforts were conducted at Midway Atoll during June, July and September 2018, and a short term field effort was conducted at Nihoa Island in September. Field work was successfully completed at four of the five field camps (Laysan, Lisianski, PHR, and Kure Atoll) and all field camp personnel, supplies, equipment, and data were collected from these sites by NOAA R/V *Oscar Elton Sette* during cruise SE-18-04 with the exception of the Kure Atoll field camp, which was collected by M/V *Imua*. The Nihoa field team, including a

seal researcher, was collected by the S/V *Makani Olu*. Two underweight weaned pups were also collected at Laysan during the SE-18-04 cruise and transported to The Marine Mammal Center's Ke Kai Ola facility in collaboration with HMSRP for rehabilitation purposes. All three vessels returned to Honolulu with all data, equipment, and supplies on September 10, 2018. The four person FFS field team was scheduled to return to Honolulu on October 11th, but the retrieval of the camp personnel was expedited to September 30th via the NOAA Ship *Hiialakai* due to approaching Hurricane Walaka. One staff member also participated in a U.S. Coast Guard flyover in October to assess damage caused by the hurricane. Upon return to Honolulu, field personnel cleaned and inventoried gear and supplies and completed reports summarizing field research and population status at each site.

Figure 2. UH Volunteer Alexa Gonzalez and JIMAR staff Paige Mino make final preparations to their zodiac before being deployed at their field site at Pearl and Hermes Reef (work conducted under PMNM-19-012).

The 2019 field season commenced in March 2019 and field personnel were trained to perform field activities and participated in securing and packing food stores. A total of eleven JIMAR seasonal staff and four volunteers were deployed to establish research camps at FFS, Laysan, Lisianski, PHR, and Kure Atoll for the 2019 field season. In May, two individuals flew to Midway Atoll to conduct surveys and train a USFWS volunteer before transiting to Kure Atoll. Two field staff departed for FFS on the M/V *Imua* on May 11th. All remaining staff departed for the field on either of two legs of the deployment on May 15th and May 23rd. The 2019 field teams began conducting research and recovery activities and field personnel are expected to remain deployed through the end of the reporting period.

Hawaiian Monk Seal Research Program

P.I.: 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, Charles Littnan

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Hawaiian Monk Seal Research Program (HMSRP) 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

Figure 1. Monitoring Hawaiian monk seal moms and pups at Kalaupapa National Historic Park (work conducted under NMFS Permit No. 16632).

focuses on connections between population biology, foraging ecology, individual health, and environmental and oceanographic parameters in the North Pacific. The program develops, tests, and implements tools to assist in recovering the species.

Progress during FY 2019

Accomplishments during FY 2019 included population monitoring and assessment, survival enhancement activities, foraging ecology characterization, health and disease evaluation, and behavioral research. Project activities and accomplishments are described in detail below.

JIMAR staff played a crucial role in the breakdown of the 2018 field research camps as well as the establishment of 2019 field research camps in the NWHI. Nine field staff and four volunteers were hired for the 2019 field season, protocols were reviewed and revised, and staff trained field personnel on how to conduct field activities such as data collection, vaccination, and specimen collection. They also procured, tested, and packed field supplies and equipment, and provided other logistical support to deploy the camps. A JIMAR staff member served as Chief Scientist on the NOAA Ship *Oscar Elton Sette* 2019 field deployment.

HMSRP staff bleach-marked and photo-identified seals throughout the main Hawaiian Islands (MHI) as they conducted population and monitoring surveys, emergency response activities, inter-island foraging ecology projects, and flipper-tagging events. HMSRP staff applied seal-mounted video cameras to seals on Oahu and Molokai. Staff traveled to Hawaii Island, Lanai, Maui, and Molokai to assist with tagging of weaned pups and vaccination efforts, and also conducted focused population assessment surveys on Molokai. A Kalaupapa monitoring plan was developed and one intermittent staff was hired to conduct monitoring activities at this very important pupping site as well as other locations on Molokai. Staff also participated in collaborative efforts to collect, rehabilitate, and release MHI and NWHI seals in concerted efforts with The Marine Mammal Center's Kei Kai Ola monk seal hospital.

Figure 2. JIMAR and NOAA staff capturing a pup for tagging on Rabbit Island, Oahu (work conducted under NMFS Permit No. 16632).

Additional accomplishments by the project included ensuring data resources remain compliant with the NOAA Plan for Increasing Public Access to Research Results requirements. Program staff continued to improve and refine the Seal Population Assessment (SPA) database, providing for greater efficiency. A new email system for field camper personnel was implemented. The project investigated the use of Bluetooth+LoRa tags to improve identification of the seals and perform a census of the seals. Project personnel also operated Unmanned Aircraft Systems to survey and assess monk seals, continued ongoing vaccinations of wild seals against morbillivirus, and trained partners in vaccination and pole syringe techniques and protocols.

The foraging ecology program deployed telemetry and animal-mounted video equipment to document individual HMS movements. Health and disease research included collecting biomedical samples in the MHI for disease surveys in conjunction with telemetry deployments and from stranded animals. Samples were then shipped to various laboratories for analysis. Emergency response efforts included de-hooking and assessment for other health concerns and performing necropsies. Staff and program volunteers continued with organization and maintenance of tens of thousands of samples in the frozen specimen archive. JIMAR personnel created a new specimen labeling system that allows specimens to be automatically numbered and barcoded upon collection. This new system greatly increased efficiency and accuracy. JIMAR personnel continued collaboration with outside researchers to assess risks posed by *Toxoplasma gondii* to monk seals and participated in ongoing maintenance of the veterinary laboratory and seawater system for live animal care. JIMAR staff began compiling data and summarizing diseases known to be a risk in monk seals in preparation for an overall population health assessment manuscript. They also began compiling data for a manuscript on vaccination against morbillivirus to be published in the near future.

Marine Turtle Recovery in the Pacific Islands Region

P.I.: Douglas S. Luther [JIMAR Project Lead: Camryn Allen]

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 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 the 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 on 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) assisting 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) maintaining efficient and secure computerized storage, management, and retrieval of sea turtle research data; and 9) training observers learning to conduct the collection of sea turtle data while aboard commercial longline fishing vessels.

Progress during FY 2019

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 and periodically on the

*Figure 1. JIMAR student assistant Lindsey Bull was awarded the People's Choice Award (Peeps) for her presentation entitled, "Impact of climate change on green sea turtle (*Chelonia mydas*, Cheloniidae) hatching success on East Island, French Frigate Shoals, Northwestern Hawaiian Islands", at The 44th Annual Albert L. Tester Memorial Symposium, University of Hawaii at Manoa, Honolulu, HI, April 10–12, 2019.*

neighbor islands; 5) organization of existing databases from aerial and in-water tow board surveys obtained through ongoing partnerships with PIFSC programs and territorial agencies; 6) longline observer training sessions; 7) research on the general biology, life history, and ecology of sea turtles in coastal marine habitats and on nesting beaches; and 8) participation in the planning, preparation, and data analysis/reporting of annual nesting field work at French Frigate Shoals (FFS), Northwestern Hawaiian Islands (NWHI).

Figure 2. JIMAR field researchers, Christina Coppenrath (left), Marylou Staman (middle), and Leah Kerscher (right), temporarily mark the shell of a female green sea turtle (honu) basking on Tern Island, FFS. The field research team will spend several months on a honu nesting beach in the NWHI and will tag all female nesting honu within FFS.

In June 2019, three field researchers (Marylou Staman, Leah Kerschner, and Christina Coppenrath) at FFS deployed satellite tags on three nesting females. They also individually identified 165 males and 252 female green sea turtles. The team confirmed nest laying by several of the identified females (including the newsworthy female named "Motherload") and deployed a handful of temperature dataloggers to monitor nest temperatures. The FFS encampment is an annual field endeavor that lasted four months this season.

JIMAR Marine Ecological Researcher Dr. Alexander Gaos bolstered the program's ability to obtain additional demographic data and understand aspects of sea turtle ecology in the Pacific Islands Region (PIR) such as hawksbill abundance, sex and sex ratio, and effects of climate change. In particular, he leads the Halawa Hawksbill Monitoring Project on Molokai, which is now one of the most productive nesting beaches in the Main Hawaiian Islands (MHI).

JIMAR Supervisor and Marine Biological Researcher Dr. Camryn Allen continued to oversee laboratory-related research and head sea turtle endocrinology research for investigation of sex, sex ratio, capture stress, and reproductive related questions. Preliminary results suggest that the sex ratio of immature green sea turtles foraging in the MHI is biased toward females at 1 male to every 3.4 females. The ultimate goal is to understand changes and climate impacts in sex ratio over time and the team was busy this past season obtaining samples from over 150 turtles around Oahu and the big Island.

Three University of Hawaii (UH) Marine Option Program (MOP) JIMAR student assistants and three JIMAR volunteers participated in stranding response and rehabilitation of sea turtles and conducted studies at FFS on nest abundance, age and growth, and hatching success. This season student assistant Lindsey Bull was deployed to FFS again for three weeks to assist the JIMAR field research team with camp set up and initial data collection. This was particularly important because of the destruction to the atoll caused by Hurricane Walaka at the end of last season.

Alexander Gaos continued collaborating with Molokai volunteers on the Halawa Hawksbill Monitoring Program and its hawksbill turtle nesting surveys. To learn more about the Hawaii hawksbill population, partnerships were formed to start monitoring Halawa beach beginning June 2018, where nesting has been opportunistically documented in the past but where no quantitative efforts had been applied. The team located and excavated three nests, gaining invaluable information on hatching success and other parameters. They also collected tissue samples from unhatched embryos for genetic research. Nightly patrols were conducted to potentially put a satellite tag on a nesting female but no turtles were observed during the four night patrolling window. To date, the monitoring program documented over 20 nests making Halawa one of the most productive hawksbill nesting beaches in the state of Hawaii, a discovery that bodes well for future recovery of this extremely endangered population.

Pacific Islands Deep Sea Coral and Sponge Initiative

P.I.: Douglas S. Luther [JIMAR Project Lead: Virginia Moriwake]

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 of developing long-term collaborative relationships between scientists from different research entities 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 Vehicles (ROVs) or manned submersibles surveys in the Central Pacific. The goal is to produce detailed records of animal observations (including the taxonomic identification, location, and environmental data) for incorporation to the DSCRTP national database in order to improve our understanding of the conditions that promote the formation of deep sea coral and sponge communities.

Progress during FY 2019

JIMAR staff was responsible for providing post cruise deliverables from expeditions in the Pacific conducted on the NOAA ship *Okeanos Explorer* (EX) and E/V *Nautilus*. These products and activities include: data retrieval, imagery, video products and creating backups; processing tracking and conductivity, temperature and density (CTD) data; organizing biological images captured by the onboard videographers and updating an online animal identification guide; creating coral, sponge, fish, and associated animal records from the dive video using the Video Annotation and Reference System (VARS) software for incorporation into the DSCRTP national database; and producing dive site characterization and regional reports.

Data. In October 2018, JIMAR staff received video and data from 11 ROV dives conducted on the E/V *Nautilus* cruise (NA101) during the previous month. The 15-minute video segments from the benthic portion of each dive were transcoded into a single dive video in MP4 format. The Ocean Exploration Trust's Nautilus Exploration Program provided merged navigation and sensor data for each of the ROV dives as text files. JIMAR staff compiled and formatted the data from the CTD and oxygen sensor data files into a single file containing latitude, longitude, depth, temperature, oxygen, salinity, and date/time fields that can be imported directly into ArcGIS for visualization of the dive tracks or merged with video annotations using custom scripts.

Imagery. For several years, JIMAR has been responsible for assembling *in situ* animal images from ROV video for an online benthic deepwater animal identification guide (https://oceanexplorer.noaa.gov/okeanos/animal_guide/animal_guide.html). For each new version of the guide, slides are populated with a photo of the animal, the current and most specific animal identification, and information about the source of the image (e.g., ocean, region, depth, time of the animal observation, ROV name, cruise, dive, and organization to credit for capturing
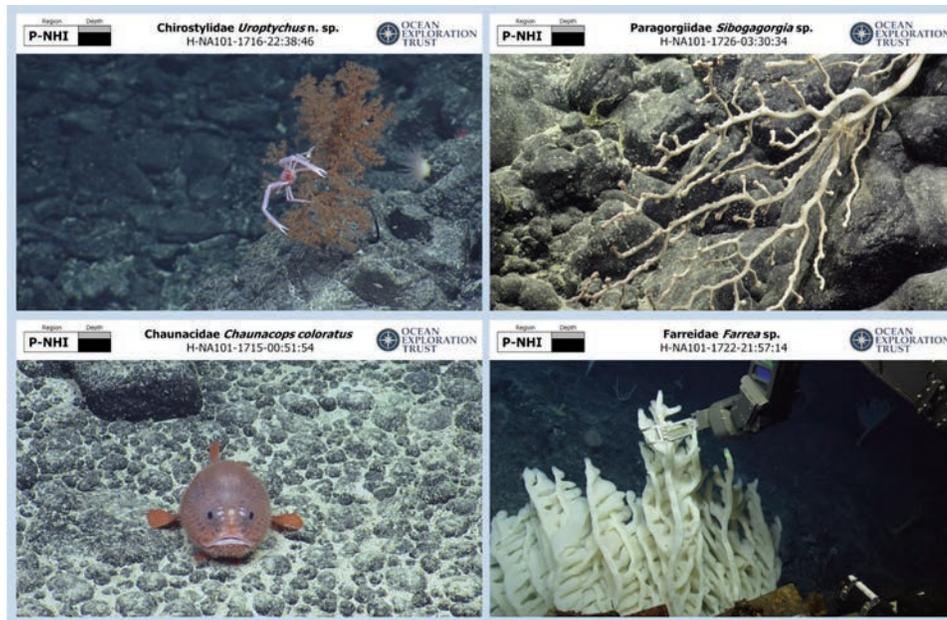
Figure 1. Example of four potential guide images for animals observed during the E/V Nautilus Cruise (images courtesy of the Ocean Exploration Trust, Exploring Enigmatic Seamounts in the Papahānaumokuākea Marine National Monument).

the image). During the report period, responses were received from more than 20 taxonomists that reviewed the animal identifications on slides produced from the 2017 EX cruises. JIMAR project staff revised, organized, and synthesized 5,600 selected images from the combined three years (2015–17) of EX cruises in the Pacific for the third version of the guide. These images were submitted to the NOAA website team for posting in January 2019. JIMAR staff also began reviewing images from the 2018 E/V *Nautilus* cruise in the Papahānaumokuākea Marine National Monument (PMNM). The dive location and environmental data necessary for slide production were associated with more than 19,000 images captured by the onboard crew. JIMAR staff started assigning preliminary animal identifications to a select portion of these images.

Video Annotation. 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 VARS software for annotating, then merged the tracking and environmental sensor data with the annotations based on their time codes and ran queries to extract the records for each dive as text files. These files are subsequently imported into a 72 field processing template for quality control review and formatted for inclusion in DSCRTP's database. During this reporting period, the team annotated video from 52 dives conducted in 2017 and eight dives conducted in 2018. More than 41,000 annotation records identifying approximately 115,000 coral and sponge individuals were submitted to DSCRTP from the 2017 EX dives. Another 12,000 records from 2018 Nautilus dives are in the review process prior to submission.

DSCRTP Dive Characterization Reports. JIMAR staff updated and edited 76 dive summaries with new maps (general area, dive site, and slope), CTD profiles, animal identifications and counts from video annotations, and

Figure 2. JIMAR Deep Sea Coral Research Associates, Sarah Bingo (left) and Meagan Putts (right), discuss the identification of a primnoid coral.

predominant substrate description in locations where animals were observed. These 2017 dive characterization reports were submitted to DSCRTP.

Regional Reports. JIMAR staff collaborated with Dr. Christopher Kelley, Program Biologist for the Hawaii Undersea Research Laboratory, to produce eight regional 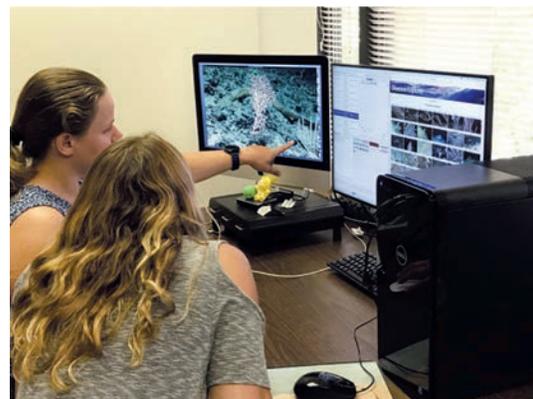reports summarizing the preliminary findings and data products from the 2015–17 EX expeditions, which explored the deep water resources within the U.S. marine national monuments and sanctuaries located throughout the Pacific. The eight regions are: PMNM; main Hawaiian Islands and Musicians Seamounts; Johnston Atoll Unit of the Pacific Remote Islands Marine National Monument (PRIMNM); Wake Island Unit of PRIMNM; Mariana Archipelago; American Samoa and the Cook Islands; Tokelau Seamounts, Phoenix Islands Protected Area, and the Howland and Baker Unit of PRIMNM; and Jarvis and Kingman-Reef Units of PRIMNM. The reports detailed the ROV dive locations; areas mapped; specimens collected; coral, sponge, and associated fauna observed; locations of large-scale, high-density coral and sponge communities; environmental conditions where corals and sponges were found; and substrate preferences. Graphical representations of regional patterns in CTD profiles and depths of oxygen minimum, along with the relative abundance of corals and sponge observations, were also included. The eight regional reports were completed and submitted to DSCRTP during this report period.

Webinar. JIMAR staff developed a OneNOAA webinar entitled, "Identifying deep-sea animals from video and still images: a guide to guide development", that presented the team's approach in identifying taxa for the Benthic Deepwater Animal Identification Guide and annotating video.

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

NOAA Sponsor: Randall Kosaki

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The JIMAR 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 scuba gear, technical diving gear (including closed-circuit rebreathers [CCRs]), remotely operated vehicles, small boats, 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 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 2019

The primary objectives of the JIMAR PMNM project are: coral reef monitoring; characterization of mesophotic coral ecosystems; quantification of benthic habitats; PMNM resource protection; and maritime archaeology. Milestones and accomplishments of each objective include the following.

Coral Reef Monitoring. PMNM was allotted 25 days at sea (DAS) in August–September 2018, but delays due to ship mechanical problems restricted the operation to four DAS. Because the length of the research cruise was insufficient to transit from Honolulu to the Papahānaumokuākea Marine National Monument, coral reef surveys were performed at Ni'ihau Island. JIMAR staff used the opportunity to refine the benthic survey methodology integrating the Structure-from-Motion (SfM) photogrammetric techniques, which was first implemented in the previous year. Benthic surveys using the SfM techniques were completed in combination with the rapid ecological assessment of reef fish and surveys for coral distributions and diseases in order to specifically evaluate the limitations of SfM to capture small details of benthic features. JIMAR staff processed all photographs from

Figure 1. JIMAR staff inspect for marine alien species on the NOAA vessel Oscar Elton Sette *as part of the entry permit requirements to the PMNM.*

the research cruise for 3-dimensional reconstruction of coral reefs and began mentoring an undergraduate intern on data extraction and analyses.

JIMAR staff participated in the University of Hawaii's (UH) QUEST Field School and selected interns for the upcoming research cruise departing July 22, 2019. Because the Pacific Islands Fisheries Science Center (PIFSC) participated in this UH partnership for the first time, PMNM JIMAR staff helped coordinate training and selection of three interns for PIFSC.

A manuscript prepared by a JIMAR project staff as lead author was submitted to the journal *PLoS ONE* and is awaiting reviewers' comments. The manuscript describes the effects of SCUBA bubbles on fish surveys in PMNM. Data was collected by JIMAR and PMNM federal staff during the RAMP cruise in September 2017.

JIMAR staff co-authored a manuscript for a peer-reviewed conference proceeding describing the associations between the distribution of coral species and structural complexity of benthic habitat at French Frigate Shoals in the NWHI. Data was collected by JIMAR staff and a UH Hilo collaborator during the RAMP cruise in September 2017. The manuscript was published in the *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*.

Characterization of Mesophotic Coral Ecosystems. As mentioned above, ship mechanical problems restricted the project's research expedition to four DAS during the reporting period. JIMAR staff utilized two operational days during that research cruise to implement a modified survey methodology that allows for continuous characterization of mesophotic fish populations while adding a new component of high-resolution benthic characterization using SfM photogrammetric techniques. Project staff processed all photographs for 3-dimensional reconstruction of mesophotic reefs and provided the divers with feedback to improve logistics for implementing the same techniques in future surveys. The mesophotic reef environment creates challenges that are different from those on shallow reefs as it is low-light, requires divers to carry a large amount of equipment, and divers' bottom time are significantly limited due to decompression obligations. These characteristics place constraints on the mesophotic survey design thus requiring occasional re-evaluation by scientists and technicians.

JIMAR staff facilitated and participated in two additional CCR trainings (Air Diluent and hypoxic trimix) to increase the capacity of PMNM's mesophotic dive operations. JIMAR staff also obtained decompression approval from NOAA Diving Safety and Control Board (NDSCB) to perform proficiency dives and training dives to help refine the survey methodology for the upcoming PMNM biogeography cruise, RA-19-02. As a result, all JIMAR project staff are now certified to reach the maximum depth of 100 m to conduct mesophotic coral ecosystem surveys. These qualifications make the PMNM JIMAR dive team the most advanced technical dive team in NOAA.
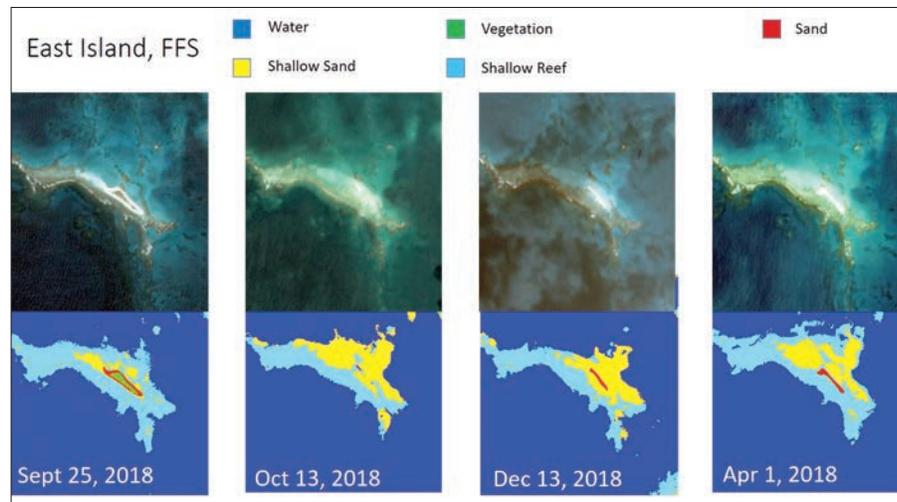
Figure 2. Time series of East Island on French Frigate Shoals (Lalo) pre- and post-Hurricane Walaka (credit: Keo Lopes).

To support both shallow and mesophotic coral reef surveys, JIMAR staff was the primary liaison between the NOAA Dive Center, NOAA Ship *Rainier*, and Pacific Region NOAA offices to help plan and install a hyperbaric chamber aboard *Rainier* for scientific divers to use during upcoming research cruises, including the PMNM biogeography cruise (RA-19-02) to the NWHI. Staff participated in several out-of-state meetings to coordinate and prepare for chamber operations on a new platform. Other logistical planning and preparation for RA-19-02 have been ongoing.

Quantification of Benthic Habitats. During the summer of 2018, JIMAR staff co-mentored a NOAA Hollings scholar on extracting benthic composition and habitat metrics from orthophotomosaics and digital elevation models, respectively. JIMAR staff analyzed all the data and prepared a manuscript that examined the behavior of different habitat metrics. The manuscript was published in the *Journal of Marine Science and Engineering*. This research evaluated, for the first time, a large variety of habitat metrics that can be extracted from 3-dimensional reconstruction of coral reefs and contribute to identifying a set of habitat metrics to characterize the 3-dimensional structure of coral reef habitats in the NWHI. The manuscript also included scripts written in R that can be freely used and/or modified by other scientists and managers to extract habitat metrics from digital elevation models, thus potentially contributing to coral reef monitoring in other regions.

JIMAR staff co-authored a peer reviewed report describing the use of SfM photogrammetric techniques for assessing damages to coral reef habitats caused by grounding events. The report was published in the NOAA Marine Sanctuaries Conservation Series.

JIMAR staff assisted the PIFSC Ecosystem Sciences Division (ESD) in the 3D reconstruction of multiple study sites quantifying the damages to benthic habitat in the NWHI caused by marine debris. To assist with classifying benthic photos from a backlog of previous years' research cruises, project staff participated with PIFSC ESD in CoralNet training to facilitate machine learning for automatic annotation of benthic functional groups.

PMNM Resource Protection. The Resource Protection Program works to reduce or mitigate threats by working within the framework of the ecosystem management approach established for the Papahānaumokuākea Marine National Monument. This involves working within the realms of the permitting system, field operations, and research and education/outreach programs. The overarching goal is to minimize the risk to natural resources by anthropogenic influences and to safeguard the human presence in the monument that is involved in conservation and research.

JIMAR staff conducted several vessel hull inspections during the year to verify the absence of alien species as part of the permitting process for entry to the PMNM. This process helps to protect the marine ecosystems of the NWHI noted for their low abundances of alien species. Staff also developed a risk analysis matrix to assist with alien species prevention/management and created a new PMNM Alien Species Database to track all known non-indigenous species found within the PMNM. Staff are currently working to publish this checklist data and engaging with partners in New Zealand to improve vessel alien species risk profiling. Project staff reviewed

several PMNM access permits to ensure applicants' activities do not harm any PMNM resources and comply with resource protection objectives.

Project staff represented the PMNM office at several multi-agency/co-trustee working groups and coordinated response partnerships to ensure the PMNM's resources are protected in the event of a ship grounding, oil spill or other natural/anthropogenic disturbances. Some of the agencies involved include Logistics Working Group, Hawaii Department of Land and Natural Resources Land Board reviews, Alien Aquatic Organism Task Force (AAOTF), Hawaii Invasive Species Council (HISC), Hawaii Ocean Safety Team (HOST), U.S. Coast Guard Area Committee, and marine debris partners. Project staff renewed Hazardous Waste Operations and Emergency Response (HAZWOPER) certifications and participated in Hazard Analysis and Critical Point training for Alien Invasive Species (AIS) prevention to maintain qualifications and increase expertise.

JIMAR project staff were also the main point-of-contact and selected resource monitor for two separate U.S. Coast Guard/National Data Buoy Center planned missions to recover a loose NOAA weather buoy from Lisianski Island. Staff were involved with all environmental reviews and salvage plan development with PMNM co-trustees and served as the liaison with the USCG Cutter *Walnut* command. Both missions were postponed and staff will continue to assist in the statement of work development to recover the buoy and assess damage caused by its grounding.

On October 4, 2018, Hurricane Walaka passed 60 nautical miles west of French Frigate Shoals. A Category 5 storm at its peak, Walaka was the strongest storm ever recorded in Hawaiian waters. Satellite images obtained on October 18 showed that East Island, a low-lying, vegetated sand island at French Frigate Shoals was almost completely washed away overnight. Fifty percent of threatened green sea turtles in Hawaii nest on East Island and 30 percent of endangered Hawaiian monk seal pups are born each year on East Island. Impacts to wildlife from losing this island are unknown but are potentially severe. Because PMNM was unable to conduct a research expedition to the NWHI last year, and the next cruise is planned for late July 2019, in situ hurricane damage assessments cannot be conducted until that time. JIMAR staff were able to calculate lost area and are monitoring the recovery of East Island via satellite imagery. Additionally, on October 22, 2018, JIMAR joined the U.S. Coast Guard and U.S. Fish and Wildlife Service on an overflight to assess the damage caused by the hurricane. Substantial damages were observed to the support structures on Tern Island including an inundation of the runway with sand. Other changes in the environment were noticeable such as the redistribution of sand and the elimination of sand spits, which are important habitat for the critically endangered Hawaiian monk seal, nesting spots for threatened green sea turtles, and nesting grounds for many migratory and resident seabirds.

Maritime Archeology. JIMAR staff are working with Vulcan Inc. staff to ensure PMNM access compliance for a future planned expedition to search for lost WWII ships from the Battle of Midway.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

Fate of Marine Debris in the Ocean and Polymer Identification using FTIR Instrumentation

Sarah-Jeanne Royer, SOEST International Pacific Research Center Postdoctoral Researcher

Purpose of the Research

In order to gain a better understanding of marine debris in the ocean, Royer and the research team conducted projects on the fate of marine debris in the ocean using GPS trackers attached to floating debris found at the ocean surface in the vicinity of Oahu. In addition, they also conducted a scientific study at James Campbell National Wildlife Refuge to monitor the presence of plastic debris on a weekly basis at low, middle and high tides. Finally, the team maintained an online database where different organizations across the Hawaiian Islands can report their findings (http://iprc.soest.hawaii.edu/news/marine_and_tsunami_debris/sightings.php).

Progress during FY 2019

The data from the James Campbell study site are currently being processed. In 2018 more than 6,000 plastic pieces collected over a 13-week period were processed using a Fourier transform infrared spectroscopy (FTIR) instrument to identify the exact type of plastic found, color, size, and abundance of each polymer type. The

data collected tracks the movement and trajectory of different types of marine debris and will be used to gain a better understanding of the small scale dynamic occurring near the coastlines of the Hawaiian Islands, which may vary from the larger scale dynamic occurring in the open ocean.

The website was updated up to the end of the fiscal year 2018 and is still available online (http://iprc. soest.hawaii.edu/news/marine_and_tsunami_debris/ sightings.php).

Future Research Plans

Royer plans to publish the results in a scientific peer-reviewed international journal and will also make a research presentation at the 27th IUGG General Assembly, to be held in Montréal, Canada, July 8–18, 2019.

Publications

- Royer, S. J., S. Ferron, S. Wilson, and M. D. Karl, 2018, Methane and ethylene from plastic in the environment, *PLOS ONE*, doi.org/10.1371/journal. pone.0200574.
- Jung, M. R., et al. [S. J. Royer], 2018, Validation of ATR FT-IR to identify polymers of plastic marine debris, including those ingested by marine organisms, *Mar. Pollut. Bull*., 127, 704-716, https://doi.org/10.1016/j. marpolbul.2017.12.061.

Presentations

- Royer, S. J., and D. Deheyn, Plastics and microfibers in the environment. 27th IUGG Conference, Montréal, Canada, 2019.
- Royer, S. J., and D. Deheyn, Discussion session on plastic degradation and emissions of GHGs and microfibre degradation. Discussion session SOLAS Open Science Conference, Sapporo, Japan, 2019.
- Royer, S. J., S. Ferrón, S. T. Wilson, and D. M. Karl, Production of hydrocarbon gases from plastic at ambient temperatures. 6th International Marine Debris Conference, San Diego, California, 2018.
- Royer, S. J., M. Flores, K. Ziemann, and K. Pacarro, 2018, Bridging community work and academia. Invited poster 6th International Marine Debris Conference, San Diego, California, 2018.
- Brignac, K. C., et al. [S. J. Royer], Polymer identification of plastic marine debris on beaches and the sea surface in the Hawaiian archipelago by FT-IR to determine sources. Invited poster at 6th International Marine Debris Conference, San Diego, California, 2018.

Figure 1. Sarah-Jeanne Royer holding microplastics at Kamilo Point, Hawaii Island, 2018.

Figure 2. Plastic pollution at James Campbell National Wildlife Refuge study site for polymer identification, 2018.

- Flores, M., S. J. Royer, and K. Pacarro, Clean beaches start at home. Invited poster at 6th International Marine Debris Conference, San Diego, California, 2018.
- Royer, S. J., J. Hafner, and N. Maximenko, Bridging citizen science and academia. Talk at the Asia Oceania Geosciences Society, Honolulu, Hawaii, 2018.
- Brignac, K. C., et al. [S. J. Royer], Polymer identification of plastic marine debris on beaches and the sea surface in the Hawaiian archipelago by FT-IR to determine sources. Invited poster Asia Oceania Geosciences Society, Honolulu, Hawaii, 2018.

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 Hawaii 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.

Characterization and Dynamics of Mesoscale and Submesoscale Oceanic Variability in the Solomon Sea Simulated by a Nested ROMS Model

P.I.: 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

High sea level variability is a prominent feature of the southwest tropical Pacific Ocean where interactions between western boundary currents, equatorial currents and mesoscale processes have the potential to influence the properties of waters upwelled at the equator. While the implications of changing ocean conditions in the equatorial Pacific for the El Niño Southern Oscillation (ENSO) and longer timescale climate variability have long been recognized, the dynamics and origin of enhanced variability in the southwest Pacific are largely unknown. The purpose of this project is to study eddy variability in the Solomon Sea western boundary current system with focus on the meso/submesoscale range (10–200 km) using a high-resolution numerical ocean model supplemented by satellite and in-situ (glider, Argo) data. The project's main objectives are: 1) to characterize the spatial and temporal scales, subsurface structure and evolution of the meso/submesoscale eddies in low latitudes; and 2) to assess the interactions between the submesoscale, mesoscale and large-scale circulation. The results will inform the physical interpretation of satellite sea surface
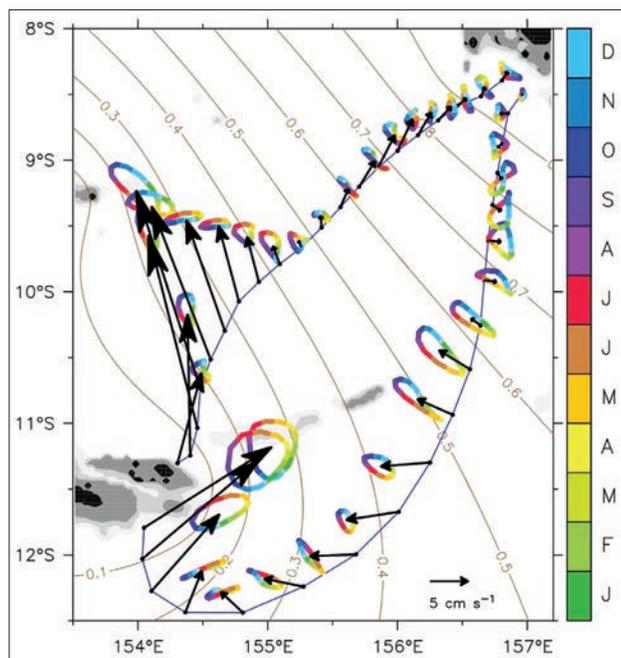
Figure 1. Mean vectors of absolute vertically-averaged velocity (black; scale vector at bottom) on the mean westbound (southern) and eastbound (northern) glider tracks. The colored shapes around each vector head show its direction and magnitude during the climatological year (color scale at right). Brown contours are contours of the cross-Sea coordinate ϕ, from ϕ = 0 on the Papua New Guinea side to ϕ = 1 on the Solomon's side. Gray shading shows bathymetry at 100 m, 500 m and 1000 m.

height observations of these eddies by clarifying their subsurface structures and generation processes.

Progress during FY 2019

During the final year of this project the primary goal was to finalize and publish results on ENSO related variations of mass and temperature advection fluxes through the Solomon Sea based on ten years of glider data. The manuscript was accepted for publication and appeared online in April 2019. Additionally, project researchers continued to refine and expand the glider data set of corrected velocities, temperature and salinity sections across the Solomon Sea with the goal of producing a ready-to-use product accessible to non-specialists and modelers. The main findings from the published manuscript are as follows.

The Solomon Sea carries the equatorward western boundary current of the South Pacific, a principal element of subtropical-equatorial communication.

Figure 2. Mean sections of equatorward velocity uφ (cm s−1; scale at right) on the two glider tracks separately (labels at lower right), shown as a function of the cross-sea coordinate φ, from φ = 0 on the Papua New Guinea side to φ = 1 on the Solomon's side. The positive direction (red) is equatorward. The two green lines separate regions with different sampling periods. Above the green line at 600 m sampling was complete throughout the record (with a single exception); between 600 m and 700 m sampling was complete after the first year; below 700 m sampling began in mid-2013. The time means shown here were computed over each period separately. White contours show isopycnals.

Eighty-seven glider transects across the mouth of the Solomon Sea over nine years describe the velocity structure and variability of this system. The time series spans two El Niños and two La Niñas, which produced large transport anomalies, up to 50% of the mean. While transport increased during El Niños and decreased during La Niñas, their signatures were inconsistent among the events. Separated glider tracks show the merging of two inflows, one from the tropics east of the Solomon Island chain, the other entering as a western boundary current generated by winds over the full subtropical gyre. A model of linear wind-driven dynamics, including western boundary currents, had skill in describing the variability of the two inflows, identifying the distinct wind forcing driving each. The model suggests that both the mean and low-frequency variability of flow entering the Solomon Sea are driven remotely by wind over the South Pacific, acting through long Rossby waves. The ultimate significance of in situ observations in this small sea will be to describe its role in subtropical-tropical heat exchange that is crucial to ENSO and longer-timescale climate variations along the equator. We take an initial step here, suggesting that temperature advection through the Solomon Sea is a first- order contribution to interannual temperature changes of the equatorial strip as a whole.
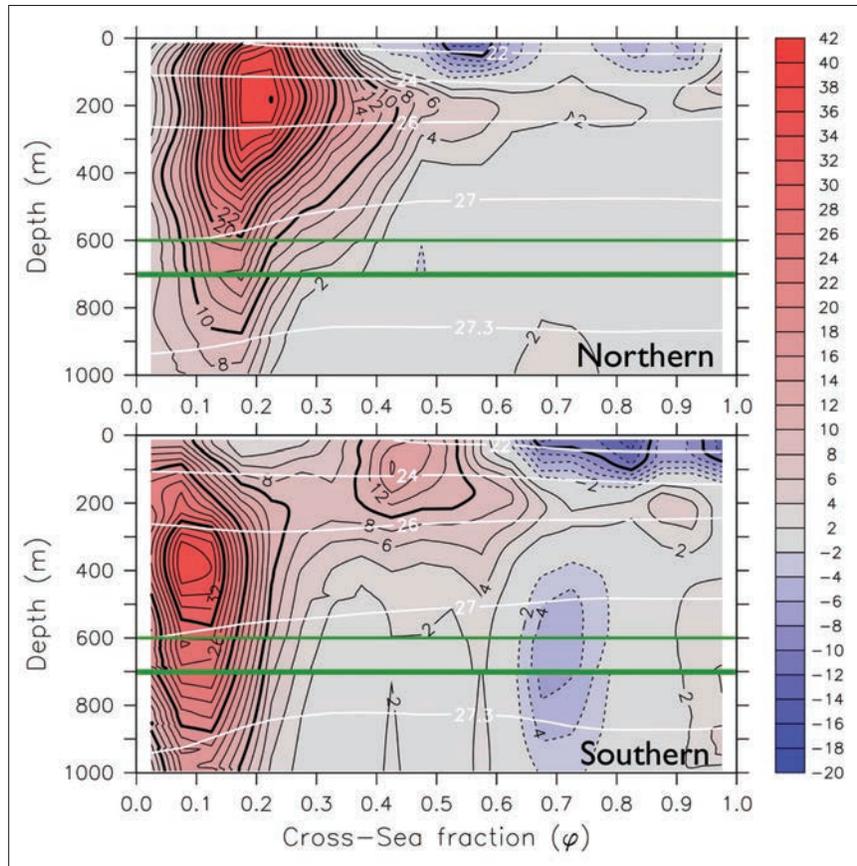
Optimizing Routine Ocean Current Measurements by the NOAA Fleet: Renewal for FY 2017-2019

P.I.: Eric Firing

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

NOAA Sponsor: Patrick L. Murphy and 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 contribute to the global climatology of ocean current measurements. However, without suitable data acquisition and processing software installed, and used routinely, this potential is not realized. The primary purpose of this project is to continue applying project software and expertise to the NOAA fleet, and continue with installations, maintenance, and consulting that began during the original two years of funding. In addition, researchers are 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 2019

The project is now in its fifth year and on track with project tasks and responsibilities. Researchers installed and maintained the University of Hawaii Data Acquisition System (UHDAS) on all 11 NOAA ships with ADCPs ready to run; two more ships are expected to enter that category this calendar year, and the project is ready to perform the installations when they do. It's anticipated that the *Oscar Dyson* will be ready in the current fiscal year and the *Thomas Jefferson* in the next fiscal year. During the reporting period the project made major improvements in its UHDAS system diagnostics and tracking software, which enabled staff to better monitor calibration parameters and ancillary data feeds. Establishment of a fully standardized "NOAA to NOAA" (N2N) data pipeline for getting all data submitted to the National Centers for Environmental Information is progressing.

An important component of the project involves interfacing with a wide range of NOAA personnel and providing training. In April 2019, JIMAR Oceanographic Data Specialist Toby Martin participated in the NOAA N2N workshop in Silver Spring, MD, and presented a "What is UHDAS" introduction to the NOAA operational information technology team. In the same month, JIMAR Oceanographic Researcher Dr. Jules Hummon gave a 3-day ADCP processing workshop in Miami attended by NOAA and academic scientists. She also worked remotely to advise John Pohl at Northwest Fisheries Science Center as he works on processing historical ADCP data from the *Bell Shimada*.

University of Hawaii 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 Hawaii 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

Honolulu, Hawaii
High-tide flooding days: 35 cm above MHHW
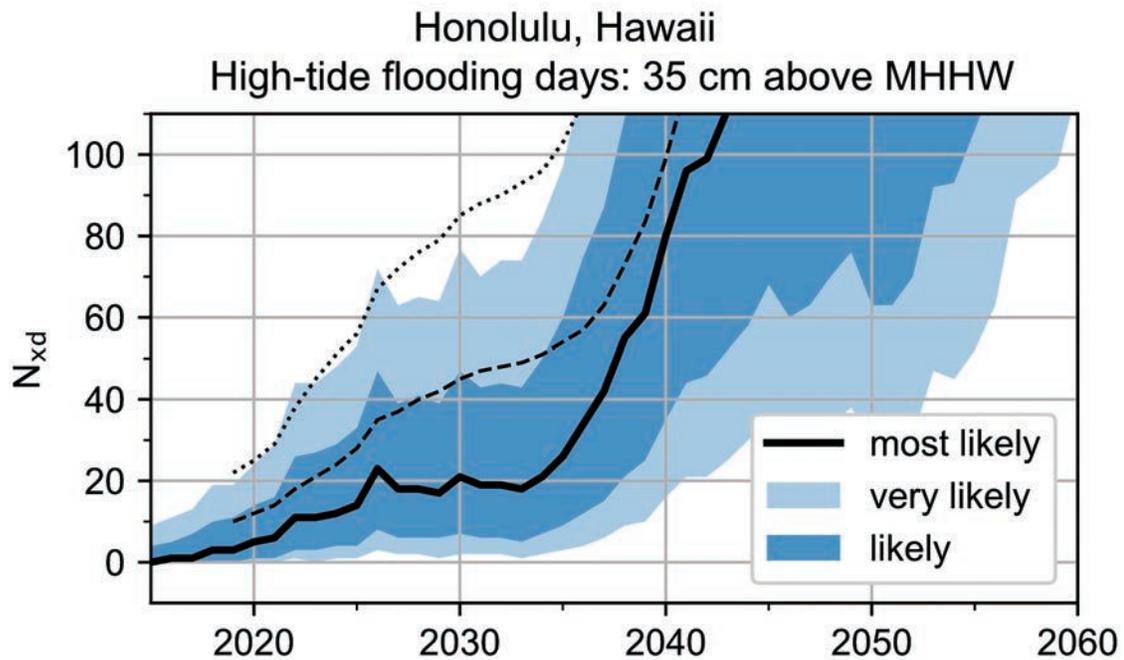
Figure 1. The number of high-tide flooding days in Honolulu during the 21st century. High-tide flooding is defined as daily maximum sea level exceeding 35 cm above mean higher high water (MHHW), which is associated with minor flooding of beaches, roads, and parking lots around urban Honolulu. Decadal fluctuations in the number of expected flooding days are due to the interaction between sea level rise and long-period (18.61 years) tidal modulations (Thompson et al., 2019, doi: 10.1029/2018JC014741).

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 IOC/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 4–6 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. 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 2019

Data management objectives for FY 2019 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 2019, UHSLC datasets were utilized in 47 peer-reviewed research articles, three governmental agency reports, and two academic theses. The project continued its efforts over the past year to improve and modernize data flow within the center; significant portions

of legacy FORTRAN data processing code were rewritten in Python, including new quality-control routines and a tool with a modern graphical user interface that greatly increased efficiency of the data processing team. Project staff tested and finalized an OPENDAP server for web-based data access (https://uhslc.soest.hawaii.edu/opendap/) and finalized the UHSLC's new station explorer (https://uhslc.soest.hawaii.edu/stations/) providing users in coastal and island communities with near-real-time access to sea level data as it is collected, as well as increased transparency and access to often-requested information such as tide calendars, tidal datums, benchmarks, etc. Tide gauge network and station maintenance objectives were exceeded during FY 2019. As a result of UHSLC efforts, fifteen of the stations funded by the Climate Program Office were serviced, which is one greater than the project's objective to visit and service fourteen of these stations. A significant challenge was presented in FY 2019 from the "week number rollover" glitch in the U.S. Global Positioning System (GPS) (see https://www.nature.com/articles/d41586-019-01048-2), which affected data loggers on thousands of scientific instruments worldwide, including the majority of the UHLSC's tide gauges. As of June 1, 2019, only four of the UHSLC's 80+ tide gauges are down due to this issue despite many being located

Figure 2. Artwork entitled "The Tides" by a Honolulu high school student inspired by a conversation about climate change and sea level rise with Dr. Matthew Widlansky, UHSLC Associate Director.

in remote locations. It's anticipated that all stations affected by this issue will be up and running by the end of FY 2020. GPS installations at tide gauges were maintained with assistance from the Pacific GPS Facility at the University of Hawaii, including a new GPS installation on Tern Island in French Frigate Shoals, which replaces a previous GPS installation destroyed during 2018 by Hurricane Walaka. GPS/GNSS data from UHSLC stations were provided to the GLOSS TIGA data center.

UHSLC researchers led multiple research projects leading to peer-reviewed articles in FY 2019, including a published paper showing how the frequency of high-tide flooding events will change with sea level rise in Honolulu during the 21st century (Figure 1), a published paper on tropical cyclone projections with implications for Pacific Island defense installations, and a recently submitted manuscript on the atmosphere-ocean dynamics involved in high sea level events experienced in Hawaii. UHSLC researchers were also the lead authors on the sea level section in the 2018 State of Climate Report to be published later this summer. Substantial progress was made on a variety of ongoing research projects at the UHSLC that will be published during the next fiscal year. Collaboration is a key component of UHSLC research goals, and project researchers collaborated with researchers outside the center on a variety of efforts related to oceanography and climate, including multiple white papers for the forthcoming Ocean Obs '19 conference, three peer-reviewed review articles stemming from international meetings, a book chapter on ENSO in a changing climate, and other manuscripts.

University of Hawaii Sea Level Center cGPS

P.I.: Philip Thompson, James Foster

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

NOAA Sponsor: David Legler

NOAA Goal(s):

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

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 by the Global Navigation Satellite System (GNSS) at tide-gauge sites. The 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 manage the data flow from GNSS sites at GCN tide gauges operated by the University of Hawaii Sea Level Center (UHSLC).

Progress during FY 2019

The project goals for 2019 were to maintain current data flow, perform one new GNSS site installation at a tide-gauge, and make three maintenance visits. Researchers continued to collect, archive and upload to the international data archives all data from the project's current network of GNSS sites installed at UHSLC tide-gauges. A new GNSS site was installed at Tern Island in the French Frigate Shoals, taking advantage of an opportunity negotiated with the U.S. Fish and Wildlife Service and NOAA, who had a ship visiting the island (the only way to access this location). In order to mitigate against the possible future loss of the monument (an existing monument on the island was destroyed by high waves generated by a recent hurricane), a new "footprint" benchmark was installed to provide for recovery of the GNSS time-series and included in the geodetic leveling network. The new site was built on the thickest most robust concrete structure available and as close as possible

Figure 1. Rainbow over the continuous GNSS site "BTNG" located at the Bitung Tide Gauge, Indonesia. Data from this station will be used to tie the sea level measurements into a global reference frame and enable better science.

to the tide-gauge sensor in order to ensure that any local vertical motions can be detected and removed from the tide-gauge records in order to recover absolute sea-level changes. Power for the site is from a solar panel and batteries and telemetry is through Iridium satellite communications with the data files sent hourly. The formal paperwork to add the site to the international GNSS@TG network is near completion and will be submitted before the end of June 2019.

Maintenance was performed for the GNSS site "BHMA" in the Bahamas. A new cell modem was installed to provide telemetry for the hourly data files and the existing GNSS receiver was replaced with a Trimble NetR9. The project also worked to troubleshoot issues with the GNSS sites on Midway and Wake Islands, recover data files that weren't successfully transmitted, and ensure materials for site maintenance were transported to those locations for onsite work. A new collaboration with the Universidad Nacional Autónoma de México ("UNAM") was initiated in an attempt to recover the existing GPS site "MNZO" in Manzanillo. Unfortunately when project staff visited this location they discovered that since the last visit by UHSLC staff, the existing monument had been uninstalled during dock renovation work. Because it will be impossible to recover that GNSS time-series, and there is now a new GNSS site nearby, the project is discussing with UNAM about where to re-install the equipment to maximize the impact. In Hawaiian waters, the project continues to maintain the continuous GPS site HNLC ever since they installed and collocated it with the Honolulu tide-gauge in 1997. Recent construction work at that location accidentally destroyed the site's communications cable. The project worked with contractors and the U.S. Coast Guard to resolve the issue and designed a new telemetry solution to reacquire the live data flow from that site.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

A Beyond Ray-Tracing Toolbox for the Analysis of Internal Wave Activity

Andrei Natarov, International Pacific Research Center Assistant Researcher

Purpose of the Research

The main research objectives are to formulate a new method for analysis and prediction of internal wave activity in the ocean and develop a numerical toolbox for this analysis. Developing a new method is necessary because of the limitations of existing approaches. Natarov's current activities include developing proposals and writing papers to explain the method and highlight its usefulness in applications. If his proposal to develop a numerical toolbox is funded by the National Science Foundation (NSF) the results of the team's work are expected to be applicable to the following JIMAR themes: Equatorial Oceanography, Ecosystem Forecasting (because better prediction of internal wave activity is expected to produce better modeling of biologically important mixing events), and Climate Research and Impacts (the project's ongoing research on internal waves in unstratified and weakly stratified media will improve understanding of the momentum and heat transfer between ocean and atmosphere).

Progress during FY 2019

The main objectives (development and submittal of the NSF proposal and publications) were met. The manuscript submitted to *Journal of Geophysical Research-Oceans* is currently under peer review.

Future Research Plans

The plans for the next year largely depend on the NSF decision on the submitted proposal. If it is rejected, a new proposal will be developed and submitted to NSF by August, 15 2019. Otherwise Natarov will begin the proposed work and proceed to connect it with the JIMAR research themes.

Publications

- Natarov, A., and K. J. Richards, 2019, On plane internal waves, their amplification, and potential to break in a rotating stratified quiescent fluid, *Geophys. Astrophys. Fluid Dynam.*, 113(3), 257-286, doi:10.1080/03091929.2018.1557654.

Presentations

• Natarov, A., Amplification of internal waves in the ocean interior and their potential to break. Workshop on Meso- and Submesoscale Dynamics, Biology, Biogeochemistry and Air-sea Interaction, University of Hawaii at Manoa, C-More Hale 2, October 23, 2018.
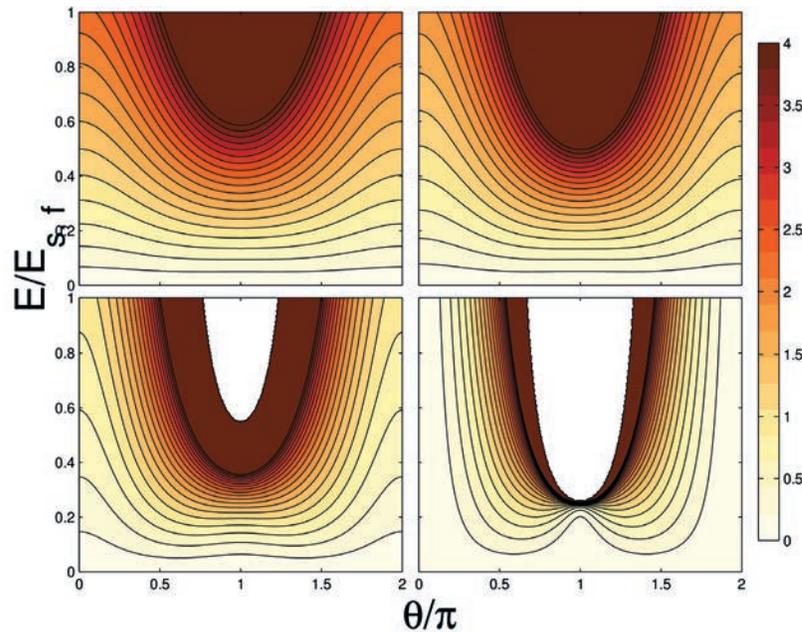
Figure 1. Froude number squared as a function of wave phase and wave energy density, for various frequencies, ranging from 1.05f (top left), 1.10f (top right), 1.35f (bottom left), to 5f (bottom right). The saturated brown color indicates susceptibility to shear instability, white color indicates convective instability.
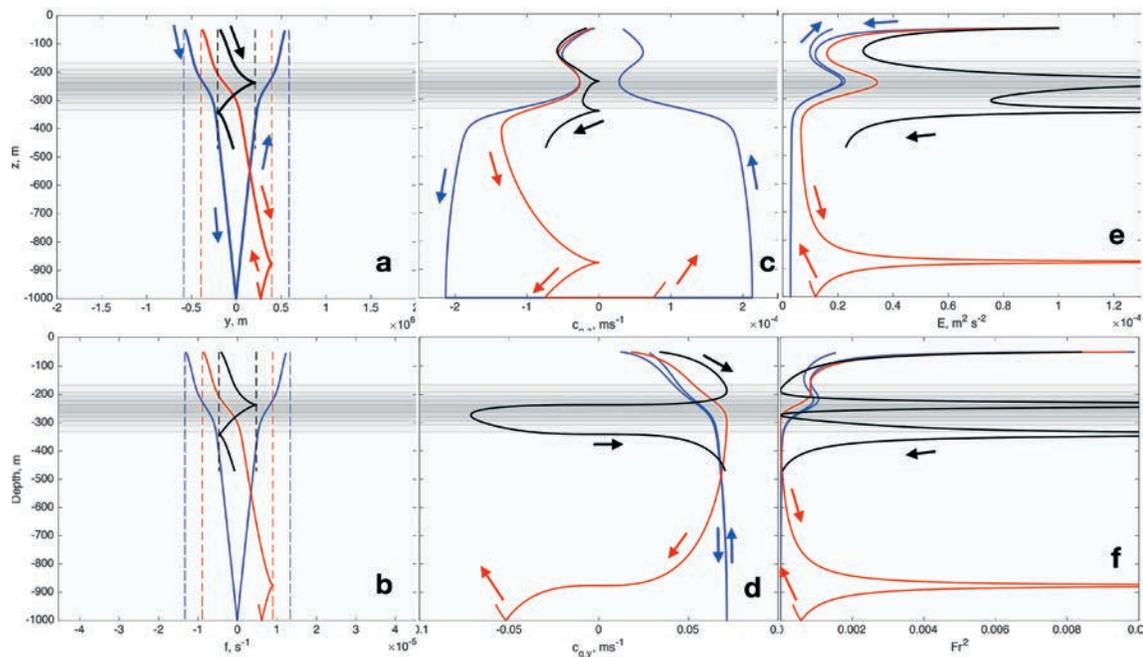
Figure 2. Comparison of various mechanisms of internal wave amplification and breaking in the interior of the tropical ocean. The lines correspond to wave periods of 5.5 days (blue), 8.3 days (red), and 17.3 days (black). Panel a) shows ray trajectories in (y, z)-plane; b) the Coriolis parameter along the trajectories; c) vertical component of the group velocity; d) meridional component of the group velocity; e) wave energy density; f) Froude number squared (a measure of susceptibility to instability and breaking) associated with the wave. Arrows show the direction of time along the segment of the trajectory closest to the arrow. Note that refraction through pycnocline leads only to a moderate amplification of the Froude number, whereas very strong amplification occurs near turning latitudes.

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 ENSO (El Nino Southern Oscillation) 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 lead to an improved understanding of which components of U.S. Department of Defense (DoD) facilities and infrastructure are potentially vulnerable to coastal flooding, how they could be affected, and 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: 1) enhance the historical diagnosis of site-specific still water level patterns and trends; 2) explore techniques that can be used to support regional analysis to address poor spatial coverage of tide gauge (TG) records; 3) extend the diagnosis and prognosis of extreme water level patterns and trends by applying it total water levels; and 4) 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 2019

The Regional Frequency Analysis (RFA) commenced with a meeting of members of the project team in November 2018. The team finalized the RFA methodology for the continental U.S. and included data from 2018. The TG data were downloaded and standardized in Matlab file format. The team now is determining if using historical extremes, e.g., inferred heights when the TG was destroyed, will be used in the analysis.

As part of the effort to identify "functional sensitivity" indicators and thresholds to evaluate coastal flooding, the project team completed an initial sensitivity assessment for Trainings, Buildings, Waterfront Structures and Transportation Infrastructure at Naval Amphibious Base-Coronado (NABC). This included the development of depth/consequence relationships. An initial impact assessment of the above infrastructure that included operational downtime and capital expenditures was completed based on the decadal threshold frequency counts derived from a hybrid climate emulator. The initial assessment was presented to the operations and planning personnel at NABC in May 2019.

The University of Hawaii's Pacific Disaster Center (PDC) has not currently worked on incorporating flood vulnerability assessment results within PDC's DisasterAWARE platform. This is due to the extension of another year of work allowing the project team to fine-tune and improve the assessment result. A meeting to discuss next steps between the project team and PDC is planned for August 2019.

Atmospheric Gases in the Remote Pacific Marine Free Troposphere Measured in Hawaii

P.I.: 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)

• Weather-Ready Nation

Purpose of the Project

The primary purpose of this project is the 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 (HgP) at the Mauna Loa Observatory (MLO), Hawaii. The objectives of this task are to accumulate a long-term record of ambient Hg0, RGM, and HgP chemistry to: 1) support atmospheric mercury chemistry research; 2) establish a baseline mercury measurement station; 3) investigate the long-range transport of mercury from South East Asia across the Pacific; and 4) deploy and evaluate improved methodologies for accurate measurements of atmospheric mercury species. In addition to this primary task, other data are measured and collected, which may elucidate the transport and transformation mechanisms of atmospheric mercury. This includes measurements of atmospheric aerosols, ozone, sulfur dioxide, elemental carbon, and meteorological variables. All of the data will be organized and archived in a database.

Progress during FY 2019

Activity was centered on routine monitoring of mercury species in the atmosphere (Hg0, RGM, HgP). Research funding for monitoring operations has been under threat in the Air Resources Laboratory (ARL), and maintaining basic operations has received priority. A novel technique for collecting and measuring RGM species, developed by the University of Nevada at Reno (UNR) was deployed at MLO in 2018–2019 and a comparison of results obtained using the two techniques is underway.

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

P.I.: Kelvin Richards

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 Hawaii. 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 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 2019

The APDRC maintains a wide suite of data transport and discovery servers including: Open-source Project for a Network Data Access Protocol (OPeNDAP)-based Thematic Real-time Environmental Distributed Data Services (THREDDS) Distributed Ocean Data 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 of in situ and gridded data set (DCHART). These servers continue to be maintained. Due to restrictions in funding, no new servers were added this year.

The APDRC data archives increased this past year due to new model output and a few satellite products. The coupled climate model runs from Coupled Model Intercomparison Project Phase 5 (CMIP5) continue to be the most heavily used within the IPRC research activities. In all, the APDRC archived almost 300 TB of data: 31% of this is output from the Earth Simulator (Ocean/Atmosphere/Coupled Model for the Earth Simulator [OFES/AFES/CFES]); coupled climate model output from CMIP experiments accounts for about 31%; and the remaining 37% is spread across the remaining data sets (approximately 120 in total). There were no upgrades to the APDRC website.

Support for the World Meteorological Office (WMO) Regional Climate Center (RCC) for the Pacific Islands (known as Regional Alliance Five-Pacific Islands [RA-V]) activities continued. The APDRC will act as the "data node" for climate data sets and also contributed to the RCC RA-V website. A new web programmer, Owen Wilcox, was hired at 50% FTE on the grant to support this effort. Unfortunately, Owen left the University in May for a new job on the mainland. Given uncertainties in funding the IPRC will delay hiring a replacement.

Pacific ENSO Applications Climate (PEAC) Center

P.I.: James Potemra

NOAA Office (of the primary technical contact): National Weather Service/Pacific Region Office

NOAA Sponsor: Raymond Tanabe

NOAA Goal(s)

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

Purpose of the Project

The Pacific ENSO Applications Climate Center (PEAC) conducts research and develops information products on the El Niño-Southern Oscillation (ENSO) climate cycle that are targeted for the U.S.-Affiliated Pacific Islands (USAPI). PEAC provides ongoing summaries of current ENSO conditions and seasonal
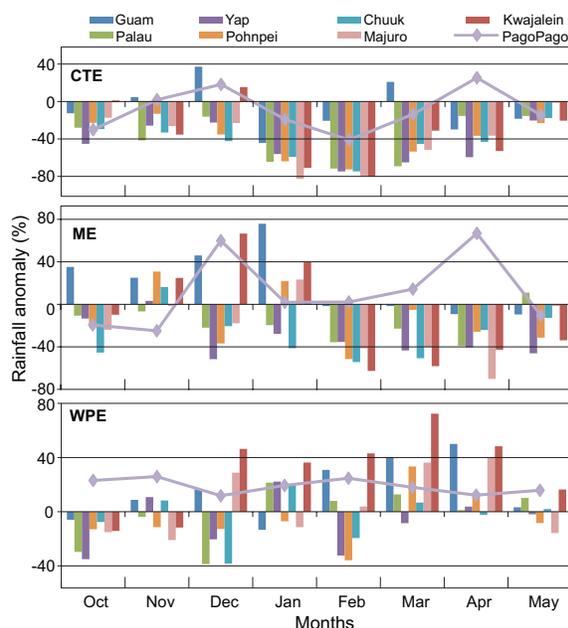
Figure 1. Monthly observed mean rainfall anomalies in the USAPIs during cold tongue El Niño (top), warm pool El Niño (middle), and mixed El Niño (bottom)] events during 1975– 2019 (Y-axis: rainfall anomaly in %, X-axis: months). (Data Source: PEAC's monthly conference call note available at https://www.weather.gov/peac/PEAC_Monthly_Call, accessed on March 21, 2019.)

rainfall, sea level, and tropical cyclones forecasts, as well as outlooks of probable ENSO impacts in the USAPI region related to rainfall, sea level, and tropical cyclone activity. An objective of PEAC is to provide timely and easily accessible information that supports planning and management activities in climate-sensitive sectors such as water resource management, fisheries, agriculture, civil defense, public utilities, and coastal zone management.

Progress during FY 2019

As part of the current transition of PEAC to the National Weather Service (NWS), PEAC Scientist Dr. Rashed Chowdhury continued working with the NWS operational products for transition. The project also continued to do its regular regional climate monitoring and reporting task, developed operational rainfall and sea level forecasts, and conducted outreach, training and capacity building activities during 2018–19. In summary, the project's regular workloads during 2018–19 are provided below.

- Prepared rainfall, sea level, and tropical cyclone forecasts on seasonal-to-interannual time-scale.
- Interpreted regional climate data and formulated assessments accessible to user groups.
- Prepared and disseminated warnings for peak ENSO conditions.
- Responded and provided feedback to user inquiries and concerns.
- Reviewed and analyzed the end-to-end product stream and fostered research to product transitions as they develop.
- Conducted regular Quarterly ENSO briefings at the NOAA IRC building in Ford Island.

In terms of research, the PEAC Center generated an island-wide projections summary of future climate change (e.g., temperature, rainfall, net water flux, and ENSO) using the latest IPCC-AR5 GCMS protocol (CMIP5) and crystalized the role of ENSO, including three different types of El Niño (e.g., warm pool El Niño [WPE], cold tongue El Niño [CTE] and mixed El Niño [ME]), in shaping and contributing to the critical climate change development capacity building efforts in the USAPI region.

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

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.
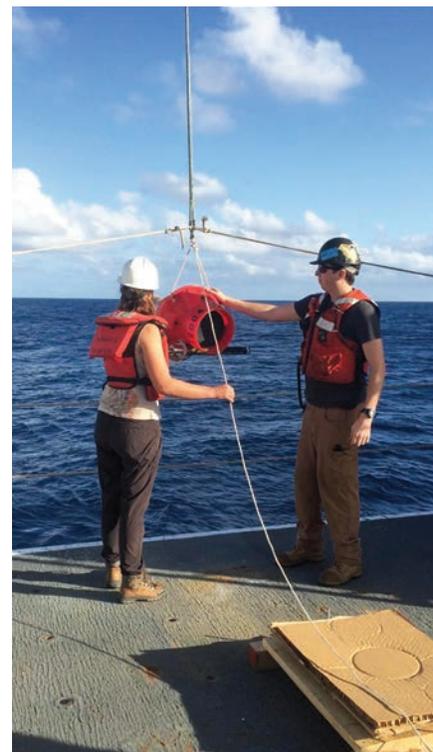
Figure 1. JIMAR Float Research Assistant Chanelle Cadot (left) deploys a Deep Argo float from the R/V Thomas G. Thompson *in the Brazil Basin.*

All Argo Float locations as of 2019-05-30
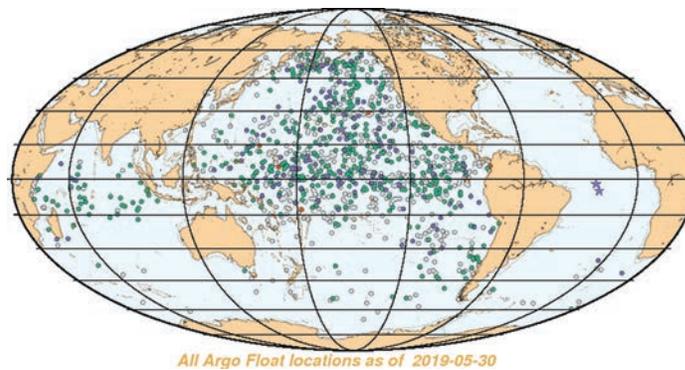
Figure 2. Most recent locations of PMEL conventional and Deep Argo floats, for which Dr. Elizabeth Steffen leads the logistics, testing, and much of the monitoring, with assistance from Chanelle Cadot. As of 30 May 2019, conventional Argo floats reporting in the past 30 days (green and blue circles) numbered 571, and deep Argo floats (green and blue stars) numbered 5.

Progress during FY 2018

At the PMEL float lab Dr. Elizabeth Steffen, with assistance from new JIMAR Float Research Associate 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 and notified the national and international databases of those deployments. Dr. John Lyman continued to perform scientific analyses of Argo and other data and contributed to 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*. 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. In May 2019, Chanelle Cadot deployed two Deep Argo floats in the Brazil Basin from the *R/V Thomas G. Thompson* during a cruise from Cape Town, South Africa to Woods Hole, MA (Fig. 2). Stated goals were met.

Transferal of Pacific ENSO Applications Climate (PEAC) Center Products and Services to Weather Forecast Office (WFO) Honolulu

P.I.: James Potemra

NOAA Office (of the primary technical contact): National Weather Service/Pacific Region Office

NOAA Sponsor: Raymond Tanabe

NOAA Goal(s):

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

Purpose of the Project

The Pacific ENSO Applications Climate Center (PEAC) conducts research and develops information products on the El Niño-Southern Oscillation (ENSO) climate cycle that are targeted for the US-Affiliated Pacific Islands (USAPI). One objective of PEAC is to provide timely and easily accessible information that supports planning and management activities in climate-sensitive sectors such as water resource management, fisheries, agriculture, civil defense, public utilities, and coastal zone management (see PEAC Center annual report). As PEAC operations become reduced due to limited resources, this project was tasked with identifying those functions within PEAC that can be moved over to the operational component of the NWS. Once identified the project will work with PEAC and NWS staff to execute this transition. This includes the training expertise provided by PEAC Center to build capacity within the Weather Forecast Office (WFO) Honolulu, Hawaii and Guam. This project will contribute to supporting the development of a regional capacity to deliver climate services within the Pacific Region.

Progress during FY 2019

Several meetings were held with both NWS and PEAC staff to outline the various functions that PEAC does including: organization of monthly regional calls; production of consensus forecasts; research on interannual variability, seasonal forecast and implications; maintenance of website; training and capacity building; and production of a quarterly bulletin. The bulletin was recently discontinued but the rest of the tasks remain. The summary document of the details behind these activities was prepared and submitted to the NWS for review.

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 to: 1) acquire nearshore observations of wave energy, sea level heights and currents along the West Maui coastline; 2) analyze the collected data to identify and quantify the components that contribute to wave induced run-up as a function of distance along the West Maui coastline; and 3) compare the analysis of the collected data to the runup estimate forecast by a model that has been set up for this domain.

Progress during FY 2019

To meet the objectives, a field program funded by the UH Sea Grant Program was developed to acquire measurements of the components that contribute to runup as a function of distance along the West Maui coastline. Figure 1 shows a map with marked locations where instrumentation was deployed in West Maui between November 2018 and June 2019. Multiple field trips were required to deploy the instruments and maintain operation of the sensors. To date, 21 data sets were collected for the winter season and the instruments are currently deployed and collecting data for the summer season.

Throughout the reporting period Tognacchini made significant progress learning data analysis techniques. The data collected is in the process of being quality controlled and analyzed to meet the objectives of identifying and quantifying the components that contribute to wave runup on West Maui.

Figure 1. Map of West Maui with locations of instrumentation deployed during AY 2019. Google Maps, 2019.

Future Research Plans

During the next year all the deployed instrumentation will be collected and the field program will be concluded. In collaboration with a NOAA coastal resilience grant, a model forecast will be in operation on the PacIOOS website. To meet the third objective, Tognacchini will analyze the data sets and compare these to a model forecast developed by Dr. Volker Roeber. Tognacchini plans to complete her master's thesis research and prepare a manuscript for publication.

Presentation

Tognacchini, C., Some surf can hurt the beach—forecasts help us prepare. Hanauma Bay Lecture Series, Honolulu, Hawaii, November 29, 2018.

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 International Pacific Research Center and Department of Atmospheric Sciences research, JIMAR hosts NOAA National Weather Service fellowship programs in the SOEST academic departments.

National Weather Service Pacific Region Fellowship Program

P.I.: Douglas S. Luther

NOAA Office (of the primary technical contact): National Weather Service/Pacific Region Office

NOAA Sponsor: Raymond Tanabe

NOAA Goal(s)

• Weather-Ready Nation

Purpose of the Project

As part of the memorandum of understanding between the University and the National Weather Service (NWS), the NWS supports graduate students in SOEST academic units.

Progress during FY 2019

During FY 2019, the NWS Fellowship Program provided ongoing educational support to the departments of Earth Sciences (formerly Geology and Geophysics), Atmospheric Sciences (DAS, formerly Meteorology) and Oceanography. The NWS Fellowship funds were used to: 1) support graduate teaching assistantships; 2) provide administrative support via undergraduate student assistants, purchase of scientific software and office research supplies; and 3) provide scientific equipment and supplies to support the Oceanography Department's Global Environmental Science (GES) program. Funds were also used to support NWS outreach travel opportunities for two Oceanography PhD candidates.

Department of Atmospheric Sciences master's student Jan van der Veken, was supported during the reporting period. The purpose of his research is to gauge changes in vulnerability of the islands and their infrastructure to unprecedented tropical cyclone activity. Research is currently being conducted utilizing climate model output to investigate tropical cyclones near the Hawaiian Islands. The Community Atmosphere Model (CAM5), the atmospheric component of the Community Earth System Model, resolves tropical cyclones with reasonable fidelity when run with high spatial resolution and tracks are generated for the model-resolved tropical cyclone. Tracks with close proximity to the islands can then be chosen from this output and downscaled using the Weather Research and Forecasting (WRF) Model in order to model wind and precipitation data associated with these storms.

This method of downscaling using the WRF will be validated through its relative skill at capturing the characteristics of hurricanes Lane and Olivia from the 2018 season. Once validated, the model resolved future tracks are then investigated to extract any changes in threshold-exceeding wind and rain events on the islands.

In general, model output shows a decrease in tropical cyclone frequency but an increase in tropical cyclone intensity, although this varies from basin to basin. The region of interest is the central Pacific and effects on the Hawaiian Islands are used as a metric for changes to tropical cyclone variability associated with anthropogenically forced climate change. It's expected that this research will show an increase in threshold-exceeding wind in rain events from tropical cyclones by the end of the 21st century. This would be consistent with the consensus on the overall increase in tropical cyclone intensity with the warming climate.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

'Eli'eli Kau Mai: Utilizing Citizen Science from the Waihona 'Ike Kupuna/Institute for Hawaiian Language Research and Translation

Paige Okamura, JIMAR Graduate Student

Purpose of the Research

At the beginning of the reporting period, Ms. Okamura was still translating articles on tsunamis but in late 2018 her focus shifted from tsunamis to eruptions in order to align with current events (the 2018 eruption in Puna, Hawaii Island). She scanned the JIMAR database and selected articles related to volcanic activity for translation. She found articles about the 1881 eruption in Puna (which entered Hilo town) that described an eruption much like the 2018 eruption. After translating several more articles about the same 1881 eruption, supervisor Dr. Kapali Lyon suggested she focus on the 1881 eruption to see if enough relevant material could be collected for future publication.

A sub-objective for the project this year was to update the website containing all available translations. As indicated in previous years,

Figure 1. Paige Okamura presenting at the He Au Honua Conference.

the project's work has outgrown the current website's capacity, making uploading and searching the content cumbersome.

Progress during FY 2019

Over the past semester, Okamura translated a total of 26 of 31 articles of various lengths relating to the 1881 eruption. The majority of the articles were quite lengthy and extremely detailed in describing the nature of the flow. She also worked with the Star Advertiser newspaper and submitted an article but publication of her submittal was put on hold.

Future Research Plans

Okamura's plans for the next fiscal year are to complete translation of the volcano articles and begin preparing them for publication. She may also create an online GIS map to link the articles to the specific places mentioned.

Presentations

- Okamura, P., 'Eli'eli Kau Mai: Bridging language and science (with a focus on "Hurricanes with a history" paper). Hawaii Conservation Conference, Hawaii Convention Center, Honolulu, July 2018.
- Okamura, P., 'Eli'eli Kau Mai: Bridging language and science. Poster for SeaGrant Federal Review, Waikii Aquarium, Honolulu, Hawaii, February 2019.
- Okamura, P., 'Eli'eli Kau Mai: Bridging language and science. Poster for LHRC Conference, University of Hawaii at Manoa Imin Center, Honolulu, March 2019.
- Okamura, P., Ka Wai 'Āwili Pū me ke Kai: Bridging language, culture, and modern science. He Au Honua Conference, University of Hawaii Maui College, March 2019.

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 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 2–40 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 two minutes to several hours in support of the NOAA-funded development and maintenance of high-spatial-resolution numerical models of coastal runup nowcasts and forecasts along the North Shore of Oahu and the west coast of Maui. A long-term objective of this program is to achieve harbor surge forecasts and coastal runup 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://oos.soest.hawaii.edu/pacioos/data_product/harborsurge/index.php).

Progress during FY 2019

As planned, the processing, integration and archiving of ongoing 1-minute and 6-minute SL observations for the 6 NOS gauges in Hawaii was achieved through 5/31/19, with most of the code operating automatically as intended. The editing, analysis and archiving GUI developed under this program in prior years continued to work correctly, even in the event of irregular data formats from either data suppliers or gauges; this has been a significant goal of the project. Year-end code automation was completed apart from one step that should be performed manually on the Kaimoku server. That step will manually archive the QC data file for the previous year. This step does not impact the archive and is simply to save intermediate files in case the project needs to rebuild the archive. This step will be automated in the near future. Also, a manual check is needed in case of a power outage. Xquartz (the Mac xserver with console and ssh packages) needs to be started manually when the power goes out. This does not impact data acquisition but it prevents the raw data from being available on Talpa for QC activities. Year-long concatenation and archiving of the data (a secondary objective for the year) was achieved.

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

Tsunami Research and Modeling

P.I.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock

NOAA Goal(s):

- Weather-Ready Nation
- Resilient Coastal Communities and Economies

Purpose of the Project

NOAA bears a national responsibility to address issues of public safety and economic costs associated with extreme weather and ocean hazards and, in particular, to "Increase Lead Time and Accuracy for Weather and Water Forecasts." Tsunami waves, with the potential for devastating effects, can in many cases be detected well in advance of coastal impact and clearly fall within that mandate. After the Indian Ocean tsunami of December 2004, the U.S. Congress passed the Tsunami Education and Warning Act that identifies four activities to further future preparedness: tsunami forecast and warning; mitigation; research; and international coordination.

Important contributions to each of these activities take place at the NOAA Center for Tsunami Research (NCTR) at the Pacific Marine Environmental Laboratory (PMEL) in Seattle through the collaborative efforts of NOAA and the JIMAR/UH scientists in the Tsunami Research Program. Basic research into tsunami generation, and numerical modeling of propagation and inundation provide the basis for forecasting, and the Short-term Inundation Forecasting for Tsunamis (SIFT) tool, developed at NCTR, is now an operational tool at NOAA's Tsunami Warning Centers, which have the operational responsibility for disseminating timely warnings. Input to the forecast system is provided by an array of bottom pressure recorders located in the Pacific, Atlantic, and Indian oceans, which detect and report in real time the passage of a tsunami wave. The instruments, called Deep-ocean Assessment and Reporting of Tsunamis (DARTs), were developed at PMEL and are deployed and serviced by the National Data Buoy Center. Array studies conducted at NCTR assist in the choice of the optimal locations for the DART buoys and assessment of the impact of instrument outages.

Other aspects of NOAA's tsunami-related activities include the U.S. National Tsunami Hazard Mitigation Program (NTHMP, a Federal/State collaborative partnership with NOAA), U.S. Geological Survey, Federal Emergency Management Agency, National Science Foundation, and the Emergency Management and Geotechnical agencies of U.S. coastal states. Modeling efforts at NCTR facilitate risk assessment for exposed communities and existing or planned infrastructure. Public education, both within the U.S. and internationally, training and capacity building for scientific and emergency planning and response, and the development of partnerships are vital to combating the tsunami threat. NCTR seeks to achieve these goals through presentations and workshops worldwide. In particular, modeling and forecast tools are customized to facilitate this mission and establish warning services for global coastal communities.

Project objectives include: 1) provide scientific and operational support for the tsunami forecast system SIFT for use at the U.S. Tsunami Warning Centers (TWC) in Hawaii (Pacific Tsunami Warning Center) and Alaska (National Tsunami Warning Center); 2) continue development, testing and updating of the SIFT components, specifically, high-resolution forecast models for U.S. coastal communities; 3) develop new tools and methodology for next-generation tsunami forecast system; 4) conduct tsunami hazard assessment studies for coastal locations in collaboration with state and federal partners and work with federal partners to develop tsunami hazard maps conforming to standard building codes for structures in the tsunami flooding zone; 5) promote accessibility and usability of historical tsunami data; and 6) help develop tsunami forecast and warning capabilities in the Pacific, Indian, and Atlantic oceans in collaboration with international partners using community modeling tools, including training, education, and capacity building.

Progress during FY 2019

Due to various delays in personnel recruitment the project work is delayed until later in the calendar year 2019. A new position recruitment was launched, the selectee accepted the offer, and is tentatively slated to begin work in September 2019.

University of Hawaii Sea Level Center—Tsunami Research

P.I.: Philip Thompson

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 Hawaii Sea Level Center (UHSLC) maintains nine water level stations in the Caribbean Sea and ten 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 2019

Five stations were visited for routine maintenance in the Caribbean (El Porvenir, Puerto Plata, Punta Cana, Santa Marta, San Andres), which met the expected five-station visit quota. For the Pacific Ocean, five stations were visited for routine maintenance by UHSLC technicians (Nuku Hiva, Hiva Oa, Talara, Callao, Matarani),

Figure 1. Rebuilt tide gauge installation on Tern Island in French Frigate Shoals, which was previously destroyed by Hurricane Walaka. Portions of the pier destroyed by the hurricane are visible in the foreground; the gauge is installed on a remaining stable portion of the pier.

which met the five-station visit quota. An additional visit was made to Tern Island to rebuild the tide gauge station destroyed by Hurricane Walaka in October 2018. All tsunami station data underwent daily and monthly quality assessments and data were archived in the UHSLC's publicly available datasets.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

Development of a Run-Up Forecast for West Maui, Part I: Inter-Model Comparison and Infragravity Wave Analyses

Assaf Azouri, JIMAR Postdoctoral Researcher

Purpose of the Research

The main objectives of this research project involve the following.

- Deploy, maintain, and recover instrumentation along the coastal region of West Maui, Hawaii in order to collect oceanographic datasets. Data analyses applied to the datasets will be used to better understand the dynamics along this highly complex coastline as well as validate a numerical model that is being used for the generation of a runup forecast for the West Maui community.
- Develop the framework of a runup forecast for the coastal region of West Maui, Hawaii. A near-real-time 6–7 day forecast of wave-driven runup will be created and made available online for public access.
- Use a numerical model to simulate future scenarios of wave-driven runups along the coastline of West Maui. Based on past scenarios from recent decades, these simulations will provide insight into potential runup events that could greatly impact the West Maui community.

Progress during FY 2019

During FY 2019, the project deployed instruments and began collecting bottom pressure datasets from numerous sites along the coastline of West Maui. This field work was augmented with numerical modeling analyses that revealed the complex structures of waves along that stretch of coast.

Assaf also began developing the wave-driven run-up forecast for West Maui; the automation of that forecast is currently being coded and tested.

Future Research Plans

During the upcoming FY Azouri will: 1) complete creation of the runup forecast for installment on an online platform provided by PacIOOS; 2) use the field data to validate the numerical model used to create the runup forecast; and 3) use the field data to learn about the dominant dynamics along the West Maui coastline, as well as the relative importance of the various runup components (setup, swash, and infragravity).

Publications

- Guiles, M., et al. [A. Azouri], 2019, Forecasts of wave-induced coastal hazards in the U.S. Pacific Islands: Past, present, and the future, *Front. Mar. Sci.*, 6, 170, doi: 10.3389/fmars.2019.00170.

Presentations

- Azouri, A., The response of reef-protected harbor environments to gravity wave forcing. 36th International Conference on Coastal Engineering 2018 (ICCE), Baltimore, Maryland, July 30–August 3, 2018.
- Azouri, A., Observations and modeling of infragravity waves in a complex reef environment. USACE Infragravity Wave Workshop: Integrating Science and Engineering Practice, Scripps Institute of Oceanography, La Jolla, California, January 16–17, 2019.

JIMAR Publications

Author(s) Names	Publication Date	Title	Published In (Journal Name, volume and page number)	Type of Publication	Citation No. or hyperlink	Project Title
Aarup, T., G. Wöppelmann, P. Woodworth, F. Hernandez, B. Vanhoorned, T. Schöne, and P. Thompson	3/1/19	Comments on the article "Uncertainty and bias in electronic tide-gauge records: Evidence from collocated sensors" by Stella Pytharouli, Spyros Chaikalis, and Stathis C. Stiros	Measurement, 125, Sept. 2018	Journal Article	https://doi.org/10. 1016/ j.measurement.2018. 12.007, http://nora.nerc. ac.uk/ id/eprint/521886	University of Hawaii Sea Level Center
Abecassis, M.	6/19/19	OceanWatch—a multi-pronged approach to disseminating ocean remote sensing data	First Operational Satellite Oceanography Symposium, College Park, MD, June 17-20, 2019	Presentation		Ocean Remote Sensing
Abecassis, M., and E. Howell	8/14/18	OceanWatch updates	CoastWatch Science Meeting, College Park, MD, Aug. 13-16, 2018	Presentation		Ocean Remote Sensing
Abecassis, M., and E. Howell	5/2/19	OceanWatch updates	CoastWatch Science Meeting, Ann Arbor, MI, April 29-May 2, 2019	Presentation		Ocean Remote Sensing
Abecassis, M., E. Howell, and J. Maurer	12/14/18	OceanWatch—a multi-pronged approach to disseminating ocean remote sensing data	AGU Fall Meeting, Washington, D.C., Dec. 10-14, 2018	Presentation		Ocean Remote Sensing
Allen, C.D.	5/17/19	Motherload: The story of a fertile turtle in the Hawaiian Islands	NOAA Fisheries Website Feature Story	Report	https://www.fisheries. noaa.gov/feature-story/ motherload-story-fertile-turtle-hawaiian-islands	Marine Turtle Recovery in the Pacific Islands Region
Ayers, A., and K. Leong	7/25/18	The changing models of regulatory compliance and their impact on fisheries management	25th Annual Hawaiʻi Conservation Conference, Honolulu, HI, July 24-26, 2018	Presentation		Socioeconomics of Western Pacific Fisheries
Barkley, H., A. Cohen, N. Mollica, R. Brainard, H. Rivera, T. DeCarlo, G. Lohmann, E. Drenkard, A. Alpert, C. Young, B. Vargas-Ángel, K. Lino, T. Oliver, K. Pietro, and V. Luu	11/8/18	Repeat bleaching of a central Pacific coral reef over the past six decades (1960-2016)	Nature Comm. Biol., 1, 177	Journal Article	https://www.nature.com/ articles/s42003-018-0183-7	Sustaining Healthy Coastal Ecosystems
Barraza, A., L.M. Komoroske, C.D. Allen, T. Eguchi, R. Gossett, E. Holland, D.D. Lawson, R.A. LeRoux, A. Long, J.A. Seminoff, and C.G. Lowe	2/8/19	Trace metals in green sea turtles (Chelonia mydas) inhabiting two southern California coastal estuaries	Chemosphere, 223, May 2019, 342-350	Journal Article	https://www. sciencedirect.com/ science/article/pii/ S0045653519301286	Marine Turtle Recovery in the Pacific Islands Region
Bolser, D.G., A. Grüss, M.A. Lopez, E.M. Reed, I. Mascareñas-Osorio, and B.E. Erisman	9/17/18	The influence of sample distribution on growth model output for a highly-exploited marine fish, the Gulf Corvina (Cynoscion othonopterus)	PeerJ, 6:e5582	Journal Article	https://peerj.com/ articles/5582/	Territorial Biosampling
Bull, L., T.T. Jones, S.L. Martin, and D.R. Kobayashi	4/12/19	Impact of climate change on green sea turtle (Chelonia mydas, Cheloniidae) hatching success on East Island, French Frigate Shoals, Northwestern Hawaiian Islands	The 44th Annual Albert L. Tester Memorial Symposium, University of Hawaii at Manoa, Honolulu, HI, April 10-12, 2019	Presentation	NA	Marine Turtle Recovery in the Pacific Islands Region
Burgos, A., B. Hamlington, P. Thompson, and R. Ray	11/28/18	Future nuisance flooding in Norfolk, VA, from astronomical tides and annual to decadal internal climate variability	Geophys. Res. Lett., 45(22), 28 Nov. 2018, 12432-12439	Journal Article	doi:10.1029/2018 GL079572	University of Hawaii Sea Level Center
Burns, J.H.R., A. Fukunaga, K.H. Pascoe, A. Runyan, B.K. Craig, J. Talbot, A. Pugh, and R.K. Kosaki	4/17/19	3D habitat complexity of coral reefs in the Northwestern Hawaiian Islands is driven by coral assemblage structure	International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-2-W10, 61-67, April 2019	Conference Proceedings	https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/ XLII-2-W10/61/2019/	Papahānaumokuākea Marine National Monument Monitoring and Research

Burns, J.H.R., K. Johnson-Sapp, K.D. Bahr, A. Fukunaga, D. Swatland, and R. Kosaki	11/27/18	Innovative 3D imaging tools for assessing damages to coral reef habitats caused by grounding events	Marine Sanctuaries Conservation Series, ONMS-18-03	Report	https://sanctuaries.noaa.gov/science/conservation/conservation_reports.html	Papahānaumokuākea Marine National Monument Monitoring and Research
Chan, H.	5/22/19	Economic impacts of Papahānaumokuākea Marine National Monument expansion on the Hawaii longline fishery	North American Association of Fisheries Economists (NAAFE) Forum, Halifax, Nova Scotia, Canada, May 22-24, 2019	Presentation		Socioeconomics of Western Pacific Fisheries
Chan, H., and M. Pan	2/1/19	Tracking economic performance indicators for small boat fisheries in America Samoa, Guam, and the Commonwealth of the Northern Mariana Islands	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-79	Report	https://doi.org/10.25923/8etp-x479	Socioeconomics of Western Pacific Fisheries
Chan, H., and M. Pan	3/1/19	Vessel level annual cost-earnings study of the Hawaii offshore handline fishery and the Hawaii small boat commercial fishery, 2014	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-80	Report	https://doi.org/10.25923/zffy-5a13	Socioeconomics of Western Pacific Fisheries
Chowdhury, M.R.	4/10/19	Pacific Region ENSO update and seasonal outlook	Indo-PACOM METCO Summit, NOAA Inouye Regional Center, Ford Island, Honolulu, HI, April 4, 2019	Presentation		Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R.	9/27/18	PEAC overview: Products, services, and research	NOAA-CPC Climate Variability Workshop, Pier 38, Honolulu, HI, Sept. 27, 2018	Presentation		Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R., and P.S. Chu	4/1/19	A study of the changing climate in the US-Affiliated Pacific Islands using observations and CMIP5 model output	Meteorol. App., 1-14	Journal Article	https://doi.org/10.1002/met.1781	Pacific ENSO Applications Climate (PEAC) Center
Couch, C., B. Vargas-Angel, and M. Winston	11/1/18	Pacific Reef Assessment and Monitoring Program benthic monitoring summary: American Samoa 2018	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR 18-016	Report	https://doi.org/10.25923/dt06-y997	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
Couch, C., B. Vargas-Angel, and M. Winston	11/1/18	Pacific Reef Assessment and Monitoring Program benthic monitoring summary: Pacific Remote Island Marine National Monument 2018	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR 18-017	Report	https://doi.org/10.25923/sgyt-y890	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
Dacks, R., T. Ticktin, A. Mawyer, S. Caillon, J. Claudet, P. Fabre, S. Jupiter, J. McCarter, M. Mejia, P. Pascua, E. Sterling, and S. Wongbusarakum	4/30/19	Developing biocultural indicators for resource management	Conserv. Sci. Pract., 1:e38	Journal Article	https://onlinelibrary.wiley.com/doi/pdf/10.1111/csp2.38	Socioeconomics of Western Pacific Fisheries
Donovan, M.K., A.M. Friedlander, J. Lecky, J.-B. Jouffray, G.J. Williams, L.M. Wedding, L.B. Crowder, A.L. Erickson, N.A.J. Graham, J.M. Gove, C.V. Kappel, K. Karr, J.N. Kittinger, A.V. Norström, M. Nyström, K.L.L. Oleson, K.A. Stamoulis, C. White, I.D. Williams, and K.A. Selkoe	11/16/18	Combining fish and benthic communities into multiple regimes reveals complex reef dynamics	Nat. Sci. Rep., 8, 16943	Journal Article	https://www.nature.com/articles/s41598-018-35057-4	West Hawaii Integrated Ecosystem Assessment
Durack, P.J., P.J. Gleckler, S.G. Purkey, G.C. Johnson, and J.M. Lyman	12/9/18	Ocean warming: From the surface to the deep in observations and models	Oceanography, 31, 2, 41-51	Journal Article	https://doi.org/10.5670/oceanog.2018.227	Profiling CTD Float Array Implementation and Ocean Climate Research
Fleming, A.H., N.M. Kellar, C.D. Allen, and C.M. Kurle	9/25/18	The utility of combining stable isotope and hormone analyses for marine megafauna research	Front. Mar. Sci., 25 September 2018	Journal Article	https://doi.org/10.3389/fmars.2018.00338	Marine Turtle Recovery in the Pacific Islands Region

Fukunaga, A.	4/11/19	Integration of structure-from-motion photogrammetry into the Reef Assessment and Monitoring Program	Department of Oceanography Seminar, University of Hawaii at Manoa, Honolulu, HI, April 11, 2019.	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., J.H.R. Burns, and R.K. Kosaki	11/20/18	Integration of structure-from-motion photogrammetry into the Reef Assessment and Monitoring Program	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018.	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., J.H.R. Burns, B.K. Craig, and R.K. Kosaki	1/28/19	Integrating three-dimensional benthic habitat characterization techniques into ecological monitoring of coral reefs	J. Mar. Sci. Eng., 7(2), 27	Journal Article	https://www.mdpi.com/2077-1312/7/2/27	Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., R. Kosaki, and B. Hauk	7/24/18	Distribution and abundance of introduced fishes on shallow and mesophotic reefs of the Hawaiian Islands	25th Annual Hawai'i Conservation Conference, Honolulu, HI, July 24-26, 2018	Presentation	http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf	Papahānaumokuākea Marine National Monument Monitoring and Research
Gaos, A.R., R.L. Lewison, M.J. Liles, A. Henriquez, S. Chavarria, and I.L. Yanez	9/1/18	Prevalence of polygyny in a critically endangered marine turtle population	J. Exper. Mar. Biol. Ecol., 506, September 2018, 91-99	Journal Article	https://www.sciencedirect.com/science/article/pii/S0022098117304501	Marine Turtle Recovery in the Pacific Islands Region
Giddens, J., D. Kobayashi, and M. Nelson	11/19/18	Assessing the vulnerability of marine life to climate change in the Pacific Region	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Ecosystem Structure and Function
Godwin, S., H. Bolick, B. Hauk, and R. Kosaki	7/24/18	Marine alien species distribution and management in the Papahānaumokuākea Marine National Monument	25th Annual Hawai'i Conservation Conference, Honolulu, HI, July 24-26, 2018	Presentation	http://www.hawaiiconservation.org/wp-content/uploads/Full-Abstract-Book_FINAL_7.6.2018.pdf	Papahānaumokuākea Marine National Monument Monitoring and Research
Gove, J.M., J. Lecky, W.J. Walsh, R.J. Ingram, K. Leong, I.D. Williams, J.J. Polovina, J.A. Maynard, R. Whittier, K.L. Kramer, E. Schemmel, S. Wongbusarakum, E. Conklin, C. Wiggins, and G.J. Williams	3/1/19	West Hawai'i Integrated Ecosystem Assessment Ecosystem Status Report	Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-19-001, 46 pp	Report	https://www.integratedecosystemassessment.noaa.gov/sites/default/files/2019-04/Gove.et_.al_.2019_West.Hawaii.Ecosystem.Status.Report%20%281%29%20%282%29.pdf	West Hawaii Integrated Ecosystem Assessment
Griffiths, E.T., J.L. Keating, J. Barlow, and J.E. Moore	11/5/18	Description of a new beaked whale echolocation pulse type in the California Current	Mar. Mammal Sci. Notes (online)	Journal Article	https://doi.org/10.1111/mms.12560	Cetacean Research Program
Hamlington, B., S. Cheon, C. Piecuch, K. Karnauskas, P. Thompson, K. Kim, J. Reager, F. Landerer, and T. Frederikse	3/21/19	The dominant global modes of recent internal sea level variability	J. Geophys. Res.-Oceans, 124(4), April 2019, 2750-2768	Journal Article	doi:10.1029/2018JC014635	University of Hawaii Sea Level Center
Hauk, B., S. Godwin, H. Bolick, K. Keogh, and R. Kosaki	11/20/18	Marine alien species distribution and management in the Papahānaumokuākea Marine National Monument	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Hill, M.C., A.L. Bradford, A.D. Ligon, A.C. Ü, C.S. Baker, D. Steel, J. Rivers, R.K. Uyeyama, and E.M. Oleson	11/20/18	Discovery of a Western North Pacific Humpback Whale (Megaptera novaeangliae) breeding area in the Mariana Archipelago	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Cetacean Research Program
Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D. Ligon, M.H. Deakos, A.C. Ü, and E.M. Oleson	11/26/18	Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: Individual affiliations, movements, and spatial use	Mar. Mammal Sci. (online)	Journal Article	https://doi.org/10.1111/mms.12567	Cetacean Research Program
Hill, M.C., E.M. Oleson, A.L. Bradford, K.K. Martien, D. Steel, and C.S. Baker	4/15/19	Pacific Islands Fisheries Science Center Mariana Archipelago cetacean surveys: A review of available data and analysis through February 2018	Prepared for the U.S. Pacific Fleet Environmental Readiness Office, 84 pp	Report	https://repository.library.noaa.gov/view/noaa/19773	Cetacean Research Program

Hutchinson, M., A. Justel-Rubio, and V.R. Restrepo	4/30/19	At-sea tests of releasing sharks from the net of a tuna purse seiner in the Atlantic Ocean	Pacific Islands Fisheries Science Center Working Paper, PIFSC WP-19-001	Report	doi: https://doi.org/10.25923/60ej-m613	Fishing Impacts on Non-Target Species
Hutchinson, M., D.M. Coffey, K. Holland, D. Itano, B. Leroy, S. Kohin, R. Vetter, A.J. Williams, and J. Wren	11/1/18	Movements and habitat use of juvenile silky sharks in the Pacific Ocean inform conservation strategies	Fish. Res., 210, February 2019, 131-142	Journal Article	doi:10.1016/j.fishres.2018.10.016, http://www.sciencedirect.com/science/article/pii/S0165783618302856	Fishing Impacts on Non-Target Species
Idier, D., X. Bertin, P. Thompson, and M. Pickering	in press	Interactions between mean sea level, tide, surge, waves and flooding: Mechanisms and contributions to sea level variations at the coast	Surv. Geophys.	Journal Article	https://doi.org/10.1007/s10712-019-09549-5	University of Hawaii Sea Level Center
Iwane, M.	3/20/19	Seeking collaboration in fisheries management: Engaging Hawaiʻi small-scale fishers to mitigate pelagic shark mortality	79th Annual Meeting of the Society for Applied Anthropology (SfAA), Portland, OR, March 19-23, 2019	Presentation		Socioeconomics of Western Pacific Fisheries
Iwane, M.	4/23/19	Substance and depth in fisheries management: Engaging Hawaiʻi small boat fishers to mitigate pelagic shark mortality	Oceanic Whitetip Shark Recovery Planning Workshop, Honolulu, HI, April 23-24, 2019	Presentation		Socioeconomics of Western Pacific Fisheries
Johnson, G.C., J. Reagan, J.M. Lyman, T. Boyer, C. Schmid, and R. Locarnini	9/25/18	Salinity	In State of the Climate in 2017, Global Oceans, Bull. Am. Meteorol. Soc., 99(8), S77-S81	Journal Article	https://www.pmel.noaa.gov/featured-publication/state-climate-2017	Profiling CTD Float Array Implementation and Ocean Climate Research
Johnson, G.C., J.M. Lyman, T. Boyer, C.M. Domingues, J. Gilson, M. Ishii, R. Killick, D. Monselan, and S. Wijffels	9/25/18	Ocean heat content	In State of the Climate in 2017, Global Oceans, Bull. Am. Meteorol. Soc., 99(8), S72-S77	Journal Article	https://www.pmel.noaa.gov/featured-publication/state-climate-2017	Profiling CTD Float Array Implementation and Ocean Climate Research
Jouffray, J.B., L.M. Wedding, A.V. Norström, M.K. Donovan, G.J. Williams, L.B. Crowder, A.L. Erickson, A.M. Friedlander, N.A.J. Graham, J.M. Gove, C.V. Kappel, J.N. Kittinger, J. Lecky, K.L.L. Oleson, K.A. Selkoe, C. White, I.D. Williams, and M. Nyström	2/13/19	Parsing human and biophysical drivers of coral reef regimes	Proc. Roy. Soc. B, 286(1896), 20182544	Journal Article	https://royalsocietypublishing.org/doi/full/10.1098/rspb.2018.2544	West Hawaii Integrated Ecosystem Assessment
Kaufman, A., S. Robinson, D. Borjesson, M. Barbieri, and C. Littnan	12/1/18	Establishing hematology and serum chemistry reference intervals for wild Hawaiian monk seals (Neomonachus schauinslandi)	J. Zoo Wildlife Med., 49, 4, 1036-1040	Journal Article	https://doi.org/10.1638/2017-0039.1	Hawaiian Monk Seal Research Program
Keating, J.L., E.M. Oleson, J. Barlow, and K. Merkens	11/19/18	An acoustic survey of beaked whale and kogia in the Main Hawaiian Islands using drifting recorders	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Cetacean Research Program
Kelley, C., S. Bingo, M. Putts, and V. Moriwake	11/19/18	Identifying and characterizing high-density coral and sponge communities on deep seamount ridges within Papahānaumokuākea Marine National Monument	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Pacific Islands Deep Sea Coral and Sponge Initiative
Kessler, W.S., H.G. Hristova, and R.E. Davis	4/22/19	Equatorward western boundary transport from the South Pacific: Glider observations, dynamics and consequences	Prog. Oceanogr., 175, July-August 2019, 208-225	Journal Article	https://doi.org/10.1016/j.pocean.2019.04.005	Characterization and Dynamics of Mesoscale and Submesoscale Oceanic Variability in the Solomon Sea Simulated by a Nested ROMS Model
Kosaki, R., A. Fukunaga, B.B. Hauk, J.C. Leonard, K.H. Lopes, and D. Wagner	11/20/18	A characterization of mesophotic reef fish assemblages of the Papahānaumokuākea Marine National Monument	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research

Kraft, D., M. Hutchinson, and B. Bowen	8/1/18	Pacific stock structure of the Silky shark (Carcharhinus falciformis) resolved with next generation sequencing	WCPFC Fourteenth Regular Session of the Scientific Committee, Busan, Republic of Korea, August 8-16, 2018	Report	https://www.wcpfc.int/node/30956	Fishing Impacts on Non-Target Species
Leong, K., S. Wongbusarakum, R. Ingram, A. Mawyer, and M. Poe	5/1/19	Improving representation of human well-being and cultural importance in conceptualizing the West Hawai'i ecosystem	Front. Mar. Sci., 01 May 2019	Journal Article	https://www.frontiersin.org/articles/10.3389/fmars.2019.00231/full	Socioeconomics of Western Pacific Fisheries
Liles, M.J., T.R. Peterson, J.A. Seminoff, A.R. Gaos, E. Altamirano, A.V. Henríquez, V. Gadea, S. Chavarría, J. Urteaga, W.P. Wallace, and M.J. Peterson	11/5/18	Potential limitations of behavioral plasticity and the role of egg relocation in climate change mitigation for a thermally sensitive endangered species	Ecol. Evol., 9(4), 1603-1622	Journal Article	http://doi.wiley.com/10.1002/ece3.4774	Marine Turtle Recovery in the Pacific Islands Region
Lopes, K.H., I. Williams, A. Gray, R. Kosaki, and J.C. Leonard	11/20/18	Effects of SCUBA bubbles on fish surveys within PMNM	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Maynard, J.A., J.M. Gove, D. Tracey, J. Johnson, J. Lecky, E. Conklin, R.V. Hooidonk, M. Donovan, J. Hospital, D. Kleiber, R. Brainard, I.D. Williams, D. Swanson, T. Oliver, W.J. Walsh, C. Wiggins, and K.L. Kramer	3/1/19	Coral reefs: Vulnerability to climate change in West Hawai'i	NOAA Special Report	Report	https://repository.library.noaa.gov/view/noaa/19813/noaa_19813_DS1.pdf	West Hawaii Integrated Ecosystem Assessment
McCoy, K., J. Asher, P. Ayotte, A. Gray, K. Lino, T. Kindinger, and I. Williams	7/27/18	Pacific Reef Assessment and Monitoring Program fish monitoring brief: Jarvis Island, Palmyra Atoll, and Kingman Reef 2018	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-18-013	Report	https://doi.org/10.25923/76pw-5d45	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
McCoy, K., J. Asher, P. Ayotte, A. Gray, K. Lino, T. Kindinger, and I. Williams	7/27/18	Pacific Reef Assessment and Monitoring Program fish monitoring brief: Howland, Baker, and Swains Islands 2018	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-18-010	Report	https://doi.org/10.25923/f5sp-pv56	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
McCoy, K., J. Asher, P. Ayotte, A. Gray, K. Lino, T. Kindinger, and I. Williams	7/27/18	Pacific Reef Assessment and Monitoring Program fish monitoring brief: Swains, Tutuila, Ofu and Olosega, Ta'u Islands, and Rose Atoll 2018	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-18-009	Report	https://doi.org/10.25923/npqt-xh37	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
McCoy, K., J. Asher, P. Ayotte, A. Gray, K. Lino, T. Kindinger, and I. Williams	12/18/18	Reef fishes and benthic habitats of the Pacific Remote Islands Marine National Monument and American Samoa	Pacific Reef Assessment and Monitoring Program, Data report: Ecological Monitoring 2018	Report	https://doi.org/10.25923/0rg6-y073	Sustaining Healthy Coastal Ecosystems
Merrifield, M., and P. Thompson	7/16/18	Interdecadal sea level variations in the Pacific: Distinctions between the tropics and extratropics	Geophys. Res. Lett., 45(13), 16 July 2018, 6604-6610	Journal Article	doi:10.1029/2018GL077666	University of Hawaii Sea Level Center
Murakawa, S.K.K., M.L. Staman, J.W. Staman, L. Bull, and C.D. Allen	2/4/19	Green sea turtle nesting and foraging migrations (2012-2017) from Rose Atoll National Wildlife Refuge	39th International Sea Turtle Symposium, Charleston, SC, Feb. 2-8, 2019	Presentation	NA	Marine Turtle Recovery in the Pacific Islands Region
Nadon, M.	5/25/19	Stock assessment of Guam coral reef fish, 2019	NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-82	Report	https://doi.org/10.25923/pyd6-7k49	Stock Assessment Research Program
Perelman, J., E. Portner, J. Drazen, and A. Choy	9/14/18	Prey patch distributions in the central North Pacific Subtropical Gyre determined through the diet of longnose lancetfish (Alepisaurus ferox)	15th Deep-Sea Biology Symposium, Monterey, CA, Sept. 9-14, 2018	Presentation		Ecosystem Structure and Function
Reininger, A., M.L. Staman, C.D. Allen, S.L. Martin, and T.T. Jones	2/4/19	Spatial distribution of green sea turtle (Chelonia mydas) nests at French Frigate Shoals, Hawaii: implications for carrying capacity?	International Sea Turtle Symposium, 2019, Charleston, SC, Feb. 2-8, 2019	Presentation	NA	Marine Turtle Recovery in the Pacific Islands Region

Restrepo, V., L. Dagorn, G. Moreno, F. Forget, K. Schaefer, I. Sancristobal, J. Muir, D. Itano, and M. Hutchinson	10/2/18	ISSF 2018-20: Compendium of at-sea bycatch mitigation research activities as of September 2018	ISSF Technical and Meeting Reports	Report	https://iss-foundation.org/knowledge-tools/technical-and-meeting-reports/download-info/issf-2018-20-compendium-of-at-sea-bycatch-mitigation-research-activities-as-of-september-2018/	Fishing Impacts on Non-Target Species
Richardson, K., R. Asmutis-Silvia, J. Drinkwin, K. Gilardi, I. Giskes, G. Jones, K. O'Brien, H. Pragnell-Raasch, L. Ludwig, K. Antonelis, S. Barco, A. Henry, A. Knowlton, S. Landry, D. Mattila, K. MacDonald, M. Moore, J. Morgan, J. Robbins, J. van der Hoop, and E. Hogan	11/24/18	Building evidence around ghost gear: Global trends and analysis for sustainable solutions at scale	Mar. Pollut. Bull., 138, 222-229	Journal Article	https://www.sciencedirect.com/science/article/pii/S0025326X18308087	Marine Debris Mitigation Project
Rollins, E.	5/22/19	The economic contributions of tournament fishing in Hawaii	North American Association of Fisheries Economists (NAAFE) Forum, Halifax, Nova Scotia, Canada, May 22-24, 2019	Presentation		Socioeconomics of Western Pacific Fisheries
Rollins, E., and S. Lovell	2/1/19	Charter fishing in Hawaii: A multi-region analysis of the economic linkages and contributions within and outside Hawaii	Mar. Policy, 100, 277-287	Journal Article	https://doi.org/10.1016/j.marpol.2018.11.032	Socioeconomics of Western Pacific Fisheries
Schaefer, K.M., D.W. Fuller, A. Aires-da-Silva, J.M. Carvajal, J. Martinez, and M.R. Hutchinson	2/19/19	Post-release survival of silky sharks (Carcharhinus falciformis) following capture by longline fishing vessels in the equatorial eastern Pacific Ocean	Bull. Mar. Sci., 95(3), July 2019, 355-369	Journal Article	https://doi.org/10.5343/bms.2018.0052	Fishing Impacts on Non-Target Species
Sculley, M.	1/14/19	Comparison of the results of the 2015 ISC striped marlin stock assessment base-case model using Stock Synthesis versions 3.24f and 3.30	ISC Billfish Working Group, Honolulu, HI, USA, Jan. 14-21, 2019, ISC/19/BILLWG-1/10	Report	http://isc.fra.go.jp/pdf/BILL/ISC19_BILL_1/ISC19_BILLWG_WP1-10.pdf	Stock Assessment Research Program
Sculley, M.	1/14/19	Standardization of the striped marlin (Kajikia audax) catch per unit effort data caught by the Hawaii-based longline fishery from 1994-2017 using generalized linear models	ISC Billfish Working Group, Honolulu, HI, USA, Jan. 14-21, 2019, ISC/19/BILLWG-1/6	Report	http://isc.fra.go.jp/pdf/BILL/ISC19_BILL_1/ISC19_BILLWG_WP1-6.pdf	Stock Assessment Research Program
Sculley, M.	1/14/19	Striped marlin (Kajikia audax) length data available from 1995-2017 in the Hawaii-based longline fishery	ISC Billfish Working Group, Honolulu, HI, USA, Jan. 14-21, 2019, ISC/19/BILLWG-1/4	Report	http://isc.fra.go.jp/pdf/BILL/ISC19_BILL_1/ISC19_BILLWG_WP1-4.pdf	Stock Assessment Research Program
Staman, M.L., C.D. Allen, S.L. Martin, A.R. Gaos, and T.T. Jones	2/4/19	Over 40 years of Hawaiian green sea turtle research: Using current trends and new research to better predict the honu population's resiliency to climate change	International Sea Turtle Symposium, 2019, Charleston, SC, Feb. 2-8, 2019	Presentation	NA	Marine Turtle Recovery in the Pacific Islands Region
Swanson, D., H. Bailey, B. Schumacher, and B. Vargas-Angel	8/1/18	Ecosystem Sciences Division standard operating procedures: Data collection for rapid ecological assessment benthic surveys	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-71	Report	https://doi.org/10.25923/39jh-8993	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
Thompson, P., M. Merrifield, E. Leuliette, W. Sweet, D. Chambers, B. Hamlington, S. Jevrejeva, J. Marra, G. Mitchum, R. Nerem, and M. Widlansky	8/1/18	Sea level variability and change	In State of the Climate in 2017, Global Oceans, Bull. Am. Meteorol. Soc., 99(8), S84-S87	Journal Article	doi:10.1175/2018BAMSStateoftheClimate.1	University of Hawaii Sea Level Center

Thompson, P., M. Widlansky, M. Merrifield, J. Becker, and J. Marra	4/24/19	A statistical model for frequency of coastal flooding in Honolulu, Hawaii, during the 21st century	J. Geophys. Res.-Oceans, 124(4), April 2019, 2787-2802	Journal Article	doi: 10.1029/2018 JC014741	University of Hawaii Sea Level Center
Vargas-Angel, B., A. DesRochers, and M. Akridge	2/21/19	Project Report: NOAA Ship Hi'ialakai, Project HA-18-01 (Legs 1, 2, and 3) [Report of the 2018 NOAA-ESD American Samoa and Pacific Remote Islands Marine National Monument Reef Assessment and Monitoring Cruise (ASRAMP)]	NOAA Institutional Repository, 88 pp	Report	https://repository.library.noaa.gov/view/noaa/19567	NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)
Venegas, R., T. Oliver, R. Brainard, M. Santos, R. Geronimo, and M. Widlansky	9/28/18	Climate-induced vulnerability of fisheries in the Coral Triangle: Skipjack tuna thermal spawning habitats	Fish. Oceanogr., 28, 117-130	Journal Article	http://doi.wiley.com/10.1111/fog.12390	Sustaining Healthy Coastal Ecosystems
Vivier, F., A. Bradford, M. Hill, E. Oleson, K. Yano, J. Pawloski, C.G. Booth, and L. Bejder	4/12/19	Calibrating unoccupied aerial system (UAS) photogrammetry to derive delphinid population demographic parameters	The 44th Annual Albert L. Tester Memorial Symposium, University of Hawaii at Manoa, Honolulu, HI, April 10-12, 2019	Presentation		Cetacean Research Program
Whitney, J.L., J. Gove, K. Smith, J. Lecky, A. Copeland, D. Kobayashi, and M. McManus	11/20/18	West Hawaii Ichthyoplankton Project: Exploring a unique ecosystem and their impact on larval fish ecology	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		West Hawaii Integrated Ecosystem Assessment
Widlansky, M. H. Annamalai, S. Gingerich, C. Storlazzi, J. Marra, K. Hodges, B. Choy, and A. Kitoh	1/1/19	Tropical cyclone projections: changing climate threats for Pacific Island defense installations	Weather Clim. Soc., 11(1), January 2019, 3-15	Journal Article	doi:10.1175/WCAS-D-17-0112.1	University of Hawaii Sea Level Center
Wren, J., and J.J. Polovina	9/18/19	Fleet dynamics and oceanographic drivers behind variations in black-footed albatross sightings in the Hawaii longline fishery	In: Report of the Workshop to Review Seabird Bycatch Mitigation Measures for Hawaii's Pelagic Longline Fisheries, Sept. 18-19, 2018. A report of the Western Pacific Regional Fishery Management Council, pp 14-15	Presentation	http://www.wpcouncil.org/wp-content/uploads/2018/11/WPRFMC_2018-Seabird-bycatch-mgmt-workshop_FinalReport.pdf	Ecosystem Structure and Function
Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry	11/19/18	HICEAS 2017: A six month ship-survey of cetaceans and seabirds throughout the Hawaiian Archipelago	Symposium on Science in Support of Archipelagic Management, Honolulu, HI, Nov. 19-20, 2018	Presentation		Cetacean Research Program
Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry	6/1/18	Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017	NOAA Technical Memorandum NMFS-PIFSC; 72	Report	https://doi.org/10.25923/7avn-gw82	Cetacean Research Program
Yoon, H., M. Widlansky, and P. Thompson	8/1/18	Nu`a Kai: Flooding in Hawaii caused by a "stack" of oceanographic process	In State of the Climate in 2017, Global Oceans, Bull. Am. Meteorol. Soc., 99(8), S88-S91	Journal Article	doi:10.1175/2018BAMS StateoftheClimate.1	University of Hawaii Sea Level Center

Appendix I List of Acronyms

3D	Three Dimension
ABT	Atlantic bluefin tuna
ACL	Annual Catch Limit
AD	Automatic Differentiation
ADCP	Acoustic Doppler Current Profiler
ADMB	Automatic Differentiation Model Builder
AGU	American Geophysical Union
ALOHA	A Long-term Oligotrophic Habitat Assessment
APDRC	Asia-Pacific Data Research Center
AR5	Fifth Assessment Report (IPCC)
ARL	Air Resources Laboratories
ARMS	Autonomous Reef Monitoring Structure
ARSHSL	Archive of Rapidly-Sampled Hawaiian Sea Level
ASBE	Annual Small Boat Evaluation
ASRAMP	American Samoa Reef Assessment and Monitoring Program
ATDD	Atmospheric Turbulence and Diffusion Division
AUV	Autonomous Underwater Vehicle
AWIPS	Advanced Weather Interactive Processing System
BET	Big Eye Tuna
BFISH	Bottomfish Fishery-Independent Survey in Hawaii
CAM5	Community Atmosphere Model
CAPAM	Center for the Advancement of Population Assessment Methodology
CAU	Calcification and Accretion Unit
CCD	Centralized Cruise Database
CCR	Closed-Circuit Rebreathers
CFSv2	Coupled Forecast System, version 2
CMIP	Coupled Model Intercomparison Project
CMIP5	Coupled Model Intercomparison Project Phase 5
CMORE	Center for Microbial Oceanography: Research and Education
CNMI	Commonwealth of the Northern Mariana Islands
COBALT	Carbon Ocean And Lower Trophics
CoRIS	Coral Reef Information System
CPU	Central Processing Unit
CPUE	Catch Per Unit Effort
CRCP	Coral Reef Conservation Program

CRIMP-2	Coral reef instrumented platform-2
CRP	Cetacean Research Program
CTD	Conductivity-Temperature-and Depth
CTE	Cold tongue El Niño
DAPPER	Data Access Protocol server
DAR	State of Hawaii Division of Aquatic Resources
DART	Deep-ocean Assessment and Reporting of Tsunamis
DAS	Department of Atmospheric Sciences
DASBR	Drifting Acoustic Spar Buoy Recorder
DAWR	Division of Aquatic and Wildlife Resources (Guam)
DCHART	Web-based server for display of in situ and gridded data sets
DCIP	DropCam Instrument Package
DFW	Division of Fish and Wildlife (CNMI)
DGC	Data Governance Council
DIAS	Document Image Archival System
DIC	Dissolved inorganic carbon
DIDSON	Dual-Frequency Identification Sonar
DLNR	Department of Land and Natural Resources
DMWR	Department of Marine and Wildlife Resources (American Samoa)
DNA	Deoxyribonucleic Acid
DoD	Department of Defense (U.S.)
DODS	Distributed Ocean Data System
DSCRTP	Deep Sea Coral Research and Technology Program
DVR	Digital Video Recorder
E/V	Exploration Vessel
EBFM	Ecosystem-Based Fisheries Management
Eco-FOCI	Ecosystems Fisheries-Oceanography Coordinated Investigations Program
eDNA	Environmental Deoxyribonucleic Acid
EEZ	Exclusive Economic Zone
EM	Electronic Monitoring
ENSO	El Niño Southern Oscillation
EOI	Earth-Oceans Interactions Program
EORP	Ecosystems Observations and Research Program
ER	Electronic Reporting
ERDDAP	Environmental Research Division Data Access Platform
ESA OC CCI	European Space Agency Ocean Color Climate Change Initiative

ESD	Ecosystem Sciences Division
E/V	Exploration Vessel
EVA	Extreme Value Analysis
EX	NOAA R/V Okeanos Explorer
FAD	Fish Aggregation Device
FEP	Fishery Ecosystem Plan
FFS	French Frigate Shoals
FMP	Fishery Management Plan
FOCI	Fisheries-Oceanography Coordinated Investigations
FOT	Final Out Turn Receipt
FRMD	Fisheries Research and Monitoring Division
FSM	Federated States of Micronesia
FSWP	Fishery Statistics of the Western Pacific
FTIR	Fourier transform infrared spectroscopy
FUS	Fisheries of the United States
FY	Fiscal Year
GCM	Generalized Circulation Model
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
GMSL	Global Mean Sea Level
GNSS	Global Navigation Satellite System
GoM	Gulf of Mexico
GPS	Global Positioning System
GPT	Geospatial Products Team
GrADS	Grid Analysis and Display System
GTS	Global Telecommunication System
GUI	Graphic User Interface
HARAMP	Hawaiian Islands Reef Assessment and Monitoring Program
HARP	High-frequency Acoustic Recording Package
HDAR	Hawaii Division of Aquatic Resources
Hg0	Elemental Mercury
HgP	Particulate Mercury
HIMB	Hawaii Institute of Marine Biology

HMS	Hawaiian Monk Seal
HPA	Hawaii Preparatory Academy
HMSRP	Hawaiian Monk Seal Research Program
IATTC	Inter-American Tropical Tuna Commission
IEA	Integrated Ecosystem Assessment
IEC	International Electrotechnical Commission
IHLRT	Institute for Hawaiian Language Research and Translation
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
IRC	Inouye Regional Center
ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
ISSF	International Seafood Sustainability Foundation
ISTS	International Sea Turtle Symposium
IT	Information Technology
IWLS	Integrated Water Level Service
JABBA	Just Another Bayesian Biomass Assessment
JIMAR	Joint Institute for Marine and Atmospheric Research
Kd490	Diffuse Attenuation Coefficient at 490 nm
LAS	Live Access Server
LED	Light Emitting Diode
LHP	Life History Program
LME	Large Marine Ecosystem
LHRC	Lāhui Hawaiʻi Research Center
MACS	Marianas Archipelago Cetacean Survey
MAPCO2	Moored Autonomous pCO2 System
MARAMP	Marianas Archipelago Reef Assessment Monitoring Program
MCMC	Markov Chain Monte Carlo
ME	Mixed El Niño
MHHW	Mean Higher High Water
MHI	Main Hawaiian Islands
MITgcm	Massachusetts Institute of Technology general circulation model
MLO	Mauna Loa Observatory
MOP	Marine Option Program

MOUSS	Modular Underwater Stereoscopic System
MPA	Marine Protected Area
MTBAP	Marine Turtle Biology and Assessment Program
N2N	NOAA to NOAA
NABC	Naval Amphibious Base - Coronado
NCEAS	National Center for Ecological Analysis and Synthesis
NCEI	National Centers for Environmental Information
NCRMP	National Coral Reef Monitoring Program
NCTR	NOAA Center for Tsunami Research (NCTR
NCWCP	NOAA Center for Weather and Climate Prediction
NDBC	National Data Buoy Center
NESDIS	National Environmental Satellite, Data, and Information Service
NGS	National Geodetic Survey
NMFS	National Marine Fisheries Service
NMSAS	National Marine Sanctuary of American Samoa
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSF	National Science Foundation
NTHMP	National Tsunami Hazard Mitigation Program
NUTS	No U-Turn Sampler
NWHI	Northwestern Hawaiian Islands
NWS	National Weather Service
OA	Ocean acidification
OAP	Ocean Acidification Program (NOAA office)
OAR	Office of Oceanic and Atmospheric Research
ODRS	Online Commercial Marine Dealer Reporting System
OFES	Ocean model For the Earth Simulator
OFES/AFES/CFES	Ocean/Atmosphere/Coupled model For the Earth Simulator
ONMS	Office of National Marine Sanctuaries
OPeNDAP	Open-source Project for a Network Data Access Protocol
OWCP	OceanWatch - Central Pacific
PacIOOS	Pacific Islands Ocean Observing System
PACOM	Pacific Command
PAR	Photosynthetically Available Radiation
PARR	Public Access to Research Results
PDC	Pacific Disaster Center

PDO	Pacific Decadal Oscillation
PATs	Pop-off archival tags
PEAC	Pacific ENSO Applications Climate Center
PHR	Pearl and Hermes Reef
PI	Principal Investigator
PIFG	Pacific Island Fisheries Group
PIFSC	Pacific Islands Fisheries Science Center
PIMPAC	Pacific Island Managed and Protected Area Community
PIR	Pacific Islands Region
PIRO	Pacific Islands Regional Office
PIROP	Pacific Islands Regional Office Observer Program
PLOS	Public Library of Science
PMEL	Pacific Marine Environmental Laboratory
PMNM	Papahānaumokuākea Marine National Monument
PRIA	Pacific Remote Island Area
PRIMNM	Pacific Remote Islands Marine National Monument
PRSN	Puerto Rico Seismic Network
PSD	Protected Species Division
PTWC	Pacific Tsunami Warning Center
PYSO	PIFSC Young Scientist Opportunity
QC	Quality Control
QUEST	Quantitative Underwater Ecological Surveying Techniques
R/V	Research Vessel
RAMNM	Rose Atoll Marine National Monument
RAMP	Reef Assessment and Monitoring Program
RA-V	Regional Alliance Five (Pacific Islands)
RCC	Regional Climate Center
RCUH	Research Corporation of the University of Hawaii
RFA	Regional Frequency Analysis
RFMO	Regional Fishery Management Organization
RGM	Reactive Gaseous Mercury
RMI	Republic of the Marshall Islands
ROMS	Regional Ocean Modeling System
ROV	Remotely Operated underwater Vehicle
RPL	Regional Purse-Seine Logsheet
R/V	Research Vessel

SAP	Stock Assessment Program
SCADA	Supervisory Control and Data Acquisition
SCUBA	Self-Contained Underwater Breathing Apparatus
SDT	Software Development Team
SfM	Structure from Motion
SHCE	Sustaining Healthy Coastal Ecosystems
SIFT	Short-term Inundation Forecasting for Tsunamis
SIO	Scripps Institution of Oceanography
SL	Sea level
SMAP	Soil Moisture Active Passive
SMOS	Soil Moisture and Ocean Salinity
SOD	Science Operations Division
SOEST	School of Ocean and Earth Science and Technology
SOP	Standard Operating Procedure
SPA	Seal Population Assessment
SPC	Secretariat of the Pacific Community
SPTT	South Pacific Tuna Treaty
SSH	Sea Surface Height
SSTP	Survey and Sampling Technologies Program
STEM	Science Technology Engineering Math
SWFSC	Southwest Fisheries Science Center
SWS	SeaWater System
TA	Total alkalinity
TB	Terabyte
TG	Tide gauge
THREDDS	Thematic Real-time Environmental Distributed Data Services
TIGA	Tide Gauge Benchmark Monitoring Project
TMB	Template Model Builder
TSI	Territorial Science Initiative
TWC	Tsunami Warning Centers
U.S.	United States
UAS	Unmanned Aerial System
UC	University of California
UH	University of Hawaii
UHM	University of Hawaii at Manoa
UHDAS	University of Hawaii Data Acquisition System

UHSLC	University of Hawaii Sea Level Center
UL	Unloading and Transshipment Logsheet
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNR	University of Nevada at Reno
USA	United States of America
USAPI	United States Affiliated Pacific Islands(Guam, Palau, Yap, Pohnpei, Majuro, Kwajalein, and Pago Pago)
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
VARS	Video Annotation and Reference System
VFP	Visual Fox Pro
VIAME	Video and Image Analytics for Marine Environment
VOC	Vessel Operation Coordination
WAP	West Antarctic Peninsula
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WMO	World Meteorological Office
WPacFIN	Western Pacific Fisheries Information Network
WPE	Warm pool El Niño
WPRFMC	Western Pacific Regional Fishery Management Council
WRF	Weather Research and Forecasting model

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, 2018–June 30, 2019

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
Atmospheric Gases in the Remote Pacific Marine Free Troposphere Measured in Hawaii	Brian Vasel	19, 39, 42, 94
Cetacean Research Program	Michael Seki	8, 80, 117
Characterization and dynamics of mesoscale and submesoscale oceanic variability in the Solomon Sea simulated by a nested ROMS model	Gary Matlock	3, 50, 84, 92, 98, 129
Data Validation at the Hawaii MAPCO2 Buoy Network in Support of a Test-Bed for Technology Development : Phase II	Gary Matlock	2, 45, 88
Ecosystem Structure and Function	Michael Seki	10, 77, 124
Ecosystems Observations and Research Program: Research Support Project	Michael Seki	37, 81, 113
Ecosystems Observations and Research Program: Science Operations Project	Michael Seki	34, 71, 112
Effects of Nitrogen Sources and Plankton Food-Web Dynamics on Habitat Quality for the Larvae of Atlantic Bluefin Tuna in the Gulf of Mexico	John Lamkin	47, 86, 136
Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center (IPRC)	Howard Diamond	1, 43, 73, 96
Fishing Impacts on Non-Target Species	Michael Seki	24, 40, 41, 56, 114
Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support	Michael Seki	38, 60, 118
Hawaiian Monk Seal Research Program	Michael Seki	7, 65, 121
Main Hawaiian Islands Commercial Fisheries Fast Track Data Project	Michael Seki	27, 52, 125
Marine Debris Mitigation Project	Michael Seki	100
Marine Turtle Recovery in the Pacific Islands Region	Michael Seki	12, 68, 115
National Weather Service Pacific Region Fellowship	Raymond Tanabe	26, 57, 95
NCRMP Pacific Reef Assessment and Monitoring Program (RAMP)	Michael Seki	123
NOAA Extended Continental Shelf Cruise to Gulf of Alaska	Margot Bohan	93
Ocean Remote Sensing	Michael Seki	25, 63, 107
Open Source ADMB Project	Michael Seki	33, 74, 106
Optimizing Routine Ocean Current Measurements by the NOAA Fleet: Renewal for FY2017-2019	Solomon Tadele	36, 53, 126
Pacific ENSO Applications Climate (PEAC) Center	Raymond Tanabe	23, 61, 127

Pacific Fisheries Monitoring Program	Michael Seki	15, 66, 101
Pacific Islands Deep Sea Coral and Sponge Initiative	Michael Seki	17, 76, 97
Pacific Islands Territorial Science Initiative (PITSI)	Michael Seki	4, 54, 102
Pacific Tuna Fishery Data Management	Michael Seki	13, 79, 120
Papahānaumokuākea Marine National Monument Monitoring and Research	Randall Kosaki	9, 70, 122
Profiling CTD Float Array Implementation and Ocean Climate Research	Gary Matlock	32, 55, 89
Research Support for PMEL Earth-Ocean Interactions Program (EOI), Ecosystems Fisheries-Oceanography Coordinated Investigations Program (Eco-FOCI), and Carbon Research Program	Gary Matlock	44
Socioeconomics of Western Pacific Fisheries	Michael Seki	20, 67, 116
Stock Assessment Research Program	Michael Seki	21, 69, 119
Sustaining Healthy Coastal Ecosystems	Michael Seki	35, 78, 108, 111
Territorial Biosampling	Michael Seki	14, 72, 105
Transferal of Pacific ENSO Applications Climate (PEAC) Center Products and Services to Weather Forecast Office (WFO) Honolulu	Raymond Tanabe	75, 103
Tsunami Research and Modeling	Gary Matlock	46
University of Hawaii Sea Level Center	David Legler	22, 59, 82, 85, 91
West Hawaii Integrated Ecosystem Assessment	Michael Seki	11, 62, 110
Western Pacific Fisheries Information Network (WPacFIN)	Michael Seki	30, 48, 104

Appendix III Visiting Scientists

DATE	NAME/AFFILIATION	PURPOSE OF VISIT
04/15/18–09/06/18	Paige Mino UH Volunteer Honolulu, HI	To participate in the 2018 Hawaiian Monk Seal Field Camp aboard the NOAA R/V Oscar Elton Sette and at the field camps on Pearl and Hermes (PHR) to conduct monk seal surveys.
04/15/18–10/02/18	Jonathan Schneiderman UH Volunteer Honolulu, HI	To participate in the 2018 Hawaiian Monk Seal Field Camp aboard the NOAA R/V Oscar Elton Sette and NOAA R/V Hi'ialakai and at the field camps on the French Frigate Shoals (FFS) to conduct monk seal surveys.
05/26/18–06/28/18	Tane Sinclair-Taylor Field Research Technician King Abdullah University of Science & Technology Thuwal, Saudi Arabia	To participate in the NOAA Research Cruise SE-18-03 aboard R/V Oscar Elton Sette in waters off the Mariana Islands with JIMAR staff and co-direct research objectives regarding ongoing collaborations on the biology of coral reef fishes and deep water snappers of commercial value in the U.S.-affiliated Pacific.
06/12/18–07/06/18	William Dunn Fisheries Biologist CNMI Department of Land & Natural Resources Saipan, MP	To participate in the PIFSC Life History Program cruise onboard the NOAA R/V Oscar Elton Sette and actively coordinate with JIMAR and PIFSC researchers to collect reef fish samples and process fish specimens which will elucidate understanding of Mariana fish population and life histories.
06/12/18–07/05/18	Jude Martinez Student University of Guam Marine Laboratory Mangilao, Guam	To participate with JIMAR staff on a fisheries research cruise onboard the NOAA R/V Oscar Elton Sette conducting fisheries research in the Northern Mariana Island by assisting in the collection of coral reef fishes and processing of biological data during the research cruise.
06/12/18–07/05/18	Jennifer Ha Student University of Guam Barrigada, Guam	To participate with JIMAR staff on a fisheries research cruise onboard the NOAA R/V Oscar Elton Sette conducting fisheries research in the Northern Mariana Island by assisting in water sampling, fish processing, data curation and sample collection during the research cruise.

06/21/18–07/07/18	Darren Coker Research Scientist King Abdullah University of Science & Technology Thuwal, Saudi Arabia	To participate in the NOAA Research Cruise SE-18-03 aboard R/V Oscar Elton Sette in waters off the Mariana Islands with JIMAR Territorial Biosampling project staff and conducting research on the biology of coral reef fishes of commercial value to the U.S. Pacific Islands and under federal evaluation.
06/25/18–07/06/18	Michael Tenorio Fisheries Biologist CNMI Department of Land & Natural Resources Saipan, MP	To participate in the PIFSC Life History Program cruise onboard the NOAA ship Oscar Elton Sette to coordinate with JIMAR and PIFSC researchers in collecting reef fish samples and process fish specimens which will elucidate an understanding of Mariana fish populations and life histories.
07/30/18–08/10/18	Elan Portner Student Stanford University Pacific Grove, CA	To collaborate with the NOAA Pacific Island Fisheries Science Center (PIFSC) and assist in the ongoing lancet fish diet monitoring project.
08/02/18–08/10/18	Carolyn Choy Assistant Professor University of California, San Diego La Jolla, CA	To collaborate with the NOAA Pacific Island Fisheries Science Center (PIFSC) and assist in the ongoing lancet fish diet monitoring project.
08/13/18–08/17/18	Christopher Piecuch Assistant Scientist Woods Hole Oceanographic Institution Woods Hole, MA	To work with UH Sea Level Center in analyzing the ECCOv4 ocean state estimate to understand the forcing and mechanisms of basin-scale sea level change patterns during recent decades and to give a seminar on "River-Discharge Effects on United States Atlantic and Gulf Coast Sea-Level Changes".
10/21/18–10/27/18	Jean-Patrice Klein Senior Scientist Universities Space Research Association (USRA) Columbia, MD	To participate in a mini-workshop on sub meso-scale motions in the upper ocean, exploring their dynamics, their interaction with the atmosphere and their impacts on biological processes and to collaborate with UH and RCUH researchers.
11/13/18–11/13/18	Tanja Heck Assistant Project Scientist University of California, Santa Cruz Santa Cruz, CA	To present research on the global assessment of climate change on fisheries at the PIFSC 2019-2023 Science Plan: Research to Support Ecosystem-Based Fisheries and Living Marine Resource Management.

11/28/18– 11/30/18	Jayantha Obeysekera Director, Sea Level Solution Center Florida International University Miami, FL	To attend The Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) Symposium and to meet with SERDP project members to discuss preliminary RFA results from the mainland US and to finalize the methodology for the Pacific.
03/13/19– 03/15/19	Matthew Alford Professor University of California, San Diego La Jolla , CA	To present a seminar on turbulence observations using the global ARGP drifting float array to better understand and predict climate change and to interact with SOEST faculty, researchers and students.
03/13/19– 03/15/19	James Girton Principal Oceanographer University of Washington Seattle, WA	To share recent work using technologies to improve the understanding of climate and sea level rise and to present a seminar on recent experiment with autonomous vehicles (EM-APEX floats and sea gliders) under an Antarctic ice shelf (Dotson). Girton will also share the early results on ocean heat transport, ice shelf melting rates and the mixing processes and interact with SOEST faculty, researchers and students.
04/22/19– 04/23/19	Meghan Soukup Research Assistant Halawa Hawksbill Monitoring Program Kaunakakai, HI	To receive training on the sea turtle processing protocol employed by NOAA's Marine Turtle Biology and Assessment Program to include participation on two field expeditions.
04/22/19– 04/23/19	Christi Feeter Research Coordinator Halawa Hawksbill Monitoring Program Kaunakakai, HI	To receive training on the sea turtle processing protocol employed by NOAA's Marine Turtle Biology and Assessment Program to include participation on two field expeditions.

Appendix IV Workshops, Meetings and Seminars

A River Runs Through It: Exploring the Influence of River Discharge on Coastal Sea Level
August 16, 2018, University of Hawaii at Manoa, Honolulu, HI
Christopher Piecuch, Woods Hole Oceanographic Institution

Patterns of Reef Fishes Across Depths and Habitats
September 20, 2018, Hanauma Bay Educational Lecture Series, Honolulu, HI
Jake Asher, JIMAR Fish Researcher, Fish Ecology and Monitoring Team, NOAA Pacific Islands Fisheries Science Center

Cryptofauna Diversity in the Tropical Pacific
September 27, 2018, Hanauma Bay Educational Lecture Series, Honolulu, HI
Molly Timmers, JIMAR Marine Ecosystems Research Project Manager, Ocean and Climate Change Team, NOAA, Pacific Islands Fisheries Science Center

Giving Baby Seals a Second Chance: Rehabilitation of Hawaiian Monk Seals from the Northwestern Hawaiian Islands
October 4, 2018, Hanauma Bay Educational Lecture Series, Honolulu, HI
Angie Kaufman, JIMAR Veterinary Laboratory Associate, NOAA, Pacific Islands Fisheries Science Center

An Acoustic Survey of Beaked Whale and *Kogia* in the Main Hawaiian Islands Using Drifting Recorders
October 4, 2018, University of Hawaii at Manoa, Honolulu, HI
Jennifer McCullough, JIMAR Senior Passive Acoustic Associate, NOAA, Pacific Islands Fisheries Science Center

Repeat Bleaching of a Central Pacific Coral Reef over the Past Six Decades
October 25, 2018, University of Hawaii at Manoa, Honolulu, HI
Hannah Barkley, JIMAR Coral Reef Ecosystem Oceanographer, NOAA, Pacific Islands Fisheries Science Center

Observations and Modeling of Coastal Infragravity Waves
November 1, 2018, University of Hawaii at Manoa, Honolulu, HI
Assaf Azouri, JIMAR Post-doctoral Researcher, University of Hawaii at Manoa

Thermal Stress on Coral Reefs Across the Pacific Islands
December 13, 2018, Hanauma Bay Educational Lecture Series, Honolulu, HI
Roberto Venegas, JIMAR Research Oceanographer and Data Analyst, NOAA Pacific Islands Fisheries Science Center

Why Turbulence Matters for Understanding Climate Variability, and How Better Global Measurements of It Would Improve Predictions
March 13, 2019, University of Hawaii at Manoa, Honolulu, HI
Matthew Alford, PhD, Professor, Scripps Institution of Oceanography

Abyssal Flow Through the Samoan Passage
March 14, 2019, University of Hawaii at Manoa, Honolulu, HI
Matthew Alford, PhD, Professor, Scripps Institution of Oceanography; James Girton, PhD, Principal Oceanographer, Applied Physics Laboratory, University of Washington; Gunnar Voet, PhD, Scripps Institution of Oceanography; and Glenn Carter, PhD, Professor, Department of Oceanography, University of Hawaii at Manoa

**Using Autonomous Vehicles to Explore Heat Transport, Melt Rates and
Mixing Under an Antarctic Ice Shelf**
March 15, 2019, University of Hawaii at Manoa, Honolulu, HI
James Girton, PhD, Principal Oceanographer, Applied Physics Laboratory, University of Washington

A High-Resolution Modeling Study of a Western Antarctic Fjord
March 28, 2019, University of Hawaii at Manoa, Honolulu, HI
Lisa Hahn-Woernle, JIMAR Post-doctoral Researcher, and Tobias Friedrich, Scientific Ocean Modeler,
PacIOOS, Department of Oceanography, University of Hawaii at Manoa

**Integration of Structure-from-Motion Photogrammetry into the Reef Assessment and
Monitoring Program**
April 11, 2019, University of Hawaii at Manoa, Honolulu, HI
Atsuko Fukunaga, JIMAR PMNM Ecological Research Statistician, NOAA Pacific Islands Fisheries
Science Center

Introduction to the OceanWatch Program and Ocean Remote Sensing Basics
April 18, 2019, University of Hawaii at Manoa, Honolulu, HI
Melanie Abecassis, JIMAR Ocean Watch Manager/Researcher, NOAA Pacific Islands Fisheries Science Center

Appendix V JIMAR Personnel

Information as of June 30, 2019

Category	Number	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	26	0	0	0	0	26
Visiting Scientist	0	0	0	0	0	0
Postdoctoral Fellow	0	0	0	0	0	0
Research Support Staff	94	3	4	67	18	2
Administrative	10	0	0	7	2	1
Total (≥ 50% support)	**130**	**3**	**4**	**74**	**20**	**29**
Undergraduate Students	9	9	0	0	0	0
Graduate Students	12	0	0	9	3	0
Employees that receive < 50% NOAA Funding (not including students)	8	0	0	1	1	6
Located at Lab (include name of lab)	4 - PMEL 101 - PIFSC 2 - ESRL 4 - PMNM					
Obtained NOAA employment within the last year	3					
Postdoctoral fellows and students from subgrantees	Postdocs: 0 Students: 0					

Appendix VI Awards

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

Joao Garriques
- 2018 RCUH Outstanding Employee Awards, Honorable Mention

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

Jessica Perelman
- Fernando Gabriel Leonida Memorial Scholarship in Fisheries Science (July 2018)

Appendix VII Graduates

Sarah Bingo, Master of Science in Marine Science, Department of Natural Science, Hawaii Pacific University, December 2018, non-thesis

Mia Iwane, Master of Science, Natural Resources & Environmental Management, University of Hawaii at Manoa, "Seeking collaboration in fisheries management: Engaging Hawaii small-scale fishers to mitigate pelagic shark mortality"

Appendix VIII 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 17	FY 18	FY 19
Peer Reviewed	**JIMAR Lead Author**	19	18	15
	NOAA Lead Author	5	3	5
	Other Lead Author	16	15	17
Non Peer-Reviewed	**JIMAR Lead Author**	16	52	41
	NOAA Lead Author	1	6	4
	Other Lead Author	0	3	6

Appendix IX 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#: NA17NMF4320250
Title: International Ecosystem Approach to Fisheries Management (IEAFM) Project—Philippines
Principal Investigator: Dr. Douglas Luther

Award#: NA17NMF4320293
Title: 2017 Cetacean Research Program—Monitoring in the Mariana Islands Range Complex
Principal Investigator: Dr. Douglas Luther

Award#: NA17NMF4320294
Title: 2017 Marine Turtle Nearshore Assessment in the Mariana Islands
Principal Investigator: Dr. Douglas Luther

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

Award#: NA16NWS4680019
Title: Towards Advancing the MJO and 1–30-day Weather Forecasting in the Fully Coupled NGGPS
Principal Investigator: Dr. Joshua Xiouhua Fu