JIMAR

Annual Report for Fiscal Year 2017

For Cooperative Agreements NA16NMF4320058, NA16NMF4320216, and NA16NMF4320219

Mark A. Merrifield, PhD
Director

SCHOOL OF OCEAN AND EARTH
SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MĀNOA

Annual Report for Fiscal Year 2017
Performance Period October 1, 2016–June 30, 2017

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Introduction

The Joint Institute for Marine and Atmospheric Research (JIMAR) manages the Cooperative Institute for the Pacific Islands Region, one of 16 NOAA cooperative institutes nationwide. JIMAR's mission is to conduct research that is necessary for understanding and predicting environmental change in the Pacific Islands Region, conserving and managing coastal and marine resources in island environments, notably the Hawaiian Islands and the U.S.-affiliated Pacific Islands, and supporting the region's economic, social, and environmental needs. Included in this report are projects under award numbers NA16NMF4320058, NA16NMF4320216, and NA16NMF4320219. JIMAR seeks to:

Mark Merrifield, Director, PhD

- 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;
- sponsor interactions through the support of visiting scientists and post-doctoral scholars;
- promote the transition of research outcomes to operational products and services that benefit the Pacific Islands Region.

JIMAR is located at the University of Hawaii at Manoa, a research-intensive land-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 substantially 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 collaborates closely with the Pacific Island Fisheries Science Center (PIFSC) at the Inouye Regional Center (IRC). 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 ~25 JIMAR projects ranging from coral reef monitoring and research, marine mammal and turtle research, human dimensions investigations and economics of fisheries, fisheries bycatch mitigation research, oceanic and reef ecosystems modeling, insular and pelagic fisheries stock assessment research, fisheries database management, and more.

JIMAR also interacts with the NOAA NWS, NESDIS, and 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), Pacific ENSO Applications Climate (PEAC) Center, and Pacific Island Ocean Observing System (PacIOOS).

JIMAR research covers eight themes, all aligned with the NOAA strategic plan and the University's Indo-Pacific mission. The themes are: (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 Pacific Islands Fisheries Science Center (PIFSC) drives the primary research and educational activities within the Institute. Here are a few highlights that demonstrate the scope of JIMAR/PIFSC research in the theme areas of ecosystem-based management, ecosystem monitoring and forecasting, and protection and restoration of resources.

- Recent studies stressed the importance of coral reef conservation for protecting herbivorous fish, which are heavily fished in many parts of the world. However, JIMAR Supervisory Reef Fish Researcher Adel Heenan led a team that found that populations of herbivorous fish vary widely from site to site, and are strongly influenced by factors including temperature and island type. This means strategies to protect these important species may not be effective unless local conditions are taken into account, and no single approach is likely to

work everywhere. (Adel Heenan, Andrew Hoey, Gareth Williams, and Ivor Williams, 2016. Natural bounds on herbivorous coral reef fishes, *Proc. R. Soc. B.*, 283(1843), 20161716, doi:10.1098/rspb.2016.1716).

- Coral reef jacks, snapper, and other top-tier coral reef predators such as sharks are well studied in waters accessible to open-circuit SCUBA divers in depths to 100 ft. However, information on predator populations in mesophotic depths (100-330 ft) remains scant, with access restricted to complicated, expensive, or hazardous survey approaches. JIMAR Marine Ecosystem Research Coordinator Jacob Asher used low-cost, baited remote underwater stereo-video systems to assess predator populations at mesophotic depths across the Hawaiian Archipelago, and this research shows that predator populations shift dramatically from shallow to mesophotic depths across that expanse. Stereo-video robustly extends the depth range of roving predator surveys, highlights important community shifts in populated versus remote parts of the Archipelago, and is well-suited for large-scale roving predator work across the Pacific. (Jacob Asher, Ivor Williams, and Euan Harvey, 2017. An assessment of mobile predator populations along shallow and mesophotic depth gradients in the Hawaiian Archipelago, *Sci. Rep.*, 7(1), 3905, doi:10.1038/s41598-017-03568-1).

- Under work led by JIMAR Cetacean BioAcoustic Technician Ali Bayless, the deep-set tuna-target commercial fishery was acoustically monitored for false killer whale vocalizations. This work included collaboration with the Hawaii Longline Association and the NOAA Pacific Islands Regional Office Observer Program. The timing of vocalizations was compared to fishing activities and depredation rates, and it was found that false killer whales are heard most often during the hauling of gear. This suggests they may be cueing into some haul-related sound, and these detections were found to move towards the vessel during the soak, then away from the vessel during the haul, further supporting an acoustic cue. It was also found that false killer whales may be depredating bait more often than catch. (Alexandra Bayless, Erin Oleson, Simone Baumann-Pickering, Anne Simonis, Jamie Marchetti, Sean Martin, and Sean Wiggins, 2017. Acoustically monitoring the Hawaii longline fishery for interactions with false killer whales, *Fish. Res.*, 190, 122-131, doi:10.1016/j.fishres.2017.02.006).

- Mesophotic coral ecosystems, also termed the 'coral twilight zone', extends beyond the diving limit of conventional SCUBA and are vastly under-studied due to their depth. JIMAR Ecological Research Statistician Atsuko Fukunaga and scientists from NOAA Papahānaumokuākea Marine National Monument analyzed mesophotic reef fish data collected in the Northwestern Hawaiian Islands using advanced mixed-gas technical diving. The study revealed diverse assemblages of reef fish at depths 30-100 m and changes in numerically abundant fish species along the island chain, with the introduced bluestriped snapper, or ta'ape, more common at the southeastern end, while atolls at the northwestern end supported more endemic species that are only found in the Hawaiian Islands. (Atsuko Fukunaga, Randall Kosaki, and Daniel Wagner, 2017. Changes in mesophotic reef fish assemblages along depth and geographical gradients in the Northwestern Hawaiian Islands, *Coral Reefs*, doi:10.1007/s00338-017-1569-6).

- JIMAR and UH Economics and Natural Resources and Environmental Management Graduate Assistant Jonathan Sweeney led a team, including JIMAR Senior Fisheries Economics Project Manager Hing Ling Chan, that developed an easy-to-use and flexible tool to produce rapid economic assessments for proposed fishery policies. They adapted a modeling strategy widely used for agricultural assessments to evaluate individual fisher responses to changes in management policy. The team simulated a proposed 10% reduction in the annual catch limit for bigeye tuna in the longline fishing fleet and found that the model successfully captures the different economic impacts felt by individual fishers. This information provides policy makers with a prediction of the range of winners and losers resulting from changes to fishery policy, and can inform which policies are more likely to gain widespread industry support. (Jonathan Sweeney, Richard Howitt, Hing Ling Chan, Minling Pan, and PingSun Leung, 2017. How do fishery policies affect Hawaii's longline fishing industry? Calibrating a positive mathematical programming model, *Nat. Resour. Model.*, doi:10.1111/nrm.12127).

- Life-history information for commercially-harvested species in the U.S. Territories is a cornerstone for effective fisheries management. A series of studies by JIMAR scientist Brett Taylor, along with researchers from the PIFSC and University of Hawaii, present highly detailed assessments of growth patterns, life span, reproductive maturity, and mortality rates of various species from the Commonwealth of the Northern Mariana Islands (CNMI) and American Samoa. Species include the forktail rabbitfish (*Siganus argenteus*) and the orange-striped emperor (*Lethrinus obsoletus*) from the CNMI, and the redlip parrotfish (*Scarus rubroviolaceus*) from American Samoa. This information sheds light on the current stock status of the species and feeds directly into stock assessments of the respective fisheries. (Brett Taylor, Zack Oyafuso, and Michael Trianni, 2017. Life history of the orange-striped emperor *Lethrinus obsoletus* from the Mariana Islands, *Icthyol. Res.*, doi:10.1007/s10228-017-0573-8).

- Visual observations by divers using open-circuit (OC) SCUBA is the standard approach to survey coral reef fishes. A study led by JIMAR Marine Ecosystem Research Coordinator Andrew Gray, along with NOAA and UH researchers and other JIMAR staff (Kevin Lino, Brian Hauk, John Rooney, Jacob Asher, and Keolohilani Lopes Jr), quantified bias in OC surveys, such as the fish avoidance of divers. A potential way to reduce avoidance is to utilize closed circuit rebreathers (CCRs), which do not produce noise or bubbles to disturb the fish. The team conducted paired OC and CCR fish surveys in the Main Hawaiian Islands at locations with high, moderate, and light fishing pressure and found no significant differences in biomass estimates between OC and CCR surveys when data were pooled across all sites, although there are differences observed at the most heavily fished location (Oahu). (Andrew Gray, Ivor Williams, Kontantinos Stamoulis, Raymond Boland, Kevin Lino, Brian Hauk, Jason Leonard, John Rooney, Jacob Asher, Keolohilani Lopes Jr, and Randall Kosaki, 2016. Comparison of reef fish survey data gathered by open and closed circuit SCUBA divers reveals differences in areas with higher fishing pressure, *PLoS ONE*, 11(12), e0167724, doi:10.1371/journal.pone.0167724).

In non-fisheries related research, a focus for JIMAR over the past year has been on science outcomes that have direct societal applications. A key example has been the extension of regional and global sea level change studies by JIMAR researchers at the University of Hawaii Sea Level Center (UHSLC) to assess and forecast extreme sea level events in the Pacific Island region. In particular, a decadal shift in Pacific trade winds has led to unusually high water levels that have impacted the Hawaiian Islands region for over a year. This high water stand in combination with seasonally high tides and mesoscale eddy variability led to record water levels throughout the 2017 summer season, including the highest daily water level in a century according to the Honolulu tide gauge record. Using new dynamical and statistical modeling techniques, the UHSLC was able to provide advanced notice of potential flooding events, and assisted the National Weather Service with the issuance of public warnings. The seasonal sea level forecasting assessments established for the Pacific Islands will be extended to all U.S. coastlines under a recently funded NOAA MAPP project led by JIMAR researcher Matthew Widlansky. The coastal high water level forecasts will be conducted within a NOAA task team that also considers forecasts for marine living resources. Another example of actionable science within JIMAR is a study on extreme drought conditions in the U.S. Affiliated Pacific Island region led by PhD student Alejandro Ludert. The outcomes of this study highlight the need to consider precipitation variability in the region beyond an overarching El Niño framework.

JIMAR devotes a portion of its annual budget to educational opportunities for K-12 students through postgraduate research training. To engage the next generation of marine scientists, JIMAR researchers working in the NOAA PIFSC and the NOAA Pacific Islands Regional Office (PIRO) regularly participate in the annual "Fisheries Science Camp" held in the Inouye Regional Center (IRC) on Ford Island, Oahu. This free, five-day camp is designed for 8th grade students from economically underserved communities and consists of several science modules, a field trip to Waikiki Aquarium, and a beach cleanup. Each segment of the camp includes hands-on experiences for the young campers in fisheries research areas such as marine debris, fish sampling techniques, and stock assessment, marine food webs, plankton, Hawaiian monk seals, and fisheries-dependent data. In addition, local teachers are engaged to develop kit lessons based on the science modules, including lesson plans to reach Hawaii students throughout the school year.

Other educational events supported during the reporting period are the 42nd Albert L. Tester Symposium (April 26-28, 2017, University of Hawaii at Manoa) and the PIFSC Young Scientist Opportunity (PYSO) 2017 summer intern program. The PYSO is a collaborative program between PIFSC and JIMAR that offers qualified participants professional scientific research experience and training under the mentorship of selected researchers of the PIFSC. JIMAR also supported participation of the Kalani High School Ocean Science Bowl team in the Hawaii Regional competition for the National Ocean Science Bowl (also known as the Aloha Bowl) held February 4, 2017 in Honolulu.

JIMAR provides administrative support for the Pacific Islands Ocean Observing System (PacIOOS) program, which empowers ocean users and stakeholders throughout the Pacific Islands by providing accurate and reliable coastal and ocean information, tools, and services. During this reporting period, PacIOOS launched its new website at http://pacioos.org to better serve partners, stakeholders, and users both on mobile and desktop devices. Dynamic and user-friendly tools allow for quick and easy access to PacIOOS' observations and models. PacIOOS continues to maintain over 30 deployed buoys, sensors, and other instruments throughout the U.S. Pacific Islands, including two new wave buoys off Kaneʻohe Bay and off Pearl Harbor, Oʻahu, Hawaii, which provide valuable wave and ocean observations in real-time. The PacIOOS Water Quality Sensor Partnership Program was launched and implemented to help researchers and resource managers throughout the insular Pacific to collect accurate

nearshore water quality measurements for ongoing research efforts. PacIOOS closely works with state and federal agencies, non-profit organizations, academic institutions, and other partners to make coastal and oceanographic data publicly available. A new series of tiger shark tracks can be viewed online, as well as numerous data sets from the Ocean Tipping Points Case Study in Hawaii. More than 1,600 individual datasets (both PacIOOS and partner data) are freely accessible through PacIOOS' data visualization platform 'Voyager' at http://pacioos.org/voyager.

Given our remote locale, JIMAR's Visiting Scientist Program provides an important mechanism to engage with experts from around the world, as well as to sponsor trips by JIMAR researchers to international conferences and workshops. This year, JIMAR hosted experts in chemical oceanography and hydrologic modeling.

It has been a busy and productive year for JIMAR. The project descriptions that follow in the next section will provide a glimpse into the vital role 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.

The Director of JIMAR 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.

JIMAR Council of Fellows from NOAA are Dr. Christofer Boggs (PIFSC), Dr. Russell Brainard (PIFSC), Dr. Edward DiMartini (PIFSC), Mr. Justin Hospital (PIFSC), Dr. Gregory Johnson (PMEL), Dr. William Kessler (PMEL), Dr. John Marra (PRCS), Dr. Michael McPhaden (PMEL), Dr. Dennis Moore (PMEL), Dr. Frank Parrish (PIFSC), Dr. Jeffrey Polovina (PIFSC), Dr. Christopher Sabine (PMEL), Dr. Michael Seki (PIFSC), and Mr. Raymond Tanabe (NWS).
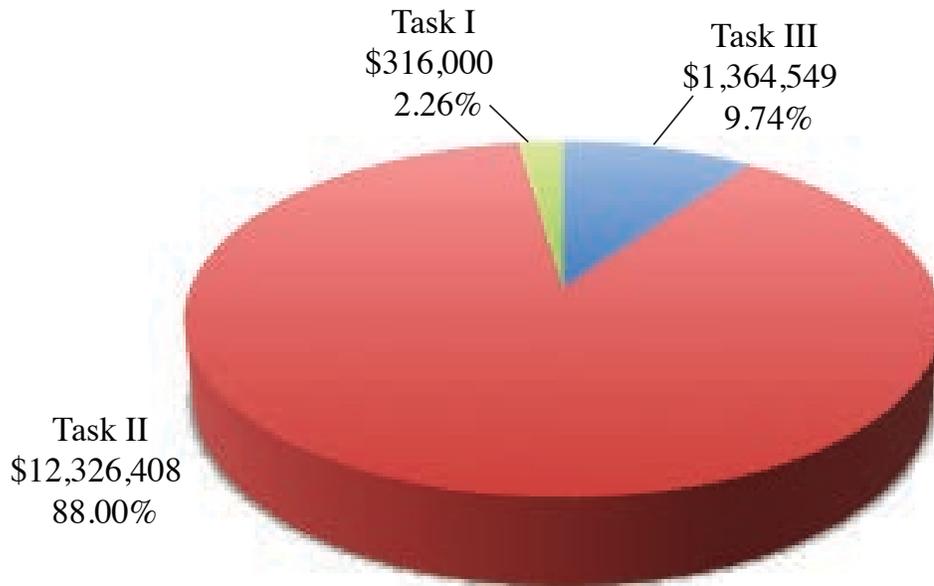
JIMAR Council of Fellows from the University of Hawaii are Dr. Gary Barnes, Dr. Steven Businger, Dr. Jeffrey Drazen, Dr. Eric Firing, Dr. Erik Franklin, Dr. Kim Holland, Dr. Roger Lukas, Dr. Douglas Luther, Dr. Margaret McManus, Dr. Anna Neuheimer, Dr. James Potemra, Dr. Brian Powell, Dr. Robert Toonen, and Dr. Bin Wang.

Task I is the base program of JIMAR. It provides research support for the visiting scientist and postdoctoral programs, and administrative support for the Institute. The University of Hawaii contributes to this task by bearing all indirect costs and paying part of the salary of the Director. Funding percentages by activity are exhibited in the following chart.

Distribution of JIMAR's Task I NOAA Funding by Activity

Student Support
1%

Education/Outreach/
Other Research Support
1%

Post-Doc/
Visiting Scientists
16%

Administration
82%
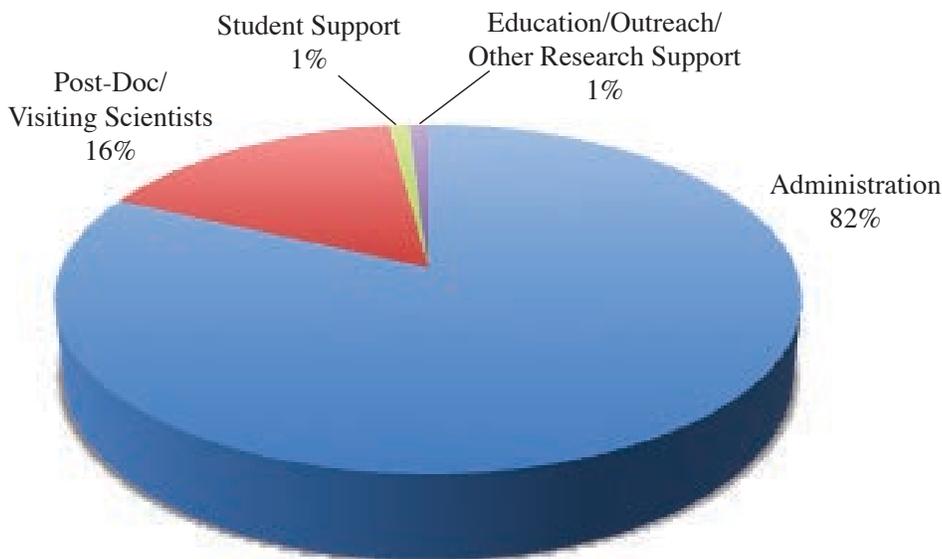
Distribution of NOAA Funding by Task (FY 2016-2017)

Task I
$316,000
2.26%

Task III
$1,364,549
9.74%

Task II
$12,326,408
88.00%

Distribution of NOAA Funding by Theme (FY 2016-2017)

Equatorial
Oceanography
$971,003
6.93%

Administrative/
Visiting Scientist
Program
$316,000
2.26%

Tropical Meteorology
$127,000
0.90%

Tsunamis and Other
Long-Period Waves
$0
0.00%

Ecosystem
Forecasting
$165,000
1.18%

Protection and
Restoration of
Resource
$2,979,337
21.27%

Climate Research
and Impacts
$1,246,707
8.91%

Ecosystem
Monitoring
$7,223,410
51.57%

Ecosystem-Based
Management
$978,500
6.98%

Accomplishments for Fiscal Year 2017

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

Budget Amount: $165,000

NOAA Goal(s):

- Resilient Coastal Communities and Economies
- NOAA Enterprise-wide Capabilities: Science and Technology Enterprise; Engagement Enterprise; Organization and Administration Enterprise

Purpose of the Project

The general purpose of the ADMB Open Source Project is to maintain and improve the ADModel 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 2017

During FY 2017, there were numerous improvements on the ADMB software. Since the release of ADMB-11.5, there have been more than 1200 changes to the main source code repository. Most of the changes included: defect fixes; added function documentation; source code readability improvements and unit testing. ADMB-11.6 was released on December 2016 and included approximately 689 changes since the previous ADMB-11.5. One major feature contributed by the TMB Project included with the release is tiny_ad, which uses C++ templates for AD computations. The feature is an alternative approach to reverse mode differentiation in ADMB. The upcoming release ADMB-11.7 will include another contribution from Cole Monnahan, who is completing his PhD at the School of Aquatic and Fisheries Sciences, University of Washington. He ported and developed the No U-Turn Sampler (NUTS) algorithm for ADMB with assistance from project members. This new feature speeds up the computation time for Markov Chain Monte Carlo (MCMC) models.

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: Phase II

P.I.: Mark A Merrifield, Eric Heinen De Carlo

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

NOAA Sponsor: Christopher Sabine

Budget Amount: $35,717

NOAA Goal(s):

- Climate Adaptation and Mitigation
- NOAA Enterprise-wide Capabilities: Science and Technology Enterprise; Engagement Enterprise; Organization and Administration Enterprise

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.

Figure 1. The CRIMP-2 MAPCO$_2$ buoy has been making automated measurements of inorganic carbon system parameters on the barrier reef of Kaneohe Bay, Oahu, Hawaii since June 2008. Kualoa Point, a spur of the Koolau Range can be seen in the background.

Progress during FY 2017

The project continued activities to support broad agency-based efforts to develop technologies to monitor coastal processes with emphasis on the inorganic carbon system (CO_2-carbonic acid system) and provide support to national and global OA observing efforts. Project researchers collected (and analyzed) bottle samples for the determination of dissolved inorganic carbon (DIC) and total alkalinity (TA) at two-week intervals (weather and sea conditions permitting) at four NOAA sponsored MAP-CO$_2$ buoys deployed on coral reefs of the island of Oahu, Hawaii. In addition

Figure 2. Deployment of Porites spp *coral nubbins at the Kilo Nalu buoy in support of a study to evaluate pH of seawater from boron isotopes incorporated in coral skeletons during their growth.*

they collected bottle samples for the same parameters during deployments of new instrumental technology by other NOAA colleagues as well as during short-term high intensity sampling experiments sponsored by other academic colleagues designed to derive a better understanding of the processes driving coral reef metabolism near fixed MAP-CO$_2$ buoy sites. The project continued to participate in the NSF and OAP sponsored interlaboratory comparison project (for inorganic carbon system parameters) conducted by Dr. Andrew Dickson, Scripps Institution of Oceanography.

Ecosystem Structure and Function

P.I.: Mark A Merrifield [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

Budget Amount: $148,400

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The goal of this JIMAR project research is to advance understanding of the structure and function of two important marine ecosystems, the subtropical pelagic ecosystem and the insular boundary ecosystem. The pelagic ecosystem work focuses on processing and analyzing a time series of lancetfish stomach contents collected by observers in the Hawaii 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 in the central North Pacific. The work on the insular boundary ecosystem uses active acoustic surveys to map the distribution of micronekton in this ecosystem with ship-based surveys and net tows around the Hawaiian Archipelago.

Figure 1. *Stomach content from a lancetfish including plastic debris. (photo: Jennifer Wong-Ala)*

Progress during FY 2017

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 JIMAR student hire documented the contents of over 350 lancetfish stomachs, identifying prey items to the species level, documenting unknown species, and working with experts in the field to identify cephalopod and fish species by providing valuable samples. All diet data was entered into a dedicated database and used for further analysis of spatial and temporal patterns. Examining the trophic ecology of these deeper-dwelling, midtrophic predators will greatly augment the understanding of variability in the structure of mesopelagic micronekton communities.

The project invited collaborator Elan Portner, Stanford University, to process the lancetfish stomach samples. He also provided valuable training to the student hire to ensure samples are analyzed consistently with established methodology.

An island-associated food web supporting apex species (including insular cetaceans) has been described off West Hawai'i. A unique assemblage of micronekton species, termed the mesopelagic boundary layer (MBL), supports this food web. This phenomenon is associated with the island slope and is distinct from the species found offshore. In collaboration with the West Hawai'i Integrated Ecosystem Assessment project, JIMAR staff participated in a research cruise onboard the NOAA *R/V Oscar Elton Sette* off the west coast of Hawai'i Island to study this insular boundary ecosystem. Active acoustic data were collected and processed to determine micronekton abundance patterns off the coast of West Hawai'i.

Ecosystems Observations and Research Program: Research Support Project

P.I.: Mark A Merrifield [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

Budget Amount: $572,073

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. These 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; Aquaculture System Support; Bottomfish Population Assessments; Outreach and Education; Benthic Habitat Mapping; Deepwater Surveys in the Line Islands; and GIS Mapping Tools Development for the Mariana Islands Area. These subprojects are reported here.
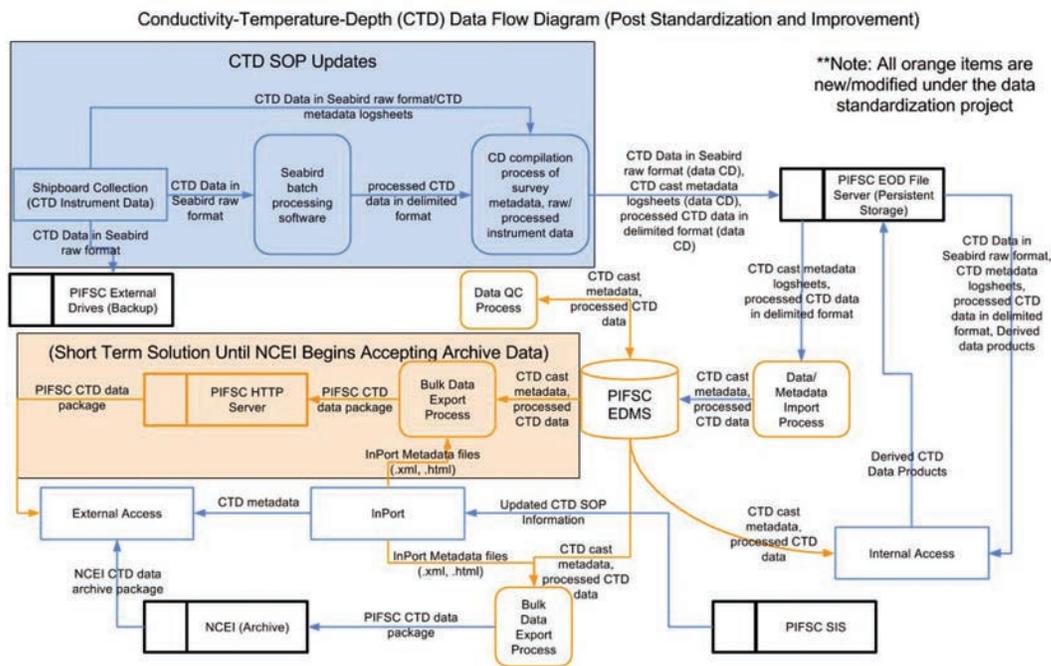

Figure 1. Data flow diagram for the proposed data system in the CTD data standardization project.
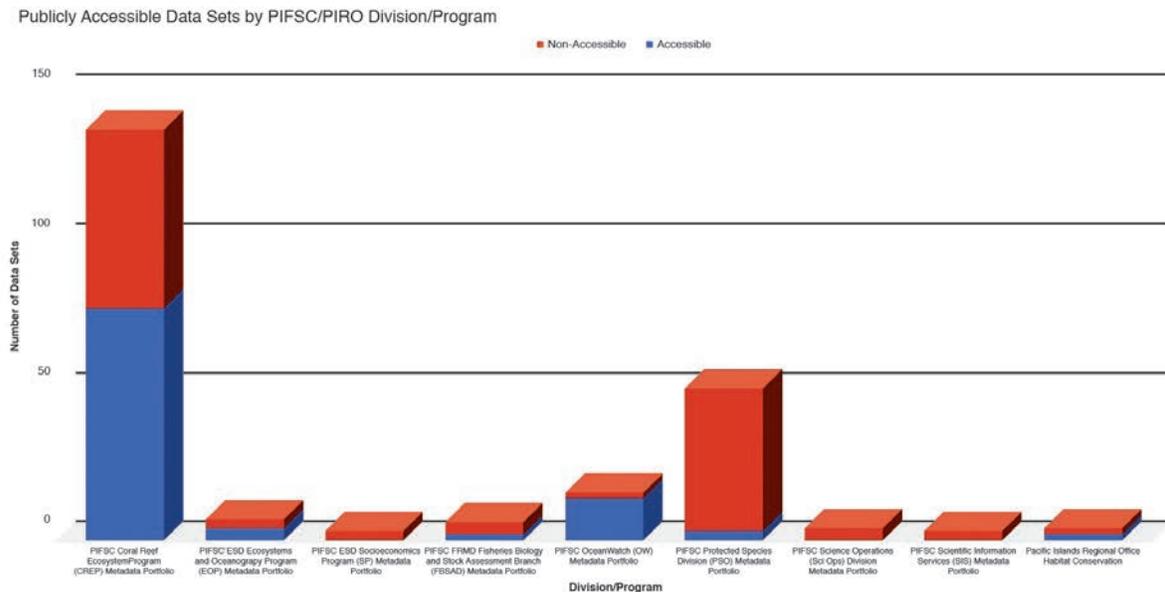
Figure 2. Summary report showing publicly accessible scientific data sets for each of PIFSC's and PIRO's divisions and programs.

Enhanced Environmental Data Management to Support Fisheries and Ecosystem Research. This project 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, data application development, and Geographic Information System (GIS) support to scientists and resource managers at the Pacific Islands Fisheries Science Center (PIFSC) to facilitate quality scientific research and resource management.

Coordinated Main Hawaiian Islands Bottomfish Population Assessments. Bottomfish research and stock assessment in the Hawaiian Islands and U.S. Territorial waters is one of the cornerstones of the insular fisheries research effort conducted at PIFSC. JIMAR plays key roles in these research areas, with several existing and proposed JIMAR projects to PIFSC focused on bottomfish research (see JIMAR annual reports on Main Hawaiian Islands Commercial Fisheries Fast Track Data Project, Territorial Biosampling, Ecosystems Observations and Research Program: Science Operations Project and the Stock Assessment Research Program). In addition, PIFSC scientists are active in bottomfish research areas, including technical and analytical efforts in the Stock Assessment, Life History, Ecosystems and Oceanography, and Coral Reef Ecosystems Programs.

Aquaculture Systems Management. The Aquaculture Systems Management project provides systems 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 partnership between JIMAR and PIFSC. JIMAR staff serves as resource, advisor, and point of contact for outreach and education activities for JIMAR, PIFSC, and PIRO outreach and communications staff, across all divisions and programs. This project directly supports the JIMAR aim of sustainable balances between the forces of coastal development and the goals of conservation/preservation through scientific and public outreach and education.

Progress during FY 2017

Enhanced Environmental Data Management to Support Fisheries and Ecosystem Research. Led by Jesse Abdul, the project fulfilled the following: assessed PIFSC data streams; data management workflows; infrastructure; and internal capacity to identify common needs and ability to accomplish the development of the necessary data solutions. Project goals, plus results, are identified in the following paragraphs.

Assess PIFSC data streams, data management workflows, infrastructure, and internal capacity to identify common needs and ability to accomplish the development of the necessary data solutions. The project developed, administered, and analyzed surveys at the program-level and data set-level to assess the state of data management in each research group. JIMAR developed documents to propose centralized data products to address common data needs across PIFSC, and compiled and analyzed the results of a skills survey to assess the data skills and training needs in PIFSC. In addition, the project provided technical guidance to the Ecosystem Sciences Division's (ESD) Human Capital Project to assist in creating a skills database for staff to facilitate assessments of the internal capacity within each ESD program.

Facilitate development of centralized data tools to satisfy common data needs and help with overall data management improvement planning and execution. The project developed a generalized Data Validation Module (DVM) to perform formalized and documented data quality control (QC) validation on Oracle relational databases to identify problematic data. JIMAR drafted a Data Management Improvement Plan (DMIP) for the Ecosystems and Oceanography Program (EOP) as an example for other PIFSC divisions and programs. JIMAR also developed generalized Structured Query Language (SQL) scripts to address various common data management needs, including verifying data, generating informational reports, generating Oracle data objects according to best practices, and performing various common database operations. These scripts are available to scientists throughout PIFSC.

Figure 3. The project website for the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) includes an interactive graphic to explore research, detailed species descriptions and illustrations, field blogs, Story Map with project updates and photographs, a "Kid's Corner," and social media. JIMAR staff played a key role in assembling the website.

Develop Standard Operating Procedures (SOPs) and distribute to document methods for accomplishing common data management and development activities within the data life cycle that integrate best practices. JIMAR developed an SOP for defining and evaluating formalized data QC criteria utilizing the DVM after feedback from the South Pacific Tuna Treaty (SPTT) project's implementation experience. In addition, the project compiled documents for proposed best practices in the areas of common data management, database development, and application development activities.

Develop procedures and data tools to facilitate the documentation and dissemination of scientific data to satisfy public access to research results (PARR) requirements. The project contributed technical content for the PIFSC PARR Implementation Plan to define specifications and collaborated with the PARR Coordination Team to develop and document bulk data download and publication procedures to comply with PARR data accessibility and archival requirements. In addition, JIMAR developed modules to create bulk download package templates, generate National Centers for Environmental Information (NCEI)-compliant bagit data packages, and upload the data packages to a web server to facilitate compliance with PARR data accessibility and archival requirements as well as reduce the manual effort required by data staff. JIMAR developed a module to verify that a given data set's download uniform resource locator (URL) defined in InPort is publicly accessible and archived for PARR compliance purposes, and developed summary PARR compliance reports to track progress throughout the duration of the PIFSC PARR Implementation Plan.

Facilitate communication and collaboration between PIFSC divisions with common data issues/needs and provide support on collaborative efforts. JIMAR led the Conductivity Temperature and Depth (CTD) data standardization project for collection, processing, and management of those data in a centralized database to increase the accessibility in coordination with scientific and technical staff in the Fisheries Research and
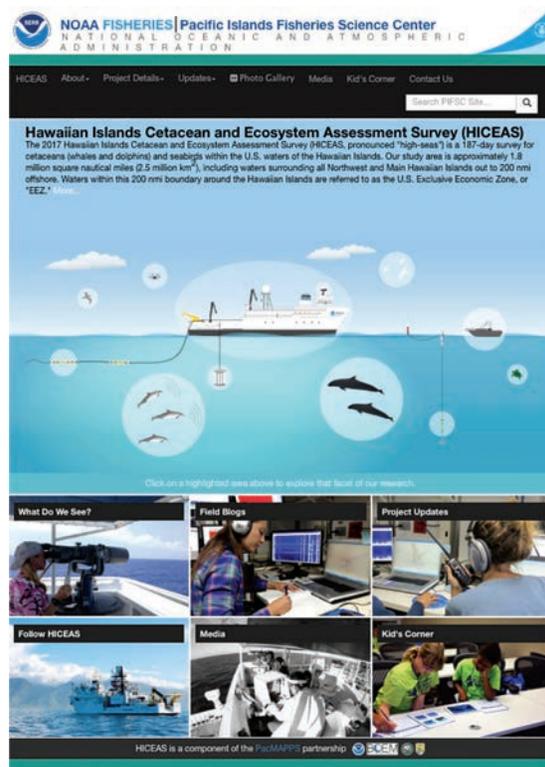
Figure 4. As part of "The Amazing World of Marine Plankton" module in the 2016 NOAA Fisheries Science Camp, students identify zooplankton under microscopes using a simple dichotomous key.

Monitoring Division (FRMD), ESD, and Science Operations Division (SOD). JIMAR drafted an implementation plan, compiled technical specifications, and collected information to assess CTD data processes.

Facilitate development of data tools, policies, and procedures for SPTT data and the migration of historical SPTT data from the Southwest Fisheries Science Center (SWFSC) to PIFSC. The project developed and documented existing, planned, and unfinished tools and procedures for the SPTT project to facilitate continued progress of data projects including the historical data migration. Project staff provided support and guidance to SPTT data staff on ongoing development and data management efforts, and provided support and guidance to SPTT data staff on implementation of the DVM to formalize and standardize the data QC evaluation process as an initial test case before the module is released for general use.

Facilitate the development of methods and tools to increase the accessibility of scientific data. In collaboration with the PARR Coordination Team, the project facilitated the documentation of PIFSC data sets and making them accessible. Researchers can search the NMFS metadata catalog for the data sets and download any data set through the corresponding download URL.

Increase internal GIS, database development, data management, and application development skills and capacity within PIFSC. The JIMAR project compiled, administered, and analyzed the results of a survey to assess the data skills and training needs in the PIFSC divisions, compiled documentation for the online Cybersecurity and Assessment Team (CSAT) Application Express (APEX) training in May 2017, and collaborated with ESD on the Human Capital Project to facilitate informed decisions for fulfilling development and data training needs.

Facilitate integration of data sets to increase usability of the data sets and to facilitate ecosystem approaches by researchers and resource managers. The project is leading the CTD data standardization project to increase the accessibility and usability of the CTD data, and will facilitate scientific staff explorations for CTD data suitable for their division/program data sets.

Other project activities accomplished during the reporting period include the following.

- The JIMAR Data Applications Developer attended the annual NOAA Environmental Data Management (EDM) workshop to gain a better understanding of Environmental Research Division's Data Access Program (ERDDAP), data formats, environmental data archives, and EDM in general.
- The JIMAR Data Applications Developer attended online CSAT APEX training to learn how to develop applications with a higher level of security.

- The JIMAR Data Applications Developer attended online training for the Socrata data dissemination platform to determine its suitability to satisfy PARR requirements for PIFSC.

Coordinated Main Hawaiian Islands Bottomfish Population Assessments. During FY 2017 JIMAR facilitated participation of staff from each division of PIFSC in several research expeditions on board the NOAA *R/V Oscar Elton Sette*, including the West Hawai'i IEA Fall (September 2016), Insular Bottomfish Survey Fall (October 2016), Insular Bottomfish Survey Spring (March 2017), and West Hawai'i IEA Spring (April 2016) cruises. Support is also tendered for bottomfish investigations from this project for other collaborating JIMAR projects: the Cetaceans Research Program; Socioeconomics of Pacific Fisheries project; Ecosystem Structure and Function project; West Hawai'i Integrated Ecosystem Assessment project; Stock Assessment Program; Fishing Impacts on Non-target Species project, and JIMAR Sustaining Healthy Coastal Ecosystems project.

Aquaculture System Management. During the reporting period, JIMAR staff (led by Aaron Moriwake) implemented a weekly exercise program and a year-round maintenance schedule to ensure system readiness for incoming animals in the four distinct units: monk seal; turtle; fish; and multi-purpose. Other project accomplishments during the reporting period included: 1) training monk seal and SWS staff on system operations; 2) coordinating daily maintenance activities with SWS staff; 3) conducting troubleshooting maintenance issues (e.g., replacing uninterruptable power supplies and burnt fuse in control panels, switching out expired ultraviolet bulbs, installing a new freshwater spray timer setup on a fractionator, reattaching acrylic cylinder on fractionator cones, etc.); 4) conducting monthly safety assessment for the SWS facility; 5) sewing and installing shade covers for two monk seal tanks and a holding area; 6) building counters for four sinks; 7) modifying drain grid covers in all four monk seal tanks making it easier to collect uneaten food (fish) parts; 8) maintaining records on equipment (repairs, maintenance, and replacement); 9) estimating cost of equipment/supply needs to run a possible Kona crab project at the SWS facility and/or IRC aquarium room; and 10) updating protocols and system operations on the PIFSC Wiki site.

JIMAR staff also provided support for two monk seals, six turtles, and six underwater video camera calibrations. When animals were housed at the SWS facility, JIMAR staff provided 24/7 emergency support through email/text alarm alerts, remote access control of cameras, and the Supervisory Control and Data Acquisition (SCADA) system.

Pacific Islands Region Fisheries Science Outreach and Education. Led by Amanda Dillon, the project produced scientific outreach and education products, programs, and services including community events, Science Camp, PIFSC Young Scientist Opportunity, and printed and online products. Activities and outreach products are described below.

Print and digital products. Project staff produced many outreach and educational printed materials and displays during the reporting period. These were used by both PIRO and PIFSC programs for dissemination to the public and other constituents and stakeholders. Outreach materials include the following.

- Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) 2017 project description poster (December 2016)
- Marine Debris Event announcements poster (April 2017)
- Campaign to Address Pacific Monument Science, Technology, and Ocean Needs (CAPSTONE) project overview poster (May 2017)
- Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) 2017 project description flyer (January 2017)
- Federal Executive Board Women's History Month Seminar flyer (March 2017)
- Marine Debris event flyer (April 2017)
- Autonomous Reef Monitoring Structures and Calcification Accretion Units informational overview flyer (April 2017)
- "Go Barbless" cards for 2017 Fish & Dive Expo (October 2016)
- "Fall in Love with Science" nametag activity (February 2017)
- HICEAS magnets (June 2017)
- "Sounds of the Deep" marine mammal acoustics interactive webpage (November 2016)
- Design element for NOAA CoastWatch and OceanWatch (http://coastwatch.noaa.gov)
- HICEAS project website (June 2017)

Ecosystems Observations and Research Program: Science Operations Project

P.I.: Mark A Merrifield [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

Budget Amount: $965,100

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 services 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 included: 1) Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region; 2) Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects; 3) Advanced Survey and Sampling Technology Development; 4) Geospatial Products; and 5) Marine National Monuments of the Pacific.

   Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. In the Pacific Islands Region, commercial fish stocks are 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 gears 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. As camera survey technologies continue to develop, there will be a continuing need for evaluation of new technology and standardization of fisheries data products across survey platforms from photo and/or video analysis.

   Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. As scientific field campaigns become more complex with multi-faceted, multi-platform, multi-disciplinary, and technologically advanced endeavors, the responsibilities of scientists within PIFSC have grown such that dedicated trained JIMAR staff is necessary to support the 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 to 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 in 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, maximizing utilization of technology assets, providing opportunities for cost sharing, cross training a wider range of expertise, and allowing 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. Creation and compilation of geospatial data is critical for the planning of research programs and publication of results. Unfortunately, access to the data and associated tools is not universally available. While some PIFSC programs have well-developed GIS capabilities and databases, others have staff

with less-developed skills and resources yet must still meet all requests related to accessing, processing and displaying spatial data. As a centralized resource, the JIMAR Geospatial Products Team (GPT) seeks to provide access to high-quality data, tools and resources that would otherwise not 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 to 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 collaboration, the project is working on a variety of ways to make data and products readily available. The Monuments Photo Library Project aims to engage and inspire by providing easy access to its repository of photos to researchers and the general public. This project collaborates with different programs within 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 2017

Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. During FY 2017 JIMAR staff led by Insular Fisheries Research Specialist William Misa (Analysis and Evaluation Team) supported the operation of the Modular Optical Underwater Survey System (MOUSS), which is 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 on the Main Hawaiian Islands Spring Bottomfish Fishery-Independent Survey aboard the NOAA *R/V Oscar Elton Sette* (SE-17-02) from March 8-22, 2017. Following the operation, a total of 117 MOUSS camera deployments were annotated by the JIMAR team, with data products subsequently delivered to the PIFSC Stock Assessment Program (SAP).

The successful operation of the MOUSS resulted in archiving the previous BotCam survey system. To ensure continuity of data streams and acceptable data quality, a gear comparison Technical Memo is being drafted to analyze image quality, light sensitivity, measurement accuracy, and fish count for MOUSS vs. BotCam survey systems. Preliminary results indicate BotCam generates an inferior image quality while MOUSS has lower light sensitivity (Fig. 1). MOUSS strengths include better object clarity and, thus, better measurement precision (Fig. 2) and more specific taxonomic identifications for some fish observations. Overall, fish species richness and relative abundance were consistent between camera systems, allowing for continuity of data
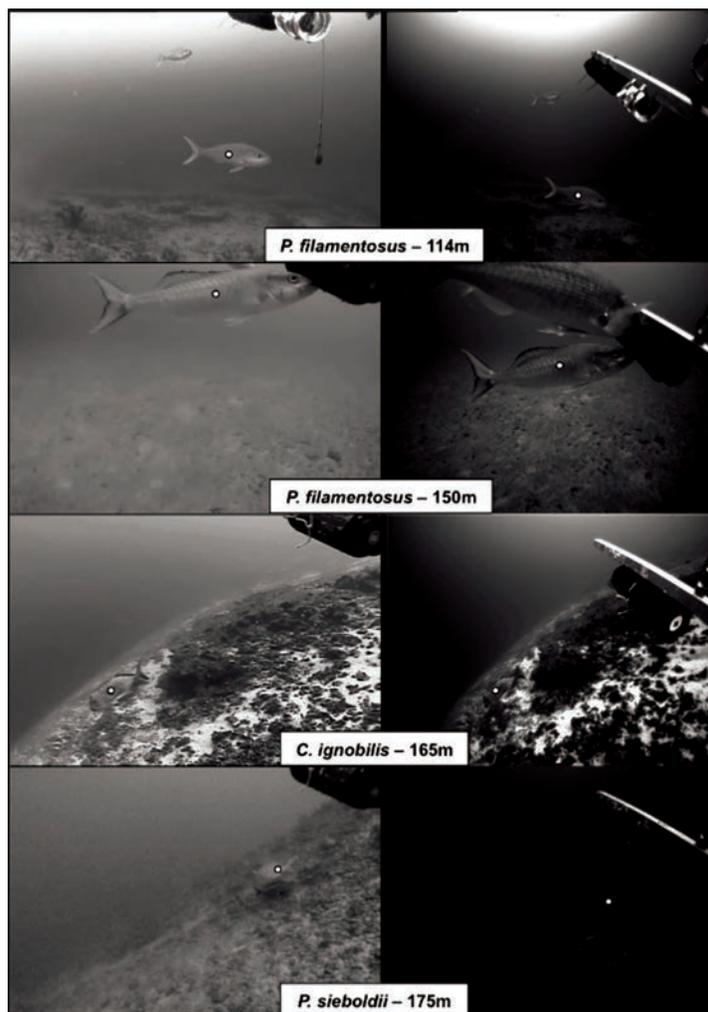

Figure 1. Image comparisons of four (4) fish individuals recorded in BotCam (left) and MOUSS (right) at different sampling depths.
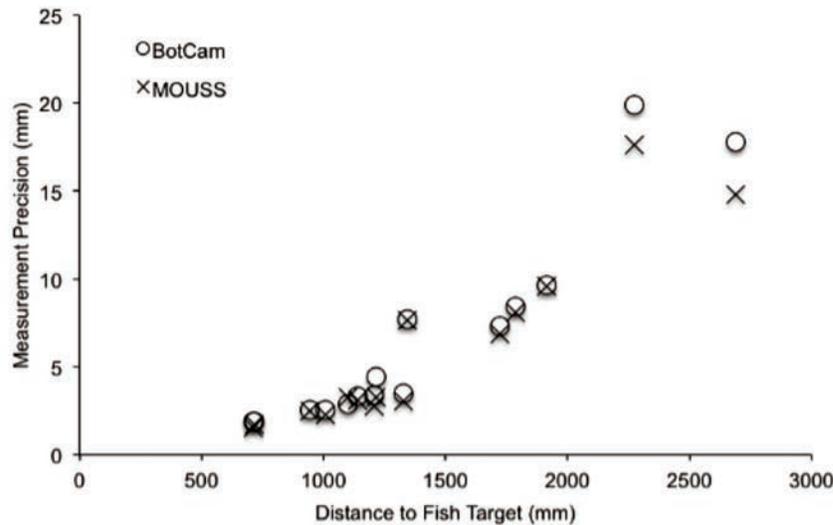
Figure 2. MOUSS and BotCam measurement precision values relative to the distance of the same fish targets (n=15).

streams. It was suggested that adjustments to camera exposure settings and post-collection image enhancement might be useful to alleviate light limitations of MOUSS at greater depths.

Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. Led by Science Operations Coordinator Russell Reardon, the project team supported many PIFSC missions and projects by providing logistical, operational, and small boat support. On cruises SE-17-02, SE-17-03, and SE-17-04, the JIMAR Field Operations Team made significant contributions to the successful completion of mission objectives. During these missions JIMAR staff provided leadership, expertise, and support for MOUSS ship-based deployments in the Main Hawaiian Islands focusing on the Bottom Fish Restricted Areas (BFRAs), trawl operations (Cobb, 10' Isaacs-Kidd, 2m ring Bongo) for the Leeward Oahu Pelagic Ecosystem Characterization (LOPEC) project, and Simrad EK-60 echo sounder and Over-the-Side-Pole (OTSP) support for West Hawaii Integrated Ecosystem Assessment (IEA) project.

JIMAR staff also provided support for small boat Vessel Operation Coordination (VOC) to ensure that small boat assets either met or exceeded NOAA Small Boat Program safety standards in order to minimize safety risks and the loss of project operational days due to mechanical breakdowns. JIMAR staff was critical during the unforeseen repairs to one of PISFC 19' SAFE Boat platforms. A Category 1 deficiency (cracked hull) would have crippled all PIFSC small boat research activities but JIMAR staff worked with NOAA Port Office and Small Boat Program Engineers to come up with solutions to resolve issues and repair the boat in time for the next mission.

Advanced Survey and Sampling Technology Development. Led by Advanced Survey and Technology Developer Jeremy Taylor, the JIMAR staff supported the SOD Survey and Sampling Technologies Project (SSTP) in a variety of field and laboratory capabilities. The team's overarching goals are to support the work of PIFSC researchers and activities that required development, evaluation, maintenance, and deployment of in-situ instrumentation and monitoring systems in the Pacific Islands Region. JIMAR staff served as technical leads for science operations and collaborated with participating researchers to fulfill their projects' technical requirements. This year SSTP's main focus is still the technical development and refinement of the MOUSS. The MOUSS Pi project is an on-going user-friendly approach for indicating that the MOUSS cameras are synchronized and working properly in the field. A Python script was written for Raspberry Pi computers and installed in custom fabricated housings. To verify that the MOUSS cameras and computers are powered on, the computers capture still images and the images are synced between cameras. This approach has significant potential to improve MOUSS deployment success rates, as it will mitigate lost drops due to camera and computer malfunctions.

During the reporting period, federal and JIMAR staff in SOD developed and evaluated the use of multiple off-the-shelf 360-degree cameras as a novel method to capture essential data in fisheries surveys and validate results using the MOUSS. The resulting SSTP evaluation and report will serve as a guide for other NOAA Fisheries Science Centers by highlighting the most appropriate camera model or suite of features necessary for a given survey application.
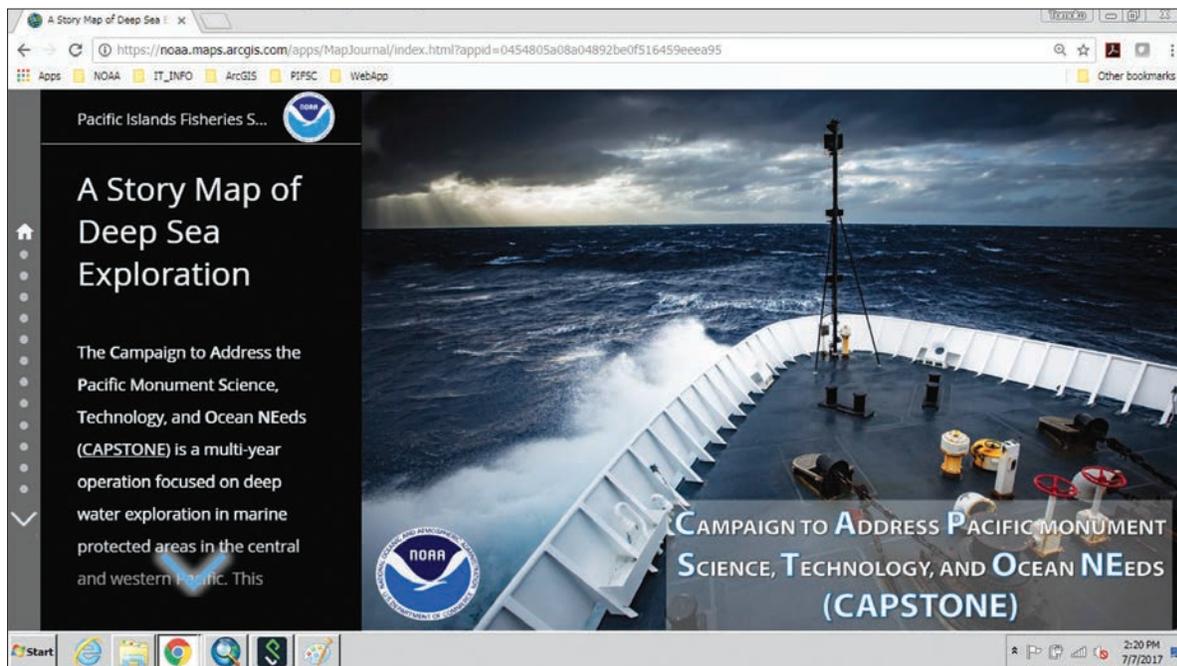
Figure 3. Screenshot of CAPSTONE Story Map.

In addition to technical support, the SSTP also supported the design and fabrication of instrumentation deployment and survey equipment. In support of the West Hawaii IEA and its research efforts focused on studying the ecological importance of surface slicks, the SSTP aided in the design, fabrication, and development of a surface plankton net that could be operated by small boat platforms. This surface plankton net was further developed from a prototype tested on the previous year's mission.

Geospatial Products. During FY 2017 the JIMAR Geospatial Products Team (GPT) staff, led by GIS Data and Web Specialist Bryan Dieter, successfully expanded the Pacific Marine National Monuments Web-Based GIS Mapping Pilot Project effort by publishing Pacific-wide data sets from the Coral Reef Ecosystem Program in ArcGIS Online. Each published ArcGIS Online service is linked to data archived in the NOAA National Centers for Environmental Information (NCEI), and documented in the web-based metadata catalog InPort. An automated workflow was established to update the services with future updates to the data, without disconnecting the services during the updates.

The Deep Sea Coral Research and Technology Program Pacific Islands Fieldwork Campaign from 2015 to 2017 aboard NOAA Ship *Okeanos Explorer* is exploring the largely unknown deep-sea ecosystems in the Central and Western Pacific Ocean. As part of this effort, the GPT was responsible for providing the summary and results of the FY 2017 *Okeanos Explorer* fieldwork. This work is in coordination with the JIMAR Pacific Islands Deep Sea Coral and Sponge Initiative project. Jazmine Panelo, one of the PIFSC Young Scientist Opportunity interns, developed an ArcGIS online Story Map for the Campaign to Address the Pacific Monument Science, Technology, and Ocean Needs (CAPSTONE) and deep-water exploration project. Her work was published through the PIFSC ArcGIS server (Fig. 3).

Marine National Monuments of the Pacific. The GPT staff also developed a consistent and standardized database of select PIFSC geospatial data (Fig. 4). This geodatabase was generated to organize the PIFSC geospatial data used in the web mapping applications as well as other data sets for visualization. The data are organized by data types and themes. Currently, data exists in multiple schemas in an Oracle geodatabase. The next step will be migration of this geodatabase to the Oracle geodatabase so that the scattered data in Oracle can be consolidated. Additionally, multiple sources of bathymetry were compiled in geodatabases to generate the synthesized bathymetry for the Marianas Region.

Development of the Monuments Photo Library was initiated on the PIFSC webserver (https://www.pifsc.noaa.gov/gallery/monuments/). The Monuments Photo Library has over 1,400 photos considered the 'best of' pictures collected within the Pacific Marine National Monuments. Staff working on the JIMAR Photo Library Project
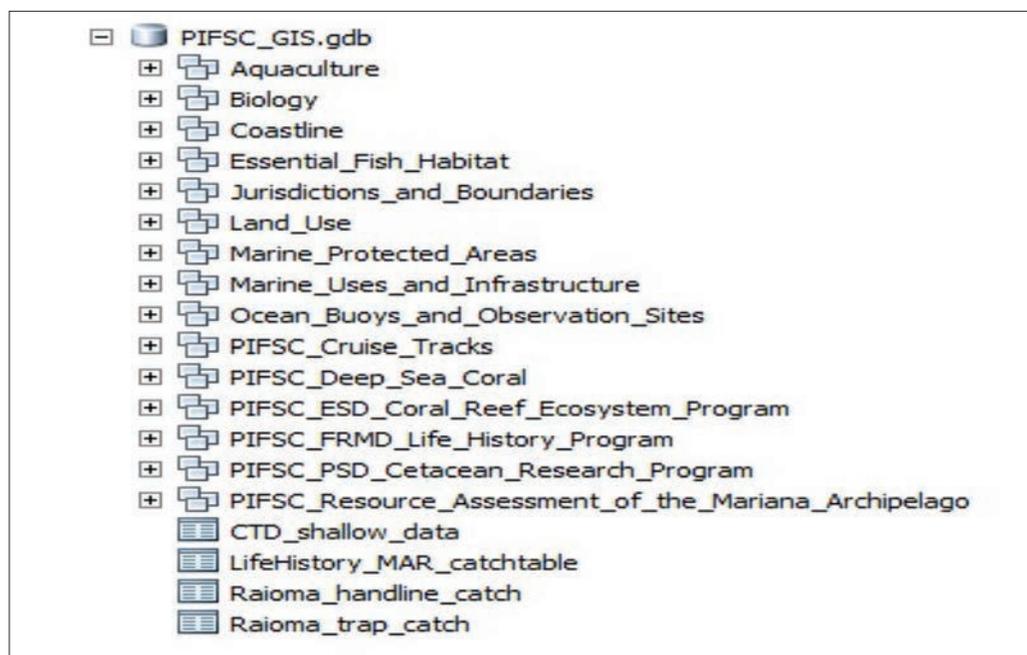
Figure 4. Standardized database.
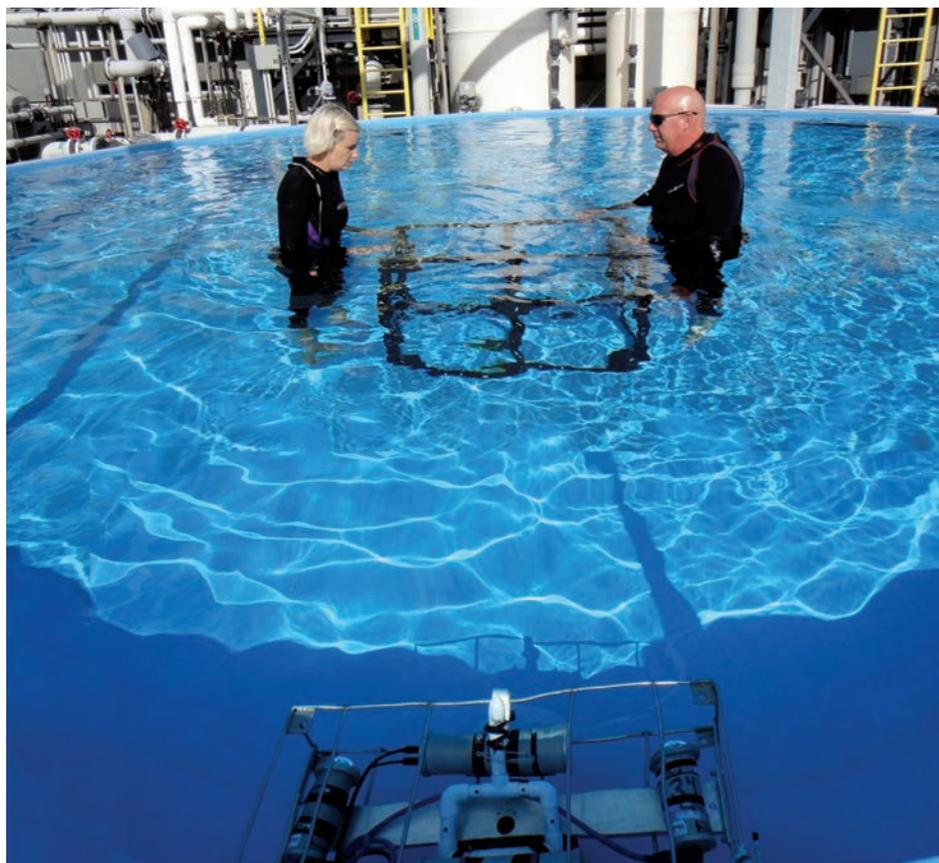
Figure 5. Dianna Miller and Christopher Demarke conduct MOUSS calibrations in the Inouye Regional Center seawater facility.
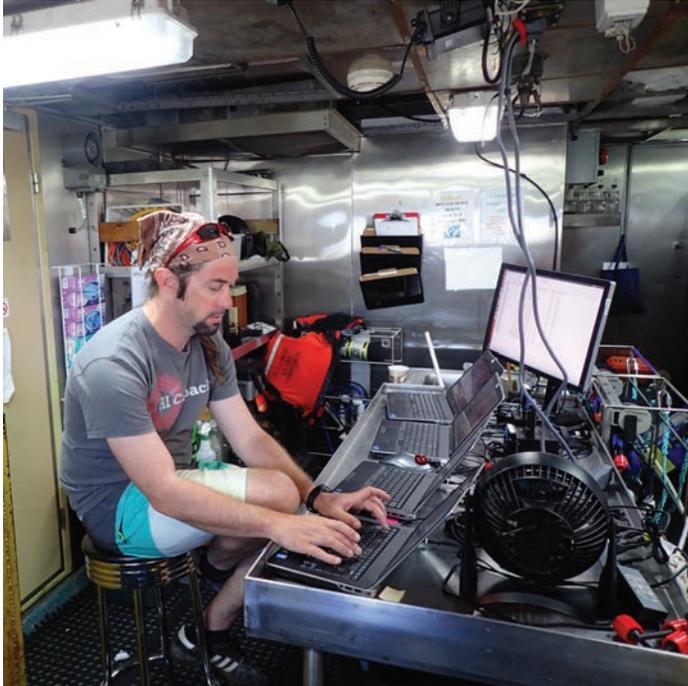
(left) Figure 6. Jeremy Taylor conducting daily downloads of MOUSS units on SE-17-02.

(below left) Figure 7. Deployment of a Drop Camera Instrument Package (DCIP) including MOUSS on Main Hawaiian Islands Spring Bottomfish Fishery-Independent Survey aboard NOAA Ship Oscar Elton Sette.

(below right) Figure 8. Russell Reardon conducting annual small boat weight test and inspections in preparation for ship-based operations.

cataloged all photos and corresponding metadata into a spreadsheet and are currently working on writing a short, descriptive caption for each photo. The spreadsheet catalog includes descriptive details about the image to ensure sufficient search results once the photo library interface is developed.

The Photo Library Project staff are also working with a PIFSC-contracted software development engineer to design a photo library interface to provide direct access to these photos by research staff and the general public. The Photo Library Associate is assisting in the design and testing phase of the photo library interface to ensure that all the data captured in the spreadsheet catalog are included in an easily accessible way into the photo library interface.

Main Hawaiian Islands Commercial Fisheries Fast Track Data Project

P.I.: Mark A Merrifield [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, Kimberly Lowe

Budget Amount: $250,000

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 Hawai'i'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 Hawai'i 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
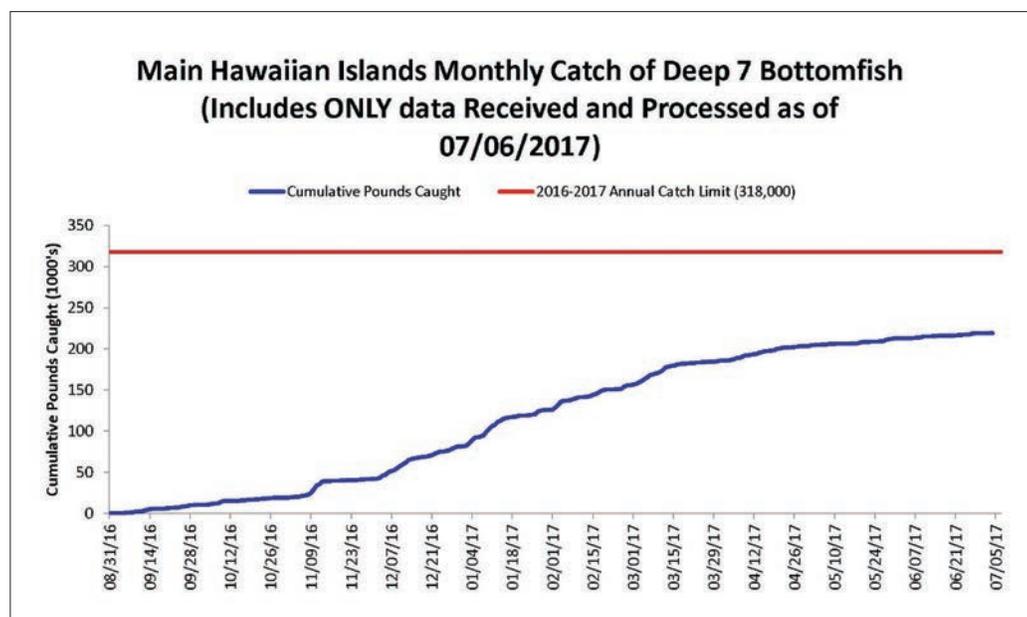

Figure 1. Accumulated pounds for the MHI deep-7 bottomfish fishery. During the current 2016-20167 MHI "Deep 7" bottomfish fishing year, 219,237 lbs or 68.9% of the ACL of 318,000 lbs was caught.
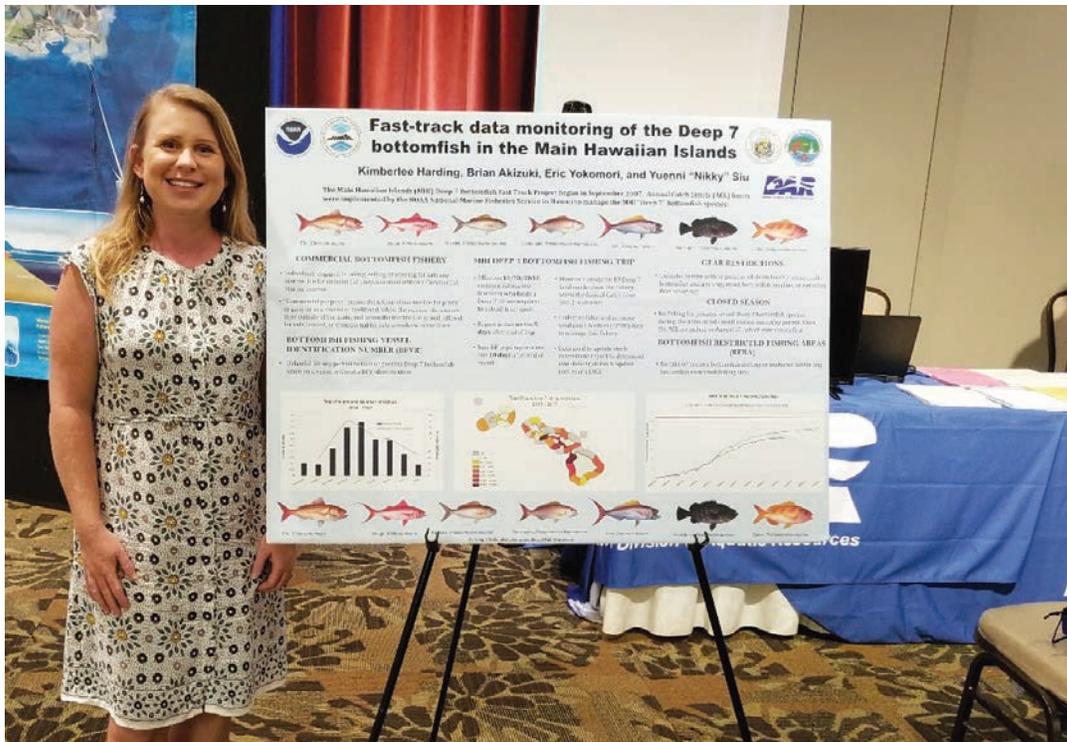
Figure 2. Kimberlee Harding at the Western Pacific Regional Fishery Management Council, Fishers Forum: From Boat to Web: Understanding Catch Reporting and Fishery Monitoring, June 21, 2017.

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 hapu'upu'u (*Hyporthodus quernus*).

The Hawai'i Revised Statutes require commercial fishers to submit their monthly fishing reports within ten days following the month in which the marine life was taken. The Department of Land and Natural Resources (DLNR) Hawai'i 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 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 2017

JIMAR staff successfully processed and fast-tracked Main Hawaiian Islands commercial catch and dealer data, including the deep-7 bottomfish fishery that is managed by a federal ACL, with the 2016-2017 fishing year at 318,000 pounds with a 42% risk of overfishing for the following species: onaga (*Etelis coruscans*), ehu (*Etelis carbunculus*), opakapaka (*Pristipomoides filament-osus*), kalekale (*Pristipomoides sie-boldii*), gindai (*Pristipomoides zonatus*), lehi (*Aphareus rutilans*), and hapu'upu'u (*Hyporthodus quernus*).

The HDAR Fishing Report System (FRS) database and its applications are being converted from the obsolete Visual FoxPro (VFP) to MySQL database. This will be an ongoing process for several years. The HDAR also began development of a new Online Commercial Marine Dealer Reporting System (ODRS) website. This website will allow Commercial Marine Dealers to report their commercial marine purchase reports online instead of submitting paper reports or emailing reports. JIMAR staff is providing support for the design and development of the ODRS website.

Ocean Remote Sensing

P.I.: Mark A. Merrifield [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

Budget Amount: $120,500

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

This project provides satellite remotely-sensed oceanographic data expertise to the NOAA OceanWatch–Central Pacific node (OWCP), including a website and database to supply near-real time, remotely sensed oceanographic and environmental data for the entire Pacific-based communities, including resource managers, researchers, educators, and the general public. The satellite-derived products include ocean surface temperature, ocean color, ocean surface topography, ocean surface wind fields, environmental indicators, and high-resolution (1.1 km) thermal infrared High Resolution Picture Transmission (HRPT) imagery from the NOAA Advanced Very High Resolution Radiometer (AVHRR) satellites. The HRPT data is collected daily by the AVHRR receiving station located in Ewa Beach, Oahu.

Progress during FY 2017

In addition to maintaining all databases and servers and servicing data to OWCP users, this project continued its collaboration with the NOAA Climate Service, Pacific Islands Region, and the NOAA Pacific Climate Information System (PacIS), in order to provide customized remote sensing data and quarterly analyses, as well as with the Pacific Islands Ocean Observing System (PacIOOS). The OWCP data is regularly integrated into the PacIS dashboard (http://www.pacificcis.org/dashboard/) and the PacIOOS Voyager (http://oos.soest.hawaii.edu/pacioos/voyager/). Project staff have been collaborating with PacIOOS to develop a custom data viewer, which will allow less tech-savvy users to visualize different data layers for various regions, generate time-series when clicking on a point in the map, and download data and images. The new data viewer will be tested and deployed publicly at the end of July 2017.
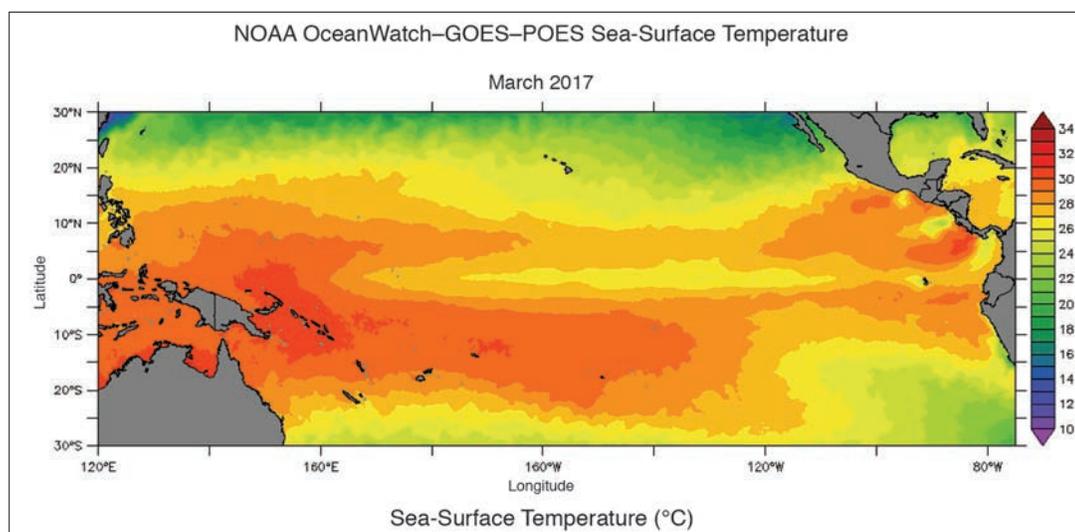

Figure 1. Sea surface temperature map provided to PacIS for their "Climate Impacts and Outlook" dashboard at http://www.pacificcis.org/dashboard/.

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

P.I.: Mark A Merrifield, Eric Heinen De Carlo

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

NOAA Sponsor: Adrienne Sutton

Budget Amount: $19,999

NOAA Goal(s):

- Climate Adaptation and Mitigation
- NOAA Enterprise-wide Capabilities: Science and Technology Enterprise; Engagement Enterprise; Organization and Administration Enterprise

Purpose of the Project

The NOAA/PMEL Carbon Group has been augmenting and expanding high-frequency observations on moorings to provide valuable information to better understand natural variability in inorganic carbon chemistry over daily to inter-annual cycles. The current NOAA ocean acidification (OA) mooring network consists of 21 moorings in coral, coastal, and open ocean environments, which hosts a standardized suite of surface sensors measuring air and seawater partial pressure of CO_2 (pCO_2), pH, temperature (T), salinity (S), dissolved oxygen (DO), fluorescence, and turbidity at all sites. Although OA is primarily driven by uptake of CO_2 from the atmosphere, many coastal and estuarine processes that affect water chemistry and the interpretation of coastal OA are manifested in subsurface waters. Furthermore, many of the most sensitive organisms (e.g., corals, shellfish) are benthic and respond primarily to subsurface water chemistry.
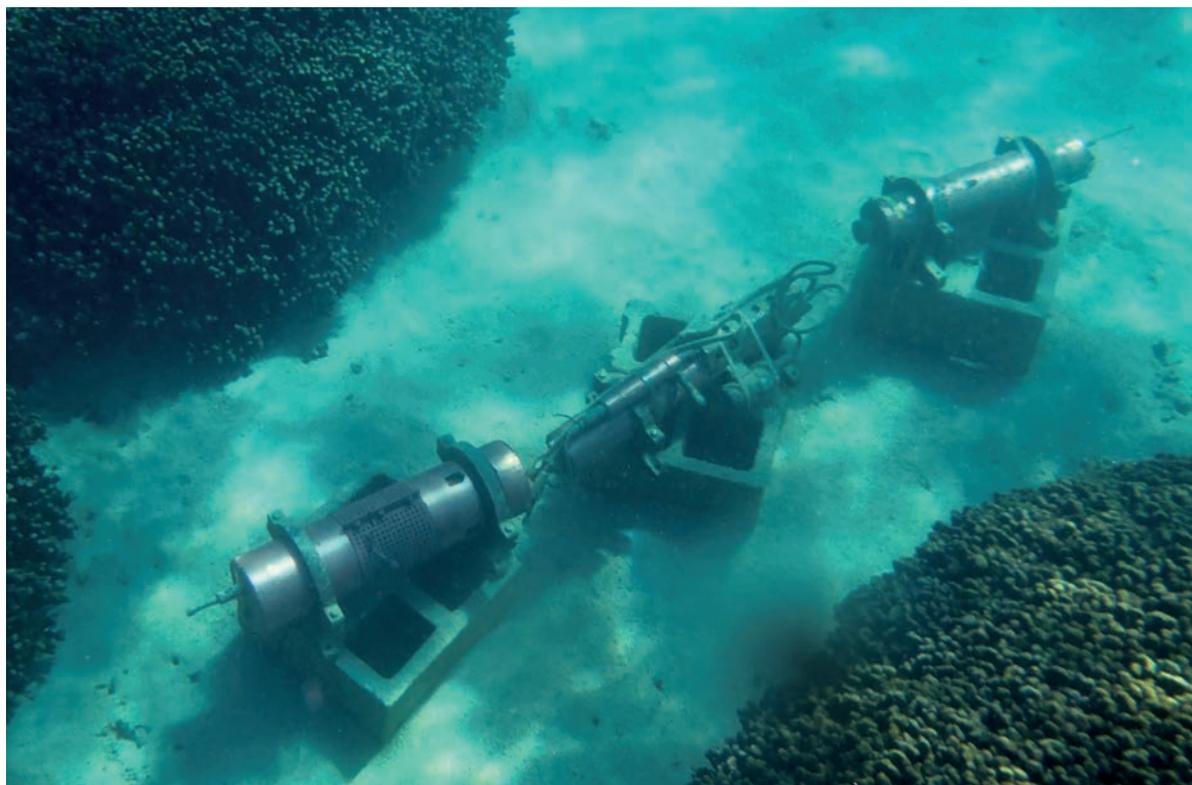
Figure 1. Set of three different sensors deployed on a sandy patch between coral heads adjacent to the CRIMP-2 buoy on the barrier reef in Kaneohe Bay, Oahu, Hawaii.

The objective of this project is to provide on-site support at existing Hawaii MAPCO$_2$ buoy sites for the evaluation of the best carbon system technologies to deploy in the subsurface, demonstrate the utility of these enhanced observations on the moorings, and make recommendations on how advanced technologies can be incorporated into the overall OA program. On-site support includes the carrying out of analyses of water samples in our laboratory at UH.

Progress during FY 2017

During the past fiscal year project researchers accomplished the following: 1) deployment of a suite of sensors on the coral reef adjoining the CRIMP-2 MAPCO$_2$ buoy in late December 2016; 2) visual examination of sensors for assessment of biofouling every two weeks between Jan and April of 2017; 3) periodic data downloads in January, March and April of 2017; and 4) collection of bottle samples during each field operation/visual examination of sensors. Sensors were recovered in late April 2017 for refurbishing at PMEL and data evaluation. Sensors are expected to be placed back in field-testing mode later this summer.

Figure 2. Close up of a SeaFET pH sensor showing evidence of biofouling.

Pacific Fisheries Monitoring Program

P.I.: Mark A. Merrifield [JIMAR Project Lead: Walter Machado]

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

NOAA Sponsor: Michael P. Seki, Keith Bigelow

Budget Amount: $405,300

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

This JIMAR project works to provide Pacific Islands Fisheries Science Center (PIFSC) with timely and accurate Fishery Management Plan (FMP) 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 Hawaii's pelagic longline fleet, which is presently and increasingly subject to international 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.

Figure 1. JIMAR staff Nate Chan with a presentation at the Fishers Forum entitled, "From Boat to WEB: catch reporting and fishery monitoring".

Progress during FY 2017

The JIMAR project staff continues to provide timely high-level support to fishery monitoring activities by providing high quality fisheries data to NMFS, PIFSC, and other JIMAR projects. The daily burden of quality control and processing logbook data has increased due to fast-tracking procedures, which were implemented to monitor Hawaii's bigeye tuna (BET) landings. This 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. The fast track monitoring also encompasses striped marlin landings due to stock concerns. JIMAR staff members have been cross-training during the year to cover the multiple facets of fast track duties during vacations, travel, and/or absences of any designated staff. The additional monitoring

Figure 2. JIMAR staff Mia Iwane explaining the benefits of using a barbless circle hook at the Hawaii Ocean Expo.

requirement increases the daily workload and are compiled weekly, or as necessary, as the quota gets taken. Additional quality control procedures and cross checks of relevant databases have been implemented as needed to continually improve the results, quality, and timeliness of the product. For example, a matching program comparing the longline logbook tuna counts to sales records at the United Fishing Agency auction was developed and is now used to validate and improve the quality of these data. The general Hawaii-permitted longline fleet-wide quarterly reports are completed 45 days after the end of the quarter. Staff collected almost 19,000 logbook pages in Hawaii and 2,500 logbook pages from American Samoa. The logbook scanning and archiving project is ongoing and will now include American Samoa longline logbooks. A photo database of Hawaii's pelagic longline fishing fleet was continually updated throughout the year and used to document the fleet on an ongoing basis.
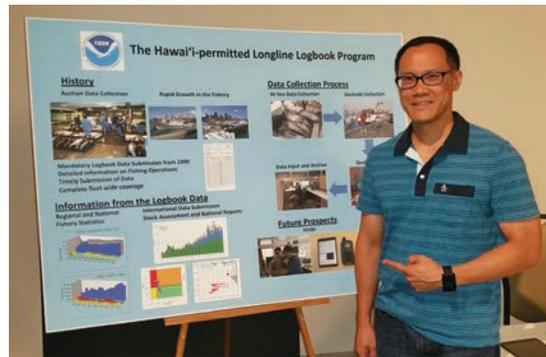
The PIFSC/JIMAR longline electronic reporting initiative is in progress. The electronic reporting system, which uses handheld tablets to record logbook information at sea, is at the stage of testing and certification by PIFSC and JIMAR staff. During this process, additional duties for the JIMAR staff in terms of distribution of tablets, tablet reporting application training of captains, and new internal procedures to transition the collecting and editing the electronic forms were added to the workload.

The PIFSC/JIMAR electronic monitoring is a project testing camera systems on longline vessels and comparing species composition data collected between cameras and simultaneous at-sea human observers. Progress has lagged due to a lack of volunteer vessels and pending the recruitment of a JIMAR Electronic Technologies Associate. Performance on the project improved as of June 30, 2017 because cameras were installed on 12 vessels and the JIMAR staffer is expected to commence employment on July 6, 2017.

Pacific Islands Territorial Science Initiative (PITSI)

P.I.: Mark A. Merrifield [JIMAR Project Lead: Toby Matthews]

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

NOAA Sponsor: Michael P. Seki, Kimberly Lowe

Budget Amount: $100,000

NOAA Goal(s)

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The overarching objective of the 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). Lack of data collection and quality control in these 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 have all contributed to inadequate data collection programs. Thus, there is a need to improve the data volume from the territories and for better quality control of those data to conduct 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 2017

The Territorial Fisheries Data Specialist completed many data and analytical requests, including an analysis of the effects of an American Samoa gas subsidy program, and produced recommendations for creel survey design in each territory based on 2016 creel data. Length-weight regressions were performed using Commercial Fisheries Bio-Sampling data to improve length-weight estimation, and two reports are currently in draft form. Most of the creel data expansions, previously written in Visual FoxPro (VFP), were rewritten in R to support the phasing out of VFP at PIFSC. The Territorial Fisheries Associate on Guam contributed many surveys to the Guam Division of Aquatic and Wildlife Resources (DAWR) creel program, performed quality control on all creel data, and assisted with database issues. Several species identification keys were also produced for use on Guam.

The Territorial Fisheries Data Specialist and Territorial Fisheries Associate, together with PIFSC federal staff and territorial agency staff, also conducted a workshop for staff at the American Samoa Department of Marine and Wildlife Resources (DMWR) and organized a pilot study on Guam. This was the third workshop during the fiscal year and covered the integration of additional length sampling into the American Samoa creel surveys. The pilot study estimates 24-hour fishing activity on Guam, with the goal of suggesting improvements to the DAWR

Figure 1. American Samoa Department of Marine and Wildlife Resources staff practicing length frequency data collection at a local fish market as part of a workshop conducted for them.
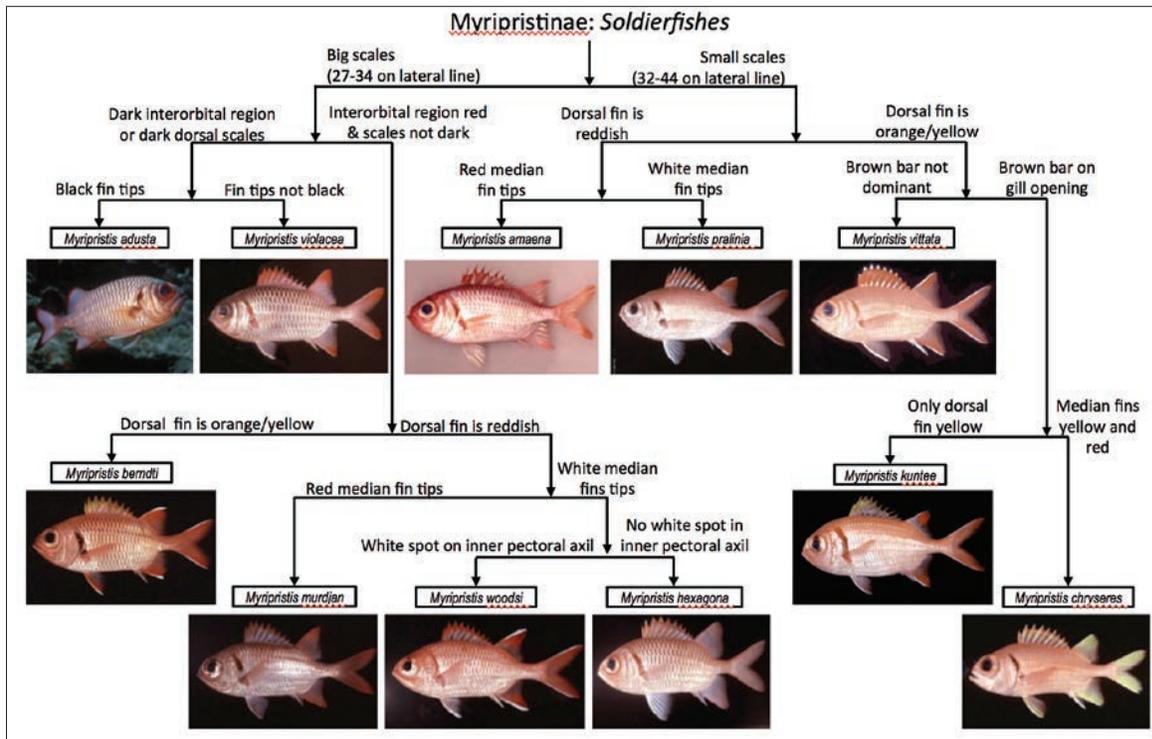

Figure 2. A soldierfish species identification key produced for use in American Samoa and Guam.

creels survey design. In total, these accomplishments fulfill the objectives established for the fiscal year with one exception. Creel survey drafts could not be completed for CNMI Division of Fish and Wildlife (DFW) due to the current absence of a creel supervisor and for American Samoa DMWR due to time constraints on the creel supervisors to review current progress on the document.

Pacific Tuna Fishery Data Management

P.I.: Mark A. Merrifield [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

Budget Amount: $175,000

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

The objective of this JIMAR 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 assessors, tuna fisheries monitors and managers, and fisheries 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 affect the development of the data management system and also collaborates with several Pacific Islands Fisheries Science Center (PIFSC) research projects and the Pacific Islands Regional Office (PIRO) for subsequent access and analysis functions and to meet monitoring and reporting requirements.

Progress during FY 2017

During the reporting period, the project continued to evaluate and develop data entry systems and a database structure for the Regional Purse Seine logsheet (RPL), Unloading and Transshipment Logsheet (UL), Final Out Turn receipt (FOT), and Length-Frequency (LF) sampling forms. The milestones achieved include: 1) development of an Application Express (APEX) application to manage the RPL data stream to replace the previous smart portable document format (PDF) method of data entry; 2) deployment of the RPL, UL, and FOT APEX applications for the PIFSC enterprise database; 3) development of a data model and APEX application to manage the LF and Species Composition (SC) sampling data stream; and 4) implementation of the generalized PIFSC Data Validation Module (DVM) for the RPL APEX application to identify data Quality Control (QC) issues so they could be addressed by project data staff.

The project is tasked with comparison of alternative systems developed by the Secretariat of the Pacific Community (SPC) for data entry and management, such as a centralized web application to enter U.S. purse seine data directly into the SPC system so that data can be downloaded directly to JIMAR/PIFSC. After reviewing the existing SPC data management systems the project decided to continue developing applications and database systems in the PIFSC enterprise database to leverage the current development investment.

JIMAR evaluated methods of Electronic Reporting (ER) from fishing vessels to reduce the lag in data integration. Such systems include integrated Fisheries Information Management System (iFIMs) software, which is currently installed on U.S. purse seine vessels. The project had multiple discussions with representatives from iFIMS to define specifications for the ER data, which will be transmitted in near-real time. There were several delays and multiple changes in specifications by iFIMS, and work was undertaken to update the ER project specifications to compensate for changes by iFIMS. The project is now awaiting test data from iFIMS in order to move forward with development activities.
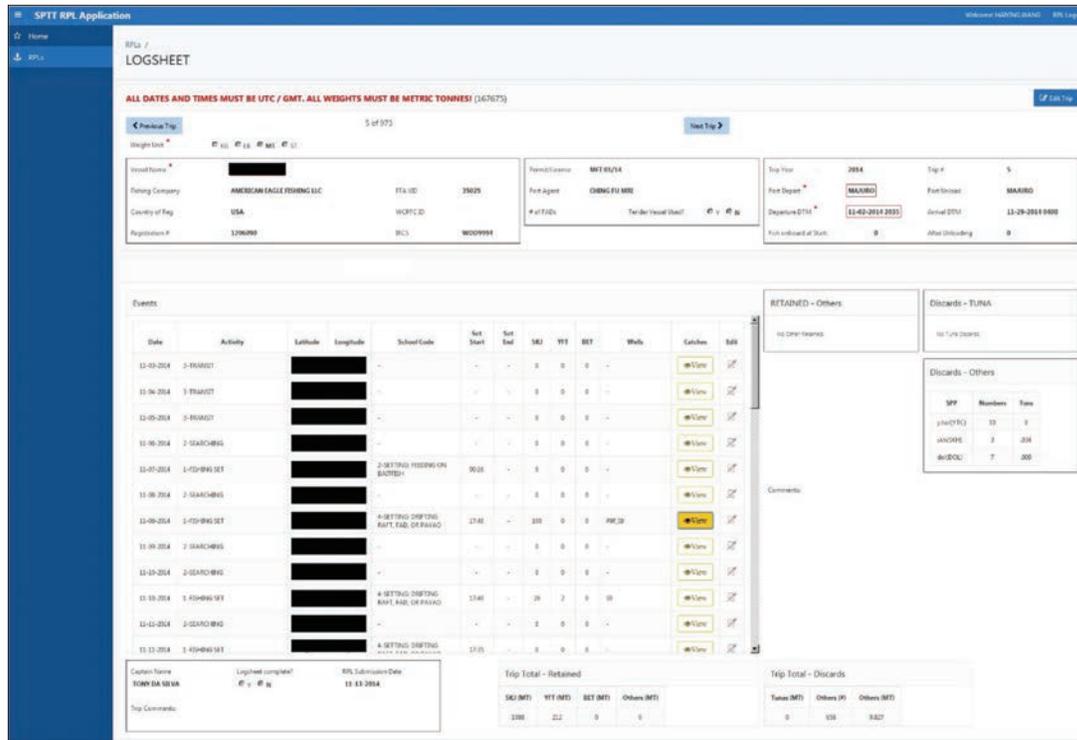
Figure 1. Screenshot of the APEX RPL data management application (confidential information has been redacted).
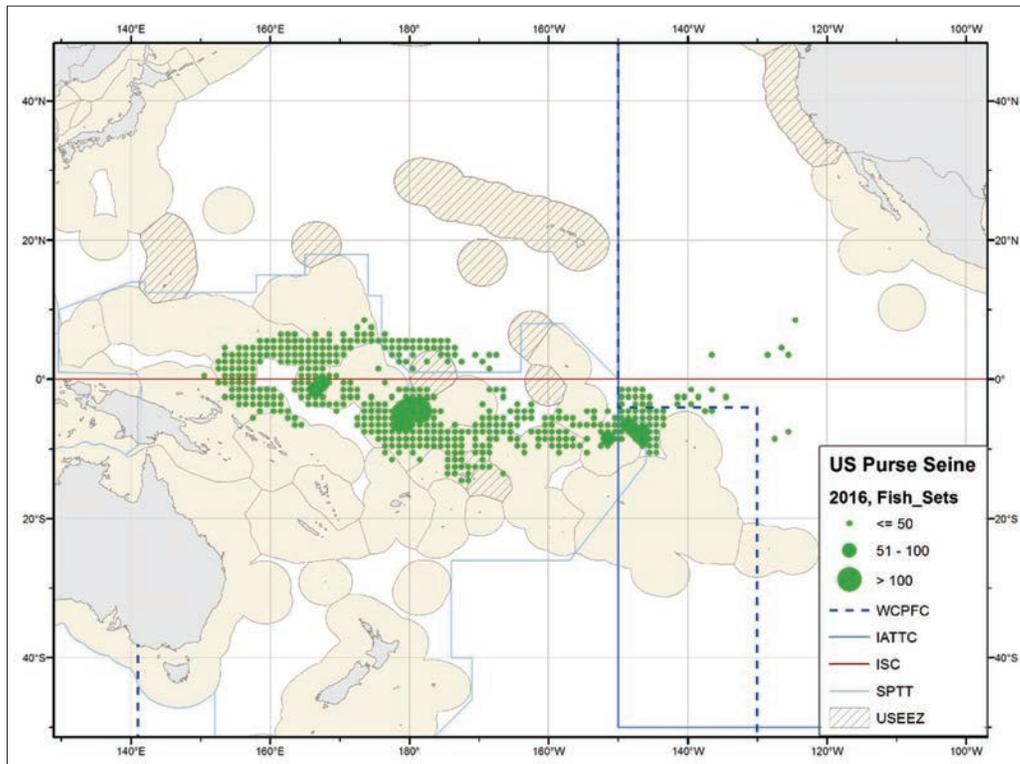

Figure 2. Distribution plot of the SPTT purse seine effort in fishing sets using graduated symbols for the calendar year 2016 showing jurisdiction areas of the WCPFC, IATTC, and ISC.

The project also committed to evaluation of integrating alternative data sources, such as observer data collected at-sea and Vessel Monitoring System (VMS) data into the database. This objective was not met this year as it was deemed a lower priority, but the objective will be revisited at a later time.

During the reporting period, JIMAR considered the data security requirements pursuant to NOAA policies. The project worked with PIFSC Information Technology Services (ITS) to implement an automated Secure File Transfer Protocol (SFTP) solution for transfer of confidential and sensitive documents from PIRO to PIFSC to facilitate the project's data management. Project staff also facilitated the Cybersecurity and Assessment Team (CSAT) review of the SPTT database and associated applications. The SPTT data application vulnerabilities were identified by the CSAT and those issues will be addressed by the project. The project's development staff attended the CSAT Oracle APEX security training to learn how to develop applications with an appropriate level of security, and the project interacts with the PIFSC Information System Security Officer (ISSO) to ensure PIFSC IT security requirements are fulfilled.

The project implemented an error-handling Oracle Programming Language extension to Structured Query language (PL/SQL) function to address specific PIFSC security controls. In addition, the project compiled and provided the necessary technical information for the RPL, UL, and FOT APEX applications to PIFSC so they could be properly vetted for security before final deployment of the applications.

Other general project improvements during the year include the following.

- Developed and evaluated data QC validation criteria for the UL and sampling data streams.
- Entered the 2016-17 RPL data, 2014-17 UL data, 2014-17 FOT data, and 2014-16 sampling data. Resolved and/or annotated QC data issues.
- Implemented a historical data package to track data changes for all applicable data entities managed in APEX applications to improve accountability within the data management system.
- JIMAR project staff attended the annual Oracle Development Tools User Group (ODTUG) Kscope 2017 conference to improve application development and data skills for the benefit of the project.
- Developed a data "freeze" process for the UL and sampling data streams to create a copy of the data at a given point in time to allow results to be reproduced in the future and new reports to be run on the frozen data. The new UL and sampling, as well as the existing RPL data freeze processes, were executed on the 2014-16 data used to generate the Regional Fishery Management Organization (RFMO) reports.
- Developed SQL and PL/SQL scripts to produce the annual U.S. Fishery Data Summary in the Western and Central Pacific Fisheries Commission (WCPFC), Inter-American Tropical Tuna Commission (IATTC), International Scientific Committee (ISC), and Pacific regions for fishing activities from 2014-16.
- Developed SQL and PL/SQL scripts to produce U.S. purse seine LF and SC sampling data summaries and provided them for the WCPFC annual data submission for fishing activities from 2014-16.
- Developed and produced U.S. Purse Seine Fishery Catch and Effort maps in the Pacific for 2016. The map products were used in the annual National Data Reports submitted to the appropriate RFMOs.

Scientific Advice and Coordination for NOAA Office of Exploration and Research's 2015-2016 "CAPSTONE" Operations in the Pacific

P.I.: Christopher Kelley

NOAA Office (of the primary technical contact): Office of Ocean Exploration and Research

NOAA Sponsor: Craig Russell

Budget Amount: $83,373

NOAA Goal(s)

- Healthy Oceans
- NOAA Enterprise-wide Capabilities: Science and Technology Enterprise; Engagement Enterprise; Organization and Administration Enterprise

Purpose of the Project

Science expertise will be acquired through the services of a science advisor supported by NOAA Office of Exploration and Research (OER). The advisor will provide advice and expertise during three phases of the

Okeanos Explorer Campaign to Address Pacific Monument Science, Technology, and Ocean NEeds (EX CAPSTONE) missions. The first phase is project planning whereby the advisor will: 1) work with OER personnel and key NOAA constituents to determine priority geographic areas and science themes for EX operations in out-years; and 2) engage the NOAA and external science and management communities to refine primary science objectives and targets for current year operations. The second phase will be the execution of annual field programs involving multidisciplinary expeditions that integrate science, education, and outreach objectives. The third phase will be the post cruise deliverables that will include high-quality data and information products generated to inform science and management needs soon after cruise completion. The advisor will essentially be the CAPSTONE Senior Scientist serving as a critical OER representative to NOAA and external partners in the U.S. Pacific Islands.

Progress during FY 2017

The project continued the work under this proposal from August 15, 2016 to February 15, 2017. The project PI was working under a related but separate proposal during the first month of the report period, as well as from February 15, 2017 to the end of the report period. As detailed in this proposal's "description of work" section, the PI has responsibilities related to: 1) out-year planning; 2) expedition planning; 3) expedition execution; and 4) post expedition deliverables. His work for this report period began with item 3 because he was one of the two onboard scientists for the fourth 2016 ROV cruise to the Wake Island Unit of the Pacific Remote Islands Marine National Monument (PRIMNM) that took place from July 27 to August 19. The final 2016 cruise, from August 25 to September 11, only involved multibeam mapping, which the PI
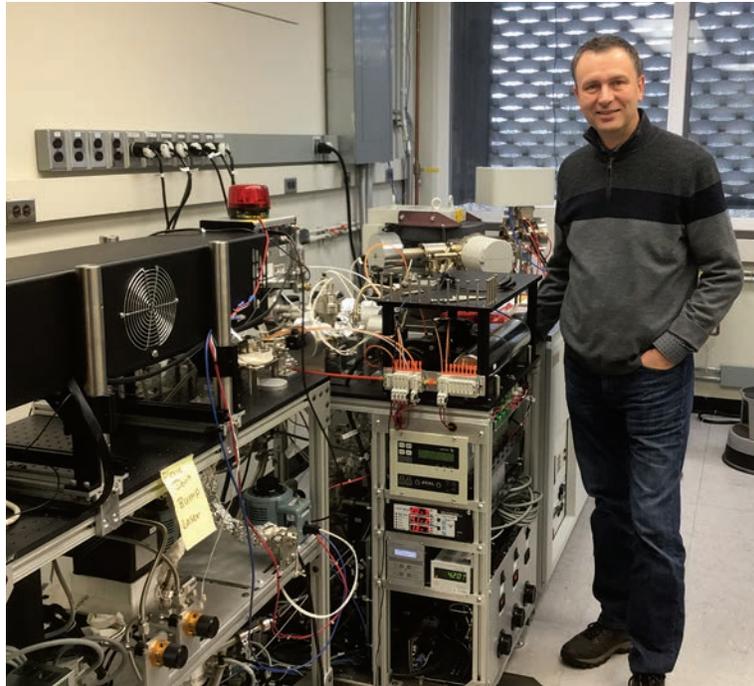

Figure1. Dr. Anthony Koppers at the Oregon State University (OSU) Repository where rock samples collected during Okeanos dives are sent.

(below) Figure 2. Ms. Holly Bolick, the Bishop Museum Marine Invertebrates Collection Manager, showing a visitor some of the corals and sponges collected during dives in the Marianas.

assisted in planning but was not actively involved in the execution. Likewise, the first 2017 EX cruise that took place from January 20 to February 11, 2017 only involved multibeam mapping, which the PI again assisted in planning but was otherwise not involved. Therefore, very little expedition execution tasks were required during the report period.

During this report period, the PI was primarily occupied with responsibilities related to items 1, 2, and 4. Since 2017 is the final year for the CAPSTONE project, very little work was required under item 1. With respect to item 2, he helped develop science priorities and plans for the 2017 EX operations in the South Pacific, Johnston Atoll, and the Musicians Seamounts, and assisted OER staff with identification of the core and auxiliary science teams in collaboration with external partners and the scientific community. Priorities and dive plans were presented to OER staff, NOAA and external partners, and interested members of the scientific community via teleconferences, webinars, and in person presentations. Regarding item 4, the PI first completed the report for the Wake Island cruise in late August. As with previous years, he then personally took custody of all of the biological and geological samples obtained during the cruises, and subsequently shipped them out to the Smithsonian and Oregon State University Geological repository, respectively. He took aliquots of the corals and sponges to Bishop Museum and worked with the invertebrate collections manager to transfer them into their collections. The PI processed many of the 2016 tracking data files in preparation for merging them later with video annotations. In December, the PI presented additional data and findings from both 2015 and 2016 dives at the American Geophysical Union Meeting in San Francisco.

Sustaining Healthy Coastal Ecosystems

P.I.: Mark A. Merrifield [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

Budget Amount: $3,410,868

NOAA Goal(s)

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The JIMAR Sustaining Healthy Coastal Ecosystems project is a multi-disciplinary research endeavor that seeks to monitor and assess the reef ecosystems in the Hawaiian Islands, including the Main Hawaiian Islands (MHI), Northwestern Hawaiian Island (NWHI) chain, extended U.S. Minor Outlying Islands (the islands and atolls of Midway, Wake, Johnston, Palmyra, Howland, Baker, Jarvis, Kingman), Commonwealth of Northern Mariana Islands (CNMI), American Samoa, and Guam. This monitoring effort informs effective management of the health and vitality of the coral reef systems. The extensive spatial range and depth of this effort requires coordinated research from the JIMAR staff in the NOAA/National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) Coral Reef Ecosystems Program (CREP) across several research teams: Coral Reef Fish; Benthic; Ocean and Climate Change; Ecospatial Information; Marine Debris Response and Operations; Data Management and International Capacity Building.

Progress during FY 2017

Coral Reef Fish Research. The JIMAR Coral Reef Fish Research Team (led by Adel Heenan) completed the following goals during the FY 2017 period.

Accomplishments by the team include the following: 1) performed ecosystem assessments and analyses of the condition and status of the coral reef fish assemblages in the MHI, NWHI, the seven islands and atolls of the Pacific Remote Island Area (PRIA), American Samoa, Guam, and the CNMI; 2) provided information and assistance to the NOAA Fisheries Research and Management Division Stock Assessment group to aid in determining population status of select target coral reef fishery species across the Pacific and information to aid

in establishing Annual Catch Limits for coral reef fisheries as mandated by the Magnuson-Stevens Act; 3) evaluated the impacts of humans on parrotfish populations across the western central Pacific; 4) conducted a feasibility assessment on integrating local and nationally collected monitoring data in American Samoa to assess marine protected area effectiveness; 5) provided data management and analytical support to the coral reef monitoring program of the State of Hawaii's Division of Aquatic Resources (DAR); 6) worked with partners to evaluate the effectiveness of management actions in Marine Protected Areas, including Kahekili, Maui; 7) improved data collection efforts to provide accurate information for ecosystem-based management and conservation efforts through method comparisons and regular training of fish team members and partners; and 8) provided support for the Integrated Ecosystem Approach to Fisheries Management (IEAFM) project.

Progress on the following goals is still underway, including: assessing the socio-environmental climate change vulnerability in American Samoa; establishing biomass baselines for the MHI; and performing a Pacific-wide biomass accumulation curve analysis.

Figure 1. Kevin O'Brien speaks during the April 13th Marine Debris Day media event with U.S. Senator Brian Schatz (right).

Completed outcomes include the following: 1) conducted Pacific Reef Assessment and Monitoring Program (RAMP) fish surveys in the MHI and NHWI, part of the PRIA (Jarvis, Howland, Baker and Wake), Guam and the CNMI; 2) produced summary briefs detailing the survey missions for the MHI, NWHI, Jarvis, southern and northern Marianas Archipelagos; 3) published an annual data report detailing summary metrics for all surveys conducted in 2016; 4) published three papers detailing comparative methods (baited remote underwater video units and closed circuit re-breathers) to analyze potential differences in abundance and biomass estimates utilizing different methods of data capture; 5) published a paper documenting the impact on the fish and benthic assemblages of the DAR Herbivore Management Area in Maui; 6) published a paper on the natural bounds on herbivorous fish populations across the western central Pacific; 7) published a technical report on the feasibility of integrating local jurisdictional with nationally collected ecosystem monitoring data to assess the efficacy of marine protected areas in Tutuila, American Samoa; and 8) produced analyzed data sets and/or data figures for DAR and other partners, per request.

Benthic Research. The JIMAR Benthic Research Team (led by Bernardo Vargas-Angel) completed the following goals during the FY 2017 reporting period: 1) provided scientific staff and expertise to support the Pacific RAMP benthic surveys in the MHI, NWHI, PRIA, Guam, and CNMI; 2) continued to investigate and evaluate coral bleaching and health condition patterns across the U.S. Pacific, in particular the effects of the 2015-2016 global bleaching event; 3) continued the analysis of reef resilience potential for coral reefs in American Samoa; 4) continued the analysis of habitat utilization for Endangered Species Act (ESA) listed species; 5) continued to improve research and data collection methods and analysis to provide information for ecosystem-based management and conservation efforts; and 6) continued to provide support for ESA and IEAFM projects.

Benthic Research Team accomplishments and deliverables include the following: 1) completed >400 benthic surveys to assess and monitor the status and trends of the coral reef benthic assemblages of the MHI, NWHI, four islands and atolls of the PRIA, Guam, and CNMI; 2) produced brief monitoring summary reports for the benthic surveys conducted for the MHI, NWHI, and PRIA; 3) completed analysis of benthic imagery collected at benthic and fish survey Rapid Ecosystem Assessment (REA) sites, Calcium Accretion Unit (CAU) sites, and climate stations for the 2016 Hawaiian Archipelago Reef Assessment and Monitoring Program (HARAMP) research cruise (~ 30,000 images); 4) successfully completed 13 data requests for benthic cover and demographics; 5) successfully prepared and delivered oral presentations for the West Maui Researcher Round Table meeting, and the American Association for the Advancement of Science Pacific Division meeting; 6) published two internal

PIFSC reports: "Standard operating procedure manual for benthic image analysis implementing CoralNet (stratified random and towed-diver imagery)" and "Baseline assessment for coral reef community structure and demographics on West Maui"; and 7) completed summary report on baseline assessments for coral cover and demographics in Vatia and Fagaʻalu bays (American Samoa).

Ocean and Climate Change Research. During FY 2017, the Ocean and Climate Change (OCC) Team (led by Tom Oliver) continued the implementation of NOAA's National Coral Reef Monitoring Plan-climate (NCRMP-climate) efforts. This entails collecting a standard suite of oceanographic and ecological data throughout each of NOAA's jurisdictions in the Pacific

Figure 2. Forty thousand kilograms (90,000 lbs.) of marine debris removed and transported from Midway and Kure Atoll staged at NOAA Inouye Regional Center for the Marine Debris Day news and press release media event.

to assess coral reef ecosystem health and quantify spatial and temporal variability related to a changing climate, including the impacts of global warming and ocean acidification.

The JIMAR OCC Team completed the following goals during the FY 2017 reporting period: 1) during the HARAMP 2016 cruise, the team executed baseline assessments of the oceanographic conditions that affect the health of the coral reef ecosystems in the MHI and NWHI; 2) during both HARAMP 2016, and the Marianas Archipelago Reef Assessment and Monitoring Program (MARAMP) 2017, the team continued monitoring oceanographic conditions and changes in these U.S.-affiliated Pacific Islands, particularly those relating to coral bleaching and ocean acidification; 3) led by Roberto Venegas, the OCC team supported the JIMAR IEAFM project with structured workshops in the Philippines to highlight the use of Visible Infrared Imaging Radiometer Suite satellite technology and climate projection models in improving fisheries management; 4) focusing on offshore references and our diurnal suite, the team continued to improve research and data collection methods and analysis to provide information for ecosystem-based management and conservation efforts; and 5) by moving OCC data to National Centers for Environmental Information (NCEI), the team improved methods and timeliness of data dissemination to partners and the public.

Completed outcomes by the OCC team include the following: 1) successfully collected, processed, and quality controlled oceanographic data collected from the MHI and NWHI during the 2016 HARAMP; 2) developed a methodological approach to assess island and atoll scale carbonate chemistry information across the U.S. Pacific islands to help contextualize current research related to ocean acidification; and 3) developed capacity and informatics pipelines to extract site-scale data from large, gridded data sets covering U.S. Pacific reef ecosystems.

Progress on the following deliverables is still underway including: 1) incorporating analysis and interpretation of data collected during the MARAMP research expedition to the CNMI and American Samoa Reef Assessment and Monitoring Program with HARAMP data in a series of data products; 2) drafting a peer-reviewed paper on the seawater chemistry and CAU data set (manuscript entitled, "Environmental drivers of coral reef carbonate accretion in the U.S. Pacific"); and 3) analyzing CAUs from HARAMP 2016 to allow remote, long-term monitoring of ocean acidification conditions affecting the coral reef ecosystems across the Pacific.

Marine Debris Response and Operations. The JIMAR Marine Debris and Operations team (led by James Morioka) met all established objectives for FY 2017. The team provided planning, logistical, and operational support for HARAMP and MARAMP cruises, and provided pre-cruise logistical and operational support for PIFSC's Modular Optical Underwater Survey System Bottom-fish cruises.

On March 31, 2017, the team successfully coordinated the removal and transport of 40,000 kg (90,000 lbs.) of marine debris from Midway and Kure Atolls in the NWHI, and the Papahānaumokuākea Marine National Monument (PMNM). This highly collaborative effort was conducted aboard the *M/V Kahana* with support

from NOAA (Marine Debris Program, PMNM, CREP), U.S. Fish and Wildlife Services (Midway Atoll National Wildlife Refuge), the State of Hawaii (Department of Land and Natural Resources), and other associated partners. The collaborative effort culminated with a Marine Debris Day news release media and outreach event on April 13th with U.S. Senator Brian Schatz, representatives from the office of U.S. Senator Mazie Hirono and U.S. Representative Colleen Hanabusa, which was covered by three local news TV stations, local newspapers (Star Advertiser), local radio (Hawaii Public Radio), and many others (Honolulu Civil Beat, etc.).

JIMAR's Marine Debris and Operations team continued to collaborate with the Protected Species Division's Hawaiian Monk Seal Research Program to develop and conduct NWHI-wide marine debris accumulation surveys and removals at Kure Atoll, Pearl and Hermes Atoll, Lisianski Island, and Laysan Island from April-August, 2017.

Figure 3. Participants from Hawai'i's Division of Aquatic Resources and Conservation Society of Pohnpei working on an exercise during a data analysis workshop led by JIMAR International Capacity Building Team.

International Capacity Building. During the reporting period, the JIMAR International Capacity Building Team (led by Supin Wongbusarakum) continued developing capacity and comprehension related to socioeconomic monitoring as a tool to improve coral reef conservation planning and management among key staff in NOAA and partner organizations in Micronesia, Hawaii, and internationally. The trained participants serve as trainers within their agencies and organizations at both country and regional levels. This year the team's primary accomplishments include improved understanding of the socioeconomic conditions of reef dependent communities and their relationships with biophysical factors in the NOAA Habitat Blueprint site Manell-Geus in Guam, and the expansion of integrated monitoring that takes into consideration socioeconomic monitoring in Micronesia and Hawaii. Such work provides a more holistic understanding of the linkages between biophysical and social factors and results in better-informed management practices. During the year, partnerships were established and strengthened with other NOAA teams (including the Ecosystem Sciences Division or ESD Human Dimension Team, Social Science Team at the Marine Hollings Laboratory and the NOAA Field Guam Office), the Global Socioeconomic Monitoring Network supported by CRCP, University of Guam, and University of Hawaii. These partnerships have resulted in increased social scientific support for management and conservation that include considerations of human impacts and human well-being.

Completed outcomes by the team for the Micronesia region include the following.

• In collaboration with the Social Science team of the NOAA's Hollings Marine Laboratory, the team offered a six day data analysis and training workshop in Palau. This training addressed needs for capacity building in social data analysis. Participants represented fisheries and coastal resource management agencies and conservation organizations from Guam, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia (Kosrae, Pohnpei, and Yap), Palau, the Republic of the Marshall Islands, and Hawaii. A document including the presentations, exercises, and quizzes was produced and shared with all partners.

• The team completed a document titled, "Recommendations for Data Management Plan of Socioeconomic Data for the Micronesia Challenge Countries", and submitted it to the Micronesia Socioeconomic Monitoring Core Team to review and finalize in November 2016.

• Team leader Dr. Wongbusarakum served as subject expert for the socioeconomic monitoring part of the Pacific Islands Regional Office (PIRO) Pacific Islands Marine Protected Areas Community Project (PIMPAC) 3-year

strategic planning meeting in February 2017. She guided the process of developing socioeconomic monitoring objectives and annual milestones for PIMPAC strategic plans from 2017 through 2020.

- Dr. Wongbusarakum also served as main trainer at a socioeconomic training workshop organized by the Micronesia Islands Nature Alliance and Micronesia Challenge and hosted in Weno, Chuuk, in April 2017. Participants came from coastal resource management agencies, environmental protection agencies, and conservation organizations from Chuuk and the Republic of Marshalls Islands. Powerpoint presentations were developed and hands-on exercises were conducted for key informant interviewing and household survey in Onei, Chuuk.

- A concept note for a college course on human dimensions of conservation was developed and submitted to the Micronesia Conservation Trust to present to the Micronesia country leaders in April 2017.

For the Hawaii region the team collaborated with the Community-Based Subsistence Fishing Areas team of the DAR and NOAA CRCP to complete a socioeconomic monitoring training agenda and a survey questionnaire for Community-Based Subsistence Fishing Practitioner Survey. Both documents were completed in February 2017.

For the Guam region the team collaborated with the NOAA field office team to develop a socioeconomic monitoring plan as an approach towards integrated monitoring in the Manell-Gues Habitat Blueprint site. The JIMAR and PIFSC staff guided and supported the NOAA field office team to analyze all household survey data collected from Merizo community in Manell Gues in the spring of 2017.

Progress on the following goals is still underway including: 1) a manuscript for peer-review titled, "Divers and snorkelers perceptions of underwater crowding in the Rock Islands Southern Lagoon, Palau"; and 2) a manuscript for peer-review titled, "Human well-being impacts: Incorporating monitoring, and evaluating human well-being in conservation programs."

Ecospatial Information Research. The JIMAR Ecospatial Information Team (led by Annette DesRochers) completed the following goals during the reporting period including the following: 1) continued supporting projects to develop web maps for the Pacific Marine National Monuments and the Pacific Remote Islands Marine National Monument (PRIMNM) Report; 2) provided geospatial support to DAR with the objective of building Geographic Information System (GIS) capacity by delivering a model builder; 3) supported the JIMAR Pacific Islands Deep-Sea Coral and Sponge Initiative project including processing of multibeam data collected during the 2015-2017 RAMP cruises; 4) updated seafloor gap analysis for the Pacific Island Region to aid in future survey planning and mapping efforts; 5) provided data and support to the project's GIS-related needs including map products and analyses; 6) provided GIS infrastructure for various CREP projects, PIFSC projects, and to outside agencies such as PIRO and the WestPac fisheries council; and 7) maintained the Pacific Islands Benthic Habitat Mapping Center website through regular updates to ensure it's a dynamic back-end based vs. static file system, and implemented a content management system.

Completed outcomes by the Ecospatial Information Team for the reporting period include the following.

- A series of benthic habitat map layers were completed for the MHI and provided to the CREP Fish Team to identify map layers that are the best predictors of reef fish distribution. Preliminary findings from this analysis were documented in the NOAA Administrative report (in review), "A sampling design performance analysis examining linkages between reef fish assemblages and benthic morphologies in the main Hawaiian Islands".

- Production of satellite derived bathymetry for five islands in the PRIMNM including Baker, Howland, Johnston, Palmyra, and Kingman.

- Submitted multibeam processing summary report from three 2015-2017 RAMP cruises for JIMAR Pacific Islands Deep-Sea Coral and Sponge Initiative project.

- Completed single beam data analysis to quantify error, identify, and implement improvements in data collection and instrument settings to support derived mapping efforts for shallow water (0-30 m) coral reef ecosystem habitats.

- Completed maps to be incorporated into the PRIMNM Monitoring Report booklet, provided project management support and lead coordination to the overall effort.

- Produced a final report documenting the process to develop an updated benthic habitat map and geomorphologic data layers for the West Hawaii Habitat Blueprint focus area.

- Published a technical memorandum for West Hawaii habitat mapping effort entitled "Acoustic characterization of mesophotic coral reef ecosystems of West Hawaii".

- Completed the activities and products for the work with the United States Agency for International Development in Timor-Leste, including the GIS Spatial Data Framework, GIS workshop, and data delivery with Final Report entitled, "Interdisciplinary baseline ecosystem assessment surveys to inform ecosystem based management planning in Timor-Leste".
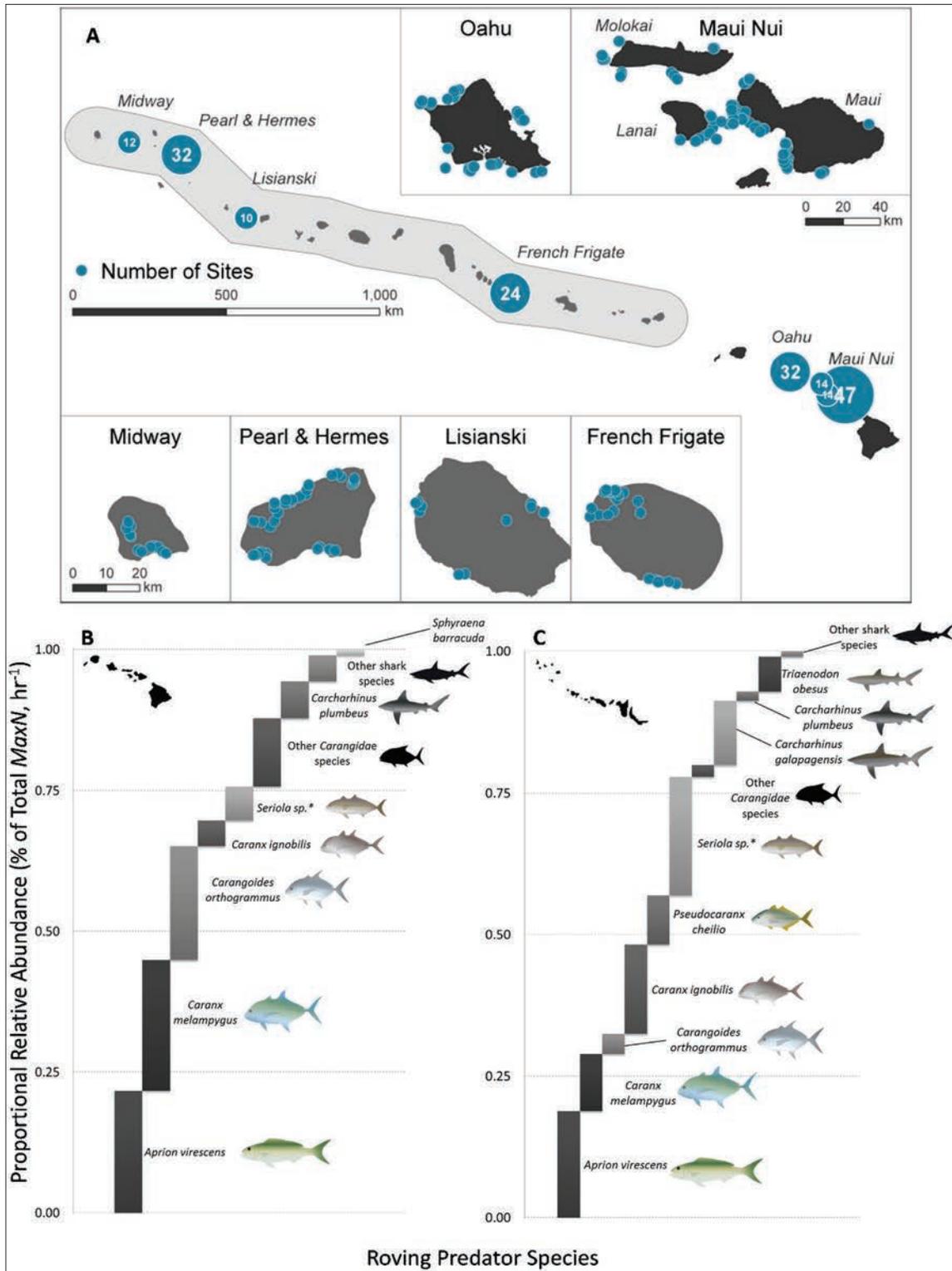
Figure 4. *New research by the fish team used baited and un-baited underwater video systems in both the MHI and the PMNM (blue circles) showed that coral reef predator populations shift dramatically when moving from shallow water to deeper mesophotic depths of ~330'.*

- Completed new benthic habitat mapping data products to support PIRO with the critical habitat designation for the Pacific ESA-listed coral species for PIRO's seven priority islands in the Pacific Islands Region, and also completed new hard/soft substrate maps for the islands Ofu, Olusanga, Tau, Tinian, Aguijan, Pagan, Rota, and Tinian.

The data, metadata, and associated products for these completed milestones were compliant with Public Access to Research Results (PARR) requirements, and made available using the NOAA Fisheries InPort Metadata catalog or the project's Pacific Islands Benthic Habitat Mapping website. Metadata documenting the products, data, and analyses were developed in the NMFS InPort system and posted on the Coral Reef Information System (CoRIS) website at http://www.coris.noaa.gov/.

Data Management. The JIMAR Data Management Team (led by Troy Kanemura) completed the following goals during the FY 2017 period.

- Provided data management and application development services for the effective stewardship of CREP's data holdings including: 1) developed and improved user interfaces for data entry and access during Pacific RAMP and other field operations, 2) provided PIFSC and JIMAR researchers and managers with databases, applications and tools so that scientific data are quality controlled, properly documented, easily accessible, and can be readily analyzed, 3) improved methods and timeliness of data dissemination to PIFSC's and JIMAR's partners and the public, including web-based data portals and applications, and 4) collaborated with CREP researchers and PIFSC data management personnel and others to develop data management policies, plans, and user guides to formalize the aforementioned efforts.
- Provided data management services to meet guidelines and directives of NCRMP, including data access, data documentation, and data archival.
- Provided data management and application development services to aid local coral reef resource management agencies in the effective stewardship of their coral reef monitoring program data sets and to facilitate efficient integration of monitoring data sets between these agencies and CREP.
- Provided guidance and support to achieve the goals and milestones laid out in the recent NOAA and NMFS data-related Policy and Procedural Directives (per PIFSC Data Management Policy, 2014) as well as the government-wide requirements outlined by PARR.
- Properly documented and archived coral reef data collected by CREP to be used in the development of a comprehensive Coral Reef Ecosystem Monitoring Report for the PRIMNM.

Completed outcomes delivered by the JIMAR Data Management Team for the project period include the following.

- Provided data management services to support CREP's HARAMP and MARAMP cruises. Services provided include: 1) assisting with mission planning; preparing, deploying, and managing the remote file management system; 2) training the designated data managers; 3) preparing, deploying, and managing the database applications to facilitate data entry, data validation, data processing, and data quality control; 4) assimilating data collected into CREP's Oracle database or file management systems; and assisting with reporting, metadata, and archival requirements.
- Provided data management support for CREP's image analysis project to incorporate results into the Oracle database from CoralNet and provided open access to still imagery as part of PARR Initiative.
- Provided data management support for Guam's Long-Term Coral Reef Monitoring Program. Specifically, the two applications developed by the data management team are: 1) the web-based data management interface deployed in 2014; and 2) image analysis ingestion script deployed in 2015.
- Provided data management support for American Samoa Department of Marine and Wildlife Resources' Data Management Initiative. The data management team developed the web-based application to facilitate data entry for data collected under the American Samoa Coral Reef Monitoring Program and the American Samoa Integrated Coral Reef Monitoring Program.
- Implemented requirements of PARR, NOAA, and NMFS Data Management Planning Procedural Directives, as well as the PIFSC Data Management Policy and provided feedback through CREP's position on the PIFSC PARR implementation team to the evolving processes as needed.
- Provided data management support to the project as part of the National Coral Reef Monitoring Program, and collaborated with the NCRMP data management team as needed.
- Provided data management support for the development of the PRIAs Monitoring Report.
- Continued implementation of the data management plan for CREP's oceanographic data.
- Continued development and expansion of the web-based data entry tool, Oracle Application Express (APEX).

Two major outcomes of the Big Earth Data Initiative project accomplished by the data management team include the following.

- Improved discoverability and promoted usability of the extensive interdisciplinary, multi-format ecosystem assessment and monitoring data collections contributing to the Pacific Remote Islands Marine National Monument booklet. This was achieved by developing metadata following the ISO 19115-2 Metadata Standard through cataloging in the NMFS centralized metadata repository (InPort) and the NOAA CRCP CoRIS.
- Provided access to those data collections in a machine-readable format through archival with the NOAA NCEI.

Territorial Biosampling

PI: Mark A. Merrifield [JIMAR Project Lead: Brett Taylor]

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

NOAA Sponsor: Michael P. Seki, Christofer Boggs

Budget Amount: $214,130

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 inhabited Pacific Islands under U.S. jurisdiction. The project ultimately endeavors to provide scientific 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, thus facilitating spatial and temporal extrapolations of these relationships to better predict harvested fish demographics with changing future ocean conditions.

Progress during FY 2017

The JIMAR Territorial Biosampling project met all proposed objectives for FY 2017. Research activities resulted in the publication of three peer-reviewed manuscripts (Taylor et al. 2017, *Ichthyological Research*; DeMartini et al. 2017, *Canadian Journal of Fisheries and Aquatic Sciences*; Winston et al. 2017, *Coral Reefs*) with an additional four under journal review or NOAA internal review.   These manuscripts cover: comprehensive age-based biology of commercially harvested species from Hawaii, the Commonwealth of the Northern Mariana Islands, and Guam; present extensive data sets examining general patterns of life history variation and the influence of fishing pressure on fish assemblages; and provide a review of future research directions for harvested parrotfishes. Project staff also led coordinated efforts to process the vast majority of fish otoliths and gonads from the Pacific Islands Fisheries Science Center Life History Project (LHP) 2016 research cruise through the

Figure 1. Two contracted staff process fish specimens derived from the Saipan Commercial Fisheries Biosampling Program. Otolith and gonad samples from these specimens will be processed to derive life-history information that will directly support stock assessments at PIFSC and facilitate regional management of marine resources.

Samoan Archipelago. Project staff also rectified existing errors in the American Samoa Commercial Fisheries Biosampling Program (CFBP) database and consequently built a relational database in Oracle Application Express that links contemporary and legacy life history data of the LHP in a common format for easy querying of multiple data sources by all LHP staff. Finally, project staff produced and collated age estimates for the blue-spine unicornfish (*Naso unicornis*) for all inhabited U.S. Pacific Island entities. This species is the most commonly harvested reef-associated species in the U.S. Pacific and will be a focus of research output for next fiscal year.

West Hawaii Integrated Ecosystem Assessment

P.I.: Mark A Merrifield [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, Jamison Gove

Budget Amount: $222,950

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The West Hawai'i Integrated Ecosystem Assessment (IEA) project aims to produce robust scientific information that directly supports current and future resource management concerns off the west coast of Hawai'i Island. This coastal zone is a region inhabited by bright reef fish, sea turtles, spinner dolphins, bottomfish, and a community of deep-sea creatures. The biological diversity and high productivity of the area makes it important to fisheries and tourism as well as a fascinating region to study a complex ecosystem. One goal of the project is to investigate surface slicks as important physical oceanographic phenomena for local ecological processes, including larval retention and recruitment. Research efforts also focused on a community of nearshore, deep-water fishes, squid,

Figure 1. Surface slicks are visible along the coast of West Hawai'i (photo: JIMAR/Jonathan Whitney).

and other micronekton and their relative importance to island-associated higher trophic groups.

Progress during FY 2017

In April 2017, the West Hawai'i IEA research team participated in a multidisciplinary effort aboard the NOAA *R/V Oscar Elton Sette* to study a dynamic ecological area along the west coast of Hawai'i Island, with JIMAR scientists spending two weeks investigating this dynamic marine ecosystem and its underlying oceanography. The expedition contributed to an established research project and previous mission completed in September 2016. JIMAR researchers focused on exploring why Hawai'i and other tropical coral reef island systems are so biologically productive. What makes these regions hotspots of species diversity that, in turn, help populate fisheries and provide coastal protection?

During the first half of the expedition, JIMAR research efforts focused on studying surface slicks: narrow, meandering lines on the ocean surface. Surface slicks are associated with increased water tension on the surface that dampen surface ripples and produce a visibly smooth, ribbon-like feature in the coastal ocean. The areas within and around slicks appear to function as biological oases, as they collect floating material and attract organisms in areas where food resources are otherwise sparse and dispersed. Researchers also believe these slicks may contribute to the recruitment and retention of early life history stages of marine organisms such as reef fish and turtles. Despite this potential biological importance, very little is known about the underlying physical mechanisms and ecological relevance of surface slicks in Hawaiʻi.
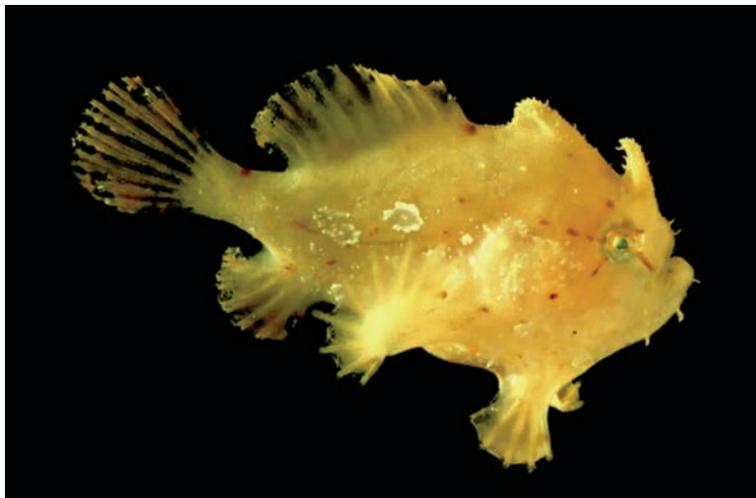

Figure 2. Tiny Commerson's frogfish (Antennarius commerson) *(photo: JIMAR/ Jonathan Whitney).*

In addition to studying the surface ocean, the West Hawaiʻi IEA research expedition also focused on marine species from the deep ocean. Previous JIMAR researchers discovered a high abundance of deep-water organisms in the South Kona region. This group of organisms, termed the "mesopelagic boundary layer community", lives within a mile from shore in relatively deep water, between 1300 and 2000 feet (400–600 m). The mesopelagic boundary layer community is thought to be an important food resource for higher trophic groups that frequent the waters off West Hawaiʻi, such as dolphins and whales. However, much remains to be explored and discovered, such as assessing what species are in this unusual ecosystem and why they prefer this particular geographic area of Hawaiʻi Island.

To study these habitats, active acoustic data, plankton and micronekton samples, and drone images of the slicks were collected and are being analyzed by JIMAR scientists and student hires. Plankton samples collected in the slicks will also be analyzed for microplastics.

Western Pacific Fisheries Information Network (WPacFIN)

P.I.: Mark A. Merrifield [JIMAR Project Lead: Toby Matthews]

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

NOAA Sponsor: Michael P. Seki, Kimberly Lowe

Budget Amount: $500,000

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

The objective of the 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 staffs work with island agency staff, contractors, fishermen, and fish dealers to create data systems that implement quality

Figure 1. Anna Regis, JIMAR Fisheries Database Assistant on Guam, volunteered at the 2016 Kid's Fishing Derby hosted by the Guam Division of Aquatic and Wildlife Resources.

Figure 2. Screenshot of the input interface for catch-per-unit-effort data summaries from the new WPacFIN website.

control measures and synthesize fishery-dependent monitoring data. This technical support enables PIFSC and the partner agencies to produce timely reports of the best available fisheries data from each island area.

Progress during FY 2017

WPacFIN staff continued converting the Visual FoxPro (VFP) database applications to MySQL and C# for WPacFIN Central and all partner agencies. Data summaries for all Plan Team reports submitted to the Western Pacific Regional Fishery Management Council were completed in MySQL and a C# interface was created for the territorial Pelagics Plan Team module. Progress was also made on the new WPacFIN website and catch-per-unit-effort data summaries were developed and made available to users through phase 2 of the new website implementation. Next, metadata documentation was completed for VFP data collections for Hawaii, American Samoa, Guam, and CNMI. Finally, annual and semi-annual summary reports were submitted to Regional Fishery Management Organizations (RFMOs), and the Fisheries of the United States (FUS) and Fishery Statistics of the Western Pacific (FSWP) reports were also completed.

These accomplishments satisfy all of the objectives established for the fiscal year, with the exception of those related to the Hawaii Division of Aquatic Resources (DAR) database. Hawaii Information Consortium (HIC) data was made compatible with DAR's 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.

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.

International Ecosystem Approach to Fisheries Management (IEAFM) Project—Philippines

P.I.: Mark A. Merrifield [JIMAR Project Lead: Supin Wongbusarakum]

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

NOAA Sponsor: Michael P. Seki, Russell Brainard

Budget Amount: $205,000

NOAA Goal(s)

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The International Ecosystem Approach to Fisheries Management (IEAFM) Project is a multi-disciplinary research and capacity development endeavor that complements the JIMAR Sustaining Healthy Coastal Ecosystems project. Its purpose is to inform and support effective coral reef system and sustainable fisheries management in the Coral Triangle (CT) and Southeast Asia regions. Using an Ecosystem Approach to Fisheries Management (EAFM), the primary project objective during FY 2017 was to provide relevant scientific expertise and technical assistance to the governments and key country partners in the Philippines and Timor Leste and international efforts related to EAFM. This work supports efforts to adopt an ecosystem-based approach throughout NOAA's broad ocean and coastal stewardship, science, and service programs. The goal of ecosystem-based management is to maintain ecosystems in a healthy, productive and resilient condition so they can provide ecosystem services and enhance human well-being.

Figure 1. Fisheries officers and staff of local government units attending an EAFM Planning and Implementation workshop in Calbayog, January 30-February 3, 2017.

Progress during FY 2017

During FY 2017, JIMAR IEAFM team staff served as scientific and EAFM advisors, trainers, subject matter experts, research partners, and coordinators to help lead, develop, and provide training and technical implementation support for an EAFM. Key accomplishments of the Philippines and Timor Leste missions and internationally are listed below.

Projects worked on by the team for the Philippines region include the following.

Provided technical assistance toward the institutionalization of an EAFM. The JIMAR IEAFM team worked with regional resource managers in the development of Philippines EAFM planning process workshop materials and provided technical support to EAFM Planning Process Implementation at priority demonstration sites of the Philippines Department of Agriculture's Bureau of Fisheries and Aquatic Resources (DA-BFAR). Specific tasks accomplished are as follows.

- The JIMAR IEAFM Team worked with the Philippines EAFM Technical Working Group, DA-BFAR, the United States Agency for International Development (USAID) Ecosystems Improved for Sustainable Fisheries Project (ECOFISH), and country partners in efforts that contributed to the formulation and implementation of the Philippines Fisheries Office Order 164—the aim of which is to institutionalize EAFM implementation across the nation. The team provided extensive technical inputs and reviews to tailor the original international Essential EAFM course (which the team also co-developed in previous years) for effective use in the Philippines context and for actual EAFM plan development under Mainstreaming-EAFM.
- JIMAR staff provided technical assistance toward developing an EAFM plan at two priority DA-BFAR sites in North Samar and Biliran in the Visayas in February and May 2017. They co-led and facilitated two one-week Mainstreaming-EAFM workshops with nearly 80 participants from over 20 Local Governmental Units and other stakeholders.
- Facilitated and technically supported fisheries stakeholders in developing two draft EAFM plans for the Ticao Pass and Saint Bernardino Straight of North Samar and Biliran Province.
- Built DA-BFAR's capacity to lead Mainstreaming-EAFM workshops.

- Revised EAFM course materials (including Handbook, Powerpoint presentations of all modules, and toolkits) to better tailor them to the Philippines context, for Mainstreaming-EAFM workshops and for future use by the local governmental units.
- Assisted in the development of two draft fisheries management plans in Visayas based on an EAFM.
- Strengthened EAFM socializations and institutionalizations among key stakeholders.
- Strengthened human well-being objectives and monitoring for an EAFM.
- Developed reports related to the workshops, technical assistance, trips and activities.

Peer-to-Peer Learning Exchange, Philippines. The IEAFM Team coordinated a Peer Exchange with DA-BFAR, Philippines Department of Natural Resources Biodiversity Management Bureau (DENR-BMB), USAID, the NOAA Pacific Islands Fisheries Science Center (PIFSC), Pacific Islands Regional Office and Office of Law Enforcement, the Western Pacific Regional Fishery Management Council, the State of Hawaii and other partners. The focus of the exchange was not only bringing together the Philippines fisheries management and NOAA partners to share and learn from each other, but also bringing together multiple parts of NMFS and regional partners to facilitate improved integration through sharing insights and discussing fisheries and marine resource management, and science for management, enforcement and governance. The exchange took place at the NOAA Inouye Regional Center, Ford Island, Honolulu, Hawaii in June 2017. A listing of deliverables includes the following.

- Executed peer-to-peer exchange workshop in Honolulu to enhance learning and exchange among JIMAR, NOAA, regional, and Philippine partners.
- Peer exchange briefing booklet, concept note, and presentations.
- Strengthened long-term scientific, management and enforcement partnerships between government-to-government agencies (DENR-BMB and DA-BFAR), and between government and NOAA, thereby increasing potential future collaboration and integration.

Technical Advisory support to monitor marine biodiversity using Autonomous Reef Monitoring Structures (ARMS), Philippines. This effort originally began with a pilot site at Verde Island Passage, Philippines, and leveraged Coral Reef Conservation Program funding and other partnerships. During this reporting year, the IEAFM team and PIFSC Coral Reef Program (CREP) staff developed a report (based on NOAA and JIMAR work) with partners to establish baseline data and standardized methods for the collection and processing of climate, ocean acidification and cryptic invertebrate biodiversity data. The intent is to provide on-line climatology data and develop guidelines on incorporating considerations of climate and ocean change for managers to use in an EAFM across the region. In addition, meta-data was generated for the information collected.

Provide technical assistance and guidance to support DENR-BMB biodiversity awareness raising, education and outreach using ARMS, Philippines. In addition to building science for climate, ocean and biodiversity monitoring, the JIMAR IEAFM Team, in collaboration with DENR-BMB and partners, provided technical guidance and graphics support towards the development of a basic phyla-based field guide. This guide includes depictions and descriptions of key phyla for ARMS outreach and community engagement activities to help create a better understanding of the Philippines cryptic biodiversity, its critical role in the larger ecosystem and the significance of the ARMS. A listing of deliverables as a result of this work includes the following.

- Biodiversity and ARMS basic outreach field guide with example phyla for cryptic marine invertebrates featuring species collected from ARMS activities in Verde Island Passage.
- Increased public understanding, awareness and interest about the significance of marine biodiversity, including cryptic organisms across the Philippines, the threat that ocean acidification poses to marine biodiversity, and the importance of marine resource management.

Develop projections of future impacts to Philippines fisheries and marine biodiversity due to ocean variability and change. The JIMAR International Team continued analyzing data sets and delivering products related to potential impacts of climate change on Philippine marine fishes and fisheries. An inventory of fishing gears and species was also conducted for high-density areas of nighttime fishing lights detected from Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) images. Associated project outputs are expect to be used by DA-BFAR officials for the "Climate Change and Disaster Risk Reduction and Management for Fisheries Development Framework" currently in development. A listing of deliverables includes the following.

- High density aggregation of nighttime lights was validated during the Feedback Workshop with DA-BFAR and information on catches and fishing gears used in each Core Fishing Area were identified.
- Peer-reviewed journal article draft "Climate-induced vulnerability of fisheries in the Coral Triangle: Skipjack

tuna thermal spawning habitats" is undergoing NOAA internal review and will be submitted to the *Journal of Fisheries Oceanography*.

- Draft peer-reviewed paper "Spatio-temporal mapping of fishing activities and prediction of suitable fishing areas from nighttime satellite images" to be submitted to *PLoS ONE*. The manuscript is undergoing final review by co-authors.
- Fish population parameters from Philippine's DA-BFAR's stock assessment data are currently being extracted to feed into the species distribution and size-structure models.

Timor-Leste Region. Through coordinated efforts of the JIMAR IEAFM Team and other JIMAR CREP staff, the ARMS data, temperature data, reef calcification data, benthic habitat data, fish survey data, and bathymetric data layers generated for Timor Leste between 2012–2016 were compiled into a comprehensive report to share with the Ministry of Agriculture and Fisheries and USAID Timor. These data sets provide essential baseline fisheries and marine resource information of the nearshore waters of Timor-Leste. The report provides the basis for science-based management for fisheries conservation, which in turn can improve food security and strengthen climate change resilience for the benefit of the people of Timor-Leste. The methods used for establishing ecological baselines for climate change in Timor-Leste, a foundation for comparing the ecological baselines under current and future stresses associated with climate change across the region, are being adopted and implemented at twenty-one sites across eight member states of the Intergovernmental Oceanographic Commission–Sub commission for the Western Pacific (IOC-WESTPAC) region. A listing of deliverables as a result of this work includes the following.

- "Interdisciplinary Baseline Ecosystem Assessment Surveys to inform Ecosystem-Based Management Planning in Timor-Leste: Final Report".
- Map book and posters.
- Spatial bathymetric and habitat data sets.
- JIMAR staff delivered the report and the associated data sets and summarized its findings in Dili, Timor Leste in June 2017.

International. In partnership with the NMFS Office of International Affairs and Seafood Inspection (IASI) and the United Nations Food and Agriculture Organization (UNFAO), the JIMAR International Capacity Building Team collaborated with the International EAFM Consortium to further develop the EAFM materials and technically support the Southeast Asia Fisheries Development Center (SEAFDEC) to implement their EAFM trainings and consultation meetings for the EAFM for Leaders, Executives and Decision-makers (LEAD) in the Association of Southeast Asian Nations (ASEAN).

With the WESTPAC, NMFS IASI, SEAFDEC and other partners, the project team co-developed EAFM LEAD toolkit materials and participated in EAFM LEAD writing workshop in October 2016. Products include animations, session plans, Powerpoint presentations, booklets, etc. (See http://www.eafmlearn.org/eafm-leaders-download-toolkit.) These materials are designed to communicate the significance of EAFM and how to implement it among leaders across levels of governments and sectors. The products were also a CREP milestone in the fall of 2016. This effort helped further build NOAA leadership in EAFM internationally.

The JIMAR International Capacity Building Team technically assisted SEAFDEC staff with their preparation for EAFM LEAD workshops in the Philippines and Vietnam in November 2016.

Socioeconomics of Western Pacific Fisheries

P.I.: Mark A. Merrifield [JIMAR Project Lead: HingLing Chan]

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

NOAA Sponsor: Michael P. Seki, Justin Hospital

Budget Amount: $203,500

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.

Figure 1. JIMAR social scientist Adam Ayers meets with Rota fishers in Songsong Chamorro Village Park, Rota, CNMI.

Progress during FY 2017

The project successfully provided support in continuing data collection and monitoring activities in the Guam and CNMI small-boat fisheries, and the database management of the Hawaii longline fishery and American Samoa longline fishery.

Project activities accomplished during FY 2017 include the following.

• A technical report is being developed for vessel-level profit assessment for Hawaii small boat commercial fisheries.

• Project staff extended existing fishery models of Hawaii's longline fishery by establishing a fishery-specific framework using Positive Mathematical Programming (PMP) models for the project on Hawaii longline fleet dynamic modeling. The model was successfully calibrated to produce base-year catch and

Figure 2. JIMAR social scientist Danika Kleiber moderating a Fish Flow workshop in Honolulu.

profits for 2012, accounting for fishers' observed activities. Simulation of a proposed reduction in the annual catch limit for bigeye tuna in the Western and Central Pacific Ocean was evaluated by measuring the impact

on individual fishers' profits and catch levels. Model predictions were evaluated to gauge predictive accuracy, accounting for changes to fuel price and labor costs representing external market conditions. This work has been accepted as the first chapter of University of Hawaii, Manoa PhD candidate Jonathan Sweeney's dissertation, and published in a peer-reviewed journal. Final metadata generated by the model calibration procedure have been uploaded to NMFS InPort to meet Public Access to Research Results (PARR) requirements.

• For Hawaii community social vulnerability indices, the Hawaii Community Social Vulnerability Index (CSVI) database was updated at the Census County Division geographic scale and a draft technical report of developed social vulnerability indices is currently awaiting external review. When the internal review is scheduled, the completed metadata will be submitted with the database for PIFSC to maintain and host.

Stock Assessment Research Program

P.I.: Mark A. Merrifield [JIMAR Project Lead: Marc Nadon]

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

NOAA Sponsor: Michael P. Seki, Annie Yau

Budget Amount: $570,000

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

PIFSC and JIMAR staff conducted collaborative assessments of pelagic fish stocks in the 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). The 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 Pacific Ocean. Researchers on this project also investigate stocks of bottomfish, coral reef fishes, and crustaceans in the Pacific Islands Region (PIR). 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.
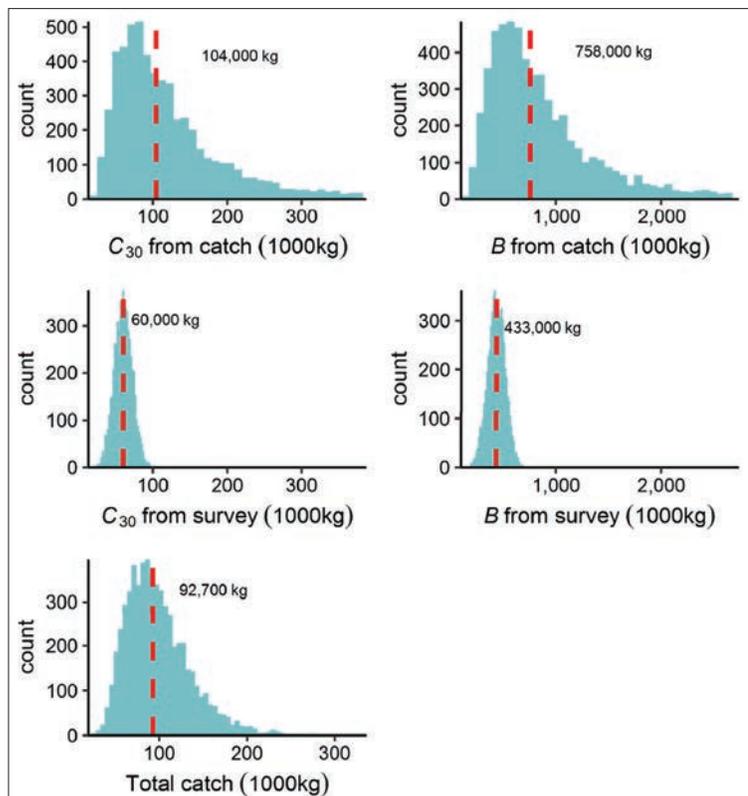

Figure 1. Biomass (B), catch at spawning potential ratio of 30% (C_{30}), and current estimate of total catch for the large snapper Aprion virescens *(uku) around the main Hawaiian Islands.*

Progress during FY 2017

For the insular assessment work, JIMAR researchers: 1) published a paper on a new meta-analytical approach to generate life history parameters in data-poor situations (see Nadon and Ault in *Canadian Journal of Fisheries and Aquatic Sciences*); 2) conducted a successful Western Pacific Stock Assessment Review of the application of length-based stock assessment to 27 Hawaii reef fish and published a large technical memorandum on this subject; and 3) continued work on the reef fish assessments for the Guam area, which will be finalized during the next reporting period. For the pelagic assessment work, JIMAR researchers participated in a suite of international scientific workshops and symposia. Of significance were the workshops of the ISC Shark Working Group and ISC Billfish Working Group. The outcome from these workshops and the associated work included: 1) data preparation for blue shark, which included data from the Pacific, including Hawaii; 2) completion of a stock assessment

Figure 2. Spatio-temporal distribution of the bullethead parrotfish around the main Hawaiian Islands, modelled from diver surveys using a new geostatistical package developed at NOAA.

for the blue shark; and 3) the completion of standardized catch rates for this species. JIMAR staff led most of these efforts and collaborated closely with federal staff on others. A paper on using fishery indicators for pelagic sharks is currently under review.

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

P.I.: Mark A. Merrifield [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

Budget Amount: $400,320

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

The JIMAR Cetacean Research Program (CRP) 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
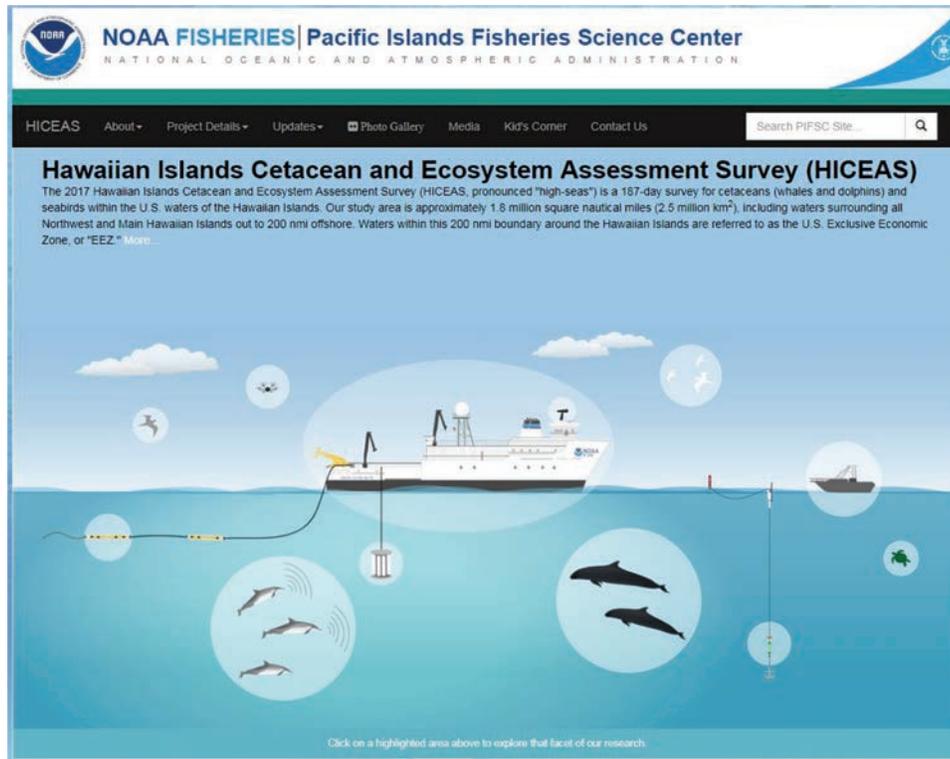
Figure 1. The HICEAS website interactive main page. Users can click on the different icons on the front page to explore the various projects and operations during HICEAS.

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 2017

The CRP spent most of FY 2017 preparing for the Hawaiian Islands Cetacean Ecosystem Assessment Survey (HICEAS). The HICEAS is a 187 day survey for cetaceans (whales and dolphins) and seabirds within the U.S. waters of the Hawaiian Islands. The study area is approximately 1.8 million square nautical miles (2.5 million km^2), including waters surrounding all Northwest and Main Hawaiian Islands out to 200 nmi offshore. The goals are to estimate how many cetaceans are in Hawaii, examine their population structure, and understand their habitat. HICEAS will provide important data for several management priorities, including the following.
- Cetacean and seabird species inventory, abundance, and habitat information for the recently expanded Papahānaumokuākea Marine National Monument.
- New abundance estimates for false killer whales in support of the False Killer Whale Take Reduction Plan (TRP), as well as for all cetacean species as required under the Marine Mammal Protection Act (MMPA).
- Updated abundance and distribution data for large whale, sea turtle, and seabird species listed under the Endangered Species Act.
- Updated cetacean and seabird assessments used to evaluate whether bycatch rates in U.S. fisheries are sustainable under the MMPA and Magnuson-Stevens Fishery Reauthorization Act.

Preparation for HICEAS included the creation of a website, which provides background information about the project, details the types of research methods that will be used, updates on the progress of the survey, photos, and downloadable activities for kids (see https://www.pifsc.noaa.gov/hiceas).

Figure 2. A longline fisherman prepares to deploy an acoustic recording device to listen for the presence of false killer whales and other cetacean species in the vicinity of the longline gear.

In addition to preparing for HICEAS, the CRP has continued to acoustically monitor the Hawai'i longline fishery for the presence of false killer whales near the fishing gear. A total of eight fishing trips have been acoustically monitored over the past year on various vessels across the fleet. Analysis of the acoustic data collected provided information about the occurrence and timing of false killer whale presence near the gear, as well as how this correlated to depredation of both target catch and bait. In addition, two manuscripts relating to this work have been published. The first, entitled "Acoustically monitoring the Hawai'i longline fishery for interactions with false killer whales" was published in *Fisheries Research*. This work involved data collected from six acoustically monitored fishing trips from a single vessel that was chartered for the effort. The second publication entitled "Using line acceleration to measure false killer whale *(Pseudorca crassidens)* click and whistle source levels during pelagic longline depredation" was published in the *Journal of the Acoustical Society of America*. This involved a collaborative effort with Scripps Institution of Oceanography to deploy cameras aimed at capturing footage of false killer whale depredation.

Cetacean Research Program—Monitoring in the Mariana Islands Range Complex

P.I.: Mark A Merrifield [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

Budget Amount: $100,000

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The primary objective of the project is the partnership with the Pacific Islands Fisheries Science Center's (PIFSC) Cetacean Research Program (CRP) to assess cetacean stocks for the protection, management, and recovery of cetacean populations in the Central and Western Pacific. The U.S. Navy developed the Monitoring Plan for the Mariana Islands Testing and Training (MITT) area as required under the Marine Mammal Protection

Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973. The overall objective of this is to collect field data that will enable the Navy and PIFSC CRP to better understand the distribution and abundance of marine mammals in the Mariana Islands Range Complex (MIRC). This JIMAR project plays a key role within the CRP working to accomplish these objectives. Visual surveys were conducted to better understand the distribution of cetaceans within the Marianas. Photo-identification, biopsy, and satellite tagging are used to evaluate population structure regionally, and to better understand species movements throughout the MITT. Data generated via implementation of this monitoring plan will be integrated into the Navy-wide Integrated Comprehensive Monitoring Program (ICMP).

Figure 1. Humpback whales off the west side of Saipan.

Progress during FY 2017

The CRP conducted surveys of cetaceans in the waters off Guam, Saipan, and Tinian in an effort to expand on the developing records of cetacean occurrence and gather information for population distribution models for species that occur in the region. Two JIMAR project efforts were carried out in 2017.

The first project was a winter effort in which the primary target species was the humpback whale (*Megaptera novaeangliae*). These surveys were a continuation of the PIFSC CRP's surveys from the 2015 and

Figure 2: Melon-headed whale encountered off of Guam in May 2017.

2016 winters. The collection of biopsy samples and photo-identifications is vital to determine the breeding population to which they belong. The small-boat surveys were conducted off Saipan during February 11-22. There were a total of 23 encounters with four cetacean species including humpback whales, short-finned pilot whales (*Globiceaphala macrorhynchus*), bottlenose dolphins (*Tursiops truncatus*), and spinner dolphins (*Stenella longirostris*). Photographs were used to confirm that a total of 25 humpback whales were encountered including two mother-calf pairs. Biopsy samples were collected from 11 humpbacks, including both mothers. Fluke images were collected from 19 humpbacks. A satellite tag was deployed on an adult short-finned pilot whale and a biopsy sample was collected from the same individual.

The summer effort was broader in focus in which no single species took priority. The small-boat surveys were conducted during May 6-26. There were 12 encounters with four confirmed cetacean species including a Bryde's whale (*Balaenoptera edeni*), melon-headed whales (*Peponocephala electra*) bottlenose dolphins, and spinner dolphins, as well as an unidentified beaked whale. Approximately 6,000 photos were taken, and biopsy samples were collected from melon-headed whales (n=12) and bottlenose dolphins (n=4). Four satellite tags were deployed; two on melon-headed whales and two on bottlenose dolphins.

In April 2017, the JIMAR CRP Program Lead presented a summary of PIFSC cetacean data collected within the Marianas 2010-2016 at the Navy Pacific Monitoring Program Review in Seattle, Washington.

Genetic data collected from melon-headed whales in the Marianas were used for a study examining the patterns of their genetic population structure within and across ocean basins. Martien et al. (Unexpected patterns of global population structure in melon-headed whales (*Peponocephala electra*), *Mar. Ecol. Prog. Ser.*, in press) found an unexpected pattern of only moderate differentiation among melon-headed whale populations and suggested that social organization may play a role.

Fishing Impacts on Non-target Species

P.I.: Mark A. Merrifield [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

Budget Amount: $174,394

NOAA Goal(s)

• Healthy Oceans

Purpose of the Project

Fishing for pelagic game is an important cultural, recreational and commercial activity in and around Hawaii. Local fishers employ a variety of means to catch target species but often have incidental interactions with threatened pelagic shark species such as oceanic whitetip *(Carcharhinus longimanus)*, silky *(C. falciformis)*, and bigeye thresher sharks (*Alopias superciliosus*). These unwanted interactions are seasonal and suggest that these species occupy fishing grounds for reasons of biological imperatives, such as feeding, mating or partuition. Typically, captured sharks are released and the major underlying assumption is that released sharks have high survivorship and continue to grow and reproduce. However, physiological stress and physical damage associated with struggling during capture may be sufficient to cause mortality after fish are released. Additionally, the nature of the release procedure or the 'handling and discard methods' used have also been

Figure 1. Twenty-five hour active track of an adult male shortfin mako shark conducted during the 2016 West Hawaii IEA cruise.

shown to influence post release survival rates. Reducing mortality to shark species with dwindling populations is important particularly for these long-lived species with low reproductive output. With this project researchers are conducting telemetry investigations to understand habitat use requirements, post-release survival rates, and identify the best handling methods for releasing sharks safely from commercial and recreational fishing gear around Hawaii.

Progress during FY 2017

To date, the project has accrued 26 days and nights of fishing effort. Catch rates of thresher sharks (the original target species) have been very low (n=2) so the project expanded the scope of the project into a larger ecological study, as the coastal waters off the west coast of Hawaii Island is an area of special interest for NOAA. The project tagged several pelagic sharks (two blue sharks, two mako sharks, two bigeye thresher sharks, and five oceanic whitetip sharks) to assess residence times and habitat use in the region. Project personnel also conducted a 25-hour active track of an adult male mako shark in coordination with the NOAA Integrated Ecosystems Assessment (IEA) program. The NOAA *R/V Oscar Elton Sette* followed the active track of the shark and conducted surveys of the deep and shallow scattering layers' movements using a Simrad EK 60 acoustic sounder to test the assumption that the diel vertical movements exhibited by pelagic sharks are due to the vertical migrations of the deep and shallow scattering layers. Some components of this work were supported by the JIMAR Stock Assessment Program project, and data garnered from these tag deployments are returning valuable information regarding post release survival rates, best handling practices and habitat use.

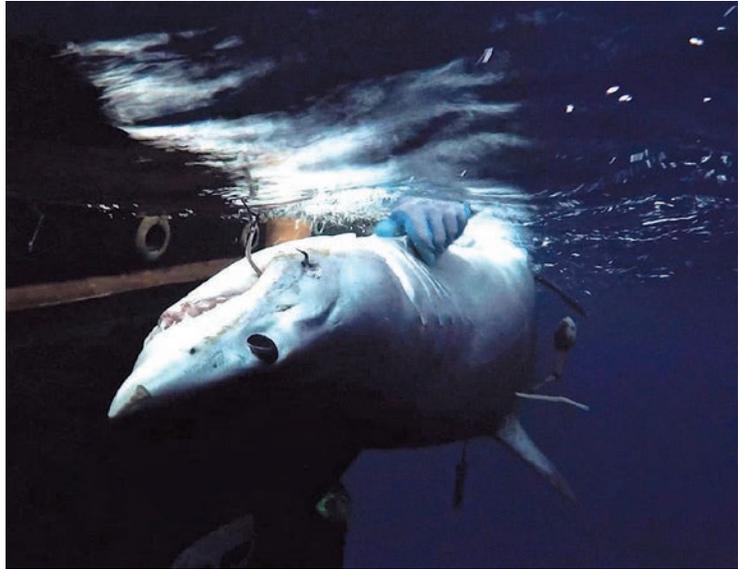*Figure 2. Mako shark tagged with a pop-off archival tag and a continuously pinging, pressure sensitive acoustic tag, prior to release and tracking.*

Figure 3. The scientific crew (pictured Dr. Melanie Hutchinson and Daniel Coffey of HIMB) actively tracking the shark with a directional hydrophone receiver and communicating the shark's heading to the vessel captain.

Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support

P.I.: Mark A. Merrifield [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

Budget Amount: $260,000

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 six main breeding sites and conduct field studies opportunistically at 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 assisted other programs and agencies by establishing and maintaining marine debris plots, conducting insect, plant, and Laysan duck surveys, and collecting sea turtle nesting data.

Progress during FY 2017

In May 2017, a total of ten field staff and five volunteers were deployed to establish field research camps at French Frigate Shoals (FFS), Laysan, Lisianski, Pearl and Hermes Reef, and Kure Atoll. Field personnel remained deployed through the end of the reporting period.

Prior to deployment, field personnel participated in securing and packing food stores and participated in training activities to mitigate shark predation on monk seals. Additional pre-deployment training and other activities by field staff are documented in the JIMAR Hawaiian Monk Seal Research Program project report.

Once deployed, field personnel collected survey and life history data and specimens, tagged and marked seals for long-term identification, monitored adult male seals for aggressive behaviors towards other seals, and participated in shark predation monitoring and mitigation to prevent monk seal pup mortality, including fishing for predatory Galapagos sharks in nearshore areas of pupping sites at FFS. Field staff also performed interventions to improve the survival of individual seals. Interventions included four disentanglements, removal of an eel from a young seal's nostril, marine debris removal to mitigate threats to seals and other wildlife, and translocations of young seals to reduce shark predation at FFS. Field personnel also monitored and rescued wildlife from entrapment due to man-made hazards at FFS. Antibiotics were administered to a juvenile seal that had dorsal injuries likely caused by adult male seal aggression.

Two weaned pups, one yearling, and one subadult seal were captured for rehabilitation at The Marine Mammal Center's Ke Kai Ola facility in collaboration with HMSRP during the 2016 field season. These seals were returned to the wild at their sites of origin at the beginning of the 2017 field season after rehabilitation over the past several months and JIMAR field staff monitored their survival once released. Field staff undertook the first vaccinations against morbillivirus on wild seals in the NWHI and participated in a monk seal vocalization study at Kure Atoll that first began during the 2016 field season at Lisianski. Field teams also monitored sea turtle nesting activity, conducted Laysan duck surveys, and provided support to NOAA/PIFSC sea turtle researchers deployed at FFS.

Figure 1. JIMAR, NOAA, and DLNR personnel offloading field supplies at Kure Atoll (photo: B. Becker).

Figure 2. JIMAR and NOAA staff cleaning up marine debris at Lisianski (photo: B. Becker).

Hawaiian Monk Seal Research Program

P.I.: Mark A. Merrifield [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

Budget Amount: $650,000

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Hawaiian Monk Seal Research Program (HMSRP) conducts research on the Hawaiian monk seal (*Neomonachus schauinslandi*; HMS), 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 for the past three years, the overall population has increased by approximately 3% annually. The program conducts studies designed to promote sound conservation and management of the species by characterizing natural and anthropogenic factors that may impede population recovery. Research focuses on connections between population

Figure 1. Getting ready to vaccinate a monk seal against morbillivirus on Rabbit Island (NMFS Permit No.16632).

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 2017

Accomplishments during the reporting period included population monitoring and assessment, survival enhancement, foraging ecology characterization, health and disease evaluation, and behavioral research. JIMAR staff played a crucial role in the establishment of seasonal field camps in the Northwestern Hawaiian Islands for the 2017 field season. JIMAR staff hired nine field staff and five volunteers, reviewed and revised protocols, trained field personnel in data, vaccination, and specimen collection techniques, procured, tested, and packed field supplies and equipment, and provided logistical support to remotely deployed field staff. Field staff departed on May 12 and a JIMAR staff member served as the field operations lead on the deployment cruise. A JIMAR staff member was also deployed on a U.S. Fish and Wildlife cruise on the *M/V Kahana* to French Frigate Shoals (FFS), Laysan, and Midway in April 2017. During the cruise, ten barrels of gasoline were delivered to FFS for the HMSRP summer field camp and monk seal surveys were conducted at all three locations. While on Midway, the JIMAR staff member trained a Fish and Wildlife Service biologist and administered the first vaccinations in the NWHI. A JIMAR staff member traveled to Kona in June to assist The Marine Mammal Center staff with the care of seals collected for rehabilitation during the 2017 deployment cruise at the monk seal hospital Ke Kai Ola.

Additional accomplishments by the program include collecting survey and life history data and specimens in the main Hawaiian Islands (MHI), and ensuring data resources were compliant with the NOAA Plan for Increasing Public Access to Research Results (PARR) requirements. Program staff continued to improve and

refine the Seal Population Assessment (SPA) database providing for greater efficiency. Improvements include creating a mechanism to check and import MHI Google Sheet entries from Island Coordinators (based on Kauai, Maui, and Hawaii Island) directly into SPA on a monthly basis, and automating the creation of weekly report summaries that can be sent from the field camps to Honolulu. JIMAR staff attended Hazardous Waste Operations and Emergency Response training in March 2017, and project personnel continued ongoing vaccinations of wild seals against morbillivirus and trained partners in vaccination and pole syringe techniques and protocols. Two staff participated in training to operate Unmanned Aircraft Systems for future

Figure 2. De-hooking response at Ka'ena Point (NMFS Permit No. 18786).

monk seal surveys and health assessment studies. Program staff conducted in-water capture training operations in February. A JIMAR staff member also traveled to Grand Isle, Louisiana to assist with and learn from the Barataria Bay Dolphin Health Assessment Program about dolphin capture techniques in order to apply them to Hawaiian monk seal in-water captures. A staff member traveled to Molokai to train cooperators in monk seal vaccination protocols and techniques to assist with vaccinations of monk seals against morbillivirus, and tagging and vaccinating weaned pups at Kalaupapa.

The foraging ecology program deployed telemetry and animal-mounted video equipment to document individual HMS movements. Health and disease research included collection of biomedical samples for disease surveys in the MHI in conjunction with telemetry deployments and from stranded animals and shipped samples for analysis at various laboratories. Emergency responses during the reporting period included the capture and hook removal of seals on Kauai and Oahu. Staff also participated in monk seal necropsies. HMSRP began reorganizing tens of thousands of samples in the frozen specimen archive, and tissue samples were reduced to smaller sizes, barcoded, and their locations were entered into the specimen database. This effort allows improved and more immediate access to samples. JIMAR personnel continued collaboration with outside researchers to assess risks posed by *Toxoplasma gondii* to monk seals and also participated in ongoing maintenance of the live animal care life support system.

Marine Turtle Recovery in the Pacific Islands Region

P.I.: Mark A Merrifield [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

Budget Amount: $375,000

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The JIMAR Marine Turtle Recovery in the Pacific Islands Region project is a component of the PIFSC Marine Turtle Biology and Assessment Program (MTBAP) and includes nine discrete elements: 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 data sets to better understand population dynamics; 5) assist with health assessments and disease investigations with focus on sea turtle fibropapilloma tumor disease; 6) administration of a sea turtle stranding and salvage network for research and live turtle rehabilitation; 7) educational outreach to the public focused on sea turtle research results; 8) maintenance of efficient and secure computerized storage, management, and retrieval of sea turtle research data; and 9) training observers in the collection of sea turtle data while aboard commercial longline fishing vessels.

Figure 1. Stakeholders for sea turtle research on Guam updated their collaborators on prospective research studies at the 'Haggen [turtle] Huddle' held on May 15, 2017. Participants included JIMAR's Dr. Camryn Allen (front center) and MTBAP scientist Dr. Summer Martin (front right), as well as representatives from NOAA PIRO, Guam DAWR, NOAA OLE, Anderson Air Force Base, U.S. FWS, Naval Base Guam, the U.S. Navy, CNMI DFW, and Guam Fishermen's Cooperative Association.

Progress during FY 2017

The core objectives were accomplished including: 1) captive 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 outer 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) research on the general biology, life history, and ecology of sea turtles in coastal marine habitats and on nesting beaches; and

Figure 2. JIMAR employees with the MTBAP conducted marine turtle surveys and in-water capture of green turtles (Chelonia mydas) and hawksbill turtles (Eretmochelys imbricata) in the nearshore waters of Guam in May 2017. Captured turtles were weighed, measured, biopsied, bled, and tagged in an effort to expand knowledge on the population demographics and fine-scale habitat use. Dr. Summer Martin (left) is restraining a juvenile hawksbill sea turtle in preparation for Dr. Camryn Allen (right) to obtain a blood sample from the jugular vein within the neck. This sample will allow her to determine the sex of the turtle via hormone analysis for an ongoing study to understand the population sex ratio within the Mariana Islands and the potential effects of climate change.

7) participation in the planning, preparation, and data analysis/reporting of annual nesting beach field work on East Island, French Frigate Shoals (FFS).

Three JIMAR seasonal hires were recruited into the project between January and May 2017 and deployed to FFS in conjunction and coordination with the JIMAR Hawaiian Monk Seal Research Program project. By the end of the reporting period, the three field researchers at FFS: deployed four satellite tags on nesting females; identified ~160 male basking turtles; identified 661 basking females with confirmed nest laying of 367 females; and counted the number of eggs in 122 nests with 50 data loggers deployed to monitor nest temperatures throughout the incubation period. The project also recruited a marine turtle researcher to bolster the program's ability to gain additional demographic data and statistically model aspects of sea turtle ecology in the PIR (e.g., abundance, sex and sex ratio, and effects of climate change). An intern hired through the PIFSC Young Scientist Opportunity program is conducting a 2017 summer study on age and growth of newly recruited green sea turtles to the MHI.

A few objectives were not met due to the turnover of JIMAR employees during the timeframe allotted to achieve the objectives. These include: 1) studying the pelagic ecology and movements of sea turtles to develop management strategies to reduce fisheries bycatch; 2) organizing longline observer training sessions; and 3) participation in and assistance with the planning of future meetings of the China/USA Working Group of the NOAA Living Marine Resources panel initiative.

Pacific Islands Deep Sea Coral and Sponge Initiative

P.I.: Mark A. Merrifield [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, Frank Parrish

Budget Amount: $429,000

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 to advance knowledge of deep-sea corals and sponges in the U.S. Pacific Islands in order to improve the management of these important resources.

The objectives of the project are to: 1) compile and synthesize existing data from deep sea coral and sponge observations in the U.S. Pacific Islands; 2) compile and create an interpretive geological substrate map for the U.S. Pacific Islands and update bathymetry and backscatter syntheses from mapping data; 3) identify and map areas of high abundance and diversity of deep-sea corals and sponges in the Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Papahānaumokuākea Marine National Monument (PMNM), Pacific Remote Islands Marine National Monument, Marianas Trench Marine National Monument, the Marianas archipelago, and in American Samoa; 4) examine the benthic and oceanographic conditions that promote development of deep-sea coral and sponge ecosystems; 5) synthesize data on temperature, currents, pH, etc. from deployed instruments in known precious coral beds and use analysis of collected precious coral skeletons as a record of environmental change; and 6) coordinate and process data from multibeam surveys of American Samoa, the Pacific Remote Islands Marine National Monument (PRIMNM), and the Mariana and Hawaiian Archipelagos in depths shallower than 500 m.

The project has two operational components: one conducted by the EcoSpatial Information Team in the Ecosystem Sciences Division (ESD) at PIFSC; and one affiliated with the Hawaii Undersea Research Laboratory (HURL) in the Department of Oceanography at the University of Hawaii at Manoa.

Figure 1. The lab and UH team on the final day when all biological specimens from 2016 were packed and shipped to the Smithsonian. Packing followed stringent U.S. shipping requirements where each specimen was drained of alcohol, double bagged in heat sealed bags, which were in turn wrapped in absorbent packing material and finally placed into a third bag before being put in the shipping boxes.

Progress during FY 2017

Accomplishments from the bathymetric mapping component of this project, conducted by JIMAR ESD staff at PIFSC include the following.

Multibeam Data Collection. New multibeam data were collected by the NOAA *R/V Hiʻialakai* (*HA*) in the Northwestern Hawaiian Islands during the Reef Assessment and Monitoring Program (HARAMP) mission and during the Mariana Archipelago Reef Assessment and Monitoring Program (MARAMP) in March–July 2017. The project team staffed the HARAMP mission to provide direct support for the multibeam operations and Conductivity Temperature and Density (CTD) activities, ancillary ship-based support was provided for MARAMP. The project team also provided land-based support for both missions. Due to technical issues related to the ship's multibeam and associated systems, HARAMP primarily served as a trial for multibeam operations in 2016. While many issues were addressed in advance of MARAMP, problems persisted and new issues arose during the mission resulting in an all-stop of multibeam operations prior to the end of the second leg of the cruise. Mapping operations were conducted in select locations as determined by a bathymetry coverage gap analysis.

Hiʻialakai Support for Multibeam Mapping. The project team provided support to the *HA* in preparation for, during, and following HARAMP and MARAMP, including: 1) troubleshooting components of the multibeam systems that weren't properly functioning; 2) provided on-going ship-based and software training to the Survey Tech and project team members; 3) coordinated software and hardware vendors and arranged land-based support; 4) provided content for the mission instructions and permits; and 5) conducted a bathymetry coverage gap analysis for the Northwestern Hawaiian islands, the Pacific Remote Island Areas surveyed during MARAMP, and the Mariana islands in advance of each relevant mission.

Multibeam Data Processing and Reporting. A draft internal report, "Multibeam bathymetry data from 2015-2017 RAMP cruises (American Samoa RAMP or ASRAMP; HARAMP; MARAMP)", was prepared by the project team detailing the activities, findings, and challenges associated with the multibeam data collections during the Reef Assessment and Monitoring Program (RAMP) missions from 2015 to 2017. In summary, it was intended that the final data would be incorporated with existing, previously acquired bathymetry data in each region to create seamless products, and update the associated bathymetry data products to be published and archived online. It was understood at the outset, however, that the original acquisition of the ASRAMP
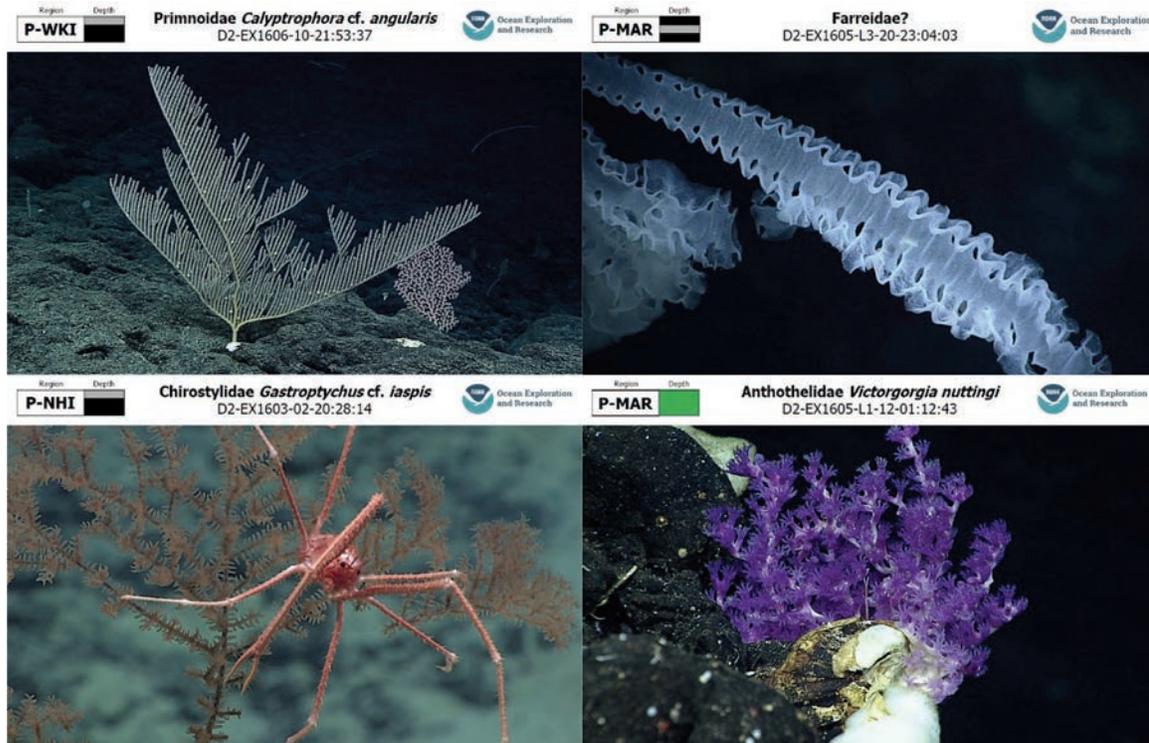
Figure 2. Example images from version 2 of the OER Deepwater Benthic Animal Guide.

and HARAMP bathymetry data was inhibited by several significant problems (e.g., sonar calibration/sea trials not implemented, therefore not detecting faulty sonar head and roll-bias; poor sound-velocity control of water column; and potentially imprecise positioning), and thus the acquired data may suffer from several intrinsic issues. Unfortunately, several of the issues persisted through to the acquisition of the MARAMP data, as results from the sea trials conducted during the mission showed that previously identified problems with the hardware had not actually been resolved.

Accomplishments by the UH HURL team to provide cruise planning logistics and post-cruise deliverables include the following.

Processing and analysis. The University of Hawaii (UH) component of the project consists of Dr. Christopher Kelley, Program Biologist for the Hawaii Undersea Research Laboratory (HURL), Virginia Moriwake, Deep Sea Animals Research Specialist, and Sarah Bingo and Meagan Putts, Deep Sea Corals Research Associates.

Dr. Kelley's responsibilities for the project are providing cruise planning and execution for expeditions on the NOAA *R/V Okeanos Explorer (EX)*, and providing *EX* post cruise deliverables. Moriwake was responsible for assisting with *EX* post cruise deliverables and extracting and formatting additional HURL coral and sponge annotation records for DSCRTP. Bingo and Putts assisted with the processing of *EX* post cruise deliverables.

Specific post cruise deliverables from the UH team include: 1) retrieved and processed all specimens and samples acquired during the cruises; 2) retrieved all data, imagery, and video products from the ship and created backup copies; 3) processed all raw data products particularly tracking, CTD, and event logs; 4) organized the biological images captured by the onboard videographers into taxonomic groups; 5) identified the animals to the lowest taxonomic level after input from taxonomic experts and created an online animal guide for use as a reference; 6) created coral and sponge records from the dive video using the Video Annotation and Reference System (VARS) software developed by the Monterey Bay Aquarium Research Institute; 7) merged these records with tracking and CTD data, extracted the VARS records, and subjected them to a quality control protocol; and 8) formatted and submitted the records for incorporation into the DSCRTP national database.

The methodology used by this team was designed to provide data products to address key priorities of the project: 1) identification of the depth distributions of corals and sponges, especially between 500 m and 4000 m; 2) identification and geo-location of areas of high abundance and diversity of deep-sea corals and sponges in the

Main Hawaiian Islands, the Papahānaumokuākea Marine National Monument, Pacific Remote Islands Marine National Monument, Mariana Trench Marine National Monument, Marianas archipelago, and American Samoa; and 3) identification of the benthic and oceanographic conditions that promote development of deep-sea coral and sponge ecosystems. In addition, the team was also tasked with the compilation and synthesis of existing data from deep sea coral and sponge observations in the U.S. Pacific Islands, implementation of protocols for the collection, identification, preservation, and cataloging of specimens collected during Remotely Operated Vehicle (ROV) dives, and extract records of fishes encountered during ROV dives.

Specimens and Samples. The 2016 *EX* cruise schedule began in mid-February 2016 and was completed in mid-September 2016 with the ship's return to Honolulu. The UH team took custody of the specimens collected in 2016 upon the ship's return and transferred them to Kelley's lab where they underwent post cruise processing prior to being transferred to their final repositories. The 2017 *EX* cruise schedule began in Honolulu in mid-January 2017 and is still underway. The ship is currently conducting the sixth cruise of this year, which is focused around Johnston Atoll. Specimens collected during the five prior cruise legs in the South Pacific were transferred to Kelley's lab after the ship returned to Honolulu in May.

Post cruise laboratory processing for specimens from both years took place during the report period. This began with an inventory of all the biological and geological samples, checking the condition of the former and adding preservative as needed, and cross-checking all specimens with the corresponding collection data recorded in the sampling database. Any errors or incomplete fields in the database or with the specimen labels were added or corrected. Table 1 provides a summary of the specimens collected either as the primary specimen, an associate of a different primary specimen, or an associate found on a rock (i.e., other).

A total of 421 animals were collected during the report period that included 175 primary (i.e., targeted) specimens of cnidarians (106), sponges (47), and other invertebrates (22), as well as 246 other invertebrates associated with these specimens (191) or found on rock samples (55). Most of the coral and sponge specimens were subsampled to obtain small pieces for curation at the Bernice Pauahi Bishop Museum in Honolulu. The remaining main portion of each coral and sponge along with all of the associates were then packed and shipped to the National Museum of Natural History (Smithsonian) for acquisition into their collections.

Many of the primary and associate specimens (i.e., 293) were also subsampled on the ship for DNA analysis as part of the Ocean Genomic Legacy (OGL) project, which provided an onboard processing kit. The UH team inventoried and cross-checked the OGL subsample vials with the database, corrected any errors, and then shipped the entire kit back to Northeastern University where the OGL project is headquartered. All 152 rock samples collected during the report period were shipped to the geological repository at Oregon State University.

Data. The tracking data, CTD data, and event log files are priority data types required to create the DSCRTP deliverables. The files were provided in their raw form so data processing steps were required in order to render the files useable. A tracking data processing template was created in Excel in order to convert the date and time fields in the raw data to a combined format that is standardized for all data types as well as imagery file names and video. The CTD data files were provided from the ship in raw Seabird hex format. Seabird data processing software was used to convert selected data into a usable format. The data in these files were then imported into a CTD data template created in Excel by the UH team and saved. Once this was completed, the tracking and CTD data were combined into a single Excel file on the basis of their converted date/time codes. This file contained latitude, longitude, depth, temperature, oxygen, salinity, and date/time fields and can be imported directly into ArcGIS for visualization of the dive tracks and environmental data or merged with video annotations using custom scripts. The UH team is currently up to date on this task: all of the 2016 and 2017 CTD and tracking data were processed and the final files were created and are ready to merge with the annotation data.

Imagery. The UH team first extracted all images from the 2016 dives that captured animals then created a taxonomic spreadsheet organized by phylum that contained hyperlink field along with the combined tracking/ CTD data for each image. The initial identifications were based on comments made in the dive event logs, comments in email correspondence with taxonomic specialists, and Kelley's experience working with deep water animal identification for HURL. Once the best possible identifications had been made, images were selected for inclusion into the next version of the online animal guide. This protocol was used last year with the 2015 imagery to train staff in the identification of deep-water animals. The project reformatted the individual guide images to include a region code and combined the 2015 and 2016 images for the updated guide. The total number of guide images now exceeds 2,900 and are in the final process of preparation before being submitted to the NOAA website team for posting.

Table 1. Summary of the specimens collected during EX 2016 and 2017 cruises.

Specimen Type	Phylum	Year	Primary	Associate	Other	Total
Primary	Cnidaria	2016	51	10	12	**73**
		2017	55	29	6	**90**
	Porifera	2016	30	5	8	**43**
		2017	17	6	9	**32**
Associate	Annelida	2016		6	1	**7**
		2017	1	11		**12**
	Arthropoda	2016		13	1	**14**
		2017		32	6	**38**
	Echinodermata	2016	8	11	7	**26**
		2017	9	48		**57**
	Mollusca	2016	1	2	3	**6**
		2017		10		**10**
	Other Invertebrate	2016	3	3	2	**8**
		2017		5		**5**

Table 2. Counts and percentages of animals from six submersible dives and one ROV dive conducted in the Line Islands.

Phylum	Number of Individuals	Percent of Individuals Counted
Arthropoda	1960	4.9%
Chordata	9997	25.2%
Cnidaria	9670	24.4%
Ctenophora	61	0.2%
Echinodermata	16740	42.2%
Mollusca	645	1.6%
Porifera	551	1.4%
Unknown	1	0.0%
Grand Total	**39625**	**100.0%**

Video. The annotation protocol developed by the UH team is the same as last report period and involved creating records of all deep sea corals, sponges, and fishes captured on the dive video as well animal associates observed on the corals and sponges. The protocol also involved the extraction of substrate and habitat data, sizes, counts, and noting identification certainties for each record. Responsibilities for the entire video annotation process were identified and assigned. The analysis team has been conducting the annotations in VARS, then applied the VARS scripts to merge the tracking/CTD data with the annotations based on their time codes, and ran queries in VARS to extract the records for each dive as text files. These files are subsequently imported into Excel and fitted into DSCRTP's seventy-two field database template. The team applies a quality control protocol to look for inconsistencies in depth, substrate, and identifications, and re-reviews the video for records with potential problems. Each identification was double-checked against the online taxonomic database to ensure correctness and consistency. Once quality control is completed for each dive, the records are then considered ready for submission to DSCRTP. By the end of this report period, the team had annotated all of the video from the thirty-seven dives conducted in 2015, all of the video from the first cruise of 2016, and half of the dives from the first cruise in the Mariana Archipelago.

Additional accomplishments. In addition to the tasks listed above, the UH team also compiled additional HURL submersible records for submission to both DSCRTP and NOAA Pacific Islands Fisheries Science Center. This task involves the extraction, formatting, and quality control on additional records from the Line Islands and Hawaii. Annotation of video from one ROV dive in the Line Islands was also completed. These new records were combined with records from six submersible dives previously annotated, and the complete data set from the seven dives was provided to NOAA staff. In all, a total of 39,625 animals were recorded from the seven dives. More than 40% of the animals identified overall were echinoderms. At Jarvis Island, that phylum accounted for more than 60% of the animal counts. In particular, crinoids and urchins were the dominant animals representing more than 50% of the animals counted. In contrast, nearly 40% of the animals identified at Kingman Reef were fish, more than 5,000 of which were scorpionfish (genus *Setarches*). Palmyra Atoll was intermediary between the other two locations, with about 45% of echinoderms and 30% fish, including more than 3,000 urchins and 2,000 *Setarches*.

The UH team was also responsible for processing and preparing 16,000 additional coral and sponge submersible records from the Hawaiian Archipelago conducted by HURL, as well as adding substrate information to 35,000 records of corals that were already submitted to DSCRTP several years ago without that information. For many of the records in both data sets, an observation time is being determined in order to merge CTD (depth, temperature, salinity, and oxygen levels) and provide the closest tracking (latitude and longitude) location. Once these tasks are completed, these records will be submitted to DSCRTP.

Papahānaumokuākea Marine National Monument Monitoring and Research

P.I.: Mark A Merrifield [JIMAR Project Lead: Brian Hauk]

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

NOAA Sponsor: Randall Kosaki

Budget Amount: $525,000

NOAA Goal(s):

- Resilient Coastal Communities and Economies

Purpose of the Project

The JIMAR Papahānaumokuākea Marine National Monument (PMNM) Monitoring and Research Project conducts primary research and monitoring activities in order to characterize the spatial distribution and composition of marine ecosystems within the PMNM and other partner NOAA Marine Sanctuary sites. Monitoring activities utilize scuba gear, technical diving gear (including closed-circuit rebreathers), small boats, and other scientific equipment, primarily to collect data on the marine ecosystems of the Northwestern Hawaiian Islands (NWHI) from 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 better advise management and policy decisions in order to conserve, protect, and enhance the biodiversity of the PMNM.

Figure 1. JIMAR/NOAA Diver conducts mesophotic fish survey at 100m in A. Samoa on mixed gas CCR (photo: Daniel Wagner).

Progress during FY 2017

The primary objectives of the JIMAR PMNM project are: coral reef monitoring; characterization of mesophotic coral ecosystems; characterization of deep-sea habitats, and PMNM resource protection. Milestones and accomplishments of each objective include the following.

Coral Reef Monitoring. There was no Reef Assessment and Monitoring Program (RAMP) cruise during FY 2017. Data from previous cruises (2007-2016) were analyzed and submitted as a manuscript to a peer-reviewed journal by JIMAR staff. That paper is currently in review by the journal *PeerJ*. The RAMP cruise for FY 2018 is scheduled for 9/6/17-9/30/17. Logistical planning, preparation, intern selection, and training have been ongoing since the FY 2017 in preparation for this cruise.

Characterization of Mesophotic Coral Ecosystems. There was no Mesophotic Research Cruise to the NWHI during FY 2017. JIMAR staff analyzed data from previous cruises (2010-2016) and published two manuscripts in the peer-reviewed journals *Coral Reefs* and *PLoS ONE*. One additional article is currently in review with the journal *BioInvasions Records*. In February 2017, JIMAR staff also participated in a collaborative project with the National Marine Sanctuary of American Samoa (NMSAS) and completed a series of technical Closed Circuit Rebreather (CCR) SCUBA surveys at depths of 200-330 feet off Tutuila Island in American Samoa. Seventeen species of fish previously unknown from this area were recorded. Several black coral and gorgonian species that are new to this area, and possibly to science, were also collected. Taxonomic identification of these species has been ongoing since the completion of the surveys for publication in peer-reviewed scientific journals.

Figure 2. JIMAR/NOAA diver conducts alien species surveys on newly discovered maritime cultural resources as part of multi-disciplinary project in Midway Atoll (photo: Bret Seymour/NPS).

In support of this project in American Samoa, JIMAR/PMNM Science Operations Associate Stephen Matadobra joined the team as a chamber operator and dive medical technician and also met with staff at the Lyndon B. Johnson Tropical Medical Center to discuss future plans for their monoplace hyperbaric chamber. This chamber was provided to the Medical Center via funds from the NMSAS to help support dive operations as well as to improve the well being of the community. Future training and operations were discussed with top staff at the Medical Center and NMSAS in order to regain the full operational status of the chamber.

Characterization of Deep-Sea Habitats. This objective was originally included for a black coral expert who worked at the PMNM office. However, shortly before the start of the JIMAR PMNM Monitoring and Research Project, he accepted a position with NOAA's Deep-Sea Coral Research and Technology Program and left the office. Due to this loss of the main staff member responsible for this collaboration, this objective was removed from the project for FY 2018. Efforts were made to survey contiguous areas in both mesophotic and deep-sea habitats of Sanctuary waters around American Samoa in February 2017 when mesophotic CCR surveys coincided with the NOAA Ship *Okeanos Explorer's* Remotely Operated Vehicle (ROV) surveys.

PMNM Resource Protection. In May 2017, JIMAR staff participated in surveys around Midway Atoll to investigate maritime heritage resources and alien invasive species. Funded by a grant from NOAA's Office of Exploration and Research, this multi-disciplinary project used magnetometer surveys to explore for sunken aircraft sites associated with the Battle of Midway in 1942 and investigated distributions of alien invasive species on and
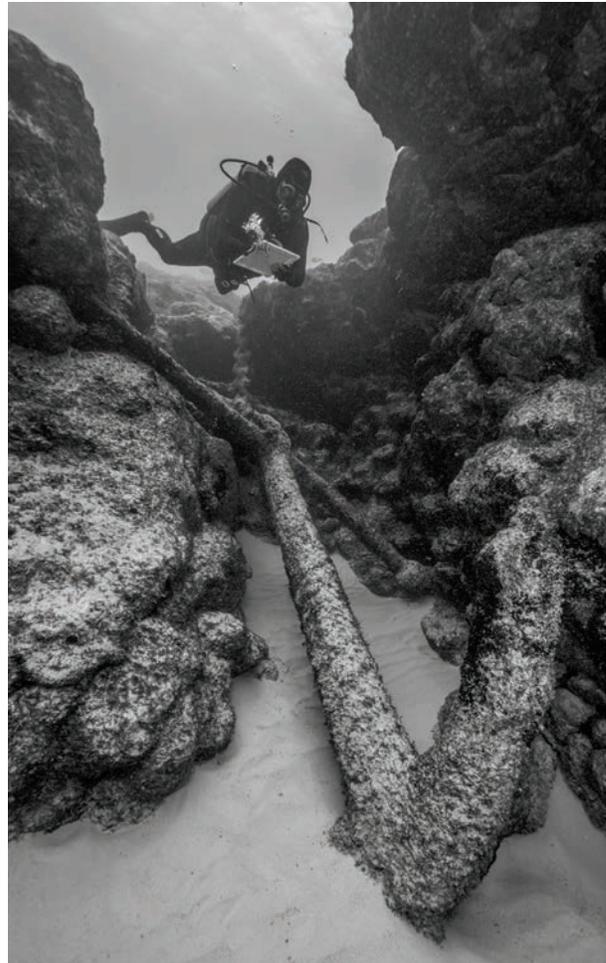
around maritime heritage resources. Data visualization and analysis for alien invasive species have been ongoing by JIMAR staff since the completion of surveys. JIMAR staff used shallow-water and mesophotic fish data to investigate the horizontal and vertical distribution of an introduced species, *Lutjanus kasmira*, in the NWHI and submitted a manuscript to a peer-reviewed journal. JIMAR staff conducted several vessel hull inspections during FY 2017 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, which are noted for their low abundances of alien species. JIMAR staff participated in several coordinated response activities and trainings to ensure the PMNM's resources are protected in the event of a ship grounding, oil spill, or other natural/anthropogenic disturbances. JIMAR staff also assisted with the coordination of marine debris removal and shipping it back to Honolulu for recycling.

Rapid Increases in Reproductive Information for Exploited Reef Fish and Enhanced Research Capacity through Training to Support Ecosystem-Based Fisheries Management in Guam

P.I.: Erik C. Franklin

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

NOAA Sponsor: Michael P. Seki, Brian Langseth

Budget Amount: $65,623

NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

One of the fundamental challenges for the assessment of tropical fish species is an accurate understanding of the reproductive dynamics of managed stocks. The sheer diversity of coral reef fishes and the supposed cost associated with detailed reproductive analysis of each species are often cited as barriers to obtaining important baseline life history information. To address these issues, Longenecker et al. (2013)[1] developed the "Jungle Histology" method for rapid, low cost, and on-site histology-based reproductive analysis with standard methods for the discipline of fish life history analyses that result in scientifically credible and publishable results. Using these approaches, the project proposed to train eight participants, including fishery professionals and students, in reef fish reproductive analysis using the Jungle Histology workshop format through an innovative, hands-on three-week workshop hosted at the University of Guam Marine Lab. The intent was that the results of the reproductive analysis training by the participants from the workshop would be used directly for sustainable fishery management practices and also submitted for publication in scientific journals.

Progress during FY 2017

The project sponsored a Jungle Histology workshop in Guam during June 3-24, 2017. It exceeded its original goal of eight participants by training 13 participants, including five fishery professionals from the Guam Department of Aquatic and Wildlife Resources and eight students from the University of Guam. The participants examined the reproductive status of seven reef fish species (*Acanthurus lineatus*, *Epinephelus hexagonatus*, *E. merra*, *Monotaxis grandoculis*, *Paracirrhites arcatus*, *Siganus argenteus*, and *S. spinus*) using methods attained during the workshop including fish dissection, resin block preparation, and gonad sectioning (Figure 1). Students performed histological interpretation of fish sex and reproductive stage for female fish from the slides of gonad sections and analyzed data to determine length-weight, length-at-maturity, fecundity, and sex ratio relationships (Figure 2).

[1] Longenecker, K., R. Langston, and H. Bolick (2013) Rapid reproductive analysis and length-dependent relationships of *Lutjanus biguttatus* (Perciformes: Lutjanidae) from Papua New Guinea, *Pac. Sci.*, 67, 295-301.
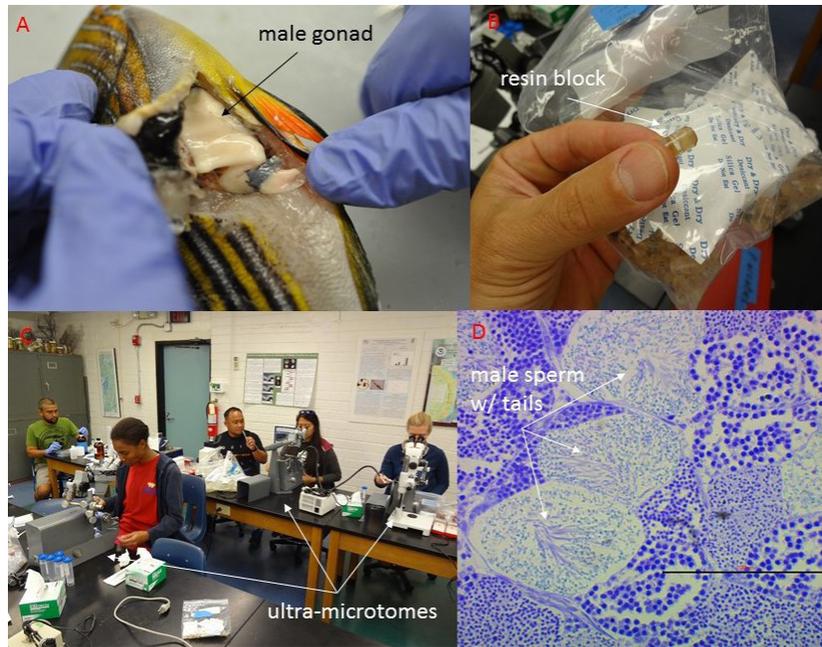
Figure 1. A visual summary of the methods used in the Jungle Histology Guam workshop: (A) dissection of the fish specimen to remove the gonad (male testes in image); (B) preparation of the gonad in a resin block for sectioning; (C) a group of Jungle Histology participants sectioning gonads in resin blocks using ultra-microtomes for preparation of histological examination; and (D) a microscopic image of a testes of the blue-lined surgeonfish Acanthurus lineatus showing male sperm with tails (image 400x magnification stained with toluidine blue).
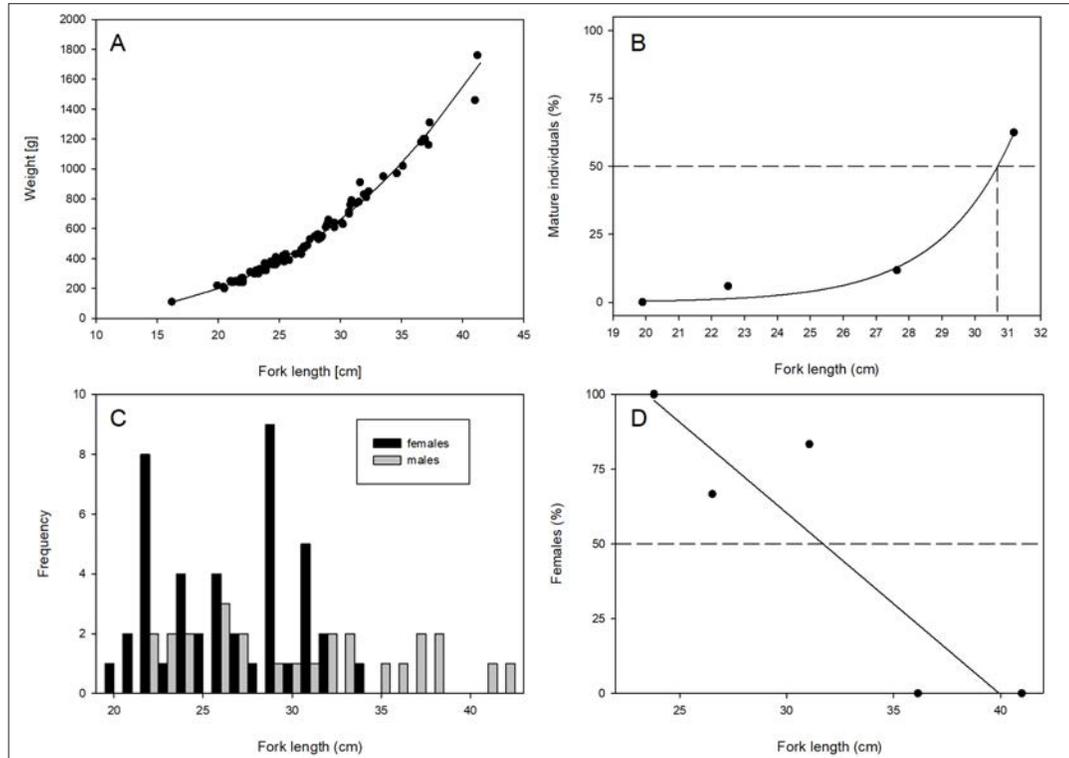
Figure 2. Life-history traits of bigeye emperor Monotaxis grandoculis in Guam. (A) Length-weight relationship; (B) female size-at-maturity; (C) sex-specific size-frequency histograms; (D) size-specific sex ratio.

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

P.I.: Mark A. Merrifield

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

NOAA Sponsor: Christopher Sabine, William S. Kessler

Budget Amount: $72,846

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 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
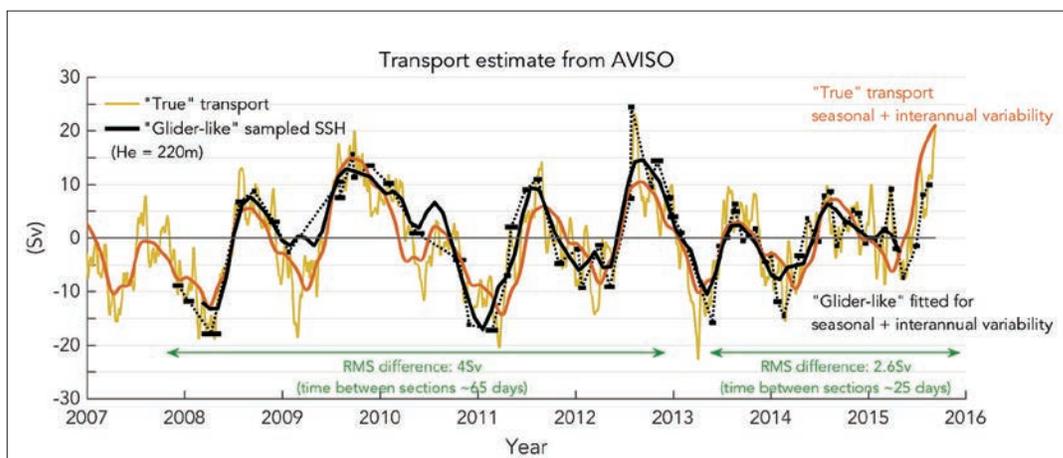
Figure 1. Two ways to estimate cross-sea transport, both using AVISO. The estimate of "true" transport is based on a simple daily cross-Sea SSH difference (yellow line). A second, "glider-like" measure samples Archiving, Validation, and Interpretation of Satellite Oceanographic Data (AVISO) at the times and locations of each glider dive, finding transport by integrating the cross-track velocity segments as is done for the actual glider data (black boxes show times of each glider transect). Both the true and glider-like AVISO-derived time series are filtered to represent the low frequency signals of interest here (heavy red and black lines, respectively). The difference is the effect of intraseasonal aliasing on glider-measured transport.
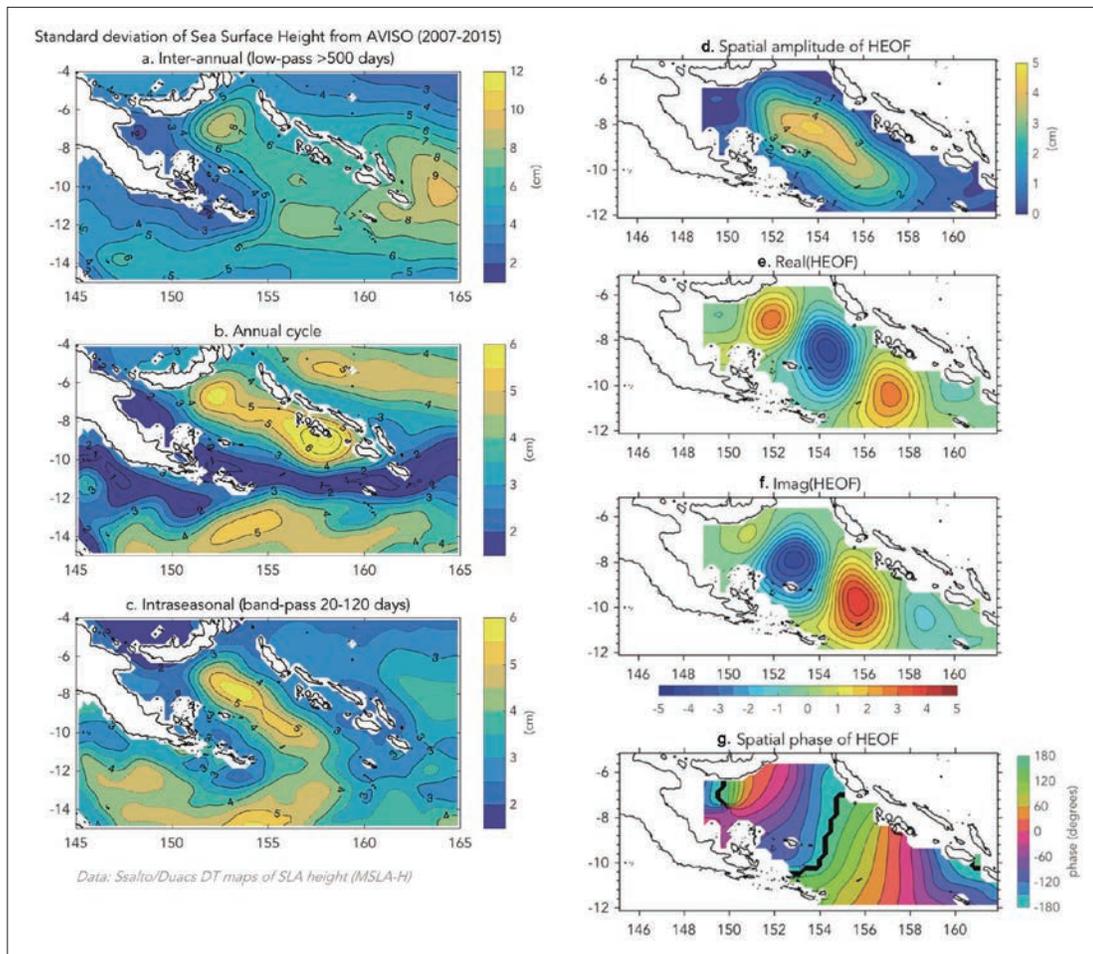
Figure 2. Left panels: (a,b,c) AVISO altimetric SSH RMS in three frequency bands. Right panels: Gravest-mode Hilbert EOF of the intraseasonal variability, representing 35% of the variability. The spatial amplitude of the HEOF (d) captures the bulk of the (c) intraseasonal signal. (e,f) The spatial pattern shows the eddy-like signals have the scale of the width of the Sea. (g) The phase shows the along-sea northwestward propagation.

the submesoscale, mesoscale and large-scale circulation. The results will inform the physical interpretation of satellite sea surface height observations of these eddies by clarifying their subsurface structures and generation processes.

Progress during FY 2017

During FY 2017 the project's primary goals were to characterize the role of meso and submesoscale eddies in the Solomon Sea circulation, in particular, how they impact the interpretation of in situ data (glider, Argo).

The interior Solomon Sea is characterized by energetic intraseasonal variability, which matches the seasonal cycle in magnitude. Analysis of altimetric sea surface height shows that the intraseasonal surface variability in the Solomon Sea is dominated by a signal with a 50-60 day period, westward phase propagation, and basin-size lateral scale (~400 km), suggestive of the excitation of low-order resonant basin modes. The signature of the surface intraseasonal eddy signal seen in altimetry can be found in the vertically-averaged glider-measured velocity, suggesting a large vertical scale. Because the time needed by the glider to a complete a section across the Solomon Sea is comparable to the 50-60 day period of the eddies, background conditions in the Solomon Sea change significantly during sampling. This explains the large observed section-to-section differences in transport estimates from the glider.

During FY 2017, the potential aliasing of slow in situ sampling was quantified by the altimetric analyses. This enabled the proper choice of spatial and temporal averaging towards credible descriptions of the vertical and

horizontal structures across the Solomon Sea. This in turn allows the U.S. to characterize the mass and heat fluxes through the Solomon Sea towards the equator, with full understanding of the errors introduced by eddy aliasing.

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 Donald E. Jones

Budget Amount: $182,084

NOAA Goal(s)

- NOAA Enterprise-wide Capabilities: Science and Technology Enterprise; Engagement Enterprise; Organization and Administration Enterprise

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 to apply project software and expertise to the NOAA fleet and continue the 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 the National Centers for Environmental Information (NCEI) so that the observations are available for future researchers.

Progress during FY 2017

The project installed its systems on all 11 of the NOAA ships that have ADCPs in place and continue to monitor their operation. The project originally planned to support three additional ships, but the installation of their ADCP hardware by NOAA has been delayed indefinitely. Much of the development required for updating project software to the next operating system release was completed. Support and analysis regarding the failure of the replacement transducer on the NOAA *R/V Oscar Elton Sette* are on-going. Initial contacts, destinations, methodologies, and channels for a data pipeline between the shipboard University of Hawaii Data Acquisition System (UHDAS) and a NOAA archive were identified.

University of Hawaii Sea Level Center

P.I.: Mark A. Merrifield

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

NOAA Sponsor: David Legler

Budget Amount: $716,073

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 climate, oceanographic, ocean engineering, and geophysical research. While UHSLC assembles time series from many tide gauge

stations, the primary focus is the set of stations that constitute the 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. Because of their importance for global and regional sea level reconstructions, vertical land motion monitoring is recommended at all GLOSS and GCOS stations and the UHSLC maintains 11 continuous Global Positioning System (GPS) receivers at these stations. A primary objective of the UHSLC is to maintain two tide gauge data sets: the Fast Delivery data set, which provides preliminary, quality-assured, hourly tide gauge data within 4-6 weeks of collection; and the Research Quality data set, which is an archive of hourly tide gauge data that have undergone a complete quality assessment generally within one year of collection. The Research Quality database is maintained in collaboration with the National Oceanographic Data Center. The UHSLC acquires tide gauge data from nearly 500 tide gauge stations maintained by

Figure 1. Sample sea level anomaly forecast for Pago Pago, American Samoa showing the predicted ending of a minor high sea level event (October–March 2016/2017). The multi-model mean 6-month forecast (green) is provided for the first half of 2017 (models are classified as dynamical [circles] or statistical [squares]) in the context of recent observations (black), decadal trend (red), and the seasonal cycle (grey). The dashed line indicates a composite of verified sea level anomalies through June 2017. Effects of recent land subsidence are removed from the tide gauge observations, which are used by some of the statistical models.

65 international agencies. UHSLC technicians and data analysts collaborate directly with international partners to maintain more than 80 high-profile stations, which are important for the global sea level observing effort. UHSLC involvement ensures that research quality data sets 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 2017

During FY 2017, project objectives for data management and station operations were accomplished as Fast Delivery and Research Quality database were updated and expanded to accommodate new data and stations. GPS installations at tide gauges were maintained with assistance from the Pacific GPS Facility at the University of Hawaii. These data are provided to the GLOSS TIGA data center. The project is committed to one new GPS installation at a tide gauge station and hopes to complete this during FY 2018. Candidate sites are being considered amongst the GLOSS Core Network stations that the project currently maintains. During FY 2017 researchers continued development of the UHSLC website, which now includes a sea level forecast page for tropical Pacific Islands. By compiling monthly sea level anomaly predictions from multiple statistical and dynamical (coupled ocean-atmosphere general circulation) models through an international collaboration, improved outlooks of relative monthly sea level anomalies (Figure 1) are achieved. This new product is generating significant interest around the Pacific and will help to drive users of the UHSLC website and data sets. Researchers collaborated with the University of Colorado and NASA JPL to develop a sea level explorer tool that will allow users to more readily interact with UHSLC data and compare with satellite altimetry. The explorer tool will launch later this year. Over the past year, a substantial amount of effort was dedicated to developing server-side software that modernizes the dataflow within the center. The outcomes of this effort will be realized during FY 2018 with the rollout of a new ERRDAP data server and data acquisition tools.

During FY 2017, a variety of studies related to long-standing research projects were published. This includes a paper devoted to understanding a recent increase in the rate of upper ocean temperature and sea surface height
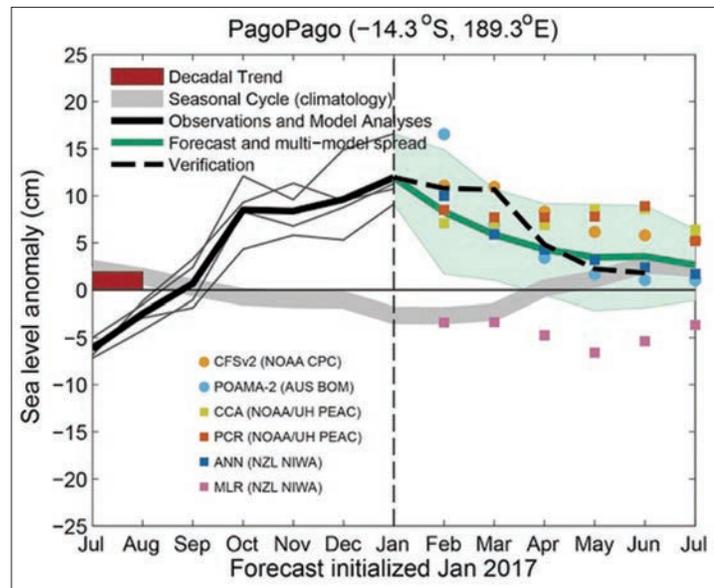
(SSH) in the Equatorial and North Indian Ocean, which was found to be related to mechanisms of wind-driven heat redistribution in the region. The project also led a team of sea level researchers in understanding how the best historical tide gauge records sample spatial structure in sea level change and whether these gauges and the average rate from the best records might be biased relative to the 'true' rate of 20th century sea level rise. UHSLC researchers were the lead authors on the sea level section in the 2016 State of Climate Report to be published later this summer, technical contributors to the National Climate Assessment for the Pacific Islands, and authors of a case study on inundation frequency for the report. Collaboration is a key component of UHSLC research goals and project staff collaborated with researchers outside the center on a variety of sea-level-related research projects including: 1) a review of the effect of internal climate variability on sea level; and 2) an assessment of the effect of atmospheric pressure on sea level variability in long tide gauge records.

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

Budget Amount: $235,723

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 the 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 regionally and nationally. 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 to 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 2017

This project involves communication and collaboration between different institutions (e.g., NOAA, Oregon State University [OSU], and University of Cantabria, Spain [UC]). The start of this project commenced with a meeting for all team members in Portland, Oregon. During this two-day meeting, the team discussed task

expectations, timeline, and delegation. Participants also identified four military installations that will be the focus of the study: Naval Base Guam; Marine Corps Base Hawaii (MCBH); Coronado Naval Base San Diego; and U.S. Army Garrison Kwajalein Atoll (USAG-KA). Since the in-person meeting, the project has maintained communication with task members through phone meetings and reported ongoing progress to DoD.

In an effort to identify indicators and thresholds that are needed to evaluate the effect of coastal flooding on facilities and infrastructure, an analysis of damage and fragility information and assessment was conducted at USAG-KA and MCBH. This entailed a review of existing literature, field surveys, and on-site interviews of managers who provided expert knowledge of critical infrastructure. Four pressure sensors were also deployed at MCBH. Initially Guam was also going to receive pressures sensors near a buoy maintained by UH, however the sensors will now be deployed at San Diego. The San Diego deployment at Coronado has been delayed to coincide with the energetic winter swell season. To enhance the historical diagnosis of site-specific still water level (SWL) patterns and trends, and to isolate the contribution of waves within TG signals, the project team first produced a White Paper that describes different extreme value analysis approaches and a rationale for the approaches used in this project. Once the TG station list was established, a time-varying Generalized Extreme Value (GEV) model with sigma as a covariate was used to assess the wave-induced signal in tide gauge data. Because TG records have poor spatial coverage, the Regional Frequency Analysis (RFA) can be used to improve this limitation. Currently, a literature review is being conducted on nonstationary RFA models in other disciplines.

Dissertations Symposium in Chemical Oceanography (DISCO) XXV

P.I.: Karen Selph

NOAA Office (of the primary technical contact): OAR/Climate Program Office/Chemical Oceanography Division

NOAA Sponsor: Stephen Piotrowicz

Budget Amount: $69,380

NOAA Goal(s):

• Healthy Oceans

Purpose of the Project

The purpose of this project is to support two symposia: the Dissertations Symposium in Chemical Oceanography (DISCO) for recent PhD graduates in chemical oceanography to present their research to their peers; and a second for more senior chemical oceanographers to discuss and formulate a report on the overall goals and future research needs in the field of chemical oceanography (COME ABOARD).

Progress during FY 2017

The DISCO XXV Symposium was held October 9-13, 2016 at the East-West Center, Honolulu. It provided recent chemical oceanography PhD graduates the opportunity to present their dissertation research in front of their professional peers, and foster professional relationships to facilitate future research benefitting the field of oceanography. In addition to an initial presentation by a senior scientist in the field, the

Figure 1. DISCO XXV Symposium attendees.

symposium consisted of sessions grouped by research subject area, discussion periods led by the graduates, and presentations by selected agency personnel explaining funding mechanisms and strategies.

Figure 2. COME ABOARD Symposium attendees.

DISCO XXV was followed by COME ABOARD (Chemical Oceanography Meeting: A Bottom-Up Approach to Research Directions) on October 14-16, 2016 (http://www.soest.hawaii.edu/disco/come-aboard-2016.htm). COME ABOARD was attended, in part, by DISCO I-XXIV alumni, 24 of whom will be chosen by a committee of peer oceanographers who served as past DISCO senior guest speakers.

The COME ABOARD meeting was attended by a wide cross-section of chemical oceanographers interested in planning and discussing future directions in the field. The overlap day of the meetings (Friday, October 14) allowed the new cohort of chemical oceanographers to interact with more senior members in the field.

These meetings were conducted successfully in October 2016 and all goals were met. The main progress to report for the COME ABOARD meeting is the submission and acceptance (pending final review) of a paper to *Marine Chemistry*, which outlines the meetings findings.

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

Budget Amount: $95,000

NOAA Goal(s)

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

Purpose of the Project

This project enhances 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 to provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community, and the public. The APDRC is organized around three main goals: providing integrated data server and management systems for climate data and products; developing and serving new climate-related products for research and applications users; and conducting climate research in support of the IPRC and NOAA research goals.

Progress during FY 2017

The APDRC maintains a wide suite of data transport and discovery servers, including: OPeNDAP-based THREDDS DODS Server (TDS); GrADS DODS Server (GDS) and DAPPER; Live Access Server (LAS); and Dchart. These servers continue to be maintained. One highlight was the release and subsequent implementation of a major upgrade to LAS. The APDRC is now running LAS-8.4 in parallel with earlier versions as its functionality is tested.

The APDRC data archives increased in part due to regular updates to the Argo products, various new data sets (e.g., CFSv2) and continued acquisition of coupled climate model output from the CMIP-5 runs. These CMIP-5 runs are most heavily used within the IPRC research activities. In addition to the Navy operational HYCOM, the APDRC servers output from a local implementation of HYCOM. In all, the APDRC has archived almost 238 TB of data: 31% of this is output from the Earth Simulator (OFES/AFES/CFES); 31% is coupled climate model output from CMIP experiments; and the remaining 37% is spread across the remaining data sets (approximately 114 in total). Upgrades to the APDRC web pages include new additions

Figure 1. Example of a web page developed by the APDRC in support of agroforestry efforts in the Marshall Islands. The website automatically generates easy-to-read gauges that provide seasonal forecast information based on data from the NOAA CFSv2.
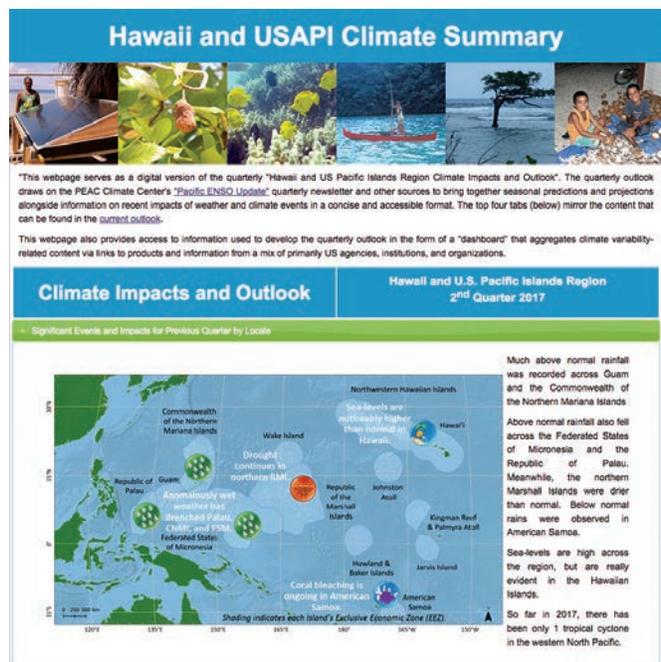
Figure 2. Example of a "dashboard" page maintained by the APDRC. This page provides Pacific Island communities with climate information and forecasts at a glance.

to the projects page that lists brief descriptions of the projects that the ADPRC supports along with direct links to these projects (http://apdrc.soest.hawaii.edu/projects).

During the past year, APDRC personnel (Potemra) participated in various activities in the insular Pacific, including local training, presentations, and workshop participation. For example, he conducted data access training at the Vanuatu Meteorological and Geohazards Division (VMGD). Locally the APDRC data servers
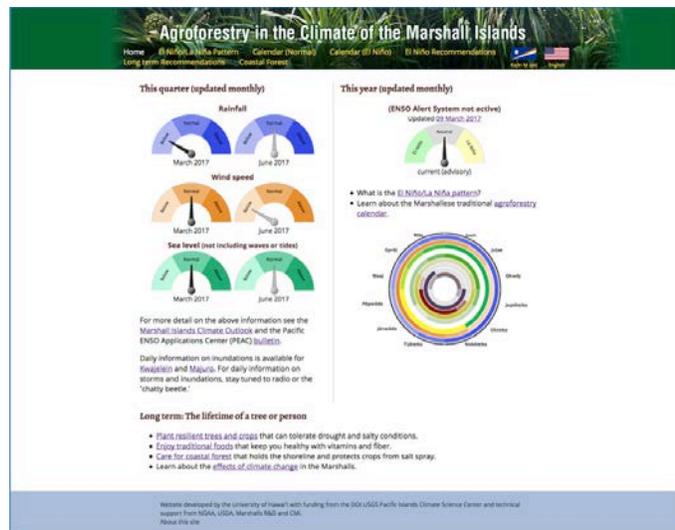
were used to produce seasonal climate outlooks, which are data-derived products used to help regional forecasters and decision makers.

Similarly, the APDRC continued to work with Pacific island communities to develop specific data products and services to help with activities in the insular Pacific. Primarily this was done by support of the real-time climate "dashboards" and quarterly reports. An on-going effort was focused on the design and implementation of a similar dashboard specific to the region of the Marshall Islands. These dashboards were developed via dialog between various federal and local agencies, local stakeholders and researchers. The implementation of the web-based tools was then done by the APDRC.

Mechanisms of Atmospheric Mercury in Transport and Transformation in the Remote Pacific Marine Free Troposphere Measured in Hawaii

P.I.: Mark A. Merrifield

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

NOAA Sponsor: Russell Schnell [Darryl T. Kuniyuki, Winston Luke]

Budget Amount: $350,508

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

Figure 1. View of gaseous oxidized mercury (GOM) permeation source and its deployment at MLO.

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 that 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 2017

Activity was centered on continuing additional tests and measurements to mitigate observed mercury measurement artifacts at MLO. Prior testing at MLO provided conclusive evidence for the presence of Hg0-HgP measurement artifacts in the inlet glassware of the commercial system. In addition, measurement biases in

the monitoring of RGM have also been identified. Additional instrumentation installed by the P.I. was used to continue to test differing methodologies to measure Hg0 and total mercury, and calculate reactive mercury (RM: RM = RGM + HgP) by difference.

The P.I. and his team also deployed a novel RGM calibration system to directly inject HgBr2 vapor (a key component of RGM) into the instrument inlets. Testing with this new device continued until December 9, 2016 under the direction of MLO staff.

Actual accomplishments during the reporting period exceeded planned activities and objectives.

Pacific ENSO Applications Climate (PEAC) Center

P.I.: Mark A. Merrifield

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

NOAA Sponsor: Raymond Tanabe

Budget Amount: $217,000

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). PEAC provides ongoing summaries of current ENSO conditions 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
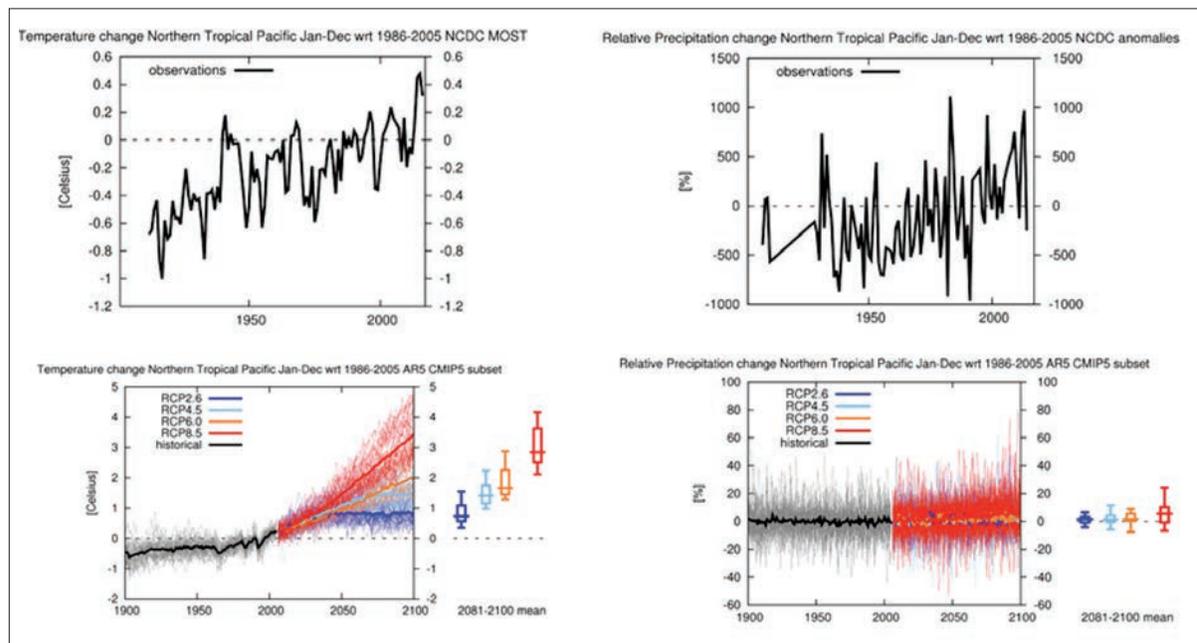
Figure 1. Top panel: Time series plots of annual mean temperature (left) and rainfall (right) anomalies (with respect to 1986-2005) over the tropical north Pacific [Data source: National Climatic Data Center (NCDC) MOST]. Bottom panel: Mean annual temperature (left) and rainfall (right) projections (anomalies with respect to 1986-2005) over the tropical north Pacific for different RCP scenarios (2.6, 4.5, 6.0, and 8.5). The black firm line denotes historical changes from 1900 to 2016.

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 2017

PEAC staff continued to work closely with Integrated Water Level Service (IWLS) partners, including the NOAA NESDIS National Centers for Environmental Information, the International Pacific Research Center, New Zealand National Institute for Water and Atmospheric Research and Met Service, Australia's Bureau of Meteorology, and the Commonwealth Scientific and Distribution Research Center to implement the expanded ensemble mean sea level anomaly forecasting scheme for the Pacific basin. The ensemble is based on statistical and dynamical model forecasts, including the operational sea level product developed at PEAC. A number of new monitoring stages were added to the forecast in 2017. Proposed plans to expand the forecast product to include wave as well as water level impacts have been delayed due to the departure of a PEAC staff member during the year.

During the past year, PEAC initiated exploratory research examining 21st century projections of climate change for the USAPI based on the IPCC-Fifth Assessment Report (AR5) coupled general circulation models (GCMs). Island-wide projections of future temperature, rainfall, sea level, and El Niño-Southern Oscillation (ENSO) conditions were explored using the latest IPCC-AR5 GCMS protocol (CMIP5), which includes 38 GCMs with up to 105 model runs. Historical temperature and rainfall variability in the region are compared to island-specific temperature and rainfall projections (Figure 1, Tables 1 and 2). Products are under consideration to convey the local impacts associated with these projections throughout the region.

The PEAC graduate research assistant conducted research to better understand the performance and skill of the PEAC rainfall-forecasting suite, especially during periods when disaster level droughts occurred in the USAPI

Table 1. Island-specific mean temperature (°C) projections for RCP 8.5 (anomalies with respect to 1986-2005) for MJJA (May-June-July-August) and NDJF (November-December-January-February).

	Temperature (°C) change projections @ RCP 8.5					
	2030s		2050s		2080s	
	MJJA	NDJF	MJJA	NDJF	MJJA	NDJF
Guam	1.1	0.8	1.8	1.4	3.6	3.4
Palau (Malakal)	1.0	0.9	1.8	1.6	3.4	3.3
FSM	1.0	0.9	1.8	1.5	3.4	3.2
RMI	0.9	0.8	1.6	1.4	3.3	3.3
American Samoa	0.9	0.8	1.3	1.4	3.0	3.0

Data Source: AR5 CMIP5 subset. FSM: Federated States of Micronesia, RMI: Republic of Marshall Islands. MJJA and NDJF are the summer and winter seasons for the northern stations, and opposite at American Samoa in the south Pacific.

Table 2. Island-wide mean precipitation (mm/day) projections (anomalies with respect to 1986-2005) for RCP 8.5 for the MJJA and NDJF seasons. Numbers in parentheses are percentage of change.

	Precipitation (mm/day) change projections @ RCP 8.5					
	2030s		2050s		2080s	
	MJJA	NDJF	MJJA	NDJF	MJJA	NDJF
Guam	1.5(12)	1.3(20)	1.6(14)	1.4(22)	1.8(15)	1.5(25)
Palau (Malakal)	1.6(12)	1.4(16)	1.8(16)	1.8(20)	2.0(20)	2.0(25)
FSM	1.4(10)	1.2(8)	1.6(12)	1.4(9)	2.0(15)	1.5(10)
RMI	0.8(8)	1.0(8)	0.9(9)	1.0(9)	1.0(10)	1.0(10)
American Samoa	Trace	0.5(5)	Trace	0.5(5)	Trace	0.5(5)

Data Source: AR5 CMIP5 subset.

region. The PEAC rainfall forecasting suite performs extremely well during El Niño events with very high skill scores obtained throughout the 2015-2016 El Niño event, for example. However, the forecast performance degrades during non-El Niño periods, notably during the disaster drought of 2013 in the Northern Mariana Islands. Ongoing research determined that this 2013 drought was not an isolated event and that it represents a mode of interannual rainfall variability of the tropical western Pacific previously not well described. The dynamics and seasonal evolution of this variability mode are currently being examined and are expected to yield new insights and forecasting methodology.

PMEL-UH Ocean Carbon Project

P.I.: David Karl

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

NOAA Sponsor: Christopher Sabine

Budget Amount: $5,739

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The primary mission of this project is to evaluate the variability in air-sea CO_2 fluxes by conducting high-resolution time-series measurements of atmospheric boundary layer and surface ocean CO_2 partial pressure (pCO_2). The Moored Autonomous pCO$_2$ (MAPCO$_2$) system collects CO_2 data from surface seawater and marine boundary air every three hours for up to a year at a time before it needs servicing. Daily summary files of the measurements are transmitted back to PMEL where the data are examined and plots of the results are posted to the web in near-real time.

Progress during FY 2017

As with previous reporting periods, this project provided one week of salary support for a member of the Hawaii Ocean Time-series (HOT) program staff (Dan Sadler) to oversee maintenance of instrumentation used for remote and shipboard measurements of atmospheric and seawater CO_2. Sadler oversaw installation and testing of instrumentation used as part of NOAA's Pacific Marine Environmental Laboratory (PMEL) measurements of the partial pressure of CO_2 (pCO_2) and pH in the tropical and subtropical Pacific Ocean. His primary effort focused on installation and servicing of instruments on the Woods Hole Oceanographic Time-series Station (WHOTS) mooring, which is a collaborative mooring program funded jointly by NOAA and NSF and led by scientists at Woods Hole Oceanographic Institution (WHOI) and the University of Hawaii. Sadler served as the local (Hawaii-based) liaison between PMEL and the University of Hawaii and provided data on seawater carbonate system measurements from Station ALOHA. Funds from this award partially offset time devoted by Sadler to these PMEL projects.

In 2016-2017, ~60 peer-reviewed papers utilized the SOCAT gridded pCO2 product https://docs.google.com/document/u/1/d/1_wvB4C3k8rmWkIlZqNhZQmTBWNBuVby5mlK3wU6hk2A/pub.

Profiling CTD Float Array Implementation and Ocean Climate Research

P.I.: Mark A. Merrifield

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

NOAA Sponsor: Gregory C. Johnson

Budget Amount: $273,357

NOAA Goal(s):

- Healthy Oceans
- Weather-Ready Nation
- Climate Adaptation and Mitigation

Purpose of the Project

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

Progress during FY 2017

Dr. Elizabeth Steffen and the PMEL float lab took delivery of 90 Argo floats this year. Dr. Steffen tested floats, monitored float performance, diagnosed and coordinated repairs of problems discovered with the floats, and worked with the manufacturer to resolve problems including multiple bugs associated with a new float controller with new firmware. In May 2017 Dr. Steffen traveled to San Diego to modify a float storage system on the *M/V Blue Fin* while it was docked in port. She also tested and loaded 21 floats on board and trained deployers. In June 2017 she traveled to Astoria, OR to install float racks onto the *R/V Falkor*. She tested and loaded floats aboard, removed crates, and trained the deployers while the vessel was still docked. She continued to work with other members of the group to deal with increased IT security restrictions, arranged for float deployments, and notified national and international databases. Stated project goals were met.
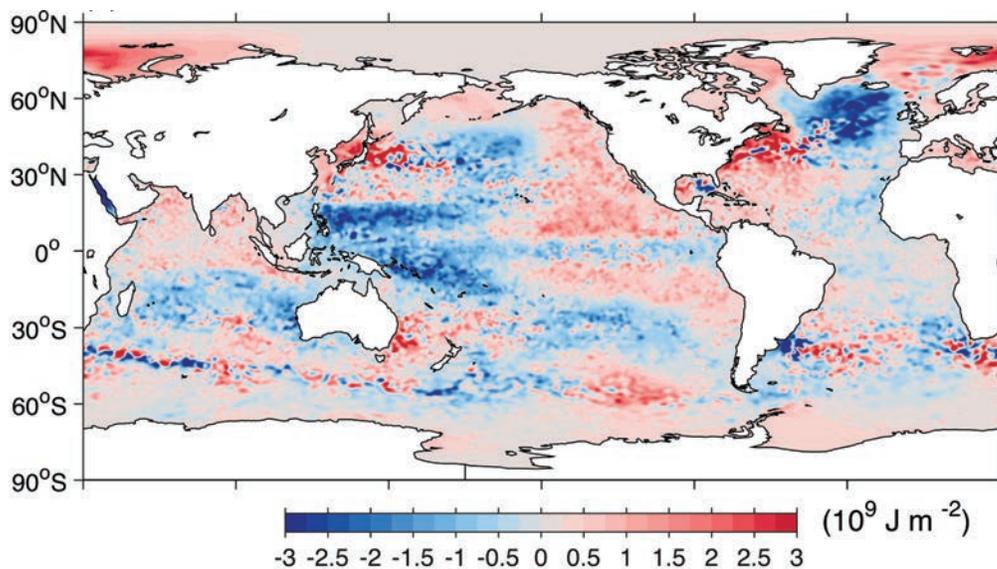
Figure 1. Upper Ocean (0–700 dbar) Ocean Heat Content Anomaly [109 J m-2] for 2015 relative to 1993–2015 estimated using in situ (mostly from Argo in recent years) temperature data and satellite altimeter sea surface height data. Red and blue areas denote warm and cold temperatures, respectively.

Figure 2. California Maritime Academy cadets aboard the Training Ship Golden Bear *assist JIMAR float research coordinator E. Steffen in testing Argo float satellite transmissions during float loading for later deployment in the Pacific Ocean (photo: E. Steffen).*

Along with JIMAR Senior Fellow Dr. Gregory Johnson, Dr. John Lyman produced and analyzed yearly maps of global upper ocean heat content from 1993 through 2016 (Figure 1) combining in situ thermal data and satellite altimetry data, as well as yearly maps of sea surface salinity from 2005 through 2016. They continued working on estimating uncertainties in and improving estimates of global ocean heat content anomalies and their trends. Dr. Lyman also continued work on updating scientific delayed-mode quality control software for the PMEL Argo floats, and performed scientific delayed-mode quality control on data from substantial numbers of PMEL Argo float profiles. This year Dr. Lyman was co-author on two annual State of the Climate in 2015 report sections. Stated goals were met.

Tropical Meteorology

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

National Weather Service Pacific Region Fellowship Program

P.I.: Mark A. Merrifield

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

NOAA Sponsor: Raymond Tanabe

Budget Amount: $127,000

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 2017

During FY 2017, the NWS Fellowship Program provided ongoing educational support to the Geology and Geophysics (G&G), Atmospheric Sciences (DAS, formerly Meteorology) and Oceanography departments. The NWS Fellowship funds were used to: 1) support graduate teaching assistantships; 2) provide research support via undergraduate student helpers and purchase scientific software and 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 OCN 105, which is an active learning course for undergraduates.

Two DAS graduate students, Dillon Dodson and David DeCou, were supported during the reporting period. Dodson completed his second year working with DAS Professor Jennifer Griswold and graduated in spring 2017 with a Master's of Science in Atmospheric Sciences. He presented his thesis ("Turbulence and droplet clustering in shallow cumulus: The effects of aerosols and cloud height") at the Annual American Meteorological Society Meeting held in Seattle, January 22-26, 2017. He is also working on publishing a two-part paper in the *Journal of Atmospheric Sciences*, with Part I to be submitted during the summer of 2017. The second DAS graduate student, DeCou, completed his first year in the DAS graduate program. His planned research activities involve examining the incoming atmospheric trade wind flow properties from the coastline of Oahu. A primary objective of his studies is to examine the relationship between temperature and humidity variations, and their implications for convective initiation over the orography.

A G&G graduate student studying planetary geoscience and remote sensing, Erin Fitch, was also supported during FY 2017. Fitch was honored with an Outstanding Student Paper Award for an invited oral presentation given at the 2016 Fall Meeting of the American Geophysical Union. The presentation was titled, "The Mechanisms and Dynamics of High-Energy Lava–Water Explosions". Fitch's research focuses on external water on volcanic processes using field methods, laboratory analysis, and numerical modeling. She is working with Dr. Sarah Fagents on several projects investigating the mechanisms and dynamics of explosive lava-water interactions in Iceland and Hawaii.

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): Pacific Marine Environmental Laboratory

NOAA Sponsor: Christopher Sabine

Budget Amount: $23,064

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 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 is 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 data set as possible of sea level fluctuations at the coasts of the Hawaiian Islands for current and future research and practical applications. Past applications of the archived data have 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 development and maintenance of both harbor surge and beach flooding nowcasts and forecasts for NOAA's PacIOOS. In FY 2017, PacIOOS and JIMAR continued supporting a graduate student, Assaf Azouri, who has been analyzing the 13 years of PTWC sea level data from Haleiwa Harbor in ARSHSL to determine the relationships between Haleiwa's suite of infragravity wave fluctuations and the many ways they are forced by gravity wave swell. Dr. Azouri defended his Ph.D. dissertation on this work in the fall of 2016 and graduated in December 2016. Dr. Azouri worked with PacIOOS product developers (especially Dr. Martin Guiles) to refine a product (http://oos.soest.hawaii.edu/pacioos/data_product/harborsurge/index.php) for PacIOOS that forecasts the occurrence of potentially damaging infragravity wave currents in Haleiwa Harbor up to a few days into the future. This work will be extended to other harbors, using the archived high-resolution sea level data in ARSHSL to establish the initial set of parameters of the transfer functions from swell to harbor infragravity waves.

Progress during FY 2017

During the past year, modernization of the extensive, mostly automated, code enabling ARSHSL's real-time data acquisition, editing and archiving activities has been completed under both JIMAR and PacIOOS funding. Large parts of this effort were a generalization of the code to accept different data and transmission formats as new stations are brought online, and a rebuilding of the graphic user interface (GUI) to make editing and archiving (the hands-on portions of the data handling) simpler and faster. The GUI also provides simple analysis tools, such as tidal harmonic analysis. In the future, selected tools will be enhanced in the future under PacIOOS funding. Currently the GUI is capable of automatically accessing and storing for hands-on editing all 1-minute

and 6-minute sampled data from the six NOS gauges in Hawaiian harbors. Incorporation into the GUI of real-time acquisition and editing of data from the 14 PTWC sea level gauges can now begin in earnest.

The ARSHSL has also been maintained online (http://ilikai.soest.hawaii.edu/arshsl/techrept/arshsl.html) by M. Luther and D. Luther, in collaboration with the NOAA-funded UH Sea Level Center (M. Merrifield, Director).

The University of Hawaii Sea Level Center—Tsunami Research

P.I.: Mark A. Merrifield

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

NOAA Sponsor: Michael Angove

Budget Amount: (funds are budgeted within The University of Hawaii Sea Level Center project budget)

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 nine 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 comply with global sea level observing system requirements for oceanographic and climate research. A typical tsunami water level station is shown in Figure 1 for Quepos, Costa Rica.

Progress during FY 2017

For the Pacific Ocean, five stations (Quepos, French Frigate Shoals, Callao, Matarani, and Talara) were visited by UHSLC technicians, which met project objectives. In addition, technicians visited Cocos Island in Costa Rica as part of the field trip to Quepos. They inspected the site for a possible new tsunami station that will be purchased by research colleagues in Costa Rica. Also during the reporting year five stations were visited in the Caribbean (Limon, El Porvenir, Grenada, San Andres, and Santa Marta), which met the expected five-station visit quota. All tsunami station data underwent daily and monthly quality assessments, with data archived at the UHSLC. Annual inspection for the research quality data set is underway and expected to be completed by September 2017.

Figure 1. UHSLC tsunami water level station at Quepos, Costa Rica.

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
Allen, C.D., S.L. Martin, J.M. Lynch, T.M. Summers, J. Hapdei, M. Rice, J.A. Seminoff, and T.T. Jones	4/1/2017	How many males are enough? Feminization of green sea turtle foraging aggregations in the Pacific	37th Annual Symposium on Sea Turtle Biology and Conservation, Las Vegas, NV, April 18-20, 2017	Conference Proceedings		Marine Turtle Recovery in the Pacific Islands Region
Asher, J., I. Williams, and E. Harvey	4/1/2017	Mesophotic depth gradients impact reef fish assemblage composition and functional group partitioning in the Main Hawaiian Islands	Front. Mar. Sci., 4, 1-18	Journal Article	http://journal.frontiersin.org/article/10.3389/fmars.2017.00098/full	Sustaining Healthy Coastal Ecosystems
Asher, J., I. Williams, and E. Harvey	12/1/2016	An assessment of mobile predator populations along shallow and mesophotic depth gradients in the Hawaiian Archipelago	Sci. Rep., 7(1), 3905	Journal Article	http://www.nature.com/articles/s41598-017-03568-1	Sustaining Healthy Coastal Ecosystems
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Bayless, A., E. Oleson, S. Baumann-Pickering, A. Simonis, J. Marchetti, S. Martin, and S. Wiggins	6/1/2017	Acoustically monitoring the Hawai'i longline fishery for interactions with false killer whales	Fish. Res., 190, 122-131	Journal Article	http://dx.doi.org/10.1016/j.fishres.2017.02.006	Cetacean Research Program
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Brainard R., T. Oliver, M. Timmers, K. Reardon, B. Vargas-Angel, I. Williams, G. Paulay, N. Knowlton, C. Meyer, E. Ransome, R. Toonen, F. Rohwer, and L. Wegley Kelly	2/27/2017	Integrated, interdisciplinary, assessment & long-term monitoring of biodiversity of coral reef ecosystems across the Pacific Islands	Association for the Sciences of Limnology and Oceanography (ASLO), Honolulu, HI, Feb 26-Mar. 3, 2017	Presentation		Sustaining Healthy Coastal Ecosystems

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Burns, J.H.R., and D. Delparte	3/3/2017	Comparison of commercial structure-from-motion photogrammetry software used for underwater three-dimensional modeling of coral reef environments	3D Virtual Reconstruction and Visualization of Complex Architectures, Nafplio, Greece, March 1-3, 2017, ISPRS/CIPA Archives, XLII-2/W3, 2017	Conference Proceedings	https://doi:10.5194/isprs-archives-XLII-2-W3-127-2017	Papahānaumokuākea Marine National Monument Monitoring and Research
Cantelas, F., H. Van Tilburg, G. Fabian, C. Kelley, J. Kinney, and A. Tully	1/1/2017	Exploring the underwater archaeology of World War II	J. Oceanogr., 30(1), 72-73	Journal Article		Scientific Advice and Coordination for NOAA Office of Exploration and Research's 2015-2016 "CAPSTONE" Operations in the Pacific
Casey, J.M., A.H. Baird, S.J. Brandl, M.O. Hoogenboom, J.R. Rizzari, A. J. Frisch, C.E. Mirbach, and S.R. Connolly	10/6/2016	A test of trophic cascade theory: fish and benthic assemblages across a predator density gradient on coral reefs	Oecologia, 183(1), 161-175	Journal Article	doi: 10.1007/s00442-016-3753-8	Open Source ADMB Project
Chowdhury, M.R, and N. Ousmane	in press	Climate change and variability impacts: CMIP5 GCMs and ENSO	Int. J. Climatol.	Journal Article	doi: 10.1002/joc.5120	Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R.	6/4/2017	The impact of climate change on Sundarbans	The Financial Express	Report	http://www.thefinancialexpress-bd.com/2017/06/04/72712/The-impact-of-climate-change-on-Sundarbans	Pacific ENSO Applications Climate (PEAC) Center
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DeMartini, E.E., A.H. Andrews, K.G. Howard, B.M. Taylor, D. Lou, and M.K. Donovan	6/7/2017	Comparative growth, age at maturity and sex change, and longevity of Hawaiian parrotfishes with bomb radiocarbon validation	Can. J. Fish. Aquat. Sci., published online June 7, 2017	Journal Article	https://doi.org/10.1139/cjfas-2016-0523	Territorial Biosampling
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Author	Date	Title	Source	Type	DOI/URL	Program
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Fassbender, A.J., et al.	in press	Perspectives on chemical oceanography in a changing environment: Participants of the COME ABOARD Meeting examine the field in the context of 40 years of DISCO	Marine Chemistry	Workshop Proceedings		Dissertations Symposium in Chemical Oceanography (DISCO) XXV
Finkbeiner, E. M., F. Micheli, N.J. Bennett, A.L. Ayers, A., E. Le Cornu, and A. Doerr	in review	Examining trade-offs in climate change response in the context of Pacific Island fisheries	Mar. Policy	Journal Article		Socioeconomics of Western Pacific Fisheries
Fukunaga, A., and R.K. Kosaki	3/2/2017	Use of multivariate control charts to assess the status of fish assemblages in the Northwestern Hawaiian Islands	Association for the Sciences of Limnology and Oceanography (ASLO), Honolulu, Hi, Feb 26 - March 3, 2017	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., R.K. Kosaki, and D. Wagner	3/15/2017	Changes in mesophotic reef fish assemblages along depth and geographical gradients in the Northwestern Hawaiian Islands	Coral Reefs	Journal Article	https://doi:10.1007/s00338-017-1569-6	Papahānaumokuākea Marine National Monument Monitoring and Research
Gorospe, K., and T. Acoba	in press	A sampling design performance analysis examining linkages between reef fish assemblages and benthic morphologies in the main Hawaiian islands	Pacific Islands Fisheries Science Center, PIFSC Administrative Report	Report		Sustaining Healthy Coastal Ecosystems
Gray A., I. Williams, K. Stamoulis, R. Boland, K. Lino, B. Hauk, J. Leonard, J. Rooney, J. Asher, K. Lopes Jr., and R. Kosaki	12/1/2016	Comparison of reef fish survey data gathered by open and closed circuit SCUBA divers reveals differences in areas with higher fishing pressure	PLoS ONE, 11(12), e0167724	Journal Article	https://doi.org/10.1371/journal.pone.0167724	Sustaining Healthy Coastal Ecosystems
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Heenan, A., K. Gorospe, A. Levine, J. Raynal, and A. Lawrence	3/1/2017	Linking local and national data to improve marine managed area monitoring and data quality in Tutuila, American Samoa: a feasibility report.	Pacific Islands Fisheries Science Center, PIFSC Working Paper WP-17-001, 52 pp	Report	https://repository.library.noaa.gov/view/noaa/14389	Sustaining Healthy Coastal Ecosystems
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Hill, M.C., A.R. Bendlin, A.C. Ü, K.M. Yano, A.L. Bradford, A.D. Ligon, and E.M. Oleson	2/3/2017	Cetacean monitoring in the Mariana Islands Range Complex, 2016	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-002, 46 pp	Report	https://doi:10.7289/V5/DR-PIFSC-17-002	Cetacean Research Program—Monitoring in the Mariana Islands Range Complex

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McCoy, K., A. Heenan, J. Asher, P. Ayotte, K. Gorospe, A. Gray, K. Lino, J. Zamzow, and I. Williams	1/1/2017	Pacific Reef Assessment and Monitoring Program Data Report Ecological monitoring 2016 --- reef fishes and benthic habitats of the main Hawaiian Islands, Northwestern Hawaiian Islands, Pacific Remote Island Areas, and American Samoa	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-001, 66 pp	Report	https://www.pifsc. noaa.gov/library/ pubs/DR-17-001. pdf	Sustaining Healthy Coastal Ecosystems
McCoy, K., A. Heenan, J. Asher, P. Ayotte, K. Gorospe, A. Gray, K. Lino, J. Zamzow, and I. Williams	10/1/2017	Pacific Reef Assessment and Monitoring Program. Fish monitoring brief: main Hawaiian Islands, 2016	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-16-053, 2 pp	Report	https://www.pifsc. noaa.gov/library/ pubs/DR-16-053. pdf	Sustaining Healthy Coastal Ecosystems
McCoy, K., A. Heenan, J. Asher, P. Ayotte, K. Gorospe, A. Gray, K. Lino, J. Zamzow, and I. Williams	4/1/2017	Summary of 2016 reef fish surveys around Kahoolawe Island	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-011, 11 pp	Report	https://repository. library.noaa.gov/ view/noaa/14168	Sustaining Healthy Coastal Ecosystems
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Natarov, S., M.A. Merrifield, J.M. Becker, and P.R. Thompson	4/14/2017	Regional influences on reconstructed global mean sea level	Geophys. Res. Lett.	Journal Article	https://doi: 10.1002/2016 GL071523	University of Hawaii Sea Level Center
Oliver, T., C. Young, and R. Brainard	2/27/2017	Synthesizing diverse approaches to observing process in the reef carbonate system	Association for the Sciences of Limnology and Oceanography (ASLO), Honolulu, Hi, Feb. 26-March 3, 2017	Presentation		Sustaining Healthy Coastal Ecosystems
Oliver, T., N. Pomeroy, C . Couch, R. Ritson-Williams, and O. Meier	6/22/2017	Defining drivers of susceptibility to and recovery from unprecedented mass coral bleaching in the Main Hawaiian Islands	American Association for the Advancement of Science (AAAS) Pacific Symposium, June 19-23, 2017, Waimea, Hawaii	Presentation		Sustaining Healthy Coastal Ecosystems

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Sakihara, T.S., A. Fukunaga, and K.A. Peyton	5/23/2017	Mugilids display distinct trait-mediated patterns with a reinvasion of para grass Urochloa mutica in a tropical estuary	Fishes, 2, 7-24	Journal Article	https://doi:10.3390/fishes2020007	Papahānaumokuākea Marine National Monument Monitoring and Research
Suka, R., and J. Rooney	4/1/2017	Acoustic characterization of mesophotic coral reef ecosystems of West Hawaii	Pacific Islands Fisheries Science Center, NOAA Technical Memorandum NMFS-PIFSC-61, April 2017, 31 pp	Report	https://doi.org/10.7289/V5/TM-PIFSC-61	Sustaining Healthy Coastal Ecosystems
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Vargas-Angel B., D. White, C. Storlazzi, T. Callender, and P. Maurin	6/26/2017	Baseline assessments for coral reef community structure and demographics on West Maui: data report	NOAA Special Publication SP-17-001	Report	https://doi.org/10.7289/V5/SP-PIFSC-17-001	Sustaining Healthy Coastal Ecosystems
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Widlansky, M., J. Marra, R. Chowdhury, S. Stephens, E. Miles, N. Fauchereau, C. Spillman, G. Smith, G. Beard, and J. Wells	3/16/2017	Multimodel ensemble sea level forecasts for Tropical Pacific Islands	J. Appl. Meteo-rol. Climatol.	Journal Article	https://doi: 10.1175/JAMC-D-16-0284.1	University of Hawaii Sea Level Center
Winston, M.S., B.M. Taylor, and E.C. Franklin	2/28/2017	Intraspecific variability in the life histories of endemic coral-reef fishes between photic and mesophotic depths across the Central Pacific Ocean	Coral Reefs, 36, 663-674	Journal Article	doi: 10.1007/ s00338-017-1559-8	Territorial Biosampling

Appendix I List of Acronyms

ACL	Annual Catch Limit
ACT	Annual Catch Target
AD	Automatic Differentiation
ADCP	Acoustic Doppler Current Profiler
ADMB	Automatic Differentiation Model Builder
AFES	Atmospheric model For the Earth Simulator
APDRC	Asia-Pacific Data Research Center
APEX	Oracle Application Express
AR5	Fifth Assessment Report (IPCC)
ARL	Air Resources Laboratories
ARMS	Autonomous Reef Monitoring Structure
ARSHSL	Archive of Rapidly-Sampled Hawaiian Sea Level
ASEAN	Association of Southeast Asian Nations
ASRAMP	American Samoa Reef Assessment and Monitoring Program
ASTWG	Advanced Sampling Technology Working Group
ATL	Analytic Template Library
AUV	Autonomous Underwater Vehicle
AVHRR	Advanced Very High Resolution Radiometer
AVISO	Archiving, Validation, and Interpretation of Satellite Oceanographic Data
AWIPS	Advanced Weather Interactive Processing System
BET	Big Eye Tuna
BFRA	Bottomfish Restricted Area
BotCam	Bottomfish video Camera
BRUVS	Baited Remote Underwater Video Station
CAPSTONE	Campaign to Address Pacific Monument Science, Technology, and Ocean Needs
CAU	Calcification Acidification Units
CCR	Closed-Circuit Rebreathers
CFBP	Commercial Fisheries Biosampling Program
CFES	Coupled model For the Earth Simulator
CFSv2	Coupled Forecast System, version 2
CIE	Center for Independent Experts
CMIP	Coupled Model Intercomparison Project
CMIP5	Coupled Model Intercomparison Project Phase 5
CNMI	Commonwealth of the Northern Mariana Islands
COME ABOARD	Chemical Oceanography Meeting: A Bottom-Up Approach to Research Directions

CoRIS	Coral Reef Information System
CPU	Central Processing Unit
CRCP	Coral Reef Conservation Program
CREP	Coral Reef Ecosystem Program
CRP	Cetacean Research Program
CT	Coral Triangle
CTD	Conductivity, Temperature, and Density
CSAT	Cybersecurity and Assessment Team
CSVI	Hawaii Community Social Vulnerability Indices
CTD	Conductivity-Temperature-and Depth
DA-BFAR	Philippines Department of Agriculture, Bureau of Fisheries and Aquatic Resources
DAR	State of Hawaii Division of Aquatic Resources
DAS	Department of Atmospheric Sciences
DAWR	Division of Aquatic and Wildlife Resources (Guam)
DCIP	Drop Camera Instrument Package
DENR-BMB	Philippines Department of Environment and Natural Resources, Biodiversity Management Bureau
DFW	Division of Fish and Wildlife (CNMI)
DIC	Dissolved inorganic carbon
DISCO	Dissertations Symposium in Chemical Oceanography
DLNR	Department of Land and Natural Resources
DMIP	Data Management Improvement Plan
DMWR	Department of Marine and Wildlife Resources (American Samoa)
DNA	Deoxyribonucleic Acid
DO	Dissolved Oxygen
DoD	Department of Defense (U.S.)
DODS	Distributed Ocean Data System
DSCRTP	Deep Sea Coral Research and Technology Program
DVM	Data Validation Module
EAFM	Ecosystem Approach to Fisheries Management
EAFM LEAD	Ecosystem Approach to Fisheries Management for Leaders Executives and Decision Makers
ECC	Exploration Command Center
ECOFISH	Ecosystems Improved for Sustainable Fisheries Project
EDM	Environmental Data Management
EEZ	Exclusive Economic Zone
ENIO	Equatorial and Northern Indian Ocean

ENSO	El Niño Southern Oscillation
EOP	Ecosytems and Oceanography Program
ER	Electronic Reporting
ERDDAP	Environmental Research Division Data Access Platform
ESA	Endangered Species Act
ESD	Ecosystem Sciences Division
EX	NOAA R/V Okeanos Explorer
FAD	Fish Aggregation Device
FFS	French Frigate Shoals
FMP	Fishery Management Plan
FOT	Final Out Turn Receipt
FRS	Fisher Reporting System (Hawaii)
FRMD	Fisheries Research and Monitoring Division
FSM	Federated States of Micronesia
FSWP	Fishery Statistics of the Western Pacific
FUS	Fisheries of the United States
FWS	Fish and Wildlife Service (U.S.)
FY	Fiscal Year
G&G	Geology and Geophysics
GCM	Generalized Circulation Model
GCOS	Global Climate Observing System
GDS	GrADS DODS Server
GES	Global Environmental Science
GEV	Generalized Extreme Value
GIS	Geographic Information System
GLOSS	Global Sea Level Observing System
GMSL	Global Mean Sea Level
GOM	Gaseous Oxidized Mercury
GPS	Global Positioning System
GPT	Geospatial Products Team
GrADS	Grid Analysis and Display System
GUI	Graphic User Interface
HA	NOAA R/V Hiʻialakai
HAR	Hawaii Administrative Rules
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
HIC	Hawaii Information Consortium
HICEAS	Hawaiian Islands Cetacean Ecosystem Assessment Survey
HIGP	Hawaii Institute for Geophysics and Planetology
HIMB	Hawaii Institute of Marine Biology
HMS	Hawaiian Monk Seal
HMSRP	Hawaiian Monk Seal Research Program
HOT	Hawaii Ocean Time-series
HPU	Hawaii Pacific University
HRPT	High Resolution Picture Transmission
HURL	Hawaii Undersea Research Laboratory
HYCOM	HYbrid Coordinate Ocean Model
IASI	Office of International Affairs and Seafood Inspection
IATTC	Inter-American Tropical Tuna Commission
ICMP	Integrated Comprehensive Monitoring Program
IDEA	NOAA Integrated Data and Environmental Activities
IEA	Integrated Ecosystem Assessment
IEAFM	International Ecosystem Approach to Fisheries Management
iFIMS	Integrated Fisheries Information Management System
InPort	Information Portal
IOC-WESTPAC	Intergovernmental Oceanic Commission-Sub commission for the Western Pacific
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
ISSO	Information System Security Officer
IT	Information Technology
ITS	Information Technology Services
IUU	Illegal, Unreported, Unregulated
IWLS	Integrated Water Level Service
JIMAR	Joint Institute for Marine and Atmospheric Research
JPL	Jet Propulsion Laboratory
LAS	Live Access Server
LEAD	Leaders, Executives and Decision-Makers

LED	Light Emitting Diode
LF	Length Frequency
LHP	Life History Program
LOPEC	Leeward Oahu Pelagic Ecosystem Characterization
MAPCO2	Moored Autonomous pCO2 System
MAPP	Modeling, Analysis, Predictions and Projections
MARAMP	Marianas Archipelago Reef Assessment Monitoring Program
MBL	Mesopelagic Boundary Layer
MCBH	Marine Corps Base Hawaii
MCMC	Markov Chain Monte Carlo
MHI	Main Hawaiian Islands
MIRC	Mariana Islands Range Complex
MITT	Monitoring Plan for the Mariana Islands Testing and Training
MLO	Mauna Loa Observatory
MMPA	Marine Mammal Protection Act
MOUSS	Modular Underwater Stereoscopic System
MTBAP	Marine Turtle Biology and Assessment Program
M/V	Marine Vessel
NALU	Natural Activities for Learning and Understanding
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NCEAS	National Center for Ecological Analysis and Synthesis
NCEI	National Centers for Environmental Information
NCRMP	National Coral Reef Monitoring Program
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NMSAS	National Marine Sanctuary of American Samoa
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPP	National Polar-orbiting Partnership
NSF	National Science Foundation
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

OC	Open-Circuit
OCC	Ocean and Climate Change
ODRS	Online Commercial Marine Dealer Reporting System
ODTUG	Oracle Development Tools User Group
OER	Office of Ocean Exploration and Research
OFES	Ocean model For the Earth Simulator
OGL	Ocean Genomic Legacy
OLE	Office of Law Enforcement, NOAA
ONMS	Office of National Marine Sanctuaries
OPeNDAP	Open-source Project for a Network Data Access Protocol
OSU	Oregon State University
OTSP	Over-the-Side-Pole
OWCP	OceanWatch-Central Pacific
PacIOOS	Pacific Islands Ocean Observing System
PaCIS	Pacific Climate Information System
PACOM	Pacific Command
PARR	Public Access to Research Results
PDF	Portable Document Format
PEAC	Pacific ENSO Applications Climate Center
PI	Principal Investigator
PIFSC	Pacific Islands Fisheries Science Center
PIMPAC	Pacific Island Managed and Protected Area Community
PIR	Pacific Islands Region
PIRO	Pacific Islands Regional Office
PL/SQL	Programming Language extension to Structured Query Language
PLOS	Public Library of Science
PMEL	Pacific Marine Environmental Laboratory
PMNM	Papahānaumokuākea Marine National Monument
PMP	Positive Mathematical Programming
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
QA	Quality Assurance
QC	Quality Control

R/V	Research Vessel
RAMP	Reef Assessment and Monitoring Program
RCC	Regional Climate Center
REA	Rapid Ecological Assessment
RFA	Regional Frequency Analysis
RFMO	Regional Fishery Management Organization
RGM	Reactive Gaseous Mercury
RM	Reactive Mercury
RMI	Republic of the Marshall Islands
ROMS	Regional Ocean Modeling System
ROV	Remotely Operated underwater Vehicle
RPL	Regional Purse-Seine Logsheet
SAP	Stock Assessment Program
SC	Species Composition
SCADA	Supervisory Control and Data Acquisition
SCUBA	Self-Contained Underwater Breathing Apparatus
SEAFDEC	Southeast Asia Fisheries Development Center
SFTP	Secure File Transfer Protocol
SIO	Scripps Institution of Oceanography
SOCAT	Surface Ocean CO2 Atlas
SOD	Science Operations Division
SOPs	Standard Operating Procedures
SOEST	School of Ocean and Earth Science and Technology
SPA	Seal Population Assessment
SPC	Secretariat of the Pacific Community
SPTT	South Pacific Tuna Treaty
SQL	Structured Query Language
SSC	Scientific and Statistical Committee
SSH	Sea Surface Height
SSTP	Survey and Sampling Technologies Program
SWFSC	Southwest Fisheries Science Center
SWL	Still Water Level
SWS	SeaWater System
TA	Total alkalinity
TDS	THREDDS DODS Server
TG	Tide gauge
THREDDS	Thematic Real-time Environmental Distributed Data Services

TIGA	Tide Gauge Benchmark Monitoring Project
TMB	Template Model Builder
TRP	Take Reduction Program
TSI	Territorial Science Initiative
UC	University of Cantabria (Spain)
UCLA	University of California Los Angeles
UFA	United Fishing Agency (Hawaii)
UH	University of Hawaii
UHDAS	University of Hawaii Data Acquisition System
UHSLC	University of Hawaii Sea Level Center
UL	Unloading and Transshipment Logsheet
UNFAO	United Nations Food and Agriculture Organization
URL	Uniform Resource Locator
U.S.	United States
USAG-KA	U.S. Army Garrison Kwajalein Atoll
USAID	United States Agency for International Development
USAPI	United States Affiliated Pacific Islands (Guam, Palau, Yap, Pohnpei, Majuro, Kwajalein, and Pago Pago)
VIIRS	Visible Infrared Imaging Radiometer Suite
VARS	Video Annotation and Reference System
VFP	Visual Fox Pro
VMGD	Vanuatu Meteorological and Geohazards Division
VMS	Vessel Monitoring System
VOC	Vessel Operation Coordination
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WESTPAC	Western Pacific
WHOI	Woods Hole Oceanographic Institution
WHOTS	WHOI Hawaii Ocean Time-series Station
WPacFIN	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Regional Fishery Management Council

Appendix II List of Awards and Related Amendment Numbers

JOINT INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH (JIMAR)
COOPERATIVE AGREEMENT NO. NA16NMF4320058 (and NA16NMF4320216*, NA16NMF4320219**)
List of Projects described in the Annual Report for the period: October 1, 2016-June 30, 2017

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
Cetacean Research Program	Michael Seki	8
Cetacean Research Program—Monitoring in the Mariana Islands Range Complex *	Michael Seki	initial
Characterization & Dynamics of Mesoscale and Submesoscale Oceanic Variability in the Solomon Sea Simulated by a Nested ROMS Model	Christopher Sabine	3
Data Validation at the Hawaii MAPCO2 Buoy Network in Support of a Test-Bed for Technology Development: Phase II	Christopher Sabine	2
Dissertations Symposium in Chemical Oceanography (DISCO) XXV	Stephen Piotrowicz	28
Ecosystem Observations and Research Program: Research Support Project	Michael Seki	37
Ecosystem Structure & Function	Michael Seki	10
Ecosystems Observations and Research Program: Science Operations Project	Michael Seki	34
Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center (IPRC)	Howard Diamond	1
Fishing Impacts on Non-Target Species	Michael Seki	24, 40, 41
Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support	Michael Seki	38
Hawaiian Monk Seal Research Program	Michael Seki	7
International Ecosystem Approach to Fisheries Management (EAFM) Project—Philippines **	Michael Seki	initial
Main Hawaiian Islands Commercial Fisheries Fast Track Data Project	Michael Seki	27
Marine Turtle Recovery in the Pacific Islands Region	Michael Seki	12
Mechanisms of Atmospheric Mercury in Transport and Transformation in the Remote Pacific Marine Free Troposphere Measured in Hawaii	Russell Schnell	19, 39, 42
National Weather Service Pacific Region Fellowship Program	Raymond Tanabe	26
Ocean Remote Sensing	Michael Seki	25
On-Site Support for OA Mooring Test-Beds: Evaluating and Expanding New Carbon Technologies to Subsurface Habitats	Adrienne Sutton	29
Open Source ADMB Project	Michael Seki	33
Optimizing Routine Ocean Current Measurements by the NOAA Fleet: Renewal for FY2017-2019	Patrick Murphy Donald Jones	36

Pacific Enso Applications Climate (PEAC) Center	Raymond Tanabe	23
Pacific Fisheries Monitoring Program	Michael Seki	15
Pacific Islands Deep Sea Coral and Sponge Initiative	Michael Seki	17
Pacific Islands Territorial Science Initiative	Michael Seki	4
Pacific Tuna Fishery Data Management	Michael Seki	13
Papanaumokuakea Marine National Monument Monitoring and Research	Randy Kosaki	9
PMEL—UH Ocean Carbon Project	Christopher Sabine	18
Profiling CTD Float Array Implementation and Ocean Climate Research	Christopher Sabine	32
Rapid Increases in Reproductive Information for Exploited Reef Fish and Enhanced Research Capacity Through Training to Support Ecosystem-Based Fisheries Management in Guam	Brian Langseth	16
Scientific Advice and Coordination for NOAA Office of Ocean Exploration and Research's 2017 "CAPSTONE" Operations in the Pacific	Craig Russell	5
Socioeconomics of Western Pacific Fisheries	Michael Seki	20
Stock Assessment Research Program	Michael Seki	21
Sustaining Healthy Coastal Ecosystems	Michael Seki	35
Territorial Biosampling	Michael Seki	14
University of Hawaii Sea Level Center	David Legler	22
West Hawaii Integrated Ecosystem Assessment	Michael Seki	11
Western Pacific Fisheries Information Network (WPACFIN)	Michael Seki	30

Appendix III Visiting Scientists

DATE	NAME/AFFILIATION	PURPOSE OF VISIT
10/13/16-10/16/16	Martha Gledhill Senior Scientist GEOMAR-Heimholtz Center for Ocean Research Germany	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16-10/16/16	Deborah Bronk Professor Virginia Institute of Marine Science Gloucester Point, VA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16-10/16/16	Ken O. Buesseler Senior Scientist Woods Hole Oceanographic Institute Woods Hole, MA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16-10/16/16	Miguel Goni Professor Oregon State University Corvallis, OR	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16-10/16/16	Kenneth Johnson Senior Scientist Monterey Bay Aquarium Research Institute Monterey, CA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.

10/13/16- 10/16/16	Lauren Juranek Assistant Professor Oregon State University Corvallis, OR	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16- 10/16/16	Gregory Cutter Professor Old Dominion University Norfolk, VA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16- 10/16/16	Patricia Matrai Senior Research Scientist Bigelow Laboratory Ocean Sciences New Castle, ME	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16- 10/16/16	Lihini Aluwihare Professor Scripps Institute of Oceanography, UCSD La Jolla, CA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16- 10/16/16	Margaret L. Estapa Assistant Professor Skidmore College Saratoga Springs, NY	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16- 10/16/16	David Nicholson Associate Scientist Woods Hole Oceanographic Institute Woods Hole, MA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.

10/13/16- 10/16/16	Sarah Fawcett Lecturer University of Cape Town Cape Town, South Africa	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/13/16- 10/16/16	David Burdige Professor Old Dominon University Norfolk, VA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16- 10/16/16	Phoebe Lam Assistant Professor University of California, Santa Cruz Santa Cruz, CA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16- 10/16/16	Karen Casciotti Associate Professor Stanford University Stanford, CA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16- 10/16/16	David Valenine Professor University of California, Santa Barbara Santa Barbara, CA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16- 10/16/16	Jay Brandes Professor Skidaway Institute of Oceanography Savannah, GA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.

10/14/16-10/16/16	Andrea Fassbender Postdoctoral Fellow UCAR Seattle, WA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16-10/16/16	Anitra Ingalls Associate Professor University of Washington Seattle, WA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16-10/16/16	Christopher Reddy Senior Scientist Woods Hole Oceanographic Institution Woods Hole, MA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16-10/16/16	Maureen Conte Associate Scientist Bermuda Institute of Ocean Sciences St. Georges, Bermuda	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16-10/16/16	George Luther Professor University of Delaware Lewes, DE	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
10/14/16-10/16/16	Adina Paytan Researcher University of California, Santa Cruz Santa Cruz, CA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.

10/14/16- 10/16/16	Ellery Ingall Professor Georgia Institute of Technology Atlanta, GA	To attend the COME ABOARD Symposium and present scientific research results, contributing to the symposium's printed volume, representing the traveler's home institution in a professional setting and participating in all required symposium activities including discussions and working in groups.
11/17/16- 11/18/16	Jayantha Obeysekera Chief Modeler South Florida Water Management District West Palm Beach, FL	To attend the DOD/SERDP kickoff meeting in Portland, OR to discuss objectives, tasks, timelines and deliverables.
04/17/17- 05/01/17	Jazmine Panelo Volunteer Honolulu, HI	To participate on the Kona IEA cruise (SE-17-04) around the Northwestern Hawaiian Islands to assist in gathering data on the physical, biological and chemical oceanography on West Hawaii's marine ecosystem.

Appendix IV Workshops, Meetings and Seminars Hosted by JIMAR

DISCO XXV: Dissertations Symposium in Chemical Oceanography XXV
October 9-13, 2016, Imin Conference Center, UH-Manoa

Robert F. Anderson	Sarah Hurley
Pamela M. Barrett	David Janssen
Melanie K. Behrens	Winifred Johnson
Anna Belcher	Sinikka T. Lennartz
Lauren Biermann	Shuting Liu
Rene Boiteau	Chris Measures
Jennifer Clarke	Hilary I. Palevsky
Jamie Collins	Shaily Rahman
Alysha I. Coppola	Daisy Ray
Alina Ebling	Amit Sarkar
Fenix Garcia-Tigreros Kodovska	Karen Selph
Johanna A.L. Goldman	Zvika Steiner
Elisa Fernández Guallart	Brittany Widner
William Haskell	Bo Yang

COME ABOARD: Chemical Oceanography Meeting: A Bottom-Up Approach to Research Directions, October 14-16, 2016, Imin Conference Center, UH-Manoa

Lihini Aluwihare	Ellery Ingall	**Remote Participants**
Robert F. Anderson	Anitra Ingalls	Zanna Chase
Sara Bender	Kenneth S. Johnson	Gabriel Filipelli
Ed Boyle	Laurie Juranek	Mtinkheni Gondwe
Jay Brandes	Angela Knapp	Angelos Hannides
Debbie Bronk	Phoebe Lam	Boris Koch
Ken O. Buesseler	George Luther	Christian Lønborg
David Burdige	Todd Martz	Allison Miller
Wei-Jun Cai	Patricia A. Matrai	Eli Moore
Karen Casciotti	Chris Measures	Joseph Needoba
Hilary Close	Simone Metz	Chris Osburn
Maureen Conte	Richard W. Murray	Artur Palacz
Greg Cutter	David (Roo) Nicholson	Kathrin Wuttig
Regina Easley	Mats Ohlson	Meng Xia
Henrietta (Hedy) Edmonds	Adina Paytan	
Meg Estapa	Robert E. Pellenbarg	
Andrea J. Fassbender	Stephen R. Piotrowicz	
Sarah Fawcett	Kim Poppendorf	
Katja Fennel	Christopher M. Reddy	
Sara Ferrón	Donald Rice	
Brian Glazer	Kathleen Ruttenberg	
Martha Gledhill	Christopher L. Sabine	
Miguel Goni	Frank Sansone	
Maxime Grand	Nayrah Shaltout	
Chris Guay	Elizabeth Sikes	
Martin Hassellöv	Eric T. Sundquist	
Mariko Hatta	David L. Valentine	
Christopher T. Hayes	Zhaohui (Aleck) Wang	
Tristan Horner	Sam Wilson	

Appendix V JIMAR Personnel

Information as of June 30, 2017

Category	Number	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	13	0	0	0	0	13
Visiting Scientist	0	0	0	0	0	0
Postdoctoral Fellow	1	0	0	0	0	1
Research Support Staff	92	5	4	63	15	5
Administrative	10	0	0	7	2	1
Total (≥ 50% support)	**116**	**5**	**4**	**70**	**17**	**20**
Undergraduate Students	18	18	0	0	0	0
Graduate Students	14	0	0	12	2	0
Employees that receive < 50% NOAA Funding (not including students)	6	0	0	1	0	5
Located at Lab (include name of lab)	4 - PMEL 100 - PIFSC 2 - ESRL 5 - PMNM					
Obtained NOAA employment within the last year	2					
Postdoctoral fellows and students from subgrantees	Postdocs: 0 Students: 0					

Appendix VI Awards

Tomoko Acoba
• Nominee for 2017 RCUH Employee of the Year

Amanda Dillon
• 2016 NOAA PIFSC Team Member of the Year, JIMAR Administrative Support

Joao Garriques
• 2016 NOAA PIFSC Team Member of the Year, Professional/Scientific/Technical I

Marc Nadon
• 2016 NOAA PIFSC Team Member of the Year, Professional/Scientific/Technical II

Brett Taylor
• 2016 RCUH Employee of the Year—2nd Place

Appendix VII Graduates

Adam L. Ayers, PhD, Environmental Planning and Resource Management, University of Hawai'i at Manoa, "From planning to practice: Towards co-management of Hawaii coral reef fisheries"

Assaf Azouri, PhD, Department of Oceanography, University of Hawai'i at Manoa, "Observations, forecast, and modeling of 0.5-200 min. infragravity oscillations in Haleiwa Harbor region, Hawai'i"

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
Peer Reviewed	**JIMAR Lead Author**	19
	NOAA Lead Author	5
	Other Lead Author	16
Non Peer-Reviewed	**JIMAR Lead Author**	16
	NOAA Lead Author	1
	Other Lead Author	0