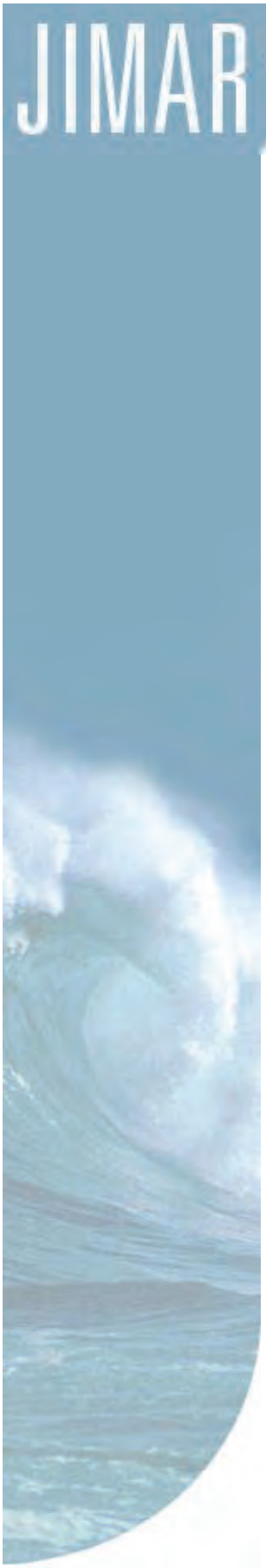
JIMAR Joint Institute for Marine and Atmospheric Research



JIMAR

Annual Report for Fiscal Year 2018

For Cooperative Agreements NA16NMF4320058, NA17NMF4320250, NA17NMF4320293, and NA17NMF4320294

Douglas S. Luther, PhD
Director

Joint Institute for Marine and Atmospheric Research
University of Hawai'i at Manoa
1000 Pope Road, Marine Sciences Building 312
Honolulu, HI 96822 USA
http://www.soest.hawaii.edu/jimar

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

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Introduction

Doug Luther, PhD, Director

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, for conserving and managing coastal and marine resources in island environments, notably the Hawaiian Islands and the U.S.-affiliated Pacific Islands, and for supporting the region's economic, social, and environmental needs. Included in this report are projects under award numbers NA16NMF4320058, NA17NMF4320250, NA17NMF4320293, and NA17NMF4320294. JIMAR seeks to:

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

Jeff Hare, PhD, Deputy Director for PIFSC Projects

JIMAR is located at the University of Hawaii (UH), a research-intensive land-grant and Sea Grant institution that maintains a service mission to the State as well as to the Pacific Islands Region. JIMAR is a unit within the School of Ocean and Earth Science and Technology (SOEST), which has developed several centers of excellence in marine, atmospheric, and earth sciences that align 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 its 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 ~23 JIMAR projects encompassing coral reef monitoring and research, marine mammal and turtle research, human dimensions investigations and economics of fisheries, fisheries bycatch mitigation research, oceanic and reef ecosystems modeling, insular and pelagic fisheries stock assessment research, fisheries database management, and more.

JIMAR also interacts with the NOAA National Weather Service (NWS), National Environmental Satellite, Data, and Information Service (NESDIS), and Office of Oceanic and Atmospheric Research (OAR) Line Offices, which support a number of projects in the research themes of equatorial oceanography, climate research and impacts, tropical meteorology, and tsunamis and other long-period ocean waves. JIMAR programs active in these areas include the University of Hawaii Sea Level Center (UHSLC), the Pacific El Niño Southern Oscillation (ENSO) Applications Climate (PEAC) Center, and the Pacific Islands Ocean Observing System (PacIOOS).

Research

JIMAR research covers eight themes, all aligned with the NOAA strategic plan and the University's Indo-Pacific mission. The themes are as follows: (1) ecosystem forecasting; (2) ecosystem monitoring; (3) ecosystem-based management; (4) protection and restoration of resources; (5) equatorial oceanography; (6) climate research and impacts; (7) tropical meteorology; and (8) tsunamis and other long-period waves.

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

- The coastal ocean and coral reefs provide seafood, resources for recreation, protection from waves and storms, and preservation of cultural practices. However, ecosystems are vulnerable to the pressures of increasing population, coastal development, fishing, pollution, and climate change. JIMAR Ecosystem Model Researcher Mariska Weijerman led a study to provide options for protection and restoration of marine ecosystems for the future using an ecosystem model to simulate alternative management strategies and evaluate indicators of key ecosystem services (Weijerman et al., 2017). The current management scenario was the poorest performer, with nearly all key ecosystem indicators decreasing or with no meaningful change. Alternative management options showed improvements in ecosystem structure and resilience. The scenario with only line fishing represented the most balanced trade-off for all indicators with positive gains for both ecosystem structure and resilience and dive tourism and only moderate losses for fisheries.
- The impacts of the 2014 thermal stress event on reefs in the Papahānaumokuākea Marine National Monument (PMNM) were assessed in a study led by JIMAR Coral Reef Researcher Courtney Couch (Couch et al., 2017). The study tested for signs of regional acclimation, and investigated long-term change in heat stress using bleaching surveys, satellite data and Structure-from-Motion technology. The 2014 event was widespread and severe with the highest stress at Lisianski Island, which experienced 20°C-weeks of thermal stress, up to 91% coral bleaching and 68% loss in coral cover that resulted in rapid and dramatic loss in reef complexity. Historical satellite data demonstrated the heat stress in 2014 was unlike any previous event and that exposure of corals to bleaching-level heat stress has increased significantly in the northern PMNM since 1982, highlighting the increasing threat of climate change to reefs.
- Ecological monitoring of a large projected area presents great challenges to scientists and managers due to its size and the wide variety of habitats it can potentially encompass. JIMAR Ecological Research Statistician Atsuko Fukunaga and a NOAA scientist from the Papahānaumokuākea Marine National Monument developed a multivariate statistical method that quickly triggers an alarm when unusual changes in the biological community structure are detected in long-term monitoring data (Fukunaga and Kosaki, 2017). This method accounts for different environmental factors (e.g., geographical locations and habitats) before examining temporal changes in biological data and can be used with any ecological monitoring data, greatly increasing the utility of monitoring data in the management of a large projected area.
- A research team including JIMAR Life History Research Scientist Brett Taylor and JIMAR Fishery Assessment Specialist Maia Kapur examined variation in body sizes of coral reef fishes across an area spanning the northern half of the Australian Great Barrier Reef. Despite observations across a wide range of environmental gradients, they found the effects of wave energy on coral reef habitats appear to be a fundamental driver in the 'pace of life', even driving some of the most basic aspects of the biology of important coral reef fishes (Taylor et al., 2017). The findings of this study foster a better understanding of how fishes interact with coral reef habitats and provide a baseline for predicting and interpreting future changes in fish productivity as it relates to coastal fisheries.
- A study led by JIMAR Marine Ecosystem Research Coordinator Kaylyn McCoy estimated fisheries catch for nearshore reef-associated fish species in Hawaii, such as parrotfish, surgeonfish, goatfish, and chub, in both the commercial and non-commercial sectors. The study revealed that non-commercial fisheries produce more than five times the catch of commercial fisheries and make up about 84% of the total nearshore catch (McCoy et al., 2018). From 2004 to 2014, the average annual non-commercial catch was 900,000 kilograms (~two million lbs.) compared to the annual average commercial nearshore catch over the same period of less than 200,000 kilograms (~500 thousand lbs).
- JIMAR Fisheries Social Research Associate Rebecca Ingram led a diverse group of individuals, including researchers, community members, and resource managers, to build a comprehensive understanding of West Hawai'i's nearshore marine ecosystem in order to inform ecosystem-based management. Participants of the study identified pressures impacting the ecosystem and influencing the delivery of ecosystem services critical to the well-being of society. Ecosystem pressures perceived to have the strongest impact are largely amenable to local management rather than requiring global mitigation. Participants also determined ecosystem services without a tangible or material use as the most vulnerable to ecosystem state change, a troubling find as these services are frequently omitted from resource management strategies (Ingram et al., 2018).

- A primary challenge of evolutionary research is identification of ecological factors that favor reproductive isolation, so studying partially isolated taxa has the potential to provide insight into the mechanisms of evolutionary divergence. A study led by JIMAR Postdoctoral Research Fellow Jonathan Whitney utilized an adaptive color polymorphism in the arc-eye hawkfish to explore the evolution of reproductive barriers without geographic isolation. They observed greater genetic divergence between color morphs on the same reefs than that between the same morphs in different geographic locations, and the team hypothesize that adaptation to contrasting microhabitats overrides gene flow and is responsible for the partial reproductive isolation observed between sympatric color morphs. Combined with complementary studies of hawkfish ecology and behavior, the genetic results indicate an ecological barrier to gene flow initiated by habitat selection and enhanced by assortative mating (Whitney et al., 2017).

Transitioning to Applications

Transitioning science outcomes to direct societal applications was a major focus for JIMAR researchers over the past year. Regional and global sea level change studies by JIMAR researchers at the UHSLC have yielded assessments and forecast tools of high sea level events up to six months in advance in the Pacific Islands region. In particular, a decadal shift in Pacific trade winds led to unusually high water levels that impacted the Hawaiian Islands region for over a year. This high water stand in combination with high spring tides and mesoscale eddy variability led to record water levels periodically throughout the 2017 summer season, including the highest daily water level in the century-long Honolulu tide gauge record. Using new dynamical and statistical modeling techniques, the UHSLC was able to provide notice of flooding threats weeks to months in advance and assisted the NWS with the issuance of public warnings. The seasonal sea level forecasting assessments established for the Pacific Islands will be extended to all U.S. coastlines under a recently funded NOAA Modeling, Analysis, Predictions, and Projections (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 of 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 researchers and administrators make fundamental contributions to the success of the PacIOOS, which empowers ocean users and stakeholders throughout the Pacific Islands by providing accurate and reliable coastal and ocean information, tools, and services (such as forecasts of ocean conditions) that are easy to access and use. PacIOOS continues to operate and maintain over 30 deployed buoys, sensors and other instruments throughout the U.S. Pacific Islands. New partners continue to be recruited into the PacIOOS regional association. A variety of PacIOOS-developed forecasts are made available to the public to enhance community resilience, including coastal inundation, wave, ocean, and atmospheric forecasts. A new ocean circulation model grid for Kāne‘ohe Bay, O‘ahu, was added to the suite of forecasts this past year, and a three-year NOAA Coastal Resilience Grant was secured to develop a high-spatial-resolution model to forecast the swell-wave-driven coastal inundation that periodically wreaks havoc on West Maui shores. Swell waves from remote storms are what make the seasonal and interannual high sea level events studied within the UHSLC (described above) so dangerous. The Maui model is being developed by Visiting Professional Colleague Volker Roeber, JIMAR Postdoctoral Fellow Assaf Azouri, JIMAR researcher Martin Guiles, and Sea Grant graduate student Camilla Tognacchini.

This year marked the ten-year anniversary for PacIOOS and a new five-year strategic framework was developed to guide PacIOOS' strategic direction. PacIOOS works closely with state and federal agencies, non-profit organizations, academic institutions, and other partners to make coastal and oceanographic data publicly available and ensure it delivers relevant information. To further improve the quality of its operations in a timely manner, PacIOOS successfully secured outside funding, including NOAA's Regional Coastal Resilience Grant, Office of Insular Affairs Technical Assistance Program funding, and U.S. Integrated Ocean Observing System Ocean Technology Transition funding. Improvements are continually being made to PacIOOS' website (http://pacioos.org) and data visualization platform, PacIOOS Voyager (http://pacioos.org/voyager), to enhance utility and accessibility.

Outreach and Education

JIMAR commemorated a groundbreaking event on February 8, 2018. Hawaiian monk seal community groups gathered with NOAA, JIMAR, UH/SOEST, and University of Hawaii Foundation staff at the Makai Research Pier on Oahu to celebrate a first-of-its-kind private donation to the University of Hawai'i Foundation to create a fund supporting Hawaiian monk seal research in honor of Danny Brooks "DB" Dunlap (deceased) and his tireless work researching and protecting Hawaiian monk seals on Oahu. The gift honoring DB was made by his widow Marilyn Dunlap, Associate Director of the Pacific Biosciences Research Center (PBRC) and Director of the PBRC Biological Electron Microscope Facility. The DB and Marilyn Dunlap Hawaiian Monk Seal Research Fund will support monk seal research through JIMAR, particularly in collaboration with the Hawaiian Monk Seal Research Program within the PIFSC Protected Species Division. Well aware of the challenges of funding in the sciences, Marilyn established the fund to be broadly flexible to allow JIMAR to address needs and opportunities of monk seal research and preservation efforts not supported under federal funding and provide public education about the seals and their value to the environment. Charles Littnan, representing PIFSC's Protected Species Division, opined, "This gift epitomizes the best of what we can hope for in concerned, motivated citizens and in folks supporting conservation work in Hawai'i." Marilyn's gift is the first private gift to JIMAR and the only fund at SOEST dedicated to supporting research on Hawaiian monk seals.

JIMAR devotes a significant portion of its annual budget to educational opportunities for K-12 students through to 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 at 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 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, stock assessment, fish life history and dissection, marine food webs, plankton, marine animal behavior, climate change, socioeconomics and sea safety. This year's camp included a field trip to Paepae o He'eia Fishpond in Kaneohe to learn about current and traditional fishing techniques, the cultural and historic significance of Hawaiian fishponds, and sand/sediment analysis methods and importance. In addition, local teachers are engaged to develop kit lessons based on the science modules, including lesson plans that appeal to Hawaii students throughout the school year.

The PIFSC Young Scientist Opportunity (PYSO) 2017 Summer Intern Program is another educational event sponsored by JIMAR. 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. Other events supported by JIMAR include the Hawaii Regional competition for the National Ocean Sciences Bowl (NOSB), called the "Aloha Bowl", held in Honolulu on February 3, 2018, and a day-long seminar, I Mōhāhā ka 'Ike: Charting how we use the Hawaiian language repository, held February 23, 2018 at the UH Manoa campus. In conjunction with the Hawaiian language repository seminar, JIMAR is also supporting UH graduate student Paige Okamura's efforts to translate Hawaiian newspaper articles from the 1800's that are of environmental and geophysical relevance. Progress of her work can be found in the tropical meteorology section of this report.

Given 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 on following pages will provide a better glimpse of 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.

JIMAR Structure and Funding

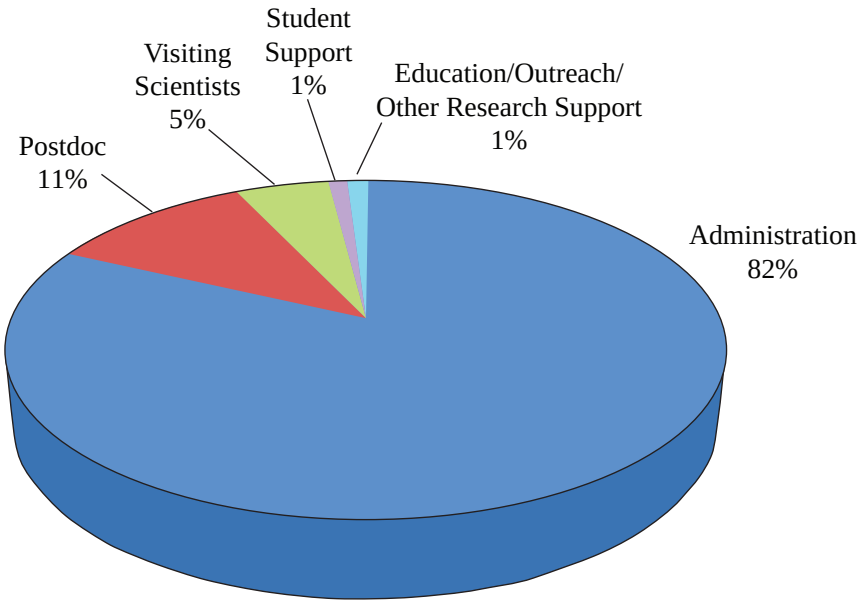
The Director of JIMAR is a regular member of the University of Hawaii faculty and is appointed through joint decisions by leaders of the University and NOAA Research. The Director reports to an Executive Board composed of University and NOAA officials. The Director manages day-to-day operations through the administrative staff (fully-supported by the Cooperative Agreement and returned indirect cost funds), Program Managers and faculty PI/Directors. A Council of Fellows advises the Director on research opportunities and promotes cooperation and scientific collaboration. The Fellows are drawn from both NOAA and the University of Hawaii.

JIMAR Council of Fellows from NOAA are Dr. Christofer Boggs (PIFSC), Dr. Russell Brainard (PIFSC), Mr. Justin Hospital (PIFSC), Dr. Gregory Johnson (PMEL), Dr. William Kessler (PMEL), Dr. John Marra (PRCS), Dr. Michael McPhaden (PMEL), Dr. Frank Parrish (PIFSC), Dr. Jeffrey Polovina (PIFSC), Dr. Michael Seki (PIFSC), and Mr. Raymond Tanabe (NWS).

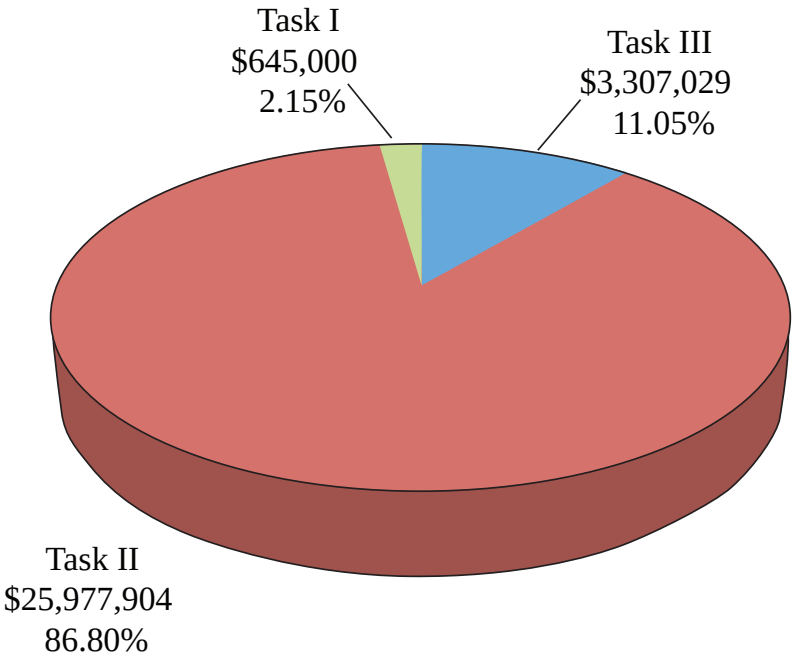
JIMAR Council of Fellows from the University of Hawaii are Dr. Steven Businger, Dr. Jeffrey Drazen, Dr. Eric Firing, Dr. Erik Franklin, Dr. Kim Holland, Dr. Margaret McManus, Dr. Anna Neuheimer, Dr. James Potemra, Dr. Brian Powell, Dr. Robert Toonen, and Dr. Bin Wang.

The following charts indicate the purposes of funds flowing through JIMAR. Task I is the base management support of JIMAR and also includes support for the visiting scientist and postdoctoral programs, general education and outreach. The University of Hawaii contributes to this Task by bearing all indirect costs, and by paying the salary of the Director. Task I funding percentages by activity are exhibited in the first chart below. Task II designates research activities involving on-going direct collaborations with NOAA scientists. The collaboration is typically fostered by the co-location of JIMAR and NOAA scientists, such as at PIFSC. Task III research activities generally have only minimal direct collaboration with NOAA scientists. Projects that fall under this task would include research that is funded by other NOAA competitive grant programs, NOAA funding announcements administered through JIMAR, NOAA awards directly to CI scientists, and funding from other federal agencies. The second chart below shows the distribution of funds by Task, and the third chart shows the same funds distributed according to the JIMAR themes listed above.

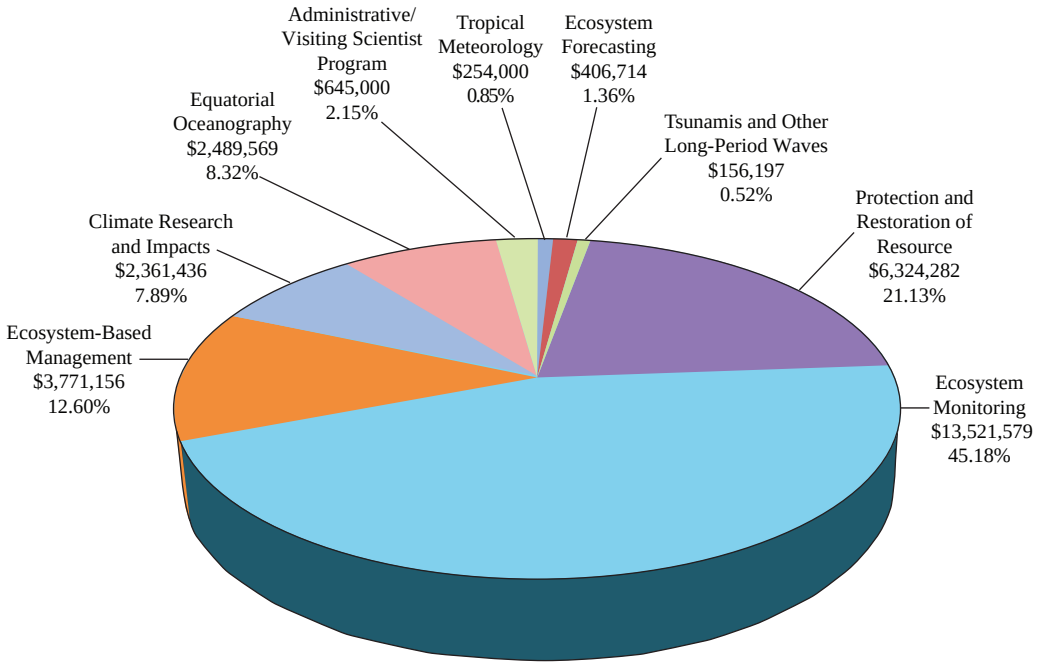
Distribution of JIMAR's Task I NOAA Funding by Activity



Distribution of NOAA Funding by Task



Distribution of NOAA Funding by Theme



Accomplishments for Fiscal Year 2018

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

Cumulative Budget Amount: $325,000

NOAA Goal(s):

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

Purpose of the Project

The general purpose of the ADMB Open Source Project is to maintain and improve the 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 worldwide.

Progress during FY 2018

One of the main goals of the project is to produce annual software releases that include bug fixes, improvements and possible new features. In December 2017, the project released ADMB-12.0 and as of June 30, 2018, there were 1,030 total downloads of the latest release binaries and source distributions. AD NUTS is the new added feature of the release, which was developed by Dr. Cole Monnahan with assistance from the project. Another feature currently being developed and investigated is the multiple CPU support in the ADMB libraries; further development of this feature will continue for the next fiscal year. The version control repository recorded a total of 923 changes and fixes to the software from the previous release ADMB-11.6. The ADMB software is used by NOAA science centers, researchers, and scientists worldwide. According to Google Scholar, ADMB was cited 286 times in 2017 and 156 times in 2018. In August 2017, a developers' workshop was held in Copenhagen, Denmark to discuss the future of ADMB and to investigate ideas for development. University of Southampton (UK) mathematician Dr. Helen Ogden made a presentation on the confidence of Laplace approximations, and Dr. Cole Monnahan discussed how to use the new feature AD NUTS for MCMC models. Finally, developers broke into smaller groups to fix and resolve numerous issues in the software including a problem with the likelihood profiler.

The following list of publications is non-exhaustive but attempts to capture a wide arrange of publications using ADMB software in 2017-18.

- Punt, A., D. Okamoto, A. MacCall, A. Shelton, D. Armitage, J. Cleary, I. Davies, S. Dressel, T. Francis, P. Levin, R. Jones, H. Kitka, L. Lee, J. McIsaac, M. Poe, S. Reifenstuhl, J. Silver, J. Schmidt, T. Thornton, R.

Voss, and J. Woodruff, 2018. When are estimates of spawning stock biomass for small pelagic fishes improved by taking spatial structure into account? *Fisheries Research*, 206, 65-78.
- Aeberhard, W., J. Flemming, and A. Nielsen, 2018. Review of state-space models for fisheries science. *Annual Review of Statistics and Its Application*, 5, 215-235.
- Forrest, R., K. Holt, and A. Kronlund, 2018. Performance of alternative harvest control rules for two Pacific groundfish stocks with uncertain natural mortality: Bias, robustness and trade-offs. *Fisheries Research*, 206, 259-286.
- Murphy, J., L. Rugolo, and B. Turnock, 2018. Estimation of annual, time-varying natural mortality and survival for Eastern Bering Sea snow crab (*Chionoecetes opilio*) with state-space population models. *Fisheries Research*, 205, 122-131.
- Feenstra, J., A. Punt, and R. McGarvey, 2017. Inferring absolute recruitment and legal size population numbers of southern rock lobster (*Jasus edwardsii*) in South Australia's Southern Zone fishery using extended forms of depletion modelling. *Fisheries Research*, 191, 164-178.
- Thorson, J., and J. Cope, 2017. Uniform, uninformed or misinformed? : The lingering challenge of minimally informative priors in data-limited Bayesian stock assessments. *Fisheries Research*, 194, 164-172.
- Truesdell, S., J. Bence, J. Syslo, and M. Ebener, 2017. Estimating multinomial effective sample size in catch-at-age and catch-at-size models. *Fisheries Research*, 192, 66-83.
- Williams, D.E., M.W. Miller, A.J. Bright, R.E. Pausch, and A. Valdivia, 2017. Thermal stress exposure, bleaching response, and mortality in the threatened coral *Acropora palmate*. *Marine Pollution Bulletin*, 124, 1, 189-197.
- Allen, S., W. Satterthwaite, D. Hankin, D. Cole, and M. Mohr, 2017. Temporally varying natural mortality: Sensitivity of a virtual population analysis and an exploration of alternatives. *Fisheries Research*, 185, 185-197.
- Ailloud, L., M. Lauretta, A. Hanke, W. Golet, R. Allman, M. Siskey, D. Secor, and J. Hoenig, 2017. Improving growth estimates for Western Atlantic bluefin tuna using an integrated modeling approach. *Fisheries Research*, 191, 17-24.
- Nadarajah, S., and Rui Li, 2017. The exact density of the sum of independent skew normal random variables. *Journal of Computational and Applied Mathematics*, 311, 1-10.

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

P.I.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock

Cumulative Budget Amount: $81,714

NOAA Goal(s):

- Climate Adaptation and Mitigation

Purpose of the Project

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

Progress during FY 2018

Earth-Oceans Interactions Program (EOI). The project maintained and calibrated Miniature Autonomous Plume Recorders (MAPRs) including physical cleaning, inspecting, replacing hardware as needed, and addressed other details to restore MAPRs to their best physical condition. Calibrations were completed for temperature, pressure, optical backscatters and oxidation-reduction potential (ORP).

Ecosystems Fisheries-Oceanography Coordinated Investigations Program (Eco-FOCI). Project staff provided laboratory support for analysis of nutrients and oxygen samples from numerous field research programs in Alaskan waters and assisted with cruise logistics and equipment maintenance. The project also performed a variety of laboratory and logistical tasks including the preparation and staging of equipment for upcoming oceanographic expeditions.

Carbon Research Program (Carbon). The project ran samples in the PMEL Carbon Program laboratory for dissolved inorganic carbon (DIC) concentrations and/or total alkalinity (TA) analyses.

Ecosystem Monitoring

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

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

P.I.: Eric Heinen De Carlo

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

NOAA Sponsor: Gary Matlock

Cumulative Budget Amount: $97,210

NOAA Goal(s):

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

Purpose of the Project

The primary objective of this project is to carry out expanded field sampling for inorganic carbon parameters in the water column of tropical coral reefs, particularly concurrent with the deployment of new technology by project research partners, and carry out laboratory-based data validation analyses that were previously not possible with the limited resources provided by other funding agencies supporting the project's Ocean Acidification (OA) research.

Progress during FY 2018

The project continued 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). Research activities also supported the goals of national and global OA observing efforts through continued collection and analysis of bottle samples for subsequent laboratory determination of dissolved inorganic carbon (DIC) and total alkalinity (TA) at two week

Figure 1. Instruments deployed on the seafloor in Kaneohe Bay, Oahu, Hawaii, between coral heads as part of an evaluation of capabilities for high endurance automated measurements of inorganic carbon system parameters.

Figure 2. View of the CRIMP-2 buoy, an NCRMP Class III site in Kaneohe Bay, Oahu, Hawaii.

intervals (weather and sea conditions permitting). Sampling takes place at four NOAA (PMEL, OAP and Sea Grant) supported MAP-CO_2 buoys that are deployed on coral reefs around the island of Oahu, Hawaii. The project also carried out short-term, high-intensity sampling experiments in conjunction with academic colleagues whose objectives are twofold: 1) derive a better understanding of the processes driving coral reef metabolism near the fixed MAP-CO_2 buoy sites (with SIO colleagues); and 2) develop new technology that allows precise and accurate automated measurement of two of the four CO_2-carbonic acid system (with PMEL and SIO colleagues). The project continued to participate in the NSF and OAP sponsored inter-laboratory comparison project (for inorganic carbon system parameters) conducted by Dr. Andrew Dickson of SIO and is pleased to report excellent results by UH graduate student, Lucie Knor, who is sponsored by a companion NOAA/UH Sea Grant project.

Ecosystem Structure and Function

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

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

NOAA Sponsor: Michael P. Seki, Phoebe Woodworth-Jefcoats

Cumulative Budget Amount: $455,680

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

This project conducts research to further advance understanding of the structure and function of an important marine ecosystem, the subtropical gyre. This work includes a range of approaches to increase understanding of this ecosystem, particularly how trophic structure is impacted by climate variability and change. One component of the project consists of processing and analyzing a time-series of lancetfish stomach contents collected by observers in the Hawaii-based longline fishery to develop an index of the pelagic micronekton community. This index is then

used to describe the spatial and temporal patterns of micronekton across the central north Pacific. Another component of the project examines fishery dependent data sets (observer, logbook, and dealer records from the Hawaii-based longline fishery) in conjunction with oceanographic data to assess spatiotemporal trends in catch composition and to identify drivers of this change. Ecosystem modeling approaches are also used to evaluate changes in ecosystem structure and function as well as the vulnerability of species to climate change.

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

Progress during FY 2018

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 reporting period, a University of Hawaii (UH) graduate assistant working with JIMAR documented the contents of about 600 lancetfish stomachs, identified prey items to the species level, documented unknown species, and worked with experts in the field to identify cephalopod and fish species by providing them valuable samples. All diet data was entered into a dedicated database and is currently being correlated with environmental variables in the central north Pacific to determine spatial and temporal patterns.

JIMAR Research Analyst Dr. Johanna Wren, used market data to construct a recruitment and forecasting index for bigeye tuna. By analyzing the weights of all bigeye tuna landed in Hawai‘i, the study identified bigeye tuna that were recently recruited into the fishery and was able to follow these cohorts through the fishery for several years. The results showed that big recruitment events are rare, with only three events in the past 18 years, and that the recent increase in catch per unit effort (CPUE) seen in the fishery is due to one of these events rather than an increase in population size. CPUE is predicted to decline in 2018 compared with 2017. This recruitment index has proven to be another useful tool for fisheries management to evaluate population dynamics in the Hawai‘i longline fishery and investigate connections with environmental processes and bigeye tuna population dynamics across the Pacific. This work was submitted for publication in the academic journal *PLOS ONE* and is currently under review.

Interactions between black-footed albatross and the Hawai‘i deep-set longline fishery increased threefold over the period 2015 through 2017 compared with the previous eight years (2006-2014). JIMAR project researchers investigated possible factors behind the increased interactions. Black-footed albatross interactions were found to increase during positive Pacific Decadal Oscillation (PDO) years because the frontal system where the albatross forage is pushed further south by the strong Aleutian low pressure system. Over the past eleven years, the PDO phase shifted from negative to positive in 2014 and has remained in the positive phase. The results show that the increase in interactions is mainly due to environmental change rather than a change in the behavior of the fishing fleet. This work was presented at the Workshop on the Factors Influencing Albatross Interactions in the Hawai‘i Longline Fishery: Towards Identifying Drivers and Quantifying Impacts, which was convened by the regional fishery council (WPRFMC) and held November 7–9, 2017 in Honolulu, HI. A NOAA Technical Memo will be developed to expand the topic at a later date.

JIMAR Climate Vulnerability Analyst, Dr. Jonatha Giddens completed species profiles for 83 fish and invertebrate species in the Pacific Region. These profiles consist of a thorough review of the literature on 12 biological and ecological attributes of the species that could be affected by climate change and species distributional range in the Pacific, and were used by experts to evaluate species vulnerability during a three-day workshop in March 2018. Sixteen fish and invertebrate experts scored species' relative vulnerability to climate change based on these profiles, as well as the overlap in projected climate exposure across the species range. The results of this study were presented at the Effects of Climate Change on the World's Oceans Conference held June 4–8, 2018 in Washington, D.C., and at the 5th International Marine Conservation Congress held June 24–29, 2018 in Kuching, Sarawak, Malaysia.

JIMAR Ecosystem Model Researcher, Dr. Mariska Weijerman is spearheading efforts to build an end-to-end Atlantis model for the main Hawaiian Islands. This model will represent a significant advancement in archipelagic-wide modeling efforts in Hawaii and requires seeking input and data from more than 20 technical experts, five local agencies, and several research departments at the University of Hawaii. This year, the physical module and the nutrient-phytoplankton-zooplankton module were successfully parametrized and the next step is to synthesize biomass, diet and fishing data for fifty-nine species groups.

Finally, the project completed an update of an existing configuration of the Massachusetts Institute of Technology general circulation model for the Hawaiian Archipelago. The time span of the model was increased from five years (2009-2014) to ten years (2007-2017), and daily atmospheric variables (solar and longwave radiation, air temperature, humidity and precipitation) were used to force the ocean model instead of a long-term average of these variables. These improvements allow the model simulation to include seasonal as well as interannual variabilities in the description of the ocean state, in particular, the recent El Niño event in 2015. The model output is currently being used to study larval transport characteristics in the Hawaiian Archipelago.

Ecosystems Observations and Research Program: Pacific Islands Fisheries and Ecosystems Support Project

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

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

NOAA Sponsor: Michael P. Seki, Noriko Shoji

Cumulative Budget Amount: $1,845,654

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 gear can be customized to survey species-specific depths, habitat types, and spatial scales. As effective management of fisheries resources becomes more critical, advancements in data collection methodologies expand 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 be developed, there will be a continuing need to evaluate the new technology and standardize fisheries data products across survey platforms from photo and/or video analysis.

Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. As scientific field campaigns become more complex with multi-faceted, multi-platform, multi-disciplinary, and technologically advanced endeavors, the responsibilities of scientists within PIFSC have grown such that dedicated trained JIMAR staff is necessary to support planning and execution of desired science endeavors. Science operational staff directs research by collaborating with JIMAR investigators to plan the effective use of equipment and resources and ensure operations are conducted safely and according to established policy. This model allows the scientists to focus on their research objectives, while expert staff helps plan, coordinate, and execute safe and effective science operations.

Advanced Survey and Sampling Technology Development. Keeping abreast of emerging new technology and maintaining current survey and sampling technological assets are vital to staying on the cutting edge of fisheries research. Coordination between dedicated JIMAR staff and researchers of different disciplines provide a broader perspective in ascertaining survey and sampling technology needs and priorities. This centralized model allows technology to be assessed for availability and effectiveness for multiple users. The need for survey and sampling technology development on a broader scale at PIFSC is essential to fostering collaboration and maximizing utilization of technology assets. It provides opportunities for cost sharing and cross training to gain a wider range of expertise. This allows scientists to focus on their research while still integrating the newest, most cost-effective data collection methods.

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 planning research programs and publishing results. Unfortunately, access to the data and associated tools is not universally available. While some PIFSC programs have well-developed 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 more readily available. By providing easy access to its repository of photos, The Monuments Photo Library Project aims to engage and inspire researchers and the general public. This project collaborates with different programs within the National Marine Fisheries Service (NMFS) to provide assistance with collecting archived photos, selecting the best images, cataloging, and updating metadata records for photos in preparation for data entry into Monuments Photo Library Interface.

Progress during FY 2018

Analysis and Evaluation of Fishery Independent Data and Collection Methods for Insular Fish Stocks in the Pacific Islands Region. During the reporting period, JIMAR staff on the Analysis and Evaluation Team supported the Modular Optical Underwater Survey System (MOUSS), 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 during the Main Hawaiian Islands (MHI) Fall Bottomfish Fishery-Independent Survey aboard NOAA Ship *Oscar Elton Sette* in October–November 2017. In addition to the MOUSS surveys aboard the *Oscar Elton Sette*, an additional research fishing vessel *F/V Ao Shibi IV,* which was operated by the Pacific Island Fisheries Group (PIFG), completed a total of forty MOUSS camera deployments around the island of Oahu under the guidance of JIMAR staff. This additional field effort completed the MHI Fall Bottomfish Fishery-Independent Survey mission. As a result of this mission, a total of 288 camera deployments that were annotated for Deep-7 bottomfish and sized-structured abundance data were delivered to PIFSC Fisheries Research and Monitoring Division's (FRMD) Stock Assessment Program (SAP) in March 2018.

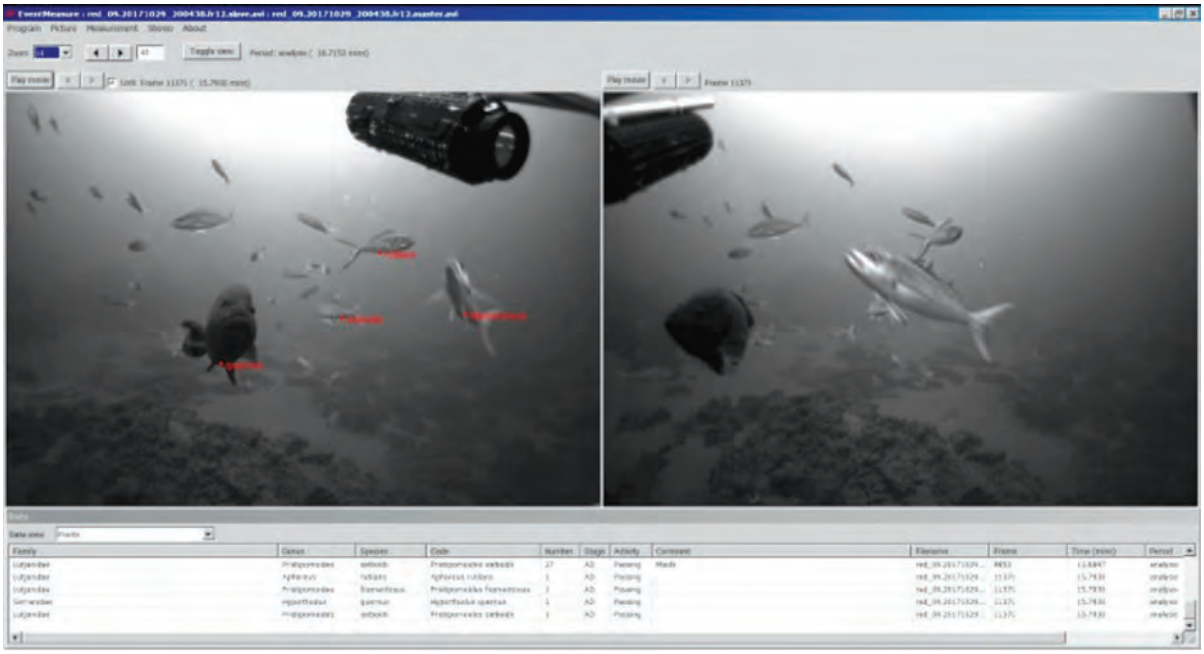


Figure 1. Screenshot of imagery from being annotated in Event Measure Software.

Through historical analysis and annotation of MOUSS video, depth limitations were observed due to lack of ambient light at increasing depth. To increase the MOUSS operational survey depth, JIMAR staff of the Survey and Sampling Technology Program (SSTP) partnered with the University of Hawaii, Hawaii Institute of Marine Biology (UH HIMB) to conduct experimental trials to test the feasibility and effectiveness of using dual-frequency identification sonar (DIDSON) "acoustic camera" technology as a potential complement to current MOUSS bottomfish surveys. The DIDSON produces near-video image quality data streams and is commonly used to obtain fish counts in turbid or low-light waters like rivers. Paired DIDSON-MOUSS fish observations were obtained using penned fish at HIMB's Coconut Island facility and preliminary data was analyzed for fish species, length, range, and camera field of view. The data showed that the DIDSON was unable to provide sufficient detail to allow for fish species identification, making it a poor fit for fisheries studies of mixed species assemblages.

The Analysis and Evaluation Team also assisted with the development of Video and Image Analytics for Marine Environment (VIAME) software after attending the VIAME automated image analysis workshop this year. New annotations of bottomfish were created using Kitware software and these annotations will help train machine learning algorithms to distinguish each of the Deep-7 bottomfish species with the eventual goal of increasing video analysis efficiency by automating certain steps in the image analysis process.

Advanced Survey and Sampling Technology Development. For researchers that required development, evaluation, fabrication, and maintenance of in-situ instrumentation and monitoring systems in the PIR, JIMAR staff supported the PIFSC Science Operations Division (SOD) SSTP in a variety of field and laboratory capabilities. JIMAR staff served as technical leads for science operations and collaborated with participating researchers to fulfill their project technical requirements. This year, SSTP supported the Protected Species Division (PSD), Cetaceans Research Program (CRP), and the Marianas Archipelago Cetacean Survey (MACS) by redesigning and fabricating a new prototype Drifting Acoustic Spar Buoy Recorder (DASBR) housing and array aboard the NOAA Ship *Oscar Elton Sette*. DASBRs are free-floating acoustic recorders designed to mitigate background noises that are associated with towed array systems and to detect species that tend to shy away from ships and other activities that create a noisy environment. DASBRs are deployed from the ship to drift on the ocean currents for several weeks at a time and consist of two hydrophones set 10 m apart and connected to a small recorder at the bottom of the buoy. The SSTP fabricated ten newly designed prototypes with upgraded housing design which could increase DASBR recovery rates.

JIMAR and federal SSTP staff designed and fabricated prototype artificial light-emitting diode (LED) lights to enhance MOUSS stereo camera system surveys currently limited by the lack of ambient light at depth. In addition

to developing the LED underwater light systems, studies are being conducted to determine the most effective light intensity (brightness required to accurately identify specific MHI bottomfish species), color (wavelength that has the least effect on fish behavior), and field of view (illuminates an area that mirrors MOUSS stereo camera field of view) to mitigate any potential impacts on Hawaiian bottomfish behavior.

Operations and Logistics Services to Support Pacific Islands Fisheries Science Center Research Missions and Projects. During the year JIMAR staff played a vital role in providing logistical, operational, small boat, laboratory, and dive research support to all PIFSC divisions, missions and projects. On two cruises, the JIMAR Field Operations team members also performed pivotal project leadership roles and made significant contributions to the successful completion of mission objectives. During these missions JIMAR staff either held the overall Project Leader position or project Operations Lead role. They provided leadership, expertise, supported MOUSS deployment operations in the Main Hawaiian Islands, and assisted in Life History data collection efforts in the Commonwealth of the Northern Mariana Islands (CNMI).

Figure 2. MOUSS survey operations conducted around the Main Hawaiian Islands.

Additionally, the SOD JIMAR field staff trained the captain and crew of PIFG cooperative *F/V Ao Shibi IV* on MOUSS camera deployments and recoveries. "Bare frame" camera deployment and recovery training were followed by "live camera" MOUSS surveys, which contributed to the completion of the MHI Fall Bottomfish Fishery-Independent Survey.

To ensure that the Ecosystem Sciences Division (ESD) and SOD small boat programs met or exceeded NOAA's safety standards and policies, JIMAR staff in the SOD Field Operations Program supported PIFSC small boat research operations by working as Vessel Operation Coordinators (VOCs) for small boat resources, maintenance and repairs. JIMAR Staff also coordinated Annual Small Boat Examination (ASBE) efforts held in November 2017. Due to the increase in resources and research collaboration, a new standard was created for existing ASBE inspections to further minimize safety risks and the loss of project operational days due to small boat mechanical breakdowns.

The project increased its function with the addition of a Dive and Laboratory Research Manager. The dive locker and lab spaces are utilized by numerous programs and agencies including PIFSC, Papahanaumokuakea Marine National Monument (PMNM), Pacific Islands Regional Office (PIRO), UH, HIMB, and United States Geological Survey (USGS). JIMAR staff managed coordination of these spaces, activities, personnel training, shared equipment use and maintenance. When UH's Hyperbaric Treatment Center (HTC) temporarily closed in October 2017, JIMAR staff helped coordinate NOAA Ship *Hi'ialakai* and NOAA Diving Center resources to temporarily relocate the containerized hyperbaric chamber (Figure 3) to the IRC. This allowed for continuation of NOAA and JIMAR dive operations with the required emergency support. Specially trained JIMAR staff also provided technical skills and labor by managing the chamber operations until the HTC resumed operations in January 2018.

(left) Figure 3. Inside the NOAA Diving Program's containerized hyperbaric chamber. (right) Figure 4. JIMAR's Jeremy Taylor and Dianna Miller preparing the MOUSS stereo camera for preliminary testing in tandem with a prototype artificial LED light.

JIMAR staff also developed training curriculum for two small boat workshops for the PSD Monk Seal Field Camps that covered maintenance, repairs and limitations of inflatable boats and outboard motors. These trainings supplemented other ongoing PSD staff training and development with the goal of field staff conducting safer small boat field operations.

Geospatial Products. Due to the vacancy in SOD's JIMAR PIFSC GIS Data and Web Services Specialist position, ongoing projects were assumed by GPT members in ESD. The objective of the Big Earth Data Initiative (BEDI) Web Mapping Project is to provide both dataset and enterprise-wise improvements by building upon previous work. As a result of the project's current efforts a collection of web-based, regional mapping services was designed to aid in the distribution of PIFSC marine science information. All web mapping services are available through a link for each data-set published with the ArcGIS Server.

The ArcGIS Server backend provides a simple, open web standard for web mapping services hosted by PIFSC. The web mapping services are incorporated into interactive mapping applications and provide an easy way to directly view the PIFSC GIS data. The applications draw data from PIFSC GIS databases and present it in a user friendly web browser interface. By using these applications, an end-user can visualize, query, filter and download the data.

Marine National Monuments of the Pacific. Due to the vacancy in SOD's JIMAR PIFSC GIS Data and Web Services Specialist position, no significant progress was made with this project.

Ecosystems Observations and Research Program: Research Support Project

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

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

NOAA Sponsor: Michael P. Seki, Evan Howell

Cumulative Budget Amount: $1,016,073

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. The project activities enable scientists to provide advice to those charged with management of the resources as mandated by legislation (e.g., Reauthorized Magnuson Stevens Act, Marine Mammals Protection Act, Endangered Species Act, etc.). Current project activities include: Environmental Data Management; Bottomfish Population Assessments; Aquaculture Systems Management; and Outreach and Education.

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

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 focused on bottomfish research (see JIMAR annual reports on Sustaining Healthy Coastal Ecosystems, 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).

Aquaculture Systems Management. The Aquaculture System Management project provides system management for the Seawater System (SWS) facility on Ford Island to support research of marine species of concern to the Pacific Island Region. This includes working closely with federal and University partners in coordinating, developing, modifying, and maintaining the captive care facility for research, culture, and rehabilitation for marine species.

Pacific Islands Region Fisheries Science Outreach and Education. The objectives of this JIMAR effort are to plan, develop and implement an effective outreach and education program via a partnership between JIMAR and PIFSC. JIMAR staff serves as resource, advisor, and point of contact for outreach and education activities for JIMAR, PIFSC, and Pacific Islands Regional Office (PIRO) outreach and communications staff, across all 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 2018

Enhanced Environmental Data Management to Support Fisheries and Ecosystem Research. Led by Jesse Abdul, one of the project's accomplishments was the formation of multiple functional groups of data professionals in the areas of data management, database development, and application development. A tactical Software Development Team with representation from all scientific divisions was identified by the Science Operations Division (SOD) Director and led by the JIMAR Supervisory Data Applications Developer, Jesse Abdul. Biweekly group meetings were recently initiated to discuss software development in PIFSC, focusing on defining and reviewing application development and database development standards and defining best practices applicable to all PIFSC divisions. A standing agenda item for all Software Development Team meetings is discussion of common software needs in each division and identifying collaboration opportunities. The Software Development Team reviewed and provided feedback for a subset of the proposed application development, database development, and version control standards and best practices developed by the JIMAR project. Three standards and one best practice were reviewed and approved by the team and recommended to PIFSC leadership for adoption.

Another recently established project goal was to develop centralized data tools to satisfy common needs and assist with overall data management improvement planning (DMIP) across PIFSC. The project developed multiple centralized data tools that integrate proposed best practices using the Procedural Language/Structured Query Language (PL/SQL) and can be installed on any Oracle database for version control, application authorization, and database logging. The project implemented these modules on active applications to evaluate the feasibility and effectiveness of the modules. A Database Version Control Module and Database Logging Module were made available to PIFSC programs. The project also developed three centralized software modules to facilitate Public

Figure 1. MTBAP Biologist Shawn Murakawa from the MTBAP explains sea turtle biology, habitat, foraging, nesting, and safe viewing information to students at the 2017 SOEST Open House on the UH Manoa campus.

Access to Research Results (PARR) compliance for PIFSC and the PIRO. The DMIP objective was deemed a lower priority and has been deferred during this project year.

The project developed centralized procedures and data tools to facilitate the documentation, dissemination, and archival of scientific data in order to satisfy the NOAA PARR mandate's requirements. During the reporting period JIMAR staff worked with NMFS and the National Centers for Environmental Information (NCEI) to define draft data archival specifications. Three software modules and a shared backend database to facilitate PARR data dissemination and archival compliance were developed: a Bulk Download Module (BDM) to generate data packages; a Data Set Information Application (DSIA) to provide on-demand access to PARR compliance reports; and an open source bagit module to generate data packages based on the draft archival specifications.

JIMAR developed data quality control criteria for the PIFSC PARR database and implemented them using a generalized Data Validation Module (DVM) framework developed by JIMAR to ensure the quality of the data packages. Based on the draft data archival specifications, the project developed the Bulk Download Guidance (BDG) that provided PIFSC and PIRO staff with a detailed standard operating procedure (SOP) to comply with PARR data dissemination and archival requirements. With support and guidance from the project, this tool was successfully used to make twenty-three data sets publicly accessible. JIMAR provided support for submission of four scientific data sets for archival with NCEI in order to work through the automated data archival process, which is currently in development.

JIMAR worked with staff from each of the PIFSC research divisions (Protected Species Division [PSD]; Ecosystems Sciences Division [ESD]; and Fisheries Research and Monitoring Division [FRMD]) to archive scientific data and make them publicly available to fulfill the NOAA PARR requirements. Project staff also reviewed the PIFSC and PIRO data inventory in the NMFS metadata repository to assess the data holdings of

Figure 2. Eighth grade students from St. Andrew's Priory School had an opportunity to tour and explore the NOAA Ship Reuben Lasker *to learn about the HICEAS, with hands-on activities including operating the "big-eye" binoculars on the ship's deck.*

each division. While deployed on a research cruise, JIMAR project staff assessed the state of Modular Optical Underwater Survey System (MOUSS) data management and developed data flow diagrams (DFDs) to identify data management improvements.

The project developed SOPs that integrate proposed best practices for securing database applications, deploying production applications, and using version control systems to provide guidance to PIFSC developers. The project also developed the BDG for fulfilling PARR requirements, which was made available to PIFSC data staff.

JIMAR established a project to standardize the PIFSC conductivity, temperature, and depth (CTD) data with intent to develop a centralized database to make standard data products widely accessible. The CTD project is planned for completion within a few months of the next project period.

During the year, JIMAR provided support and guidance on data management and data system development to multiple PIFSC programs and projects: Life History Program (LHP); International Fisheries Program (IFP); and South Pacific Tuna Treaty (SPTT).

Another recently established project objective was to facilitate integration of data sets collected by different PIFSC divisions to increase their usability and facilitate ecosystem approaches by researchers and resource managers, however, this objective was deemed a lower priority and has been deferred for future effort.

PIFSC solicited a pilot project to explore the suitability of the Google Cloud platform to satisfy data needs and in response the project developed a working prototype of a dynamic data-driven web application to visualize MOUSS surveys and preview or download processed MOUSS video data.

PIFSC identified a Big Earth Data Initiative (BEDI) priority project to archive MOUSS video data, and JIMAR provided support and guidance on various aspects of data management for the MOUSS data set to facilitate the archival of the large video data set. The project served as the data point of contact with NCEI and NMFS for

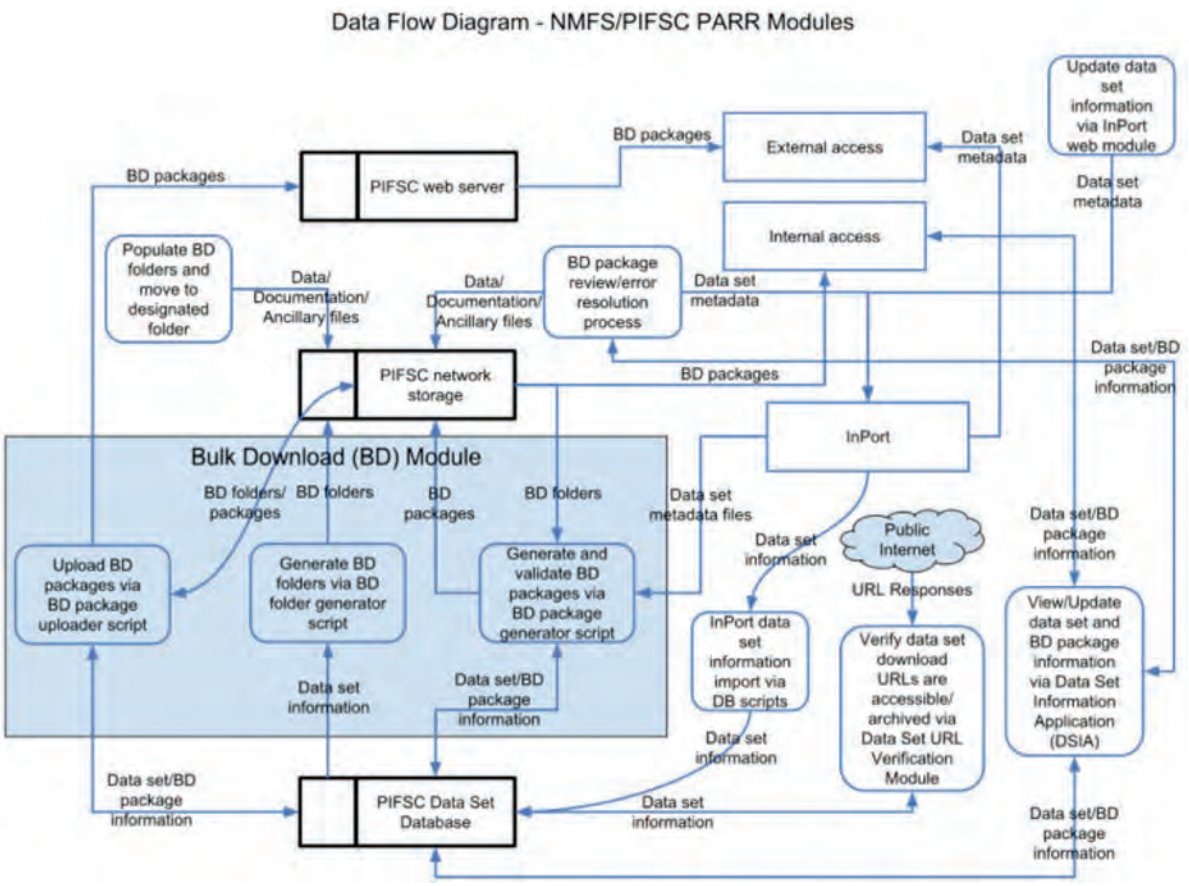


Figure 3. Formal data flow diagram illustrating the data flow from each of the NMFS/PIFSC Modules utilized for PARR compliance purposes.

the BEDI project to ensure that documentation and data requirements were fulfilled and also made the necessary adjustments in the PARR procedures. JIMAR updated the BDM and bagit module to successfully generate data archival packages for the large data set, and the project was involved in project management functions to ensure required tasks were identified and completed.

JIMAR staff participated in the annual NOAA Environmental Data Management (EDM) Workshop to learn more about the coordinated national efforts. In addition, the project provided comprehensive feedback for the PIFSC 5-year Science Plan and researched multiple potential multi-year data projects. JIMAR provided feedback on the formal national NMFS EDM Program Review document.

Coordinated Main Hawaiian Islands Bottomfish Population Assessments. During the reporting period JIMAR facilitated participation of staff from several divisions of PIFSC on research expeditions on board the NOAA *R/V Oscar Elton Sette*, including the Insular Bottomfish Survey (October–November 2017) and the Marianas Life History cruise (May–June 2018). Support was also tendered for bottomfish investigations for other collaborating JIMAR projects: the Territorial Biosampling; EORP Science Operations; Ecosystem Structure and Function; West Hawaii Integrated Ecosystem Assessment; Fishing Impacts on Non-target Species; and Sustaining Healthy Coastal Ecosystems projects.

Aquaculture System Management. Led by Aaron Moriwake, the JIMAR staff implemented a weekly exercise program and a year-round maintenance schedule to ensure system readiness for incoming animals in the four (monk seal, turtle, fish, and multi-purpose) distinct units. JIMAR trained Marine Turtle Biology and Assessment Program (MTBAP) staff and other staff on system operations and coordinated daily activities within the yard with SWS staff and researchers from PIFSC. Other support included resolving maintenance issues on the Supervisory Control and Data Acquisition (SCADA) system such as camera and ultraviolet system failures, and troubleshooting broken, leaking, and malfunctioning equipment. JIMAR staff conducted monthly safety assessments for the SWS

facility, enhanced a monk seal holding area by sewing and installing a shade cover, and upgraded the SWS facility by adding a new valve on the turtle system to allow easier access to seawater for use by other programs. Records on the repair, maintenance, and replacement of equipment were archived on a shared Google document. In addition, updated system operation protocols were logged on the PIFSC Wiki site and in a binder in the SCADA room.

Within the reporting period, JIMAR provided support for three monk seals, 14 turtles, a Cetacean Research Program (CRP) High-frequency Acoustic Recording Package (HARP) seawater immersion test, a coral recruitment camera study, and two underwater video camera calibrations for the MOUSS. When animals are housed at the SWS facility, JIMAR staff provided 24/7 emergency support through email/text alarm alerts, and remote access control of cameras and the 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, educational opportunities, career fairs, Science Camp, PIFSC Young Scientist Opportunity, and printed and online products. Activities and outreach products are described below.

Outreach and educational activities. Staff participated in community and educational events to communicate information about JIMAR and NOAA's missions, programs, and policies, and encourage the public to learn about and support healthy ocean ecosystems and marine science research. These events were also ideal opportunities to provide career guidance for students and inspire the next generation of marine scientists. In the past year, the project participated in the following events: Fall 2017 Career Fair at the University of Hawai'i at Mānoa, October 10, 2017; SOEST Open House, October 20-21, 2017; Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) ship tour of the NOAA Ship *Reuben Lasker*; activities for St. Andrews Priory's science class students, November 2017; Hawaii P-20 Partnerships for Education Career Day, an event for middle school students from low-income communities, held February 15, 2018 at the Hawaii Convention Center; Sacred Hearts Academy Annual Science Symposium, February 17, 2018; and World Oceans Day at Ko Olina Resort, June 10, 2018.

2017 NOAA Fisheries Science Camp. The fourth annual NOAA Fisheries Pacific Islands Region Science Camp was held July 10-14, 2017, at the NOAA Inouye Regional Center and is a joint collaboration between PIFSC, PIRO, and JIMAR staff. This year's theme was "Using Technology to Study Ocean Life and Ecosystems". The Science Camp encourages participation from middle school students from underserved communities and charter schools on Oahu. Nearly eighty NOAA federal and JIMAR staff and interns developed and taught nine different science modules to provide a unique hands-on experience for the campers. Modules are based on current fisheries research areas such as marine debris, fish sampling techniques and stock assessments, fish life history and dissection, marine food webs, plankton, Hawaiian monk seals, sea turtles and climate change, socioeconomics, and sea safety. This year's camp included a field trip to *Paepae o He'eia* Fishpond in Kaneohe to learn about current and traditional fishing techniques, the cultural and historic significance of Hawaiian fishponds, and sand/sediment analysis methods and importance.

PIFSC Young Scientist Opportunity (PYSO). PYSO is a highly successful collaborative program coordinated by PIFSC and JIMAR that offers qualified undergraduate college science student participants professional scientific research experience and formal training opportunities tailored to meet their educational and professional goals and interests. In 2017 the PYSO program selected four highly-qualified undergraduate students to participate in summer research with JIMAR and federal staff at PIFSC. The 2017 PYSO students and field of research are described below.

- Karla Balagso from the University of Hawai'i at Mānoa worked with JIMAR's Jonathan Whitney and federal staff Don Kobayashi and Jamison Gove to investigate the composition and abundance of microplastics in coastal slicks located offshore of the west coast of Hawaii Island, as part of JIMAR's Integrated Ecosystem Assessment project.
- Courtney Bonilla from Chapman University worked with JIMAR's Audrey Rollo and federal staff Ruhul Amin to analyze optical videos taken by the MOUSS to observe how atmospheric and oceanic conditions affect water visibility.
- Rachel Holton from Humboldt State University worked with JIMAR's Ali Bayless, Amanda Dillon, Kym Yano, and federal staff Phoebe Woodworth-Jefcoats on science communications projects focused on HICEAS and climate change.
- Mary Margaret Stoll from Amherst College and Dartmouth College worked with federal staff T. Todd Jones, Summer Martin, and Shawn Murakawa to age juvenile green sea turtles.

Outreach and Science Communications. Twenty-four "newsroom" sessions were developed to coordinate science communications and education, and to publicize outreach opportunities for research expeditions, scientific publications, and projects for staff from all PIFSC and JIMAR programs, PIRO, and external project partners.

Print and digital products. Project staff produced many outreach and educational products for PIFSC and PIRO staff to use and disseminate to students, stakeholders and the general public, including fact sheets, brochures, posters, displays, and presentations. Outreach materials include the following.

- Perspectives on the Occurrence and Distribution of Rare and Arcane Pelagic Predators in the North Pacific Gleaned from Fishery Observer Program Information poster (February 2018)
- Bringing Human Well-Being into Integrated Ecosystem Assessments poster (June 2018)
- Surveying a Vast Ocean, Bigeye tuna, Bottomfish, Coral Reefs, Hawaiian Islands Cetacean and Ecosystem Assessment Survey flyer (August 2017)
- PIFSC Internships and Volunteer Opportunities flyer (October 2017)
- Voices from American Samoa's Fisheries flyer (January 2018)
- Research expedition returns to American Samoa flyer (May 2018)
- Hawai'i Bottomfish Still On Top: NOAA's 2018 Hawai'i Deep-7 Bottomfish Assessment Highlights flyer (June 2018)
- Marine debris poster and sea turtle nest model for SOEST Open House (October 2017)
- Banner, posters, program, and name tags for West Hawaii's Marine Ecosystem Symposium (December 2017)
- Aerial photographs from UAS survey, "Count the protected species" interactive activity for World Ocean's Day event (June 2018)
- Thirty-one feature stories on NOAA Fisheries website (web content)
- Eight Science Blogs (web content)
- ArcGIS Story Map, "Science and Stewardship in the Northwestern Hawaiian Islands" (web content)
- ArcGIS Story Map, "Sea Tales" (web content)
- NOAA Photo Story, "Rescued seals make it home for the holidays" (web content)
- NOAA Web Story, "Whale science on the high seas" (web content)

Main Hawaiian Islands Commercial Fisheries Fast Track Data Project

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

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

NOAA Sponsor: Michael P. Seki, Kimberly Lowe

Cumulative Budget Amount: $435,000

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 Hawaii's commercial fisheries and fish dealer data, including the deep-7 bottomfish fishery that is managed by a federal Annual Catch Limit (ACL).

The ACL is set by the Western Pacific Regional Fishery Management Council (WPRFMC) in the State of 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 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*).

Hawai‘i Revised Statutes require commercial fishers to submit their monthly fishing reports within ten days following the month in which marine life was taken. The Department of Land and Natural Resources (DLNR) Hawaii Division of Aquatic Resources (HDAR) implemented a new Administrative Rule on September 1, 2011, requiring commercial fishermen who catch deep-7 species to submit trip reports within five days of their trip 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 2018

JIMAR staff successfully processed and fast-tracked the Main Hawaiian Islands commercial catch and dealer data reports, including the deep-7 bottomfish fishery that is managed by a federal ACL, with the 2017-2018 fishing year (ending August 31, 2018) at 306,000 pounds with a 39% risk of overfishing for the following species: onaga (*Etelis coruscans*); ehu (*Etelis carbunculus*); opakapaka (*Pristipomoides filamentosus*); kalekale (*Pristipomoides sieboldii*); gindai (*Pristipomoides zonatus*); lehi (*Aphareus rutilans*); and hapu‘upu‘u (*Hyporthodus quernus*).

In July 2017 the DLNR-HDAR began developing the new Online Commercial Marine Dealer Reporting System (ODRS).

Figure 1. Kimberlee Harding, JIMAR supervisor, staffing the Division of Aquatic Resources informational table at the 173rd Western Pacific Regional Fishery Management Council Meeting, Fisher’s Forum: Going Deep: A Hawaii’s Bottomfish Story.

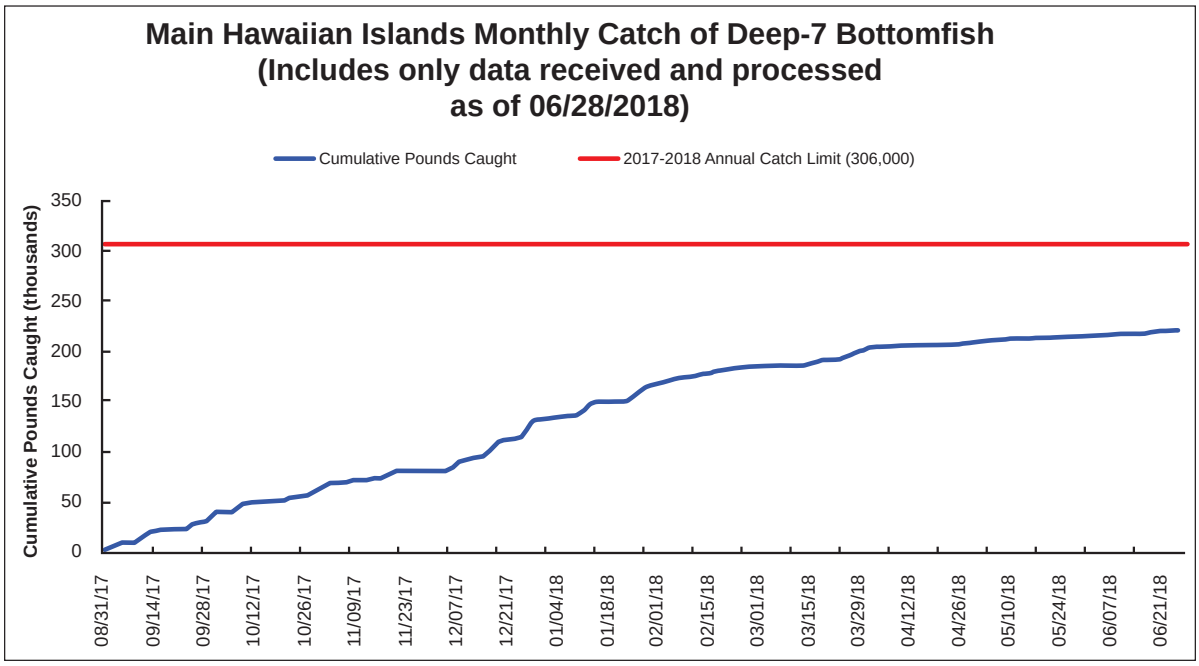


Figure 2. Accumulated pounds for the MHI deep-7 bottomfish fishery during 2017-2018 fishing year (209,298 lbs or 68.4% of the ACL of 306,000 lbs).

In June 2018 HDAR received the first prototype of the public interface webpage and began the testing phase. The website will allow commercial marine dealers to report their commercial marine purchase reports online instead of submitting paper or emailed reports. JIMAR staff provided support for the design and development of the ODRS website.

To improve fast tracking of commercial marine dealer data, DLNR-HDAR implemented new reporting requirements for all commercial marine dealers. Every dealer is required to submit a report of all marine life obtained, purchased, transferred, exchanged, or sold during a weekly reporting period.

Progress was made on the multi-year conversion of the obsolete Visual FoxPro (VFP) based, HDAR Fishing Report System (FRS) to a MySQL database, using C++ applications. The Oracle database was converted to a MySQL database and its applications are still being developed by Western Pacific Fisheries Information Network (WPacFIN).

Ocean Remote Sensing

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

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

NOAA Sponsor: Michael P. Seki, Evan Howell

Cumulative Budget Amount: $238,648

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

This JIMAR project distributes a suite of reprocessed, delayed and near real-time satellite oceanographic data products to the scientific community, management and conservation agencies, and general public through web-based services. These datasets include: sea surface temperature; dynamic sea surface topography and geostrophic currents; surface winds; and ocean color products, such as chlorophyll-a concentration, photosynthetically available radiation (PAR), and diffuse attenuation coefficient at 490 nm (Kd490). These products are available at various temporal (daily, weekly, monthly) and spatial scales (regional or global). The project also works with local, regional, and international users to explore and foster new partnership opportunities and develop a suite of climate indicators for research purposes.

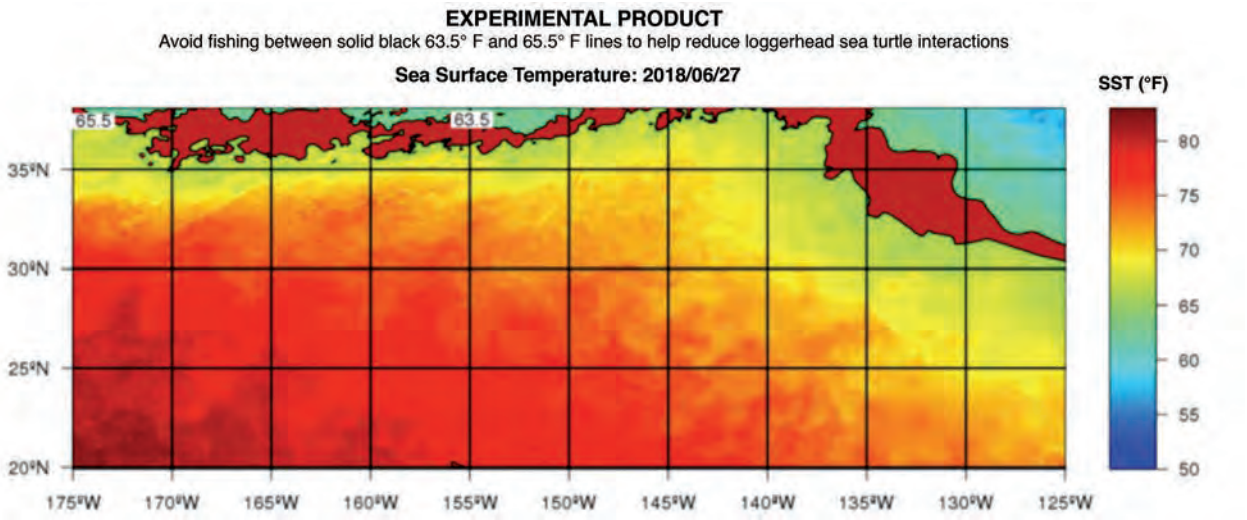


Figure 1. Example of a TurtleWatch product.

Progress during FY 2018

In addition to maintaining all databases and servers and servicing data to OceanWatch-Central Pacific (OWCP) users, the 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 updated to the PacIS dashboard (http://www.pacificcis.org/dashboard/) and the PacIOOS Voyager site (http://www.pacioos.hawaii.edu/voyager/).

The project also collaborated with PacIOOS to develop a custom data viewer that allows 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 was tested and deployed publicly.

A new web project server was set up and a new data processing server is being developed to allow for more data storage and the use of the latest tools and platforms.

JIMAR OceanWatch Researcher/Manager, Dr. Melanie Abecassis, assisted the regional fishing council by investigating a recent increase in loggerhead interactions in the shallow-set longline fishery. Higher interactions appear to be independent of changes in fishers' behaviors or environmental changes but may reflect increasing turtle populations. The TurtleWatch product was re-examined using all interaction data from 2004 to the present to evaluate its robustness. TurtleWatch provides daily maps of sea surface temperatures with a range of temperatures identified as the zone to avoid in order to reduce turtle interactions.

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

P.I.: Eric Heinen De Carlo

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

NOAA Sponsor: Adrienne Sutton

Cumulative Budget Amount: $19,999

NOAA Goal(s):

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

Purpose of the Project

The NOAA/PMEL Carbon Group has been augmenting and expanding high-frequency observations on moorings to provide valuable information 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 that host 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

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 of Kaneohe Bay, Oahu, Hawaii

the interpretation of coastal OA are manifested in subsurface waters. Furthermore, many of the most sensitive organisms (e.g., corals, shellfish) are benthic and respond primarily to subsurface water chemistry.

The objective of this project is to provide on-site support at existing 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 carrying out of analyses of water samples in our laboratory at UHM.

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

Progress during FY 2018

There were no field activities during the past fiscal year. Activities on this project consisted of the provision of ancillary data to the technical lead at PMEL for sensors on the CRIMP-2 MAPCO2 and periodically collecting "validation" bottle samples.

Pacific Fisheries Monitoring Program

P.I.: Douglas S. Luther [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

Cumulative Budget Amount: $790,300

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

This JIMAR project works to provide the Pacific Islands Fisheries Science Center (PIFSC) with timely and accurate Fishery Ecosystem Plan (FEP) logbook data and other fishery information for use in research and management to work 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 and American Samoa'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.

Progress during FY 2018

The JIMAR staff continued to provide timely high level support to fishery monitoring activities by providing high quality fisheries data to NMFS, PIFSC, and other JIMAR projects. The initial task of key punching the logbook data is the responsibility of JIMAR staff and the number of longline fishing vessels has been steadily increasing

each year. Fast tracking procedures that were implemented to monitor Hawaii's bigeye tuna (BET) landings require additional effort with the increased number of fishing vessels. The fast tracking information is used in forecasting landings to predict possible closure dates of the Hawaii-permitted longline BET fishery if the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) annual quota is predicted to be reached.

The fast track monitoring also encompasses striped marlin landings due to stock concerns. The JIMAR staff was cross-trained to cover the multiple facets of fast track duties. The fast tracking requirement increased the daily workload as tallies are compiled weekly or as necessary as the quota gets taken. Additional quality control procedures and cross checks of relevant databases were implemented as needed to continually validate and improve the results, quality, and timeliness of the product. The cross-checks involve a

Figure 1. Project ER team demonstrating electronic longline logs to Hawaii Longline Association Board of Directors. L to R: JIMAR Database and Applications Developer, Ashley Tomita; JIMAR Scientific Information Associate, Nathan Chan; JIMAR Fisheries Database Assistant, Emeline Kalahiki.

Figure 2. JIMAR Fishery Monitoring Associate Matthew Carnes in a presentation on the project's electronic monitoring effort at the 9th Fisheries Observer and Monitoring Conference in Vigo Spain, June 2018.

matching program that compares the longline logbook tuna counts to sales records from dealer data. The fisheries observer data are reconciled with Hawaii longline logbook data.

Beginning in 2017, JIMAR added a new electronic monitoring (EM) capability to the project. The electronic monitoring tests the use of mounted video monitoring on longline vessels to compare catch to the logbooks and simultaneous on board observer data. During the reporting period, over 200 fishing trips with mounted camera systems and data were recorded and collected with over 2,200 hauls. Of the hauls, 312 were concurrent with sea observers. Nearly 60% of these video recorded hauls had observer data, which were viewed and compared. Overall the EM systems detect 89% of all catches (kept and discarded) and there is no statistical difference between the total amount of kept species between the two data sets.

The Electronic Reporting (ER) team, comprised of JIMAR and PIFSC staff, continued working with a developer on an Android application enabling longline captains to securely submit their logbook data electronically in real time. In order to ensure a high quality product, extensive in-office testing was conducted and followed by at-sea testing by volunteer captains.

Project staff held biweekly teleconference meetings with the ER application developer to discuss the developer's progress and provide feedback from in-office and at-sea beta testing. The team also began work with a second contractor on a back-end application to download, decrypt, format, and process the incoming ER data to be compatible with the current operating procedures.

The electronic logbook application was installed on Android tablets and deployed to six captains aboard five longline fishing vessels. Fourteen trips with 1,450 records were successfully transmitted by the captains and received at PIFSC. All at-sea users responded positively to the ER application and requested the use of a tablet in the future. Captains preferred real-time electronic submissions over paper log sheets because the application was user friendly and data could be entered quickly.

Adoption of ER will greatly improve the timeliness of data availability for Regional Fishery Management Organization (RFMO) reporting, forecasting fishing area closures, and use by scientists and researchers. Implementing ER will also remove the need for JIMAR staff to manually enter or key punch the fisheries data, thus freeing up their time to work on other project activities.

The general Hawaii-permitted longline fleet-wide quarterly reports are completed forty-five 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.

Pacific Islands Territorial Science Initiative

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

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

NOAA Sponsor: Michael P. Seki, Kimberly Lowe

Cumulative Budget Amount: $220,000

NOAA Goal(s)

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

The overarching objective of the JIMAR Pacific Islands Territorial Science Initiative (TSI) project is to improve the volume and quality control of catch data from the fisheries of the U.S. Pacific territories of Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands (CNMI). Insufficient data collection and quality control in 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 cumulative budgets of territorial governments, relatively low commercial value of the diverse and small-scale fisheries, and limited physical presence of National Marine Fisheries Service (NMFS) staff in these islands all detract from

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.

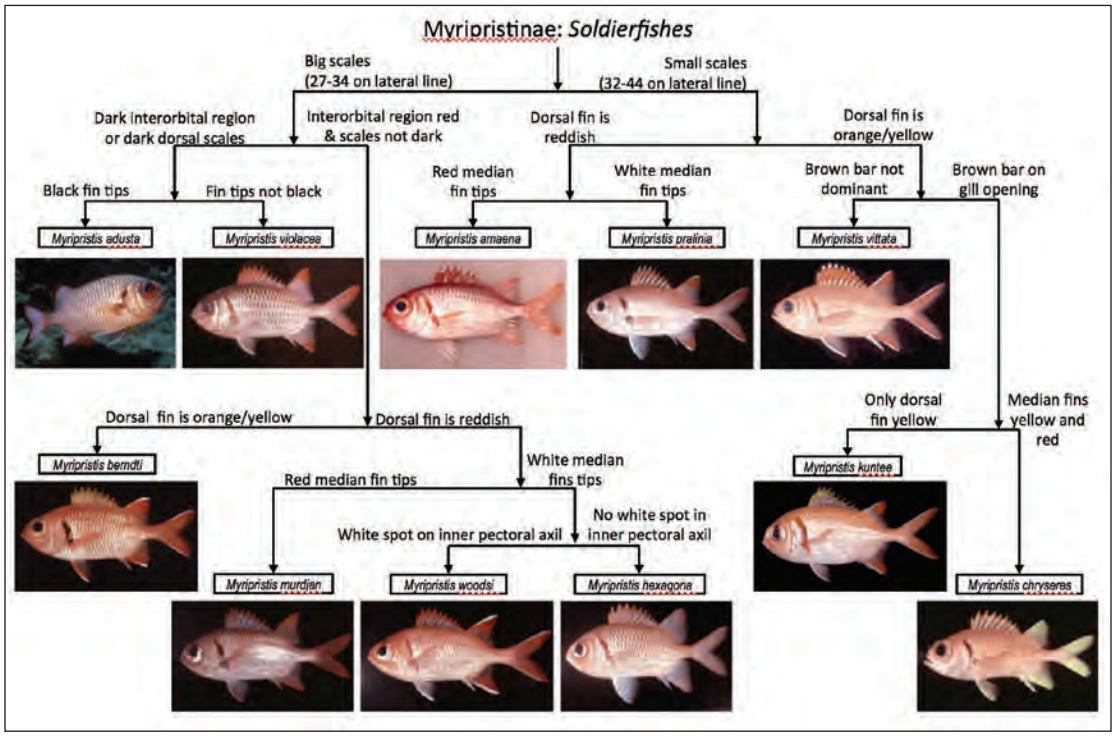


Figure 2. A soldierfish species identification key produced for use in American Samoa and Guam.

the efficacy of data collection programs. Thus, there is a need to improve the amount and detail of fisheries monitoring data collected from the territories along with improving quality control, in order to enable fisheries scientists to conduct more accurate stock assessments. The TSI project collaborates with several other JIMAR projects and Pacific Islands Fisheries Science Center (PIFSC) programs to promote better communication with management agencies in the territories, establish and improve protocols for fisheries monitoring and sampling, and develop tools for data expansion and summary analyses.

Progress during FY 2018

JIMAR's Territorial Fisheries Data Specialist, Toby Matthews, completed many data and analytical requests, including an analysis of the effects of an American Samoa fuel subsidy program for fishing vessels and recommendations to improve creel survey design in each territory based on 2016 creel data. Length-weight regressions were performed using commercial fisheries bio-sampling data to evaluate whether length-weight estimation algorithms in place could be improved and specific recommendations were developed for each territory (two reports have been drafted). All six of the creel data expansion algorithms (one each for boat-based and shore-based creel surveys in Guam, CNMI and American Samoa), previously in Visual FoxPro (VFP), were rewritten in R to support WPacFIN Central phasing out the use of VFP. Three R applications were also developed (one for each territory) to estimate a species-level variance of annual total boat-based and shore-based creel survey landings.

The JIMAR Territorial Fisheries Associate on Guam produced surveys for the Guam Division of Aquatic and Wildlife Resources (DAWR) creel program, performed quality control on all creel data, and assisted with database issues. The Guam Associate also produced several species identification keys for use on Guam using lessons learned from workshops conducted in American Samoa.

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

In total, these accomplishments fulfilled the objectives established for the fiscal year with two exceptions. A creel survey manual could not be drafted for the CNMI Division of Fish and Wildlife (DFW) due to the absence of a territorial creel supervisor (unfilled vacancy). For American Samoa DMWR, the draft creel survey manual was not completed due to other time constraints and a prolonged illness that prevented creel survey supervisors from reviewing the document.

Pacific Tuna Fishery Data Management

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

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

NOAA Sponsor: Michael P. Seki, Keith Bigelow

Cumulative Budget Amount: $339,400

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

This objective of this project is to develop improved data management tools to preserve and provide scientific and management access to purse seine tuna fishery data obtained by U.S. flagged vessels licensed under the South Pacific Tuna Treaty (SPTT). This important data set is of high value to tuna stock assessment scientists, tuna fisheries monitoring, fisheries managers and policy makers. JIMAR developed contemporary tools to enable access to these data and a system for sustained data management. The project coordinates with several NOAA

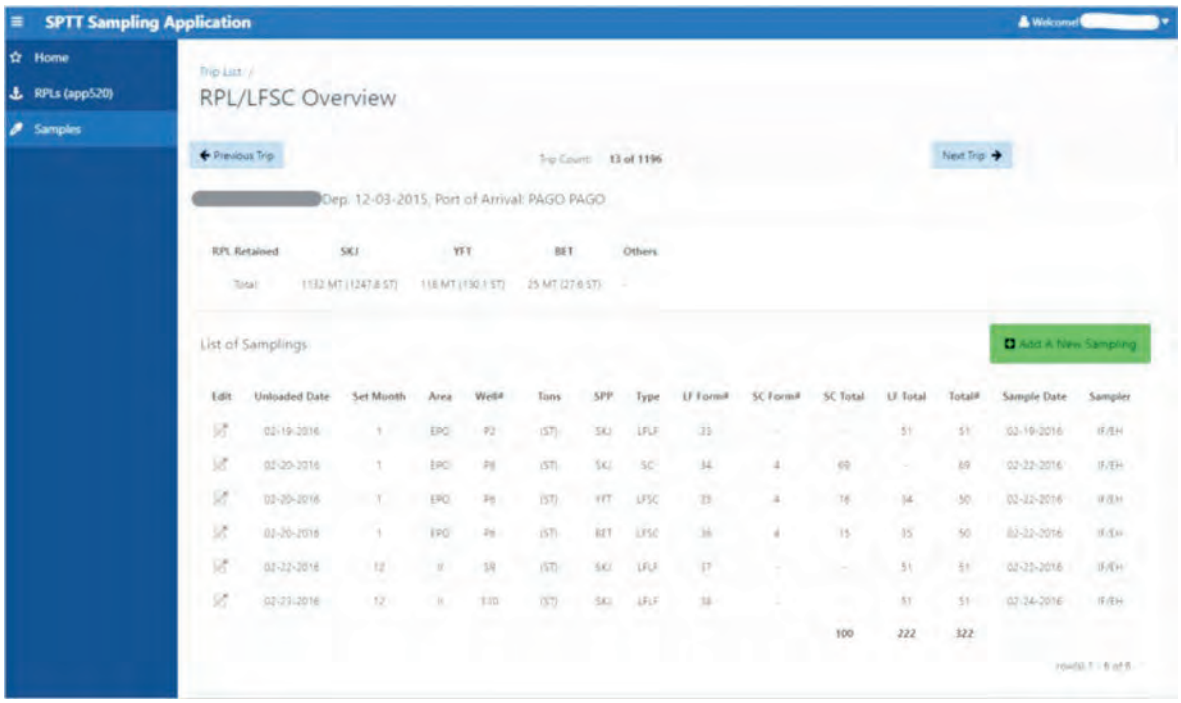


Figure 1. Screenshot of the updated production sampling data management application (confidential information has been redacted).

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

Progress during FY 2018

The project continued to make improvements on existing data management applications for the regional purse seine log sheets (RPL), unloading and transshipment log sheets (UL), final out turn receipts (FOT), and sampling form data streams. Quality assurance (QA) validation criteria in the management applications for each data stream to help prevent errors during data entry and improve quality were also implemented. The RPL, UL, and FOT data management applications were updated by the project to resolve usability issues. The sampling data management application was updated to improve its usability and was deployed to the production server to facilitate all SPTT data that is currently keypunched and managed in the production systems. The sampling data that was previously managed temporarily in the test database due to time constraints was migrated to the production database.

The project met its goals to provide a suite of standard reports for the SPTT data set to fulfill management and treaty requirements. The project developed, implemented and documented multiple reusable database scripts for producing the annual U.S. Purse Seine Fishery Data Summaries for the Western and Central Pacific Fisheries Commission (WCPFC), Inter-American Tropical Tuna Commission (IATTC), International Scientific Committee (ISC), the High Seas/U.S. Exclusive Economic Zone (EEZ)/Non-US EEZ areas, and the entire Pacific Ocean. These scripts greatly reduced the amount of effort required to generate these statistics and will be utilized from this point forward. JIMAR developed the 2017 U.S. Purse Seine Fishery Catch and Effort maps in the Pacific for the annual Regional Fishery Management Organization (RFMO) reports. To increase efficiency in data generation the project updated and documented the scripts for producing the 2014-2017 sampling data summaries for the annual Secretariat of the Pacific Community (SPC) data submission. In addition, JIMAR documented the sampling data model and sent it to SPC and the Pacific Islands Forum Fisheries Agency (FFA) to increase their understanding of the PIFSC sampling data stream. JIMAR project staff updated and documented the database scripts for generating the port transshipment summary for the annual NOAA and U.S. Coast Guard report to

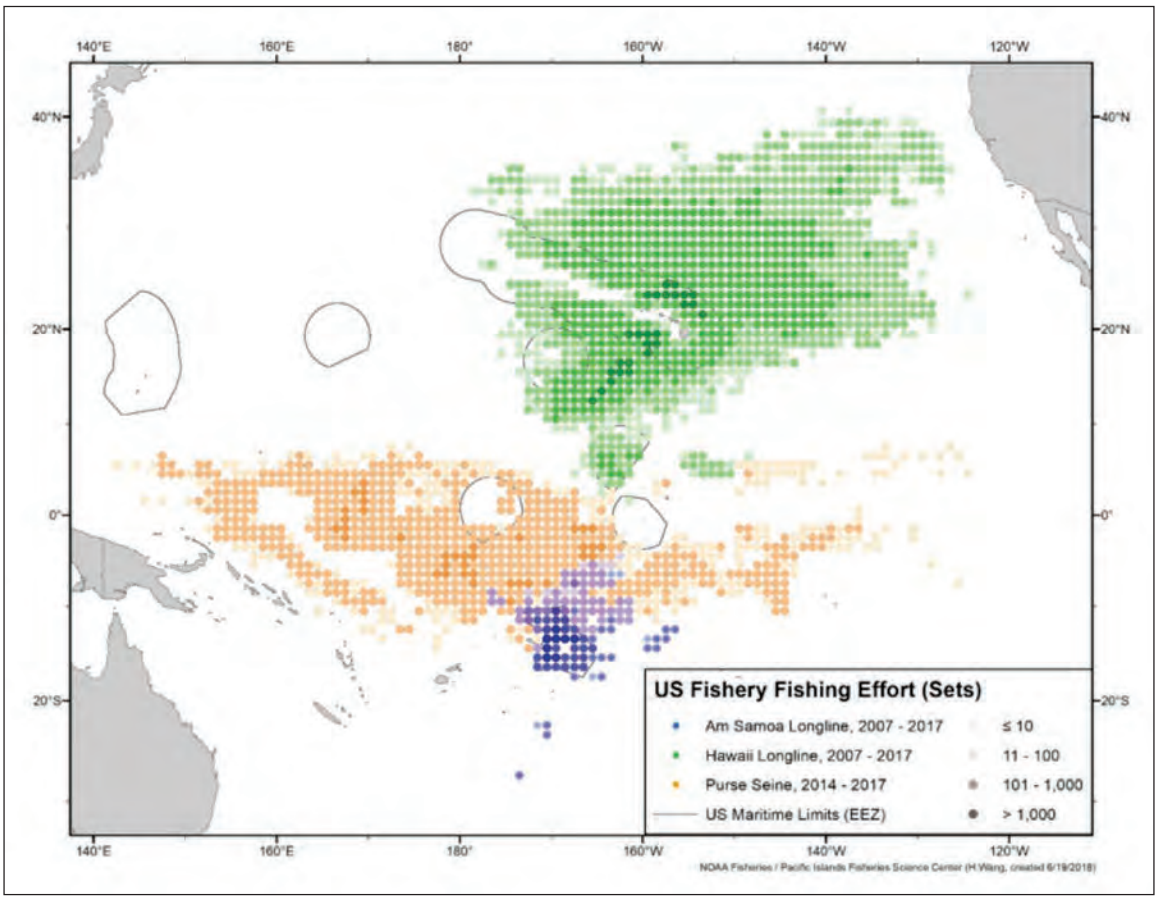


Figure 2. Distribution plot of the U.S. pelagic fisheries fishing effort in the Pacific Islands Region showing the U.S. EEZs in the western and central Pacific Ocean region.

Congress and ensured that all of the required SPTT data reports were provided early or on time. Twenty-nine separate SPTT data requests were fulfilled during the year, and a new standard report form was developed for fishing day statistics to aid in resource management decisions.

JIMAR fulfilled its goal to improve the quality of data currently managed in the PIFSC enterprise database by developing and implementing formal quality control (QC) validation criteria for each data stream. JIMAR developed and implemented QC validation criteria for the sampling and UL data streams as well as the net-sharing component of the RPL data stream to ensure the quality of the data used for the annual reports. After the production RPL data management application was deployed the project streamlined the process by reassessing the existing RPL QC validation criteria and deactivating the QC checks that were no longer relevant.

To facilitate near real-time reporting of logbook data from the PIFSC enterprise database an automated data import module was planned to parse and load RPL data provided electronically by the integrated Fisheries Information Management System (iFIMS). In the previous reporting year, the project requested sample electronic logbook data from iFIMS based on April 2017 specifications; updated specifications and sample data were not provided until late in the current project year. The federal program will employ a contractor to develop the automated data import module for the iFIMS longline electronic reporting (ER) data and this import module can be leveraged and modified to process the purse seine ER data. The project needs final specifications from the data provider before development on the data import module can begin. The project plans to develop a requirements document and a scope of work once the finalized iFIMS specifications are ready. JIMAR will serve as the technical point of contact (POC) with the contractor to verify that the deliverables satisfy the requirements and JIMAR staff will then implement the deliverables.

The project originally planned to develop database models and management applications for other forms not currently entered into the PIFSC enterprise database (e.g., discard forms, transshipment forms, mate's receipts, etc.). This objective was deemed a lower priority and has been deferred during this project year. In addition, plans to evaluate integrating alternative data sources, such as at sea observer data and vessel monitoring system (VMS) data into the database was also determined to be lower priority and has been deferred during this project year.

The project fulfilled its goal to comply with data security requirements pursuant to NOAA information technology (IT) data and security policies. The project compiled required technical and security documentation and completed necessary paperwork to deploy the sampling data management application to the production server. The project met with PIFSC Information Technology Services (ITS) and provided additional information about the sampling application to ensure the application satisfied PIFSC IT security requirements. Exact copies of the production SPTT data management applications and a copy of the production SPTT database that contained no confidential data were created to provide a safe way for ITS to scan the applications for security vulnerabilities without potentially compromising the production database.

During the reporting period JIMAR also maintained the SPTT database and made changes to the data model to implement new procedures and prevent common data issues. The project electronically entered the data collected under SPTT during the reporting period and performed data QC. JIMAR performed routine data management throughout the year including managing reference data, "freezing" data in preparation for the required annual reports, and providing support and guidance during the data QC process.

Other PIFSC and PIRO objectives that the project worked on during the reporting period are listed below in order from highest to lowest priority.

- *Develop a process to receive ER data and create reports to calculate fishing days and tally fish aggregation device (FAD) sets*. The project worked with iFIMS to review and provide feedback for their current data transmission specifications and is awaiting a response. In the short-term the project retrieves RPL data on a daily basis either from email notices or by manually logging into the iFIMS server; these data are entered using the RPL application. The project developed repeatable processes to generate fishing day statistics and FAD set tallies to fulfill resource management requirements.
- *Construct the sampling data model and keypunch the sampling data*. The sampling data model and application were temporarily deployed on the test servers to facilitate data entry for the previous year and the data and application were successfully migrated and released to the production server in November 2017. All available sampling data were successfully entered into the SPTT database by March 2018. The sampling data were validated using multiple data QC criteria and successfully frozen in March 2018 to facilitate the 2018 RFMO reports. Additional sampling reports were developed to fulfill various scientific and resource management needs.
- *Complete the migration of the historical SPTT data from the Southwest Fisheries Science Center (SWFSC) to PIFSC*. JIMAR staff reviewed the existing historical data migration procedures and scripts in preparation for the upcoming trip to SWFSC in July 2018. The purpose of this trip is to collaborate with the data professionals that developed and maintained their SPTT database so the project can advance its efforts to migrate the historical data to PIFSC. The project expects the historical data migration to be completed by September 2018.
- *Track the documents and processing workflow for each data stream*. To improve usability of the document and workflow tracking application JIMAR assessed and provided suggestions to the collaborator developing the application. The project reviewed and tested multiple procedures developed for the tracking application and is working with PIFSC ITS to provide tracking application access to authorized PIRO staff in American Samoa so that purse seine fishing trips can be tracked directly in the application when they begin.

Research Support for Ocean Exploration and Research: The Acoustic Dimensions of Ocean Exploration

P.I.: Darren T. Lerner

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

NOAA Sponsor: David McKinnie

Cumulative Budget Amount: $37,571

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

This project will help refine concepts for the acoustic dimension of ocean exploration, identify techniques and approaches for collecting sound measurements for purposes of baseline characterization of the deep ocean, and identify areas of research in soundscapes relevant to UH and NOAA priorities, interests, and capabilities.

Progress during FY 2018

During FY 2018, the project increased partnerships between NOAA OER and other agencies through various activities and advanced the acoustic dimension of ocean exploration. The project led a fisheries sonar workshop and coordinated input on the acoustic priorities for OER. Through this workshop the project's techniques and acoustics data collection were aligned with other institutions to support a national program of acoustic ocean exploration. Another benefit of the workshop was an increase in requests from individuals wanting to utilize project data. The next step is to complete a technical report on these acoustic recommendations and priorities. Project staff furthered the advancement of acoustic data processing and visualization through collaborations with University of California, San Diego. The project co-organized the National Ocean Exploration Forum to identify key characteristics of a national program of ocean exploration—the kind of national program called for in the President's Panel on Ocean Exploration (2000); a National Academy of Sciences study (Exploration of the Seas, 2003); and the Ocean Exploration Act of 2009 (PL 111-11). In co-organizing the forum the project developed a demonstration on how to visualize acoustic data and ensonify non-acoustic data to begin elucidating hidden features. A report on the forum is being finalized.

The project aligned the acoustic data calibration and collection of two ocean exploration ships, NOAA Ship *Okeanos Explorer* and *R/V Falkor*, to facilitate a national ocean exploration and allow comparison between the two programs. This ensures that the acoustic data can be explored across programs and time dimensions. The project began discussions on the metrics required and future techniques needed for baseline characterization of the ecosystem in unexplored regions. Work during the next year will focus on implementing these techniques.

Figure 1. Shahrokh Yadegari, a professor at the Jacobs School of Engineering, University of California, San Diego, demonstrates how to explore and visualize acoustic data differently. This demonstration, part of the National Ocean Exploration Forum: Ocean Exploration in a Sea of Data, was in collaboration with NOAA and University of Hawaii and demonstrated that acoustics and current technology can be used to understand more about ecosystem dynamics. (image courtesy of Jacobs School of Engineering, University of California, San Diego).

Figure 2. NOAA Ship Okeanos Explorer *at dock in Honolulu, HI. (image courtesy of the NOAA Office of Ocean Exploration and Research, Deep-Sea Symphony: Exploring the Musicians Seamounts, and Art Howard).*

Sustaining Healthy Coastal Ecosystems

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

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

NOAA Sponsor: Michael P. Seki, Russell Brainard

Cumulative Budget Amount: $6,392,366

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); the Northwestern Hawaiian Islands (NWHI) chain; the extended U.S. Minor Outlying Islands (the islands and atolls of Midway, Wake, Johnston, Palmyra, Howland, Baker, Jarvis, Kingman); the Commonwealth of Northern Mariana Islands (CNMI); American Samoa; and Guam. The objective of this project is to support effective management by providing high-quality scientific data on the health and vitality of coral reefs in the U.S. Pacific Islands. This interdisciplinary, integrated approach to ecosystem monitoring requires coordinated research from the JIMAR staff in the NOAA NMFS Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) across six research focuses: Fish Ecology and Monitoring; Benthic Ecology and Monitoring; Ocean and Climate Change; Ecospatial Information; Marine Debris Response; and International Capacity Building.

Progress during FY 2018

During the year, there were four sub-projects comprising the Sustaining Healthy Coastal Ecosystems Project: Pacific Coral Reef Ecosystem Assessment and Monitoring; Mapping and EcoSpatial Information Products; Marine Debris Removal; and Strengthening Sustainable Socioeconomic Monitoring of Reef-Dependent Communities. Progress and accomplishments for each of these sub-projects are listed below.

Pacific Coral Reef Ecosystem Assessment and Monitoring. JIMAR supported research on ESA-listed corals through the collection of presence/absence and demographic data, and the development of data-driven products to assess species occurrence and abundance, habitat use, potential impacts, and spatial demographic dynamics. Staff conducted quality assurance/quality control and summarized data gathered by the benthic team in 2017 including automated R scripts to facilitate easier reporting of Pacific-wide and island-scales datasets in a timely manner.

JIMAR completed benthic image analyses from the 2017 Marianas Reef Assessment and Monitoring Program (MARAMP) cruise and a CRCP deliverable report on identifying coral reef resilience potential in American Samoa based on Pacific Reef Assessment and Monitoring Program (RAMP) survey data.

Staff collaborated with regional and fisheries managers in Hawaii, Guam, CNMI, and the Pacific Remote Islands Marine National Monument (PRIMNM) to provide ad hoc monitoring, technical assistance, and data synthesis. Project staff coordinated with the Pacific Islands Regional Office (PIRO) and Office of Habitat Conservation (OHC) to plan and participate in a series of workshops to improve regional communication, collaboration, and leverage.

Project staff submitted peer-reviewed manuscripts to the journal *Scientific Data* summarizing the reef fish monitoring dataset, *Bulletin of the American Meteorological Society* on ecological impacts of the 2015-16 El Niño in the Central Equatorial Pacific, and *Frontiers in Marine Science* on biomass baselines and potential recovery for Hawaiian reef fish. A manuscript on the effects of the 2015-16 El Niño warm event on corals at Jarvis Island is currently in editorial review.

Project staff finalized the Annual Data Report (2017) for Fish Surveys for all RAMP efforts. In addition, the 'Coral Reef Condition Report Card for American Samoa' was completed and JIMAR assisted the NOAA Coral Reef Conservation Program (CRCP) in developing report cards for Hawaii Archipelago, U.S. Pacific Remote Islands, and Mariana Archipelago (Guam and CNMI).

Figure 1. JIMAR diver using cameras to capture a photomosaics of coral reef habitats.

Progress on the following objectives are still underway, in part due to unexpected delays with the American Samoa Reef Assessment and Monitoring Program (ASRAMP) cruise.

- Data summary brief templates were developed and will be submitted upon cruise completion for ASRAMP 2018 for both fish and benthic datasets.
- Datasets from 2017 MARAMP research cruises are currently undergoing final quality control and submission for archive to CRCP Coral Reef Information System (CoRIS) and the National Centers for Environmental Information (NCEI).

In addition, analyses are underway for a manuscript on the spatial and temporal patterns of the differences between sea surface temperature and subsurface temperature on coral reefs, and for community level vulnerability assessment and climate-change management recommendations for villages in Tutuila, American Samoa.

Mapping and EcoSpatial Information Products. JIMAR project staff provided the PIRO with maps and metadata of hard/soft substrates and coral cover for their Tier 2 and Tier 3 islands in the Pacific Islands region (~17 locations), and updated bathymetric contours where new data are available. In addition, staff developed a component of the National Coral Reef Monitoring Program (NCRMP) 'common maps' for the islands and atolls of the Marianas and the PRIMNM and will post the products and documentation on the University of Hawaii's Pacific Islands Benthic Habitat Mapping Center (PIBHMC) website.

JIMAR also completed benthic habitat mapping and characterization sections, including the figures and content for the PRIMNM Report.

Project staff developed new Oracle-based data services for the project's monitoring and mapping data to be incorporated into the PIFSC web mapping applications and developed new satellite-derived data products for the Pacific Islands with gaps in bathymetry and/or benthic habitat data.

JIMAR staff designed, developed, and tested a method to derive habitat data from imagery processed using Structure from Motion (SfM) software, and are publishing the findings as a PIFSC internal report.

Progress is still underway on the following objectives listed below.

- Development of strata maps for the Protected Species Toolbox was delayed until fall 2018 due to staff attrition.
- Multibeam data from MARAMP was not collected successfully due to technical problems with the instrument.
- Final training to provide GIS capacity to the State of Hawaii in support of resource management needs and activities is scheduled for late summer.

Marine Debris Removal. This sub-project has been training and planning for a two-month mission to conduct a marine debris survey and removal operations in the NWHI during September–October 2018. JIMAR staff distributed information about marine debris issues to management agencies and the general public, opportunistically

aided in local marine debris related emergency responses, and conducted marine debris survey and removal operations in the MHI.

Staff are actively developing revised protocols for measuring the impacts of derelict fishing gear on coral reef ecosystems and establishing long-term coral reef monitoring sites. Images of derelict fishing nets in place and of reef habitat post-removal are being collected and compiled into photo mosaics to be completed during the debris removal mission in the fall.

Strengthening of Socioeconomic Monitoring for Coral Reef Conservation. Presentation slides for socioeconomic monitoring training workshops were developed and presentations delivered in socioeconomic monitoring training workshops in Pohnpei in September 2017 and in Weloy, Yap in December 2017.

JIMAR staff completed a document titled "Additional Indicators for Monitoring Social Impacts of the Micronesia Challenge", that was submitted to the Pacific Islands Marine Protected Areas Community (PIMPAC) and shared with the socioeconomic monitoring core team in February 2018.

A concept note on a human dimension course for a natural resource management program at high level educational institutes in Micronesia was submitted to PIMPAC and the Micronesia Conservation Trust in May 2017.

Progress is still underway on the following objectives listed below.

- Development of a manuscript on integrated monitoring based on lessons from Habitat Blueprint site Manell-Gues, Guam. Two of the five sections were completed with the remaining sections under draft and expected to be completed by August 2018.
- A training-of-trainer and strategic planning workshop is scheduled for August 27-September 7, 2018 in Pohnpei and a draft agenda of the workshop was developed.

Territorial Biosampling

P.I.: Douglas S. Luther [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, Joseph O'Malley

Cumulative Budget Amount: $423,730

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Territorial Biosampling project conducts both fundamental and innovative life-history research on federally-managed coral reef fish and bottomfish species of commercial, ecological, and cultural value, with a geographic focus on the Pacific Islands under U.S. jurisdiction. The project 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.

Figure 1. NOAA Ship Oscar Elton Sette *pulls into the caldera at Maug, Northern Mariana Islands. JIMAR Territorial Biosampling staff led research efforts during the Mariana Archipelago Life History Research Cruise (SE-18-02) in the roles of chief scientist and data/fish processing lead.*

Figure 2. JIMAR Territorial Biosampling visiting scientists (left to right, Dr. Joseph DiBattista, Dr. Michael Berumen, and Tane Sinclair-Taylor) process fish specimens in the wet lab of the NOAA Ship Oscar Elton Sette *during the Mariana Archipelago Life History Research Cruise (SE-18-02).*

Progress during FY 2018

The project met all proposed objectives for the performance year. Research activities resulted in several publications, including journal articles, book chapters, and presentations led by Territorial Biosampling staff. These manuscripts and presentations focused on the U.S. Pacific regions and covered: comprehensive age-based biology of commercially-harvested species from American Samoa, Guam, and CNMI; examination of extensive data sets exploring patterns of life-history variation and fishing impact across various spatial scales and geographic regions; and reviewed the current state of research and future directions for coral reef and deepwater eteline fisheries. Project staff also monitored data collection from the Commercial Fisheries Biosampling Programs in Guam and the CNMI, managed the internal database of the Life History Program, and provided otolith training workshops in Guam and the CNMI with collaborators and other project partners. Finally, JIMAR Territorial Biosampling staff led research efforts on the 2018 Mariana Archipelago Life History Research cruise (SE-18-02), where JIMAR staff acted in the roles of chief scientist and Data/Fish Processing Lead.

West Hawaii Integrated Ecosystem Assessment

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

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

NOAA Sponsor: Michael P. Seki, Jamison Gove

Cumulative Budget Amount: $427,190

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

The Kona coast of Hawaii Island, more commonly referred to as "West Hawaii" by the local community, is home to a diverse group of species including ornamental fish, lush coral reefs, sea turtles, cetaceans and manta rays. West Hawaii also supports a myriad of ecosystem services important to the community including eco-tourism, an aquaculture industry, and recreational and aquarium fisheries. The balance of these human activities with natural processes is important to sustaining ecosystem health in this important region.

The West Hawaii Integrated Ecosystem Assessment (IEA) was formed in 2010 to develop a comprehensive understanding of the marine ecosystem in the Kona coastal region of Hawaii Island to help support management decisions. The JIMAR West Hawaii IEA project aims to produce robust scientific information that directly supports current and future resource management concerns in the region.

Progress during FY 2018

Over the past year, the project focused considerable efforts on building relationships with Hawaii State, Federal, and non-governmental agencies, and engaging local community organizations to understand management and community needs in this ecosystem. These diverse relationships resulted in numerous JIMAR led contributions that are highly supportive and complementary to management efforts in the region. For example, JIMAR Fisheries Social Research Associate Rebecca Ingram used a participatory process to produce West Hawaii's first conceptual ecosystem model that provides key insights into the region's social-ecological-system, highlights the importance of cultural ecosystem services, and elucidates the high proportion of ecosystem pressures that are amenable to local management action (to be published in July 2018). Additionally, through a collaborative effort with the State's Division of Aquatic Resources (DAR), JIMAR Ecosystem Researcher Mariska Weijerman (and co-authors) evaluated a suite of management strategies at Puakō to provide ecosystem services to human users (e.g., marine tourists and recreational fishers) while monitoring and enhancing the reef's ability to recover from local pressures (resilience). This research highlighted the inadequacy of current management, the trade-offs and efficacy of alternative strategies, and will serve as a core tenet of the State's management portfolio moving forward. Similarly, the project participated in an effort to produce the most comprehensive high-resolution maps of human and environmental pressure information ever assembled for the main Hawaiian Islands. These types of efforts provide the foundation for the State's resource management process (see Wedding et al., 2018).

In addition to management-related efforts, the West Hawaii IEA also served as a catalyst for bringing together researchers, managers and community members to discuss conservation and science in the region. JIMAR staff assisted with coordination of the 4th Symposium on West Hawaii Marine Ecosystem: Bridging the Gap between Science and Management, held December 5-6, 2017 in Kailua-Kona, Hawaii Island. Over 250 participants gathered for the two day event that highlighted current research and understanding of marine ecosystem health in West Hawaii. As the only such forum focused on West Hawaii, the symposium developed strong connections in the region and established the IEA program as a key partner in research, conservation, and management of West Hawaii's marine ecosystems.

JIMAR scientists also focused on researching key aspects of marine ecosystem dynamics in West Hawaii. Recent research expeditions facilitated the collection of a wide range of ecological and oceanographic information with direct relevance to regional management concerns. For example, research focused on larval fish through the investigation of surface slicks: narrow, meandering lines along the surface ocean. The areas within and around slicks aggregate floating material and attract organisms in areas where food resources are otherwise sparse and

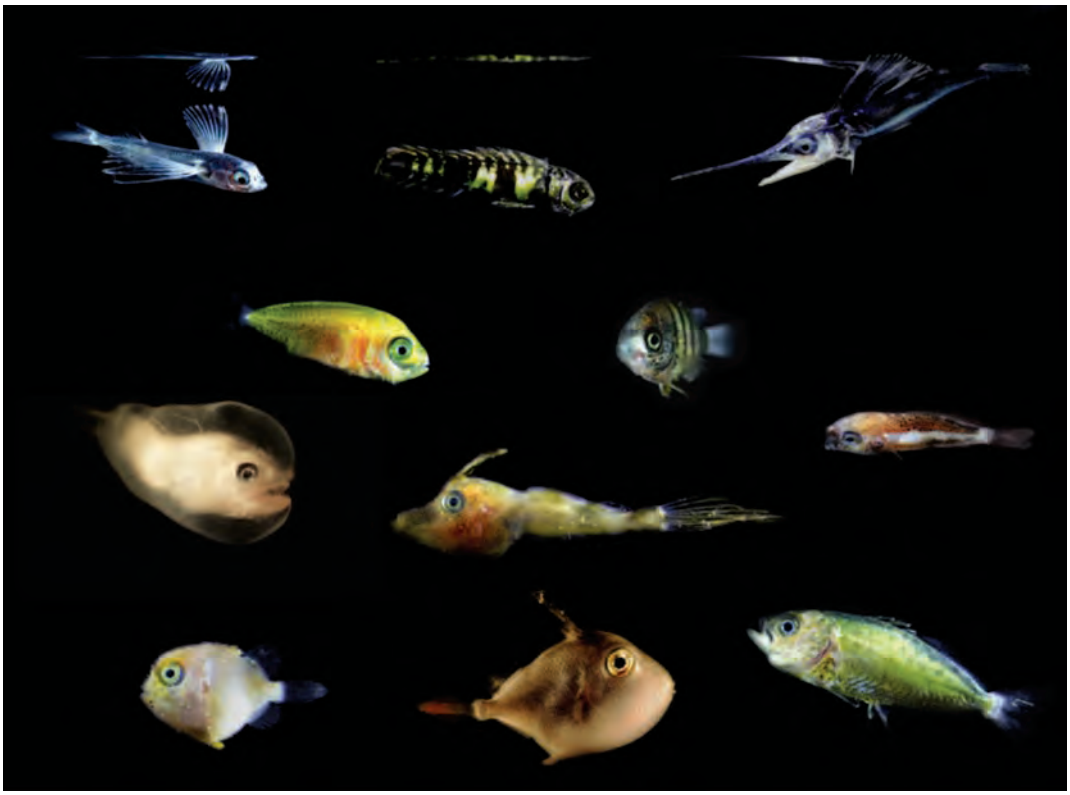


Figure 1. Example larval and juvenile fishes caught as part of the surface slick work in West Hawaii (Photo: Jonathan Whitney).

dispersed. These areas function as biological oases and contribute to the recruitment and retention of early life history stages of fishes. Additionally, JIMAR research also focused on understanding the deep water, nearshore biological hotspot identified by the IEA off West Hawaii. This hotspot is dominated by the mesopelagic boundary layer organisms, which are deep-water micronekton that live within a mile from shore at depths of 400–600 m. The mesopelagic boundary layer community is an important food resource for higher trophic groups that frequent the waters in the region.

Western Pacific Fisheries Information Network (WPacFIN)

P.I.: Douglas S. Luther [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

Cumulative Budget Amount: $699,385

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 staff work

with island agency staff, contractors, fishermen, and fish dealers to create data systems that implement quality control measures and synthesize fishery-dependent monitoring data. This technical support enables PIFSC and the partner agencies to produce timely reports of the best available fisheries data from each island area.

Progress during FY 2018

WPacFin staff continued converting the Visual FoxPro (VFP) database applications to MySQL and C# for WPacFIN Central and all partner agencies. Data summaries for reports to the Western Pacific Regional Fishery Management Council were completed in MySQL. A C# interface was created for the territorial Pelagics Plan Team module. The project made progress on the new WPacFIN website and supported completion of Phase I-II user queries by providing nonconfidential species- and gear-based data views and catch-per-unit-effort data views for service on the web. Project staff completed metadata documentation for all VFP data collections for Hawaii, American Samoa, Guam, and CNMI. Annual and semi-annual summary reports were submitted to Regional Fishery Management Organizations (RFMOs) and the NMFS publication Fisheries of the United States (FUS). Due to an unfilled position vacancy the publication "Fishery Statistics of the Western Pacific" was not completed.

These accomplishments satisfied most of the objectives established for the fiscal year, with the exception of one publication and those related to the Hawaii Division of Aquatic Resources (DAR) database. Hawaii Information Consortium data was made compatible with DAR's MySQL database directly through MySQL adjustments and without the need for a separate C# interface. However, a C# interface still needs to be created to allow users to perform data summaries.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

Cryptofauna Metabarcoding

Molly Timmers, JIMAR Graduate Student

Purpose of the Research

The main focus of this research examined the present-day variation in the abundance, distribution, and diversity of non-model coral reef associated organisms across predominantly broad spatial and environmental gradients (Chapters 1 and 2). The secondary focus of this research is to improve understanding of the effects of ocean acidification and warming on the biodiversity of cryptofauna communities (Chapter 3).

Unlike fish and corals, current knowledge on the diversity and community structure of the cryptofauna community is severely limited across geographic and environmental scales. This is in part due to the sheer diversity of this group, poor state of taxonomic knowledge and expertise, and difficulty in extracting them from the reef matrix. By integrating morphometric and molecular metabarcoding techniques from Autonomous Reef Monitoring Structures (ARMS), standardized collection devices retrieved across the Central and Western Pacific, this research asks the following questions.

- Are biodiversity patterns inferred from fish and corals representative of the spectrum of biological diversity on coral reef communities? (Chapter one)
- How does habitat heterogeneity, complexity, and area influence cryptofauna diversity? (Chapter one)
- How does cryptobiota diversity shift across large biogeographic and environmental gradients? (Chapter two)
- What are the underlying relationships between cryptobiota community structure, reef state, and biogeography? (Chapter two)
- How will increased temperature and acidification impact cryptofauna biodiversity? (Chapter three)
- What functional groups are particularly sensitive to or tolerant of increased temperature and acidification? (Chapter three)

Progress during FY 2018

Chapter one analysis was completed and writing commenced. All sequences for chapter two were submitted and run through the bioinformatics pipeline. The 2-year mesocosm field work for chapter three was completed June 19, 2018.

The majority of challenges during this time period concerned metabarcoding (chapter two). The first major roadblock was the delay in sequencing by the HIMB Sequencing Facility. Sequences were submitted October 11, 2017 and not returned until April 9, 2018. This six-month turnaround time delayed progress on chapter two.

The second challenge was acquiring enough computer power to push through the bioinformatics pipeline to analyze the sequences. Timmers worked with IT at the NOAA facility to establish the first genetic-based server at the center, genseq01. Over 100 million raw sequences from 640 samples were parsed across three machines/servers (one at NOAA and two at HIMB) to get through the pipeline. Even with three computer/server sources, it took nine weeks to complete.

Future Research Plans

Timmers' intentions are to defend during the period May-June of 2019. She started writing chapter one and plans to submit this for publication by September 2018. For chapter two, although the sequences are through the pipeline, those sequences (OTUs) that were not identified are currently being run through an HMM algorithm to phylogenetically assign them to a higher level taxonomic classification. This process should be completed by mid-August 2018. Once completed, she will have about one month of analysis remaining for chapter two and plans to submit chapter two for publication by December 2018–January 2019.

By the end of August 2018, the lab work for chapter three will be completed. Timmers anticipates submitting this chapter for publication by March of 2019. She is also collaborating on five other publications, three of which should be submitted to peer-reviewed journals by March 2019.

Publications

- DesRochers, A., M.A. Timmers, et al., 2017. Interdisciplinary baseline ecosystem assessment surveys to inform ecosystem-based management planning in Timor-Leste: Final Report. NOAA Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-17-02, 234 p.
- Moews-Asher, M., C. Castor, K. Reardon, and M.A. Timmers, 2018. Field guide to cryptic marine invertebrates of the Philippines: A sample of biodiversity from Autonomous Reef Monitoring Structures. NOAA Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-18-004, 86 p.

Presentations

- "The ARMS race: assessing and monitoring cryptic coral reef diversity across the Pacific". Presentation at Colgate University, November 28, 2017.
- "COI bioinformatics using the Chewbacca pipeline". A five hour DNA metabarcoding workshop conducted May 2, 2018 at University of Hawaii, Hawaii Institute of Marine Biology.
- "Cryptofauna coral reef biodiversity across spatial and environmental gradients in the tropical Pacific". Presentation at the World Conference on Marine Biodiversity, May 16, 2018, Montreal Canada.

Awards

- Recipient of the Colonel Willys E. Lord and Sandina L. Lord Scholarship
- Selected as 2018 NOAA Population Dynamics Fellow

Investigating Surface Slicks as Critical Nursery Habitat for Larval Fish in West Hawai'i

Jonathan Whitney, JIMAR Postdoctoral Researcher

Purpose of the Research

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

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

Progress during FY 2018

The project completed processing of 650 plankton samples collected for the slick project during two Integrated Ecosystem Assessment (IEA) cruises in 2016 and 2017. The broad scope of the project required that researchers explore nearly every part of the planktonic community to investigate how surface slicks influence larval fish ecology. Detailed ecological information was provided for nearly 10,000 individual larval fish representing more than 75 species that were collected in surface slicks. Lead researcher Jonathan Whitney completed the analysis and synthesis of these data for the 2016 IEA cruise and is in the process of writing a manuscript on the patterns of biological accumulation in surface slicks in West Hawaii. This first paper will serve as the foundation for several more papers being generated from this research.

Research conducted by the collaborative team revealed how nearshore surface slicks serve as nursery habitat for ecologically and commercially important fishes. A diverse assemblage of larval fish is concentrated in slicks including many commercially important predators such as billfish and mahi mahi, coastal schooling pelagics like jacks, and many species of coral reef fish. Results indicate that slicks enhance the accumulation of organic debris and nutrients to the surface waters, resulting in higher abundance of phytoplankton that in turn translates up the food chain. More phytoplankton provides more food for zooplankton, like copepods, which are a major prey item of larval fish. The dense concentrations of zooplankton found in slicks provide larval fish with a rich food source that likely leads to enhanced growth and survival. As slicks move along the coastline, they bring dense concentrations of plankton with them. The shoreward progression of many slicks may enhance local retention of early larval stages by preventing them from getting swept offshore and help deliver late larval stages back to nearshore habitats. Therefore, movement patterns of slicks could strongly influence larval dispersal and how local populations are replenished.

The project identified four mechanisms driving the formation of slicks in West Hawai'i: internal wave slicks; headland fronts; groundwater discharge fronts; and Langmuir cells. By learning about the mechanisms behind slick formation, researchers gain a better understanding of how ocean conditions can affect this important part of the ecosystem. These results are currently being synthesized into the project's second manuscript outlining the underlying physical mechanisms of slicks.

The project organized a third field season of slick sampling aimed at capturing the peak of the coral reef fish larval recruitment period. This shore-based research mission planned for early July of 2018 will serve as an integral time point that will complete this three-year sampling effort (2016-2018).

Project researchers are also working with community members to mount time lapse camera systems that the project designed and built onto homes and businesses with clear scenic views of the ocean. Time-lapse footage is being used to observe the movement and "behavior" of slicks over the course of days-to-seasons and provide insights into the mechanisms that cause slicks to form. Imagery can also be transformed into map overlays, used to measure the speed at which slicks move and validate what is seen in satellite imagery. The use of these technologies allows researchers to produce reliable density estimates of plankton, larvae and plastics across the entire coastline, which will ultimately help to model and predict future changes.

West Hawaii Ichthyoplankton Time Series. This FY the project was awarded a grant from the Fisheries And The Environment (FATE) program, which allowed the project to expand the research program into the first ichthyoplankton time series in the Hawaiian Islands. This research extension leverages an underutilized dataset that has not yet been analyzed in its entirety due to a backlog in sample processing. Beginning in 1997, PIFSC conducted ichthyoplankton surveys in West Hawaii including extensive neuston collections both inside and outside of surface slicks. Because the original intent of the collection program was focused on bio-sampling for a few targeted commercial species (e.g., billfish and tuna), the majority of the ichthyoplankton community sampled remained unprocessed in wet-archives. This 20-year time series provides an invaluable resource for examining year-to-year patterns of variability in larval abundance and distribution of multiple commercially and ecologically important taxa as well the spatial extent and physical drivers of key oceanographic features.

To date, the project constructed a database of all neustonic plankton collections made in West Hawaii and physically inventoried and organized 821 plankton tows collected between 1997 and 2013. The research team has

already begun processing these samples, which includes the removal, identification, and enumeration of all larval fish in more than 40 samples dating back to 1997. This dataset will allow researchers to explore annual variability and stability of the interactions between larval fish and surface slicks.

Future Research Plans

The major focus for the next FY is to complete data analysis and synthesize all findings into five prospective manuscripts.

- Biophysical Coupling I: Surface slicks as nursery habitat for larval fishes and invertebrates [Whitney et al.]
- Biophysical Coupling II: Fronts and internal wave slicks off west Hawaii as drivers of biological accumulation [Smith et al.]
- Microplastics accumulation in surface slicks and fronts [Whitney et al.]
- Large-scale spatial and temporal patterns of surface lines off west Hawaii, and underlying drivers [Smith et al.]
- Multi-year comparison of larval accumulation in surface lines off west Hawaii and relationship to recruitment [Whitney et al.]

The project will process the biological and physical samples collected during the summer field mission (July 9-20, 2018). Analyses will continue on results from the second and third field seasons and will be incorporated with the first year data. All findings will be synthesized into a more comprehensive manuscript that will assess intra-annual variation in larval fish dynamics.

Plans for the West Hawaii Ichthyoplankton Time Series. The project will continue processing and assembly of a 20-year (1997-2017) PIFSC time series of neustonic ichthyoplankton collections from West Hawaii in order to assess inter-annual variation in larval abundance and distribution. Next they will assemble data from historical collections with ichthyoplankton and zooplankton surveys from the three recent research cruises that provide high-resolution biophysical coupled sampling of more than 150 slicks sampled across three seasons to assess intra-annual variation in larval dynamics. Researchers will then analyze both ichthyoplankton data sets individually and comparatively to assess patterns of change in abundance, distribution, and assemblages of key species.

Publications

- Wong-Ala, J., C. Comfort, J.M. Gove, M.A. Hixon, M.A. McManus, B.S. Powell, J.L. Whitney, and A. Neuheimer, 2018. How life history characteristics shape settlement success of coral reef fishes, *Frontiers in Marine Science*, 5:65:1-12, https://doi.org/10.3389/fmars.2018.00065.
- Whitney, J.L., M.J. Donahue, and S.A. Karl, 2017. Niche divergence along a fine-scale ecological gradient in sympatric color morphs of a coral reef fish, *Ecosphere*, 9(1):e02015, https://doi.org/10.1002/ecs2.2015.
- Whitney, J.L., M.J. Bowen, and S.A. Karl, 2018. Flickers of speciation: Sympatric color morphs of the arc-eye hawkfish, *Paracirrhites arcatus*, reveal key elements of incipient divergence-with-gene-flow, *Molecular Ecology*, 27(6):1479-1493, https://doi.org/10.1111/mec.14527.

Presentations

- Whitney, J.L., K. Smith, J. Lecky, J. Gove, A. Copeland, D. Kobayashi, and M. McManus, 2018. Surface slicks as biological hotspots in West Hawaii: Biophysical interactions and their implications for larval ecology. Presentation at the 2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018.
- Whitney, J.L., K. Smith, J. Gove, J. Lecky, A. Copeland, D. Kobayashi, and M. McManus, 2017. Surface slicks as important nursery habitat for larval fish in West Hawaii. Presentation at the Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawaii, December 5-6, 2017.
- Whitney, J.L., J. Gove, D. Kobayashi, J. Lecky, K. Smith, and M. McManus, 2017. Surface slicks as nursery habitat for diverse assemblage of fish larvae in west Hawaii. Presentation at the XIth International Larval Biology Symposium, Honolulu, Hawaii, August 10-13, 2017.
- Smith, K., J.L. Whitney, K. Smith, J. Lecky, J. Gove, A. Copeland, D. Kobayashi, and M. McManus, 2018. Physical drivers of biological accumulation in surface slicks and small-scale fronts along Hawaii's western coast. Presentation at the 2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018.
- Smith, K., J.L. Whitney, K. Smith, J. Lecky, J. Gove, A. Copeland, D. Kobayashi, and M. McManus, 2017. Physical drivers of West Hawaii's surface slicks and their effects on larval fish accumulation. Presentation at

the Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawaii, December 5, 2017.

Awards

- 2017-2018 Fisheries and The Environment (FATE) research grant for research entitled, "Identifying oceanographic features as critical nursery habitat for early stages of commercially important Hawaiian shore fish and coastal fish".

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.

Socioeconomics of Western Pacific Fisheries

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

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

NOAA Sponsor: Michael P. Seki, Justin Hospital

Cumulative Budget Amount: $815,500

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 local economies and communities and constant changes in fishery management and regulations.

Progress during FY 2018

The project successfully provided support for socioeconomic database management of the Hawaii longline fishery and American Samoa longline fishery and continued data collection and monitoring activities in American Samoa, Guam, and CNMI small-boat fisheries. A draft NOAA technical memorandum that tracked the economic performance indicators of small boat fisheries in the three island areas was completed and is currently under final internal review.

Project activities accomplished during FY 2018 include the following.

- *Cost-earnings study of the CNMI and Guam small boat fisheries*. The field work is underway and expected to be completed in the fall of 2018. The next step will be to prepare data analysis for a technical report.
- *Economic impact analysis: Papahānaumokuākea Marine National Monument expansion*. A quantitative analysis was completed and a manuscript is currently under development.
- *Gather baseline data for historical fishing practices in the Papahānaumokuākea Marine National Monument*. A qualitative analysis was completed based on interviews transcription and a NOAA technical memorandum is under development.
- *Provide assistance to the national community social vulnerability indicators work plan*. A NOAA technical memorandum was published during the reporting period.

Figure 1. Students participating in the socioeconomics Science Camp module lead by JIMAR economist Emily Rollins.

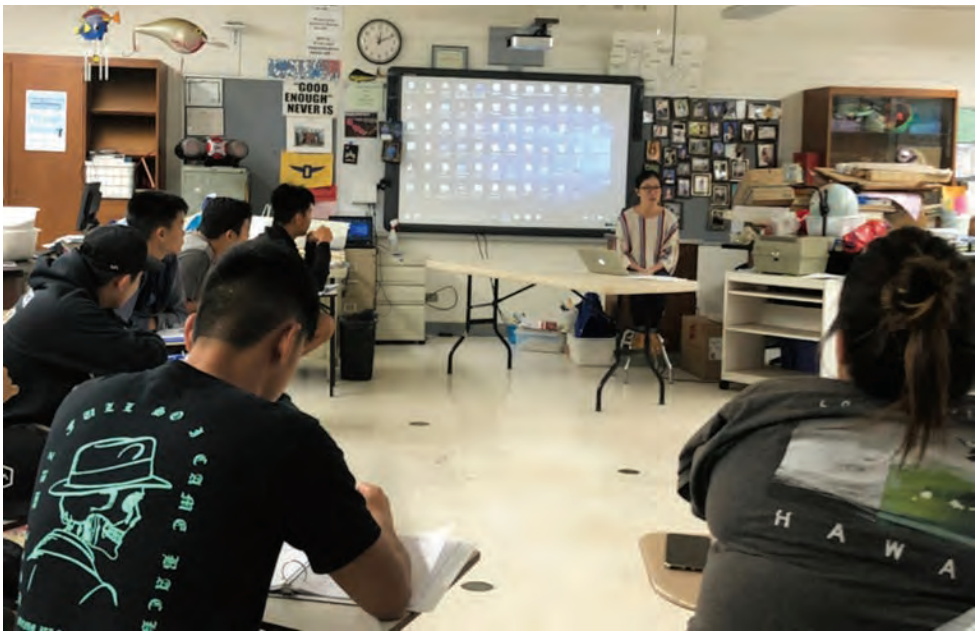


Figure 2. JIMAR graduate assistant Mia Iwane discusses the results of a survey given out at the beginning of the 2018 WPRFMC summer fisheries class on June 19, 2018, at Moanalua High School in Honolulu. The survey had a mix of qualitative and quantitative questions, and gathered information on gender, the number of times the participants eat fish in a week, and their opinion on the Papahānaumokuākea monument. The purpose of this module is to introduce students to qualitative data collection through surveys and what can be done with the information.

- *Creation of a longitudinal database for Hawaii and American Samoa longline limited entry permit ownership.* The Hawaii limited entry permit database and database documentation was completed. Future work tasks include drafting a manuscript that analyzes ownership and consolidation in the Hawaii longline fishery and developing a database to track the permit ownership and transfers in the American Samoa longline fishery.

- *Improve understanding of sensitive/non-compliant issues in western Pacific fisheries*. Twenty-nine interviews were conducted with compliance experts from across the western Pacific region. The interview notes were coded and analyzed and will be integrated into a draft manuscript. A potential pilot project was identified and JIMAR staff will begin developing data collection instruments, protocols, and an Office of Management and Cumulative Budget clearance application.
- *Broaden the social components in the West Hawaii Integrated Ecosystem Assessment (IEA)*. JIMAR staff developed a conceptual framework that strengthens the social components of the IEA, identified social indicators that focus on human well-being domains, applied appropriate social scientific methods for data collection, and validated the framework through relevant stakeholders and other IEA region feedback. A NOAA administrative report on integrating social components in the IEA model is under development.
- *Improve understanding of consumer preferences for aquaculture in the Pacific Islands Region*. An undergraduate thesis was successfully completed by JIMAR staff in the Global Environmental Science Program at the University of Hawaii at Manoa, and the results will be presented at the Hawaii Conservation Conference in July 2018.
- *Evaluation of interactions between oceanic whitetip sharks and Kona's small-boat fish aggregating device-associated fisheries in a human dimension context*. Twenty-five interviews were conducted and interview transcription is underway. JIMAR staff will continue to interview and collect data throughout the summer of 2018, synthesize preliminary results for presentation to interviewees, and finalize a NOAA technical memorandum in FY19.
- *Cost-earnings study of Hawaii charter fishing*. An economic contribution analysis was successfully conducted on the Hawaii charter fishing fleet. A manuscript of the analysis was submitted for publication in a peer-reviewed journal and is pending approval. The research will be presented at the International Institute of Fisheries Economics & Trade in July 2018.
- *Cultural fishing in American Samoa*. This was a special project requested by the Western Pacific Regional Fishery Management Council (WPRFMC) to provide more information on defining cultural fishing. JIMAR staff completed field work in American Samoa, summarized results, and presented findings at the Meeting of the Scientific and Statistical Committee and Council meeting in March 2018. A manuscript is under development.

Stock Assessment Research Program

P.I.: Douglas S. Luther [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

Cumulative Budget Amount: $886,910

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

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

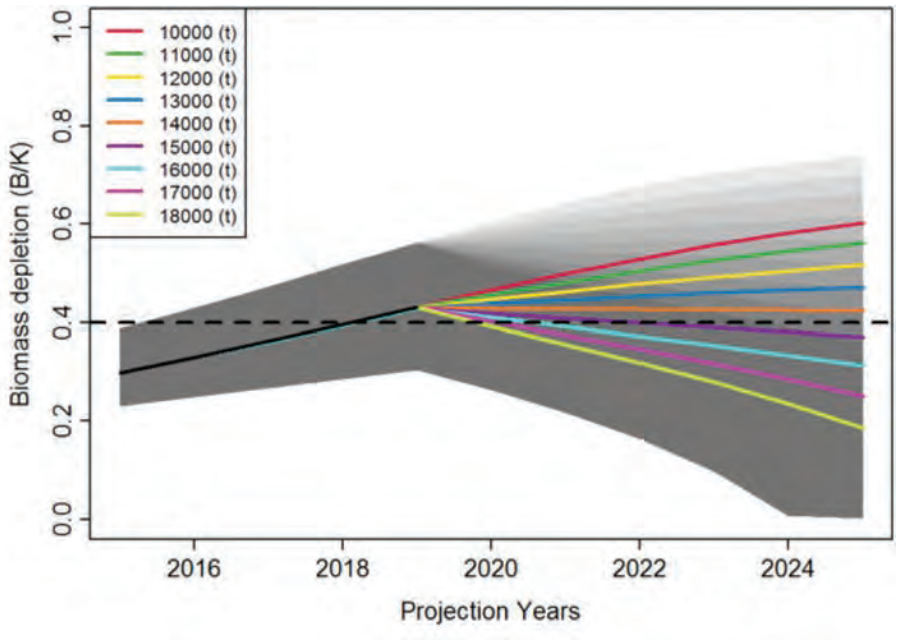


Figure 1. Example of a projection plot for biomass depletion from the new R package created at PIFSC called Just Another Bayesian Biomass Assessment (JABBA).

Progress during FY 2018

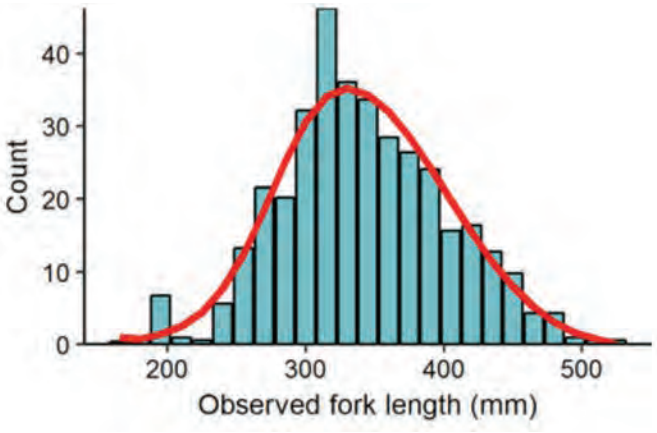


*Figure 2. Model predicted fit vs. observed size structure (vertical bars) for the steephead parrotfish (*Chlorurus microrhinos*) in Guam.*

For the insular assessment work, JIMAR researchers collaborated on a journal paper on a new surplus-production model R package (Just Another Bayesian Biomass Assessment; JABBA), conducted a successful Western Pacific Stock Assessment Review (WPSAR) review of the application of length-based stock assessment model to twelve Guam reef fish, and finalized a large technical memorandum on this subject. Work continued on the Hawaii Kona crab assessment and this project will be finalized early in 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 Billfish Working Group. The outcome from these workshops and the associated work included completion of standardized catch rates for the north Pacific swordfish, and completion of a stock assessment for this species. JIMAR Stock Assessment Computer and Database Specialist Eric Fletcher completed work on an R package aimed at calibrating high species diversity datasets collected using different methods. JIMAR staff led most of these efforts and collaborated closely with federal staff on others.

Some projects are slightly delayed due to stock assessment work being prioritized. JIMAR Fishery Assessment Specialist Maia Kapur is working on submittal of a paper on generating life history priors for the Kona crab and JIMAR Stock Assessment Supervisory Scientist Marc Nadon is assisting on a scientific paper extending a data-poor life history approach to new fish families.

Several publications were completed by JIMAR staff in the 2017-2018 reporting period including reports for the ISC Billfish and Shark working groups and a comprehensive NOAA technical memo.

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.: Douglas S. Luther [JIMAR Project Lead: Marie Hill]

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

NOAA Sponsor: Michael P. Seki, Erin Oleson

Cumulative Budget Amount: $821,088

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Cetacean Research Program (CRP) project is charged with assessing the status of cetacean stocks within the U.S. Exclusive Economic Zone (EEZ) waters of the Pacific Islands Region (PIR), which encompasses the EEZ around the entire Hawaiian Archipelago, Johnston Atoll, Kingman Reef and Palmyra Atoll, Baker and Howland Islands, Jarvis Island, American Samoa, Wake Island, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). At least 34 cetacean stocks occur in the Hawaiian EEZ alone, and many more exist in the other PIR EEZs, though most are largely unstudied. Assessment of cetacean stocks includes conducting inventories of species within each PIR EEZ, followed by evaluation of the structure of the stocks within each EEZ, the population status of each stock, and evaluation and mitigation of human impacts on cetacean stocks.

Progress during FY 2018

During the past year, the CRP conducted the Hawaiian Islands Cetacean Ecosystem Assessment Survey (HICEAS). This visual and passive acoustic ship survey for cetaceans and seabirds within U.S. waters surrounding the Hawaiian Islands is a collaborative effort between the NOAA Pacific Islands Fisheries Science Center and the NOAA Southwest Fisheries Science Center. During 179 days-at-sea, the NOAA Ships *Oscar Elton Sette* and *Reuben Lasker* collectively surveyed approximately 24,000 km of on-effort trackline. There were 345 sightings of cetacean groups representing at least 23 cetacean species. The short-finned pilot whale (*Globicephala macrorhynchus*) was the most frequently sighted species in the Hawaii EEZ. Approximately 36,000 photos and 111 biopsy samples were collected from cetacean groups. Satellite tags were deployed on three short-finned pilot whales and five false killer whales (*Pseudorca crassidens*). Aerial photographs of short-finned pilot whales and spinner dolphins (*Stenella longirostris*) were collected using a hexacopter, also known as an unmanned aerial vehicle (UAV). There were 766 passive acoustic detections of separate cetacean groups during daytime monitoring of the towed hydrophone array and 188 were linked to visual sightings, providing visual confirmation of species identification of detected sounds for 24 cetacean species. A total of 58 seabird species were recorded of which the vast majority were Puffinus shearwaters (wedge-tailed and slender-billed) followed by sooty tern and Bonin petrel.

Acoustic monitoring of the Hawaii deep-set longline fishery continued throughout the past year through acoustic recorder deployments and general outreach with fishermen. There were eight deployments on eight different vessels including both American and Vietnamese-American owned. Each deployment was conducted via the Pacific Islands Regional Office Observer Program with fisheries observers taking associated notes for each deployment. A total of 56 sets were acoustically monitored during these trips and the acoustic data was

Figure 1. Aerial image of short-finned pilot whales taken during HICEAS using a camera attached to a hexacopter (collected under permit; K. Yano).

Figure 2. Scientific and ship's crew for Sette's *leg 3 and Lasker's leg 2 of HICEAS.*

analyzed for false killer whale occurrence and compared with catch and bait depredation. This collaborative work with fishermen will be presented at the upcoming Hawaii Conservation Conference in July 2018. In addition, a new version of the longline High Frequency Acoustic Recording Package (HARP) used to collect acoustic data was developed by engineers at Scripps Institution of Oceanography in early 2018. Two new systems delivered to the CRP at PIFSC were extensively tested in the lab and are currently being tested out in the field.

Deep Sea Coral Submersible Dives

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

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

NOAA Sponsor: Michael P. Seki, Frank Parrish

Cumulative Budget Amount: $166,318

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

This JIMAR project supported a single dive in the Pisces IV submersible and another dive in the Pisces V submersible on August 28, 2017. Both vehicles are owned and operated by the University of Hawaii Undersea Research Laboratory (HURL) and have been used during the past 30 years to support research projects on precious and non-precious corals found at depths below 200 m.

In addition, the project supported a dive in the Pisces IV submersible and two dives in the Pisces V submersible on August 29-30, 2017 for a project led by Dr. Samuel Kahng of the Hawaii Pacific University (HPU). Dr. Kahng has previously used these vehicles to survey areas off the Kona coast of Hawaii Island where lava flows of known ages are present.

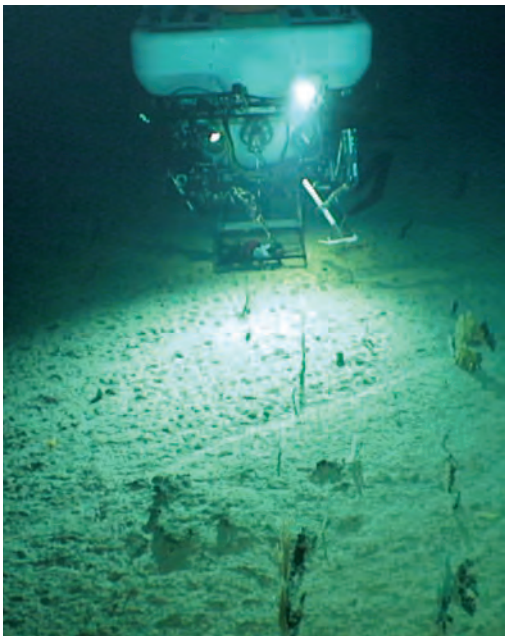


Figure 1. HURL submersible Pisces IV recovering the tilt current meter during the August 28 deployment.

Progress during FY 2018

Summary information for each dive is provided below.

Date	Dive #	Location	Latitude	Longitude	Depth	PI	Title
08/28/17	P4-319	Makapu‘u, Oahu	21.2939	-157.5426	421 m	Frank Parrish	Coral Bed Study Site Survey
08/28/17	P5-885	Makapu‘u, Oahu	21.2939	-157.5426	418 m	Frank Parrish	Coral Bed Study Site Survey

Date	Dive #	Location	Latitude	Longitude	Depth	PI	Title
08/29/17	P5-886	Kailua-Kona, Hawaii	19.6509	-156.0470	634 m	Sam Kahng	Coral Bed Study Site Survey
08/30/17	P4-320	Kailua-Kona, Hawaii	19.224	-155.9114	575 m	Sam Kahng	Coral Bed Study Site Survey
08/30/17	P5-887	Kailua-Kona, Hawaii	19.2219	-155.9123	634 m	Sam Kahng	Coral Bed Study Site Survey

The purpose of the August 28 dives was to survey the Makapu‘u precious coral study site located off Oahu, examine growth rates of known colonies of commercially valuable deep sea corals, and recover as well as re-deploy instruments previously established at this location. Of particular importance was the recovery of data from the instruments on current velocity and direction at different points within the coral bed. The instruments were successfully recovered during the dives and their data were recently shared with partners in the JIMAR

Pacific Islands Deep Sea Corals and Sponge Initiative project and at the NOAA Deep Sea Coral Research and Technology Program workshop held in Honolulu in April 2018.

The purpose of the August 29-30 dives was twofold: the first being to conduct additional surveys of two study sites on and near the submerged lava flows where the deep sea coral communities had been impacted during volcanic eruptions. This project attempts to better understand disturbance and recovery of deep sea coral communities and whether succession of different coral species is occurring. These surveys were successfully conducted and the data acquired are still being analyzed in Dr. Kahng's lab at HPU. The secondary purpose was to relocate and recover markers previously placed at the site and collect rocks and specimens of selected species of precious pink and red corals.

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

P.I.: Karen E. Selph

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

NOAA Sponsor: John Lamkin

Cumulative Budget Amount: $94,477

NOAA Goal(s):

- Healthy Oceans
- Resilient Coastal Communities and Economies

Purpose of the Project

Effective management of the Atlantic bluefin tuna (ABT) depends upon understanding environmental constraints on stock recruitment, which is among the highest priorities for NMFS management-based research. The objective of this proposal is to improve western ABT stock assessment by linking variability in nitrogen sources and food web dynamics in the Gulf of Mexico (GoM) to habitat quality, feeding, growth and survival for ABT larvae.

Progress during FY 2018

During this reporting period, all flow cytometry samples from the first research expedition (May 2017) were analyzed and the data shared at a February 2018 workshop in Portland, OR. The PI also participated in the second research expedition on the NOAA Ship *Nancy Foster* (April-May 2018) and collected all planned samples.

(top) Figure 1. A CTD rosette on deck at sunset in the Gulf of Mexico.

(right) Figure 2. NOAA Ship Nancy Foster *in Pascagoula, MS (dry dock, with captain in foreground).*

Fishing Impacts on Non-target Species

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

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

NOAA Sponsor: Michael P. Seki, Keith Bigelow

Cumulative Budget Amount: $238,276

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

Shark bycatch in commercial fisheries on the high seas and in local Hawaii fisheries targeting tuna and billfish are contributing significantly to population declines of pelagic species across whole ocean basins. In the Pacific Ocean, both silky (*Carcharhinus falciformis)* and oceanic whitetip (*C. longimanus*) sharks have been assessed as overfished and overfishing for both species is currently occurring. Furthermore, oceanic whitetip sharks are now listed under the U.S. Endangered Species Act as threatened with extinction. In this JIMAR project several research objectives aimed at reducing mortality for sharks during incidental interactions with commercial fishers, are being carried out.

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

Progress during FY 2018

To get quantitative estimates of post release mortality rates of sharks discarded in longline fisheries, JIMAR deployed 134 survivorship satellite tags on sharks captured incidentally in the Hawaii tuna and American Samoa longline fisheries. The subsequent data provide estimates of mortality, which is now being implemented into

Figure 1. Oceanic whitetip shark acoustically tagged by one of the participating fishermen in Kona.

Figure 2. An observer tagging an oceanic whitetip shark with a survivorship satellite tag during a commercial tuna longline trip.

population projections using stock synthesis. This study also provided quantitative data on shark handling and discard methods; JIMAR project staff discovered that over 60% of caught sharks are discarded by cutting the line with various lengths of trailing gear attached to each animal (between 0.3 and 17.2 m). These important results will be developed into presentations to the scientific committees of the Western and Central Pacific Fisheries Commission (WCPFC) and the Western Pacific Regional Fishery Management Council (WPRFMC).

In the community tagging program, which seeks to understand habitat use and movement behavior of the threatened oceanic whitetip shark, JIMAR staff developed training materials and held five workshops to train commercial fishers around Kona in tagging methods for oceanic whitetip sharks (OCS). During these workshops, discussions centered on the threatened status of the species, biology and research objectives for this study, and informing fishers about the importance of conservation. JIMAR staff also taught tagging methods and requested feedback from fishers on potential strategies to reduce mortality. There are now 22 fishers trained and actively tagging oceanic whitetip sharks. Since October 2017, when this study began, the trained fishers have already tagged 16 oceanic whitetip sharks. Researchers also installed the acoustic array of receivers and completed one round of recoveries of the receivers on the west Hawaii FADs. The data on these receivers showed multiple visits and periods of residency of several sharks tagged by the project. JIMAR researchers also began collaboration with Liquid Robotics to put acoustic receivers on their wave gliders technology to gain additional insights into OCS movements when they are away from the FADs.

Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support

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

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

NOAA Sponsor: Michael P. Seki, Charles Littnan

Cumulative Budget Amount: $615,800

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

JIMAR's Hawaiian Monk Seal Research Program (HMSRP), in collaboration with the NOAA Pacific Islands Fisheries Science Center Protected Species Division (PIFSC PSD), conducts studies on the Hawaiian monk seal (*Neomonachus schauinslandi*), the most endangered marine mammal occurring entirely within U.S. jurisdiction.

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

Progress during FY 2018

The 2017 summer field season commenced prior to the start of the reporting period. By July 1, 2017, a total of 15 field staff and volunteers established monk seal field research camps at French Frigate Shoals (FFS), Laysan, Lisianski, Pearl and Hermes Reef, and Kure Atoll. While 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, conducted necropsies on dead seals, and participated in shark predation monitoring and mitigation to prevent monk seal pup mortality, including fishing for predatory Galapagos sharks in nearshore areas around pupping sites at FFS.

Field staff also performed interventions to improve the survival of individual seals. Interventions included disentangling seals from marine debris, reuniting mom/pup pairs, marine debris removal from beaches 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 also administered to seals in order to treat abscesses.

Figure 1. Weaned pup Midway Atoll (NMFS Permit No. and PMNM-2018-014).

Figure 2. Field camp Lisianski (PMNM-2018-014).

Field staff vaccinated wild seals against morbillivirus for the first time in the NWHI during the 2017 field season and participated in a monk seal vocalization study at Kure Atoll, which 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. Field staff was deployed through September 3, 2017 except for the field staff at FFS, who remained deployed until October 10, 2017. One juvenile seal was captured at FFS and taken to The Marine Mammal Center's Ke Kai Ola facility in collaboration with HMSRP at the end of the field season. Upon return to Honolulu, field personnel cleaned and inventoried gear and supplies and completed reports summarizing field research and population status at each site.

In March and April 2018, two JIMAR staff members participated in a short field camp at FFS to collect monk seal life history data, monitor and mitigate wildlife entrapments, and monitor for invasive species. They remained at the camp until the 2018 field camp deployment cruise arrived in April. During the cruise, a total of ten field staff and four volunteers were deployed to establish research camps at FFS, Laysan, Lisianski, Pearl and Hermes Reef, and Kure Atoll for the 2018 summer field season. Two of those staff flew to Midway Atoll overnight and conducted surveys there before transiting to their summer field sites. Prior to deployment, all field personnel participated in securing and packing food stores, training activities for sexual harassment avoidance, and 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. The 2018 field teams conducted research and recovery activities described during the 2017 field season and field personnel remained deployed through the end of the reporting period.

Hawaiian Monk Seal Research Program

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

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

NOAA Sponsor: Michael P. Seki, Charles Littnan

Cumulative Budget Amount: $1,326,700

NOAA Goal(s)

- Healthy Oceans

Purpose of the Project

The JIMAR Hawaiian Monk Seal Research Program (HMSRP) conducts research on the Hawaiian monk seal (HMS; *Neomonachus schauinslandi*), the most endangered marine mammal occurring entirely within U.S. jurisdiction. There are approximately 1,400 monk seals remaining, the majority of which occur at the six highly studied sites in the Northwestern Hawaiian Islands (NWHI) where abundance is estimated to have declined by two thirds since the late 1950s. Apparent stability or population growth in the NWHI in recent years substantially influences overall trends, and the average growth rate of the overall population has been approximately 2% per year since 2013. The program conducts research designed to promote sound conservation and management of the species by characterizing natural and anthropogenic factors that may impede population recovery. Research focuses on connections between population biology, foraging ecology, individual health, and environmental and oceanographic parameters in the North Pacific. The program develops, tests, and implements tools to assist in recovering the species.

Figure 1. JIMAR staff on Rabbit Island preparing to capture a weaned pup for flipper tagging (NMFS Permit No. 16632).

Figure 2. JIMAR staff preparing to capture a young seal for hook removal (NMFS Permit No. 18786).

Progress during FY 2018

Accomplishments during FY 2018 included population monitoring and assessment, survival enhancement, foraging ecology characterization, health and disease evaluation, and behavioral research. Project activities and accomplishments are described in detail below.

JIMAR staff played a crucial role in the breakdown of the 2017 field research camps as well as the establishment of 2018 field research camps in the NWHI. Eight field staff and four volunteers were hired for the 2018 field season, protocols were reviewed and revised, and staff trained field personnel in data collection, vaccination, specimen collection techniques, and shark mitigating procedures. They also procured, tested, and packed field supplies and equipment, and provided other logistical support to deploy the camps. The 2018 field staff departed for the field on April 15, 2018 on the NOAA Ship *Oscar Elton Sette* and JIMAR staff served as field operations lead and chief scientist on the cruise.

JIMAR staff presented at the Hawaii Conservation Conference in July 2017 and at the 22nd Biennial Conference on the Biology of Marine Mammals in October 2017. JIMAR staff and volunteers also participated in the transport, release, and post release monitoring of two seals at Midway Atoll in November 2107. While deployed to Midway atoll, staff collected life history data on the Midway monk seal subpopulation. Prior to release, the seals were rehabilitated at The Marine Mammal Center's Kona monk seal hospital in collaboration with the HMSRP. Staff also deployed for two short camps at French Frigate Shoals (FFS) in the late winter/spring to collect monk seal life history data, monitor and mitigate wildlife entrapments, and monitor for invasive species. During deployment, one team of JIMAR staff tested new technologies to assess the potential for increasing efficiency collecting monk seal population data. This team also conducted surveys at Midway Atoll before returning from the field.

Additional accomplishments by the project included collecting survey and life history data and specimens in the main Hawaiian Islands (MHI) and ensuring data resources remain compliant with the NOAA Plan for Increasing Public Access to Research Results requirements. Program staff continued to improve and refine the Seal Population Assessment (SPA) database and other program databases providing for greater efficiency. Improvements included refining the mechanism to check and import MHI Google Sheet entries from cooperators (on Kauai, Oahu, Maui, and Hawaii Island) directly into SPA on a regular basis and automating the creation of weekly report summaries that can be sent from the field camps to Honolulu. Project personnel also operated Unmanned Aircraft Systems to survey and assess monk seals and continued ongoing vaccinations of wild seals against morbillivirus as well as training partners in vaccination and pole syringe techniques and protocols.

The foraging ecology program deployed telemetry and animal-mounted video equipment to document individual HMS movements. Health and disease research included collection of biomedical samples in the MHI

for disease surveys in conjunction with telemetry deployments and from stranded animals. Samples were then shipped to various laboratories for analysis. Emergency response efforts during the reporting period included capturing seals for hook removal and health assessment concerns on Oahu, and conducting monk seal necropsies. Staff and program volunteers also completed the reorganization of tens of thousands of samples in the frozen specimen archive. Tissue samples were reduced to smaller sizes, barcoded, and their locations were entered into the specimen database. This effort allows more efficient 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 veterinary laboratory and seawater system for live animal care. JIMAR personnel also created a patient database linking animal life history data in the program's SPA database, and assisted the program's veterinarian with live animal care and research projects, including the development of a manuscript (in revision) establishing HMS blood reference intervals.

Marine Turtle Recovery in the Pacific Islands Region

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

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

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

Cumulative Budget Amount: $753,000

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 datasets to better understand population dynamics; 5) assist with health assessments and disease investigations; 6) administration of a sea turtle stranding and salvage network for research and live turtle rehabilitation; 7) educational outreach to the public focused on sea turtle research results; 8) maintenance of efficient and secure computerized storage, management, and retrieval of sea turtle research data; and 9) training of observers training in the collection of sea turtle data while aboard commercial longline fishing vessels.

Progress during FY 2018

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

In June 2018, three field researchers on FFS deployed three satellite tags on two males encountered during a non-terrestrial emergence ('basking') and a third tag on a nesting female. They individually identified 130 males and 154 female green sea turtles. The team confirmed nest laying of 149 females and counted the number of eggs in 130 nests out of 219 total nests laid. The FFS encampment is an annual field endeavor lasting 4-5 months.

A new JIMAR Marine Ecological Researcher Dr. Alexander Gaos joined the project to bolster the program's ability in obtaining additional demographic data and understanding aspects of sea turtle ecology in the Pacific

Figure 1. JIMAR field researchers, Lindsey Bull (left) and Marylou Staman (right), measure the length of a female green sea turtle (honu) basking on Tern Island, FFS. The sex of the turtle is determined by the length of its tail. The field research team will spend several months on the main honu nesting beach in the NWHI and will tag all female nesting honu on FFS.

Islands Region (PIR) such as hawksbill abundance, sex and sex ratio, and effects of climate change. JIMAR Marine Biological Researcher Dr. Camryn Allen developed a new sea turtle endocrinology laboratory in PIFSC for investigation of sex, sex ratio, capture stress, and reproductive related questions. JIMAR analyzed 34 blood plasma samples obtained from immature turtles captured in the Mariana Islands in 2017 to determine the sex of the juvenile turtles. The sex ratio of immature green sea turtles foraging in the Main Hawaiian Islands and Mariana Islands is biased toward females at 1 male to every 3.4 females. The ultimate goal is to understand changes and climate impacts in sex ratio over time.

Three University of Hawaii (UH) Marine Option Program (MOP) JIMAR Student Assistants and three JIMAR volunteers participated in stranding responses and rehabilitation for sea turtles. They also conducted studies on nest abundance at FFS and diet composition of turtles incidentally captured in longline fisheries.

An interdisciplinary team including JIMAR, PIFSC, and NOAA Southwest Fisheries Science Center (SWFSC) researchers was formed to create population models to understand fishery interactions in the high seas for multiple sea turtle species. The team held three meetings and produced a write-up to support a Section 7 Biological Opinion that will be submitted by the end of 2018.

During the reporting period MTBAP staff participated in various education and outreach events including the following.

- 2017 NOAA Fisheries Science Camp. MTBAP staff led a module entitled “Sea turtle sex and climate change effects”.
- Presented research findings at two separate seminars at the UH School of Ocean and Earth Science and Technology (SOEST) seminar series.
- Conducted a hands on workshop for the U.S. Fish and Wildlife Service (USFWS) on how to identify the species, measure, obtain samples, and sex (via hormone analysis) a turtle. They learned the importance of understanding sea turtle sex ratios at foraging grounds and the potential effects of climate change upon temperature-dependent sex determination in sea turtle populations.
- In May 2018, Dr. Gaos visited Molokai and teamed up with a group of local volunteers to encourage visitation of hawksbill nesting sites every few days in order to monitor activity. The project has now been formalized by the name “Halawa Hawksbill Monitoring Program”.

Pacific Islands Deep Sea Coral and Sponge Initiative

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

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

NOAA Sponsor: Michael P. Seki, Frank Parrish

Cumulative Budget Amount: $827,000

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 of developing long-term collaborative relationships between scientists from different research entities and advancing knowledge of deep-sea corals and sponges in the U.S. Pacific Islands to improve the management of these important resources.

The immediate objectives of the project are to: 1) identify, compile and synthesize existing deep sea coral and sponge survey data in the U.S. Pacific Islands; 2) extract, compile, and synthesize data from new surveys of deep sea corals and sponges conducted by the NOAA Ship *Okeanos Explorer* (EX); 3) create updated bathymetry and backscatter syntheses from existing multibeam data and new multibeam data obtained by EX mapping surveys. The surveys were conducted in the Main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI) within the Papahānaumokuākea Marine National Monument (PMNM), the Line Islands within the Pacific Remote Islands Marine National Monument (PRIMNM), the Mariana Archipelago inside and outside of the Mariana Trench Marine National Monument (MTMNM), and American Samoa; 4) based on the data obtained from the surveys, create maps of known areas of high abundance and diversity of deep-sea corals and sponges in the U.S. Pacific Islands; 5) examine the benthic and oceanographic conditions that promote development of deep-sea coral and sponge ecosystems; 6) synthesize data on temperature, currents, and pH from deployed instruments in known precious coral beds and use analysis of collected precious coral skeletons as a record of environmental change;

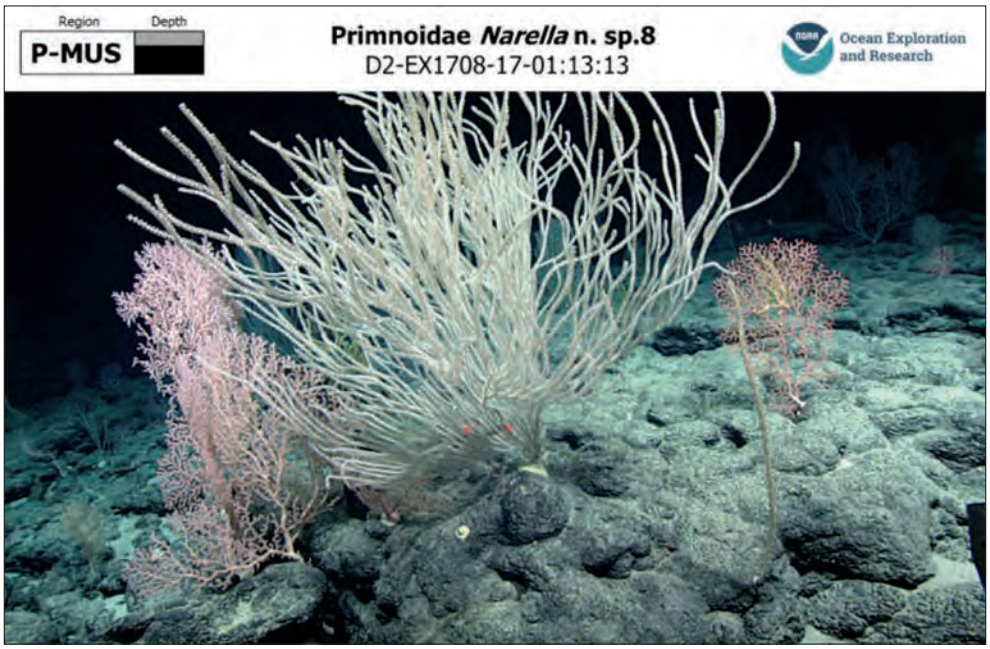


Figure 1. Example image for the Deepwater Benthic Animal Identification Guide of a coral community at Rapano Ridge in the Musicians Seamounts, including a new species of primnoid *coral.*

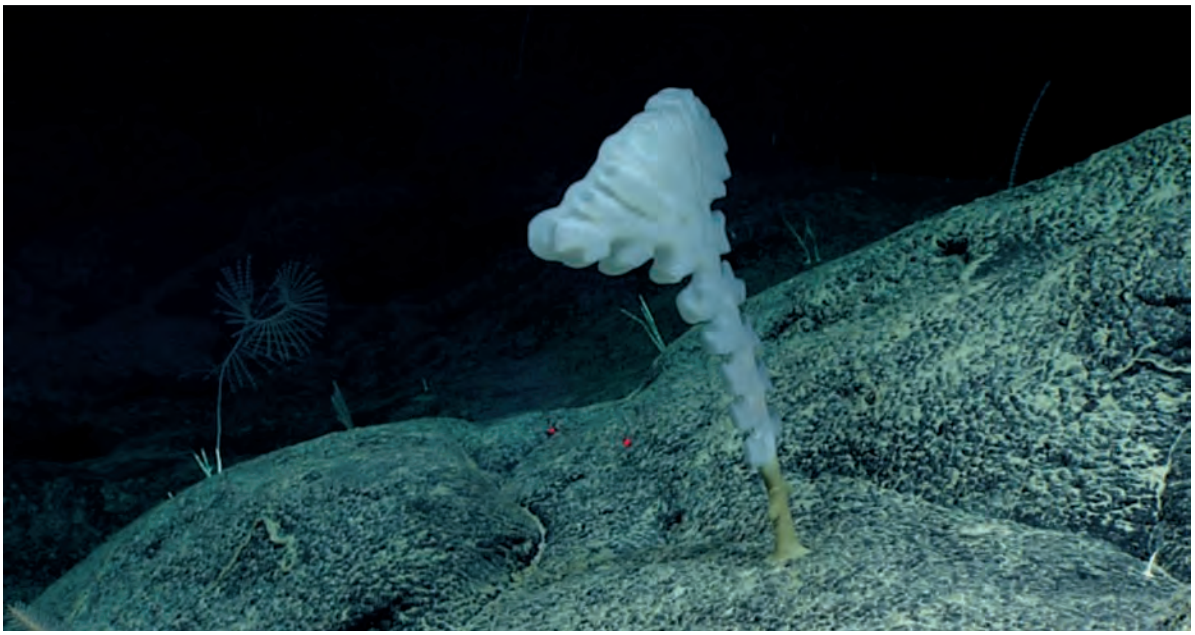


Figure 2. An in situ *image of collected sponge specimen that is an undescribed genus in the family* Farreidae *(image: NOAA Office of Ocean Exploration and Research, 2017 Laulima O Ka Moana).*

and 7) extract and quantify DNA from roughly 200 antipatharian coral samples and sequence the restriction site associated DNA (RAD) libraries for population connectivity and stock structure analyses of black corals collected in the MHI.

Progress during FY 2018

The majority of the project's work took place on the Manoa campus of the University of Hawaii (UH) and the team consists of: Dr. Christopher Kelley, Program Biologist for the Hawaii Undersea Research Laboratory (HURL); Virginia Moriwake, JIMAR Deep Sea Animals Research Specialist; and Sarah Bingo and Meagan Putts, JIMAR Deep Sea Corals Research Associates.

The team was responsible for planning and execution of expeditions on the EX in the Pacific and providing post cruise deliverables. These products include: processing specimens acquired during the cruises; retrieving data, imagery, and video products from the ship and creating backups; processing raw tracking and conductivity, temperature, density (CTD) data; organizing biological images captured by the onboard videographers and updating an online animal identification guide; creating coral, sponge, and associated animal records from the dive video using the Video Annotation and Reference System (VARS) software for incorporation into the DSCRTP national database; and producing dive characterization and regional reports.

In addition, the team was tasked with the compilation and synthesis of existing data from deep sea coral and sponge observations in the U.S. Pacific Islands, preparing additional HURL coral and sponge annotation records for DSCRTP, and annotation of fishes encountered during remotely operated vehicle (ROV) dives.

The methodology used by the team was designed to provide data products to address key priorities of the project: the identification of the depth distributions of deep-sea corals and sponges; identification and geo-location of areas of high abundance and diversity of deep-sea corals and sponges in surveyed Pacific monuments; and identification of the benthic and oceanographic conditions that promote development of deep-sea coral and sponge ecosystems.

Specimens. Two field expeditions were conducted within the reporting period, one in the Johnston Atoll area of the PRIMNM in July 2017 and the other in the Musicians Seamounts in September 2017. Specimens collected during the cruises were transferred to the laboratory after the ship returned to Honolulu where they were processed and sent to their final repositories.

Post cruise laboratory processing for specimens included an inventory of all biological and geological specimens, checking the condition of the former and adding preservative as needed, and cross-checking corresponding

collection data recorded in the sampling database. Table 1 provides a summary of the primary (targeted) and associated specimens collected.

Table 1: Summary of the specimens collected during Johnston Atoll and Musicians Seamounts cruises.

Specimen Type	Animal Group	Johnston Atoll	Musicians Seamount	Grant Total
Biological	Annelida	8	6	**14**
	Arthropoda	13	8	**21**
	Bryozoa	1	5	**6**
	Chordata-fish		2	**2**
	Chordata-tunicate		2	**2**
	Cnidaria	22	71	**93**
	Ctenophora	1	1	**2**
	Echinodermata	10	13	**23**
	Mollusca	2	8	**10**
	Platyhelminthes		1	**1**
	Porifera	15	23	**38**
	Unknown	1	2	**3**
Biological Total		**73**	**142**	**215**
Geological		**24**	**36**	**60**
Grand Total		**97**	**178**	**275**

A total of 215 animals were collected during the reporting period, including 93 cnidarians and 38 sponges. 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 packed and shipped to the Smithsonian National Museum of Natural History for acquisition into their collections. Many (131 animals) of the primary and associate specimens 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 subsequently shipped the entire kit back to Northeastern University where the OGL project is headquartered. Sixty rock samples were also collected during the reporting period and shipped to the geological repository at Oregon State University.

Data. Tracking and CTD data from each ROV dive are required to create the DSCRTP deliverables. The NOAA Office of Exploration and Research (OER) provides only the raw data files from the EX cruise, so data processing steps are required. Tracking and CTD data are merged into a file containing latitude, longitude, depth, temperature, oxygen, salinity, and date/time fields that will be imported directly into ArcGIS for visualization of the dive tracks or merged with video annotations using custom scripts. The UH team processed the CTD and tracking data from 36 dives during the report period.

Imagery. For several years, the UH team has been responsible for assembling *in situ* animal images from ROV video and related information for an online benthic animal identification guide (https://oceanexplorer.noaa.gov/okeanos/animal_guide/animal_guide.html). The second version of the guide, with more than 3,000 images from 2015 and 2016 cruises, was submitted to the NOAA website team for posting in September 2017. The team also began working to incorporate images from 2017 EX cruises during this report period. The location and environmental data were associated with more than 30,000 images captured by the onboard videographers. A spreadsheet with the image name, dive number, general region, latitude, longitude, depth, temperature, oxygen, salinity, and date/time fields was generated. Images from these dives that captured animals while the ROV was on the ocean seafloor were reviewed and candidate images were selected to help with new animal identifications and to improve the guide. Initial identifications were based on comments made in the dive event logs, email correspondence with taxonomic specialists, and Dr. Kelley's experience working with deep water animal identification for HURL. The animal identifications and taxonomy were incorporated into the image spreadsheet.

In early 2017 a macro-enabled PowerPoint file with Visual Basic for Applications (VBA) code written by the UH team was developed to generate and export slides from the data into the image spreadsheet. Each slide was populated with the photo of the animal, the current and most specific animal identification, and information about the source of the image (e.g., an ocean and region code, color indicator of the depth range, the dive number and time where the animal was seen, as well as a logo for the organization that captured the image). More than 4,900 slides have been created and sent off to taxonomic experts for review.

Video. The annotation protocol developed by the project is the same as the last reporting 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. The analysis team conducted 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 72-field database template. The team applied a quality control protocol to look for inconsistencies in depth, substrate, and identifications and reviewed the video for records with potential problems. Identifications were double-checked against the online taxonomic database to ensure correctness and consistency. Once quality control is completed for each dive, the records are considered ready for submission to DSCRTP. During this report period, the team annotated video from 45 dives conducted in 2016 and 25 dives conducted in 2017. More than 30,000 animal records were submitted to DSCRTP from the last cruise in 2015 and from all the dives in 2016. Another 7,500 records from 23 dives conducted in 2017 are in the final stages of review prior to submission.

The JIMAR 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 information to 35,000 records of corals that were already submitted to DSCRTP several years ago. For many of the records in both datasets, 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.

DSCRTP Dive Characterization Reports. JIMAR updated and edited over 100 dive summaries with new maps (general area, dive site, and slope), CTD profiles, animal identifications and counts, and predominant substrate description in locations where animals were observed. All 2015 and 2016 dive characterization reports were completed. The 2016 reports were submitted to DSCRTP and the 2015 reports will be submitted after a final quality check.

Regional Reports. The team also began working on the creation of two reports for the project to summarize the data products and preliminary findings for the NWHI and the Mariana Archipelago. The reports detail the areas mapped, location of new seamounts, ROV dive locations, specimens collected, and shipboard and shore-based cruise participants. Descriptive analyses of the environmental conditions, densities of coral and sponge communities, and substrate preferences were also included.

Papahānaumokuākea Marine National Monument Monitoring and Research

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

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

NOAA Sponsor: Randall Kosaki

Cumulative Budget Amount: $1,025,000

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

The JIMAR Papahānaumokuākea Marine National Monument (PMNM) Monitoring and Research Project conducts primary research and monitoring activities 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 to collect data on the marine ecosystems of primarily the Northwestern Hawaiian Islands (NWHI) during research cruises. Subsequent specimen processing, data analyses, and scientific publication are based out of PMNM's offices at the NOAA Inouye Regional Center in Honolulu. The objective of this characterization is to advise management and policy decisions in order to conserve, protect and enhance the biodiversity of the PMNM.

Figure 1. PMNM dive boat transiting to Hi'ialakai as seen from 360° camera (photo: John Burns).

Progress during FY 2018

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

Coral Reef Monitoring. JIMAR staff participated in the Reef Assessment and Monitoring Program (RAMP) HA-17-04 Cruise for 25 days at sea (DAS) in September 2017. JIMAR conducted rapid ecological assessments of reef fish, corals, non-coral invertebrates, and surveyed coral health. Additionally, JIMAR staff led the investigation for an open circuit SCUBA-closed circuit rebreather comparison study to determine the effects of SCUBA exhaust on fish surveys; a publication on the study is currently in progress. JIMAR assisted research teams from Hawaii Institute of Marine Biology and Australian Institute of Marine Science and also trained/mentored three distinguished undergraduate interns from the University of Hawaii's QUEST program.

Data from previous RAMP cruises (2007-2016) were analyzed and a manuscript was submitted to the peer-reviewed journal *PeerJ*. This study described use of multivariate control charts to detect unusual changes in the biological community structure in the long-term RAMP monitoring data, thus providing researchers and managers with means to quickly evaluate the ecological status of the PMNM after each RAMP cruise. JIMAR PMNM Ecological Research Statistician Dr. Atsuko Fukunaga presented this study at the Statistics in Ecology and Environmental Monitoring (SEEM) conference held December 6-8, 2017 in Queenstown, New Zealand.

JIMAR staff co-authored a *PLoS ONE* journal manuscript that describes a mass coral bleaching event on shallow reefs of Lisianski Island in the NWHI for which data collected during previous cruises (2014-2015) were used. Follow-up surveys of this mass bleaching were also performed by JIMAR during the RAMP cruise for FY 2018 and will continue on future cruises in order to capture changes in and/or recovery of the reefs. Another RAMP cruise is scheduled for August-September 2018 and logistical planning, preparation, and training are currently underway.

To support coral reef monitoring JIMAR planned, implemented and installed an emergency hyperbaric chamber for use by NOAA divers so local monitoring and training operations could continue uninterrupted. This happened during a time when the local hyperbaric chamber at Kuakini Hospital was closed and no other chamber was available on Oahu. JIMAR staff planned and installed a permanent hyperbaric chamber at the Inouye Regional Center to act as a backup facility to support PMNM and JIMAR diving operations.

Characterization of Mesophotic Coral Ecosystems. Although there was no mesophotic/biogeo research cruise to the NWHI during the reporting period, JIMAR staff were methodically training on a new technical closed circuit rebreather (CCR) unit in preparation for FY 2019 expeditions. An intensive 12 day, CCR training program was successfully completed in June 2018 thus allowing JIMAR staff to be NOAA certified to reach depths of 100 m in order to conduct mesophotic coral ecosystem surveys.

JIMAR analyzed data from previous cruises (2010-2016) and published an article in the peer-reviewed journal *BioInvasions Records* on abundance and distribution of alien fishes in the PMNM. This study revealed that lower mesophotic reefs in the northwestern half of the NWHI were free from alien fishes.

During the week of March 5, 2018, JIMAR Science Operations Associate Stephen Matadobra held a workshop in American Samoa on hyperbaric chamber operations and dive emergency protocols. The workshop was offered to staff of NOAA's National Marine Sanctuary of America Samoa (NMSAS), the Lyndon B. Johnson Tropical Medical Center in Pago Pago, as well as to local dive partners including National Park Service, Atlantic Pacific Marine, and the Department of Marine and Wildlife Resources. The workshop included lecture discussions and hands-on operations to reinforce previous training in hyperbaric treatment and dive emergencies. Matadobra also met with other industry partners (Industrial Gases) to observe their procedures and offered suggestions on maintenance, emergency procedures and preventing diving casualties. 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.

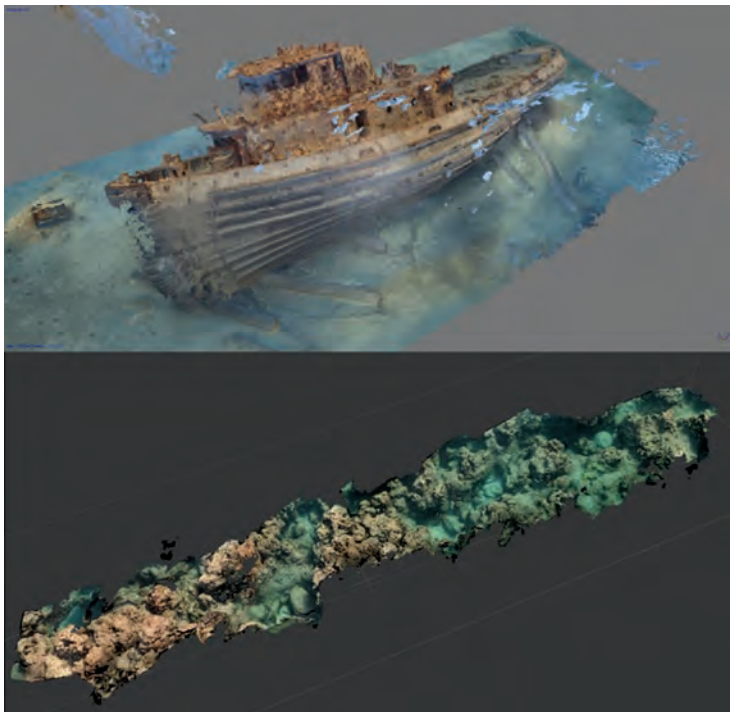


Figure 2. PMNM JIMAR utilize 3D photogrammetry to accurately replicate maritime archeology sites and benthic habitat with millimeter accuracy via a series of overlapping photos and processing intensive software (photo: Steven Matadobra and Jason Leonard; 3D image processed by Keolohilani H. Lopes Jr. and Atsuko Fukunaga).

Quantification of Benthic Habitats. JIMAR successfully integrated a cutting-edge photogrammetric method for three dimension (3D) reconstruction of coral reefs into RAMP fish surveys. Resulting overlapping photo images collected from 92 sites were also processed by JIMAR staff to obtain 3D mesh models, orthomosaics and digital elevation models. Since May 2018, JIMAR has been co-mentoring a NOAA Hollings scholar to extract benthic composition and a wide range of habitat complexity metrics from orthomosaics and digital elevation models. This is an extremely important step in determining a set of the most efficient and appropriate habitat variables to describe coral reef habitat in the NWHI. This set of variables will ultimately be used to examine associations between fish assemblages and reef habitat in the NWHI.

Because the low-light mesophotic environment, combined with each diver's extensive amount of dive and science gear and extremely limited divers' bottom time, all place constraint on the survey design, JIMAR also worked on logistics for implementing the same photogrammetric method for use in mesophotic surveys during the upcoming Mesophotic/BioGeo cruise for FY 2019.

PMNM Resource Protection. In May 2017, JIMAR staff participated in surveys around Midway Atoll to investigate distributions of alien invasive species on and around maritime heritage resources. Several components of the project have been ongoing since the completion of surveys such as data visualization, analysis and report compilation for alien invasive species. JIMAR used shallow-water and mesophotic fish data to investigate the horizontal and vertical distribution of an introduced species, *Lutjanus kasmira*, in the NWHI and published an article in the journal *BioInvasions Records*. As part of the permitting process for entry into the PMNM, JIMAR staff conducted several vessel hull inspections during the year to verify the absence of alien species. This important process helps to protect the marine ecosystems of the NWHI, which are noted for their low abundances of alien species. JIMAR staff reviewed several PMNM access permits to ensure applicants' activities do not harm any PMNM resources and comply with resource protection objectives. JIMAR staff participated in several

coordinated response activities, working groups 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 assisted with coordination of upcoming marine debris removal efforts for a concerted FY 2018-2019 effort and assisted NOAA's Damage Assessment Remediation and Restoration Program with a coral nursery project to develop an off-shore nursery near Oahu to assist in remediation projects.

Maritime Archeology. In May 2017, JIMAR participated in surveys around Midway Atoll to investigate maritime heritage resources and create 3D-photomosaics of historical artifacts. Data visualization and analysis and mapping product creation have been ongoing since the completion of surveys and the final report was written in conjunction with JIMAR staff during the reporting time frame.

In July 2017, JIMAR staff assisted with the operations for a local maritime archeology course offered by UH Manoa called Maritime Archeology Survey Techniques. The course is sponsored by NOAA and teaches college students underwater archeology methods while mapping culturally significant wrecks off the coast of Oahu. JIMAR staff acted as coxswain and provided logistical support.

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

Cumulative 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)* 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 2018

The project exceeded its initial goal of eight participants and trained 13 participants including five fishery professionals from the Guam Department of Aquatic and Wildlife Resources and eight students from the University of Guam during a "Jungle Histology" workshop in Guam held June 3-24, 2017. The participants examined the reproductive status of seven reef fish species (*Acanthurus lineatus, Epinephelus hexagonatus, E. merra, Monotaxis grandoculis, Paracirrhites arcatus, Siganus argenteus, S. spinus*) using methods learned during the workshop including fish dissection, resin block preparation, and gonad sectioning (Figure 1). Students performed

*Longenecker, K., R. Langston, 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).*

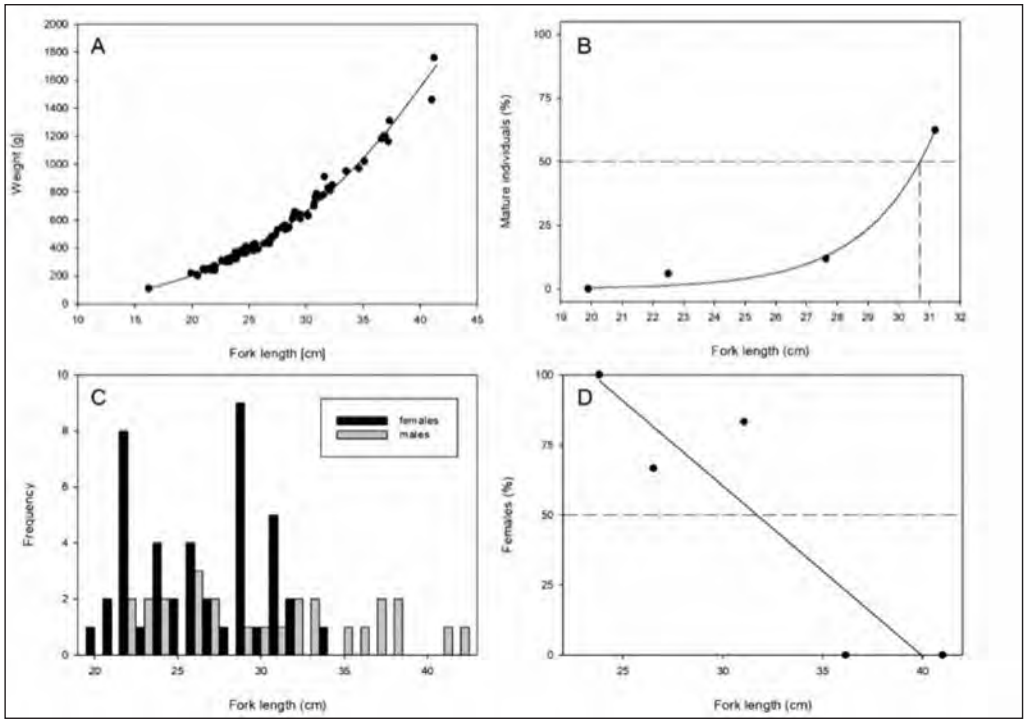


Figure 2. Life-history traits of bigeye emperor Monotaxis grandoculis *in Guam. (A) Length-weight relationship; (B) female size-at-maturity; (C) sex-specific size-frequency histograms; (D) size-specific sex ratio.*

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). Project researchers collaborated with Jungle Histology Guam participants to complete data analysis and reporting of results for the reef fish species examined during the workshop for future publication in an academic journal.

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.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock, William S. Kessler

Cumulative Budget Amount: $96,846

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

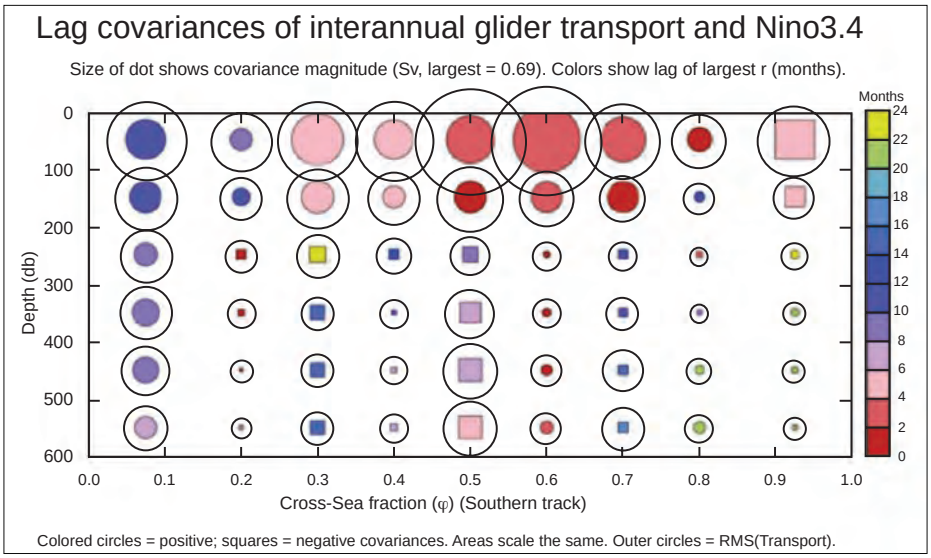


Figure 1. Best lag covariances of glider-measured interannual transport split into vertical and cross-section bins and Nino3.4 SST. Size of the dot shows the covariance magnitude, color shows the lag of largest correlation (months; scale at right). Circles indicate where the highest correlation of transport lags Nino3.4, squares indicate where transports leads.

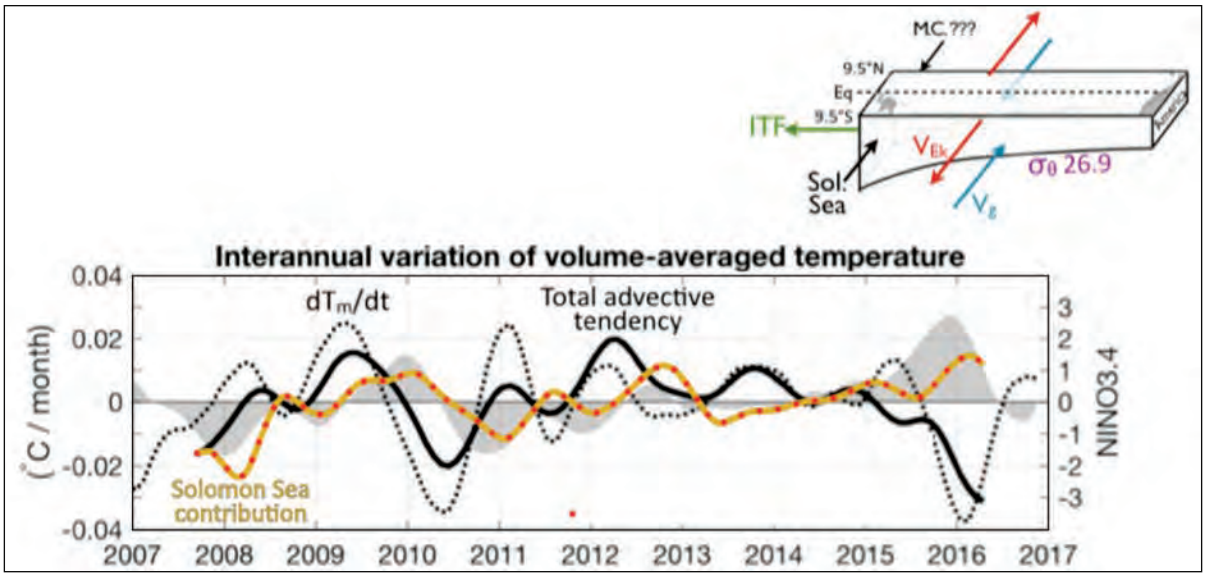


Figure 2. Role of meridional advection for the rate of change in temperature of the Pacific equatorial band above sigma-theta 26.9 (volume shown in the top right insert). The dashed line shows the rate of change of equatorial temperature filtered for interannual timescales. The solid black line shows the total meridional advective tendency of temperature that includes the geostrophic Vg and Ekman Vek components at 9.5S and 9.5N. The yellow line shows the Solomon Sea contribution, with RMS 80% as large as the total contribution. The grey shading shows the NINO3.4 index.

equatorial Pacific for the El Niño Southern Oscillation 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 a focus on the meso/submesoscale range (10-200 km) using a high-resolution numerical ocean model supplemented by satellite and in-situ (glider, Argo) data. The project's main objectives are: 1) to characterize the spatial and temporal scales, subsurface structure and evolution of the meso/submesoscale eddies in low latitudes; and 2) to assess the interactions between the submesoscale, mesoscale and large-scale circulation. The results will inform the physical interpretation of satellite sea surface height observations of these eddies by clarifying their subsurface structures and generation processes.

Progress during FY 2018

During FY 2018 the project continued analysis on characterizing the role of mesoscale eddies in the Solomon Sea circulation, in particular, how they impact the interpretation of in situ data (glider).

The interior Solomon Sea is characterized by energetic intraseasonal variability, which matches in magnitude that of the seasonal cycle. 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. Understanding of the potential aliasing of slow in situ sampling enables proper choices of spatial and temporal averaging towards credible descriptions of the vertical and horizontal structures across the Solomon Sea. This in turn allows the project to characterize the mass and heat fluxes through the Solomon Sea towards the equator with full understanding of the errors introduced by the 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

Cumulative Budget Amount: $381,561

NOAA Goal(s)

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

Purpose of the Project

The NOAA research fleet includes many ships with acoustic Doppler current profilers (ADCPs). These instruments have the potential to aid a wide variety of NOAA programs using the ships and to contribute to the global climatology of ocean current measurements. 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 National Centers for Environmental Information (NCEI) so that the observations are available for future researchers.

Progress during FY 2018

The project continues to monitor and support its installations on all 11 of the ADCP-equipped NOAA ships. Support and analysis regarding the failure of both transducers on the *Okeanos Explorer* are on-going. The ADCP on the *Oscar Elton Sette* was restored but the data quality of the final current measurements remains degraded owing to lack of an accurate heading sensor. The system on the *Henry Bigelow* was also brought back online after a beam failure. Planned major software upgrades were installed on the *Ron Brown*, *Pisces* and *Bell Shimada*.

A major goal of the project is to establish a data pipeline between the shipboard UH data acquisitions systems and a NOAA archive; the components were tested this year. JIMAR Oceanographic Data Specialist Toby Martin presented progress on this at the NOAA N2N meeting held in Boulder in May. Dr. Julia Hummon gave a presentation at the NOAA Environmental Data Management Workshop in Silver Spring, MD in April. Mr. Martin also held a NOAA Survey Tech training workshop in Virginia Beach in November with over 20 participants attending.

With partial support from this project two JIMAR Data Programmer/Analysts (Dr. Uggo de Pinho and Dr. Thomas Roc) joined the project and are contributing to the NOAA ship support and software development. Dr. Roc developed an issue tracking system that has greatly aided the project's monitoring capabilities. Most of the development required for a major update of the software and installation system to the next operating system release (Ubuntu 18.04 LTS) has been completed. This included a switch to Python 3.

University of Hawaii Sea Level Center

P.I.: Philip Thompson

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

NOAA Sponsor: David Legler

Cumulative Budget Amount: $2,011,162

NOAA Goal(s)

- Climate Adaptation and Mitigation
- Resilient Coastal Communities and Economies

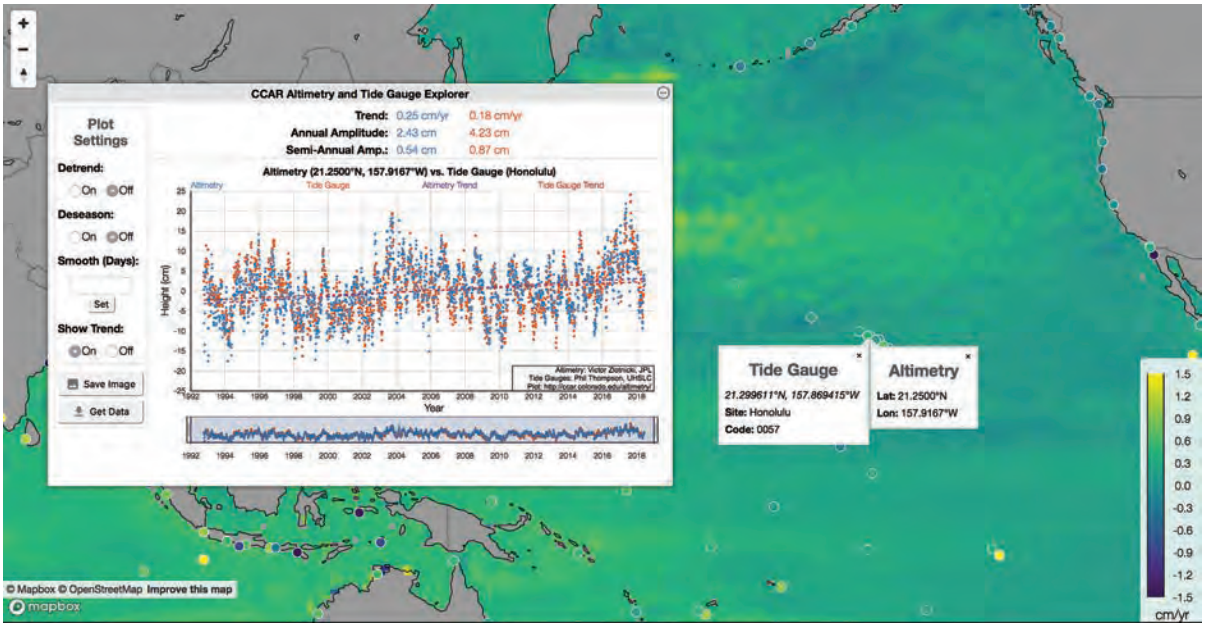


Figure 1. The Sea Level Explorer is a collaboration between the UHSLC, University of Colorado, and NASA JPL. It allows users to quickly access up-to-date sea level data with the ability to place local tide gauge observations into the broader spatial context of open-ocean sea level observations from satellite altimetry (http://ccar.colorado.edu/altimetry/).

Purpose of the Project

The purpose of the University of Hawaii Sea Level Center (UHSLC) project is to ensure that tide gauge data from around the world are collected, quality assessed, distributed, and archived for use in monitoring and research applications related to climate, oceanography, ocean engineering, and geophysics. While UHSLC assembles time series from many tide gauge stations, the primary focus is the set of stations that constitute the IOC/UNESCO Global Sea Level Observing System (GLOSS) and the Global Climate Observing System (GCOS). The GLOSS and GCOS networks cover most major oceanic islands and island chains, with a subset of available continental coastal stations distributed evenly around the margins of ocean basins. The UHSLC fulfills this purpose via two parallel and complementary activities. First, the UHSLC is a primary data center in the international GLOSS system, curating and distributing two tide gauge datasets: the Fast Delivery dataset, which provides preliminary, quality-assured, hourly and daily tide gauge data within 4-6 weeks of collection; and the Research Quality dataset, which is an archive of hourly and daily tide gauge data that have undergone a complete quality assessment within one year of collection. The Research Quality database is maintained in collaboration with the National Oceanographic Data Center and, for this purpose, the UHSLC acquires tide gauge data from nearly 500 tide gauge stations maintained by 65 international agencies. Second, UHSLC technicians and data analysts collaborate directly with international partners to maintain more than 80 high-profile water level stations that are essential for sea level and tsunami observing efforts. In addition, vertical land motion monitoring is recommended at all GLOSS and GCOS stations for the proper attribution of local sea level changes. The UHSLC maintains continuous Global Positioning System (GPS) receivers at eleven stations to monitor land motion. UHSLC involvement ensures that research quality and near real-time monitoring datasets are available from otherwise sparsely sampled areas of the global ocean and that developing nations have access to training, technical support, and data processing services as needed.

Progress during FY 2018

Data management objectives for FY 2018 were met as the Fast Delivery and Research Quality databases were updated and expanded to accommodate new data and stations. The importance and success of ongoing efforts to provide these data to the research community is supported by the more than 70 publications published during FY 2018 that utilize and cite UHSLC datasets. The project continued to improve and modernize data flow within

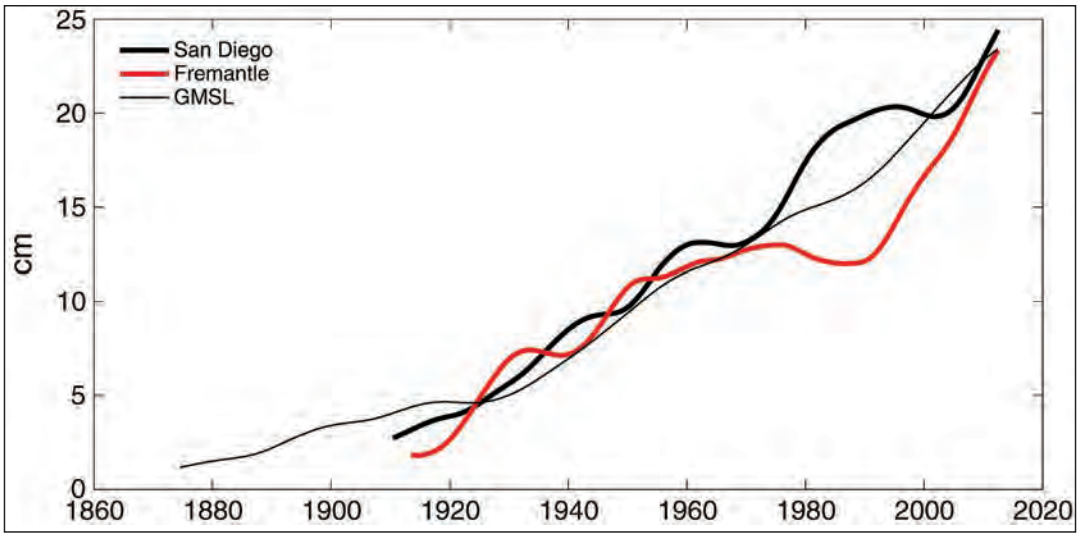


Figure 2. Low-pass-filtered sea level from San Diego, CA and Fremantle, Australia. The clear anti-correlation is striking given the geographical separation in different ocean basins and across the equator. The large multidecadal anomalies toward the end of the record suggest a period of weakened trade winds that is unmatched during the rest of the 20th century.

the center, including a significant rewrite of essential data-handling software. These improvements enabled more frequent and automated updates to datasets, new data formats, and increased metadata consistency within the UHSLC and with other GLOSS data centers. These foundational improvements enabled new options for accessing and interacting with UHSLC data. The project soft launched an Open-source Project for a Network Data Access Protocol server for web-based data access (https://uhslc.soest.hawaii.edu/opendap/), which will be publicly advertised after some additional testing and improvements are done. They also developed a prototype station explorer (https://uhslc.soest.hawaii.edu/stations/) that will provide users in coastal and island communities with near real-time access to sea level data as it is collected as well as increased transparency and access to often-requested information such as tide calendars, tidal datums, benchmarks, etc. Finally, a multi-year collaboration with the University of Colorado and NASA Jet Propulsion Laboratory (JPL) culminated in an operational sea level explorer tool that allows users to more readily place local tide gauge data in the broader spatial context of open-ocean sea level observations from satellite altimetry (http://ccar.colorado.edu/altimetry/). The majority of tide gauge network and station maintenance objectives were met during FY 2018. Thirteen core stations were serviced as a result of UHSLC efforts, which is one short of the objective to visit and service 14 stations. This slippage was caused by the need to move and fully replace the UHSLC station in Cilacap, Indonesia, which required two separate visits to the station locale, leaving no funding for a visit to a fourteenth station. GPS installations at tide gauges were maintained with assistance from the Pacific GPS Facility at the University of Hawai‘i and included a new GPS installation at Cilacap, which coincided with the new tide gauge installation. GPS/Global Navigation Satellite System (GNSS) data from UHSLC stations were submitted to the GLOSS Tide Gauge Benchmark Monitoring Project (TIGA) data center.

During FY2018, UHSLC researchers were involved in a variety research projects. This included a paper devoted to using long sea level records to understand the differing roles of tropical and extratropical variability in multidecadal Pacific climate variability during the 20th century. UHSLC researchers were also the lead authors on the sea level section in the 2018 State of Climate Report to be published later this summer and supervised a graduate student’s authorship of a side bar in the report. Substantial progress was made on multiple ongoing UHSLC-sponsored research projects that will be published during the next fiscal year. Collaboration is a key component of UHSLC research goals and project scientists collaborated with researchers outside the center on a variety of sea-level and climate-related research projects including: 1) multi-year predictability of climate, drought, and wildfire; and 2) observation-driven estimation of the spatial variability of 20th century sea level rise.

University of Hawaii Sea Level Center cGPS

P.I.: Philip Thompson, James Foster

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

NOAA Sponsor: David Legler

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

NOAA Goal(s):

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

Purpose of the Project

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

Progress during FY 2018

The project goals for 2018 were to maintain current data flow, perform one new GNSS site installation at a tide-gauge, and make three maintenance visits. Researchers continued to collect, archive, and upload all data from the project's current network of GNSS sites installed at UHSLC tide-gauges to the international data archives. A new GNSS site was installed at Cilacap, Indonesia, where demolition and construction at the previous tide-gauge site forced the relocation of the project's equipment. The new site was built on the solid concrete sea-wall, as close as possible to the tide-gauge sensor, in order to ensure that any local vertical motions can be detected and removed from the tide-gauge records in order to recover absolute sea-level changes. Power is obtained from a solar panel and batteries and telemetry is through a cell modem. Site conditions at this new location required the GNSS installation to be placed about 200 m from the tide-gauge in order to get optimum sky-view and ensure excellent data quality.

Figure 1. The newly installed continuous GNSS site "CILI" at Cilacap, Indonesia. The previous tide-gauge and GNSS site had to be moved due to demolition and construction at the old location. The tide gauge is about 200 m to the left.

Project staff conducted maintenance trips to the GNSS sites "BNOA" and "BTNG", located at Benoa and Bitung, Indonesia to resolve hardware and power issues and install new cell modems to provide cheaper, more robust data communications. A planned maintenance trip to install a similar cell modem at the GNSS site "BHMA" in the Bahamas was delayed due to the impacts of last season's hurricane. Final planning is underway to complete this trip, recover the old data and bring the data stream online for daily downloads. Support was also provided to the National Geodetic Survey (NGS) to troubleshoot issues with the GNSS sites on Midway and Wake Islands and ensure materials for site maintenance were transported to those locations for on-site work.

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 Niño 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

Cumulative Budget Amount: $486,338

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 impacts of coastal flooding in a changing climate on the vulnerability of built and natural environments. The results will advance the practical applications of coastal flooding analysis and lead to an improved understanding of which components of U.S. Department of Defense (DoD) facilities and infrastructure are potentially vulnerable to coastal flooding, how they could be affected, and how species and ecosystems associated with DoD lands and waters will respond in a changing climate. They will be amenable to incorporation into site and region-specific tools and models to inform decision and policy making. The results will have broad interest within the region and the nation. In summary, the project will: 1) enhance the historical diagnosis of site-specific still water level patterns and trends; 2) explore techniques that can be used to support regional analysis to address poor spatial coverage of tide gauge (TG) records; 3) extend the diagnosis and prognosis of extreme water level patterns and trends; 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 on assets on an individual basis and in aggregate under different climate change scenarios.

Progress during FY 2018

To enhance the historical diagnosis of site-specific still water level (SWL) patterns and trends to isolate contribution of waves within TG signals, the project team first analyzed extreme SWL using a time-varying Generalized Extreme Value (GEV) model with different climate indices as covariates. This included the El Niño Southern Oscillation (ENSO) indices, climate indices in the Atlantic, and a wave climate index from a global wave reanalysis (GOW) product. Using Sweet et al. (2017)* relative sea-level rise (SLR) projections, the project produced a set of forecast products that displayed future return levels at different SLR scenarios

and then delineated when the current 50-yr return level event becomes an annual event. Because TG records have poor spatial coverage, the Regional Frequency Analysis (RFA) can be used to improve this limitation. A literature review was completed on nonstationary RFA models in other disciplines. Currently RFA has not been completed. The goals of this task have been expanded to estimate a regional probability distribution on a gridded basis for most U.S. coastlines (not just the Pacific basin) and develop a local flood index event based upon NOAA tidal predictions. A preliminary investigation on using satellite altimeter data to help delineate extreme value distributions from a wider spatial perspective was conducted by comparing and calibrating altimetry data with tide gauge data. Preliminary results were presented at the mid-project meeting and the project team decided to continue pursuing this research.

Two site visits to the Naval Base Coronado and Naval Amphibious Base (NAB) in San Diego occurred. The first visit included on-site interviews with managers who provided expert knowledge of critical infrastructures. The project team completed a summary report of all three site visits to the Marine Corps Base Hawaii (MCBH), NAB, and U.S. Army Garrison Kwjalein Atoll (USAG-KA). The project team selected NAB for a more detailed exemplar of assessment methodology. The second site visit was to help identify critical missions for the exemplar methodology. The project team met with the base commander and other base personnel to fill gaps in required data. Project staff visited all critical facilities and documented base elevation and facility configuration. Progress on the assessment methodology was presented at the mid-project meeting in May 2018.

Observations of waves and water level completed at NAB and MCBH will be used to test and improve wave transformation models and estimates of wave-driven extreme water levels.

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

Cumulative Budget Amount: $237,299

NOAA Goal(s)

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

Purpose of the Project

This project is a continuation of activities at the Asia-Pacific Data-Research Center (APDRC) in support of climate research within the International Pacific Research Center (IPRC) at the University of Hawaii. The project's primary goal is to meet critical regional needs for ocean, climate and ecosystem information. The APDRC does this through local support of climate research activities but also by generating relevant data products for a broad spectrum of users throughout the Asia-Pacific region. The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and provide one-stop shopping for 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 2018

The APDRC maintains a wide suite of data transport and discovery servers, including: the Open-source Project for a Network Data Access Protocol-based Thematic Real-time Environmental Distributed Data Service Distributed

*Sweet, W.V., R.E. Kopp, C. Weaver, J. Obeysekera, R. Horton, E.R. Thieler and C. Zervas, 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Tech. Rep. NOS CO-OPS 83.

Ocean Data System (OPENDAP THREDDS DODS) server (TDS); Grid Analysis and Display System (GrADS) DODS server (GDS) and Data Access Protocol Server (DAPPER); a Live Access Server (LAS); and DCHART, a web-based server for display of in-situ end gridded data sets. These servers continue to be maintained. This past year the APDRC added an Environmental Research Division Data Access Platform (ERDDAP) service for in situ measurements. ERDDAP was developed by the NOAA Fisheries Science Center and provides standard data access services for a wide range of data types. The APDRC will consider migrating all DCHART services to ERDDAP in the coming year.

The APDRC data archives increased this past year due to new forecast model output (Coupled Forecast System ver. 2 [CFSv2] and National Centers for Environmental Prediction [NCEP]), updates to the Ocean Model for the Earth Simulator (OFES), and additional coupled climate model output. These CMIP5 runs are most heavily used within the IPRC research activities. In all, the APDRC has archived almost 275 TB of data: 31% of this is output from the Earth Simulator (OFES/AFES/CFES); coupled climate model output from CMIP experiments accounts for about 31%; the remaining 37% is spread across the remaining data sets (approximately 120 in total). Upgrades to the APDRC web pages include new additions to the projects page that lists a brief description of the projects that the ADPRC supports along with direct links to the projects (http://apdrc.soest.hawaii.edu/projects).

One particular highlight of the year was support of the developing World Meteorological Office (WMO) Regional Climate Center (RCC) for the Pacific Islands (known as RA-V). The APDRC will act as the "data node" for climate data sets and also contributed to the RCC RA-V website.

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

P.I.: Douglas S. Luther

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

NOAA Sponsor: Russell Schnell [Darryl T. Kuniyuki]

Cumulative 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 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 2018

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. in September 2016 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 at MLO in November 2017 to directly inject HgBr2 vapor (a key component of RGM) into the instrument inlets. Unfortunately, numerous equipment malfunctions prevented the successful testing of this device.

A novel technique for collecting and measuring RGM species, developed by the University of Nevada at Reno (UNR), was also deployed in February 2018.

Pacific ENSO Applications Climate (PEAC) Center

P.I.: James Potemra

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

NOAA Sponsor: Raymond Tanabe

Cumulative Budget Amount: $434,000

NOAA Goal(s)

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

Purpose of the Project

The Pacific El Niño Southern Oscillation (ENSO) Applications Climate Center (PEAC) conducts research and develops information products on the ENSO climate cycle that are targeted for the U.S.-Affiliated Pacific Islands (USAPI). PEAC provides ongoing summaries of current ENSO conditions and seasonal rainfall, sea level, and tropical cyclone forecasts, as well as outlooks of probable ENSO impacts in the USAPI region related to rainfall, sea level, and tropical cyclone activity. An objective of PEAC is to provide timely and easily accessible information that supports planning and management activities in climate-sensitive sectors such as water resource management, fisheries, agriculture, civil defense, public utilities, and coastal zone management.

Progress during FY 2018

PEAC Scientist Rashed Chowdhury continued to work closely with Integrated Water Level Service (IWLS) partners to implement the expanded ensemble mean sea level anomaly forecasting scheme for the Pacific basin.

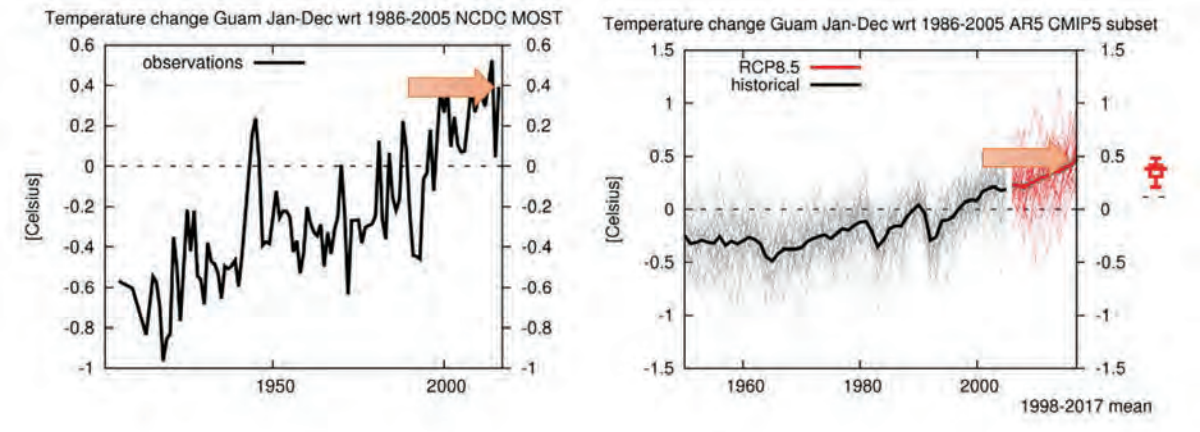


Figure 1. Time series plots of annual relative mean temperature change anomalies with respect to baseline period 1986-2005) for Guam. The left panel shows observation-based time series plots from 1950-2017 (data source: NCEI). The right panel shows corresponding multi-model ensemble (38 GCMs, 78 runs) spread and mean (thick line) (the scales for the vertical axis in right panel are different). A box plot for RCP4.5 (blue) and RCP8.5 (red) is also shown (note that anomaly is presented with respect to the 1986-2005 base period; also note that the recent global emission is already slightly above RCP 8.5; therefore, the high emission has been chosen for temperature analyses).

Figure 2. Tides and inundation pictures in Majuro, Marshalls Island during February 3-4 high tides. Event is associated with La Niña driven northerly swell from northern Pacific storm (photo: Guard, Wallace and Wilfred).

The ensemble is based on statistical and dynamical model forecasts including the operational sea level product developed at PEAC. The project continued developing a suite of National Weather Service (NWS) operational products that were distributed through the NWS long wire system Advanced Weather Interactive Processing System (AWIPS). In addition to routine work, 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 have occurred in the USAPI region.

The PEAC Center generated island-specific future climate change projections by using Intergovernmental Panel on Climate Change Fifth Assessment Report-Coupled Model Intercomparison Project Phase 5-Generalized Circulation Model (IPCC AR5-CMIP5-GCM) multi-model ensembles under different representative concentration pathway (RCPs) scenarios. This island-specific long-term climate information significantly increased the capability to support long-term planning and management schemes in climate-sensitive sectors in the USAPI region. This information is also an important part of the PEAC's education and outreach program.

PMEL-UH Ocean Carbon Project

P.I.: David Karl

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

NOAA Sponsor: Gary Matlock

Cumulative 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 they need servicing. Daily summary files of the measurements are transmitted back to Pacific Marine Environmental Laboratory (PMEL) where the data are examined and plots of the results are posted to the web in near real-time.

Progress during FY 2018

As with previous reporting periods, this project provided support to oversee maintenance of instrumentation used for remote and shipboard measurements of atmospheric and seawater CO_2. Project funds were used to service instrumentation used as part of NOAA's PMEL measurements of the partial pressure of CO_2 (pCO_2) and pH in the tropical and subtropical Pacific Ocean. No further upgrades to instrumentation were required by the project during this period.

Profiling CTD Float Array Implementation and Ocean Climate Research

P.I.: Douglas S. Luther

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

NOAA Sponsor: Gregory C. Johnson

Cumulative Budget Amount: $656,172

NOAA Goal(s):

- Healthy Oceans
- Weather-Ready Nation
- Climate Adaptation and Mitigation
- NOAA Enterprise-wide Capabilities: Observing, Modeling, and Engaging for all Goals

Purpose of the Project

JIMAR works with U.S. and International Argo Project partners, especially NOAA/Pacific Marine Environmental Laboratory (PMEL), on three aspects of the Argo Program. The first objective involves conventional Argo float testing, deployment, and data/engineering evaluation. The second objective involves Deep Argo float testing, deployment, and data/engineering evaluation. The third objective involves delayed-mode quality control of conventional and Deep Argo float data and ocean climate research using data from these floats and other sources.

Progress during FY 2018

At the PMEL float lab Dr. Elizabeth Steffen, with assistance from Alexandra Brewer, continued to test floats, monitor float performance (Figure 1), diagnose and coordinate repairs of problems discovered with the floats, and

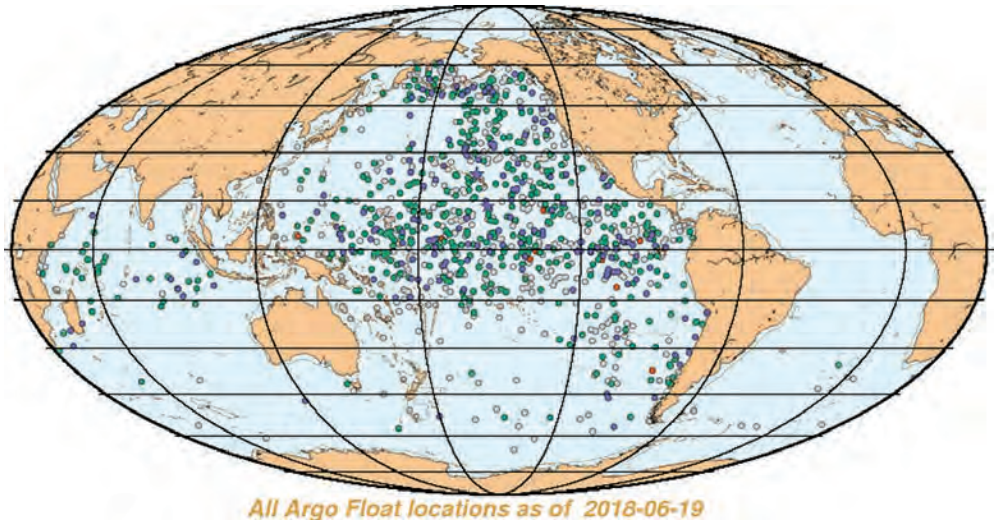


Figure 1. Most recent locations of PMEL conventional and Deep Argo floats. As of June 21, 2018, conventional Argo floats reporting in the past 30 days (green and blue circles) numbered 586, and Deep Argo floats (green and blue stars) numbered 3.

work with the manufacturer to resolve problems. They also arranged for float deployments and notified the national and international databases of those deployments. Dr. John Lyman continued to perform scientific analyses of Argo and other data, and contributed to the Global Oceans chapter of the annual State of the Climate report published as a special supplement to the *Bulletin of the American Meteorological Society*. He also worked with other members of the group on Deep Argo IT infrastructure and performed scientific delayed-mode quality control on data from substantial numbers of PMEL Argo float profiles. Three Deep Argo floats were deployed during FY 2018, two by Dr. Steffen from the *R/V Ka'imikai-O-Kanaloa* during Hawaii Ocean Time Series Cruise 302 (Figure 2) and the third by scientists on the *R/V Kilo Moana* during a Deep Clarion Clipperton Zone (CCZ) cruise. Stated project goals were met.

Figure 2. Dr. Elizabeth Steffen (left) and Marine Tech Elizabeth Ricci (right) deploy a Deep Argo float from the R/V Ka'imikai-O-Kanaloa *during Hawaii Ocean Time Series Cruise 302.*

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

P.I.: James Potemra

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

NOAA Sponsor: Raymond Tanabe

Cumulative Budget Amount: $122,000

NOAA Goal(s):

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

Purpose of the Project

The objective of this project is to integrate the functions of the Pacific El Niño Southern Oscillation (ENSO) Applications Climate (PEAC) Center into the National Weather Service (NWS) operations to enable advancement and development of products and services to support mission delivery needs of NWS in the Pacific Region. This includes the training expertise provided by the PEAC Center to build capacity within the Weather Forecast Office (WFO) in Honolulu, Hawaii and Guam. This project will contribute to supporting the development of a regional capacity to deliver climate services within the Pacific Region.

Progress during FY 2018

Due to personnel changes and funding delays work on the project has been delayed to later in the fiscal year. A research assistant from the University of Hawaii has been hired and will begin work in August 2018.

Tropical Meteorology

SOEST is uniquely qualified for geophysical research in tropical regimes, and the Department of Atmospheric Sciences provides world-class research in the areas covered under this theme. In addition to facilitating 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.: Douglas S. Luther

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

NOAA Sponsor: Raymond Tanabe

Cumulative Budget Amount: $254,000

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 2018

During FY 2018, 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 administrative support via undergraduate student helpers, purchase of scientific software and office research supplies; and 3) provide scientific equipment and supplies to support the Oceanography Department's Global Environmental Science (GES) program. Funds were also used to support OCN 331 an active learning course for undergraduates.

Two DAS graduate teaching assistants, David DeCou and Tyler Jewel, were supported during the reporting period. DeCou just completed his second year working with DAS Assistant Professor Alison Nugent. His thesis entitled "The application of kites to studying the marine atmospheric boundary layer" was submitted for review and DeCou is scheduled to finish his degree this summer. His research involves the development, testing, and application of a low-cost atmospheric sampling technique using kites, for use in studying the marine atmospheric boundary layer. In this project, meteorological sensors were attached along a kite string at fixed intervals in order to sample the steady incoming trade wind flow off the windward shore of Oahu. The goal is to sample the flow characteristic of the undisturbed upstream environment and apply observations to the study of convective initiation. Miniaturized sensors were used to directly observe temperature, relative humidity, pressure, and GPS information. Using these instruments, researchers can create vertical profiles of the lower atmosphere as well as time-series datasets. They successfully built confidence in their datasets and the accuracy of the sensors by repeatedly verifying expected atmospheric patterns.

During the kite experiments, the research team flew sensors as high as possible given the string length, roughly 400-600 m above sea level, and took measurements at a quasi-steady altitude for periods of at least 30 minutes. They observed variations in temperature and specific humidity along these constant altitude portions and, after correcting temperature for small altitude variations, found a strong negative correlation in these variables in roughly half of their obtained datasets. These strongly anti-correlated variations in temperature and humidity were found previously during an aircraft field campaign (Dominica Experiment: Orographyic Precipitation in the Tropics [DOMEX]) and are theorized to be important for convective initiation. Patches of cool, moist air and warm, dry air are found after parcels in the incoming flow undergo a buoyancy sorting process. The cool, moist patches are theorized to act as "seeds" of convection as they reach their lifting condensation level (LCL) first as the entire layer is lifted over the higher terrain of the island. Flights where this T' and qv' relationship is not found

are likely cases where the parcels were disturbed by moist cloud processes or by the island itself and did not have time to undergo buoyancy sorting. Strongly anti-correlated T' and qv' patches have been found in a relatively shallow layer, ~80 m in depth. Additional sampling is needed to obtain an improved estimate of the vertical and horizontal extent of these perturbations.

Tyler Jewel, the second DAS graduate student supported by the NWS Fellowship Program, is expected to graduate Fall/Winter 2018. His thesis entitled, "The relationship between the consistency of swell events and open-ocean wind fields" is under review. His research analyzes XYZ Buoy displacement data for arrival times of the largest waves and 10-m GFS modeled wind to isolate areas with wind fetches directed towards the buoy. Verification of the findings will come from comparison with video footage at key locations. Currently Jewel is developing a program to analyze both the buoy data and the GFS model winds, with the goal of discerning both sneaker sets and lulls in the data and relating them to the nature of the winds and fetches. He is working closely with the NWS marine desk at the Honolulu Forecast Office and the results will be refined into a forecast product used to improve public safety at beaches.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

'Eli'eli Kau Mai: Utilizing Citizen Science from the Waihona 'Ike Kupuna

Paige Okamura, JIMAR Graduate Student

Purpose of the Research

The focus of this year's research shifted slightly per a request from JIMAR Director Dr. Douglas Luther and due to current events (Kilauea Volcano eruption). In previous years, Okamura's main focus was to translate Hawaiian language accounts of volcanic, seismic, and tsunami activity. But during a September 2017 meeting with supervisor (*kumu*) Puakea Nogelmeier and Dr. Luther, she was asked to look at articles that mentioned how Hawaiians reacted during the drawback stage of a tsunami. Did they know the drawback was an indicator of a possible impending surge? And was that kind of information passed down through generations and/or by experience? Researching Hawaiian language accounts of volcanic eruptions was already an established research focus but since the current eruption of Kilauea Volcano (Puna District, Hawaii Island) earlier this year, Okamura extracted more eruption articles to translate and add to the current body of work that has already been done in that area.

Progress during FY 2018

As of July 2018, approximately 350 articles were translated of which 322 of those articles were uploaded to the Institute for Hawaiian Language Research & Translation (IHLRT) website. The majority of the articles are related to volcanic, seismic, and tsunami events, but a handful of articles related to drought are also included. This is a result of ongoing collaboration with Pauline Chinn from the UH Mānoa College of Education's Kahua A'o program to help provide resources that support their science, technology, engineering, and math (STEM) curriculum.

Kumu Nogelmeier retired on May 31, 2018. As a result, IHLRT is moving under Dr. Punihei Lipe's interim directorship, and Dr. Kapali Lyon has stepped in to oversee and edit translations. Among other things in transition is the position of the IHLRT website. Currently, the website is housed/hosted on the UH Sea Grant website. However, plans are moving forward to house it under Dr. Lipe's new website for the Native Hawaiian Place of Learning programs currently under construction. Uploading of the project's new content was put on hold until Dr. Lipe's program website is established.

The JIMAR "database", in its initial form as a Microsoft Excel spreadsheet, was uploaded and stored on Google Drive by the previous graduate research assistant (GRA) in order to accommodate its growth and to allow others who may be interested in its contents the opportunity to access, update and edit it. An ongoing issue is that the project has outgrown the website and also that the database has limited search capabilities and format. The project will research possibilities of migrating data to a database software and/or possibly creating a new database from scratch. A server will be required to host the database.

A copy of the database is available on the IHLRT website so that people can access it and find citations for the articles. Each article is listed with a link to the digital image of the original on the Office of Hawaiian Affairs

(OHA) Papakilo Database website (www.papakilodatabase.com). Each translation is presented along with the original and a full citation.

Future Research Plans

A future goal for the project is to publish all the translations produced to date, as an article in either a scientific or language focused journal. Much like the hurricane paper authored by Businger et al., to be able to pick an event (a historical eruption perhaps) and look at all the accounts collected and translated would prove to be a valuable resource. Okamura may work with a professor to co-author the paper.

Publications

- In January, a multi-authored paper by Steve Businger, Puakea Nogelmeier, Pauline Chinn (College of Education), and Thomas Schroeder, titled "Hurricane with a History: Hawaiian Newspapers Illuminate an 1871 Storm", was published in the *Bulletin of the American Meteorological Society*.* Articles translated by previous GRAs funded by JIMAR provided the historical research for the paper. The research in this paper also aided in continual requirement of hurricane insurance for Hawai'i island residents, prior to the arrival of hurricane Iselle.
- Recently, Hawai'i Public Radio highlighted our work twice in the last three months, and gave us both online and on-air presence. The first covered the hurricane paper and other storm coverage. The second was about historical eruption accounts. Both articles can be found online at "1871 Hurricane Uncovered: Hawaiian Newspapers Reveals Hawai'i's True Hurricane Risk" (http://hawaiipublicradio.org/post/1871-hurricane-uncovered-hawaiian-newspapers-reveals-hawai-i-s-true-hurricane-risk), and "#Lava in Old Hawaiian Newspapers" (http://hawaiipublicradio.org/post/lava-old-hawaiian-newspapers)

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Presentations

- In October of 2017, the research was presented to a joint IHLRT panel for the Lāhui Hawai'i Research Center's student conference held at Kamakakūokalani Center for Hawaiian Studies. The focus of the conference was highlighting student research being done on campus. The IHLRT GRAs co-presented on their individual research work and answered questions from the audience on the value of translation work, and the ethical issues that sometimes arise in their field of work.
- In November of the same year, the GRAs also presented to the community at one of Hanauma Bay's community science talk nights. These talks allow the community to see what scientists and researchers have been working on. These talks are held weekly and are open to the public. It also allowed Okamura to present her work and remind the community that the public has access to all of their translations.
- This summer, there are two upcoming presentations. The first will be on July 19th for the Maile Mentors program run by Dr. Rosie Alegado in tandem with the Native Hawaiian Student Services (NHSS) department for STEM students. This upcoming presentation will be about how immersion in culture and language affects our research and our perspectives in academia. The second presentation is at this year's Hawaii Conservation Alliance conference at the end of July. Okamura will be presenting as part of a symposium with other Hawaiian-related science researchers. Her presentation will focus on the hurricane paper along with eruption articles as it relates to the current eruption in Puna.

*Businger, S., P. Nogelmeier, P.W.U. Chinn, and T. Schroeder, 2018. Hurricane with a history: Hawaiian newspapers illuminate an 1871 storm, *Bulletin of the American Meteorological Society*, pp. 137-147, https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-16-0333.1, Final form: 16 June 2017, published online 1 February 2018.

Tsunamis and Other Long-Period Ocean Waves

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

Archive of Rapidly Sampled Hawaiian Sea Level

P.I.: Douglas S. Luther

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

NOAA Sponsor: Michael P. Seki

NOAA Goal(s)

- Weather-Ready Nation
- Resilient Coastal Communities and Economies

Purpose of the Project

The Archive of Rapidly Sampled Hawaiian Sea Level (ARSHSL) is intended to provide an Internet-accessible, public database of rapidly-sampled ($\Delta t \leq 6$ minutes) sea level observations from Hawaiian coastal sea level gauges previously or currently maintained by the National Ocean Service (NOS) and Pacific Tsunami Warning Center (PTWC). The main objective of ARSHSL, originally established by NOAA in 1997, is to ensure a consistent repository for rapidly-sampled sea level in the Hawaiian Islands for the study of tsunamis and related infra-gravity wave signals (including coastal-trapped waves and harbor oscillations) at periods of 2-40 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 dataset as possible of sea level fluctuations along 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 NOAA-funded development and maintenance of high-spatial-resolution numerical models of coastal runup nowcasts and forecasts along the North Shore of Oahu and the west coast of Maui. A long-term objective of this program is to achieve harbor surge forecasts and coastal runup forecasts in other Hawaiian harbors or along other coasts, using the archived high-temporal-resolution sea level data in ARSHSL to validate empirical or numerical models. Such forecasts are disseminated on the PacIOOS website as they are established (http://oos.soest.hawaii.edu/pacioos/data_product/harborsurge/index.php).

Progress during FY 2018

As planned, the processing, integration and archiving of ongoing 1-minute and 6-minute sea level observations for the six NOS gauges in Hawaii were achieved. Glitches in the archiving code related to the transition from year 2017 to year 2018 were discovered and fixed. All corrupted files due to the glitches were corrected manually. Automation of concatenation of hourly datasets (a secondary objective for the year) was achieved as a by-product of this code upgrade. The editing, analysis and archiving graphic user interface developed during the last report period is working very well even in the event of irregular data formats from either data suppliers or gauges.

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

Tsunami Research and Modeling

P.I.: Douglas S. Luther

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

NOAA Sponsor: Gary Matlock

Cumulative Budget Amount: $156,197

NOAA Goal(s):

- Weather-Ready Nation
- Resilient Coastal Communities and Economies

Purpose of the Project

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

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

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

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

Progress during FY 2018

Due to delays in personnel recruitment project work has been delayed to later in the fiscal year. The project will begin work once the position has been filled.

University of Hawaii Sea Level Center—Tsunami Research

P.I.: Philip Thompson

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

NOAA Sponsor: Michael Angove

Cumulative 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 ten water level stations in the Pacific Ocean in support of regional tsunami warning and sea level monitoring. The Caribbean portion of the project was developed in collaboration with the Puerto Rico Seismic Network (PRSN). The 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's involvement ensures that the water level stations remain operational and transmitting real-time, high-frequency data while also complying with global sea level observing system requirements for oceanographic and climate research. A typical tsunami water level station is shown in Figure 1 for Quepos, Costa Rica.

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

Progress during FY 2018

Five stations were visited in the Caribbean (Punta Cana, Puerto Plata, Limon, Roseau, Bullen Bay), which met the expected five station visit quota. The Roseau station had to be completely rebuilt after the previous installation was destroyed by Hurricane Maria. For the Pacific Ocean, three stations (Legaspi, Quepos, Acajutla) were visited for routine maintenance by UHSLC technicians, and one new tsunami station was installed on the strategically located Cocos Island. The four total Pacific visits fell one short of project objectives due to the cost of building two installations from the ground up in Roseau and Cocos Island. This temporary reduction in Pacific visits did not affect project deliverables or up-time of real-time water level data from the Pacific tsunami gauges. All tsunami station data underwent daily and monthly quality assessments with data archived at the UHSLC. Annual inspection for the research quality dataset is underway and expected to be completed by October 2018.

(right) Figure 2. The UHSLC's new tsunami detection tide gauge on remote Cocos Island, Costa Rica. The island is located in the open ocean about 350 miles off the Pacific Central American coast and will provide additional tsunami warning lead-time and improved tsunami modeling in the region.

Progress Reports from JIMAR-supported Graduate Students and Postdoctoral Researchers

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

Assaf Azouri, JIMAR Postdoctoral Researcher

Purpose of the Research

The main objectives of this research involve the following: 1) collection of oceanographic datasets by deploying instruments at selected coastal and harbor sites, as well as use outputs from numerical models; 2) applying data analysis to these data to reveal the low-frequency response (via infragravity waves) of the coast to varying strengths and directions of sea and swell waves; 3) identify the dominant type of waves and the corresponding processes that are responsible for triggering significant run-up and flooding events along the coast; 4) use the numerical modeling simulations to create spectral maps that reveal the spatial distribution of infragravity (IG) waves along the coast, with particular focus on standing wave patterns of such waves; and 5) execute a thorough comparison between three high-resolution coastal wave models to identify which model will be most suitable for the task of generating a new, near real-time, run-up forecast system for West Maui coastline.

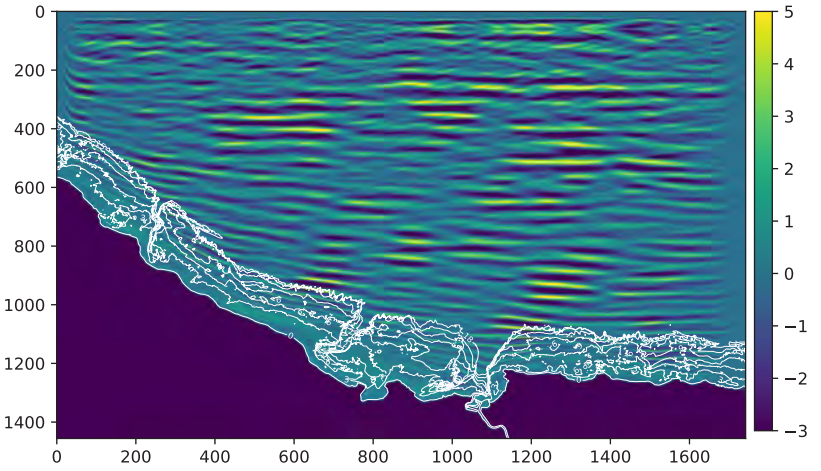

Figure 1. BOSZ free surface output at t = 1000 sec for the computational domain of O'ahu's North Shore. Units: meters.

Progress during FY 2018

Significant progress was made during this most recent FY including the following.

Analyses of data sets from historical observational and from recent numerical modeling simulations revealed the existence of highly energetic IG waves of various types and showed that they are highly site dependent. After successfully comparing the three models to each other, and comparing all of them to observations, Azouri was able to

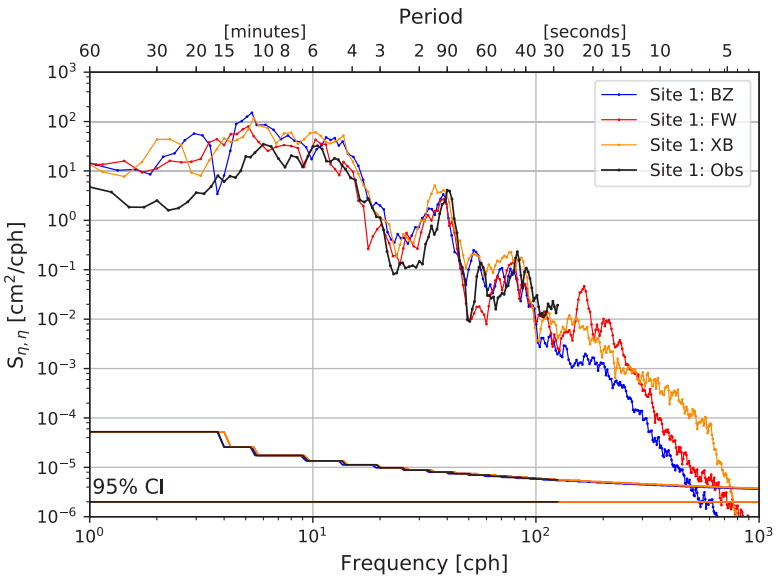

Figure 2. Comparison of sea level power spectral densities (PSDs) generated using BOSZ (BZ; blue curve), FUNWAVE (FW; red curve), XBeach (XB; orange curve) model outputs, versus the observed sea level (PSD; black curve), at site 1 (south basin) inside Hale'iwa Harbor, O'ahu. The 95\% confidence interval for each independent spectrum estimate is shown at the bottom.

validate all models and identify the one that is most suitable for the project's West Maui run-up forecast project. A preliminary analysis that resulted in new spectral maps for one of the suggested West Maui domains revealed very complex structures of standing IG wave patterns along the coastline and a strong spatial dependence of the different period bands.

Future Research Plans

During the upcoming FY, Azouri will continue applying various data analysis techniques to assist the project in identifying the types and generation mechanisms of the dominant IG waves along West Maui.

In addition to using numerical modeling data, Azouri will also execute a field study that involves deployment of instruments and collection of new data from selected sites along the West Maui coastline. This will be used to assist with model validation efforts.

Azouri will also be involved in the creation of the near real-time wave run-up forecast system, which is the main goal of the West Maui project.

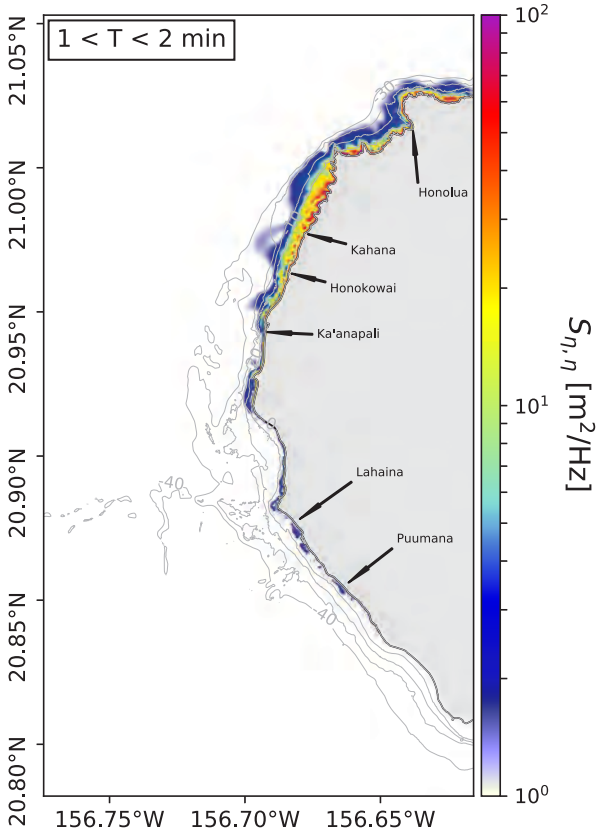

Figure 3. Power spectral density map for the 1-2 min period band, generated with free surface output from BOSZ for the scenario of a swell arriving from due north.

Presentations

- "Existence and forcing of resonant infragravity oscillations on harbor to island scales". Presentation at the Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018.
- Project presentation at the UH-Japan Symposium, University of Hawaii, Honolulu, Hawaii, September 7-8, 2017. Event sponsored by UH Sea Grant.
- Project presentation at the 15th Annual Meeting Asia Oceania Geosciences Society (AOGS) Conference, Honolulu, Hawaii, June 3-8, 2018. Ecosystem Monitoring Protection and Restoration of Resources.

JIMAR Publications

Author(s) Names	Publication Date	Title	Published In (Journal Name, vol. & page no.)	Type of Publication	Citation No. or hyperlink	Project Title
Aledandrini, S., A. Copeland, and D. Miller	2018	EK60 calibration report, *R/V Falkor*		Report		Research Support for Ocean Exploration and Research: The Acoustic Dimensions of Ocean Exploration
Allen, C.D., H.L. Haas, R.J. Smolowitz, S.H. Patel, and J.A. Seminoff	2/23/18	Corticosterone concentrations in migratory loggerhead sea turtles	International Sea Turtle Symposium, Kobe, Japan, February 18-23, 2018	Conference Proceedings		Marine Turtle Recovery in the Pacific Islands Region
Amin, R., B. Richards, W. Misa, J. Taylor, D. Miller, A. Rollo, C. Demarke, H. Singh, G. Young, J. Childress, J. Ossolinski, R. Reardon, and K. Koyanagi	10/11/17	The modular optical underwater survey system	Sensors, 17, 10, 2309	Journal Article	https://doi.org/10.3390/s17102309	Ecosystems Observations and Research Program: Pacific Islands Fisheries and Ecosystems Support Project
Ayers, A.	8/1/17	Socioeconomic monitoring reveals differential impacts and unintended consequences of bigeye tuna conservation	Resilience 2017, Stockholm, Sweden, August 20-23, 2017	Presentation		Socioeconomics of Western Pacific Fisheries
Ayers, A.	1/1/18	The Commonwealth of the Northern Mariana Islands fishing community profile: 2017 update	NOAA Technical Memorandum NOAA-TM-NMFS-PIF-SC-66, 57 pp	Report	https://repository.library.noaa.gov/view/noaa/17122 https://doi.org/10.7289/V5/TM-PIFSC-66	Socioeconomics of Western Pacific Fisheries
Ayers, A.	7/10/17	Transaction costs, design principles, and co-management of Hawai‘i coral reef fisheries	International Association for the Study of the Commons (IASC) XVI Biennial Conference, Utrecht, Netherlands, July 10-14, 2017	Presentation		Socioeconomics of Western Pacific Fisheries
Ayers, A.	4/16/18	Whose right to manage? Distribution of property rights affects equity and power dynamics in co-management	The 7th International Conference on Environmental Future: Humans and Island Environments, Honolulu, Hawai‘i, April 16-20, 2018	Presentation		Socioeconomics of Western Pacific Fisheries
Bigelow, K., M. Iwane, H. Wang, and V. Post	9/25/17	Species composition in the USA purse seine fishery as estimated by regional purse seine logsheets and cannery receipts	WCPFC Thirteenth Regular Session of the Scientific Committee, Rarotonga, Cook Islands, August 9-17 2017	Report	https://www.wcpfc.int/node/29499	Pacific Tuna Fishery Data Management
Brainard R., T. Oliver, M. McPhaden, A. Cohen, R. Venegas, A. Heenan, B. Vargas-Ángel, R. Rotjan, S. Mangubhai, E. Flint, and S. Hunter	1/1/18	Ecological impacts of the 2015/16 El Niño in the Central Equatorial Pacific	Bulletin of the American Meteorological Society, 99, 21	Journal Article	https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-17-0128.1	Sustaining Healthy Coastal Ecosystems

Burns, J.H.R., D. Delparte, R.D. Gates, and M. Takabayashi	2/16/18	New insights into coral reefs provided by 3D computer vision technology	2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Cantwell, K., K. Elliott, C. Kelley, and S. Gottfried	3/1/18	CAPSTONE sampling overview: Providing insights in the remote Pacific	In Raineault, N.A, J. Flanders, and A. Bowman, (eds.), 2018. New frontiers in ocean exploration: The *E/V Nautilus*, NOAA Ship *Okeanos Explorer*, and *R/V Falkor* 2017 field season. Oceanography, 31, 1, supplement, 84-85	Journal Article	https://doi.org/10.5670/oceanog.2018.supplement.01	Pacific Islands Deep Sea Coral and Sponge Initiative
Chikamoto, Y., A. Timmermann, M. Widlansky, M. Balmaseda, and L. Stott	7/26/17	Multi-year predictability of climate, drought, and wildfire in southwestern North America	Scientific Reports, 2017	Journal Article	https://doi.org/10.1038/s41598-017-06869-7	University of Hawaii Sea Level Center
Chowdhury, M.R.	Forthcoming	An outlook on changing climate in the U.S.-Affiliated Pacific Islands	Meteorological Applications	Journal Article	https://rmets.onlinelibrary.wiley.com/journal/14698080	Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R.	2/22/18	ENSO and climate variability and change: A look back at 2017	National Seminar on Climate Change, Chittagong University of Engineering and Technology, Chittagong, Bangladesh, February 22, 2018	Presentation	http://www.cuet.ac.bd/	Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R.	4/17/18	Impacts of changing climate on water resources: A CMIP5-model based perspective for the U.S.-Affiliated Pacific Islands	7th International Conference on Environmental Future, Honolulu, HI, April 16-20, 2018	Presentation	http://manoa.hawaii.edu/7ICEF/	Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R.	5/24/18	Impacts of ENSO and changing climate on water resources: U.S.-Affiliated Pacific Islands	16th Annual Climate Prediction Applications Science Workshop (CPASW), North Dakota State University, Fargo, ND, May 22-24, 2018	Presentation	https://www.ag.ndsu.edu/cpasw/documents/program-pdfs/session-8/03-chowdhury-cpasw18-thurssession8-enso.pdf	Pacific ENSO Applications Climate (PEAC) Center
Chowdhury, M.R.	1/18/18	Pacific Region ENSO update and seasonal outlook	NOAA Inouye Regional Center, Ford Island, Honolulu, HI, presentations on January 8, 2018 and June 26, 2018	Presentation		Pacific ENSO Applications Climate (PEAC) Center

Couch, C.S., J.H.R. Burns, G. Liu, K. Steward, T.N. Gutlay, J. Kenyon, M. Eakin, and R. Kosaki	9/27/17	Mass coral bleaching due to unprecedented marine heatwave in Papahānaumokuākea Marine National Monument (Northwestern Hawaiian Islands)	PLoS ONE	Journal Article	https://doi.org/10.1371/journal.pone.0185121	Papahānaumokuākea Marine National Monument Monitoring and Research
Courtney, T., E.H. DeCarlo, H.N. Page, K.D. Bahr, A. Barro, N. Howins, R. Tabata, G. Terlouw, and A.J. Andersson	2/1/18	Recovery of reef-scale calcification following a bleaching event in Kane`ohe Bay, Hawai`i	Limnology and Oceanography Letters	Journal Article	https://doi.org/10.1002/lol2.10056	Data Validation at the Hawaii MAPCO2 Buoy Network in Support of a Test-Bed for Technology Development
Crance, J.L., C.L. Berchok, and J.L. Keating	9/26/17	Gunshot call production by the North Pacific right whale, *Eubalaena japonica*, in the southeastern Bering Sea	Endangered Species Research, 34, 251-267	Journal Article	https://doi.org/10.3354/esr00848	Cetacean Research Program
Eyre, B., T. Cyronak, P. Drupp, E.H. DeCarlo, J. Sachs, and A.J. Andersson	3/1/18	Coral reefs will transition to net dissolving before end of century	Science	Journal Article	https://doi.org.10.1126.science.aao1118	Data Validation at the Hawaii MAPCO2 Buoy Network in Support of a Test-Bed for Technology Development
Finkbeiner, E., F. Micheli, N. Bennett, A. Ayers, E. Le Cornu, and A. Doerr	2/1/18	Exploring trade-offs in climate change response in the context of Pacific Island fisheries	Marine Policy, 88, 359-364	Journal Article	https://www.sciencedirect.com/science/article/pii/S0308597X17301872?via%3Dihub	Socioeconomics of Western Pacific Fisheries
Fukunaga, A., and R.K. Kosaki	7/31/17	Use of multivariate control charts to assess the status of reef fish assemblages in the Northwestern Hawaiian Islands	PeerJ	Journal Article	https://doi.org/10.7717/peerj.3651	Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., R.K. Kosaki, and B.B. Hauk	7/31/17	Distribution and abundance of the introduced snapper *Lutjanus kasmira* (Forsskål, 1775) on shallow and mesophotic reefs of the Northwestern Hawaiian Islands	BioInvasions Records	Journal Article	https://doi.org/10.3391/bir.2017.6.3.12	Papahānaumokuākea Marine National Monument Monitoring and Research
Fukunaga, A., R.K. Kosaki, and J.H.R. Burns	12/8/17	Reef assessment and monitoring program of the Papahānaumokuākea Marine National Monument	Statistics in Ecology and Environmental Monitoring Conference (SEEM 2017), Queenstown, New Zealand, December 6-8, 2017	Presentation		Papahānaumokuākea Marine National Monument Monitoring and Research
Gaos, A.R., R.L. Lewison, M.J. Liles, A. Henriquez, S. Chavarria, I.L. Yanez, K.R. Stewart, A. Frey, T.T. Jones, and P.H. Dutton	2/23/18	Prevalence of polygyny in a critically endangered marine turtle population	International Sea Turtle Symposium, Kobe, Japan, February 18-23, 2018	Conference Proceedings		Marine Turtle Recovery in the Pacific Islands Region
Gorospe, K., and T. Acoba	11/1/17	A survey design performance analysis examining linkages between reef fish assemblages and benthic morphologies in the Main Hawaiian Islands	NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-64, 35 pp	Report	ftp://ftp.library.noaa.gov/noaa_documents.lib/NMFS/PIFSC/TM_NMFS_PIFSC/NOAA_Tech_Memo_PIFSC_64.pdf	Sustaining Healthy Coastal Ecosystems

Gorospe, K., M. Donahue, A. Heenan, J. Gove, I. Williams, and R. Brainard	5/1/18	Local biomass baselines and the recovery potential for Hawaiian coral reef fish communities	Frontiers in Marine Science, 5, 13	Journal Article	https://www.frontiersin.org/articles/10.3389/fmars.2018.00162/full	Sustaining Healthy Coastal Ecosystems
Hamlington, B., A. Burgos, P. Thompson, F. Landerer, C. Piecuch, S. Adhikari, L. Caron, J. Reager, and E. Ivins	3/15/18	Observation-driven estimation of the spatial variability of 20th Century sea level rise	Journal of Geophysical Research-Oceans, 123, 3, 2129-2140	Journal Article	https://doi.org/10.1002/2017JC013486	University of Hawaii Sea Level Center
Heenan, A., I. Williams, T. Acoba, A. DesRochers, R. Kosaki, T. Kanemura, M. Nadon, and R. Brainard	12/5/17	Long-term monitoring of coral reef fish assemblages in the Western Central Pacific	Scientific Data, 4, 170176	Journal Article	http://www.nature.com/articles/sdata2017176	Sustaining Healthy Coastal Ecosystems
Hoey, A.S., B.M. Taylor, J. Hoey, and R.J. Fox	3/7/18	Parrotfishes, are we still scraping the surface? Emerging topics and future research directions	In Hoey, A.S. and R.M. Ronaldo (eds.), Biology of Parrotfishes, CRC Press, Chapter 17	Book Chapter	https://www.crcpress.com/The-Biology-and-Ecology-of-Parrotfishes/Hoey-Bonaldo/p/book/9781482224016	Territorial Biosampling
Hutchinson, M., F. Poisson, and Y. Swimmer	8/2/17	Developing best handling practice guidelines to safely release mantas, mobulids and stingrays captured in commercial fisheries	WCPFC Thirteenth Regular Session of the Scientific Committee, Rarotonga, Cook Islands, August 9-17 2017	Report	WCPFC-SC13-2017/EB-IP-07/SC13-ISG-5	Fishing Impacts on Non-Target Species
Ingram, R., K. Leong, and S. Wongbusarakum	6/12/18	Bringing human well-being into integrated ecosystem assessments	Boundary Spanning: Advances in Socio-Environmental Systems Research International Symposium, Annapolis, MD, June 11-13, 2018	Presentation		West Hawaii Integrated Ecosystem Assessment
Ingram, R., K. Oleson, and J. Gove	5/2/18	Revealing complex social-ecological interactions through participatory modeling to support ecosystem-based management in Hawai‘i	Marine Policy, 94, 180-188	Journal Article	doi.org/10.1016/j.marpol.2018.05.002	Socioeconomics of Western Pacific Fisheries
Ingram, R., K. Oleson, and J. Gove	12/5/17	Revealing social and ecological interactions through participatory modeling in Hawai‘i	Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawai‘i, December 5-6, 2017	Presentation		West Hawaii Integrated Ecosystem Assessment
Iwane, M.	12/6/17	Exploring oceanic whitetip shark interactions in Hawai‘i's small-scale fisheries through fisher engagement	Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawai‘i, December 5-6, 2017	Presentation		Socioeconomics of Western Pacific Fisheries

Jensen, M.P., C.D. Allen, T. Eguchi, I. Bell, E. LaCasella, W.A. Hilton, C.A.M. Hof, and P.H. Dutton	1/8/18	Environmental warming and feminization of one of the largest sea turtle populations in the world	Current Biology, 28, 1, 154–159.e4	Journal Article	https://www.cell.com/current-biology/fulltext/S0960-9822(17)31539-7	Marine Turtle Recovery in the Pacific Islands Region
Johnson, G.C., J.M. Lyman, T. Boyer, C.M. Domingues, J. Gilson, M. Ishii, R. Killik, D. Monselesan, and S.E. Wijffels	8/1/17	Global Oceans: Ocean heat content [In "State of the Climate in 2016"]	Bulletin of the American Meteorological Society, 98, 8, S66–S69	Journal Article	doi:10.1175/2017BAMSStateoftheClimate.1	Profiling CTD Float Array Implementation and Ocean Climate Research
Kaufman, A.	10/28/17	Exploring software and strategies to connect research data streams from health and specimen archives to population and life history data. What we wish we knew	22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, October 22-27, 2017	Presentation		Hawaiian Monk Seal Research Program
Kelley, C., C. Mah, M. Malik, and K. Elliott	3/1/18	Laulima o ka moana: Exploring deep monument waters around Johnston Atoll	In Raineault, N.A, J. Flanders, and A. Bowman, (eds.), 2018. New frontiers in ocean exploration: The *E/V Nautilus*, NOAA Ship *Okeanos Explorer*, and *R/V Falkor* 2017 field season. Oceanography, 31, 1, supplement, 80-81	Journal Article	https://doi.org/10.5670/oceanog.2018.supplement.01	Pacific Islands Deep Sea Coral and Sponge Initiative
Kessler, W.S., R. Davis, H.G. Hristova, and J. Sherman	2/16/18	10 years of glider transects across the Solomon Sea low-latitude western boundary current	2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018	Conference Proceedings	https://agu.confex.com/agu/os18/meetingapp.cgi/Paper/305948	Characterization and Dynamics of Mesoscale and Submesoscale Oceanic Variability in the Solomon Sea Simulated by a Nested ROMS Model
Kleiber, D.	7/7/17	Gender/women relations within coastal and fisheries communities: From past to present III	Center for Maritime Research, MARE Conference 2017, People and the Sea IX: Dealing with Maritime Mobilities, Amsterdam, Netherlands, July 5-7, 2017	Presentation	http://www.marecentre.nl/wp-content/uploads/Programme-book-2017-final.pdf	Socioeconomics of Western Pacific Fisheries
Kleiber, D., D. Kotowicz, and J. Hospital	1/1/18	Applying national community social vulnerability indicators to fishing communities in the Pacific Island region	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-65	Report	https://repository.library.noaa.gov/view/noaa/17121	Socioeconomics of Western Pacific Fisheries
Kosaki, R.K., A. Fukunaga, and B.B. Hauk	9/1/17	Scientist discover large ta'ape-free zone on deep coral reefs of the Northwestern Islands	Hawaii Fishing News, 42, 9, p. 14	Other		Papahānaumokuākea Marine National Monument Monitoring and Research
Langseth, B., J. Syslo, A. Yau, M. Kapur, and J. Brodziak	2/1/18	Stock assessment for the Main Hawaiian Islands Deep 7 Bottomfish Complex in 2018, with catch projections through 2022	NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-69	Report	https://doi.org/10.7289/V5/TM-PIFSC-69	Stock Assessment Research Program

Lecky, J., J. Gove, B. Whittier, K. McCoy, and W. Walsh	12/5/17	Mapping anthropogenic stressors over time and space for the nearshore environment in West Hawaii	Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawai'i, December 5-6, 2017	Presentation		West Hawaii Integrated Ecosystem Assessment
McCoy, K., A. Heenan, J. Asher, P. Ayotte, K. Gorospe, A. Gray, K. Lino, J. Zamzow, and I. Williams	4/1/18	Pacific Reef Assessment and Monitoring Program Ecological monitoring 2017—reef fishes and benthic habitats of the Northwestern Hawaiian Islands, Pacific Remote Islands Marine National Monument, and the Mariana Archipelago	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-18-008, 74 pp	Report	https://doi.org/10.7289/V5/DR-PIFSC-18-008	Sustaining Healthy Coastal Ecosystems
McCoy, K., A. Heenan, J. Asher, P. Ayotte, K. Gorospe, A. Gray, K. Lino, J. Zamzow, and I. Williams	8/28/17	Pacific Reef Assessment and Monitoring Program Fish monitoring brief: Northwestern Hawaiian Islands, 2016	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-030, 2 pp	Report	https://repository.library.noaa.gov/view/noaa/14978	Sustaining Healthy Coastal Ecosystems
McCoy, K., I. Williams, A. Friedlander, H. Ma, L. Teneva, and J. Kittinger	4/16/18	Estimating nearshore coral reef-associated fisheries production from the main Hawaiian Islands	PLoS ONE, 13, e0195840	Journal Article	http://dx.plos.org/10.1371/journal.pone.0195840	Sustaining Healthy Coastal Ecosystems
McKinnie, D., and A. Copeland	3/1/18	2017 National Ocean Exploration Forum: Ocean Exploration in a Sea of Data	In Raineault, N.A, J. Flanders, and A. Bowman, (eds.), 2018. New frontiers in ocean exploration: The *E/V Nautilus*, NOAA Ship *Okeanos Explorer*, and *R/V Falkor* 2017 field season. Oceanography, 31, 1, supplement, 3	Journal Article	https://doi.org/10.5670/oceanog.2018.supplement.01	Research Support for Ocean Exploration and Research: The Acoustic Dimensions of Ocean Exploration
Merrifield, M., and P. Thompson	6/19/18	Interdecadal sea level variations in the Pacific: Distinctions between the tropics and extratropics	Geophysical Research Letters, 45, 13	Journal Article	https://doi.org/10.1029/2018GL077666	University of Hawaii Sea Level Center
Meyer, C.G., J.M. Anderson, D. Coffey, M.R. Hutchinson, M.A. Royer, and K.N. Holland	3/21/18	Habitat geography around oceanic islands influences tiger shark (*Galeocerdo cuvier*) spatial behaviour and shark bite risk at ocean recreation sites	Scientific Reports, 8, 4945	Journal Article	https://www.nature.com/articles/s41598-018-23006-0	Fishing Impacts on Non-Target Species
Miller, B.S., S. Wotherspoon, S. Rankin, S. Calderan, R. Leaper, and J.L. Keating	1/1/18	Estimating drift of directional sonobuoys from acoustic bearings	Journal of the Acoustical Society of America, 143, 1, EL25-EL30	Journal Article	https://doi.org/10.1121/1.5020621	Cetacean Research Program
Payne, N., C. Meyer, J. Smith, J. Houghton, A. Barnett, B. Holmes, I. Nakamura, Y. Papastamatiou, M. Royer, D. Coffey, J. Anderson, M. Hutchinson, K. Sato, and L. Halsey	3/8/18	Combining abundance and performance data reveals how temperature regulates coastal occurrences and activity of a roaming apex predator	Global Change Biology, 24, 5, 1884-1893	Journal Article	https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14088	Fishing Impacts on Non-Target Species

Reed, E.	4/4/18	Goatfish: tropical shallow-water reef fish life history in question	2018 MAR-VLS 3rd National Workshop, Panama City, Florida, April 4-7, 2018	Conference Presentation		Territorial Biosampling
Schumacher, B., B. Vargas-Angel, and S. Heron	3/1/18	Identifying coral reef resilience potential in Tutuila, American Samoa based on NOAA coral reef monitoring data	NOAA Special Publication NMFS-PIFSC-SP-18-003, 16 pp	Report	https://repository.library.noaa.gov/view/noaa/17371	Sustaining Healthy Coastal Ecosystems
Sculley, M., and A. Yau	5/18/18	Input data available for the North Pacific swordfish stock assessment in Stock Synthesis	ISC Billfish Working Group, Shizuoka, Japan, April 17-24, 2018, ISC/18/BILLWG-02/01	Report	https://doi.org/10.7289/V5/WP-PIFSC-18-002	Stock Assessment Research Program
Sculley, M., and A. Yau	5/21/18	Preliminary comparisons of the stock synthesis assessment model for North Pacific swordfish	ISC Billfish Working Group, Honolulu, HI, Jaunary 17-23, 2018, ISC/18/BILLWG-01/08	Report	https://doi.org/10.7289/V5/WP-PIFSC-18-004	Stock Assessment Research Program
Sculley, M., H. Ijima, and Y.J. Chang	6/29/18	A base-case model in Stock Synthesis 3.30 for the 2018 North Pacific swordfish stock assessment	ISC Billfish Working Group, Shizuoka, Japan, April 17-24, 2018, ISC/18/BILLWG-02/02	Report	https://doi.org/10.7289/V5/WP-PIFSC-18-005	Stock Assessment Research Program
Sculley, M., M. Kapur, and A. Yau	5/18/18	Size composition for swordfish (*Xiphias gladius*) in the Hawaii-based pelagic longline fishery from 1995-2016	ISC Billfish Working Group, Honolulu, HI, Jaunary 17-23, 2018, ISC/18/BILLWG-01/02	Report	https://doi.org/10.7289/V5/WP-PIFSC-18-003	Stock Assessment Research Program
Sculley, M., M. Kapur, and A. Yau	5/18/18	Standardization of swordfish (*Xiphias gladius*) catch per unit effort data caught by the Hawaii-based longline fishery from 1994-2016 using generalized linear models	ISC Billfish Working Group, Honolulu, HI, Jaunary 17-23, 2018, ISC/18/BILLWG-01/05	Report	https://doi.org/10.7289/V5/WP-PIFSC-18-001	Stock Assessment Research Program
Smith, J., M. Putts, E. Mittelstaedt, K. Cantwell, E. Lobecker, and M. White	3/1/18	Deep-sea symphony: Exploration of the Musicians Seamounts	In Raineault, N.A, J. Flanders, and A. Bowman, (eds.), 2018. New frontiers in ocean exploration: The *E/V Nautilus*, NOAA Ship *Okeanos Explorer*, and *R/V Falkor* 2017 field season. Oceanography, 31, 1, supplement, 82-83	Journal Article	https://doi.org/10.5670/oceanog.2018.supplement.01	Pacific Islands Deep Sea Coral and Sponge Initiative
Smith, K., J. Whitney, J. Lecky, J. Gove, A. Copeland, D. Kobayashi, and M. McManus	2/13/18	Physical drivers of biological accumulation in surface slicks and small-scale fronts along Hawaii's western coast	2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018	Presentation		West Hawaii Integrated Ecosystem Assessment

Smith, K., J. Whitney, J. Lecky, J. Gove, A. Copeland, D. Kobayashi, and M. McManus	12/5/17	Physical drivers of West Hawaii's surface slicks and their effects on larval fish accumulation	Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawai'i, December 5-6, 2017	Presentation		West Hawaii Integrated Ecosystem Assessment
Stamoulis, K., J. Delevaux, I. Williams, M. Poti, J. Lecky, B. Costa, M. Kendall, S. Pittman, M. Donovan, L. Wedding, and A. Friedlander	2/1/18	Seascape models reveal places to focus coastal fisheries management	Ecological Applications, 28, 4, 910-925	Journal Article	https://doi.org/10.1002/eap.1696	West Hawaii Integrated Ecosystem Assessment
Storlazzi, C., S. Gingerich, P. Swarzenski, O. Cheriton, C. Voss, F. Oberle, J. Logan, K. Rosenberger, T. Fregoso, S. Rosa, A. Johnson, L. Erikson, D. Field, G. Piniak, A. Malhotra, M. Finkbeiner, A. van Dongeran, E. Quataert, A. van Rooijen, E. Elias, M. Gawehn, A. Hariharasubramanian, M. Widlansky, J. Hafner, and C. Zhang	8/31/17	The impact of sea-level rise and climate change on Department of Defense installations on atolls in the Pacific Ocean (RC-2334)	Defense Technical Information Center	Report	http://www.dtic.mil/dtic/tr/fulltext/u2/1053105.pdf	University of Hawaii Sea Level Center
Sullivan, M., M. Barbieri, A. Kaufman, J. Baker, A. Harting, and C. Littnan	10/23/17	Quarantine considerations for Hawaiian monk seals in the case of an infectious disease outbreak	22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, October 22-27, 2017	Presentation		Hawaiian Monk Seal Research Program
Swanson, D., M. Winston, and B. Vargas-Angel	11/14/17	Pacific Reef Assessment and Monitoring Program benthic REA monitoring summary: Howland and Baker Islands 2017	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-038, 4 pp	Report	https://repository.library.noaa.gov/view/noaa/16209	Sustaining Healthy Coastal Ecosystems
Swanson, D., M. Winston, and B. Vargas-Angel	10/25/17	Pacific Reef Assessment and Monitoring Program benthic REA monitoring summary: Jarvis Island 2017	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-035, 4 pp	Report	https://repository.library.noaa.gov/view/noaa/16087	Sustaining Healthy Coastal Ecosystems
Swanson, D., M. Winston, and B. Vargas-Angel	10/25/17	Pacific Reef Assessment and Monitoring Program benthic REA monitoring summary: northern Mariana Islands 2017	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-037, 4 pp	Report	https://repository.library.noaa.gov/view/noaa/16089	Sustaining Healthy Coastal Ecosystems
Swanson, D., M. Winston, and B. Vargas-Angel	10/25/17	Pacific Reef Assessment and Monitoring Program benthic REA monitoring summary: southern Mariana Islands 2017	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-036, 4 pp	Report	https://repository.library.noaa.gov/view/noaa/16088	Sustaining Healthy Coastal Ecosystems
Swanson, D., M. Winston, and B. Vargas-Angel	10/25/17	Pacific Reef Assessment and Monitoring Program benthic REA monitoring summary: Wake Atoll 2017	Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-17-034, 4 pp	Report	https://repository.library.noaa.gov/view/noaa/16086	Sustaining Healthy Coastal Ecosystems
Tagami, D., and H. Wang	1/17/18	Spatial distribution of swordfish catches for longline fisheries in the Western Central North Pacific	ISC Billfish Working Group, Honolulu, HI, Jaunary 17-23, 2018, ISC/18/BILLWG-01/10	Report	http://isc.fra.go.jp/reports/bill/bill_2018_1.html	Pacific Tuna Fishery Data Management

Taylor, B.M.	10/3/17	Global patterns of intraspecific life-history variation reveal hierarchical importance of environmental drivers in widespread coral reef fishes	The 10th Indo-Pacific Fish Conference, Tahiti, French Polynesia, October 2-6, 2017	Presentation		Territorial Biosampling
Taylor, B.M.	9/5/17	Protogynous hermaphroditism	In Vonker, J. and T.K. Shackelford (eds.), Encyclopedia of Animal Cognition and Behavior, Springer Intl. Publishing	Book Chapter	https://doi.org/10.1007/978-3-319-47829-6_1950-1	Territorial Biosampling
Taylor, B.M.	3/27/18	Standing out in a big crowd: Peculiar demography facilitates dominance of *Naso unicornis* in Pacific coral-reef fisheries	4th Guam Coral Reef Symposium, Tumon, Guam, March 27, 2018	Presentation		Territorial Biosampling
Taylor, B.M., and E. Cruz	11/29/17	Age-based and reproductive biology of the Pacific longnose parrotfish *Hipposcarus longiceps* from Guam	PeerJ, 5, e4079	Journal Article	https://doi.org/10.7717/peerj.4079	Territorial Biosampling
Taylor, B.M., E.D.L. Trip, and J.H. Choat	3/7/18	Dynamic demography: Investigations of life-history variation in the parrotfishes	In Hoey, A.S. and R.M. Ronaldo (eds.), Biology of Parrotfishes, CRC Press, Chapter 4	Book Chapter	https://www.crcpress.com/The-Biology-and-Ecology-of-Parrotfishes/Hoey-Bonaldo/p/book/9781482224016	Territorial Biosampling
Taylor, B.M., S.J. Brandl, M. Kapur, W.D. Robbins, G. Johnson, C. Huveneers, P. Renaud, and J.H. Choat	12/28/17	Bottom-up processes mediated by social systems drive demographic traits of coral-reef fishes	Ecology, 99, 642-651	Journal Article	https://doi.org/10.1002/ecy.2127	Territorial Biosampling
Taylor, B.M., Z.S. Oyafuso, C.B. Pardee, D. Ochavillo, and S.J. Newman	6/18/18	Comparative demography of commercially-harvested snappers and an emperor from American Samoa	PeerJ, 6, e5069	Journal Article	https://doi.org/10.7717/peerj.5069	Territorial Biosampling
Thompson, P.	2/5/18	Sea Level: Current knowledge, gaps, and challenges	Understanding Flooding on Reef-lined Island Coasts Workshop, Honolulu, HI, February 5-7, 2018	Presentation		University of Hawaii Sea Level Center
Thompson, P., M. Merrifield, E. Leuliette, W. Sweet, D. Chambers, B. Hamlington, S. Jevrejeva, J. Marra, G. Mitchum, and R. Nerem	9/6/17	Global Oceans: Sea level variability and change [In "State of the Climate in 2016"]	Bull. Am. Meteorol. Soc., 98, 8, S79-81	Journal Article	https://journals.ametsoc.org/doi/abs/10.1175/2017BAMSStateofthe-Climate.1	University of Hawaii Sea Level Center
Thompson, P., M. Widlansky, M. Merrifield, J. Becker, and J. Marra	2/12/18	Nuisance flooding in Honolulu, HI during the 21st century	2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018	Presentation		University of Hawaii Sea Level Center
Thompson, P., M. Widlansky, M. Merrifield, J. Becker, and J. Marra	6/11/18	Passive flooding due to SLR in Honolulu during the 21st century	NASA/JPL Ice Sheet System Model (ISSM) Workshop, Honolulu, HI, June 11-12, 2018	Presentation		University of Hawaii Sea Level Center

Wedding, L., J Lecky, J. Gove, H. Walecka, M. Donovan, G. Williams, J.-B. Jouffray, L. Crowder, A. Erickson, K. Falinski, A. Friedlander, C. Kappel, J. Kittinger, K. McCoy, A. Norstrom, M. Nystrom, K. Oleson, K. Stamoulis, C. White, and K. Selkoe	3/1/18	Advancing the integration of spatial data to map human and natural drivers on coral reefs	PLoS ONE, 13, 3, e0189792	Journal Article	https://doi.org/10.1371/journal.pone.0189792	West Hawaii Integrated Ecosystem Assessment
Weijerman, M., J.M. Gove, I.D. Williams, W.J. Walsh, D. Minton, and J.J. Polovina	2/19/18	Evaluating management strategies to optimise coral reef ecosystem services	Journal of Applied Ecology, 55, 4, 1823-1833	Journal Article	doi:10.1111/1365-2664.13105	Ecosystem Structure & Function
Whitney, J., K. Smith, J. Gove, J. Lecky, A. Copeland, D. Kobayashi, and M. McManus	12/5/17	Surface slicks as important nursery habitat for larval fish in West Hawai‘i	Symposium on West Hawaii's Marine Ecosystem: Bridging the Gap Between Science and Management, Kailua-Kona, Hawai'i, December 5-6, 2017	Presentation		West Hawaii Integrated Ecosystem Assessment
Whitney, J.L., B.W. Bowen, and S.A. Karl	2/8/18	Flickers of speciation: Sympatric colour morphs of the arc-eye hawkfish, *Paracirrhites arcatus*, reveal key elements of divergence with gene flow	Molecular Ecology, 27, 6, 1479-1493	Journal Article	https://doi.org/10.1111/mec.14527	West Hawaii Integrated Ecosystem Assessment
Whitney, J.L., M.J. Donahue, and S.A. Karl	2018	Niche divergence along a fine-scale ecological gradient in sympatric color morphs of a coral reef fish	Ecosphere, 9, 1, e02015	Journal Article	https://doi.org/10.1002/ecs2.2015	JIMAR Visiting Scientist
Whitney, J.L., K. Smith, J. Lecky, J. Gove, A. Copeland, D. Kobayashi, and M. McManus	2/11/18	Surface slicks as biological hotspots in West Hawai‘i: biophysical interactions and their implications for larval ecology	2018 Ocean Sciences Meeting, Portland, Oregon, February 11-16, 2018	Presentation		West Hawaii Integrated Ecosystem Assessment
Widlansky, M.	9/8/17	Forecasting future sea level changes for vulnerable islands	4th University of Hawai‘i–University of Tokyo Joint Symposium on Ocean, Coastal and Atmospheric Sciences, Honolulu, HI, September 7-8, 2017	Presentation		University of Hawaii Sea Level Center
Widlansky, M.	1/1/18	Pacific Island Sea Level Forecast tool	NOAA webinar	Presentation		University of Hawaii Sea Level Center
Widlansky, M., M. Merrifield, J. Marra, and P. Thompson	7/14/17	Multi-model seasonal sea level forecasts for vulnerable coasts	Conference report, Regional sea level changes and coastal impacts 10-14 July 2017, New York, USA, 35 pp	Conference Proceedings	http://www.clivar.org/sites/default/files/documents/WCRP-Report-No8-2018-SLC2017.pdf	University of Hawaii Sea Level Center
Widlansky, M., M. Merrifield, P. Thompson, H. Annamalai, and J. Marra	1/1/18	Forecasting seasonal sea level changes for Pacific islands	AMS 98th Annual Meeting, 16th Symposium on the Coastal Environment, Austin, TX, January 7-10, 2018	Presentation		University of Hawaii Sea Level Center

Widlansky, M., M. Merrifield, P. Thompson, H. Annamalai, and J. Marra	2/1/18	Forecasting seasonal sea levels for the U.S. Coast: challenges and opportunities	2018 Ocean Sciences Meeting, Session: Causes of Contemporary Sea Level Variability and Change from Global to Coastal Scales, Portland, Oregon, February 11-16, 2018	Conference Proceedings		University of Hawaii Sea Level Center
Widlansky, M., X. Long, H. Annamalai, M. Merrifield, P. Thompson, and J. Marra	6/1/18	Forecasting unusual seasonal sea level anomalies around tropical Pacific islands	AOGS 15th Annual Meeting, Session: Seasonal Climate Predictability and Applicability, Honolulu, HI, June 3-8, 2018	Presentation		University of Hawaii Sea Level Center
Wong-Ala, J., C. Comfort, J. Gove, M. Hixon, M. McManus, B. Powell, J. Whitney, and A. Neuheimer	3/1/18	How life history characteristics and environmental forcing shape settlement success of coral reef fishes	Frontiers of Marine Science, 5, 65	Journal Article	https://doi.org/10.3389/fmars.2018.00065	West Hawaii Integrated Ecosystem Assessment

Appendix I List of Acronyms

3D	Three Dimension
ABT	Atlantic bluefin tuna
ACL	Annual Catch Limit
AD	Automatic Differentiation
ADCP	Acoustic Doppler Current Profiler
ADMB	Automatic Differentiation Model Builder
AFES	Atmospheric model For the Earth Simulator
APDRC	Asia-Pacific Data Research Center
AR5	Fifth Assessment Report (IPCC)
ARL	Air Resources Laboratories
ARMS	Autonomous Reef Monitoring Structure
ARSHSL	Archive of Rapidly-Sampled Hawaiian Sea Level
ASA	Acoustical Society of America
ASBE	Annual Small Boat Evaluation
ASRAMP	American Samoa Reef Assessment and Monitoring Program
ATDD	Atmospheric Turbulence and Diffusion Division
AWIPS	Advanced Weather Interactive Processing System
BDG	Bulk Download Guidance
BDM	Bulk Download Module
BEDI	Big Earth Data Initiative
BET	Big Eye Tuna
BOSZ	Boussinesq model for Ocean and Surf Zones
CAO	Carnegie Airborne Observatory
CATS	Customized Animal Tracking Solutions
CCR	Closed-Circuit Rebreathers
CCZ	Clarion Clipperton Zone
CFSv2	Coupled Forecast System, version 2
CI	Cooperative Institute
CMIP	Coupled Model Intercomparison Project
CMIP5	Coupled Model Intercomparison Project Phase 5
CNMI	Commonwealth of the Northern Mariana Islands
CoRIS	Coral Reef Information System
CPU	Central Processing Unit
CPUE	Catch Per Unit Effort

CRCP	Coral Reef Conservation Program
CRP	Cetacean Research Program
CTD	Conductivity-Temperature-and Depth
DA-BFAR	Philippines Department of Agriculture, Bureau of Fisheries and Aquatic Resources
DAPPER	Data Access Protocol server
DAR	State of Hawaii Division of Aquatic Resources
DART	Deep-ocean Assessment and Reporting of Tsunamis
DAS	Department of Atmospheric Sciences
DASBR	Drifting Acoustic Spar Buoy Recorder
DAWR	Division of Aquatic and Wildlife Resources (Guam)
DCHART	Web-based server for display of in situ and gridded data sets
DENR-BMB	Philippines Department of Environment and Natural Resources, Biodiversity Management Bureau
DeSSC	Deep Submergence Science Committee
DFD	Data Flow Diagram
DFW	Division of Fish and Wildlife (CNMI)
DIC	Dissolved inorganic carbon
DIDSON	Dual-Frequency Identification Sonar
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
DOMEX	DOMinica EXperiment: Orographic Precipitation in the Tropics
DSCRTP	Deep Sea Coral Research and Technology Program
DSIA	Data Set Information Application
DVM	Data Validation Module
EAFM	Ecosystem Approach to Fisheries Management
ECOFISH	Ecosystems Improved for Sustainable Fisheries Project
Eco-FOCI	Ecosystems Fisheries-Oceanography Coordinated Investigations Program
EDM	Environmental Data Management
EEZ	Exclusive Economic Zone
EM	Electronic Monitoring
ENIO	Equatorial and Northern Indian Ocean

ENSO	El Niño Southern Oscillation
EOI	Earth-Oceans Interactions Program
EORP	Ecosystems Observations and Research Program
ER	Electronic Reporting
ERDDAP	Environmental Research Division Data Access Platform
ESA	Endangered Species Act
ESD	Ecosystem Sciences Division
EX	NOAA R/V Okeanos Explorer
FAD	Fish Aggregation Device
FEP	Fishery Ecosystem Plan
FFS	French Frigate Shoals
FMP	Fishery Management Plan
FMU	Fisheries Management Unit
FOO	Fisheries Office Order
FOT	Final Out Turn Receipt
FRMD	Fisheries Research and Monitoring Division
FRS	Fisher Reporting System (Hawaii)
FSM	Federated States of Micronesia
FSWP	Fishery Statistics of the Western Pacific
FUNWAVE	Fully Nonlinear Boussinesq Wave Model
FUS	Fisheries of the United States
FY	Fiscal Year
GCM	Generalized Circulation Model
GCN	Global Sea-level Observing System Core Network
GCOS	Global Climate Observing System
GDS	GrADS DODS Server
GEV	Generalized Extreme Value
GFS	Global Forecast System
GIS	Geographic Information System
GLOSS	Global Sea Level Observing System
GMSL	Global Mean Sea Level
GNSS	Global Navigation Satellite System
GoM	Gulf of Mexico
GOW	Global Ocean Wave reanalysis
GPD	Generalized Pareto Distribution
GPS	Global Positioning System

GPT	Geospatial Products Team
GRA	Graduate Research Assistant
GrADS	Grid Analysis and Display System
GUI	Graphic User Interface
HARP	High-frequency Acoustic Recording Package
HDAR	Hawaii Division of Aquatic Resources
Hg0	Elemental Mercury
HgP	Particulate Mercury
HICEAS	Hawaiian Islands Cetacean Ecosystem Assessment Survey
HiMARC	Hawaii Monitoring and Research Collaboration
HIMB	Hawaii Institute of Marine Biology
HMM	Hidden Markov Model
HMS	Hawaiian Monk Seal
HMSRP	Hawaiian Monk Seal Research Program
HPU	Hawaii Pacific University
HTC	Hyperbaric Treatment Center
HURL	Hawaii Undersea Research Laboratory
IATTC	Inter-American Tropical Tuna Commission
ICMP	Integrated Comprehensive Monitoring Program
IEA	Integrated Ecosystem Assessment
IEAFM	International Ecosystem Approach to Fisheries Management
IEC	International Electrotechnical Commission
iFIMS	Integrated Fisheries Information Management System
IFP	International Fisheries Program
IG	Infragravity
IHLRT	Institute for Hawaiian Language Research and Translation
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
IRC	Inouye Regional Center
ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
IT	Information Technology
ITS	Information Technology Services

IWLS	Integrated Water Level Service
JABBA	Just Another Bayesian Biomass Assessment
JIMAR	Joint Institute for Marine and Atmospheric Research
JPL	Jet Propulsion Laboratory
Kd490	Diffuse Attenuation Coefficient at 490 nm
LAS	Live Access Server
LCL	Lifting Condensation Level
LED	Light Emitting Diode
LHP	Life History Program
MACS	Marianas Archipelago Cetacean Survey
$MAPCO_2$	Moored Autonomous pCO_2 System
MAPP	Modeling, Analysis, Predictions and Projections
MAPRs	Maintained and calibrated Miniature Autonomous Plume Recorders
MARAMP	Marianas Archipelago Reef Assessment Monitoring Program
MARVLS	Maturity Assessment and Reproductive Variability of Life Stages
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
MOP	Marine Option Program
MOUSS	Modular Underwater Stereoscopic System
MTBAP	Marine Turtle Biology and Assessment Program
MTMNM	Mariana Trench Marine National Monument
N2N	NOAA to NOAA
NAB	Naval Amphibious Base
NASA	National Aeronautics and Space Administration
NCEAS	National Center for Ecological Analysis and Synthesis
NCEI	National Centers for Environmental Information
NCRMP	National Coral Reef Monitoring Program
NCTR	NOAA Center for Tsunami Research (NCTR
NESDIS	National Environmental Satellite, Data, and Information Service
NFRDI	Philippines National Fisheries and Research Development Institute
NGS	National Geodetic Survey

NMFS	National Marine Fisheries Service
NMSAS	National Marine Sanctuary of American Samoa
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSF	National Science Foundation
NTHMP	National Tsunami Hazard Mitigation Program
NUTS	No U-Turn Sampler
NWHI	Northwestern Hawaiian Islands
NWS	National Weather Service
OA	Ocean acidification
OAP	Ocean Acidification Program (NOAA office)
OAR	Office of Oceanic and Atmospheric Research
OCS	Oceanic Whitetip Shark
ODRS	Online Commercial Marine Dealer Reporting System
OER	Office of Ocean Exploration and Research
OFES	Ocean model For the Earth Simulator
OFES/AFES/CFES	Ocean/Atmosphere/Coupled model For the Earth Simulator
OGL	Ocean Genomic Legacy
OHA	Office of Hawaiian Affairs
OHC	Office of Habitat Conservation
ONMS	Office of National Marine Sanctuaries
OOI	Ocean Observatories Initiative
OPeNDAP	Open-source Project for a Network Data Access Protocol
ORP	oxidation-reduction potential
OTU	Operational Taxonomic Unit
OWCP	OceanWatch - Central Pacific
PacIOOS	Pacific Islands Ocean Observing System
PaCIS	Pacific Climate Information System
PACOM	Pacific Command
PAR	Photosynthetically Available Radiation
PARR	Public Access to Research Results
PDO	Pacific Decadal Oscillation
PEAC	Pacific ENSO Applications Climate Center
PI	Principal Investigator
PIBHMC	Pacific Islands Benthic Habitat Mapping Center
PIFG	Pacific Island Fisheries Group

PIFSC	Pacific Islands Fisheries Science Center
PIMPAC	Pacific Island Managed and Protected Area Community
PIR	Pacific Islands Region
PIRO	Pacific Islands Regional Office
PIROP	Pacific Islands Regional Office Observer Program
PIT	Passive Integrated Transponder
PL/SQL	Procedural Language/Structured Query Language
PLOS	Public Library of Science
PMEL	Pacific Marine Environmental Laboratory
PMNM	Papahānaumokuākea Marine National Monument
POC	Point of Contact
PRIMNM	Pacific Remote Islands Marine National Monument
PRSN	Puerto Rico Seismic Network
PSD	Protected Species Division
PSDs	Power Spectral Densities
PTWC	Pacific Tsunami Warning Center
PYSO	PIFSC Young Scientist Opportunity
QA	Quality Assurance
QC	Quality Control
qv	water vapor mixing ratio
QUEST	Quantitative Underwater Ecological Surveying Techniques
R/V	Research Vessel
RAD	Restriction site associated DNA
RAMP	Reef Assessment and Monitoring Program
RA-V	Regional Alliance Five (Pacific Islands)
RCC	Regional Climate Center
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
SAND	Snorkeling Assessments and New Discoveries
SAP	Stock Assessment Program

SCADA	Supervisory Control and Data Acquisition
SCUBA	Self-Contained Underwater Breathing Apparatus
SfM	Structure from Motion
SHCE	Sustaining Healthy Coastal Ecosystems
SIFT	Short-term Inundation Forecasting for Tsunamis
SIO	Scripps Institution of Oceanography
SOD	Science Operations Division
SOEST	School of Ocean and Earth Science and Technology
SOP	Standard Operating Procedure
SPA	Seal Population Assessment
SPC	Secretariat of the Pacific Community
SPTT	South Pacific Tuna Treaty
SSH	Sea Surface Height
SSTP	Survey and Sampling Technologies Program
STEM	Science Technology Engineering Math
SWFSC	Southwest Fisheries Science Center
SWL	Still Water Level
SWS	SeaWater System
T	Temperature
TA	Total alkalinity
TG	Tide gauge
THREDDS	Thematic Real-time Environmental Distributed Data Services
TIGA	Tide Gauge Benchmark Monitoring Project
TMB	Template Model Builder
TSI	Territorial Science Initiative
TWC	Tsunami Warning Centers
U.S.	United States
UAV	Unmanned Aerial Vehicle
UH	University of Hawaii
UHDAS	University of Hawaii Data Acquisition System
UHSLC	University of Hawaii Sea Level Center
UK	United Kingdom
UL	Unloading and Transshipment Logsheet
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
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)
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VARS	Video Annotation and Reference System
VBA	Visual Basic for Applications
VFP	Visual Fox Pro
VHF	Very High Frequency
VIAME	Video and Image Analytics for Marine Environment
VMS	Vessel Monitoring System
VOC	Vessel Operation Coordination
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WFO	Weather Forecast Office
WMO	World Meteorological Office
WPacFIN	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Regional Fishery Management Council
WPSAR	Western Pacific Stock Assessment Review

Appendix II List of Awards and Related Amendment Numbers

JOINT INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH (JIMAR)
COOPERATIVE AGREEMENT NO. NA16NMF4320058
(and NA17NMF4320250[1], NA17NMF4320293[2], NA17NMF4320294[3], NA170AR4310110[4], NA16NWS4680019[5])
List of Projects described in the Annual Report for the period: July 1, 2017–June 30, 2018

Title	NOAA Technical Lead/Sponsor	Amendment Number(s)
Analysis of the Vulnerability of Military Installations in the Pacific Basin to Coastal Flooding	John Marra	31, 64
Cetacean Research Program	Michael Seki	8, 80
Cetacean Research Program—Monitoring in the Mariana Islands Range Complex[2]	Michael Seki	initial
Characterization and Dynamics of Mesoscale and Submesoscale Oceanic Variability in the Solomon Sea Simulated by a Nested ROMS Model	Gary Matlock	3, 50, 84
Data Validation at the Hawaii MAPCO2 Buoy Network in Support of a Test-Bed for Technology Development	Gary Matlock	2, 45, 88
Deep Sea Coral Submersible Dives	Michael Seki	49
Ecosystem Structure and Function	Michael Seki	10, 77
Ecosystems Observations and Research Program: Pacific Islands Fisheries and Ecosystems Support Project	Michael Seki	34, 71
Ecosystems Observations and Research Program: Research Support Project	Michael Seki	37, 81
Effects of Nitrogen Sources and Plankton Food-Web Dynamics on Habitat Quality for the Larvae of Atlantic Bluefin Tuna in the Gulf of Mexico	John Lamkin	47, 86
Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center (IPRC)	Howard Diamond	1, 43, 73
Fishing Impacts on Non-Target Species	Michael Seki	24, 40, 41, 56
Hawaiian Monk Seal Northwestern Hawaiian Islands Research Seasonal Support	Michael Seki	38, 60
Hawaiian Monk Seal Research Program	Michael Seki	7, 65
International Ecosystem Approach to Fisheries Management (IEAFM) Project—Philippines[1]	Michael Seki	initial
Main Hawaiian Islands Commercial Fisheries Fast Track Data Project	Michael Seki	27, 52
Marine Turtle Nearshore Assessment in the Mariana Islands[3]	Michael Seki	initial
Marine Turtle Recovery in the Pacific Islands Region	Michael Seki	12, 68
Mechanisms of Atmospheric Mercury in Transport and Transformation in the Remote Pacific Marine Free Troposphere Measured in Hawaii	Brian Vasel	19, 39, 42
Multi-Model Seasonal Sea Level Forecats for the U.S. Coast[4]	Daniel Barrie	initial
National Weather Service Pacific Region Fellowship Program	Raymond Tanabe	26, 57
Ocean Remote Sensing	Michael Seki	25, 63

On-Site Support for OA Mooring Test-Beds: Evaluating and Expanding New Carbon Technologies to Subsurface Habitats	Gary Matlock	29
Open Source ADMB Project	Michael Seki	33, 74
Optimizing Routine Ocean Current Measurements by the NOAA Fleet: Renewal for FY2017–2019	Patrick Murphy Donald Jones	36, 53
Pacific Enso Applications Climate (PEAC) Center	Raymond Tanabe	23, 61
Pacific Fisheries Monitoring Program	Michael Seki	15, 66
Pacific Islands Deep Sea Coral and Sponge Initiative	Michael Seki	17, 76
Pacific Islands Territorial Science Initiative	Michael Seki	4, 54
Pacific Tuna Fishery Data Management	Michael Seki	13, 79
Papahānaumokuākea Marine National Monument Monitoring and Research	Randy Kosaki	9, 70
PMEL-UH Ocean Carbon Project	Gary Matlock	18
Profiling CTD Float Array Implementation and Ocean Climate Research	Gary Matlock	32, 55
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
Research Support for Office of Ocean Exploration and Research: The Acoustic Dimensions of Ocean Exploration	David McKinnie	83, 87
Research Support for PMEL Earth-Ocean Interactions Program (EOI), Ecosystems Fisheries-Oceanography Coordinated Investigations Program (Eco-FOCI), and Carbon Research Program	Gary Matlock	44
Socioeconomics of Western Pacific Fisheries	Michael Seki	20, 67
Stock Assessment Research Program	Michael Seki	21, 69
Sustaining Healthy Coastal Ecosystems	Michael Seki	35, 78
Territorial Biosampling	Michael Seki	14, 72
Towards Advancing the MJO and 1–30-day Weather Forecasting in the Fully Coupled NNGPS[5]	Christopher Hedge	initial
Transferal of Pacific ENSO Applications Climate (PEAC) Center Products and Services to Weather Forecast Office (WFO) Honolulu	Raymond Tanabe	75
Tsunami Research and Modeling	Gary Matlock	46
University of Hawaii Sea Level Center	David Legler	22, 59, 82, 85
West Hawaii Integrated Ecosystem Assessment	Michael Seki	11, 62
Western Pacific Fisheries Information Network (WPACFIN)	Michael Seki	30, 48

Appendix III Visiting Scientists

DATE	NAME/AFFILIATION	PURPOSE OF VISIT
11/06/17- 11/09/17	Jayantha Obeysekera Chief Modeler South Florida Water Management District West Palm Beach, FL	To attend a SERDP project workshop in La Jolla, CA to assess impacts of sea level rise on military installations, in particular, to look at coastal installations in an urban environment and to visit the sites.
12/04/17 -12/06/17	Jeffrey Polovina Scientist (Retired) Kailua, HI	To participate in the Symposium on West Hawaii's Marine Ecosystem in Kona, HI and present research related to satellite sea surface temperature in the Kona region.
12/18/17- 12/20/17	Christopher Hunt Research Scientist University of New Hampshire Durham, NH	To install and instruct JIMAR/PIFSC scientists on UNH laboratory's total alkalinity flow-through system which is to be installed on board the NOAA vessel *Hi'ialakai* and used extensively for the Reef Assessment and Monitoring Program research cruise.
01/16/18- 01/19/18	Andrew Collins Research Scientist University of Washington Seattle, WA	To install and instruct JIMAR/PIFSC scientists on UW laboratory's partial pressure of carbon dioxide flow-through system which is to be installed on board the NOAA vessel *Hi'ialakai* and used extensively for the Reef Assessment and Monitoring Program research cruise.
03/12/18- 03/17/18	John Howard Choat Professor James Cook University Australia	To participate in a collaborative workshop with NOAA, JIMAR and UH scientists to assess the vulnerability of Pacific fish and invertebrate species to the impact of climate change in the region and to conduct fisheries research.
04/11/18- 04/16/18	Adam Young Project Scientist University of California, San Diego Scripps Institution of Oceanography La Jolla, CA	To participate in a field experiment at Kaneohe Marine Base as part of the SERDP project. Provided additional wave sensors and assistance with topographic surveys during the experiment.
04/30/18- 05/10/18	Pascale Lherminier Researcher, Physical Oceanography Laboratoire d'Oceanographie Physique et Spatiale France	To collaborate with colleagues at the University of Hawaii concerning the operation and processing of Shipboard ADCP current measurement methodologies in support of ongoing GO-SHIP and other climate monitoring ocean expeditions. Presented a seminar on the Atlantic Meridional Overturning Circulation-OVIDE-A25, a biennial hydrographic transect across the North Atlantic Subpolar Gyre since 2002.

05/19/18- 05/26/18	Jayantha Obeysekera Director, Sea Level Solution Center Florida International University Miami, FL	To attend the mid-project review meeting held in Santander, Spain, for Advancing Best Practices for the Analysis of the Vulnerability of Military Installations in the Pacific Basin to Coastal Flooding Under a Changing Climate.
05/21/18- 05/25/18	Santiago Herrera Assistant Professor Biological Sciences Department Lehigh University Bethlehem, PA	To participate in meetings and discussion about the results and future directions for the Pacific Islands Deep Sea Coral and Sponge Research Initiative.
05/22/18- 05/25/18	E. Brendan Roark Assistant Professor/Director of Environmental Programs Department of Geography Texas A&M University College Station, TX	To participate in meetings and discussion about the results and future directions for the Pacific Islands Deep Sea Coral and Sponge Research Initiative.
05/27/18- 06/02/18	Kristen McGovern Program Aide Texas A&M University Galveston, TX	To participate in field activities with the Hawaiian Monk Seal Research Program (HMSRP) staff and train the staff in the programming and safe deployment/retrieval of a specialized instrument designed to mount on marine mammals to track foraging behavior and how to recover the data once the instrument is retrieved.
06/08/18- 06/28/18	Joseph DiBattista Curator of Fishes Australian Museum Research Institute Sydney, Australia	To participate in a NOAA research cruise aboard research vessel *Oscar Elton Sette* to conduct fisheries research in the Northern Mariana Islands. Also to collaborate with JIMAR Territorial Biosampling project staff in researching the biology of coral reef fish of commercial value to the U.S. Pacific Islands and under federal evaluation.

Appendix IV Workshops, Meetings and Seminars

- **Nu‘a Kai (Piled Ocean): Record-breaking Honolulu Sea Levels and Future Implications**
  November 6, 2017, University of Hawaii at Manoa, Honolulu, HI
  Phil Thompson, PhD, Associate Director, UHSLC, University of Hawaii Sea Level Center, University of Hawaii at Manoa

- **Unraveling Life-history Variation in Coral Reef Fshes: It’s More Complex Than You Think**
  March 9, 2018, University of Hawaii at Manoa, Honolulu, HI
  Brett Taylor, PhD, JIMAR Fisheries Life History Biologist, NOAA, Pacific Islands Fisheries Science Center

- **Nesting Biology, Spatial Ecology and Genetic Characteristics of Hawksbill Marine Turtles**
  April 19, 2018, University of Hawaii at Manoa, Honolulu, HI
  Alexander R. Gaos, PhD, JIMAR MTBAP Marine Ecological Researcher, NOAA, Pacific Islands Fisheries Science Center

- **Feminization of Green Sea Turtle Foraging Aggregations in the Pacific: Establishing Foraging Ground Sex Ratios for Climate Change Research**
  April 26, 2018, University of Hawaii at Manoa, Honolulu, HI
  Camryn D. Allen, PhD, JIMAR MTBAP Biological Marine Researcher, NOAA, Pacific Islands Fisheries Science Center

- **OVIDE-A25, A Biennial Hydrographic Transect Across the North Atlantic Subpolar Gyre Since 2002: Overview of the Main Scientific Findings about the Variability of the Atlantic Meridional Overturning Circulation and Its Impact on the CO_2 Physical Pump**
  May 4, 2018, University of Hawaii at Manoa, Honolulu, HI
  Pascale Lherminier, PhD, Ifremer, Laboratoire d’Oceanographie Physique et Spatiale

NASA/JPL Ice Sheet System Model (ISSM) Sea-Level Science Workshop
June 11-12, 2018, Asia Room, Imin Conference Center, UH Manoa

Surendra Adhikari
Eric Larour
Alireza Bahadori
Indrana Das
Zhiling Xie
Licheng Geng
Yeontaek Choi
Fabian Schloesser
Astrid Strunk
Mohammad Chowdhury
Andrew Hoffman
Leanne Wake
Martin Rückamp
Emilia Jin
Kambiz Teimour Najad
Quang Wei
Hark-Soo Song
Hyuk Kang
Xuebin Zhang
Emily Schwans
Johnoel Ancheta
Philip Thompson
Eric Ivins
Lambert Caron
Gerald Bawden
Ben Hamlington

Appendix V JIMAR Personnel

Information as of June 30, 2018

Category	Number	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	23	0	0	0	0	23
Visiting Scientist	0	0	0	0	0	0
Postdoctoral Fellow	0	0	0	0	0	0
Research Support Staff	107	2	5	61	32	7
Administrative	10	0	0	7	2	1
Total (≥ 50% support)	**140**	**2**	**5**	**68**	**34**	**31**
Undergraduate Students	17	17	0	0	0	0
Graduate Students	11	0	0	11	0	0
Employees that receive < 50% NOAA Funding (not including students)	9	0	0	0	0	9
Located at Lab (include name of lab)	3-PMEL 120-PIFSC 2-ESRL 4-PMNM					
Obtained NOAA employment within the last year	2					
Postdoctoral fellows and students from subgrantees	Postdocs: 0 Students: 0					

Appendix VI Awards

Tomoko Acoba
- 2017 RCUH Employee of the Year, Researcher/Project Manager/Professional Category

Brittany Huntington
- 2018 NOAA PIFSC Team Member of the Year Award, Professional/Scientific/Technical

Alexandra Reininger
- Best Internship Paper Award and Anna Toy Ng Memorial Scholarship for presentation on her research with the NOAA Marine Turtle Biology and Assessment Program at the University of Hawaii Marine Option Program Symposium, April 21, 2018.

Jeremy Taylor
- 2017 NOAA PIFSC Team Member of the Year Award, Professional/Scientific/Technical

Supin Wongbusarakum
- 2017 NOAA PIFSC Team Member of the Year Award, Professional/Scientific/Technical

Kymberly Yano
- 2017 NOAA PIFSC Team Member of the Year Award, Professional/Scientific/Technical

Appendix VII Graduates

Marie Ferguson, Master of Science, Department of Oceanography, University of Hawaii at Manoa, "Explaining spatial variation in coral size structure in American Samoa"

Alejandro Ludert, PhD, Department of Atmospheric Sciences, University of Hawaii at Manoa, "Characterization of non-El Niño induced dry conditions across the U.S. Affiliated Pacific Islands"

Jonathan Sweeney, PhD, Economics, University of Hawaii at Manoa, "Policy evaluation, production decisions, and Hawaii's longline fishery"

Appendix VIII Publication Summary

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

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

Appendix IX Progress Reports for Associated Awards

International Ecosystem Approach to Fisheries Management (IEAFM) Project—(Philippines) Cooperative Agreement No. NA17NMF4320250 Reporting Period 10/1/17–6/30/18

P.I.: Douglas S. Luther [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: $163,746

NOAA Goal(s):

- Healthy Oceans

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. In FY 2018, the project's main objectives were to provide scientific expertise and technical assistance to the governments and key country partners in the Philippines to implement ecosystem approaches in sustainable fisheries management. With the IEAFM project ending in July 2018, the project successfully completed all activities with planned deliverables for the Philippines. The overall 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.

Progress during FY 2018

During the project year, the JIMAR IEAFM team staff continued to serve 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 EAFM. Key accomplishments for the Philippines missions are as follows.

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

Provided technical assistance and advisory support on EAFM mainstreaming, developed and implemented an EAFM Plan at a priority BFAR demonstration site, Philippines. In line with the Philippines Bureau of Fisheries and Aquatic Resources (BFAR) efforts to mainstream EAFM throughout the Philippines, an EAFM Planning and Implementation workshop was conducted in November 2017 for the fisheries management unit (FMU) of the Visayan Sea. The JIMAR IEAFM team leader participated in the workshop and provided technical support to the BFAR team and the coordinating local non-governmental organization, Oceana Philippines. This ensured a successfully conducted EAFM planning and implementation workshop and facilitated the development of a draft fisheries management plan for the Visayan Sea FMU.

This workshop followed a series of JIMAR and NOAA supported Essential EAFM training workshops and other pilot EAFM planning and implementation workshops with participation of stakeholders from different provinces in the Philippines. The outcomes of these workshops include a better understanding and use of EAFM as a holistic tool for fisheries management among the participants from the Visayan area, as well as enhanced technical knowledge and skills among the BFAR and local workshop organizers and facilitators. Longer-term outcomes as a result of this workshop could include the implementation of the EAFM plan and improved fisheries management in the Visayan Sea, which addresses key identified issues to strive for balancing ecological health with human well-being through good fisheries governance. The EAFM outcomes in Visayas contribute to accomplishing a national mandate that requires all activities of BFAR be developed and implemented following EAFM principles, including developed EAFM plans adopted by all stakeholders in the entire country.

Figure 1. IEAFM team staff presenting the project outputs to DA-BFAR Regional Directors in Quezon City, Philippines, April 25–27, 2018.

The following deliverables were produced by the JIMAR IEAFM team staff for use by its regional partners and constituents.

- Conducted multiple presentations during the EAFM Planning and Implementation workshop to help guide the development of different sections in the EAFM management plan. The presentations included one that synthesized participant concerns and capabilities, what/why of EAFM, and foundations of sustainable livelihoods in fisheries. Staff also facilitated the plenary discussions on management objectives and actions, monitoring and evaluation, and served as the lead facilitators for the human well-being working group throughout the workshop.
- Developed materials on mainstreaming EAFM through planning and implementation process. These include a handbook, workbook, toolkit document, and a brochure. These can be found on the Philippines' Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR) website, www.bfar.da.gov.ph/PUBLICATIONCAPTUREDIVISION.jsp.
- A JIMAR IEAFM team staff member served as an invited resource to support the development of EAFM management plan draft, which continues to be revised by BFAR Region 6 and Oceana Philippines.

Developed projections of future impacts to Philippines fisheries and marine biodiversity due to ocean variability and change. During the reporting period, the project focused on completing the analyses of projected changes in suitable habitats for top commercially important marine fish species of the Philippines and producing manuscripts and reports for publication. The habitat suitability projections were based on information on global species occurrence data supplemented with data from the Philippines' National Stock Assessment Program. Future changes were assessed utilizing available high-resolution regional climate model outputs of ocean changes in Philippine seas up to the year 2100. Project outputs were used by DA-BFAR in the on-going delineation of the Philippines' Fisheries Management Areas and the development of a climate change and disaster risk reduction

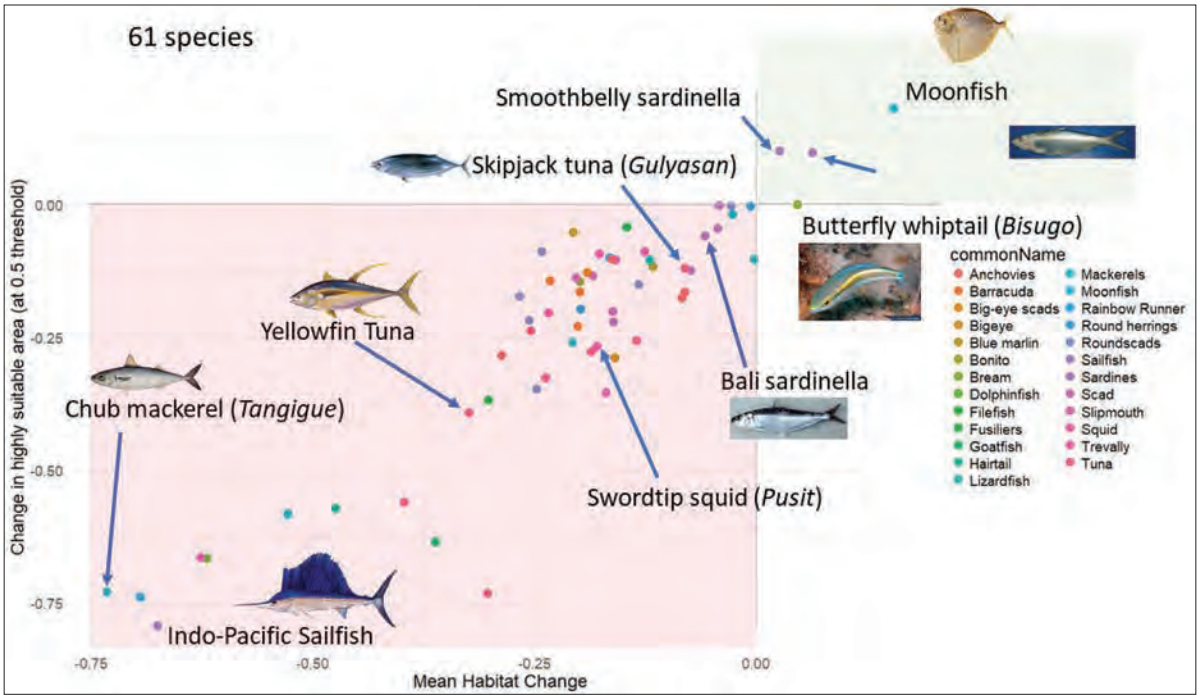

Figure 2. Results of suitable habitat change analyses for the Philippines' 61 top commercial marine fishes show changes in the areas of highly suitable habitat (y-axis) and average habitat suitability change per unit area (x-axis). Upper-right quadrant shows species that would "benefit" from projected changes in ocean conditions while those on the lower-left quadrant are species that would experience fewer suitable areas and declines in suitability of remaining areas. Names in parentheses are local fish names.

and management for fisheries development framework. JIMAR IEAFM staff facilitated and participated in three workshops organized by DA-BFAR, and produced two publications and a final report in the form of a map compilation booklet, which will be published by DA-BFAR.

Deliverables produced by the JIMAR IEAFM team under this research focus include the following.

- JIMAR IEAFM team staff member (Rollan Geronimo) served as an invited participant to DA-BFAR's "Stakeholders Consultation/Workshop on the Demarcation of Fisheries Management Areas, Reference Points and Harvest Control Rules—Luzon Cluster" (November 2017). He provided inputs into the delineation of the Philippines' fisheries management areas based on the identification of core fishing areas using the Visible Infrared Imaging Radiometer Suite (VIIRS) boat detection data.
- In January 2018 JIMAR staff presented a summary of climate change impacts on tuna for DA-BFAR's workshop on the "Development of General Guidelines for Incorporating Climate Change Impacts on the Management of Highly Migratory Fish Species".
- In April 2018 JIMAR staff organized and facilitated a final feedback workshop with DA-BFAR director, regional directors, and regional technical staff.
- A paper entitled, "Climate-induced vulnerability of fisheries in the Coral Triangle: Skipjack tuna thermal spawning habitats", was accepted for future publication in the *Journal of Fisheries Oceanography*.
- A paper entitled, "Mapping fishing activities and suitable fishing grounds using nighttime satellite images", was submitted to the journal *Remote Sensing of Environment*.
- A report is currently under development on "Projected Impacts of Climate Change on Philippine Marine Fisheries", providing maps of suitable habitat changes for 60 top commercial marine fish species.

Peer-to-Peer Learning Exchange, Philippines. During the project year, the IEAFM team developed and shared a comprehensive report from the peer-to-peer exchange "Ecosystem-based Fisheries Management and Conservation: A Partnership in Governance, Management, Science and Enforcement" held between the U.S. and Philippines governments during June 26–30, 2017, in Honolulu, Hawaii. Supported by the U.S. Agency for International Development (USAID), NOAA agencies (Pacific Islands Fisheries Science Center, Pacific

Figure 3. EAFM Planning and Implementation workshop for the Visayan Sea workshop in Bacolod City, Philippines, November 20-23, 2017. JIMAR's Supin Wongbusarakum (seated second from the right, front row) and BFAR/USAID/NOAA coordinator Alett Nunez (seated third from the right, front row) both served as facilitators, presenters and resources.

Islands Regional Office, and Office of Law Enforcement), and in partnership with the Philippines DA-BFAR and Philippines Department of Natural Resources, Biodiversity Management Bureau (DENR-BMB), this effort focused on exchanging useful learning points in governance, management, science applied to management, and enforcement experiences and approaches. The extensive report includes highlights from many presentations, discussions, and site visits, as well as next steps and recommendations for future such exchanges.

In addition, because the exchange fostered relationships between leaders and high level practitioners in fisheries and marine resource management, and science and enforcement agencies from the governments of the Philippines and the U.S., the JIMAR IEAFM team provided further assistance by following up on engagements between the different groups and synergies. The team provided a platform for subsequent exchanges between NOAA and the Philippines and Indonesian agencies.

Provide technical assistance and guidance to support DENR-BMB biodiversity awareness raising, education and outreach using Autonomous Reef Monitoring Structures (ARMS), Philippines. Based on organisms collected from Autonomous Reef Monitoring Structures (ARMS) in the Philippines, a report was developed as a field guide for an array of Philippines' cryptic marine invertebrates and used by the Philippines DENR-BMB in Hands-on-ARMS outreach events during the Month of the Ocean in May 2018. This field guide was published as a NOAA PIFSC Special Publication and will be used for future outreach as well.

The goal of this outreach field guide is to help non-taxonomists and citizen scientists learn about and make basic identifications of motile cryptofauna using example images from organisms > 2 mm in size collected from ARMS at Verde Island Passage. The identifications within the guide are presented at the phylum to family levels, and include the common names of representative organisms collected and imaged from the ARMS. The guide further includes general Philippine biodiversity, threats and potential climate change and ocean acidification impacts, as well as information about ARMS methods.

Publications

- Moews-Asher, M., C. Castor, K. Reardon, and M. Timmers, 2018. Field guide to cryptic marine invertebrates of the Philippines: A sample of biodiversity from Autonomous Reef Monitoring Structures. NOAA Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-18-004, 86 pp.

Cetacean Research Program—Monitoring in the Mariana Islands Range Complex
Cooperative Agreement No. NA17NMF4320293
Reporting Period 10/1/17–6/30/18

P.I.: Douglas S. Luther [JIMAR Project Lead: Marie Hill]

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

NOAA Sponsor: Michael P. Seki, Erin Oleson

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 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 by working to accomplish these objectives. Visual surveys are 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 are being integrated into the Navy-wide Integrated Comprehensive Monitoring Program (ICMP).

Figure 1. Humpback whale calf breaching off the west side of Saipan (collected under permit; photo M. Hill).

Figure 2. Rough-toothed dolphin encountered north of Saipan at Marpi Reef (collected under permit; photo A. Bradford).

Progress during FY 2018

During February 2018 the CRP conducted 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 winter surveys of 2015–2017. The collection of biopsy samples and photo-identifications is vital to determine the breeding population to which they belong. Small boat surveys were conducted off Saipan during 14–28 February. There were a total of twelve encounters with four cetacean species including humpback whales, rough-toothed dolphins (*Steno bredanensis*), bottlenose dolphins (*Tursiops truncatus*), and spinner dolphins (*Stenella longirostris*). Photographs confirmed that the field team encountered fifteen humpback whales including three mother-calf pairs. Biopsy samples were collected from six humpbacks including two mothers, and fluke images were collected from ten humpbacks. Humpback whale photo and biopsy data collected by the CRP are used in a collaborative project with international partners from Russia, Japan, the Philippines, and U.S. to investigate the connections of Mariana Islands humpback whales to other breeding and feeding locations.

In October, the JIMAR CRP Program Lead gave an oral presentation on the CRP humpback whale research in the Mariana Islands at the 22nd Biennial Conference on the Biology of Marine Mammals, held October 22–27, 2017 in Halifax, Nova Scotia.

Publications

- Merkins, K.P.B, D. Mann, V.M. Janik, D. Claridge, M.C. Hill, and E. Oleson, 2018. Clicks of dwarf sperm whales (*Kogia sima*), Marine Mammal Science Journal, doi.org/10.1111/mms.12488.
- Hill, M.C., A.L. Bradford, A.D. Ligon, A.C. Ü, and E.M. Oleson, 2018. Cetacean monitoring in the Mariana Islands Range Complex, 2017. PIFSC Data Report, doi.org/10.7289/V5/DR-PIFSC-18-002.

Presentations

- Hill, M., A.L. Bradford, A.D. Ligon, A.C. Ü, C.S. Baker, D. Steel, J. Rivers, R.K. Uyeyama, and E.M. Oleson, 2017. Discovery of a Western North Pacific Humpback Whale (*Megaptera novaeangliae*) wintering area in the Mariana Archipelago. 22nd Biennial Conference on the Biology of Marine Mammals, Halifax, Nova Scotia, October 22-27, 2017.

Marine Turtle Nearshore Assessment in the Marianas Islands
Cooperative Agreement No. NA17NMF4320294
Reporting Period 10/1/17–6/30/18

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

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

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

Budget Amount: $191,000

NOAA Goal(s):

- Healthy Oceans

Purpose of the Project

The main objective of the Marine Turtle Biology and Assessment Program (MTBAP) project is to obtain population assessments of green and hawksbill sea turtles in the Mariana Islands. Joint Institute for Marine and Atmospheric Research (JIMAR) researchers in the MTBAP conduct marine turtle in-water and nesting surveys throughout the Marianas Archipelago.

The MTBAP strives to increase understanding of marine turtle biology and ecology in support of management needs and species recovery goals, as mandated through the U.S. Endangered Species Act (ESA) and other federal statutes. The research work includes understanding the potential impacts of anthropogenic sound on the foraging ecology and behavior of marine turtles at sea. Such research requires technology that can be safely mounted and recovered from turtles, and can withstand the harsh marine environment (salt water, pressure at depth, percussive damage, etc.).

The U.S. Navy developed the following monitoring questions for the Mariana Islands Training and Testing (MITT) study area as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973.

• What are the occurrence, habitat use, and population structure of sea turtles in the MITT study area?
• What is the exposure of cetaceans and sea turtles to explosives and/or sonar in the MITT study area?

These MITT questions outline the scope of monitoring that the MTBAP and JIMAR will undertake to understand marine mammal and sea turtle distribution and, ultimately, the impacts from Navy training and testing. In the reporting year, the project is committed to capture, tag, and track sea turtles in the MITT to better understand sea turtle distribution, movements, population structure, and abundance in this region. The Pacific Islands Fisheries Science Center (PIFSC) and JIMAR plan to tag up to 300 sea turtles in the Mariana Islands with a combination of metal alloy flipper tags and sub-dermal Passive Integrated Transponder (PIT) tags. Additionally, up to 20 of these turtles will be affixed with satellite biotelemetry tags. JIMAR will further analyze the capture data and tracking information and provide summary

Figure 1. JIMAR Marine Biological Researcher Dr. Camryn Allen (right) and PIFSC Research Ecologist Dr. Summer Martin arrived in Guam with all of the equipment and supplies required to capture and sample thirty-four sea turtles during their two weeks of field work in the Mariana Islands.

reports. The results of this analysis are anticipated to provide information on the seasonal use of the MITT by these species. Used in concert with additional survey data in the Marianas, in particular, aerial surveys provided by Guam Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR) and in-water towed diver surveys provided by PIFSC, the data can inform on the spatial distribution and relative abundance of sea turtle populations locally. Study objectives are driven by the specific questions outlined in the MITT monitoring plan.

Figure 2. In October 2017, JIMAR Marine Biological Researcher, Dr. Camryn Allen opportunistically provided educational outreach to the local public in Saipan upon returning to shore following sea turtle capture.

Progress during FY 2018

The project accomplished its core research objectives including: 1) collected and managed biological samples; 2) conducted educational outreach; 3) participated in field capture of marine turtles within the Mariana Islands; 4) organized existing databases from aerial and in-water tow board surveys obtained through ongoing partnerships with PIFSC programs and territorial agencies; 5) continued research on the general biology, life history, and ecology of sea turtles in coastal marine habitats and on nesting beaches; and 6) participated in the planning, preparation, and data analysis/reporting of annual nesting beach field work within the Mariana Islands. Dr. Camryn Allen (JIMAR Supervisor, Marine Biological Researcher) participated in a field research trip to the Mariana Islands in October 2017. Though permitted to tag all species encountered, only green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles have been tagged to date. The field team captured twenty-four green and hawksbill sea turtles during this trip and eighteen turtles were outfitted with satellite tags to monitor movement and migration to understand habitat use. All turtles were sampled for skin and blood for genetic origin and sex ratio studies. Dr. Alexander Gaos (JIMAR Marine Ecological Researcher) worked with the electronic tag manufacturer Customized Animal Tracking Solutions (CATS) to develop an archival acoustic-video tag that has the ability to record sound underwater (i.e., hydrophone) and record video data, which in concert will allow for the evaluation of turtle response to noise and how noise may impact foraging ecology and behavior. Other data the tags will record include location, three-dimensional movement, velocity, and depth to help understand habitat use, energetic cost and other components vital to understanding the ecology of the taxon. The CATS tags will incorporate both acoustic and very high frequency (VHF) tracking devices that will help locate turtles when submerged or at the water's surface, respectively, in order to ensure recovery of the deployed CATS tags. The VHF and acoustic transmitters and tracking equipment were acquired in May 2018 and then subsequently shipped to the manufacturer to be fitted for the archival acoustic-video tag. The archival acoustic-video tag fitting will be underway during July 2018. Dr. Gaos also analyzed telemetry data for the Navy MITT annual report to understand sea turtle movements in relation to temperature and depth.

Publications

- Allen C.D., S.L. Martin, J.M. Lynch, T.M. Summers, J. Hapdei, M. Rice, J.A. Seminoff, and T.T. Jones, 2017, How many males are enough? Feminization of green sea turtle foraging aggregations in the Pacific. Conference Proceedings of the International Society for Wildlife Endocrinology, August 14-16, 2017, Orlando, FL.
- Martin S.L., A.R. Gaos, and T.T. Jones, 2018, Sea turtle tagging in the Mariana Islands Training and Testing (MITT) study area. PIFSC Data Report DR-18-001, doi.org/10.7289/V5/DR-PIFSC-18-001.

Multi-model Seasonal Sea Level Forecasts for the U.S. Coast
Cooperative Agreement No. NA17OAR4310110
Reporting Period September 1, 2017–May 31, 2018

P.I./Co-P.I.: Gary T. Mitchum, Mark Merrifield/Matthew J. Widlansky, Philip R. Thompson, H. Annamalai

NOAA P.I./Co-P.I.: Arun Kumar/William V. Sweet, Eric Leuliette, John J. Marra

Purpose of the Project

- Exploring the processes responsible for sea level variability on monthly to interannual timescales in the Pacific, Atlantic, Gulf of Mexico, and Caribbean coastal regions.
- Processing sea level forecasts from operational as well as experimental modeling frameworks to develop a prototype ensemble seasonal prediction system for coastal sea level anomalies.
- Using the multi-model prediction system to provide monthly outlooks for seasonal sea level anomalies across the Nation.

Progress during FY 2018

Summary of project activities

The primary activities during Year 1 were to set up the research infrastructure and collaborative platforms needed to produce and then assess multi-model seasonal sea level forecasts. The project began with an explorative assessment of observed recent sea level variability. An archive of retrospective forecasts was built using sea surface height data made available from multiple modeling groups, which was assessed against observations. A coupled ocean atmosphere General Circulation Model (GCM) was configured, which will be used throughout the project to conduct sensitivity experiments, as well as to support seasonal forecasting efforts. These activities were organized across the team (University of Hawaii [UH], NOAA, and University of South Florida [USF]) mostly via web meetings. Collaborative efforts have mostly centered on organizing the Marine Prediction Task Force (MPTF; NOAA-MAPP), for which the project has taken a lead role.

Studies of recent extreme sea level events (e.g., high sea levels around Hawaii during 2017; Yoon et al. in press) informed on the oceanic and atmospheric processes associated with seasonal sea level variability (Fig. 1a). Regional focus has so far been on the tropical Pacific, although all observations and modelling data on a global-basis are being archived, which will support the planned analyses of sea level variability and predictability along the U.S. East and West Coasts. Successfully forecasting future seasonal sea level variability may provide enhanced information about the threat of coastal flooding, especially in the context of other climate phenomena that affect sea level or waves (e.g., tropical cyclones; Widlansky et al. in review). A postdoc was recruited (Xiaoyu Long, Ph.D. from North Carolina State University) and joined UH in December 2017. The postdoc has been designing ocean-only GCM sensitivity experiments to diagnose the mechanisms associated with sea level variability. This modeling experience will support setting up the forthcoming ocean-data assimilation and forecasting simulations. At USF, a Ph.D. level research associate has been assigned to this project half-time to focus on applying sea level forecasts along the Gulf of Mexico and Atlantic U.S. Coasts.

Recent seasonal sea level anomalies

Since the end of strong El Niño during early 2016, neutral or weak La Niña conditions have occurred. Sea level anomalies during 2017 (Fig. 1b) have generally been below-normal in the equatorial Pacific and above-normal in the tropical northern Pacific, especially around Hawaii. The tide gauge in Honolulu observed the highest hourly water level during August 2017, since records began in 1905, along with multiple high-water events throughout the year (Yoon et al. in press). Along the U.S. Mainland Coast, 2017 annual mean sea levels measured by satellite altimetry were mostly close to normal, if the long-term sea level rise trend is ignored. Such sea level patterns were discussed in the "2017 State of the Climate Report" (Thompson et al. in press), as well as the seasonal differences throughout the year (e.g., high sea levels in the tropical northern Pacific propagated from east to west, with phase speeds increasing with latitude, consistent with oceanic Rossby wave dynamics). Compared to the average monthly sea level variability (Fig. 1a), the largest 2017 sea level anomalies mostly occurred in regions where they are expected (e.g., in the near-equatorial northern Pacific as well as the central Gulf of Mexico; Fig. 1b). Perhaps the most unusual sea level pattern consisted of positive anomalies in the tropical northern Pacific between Hawaii

and Mexico—a region of typically low variability. Considering only satellite altimetry data, monthly sea level variability is also low immediately along the North American Coast compared to offshore, as was observed during 2017. The project began to explore the large-scale, satellite-measured, sea level variability in comparison to the shore-based tide gauge network observations.

Scientific findings

The leading mechanisms of recent extreme sea levels around Hawaii were diagnosed (Long et al. in preparation) as part of Objective #1 (understanding sea level variability processes). After strong El Niño events, sea levels typically rise in the northeastern Pacific near the coast; however, 2016/17 was unique that high sea levels extended westward into the tropical northcentral Pacific (Figs. 1b and 2). Compared to 1998/99 (i.e., after the previous strong El Niño), surface winds were more favorable for westward-propagating high sea levels to either amplify, or at least not dissipate rapidly. Specifically, in the tropical northeastern Pacific, there was more Ekman pumping during 2016 compared to 1998 (Fig. 2). Interestingly though, in a multi-year sense, the wind-stress curl patterns

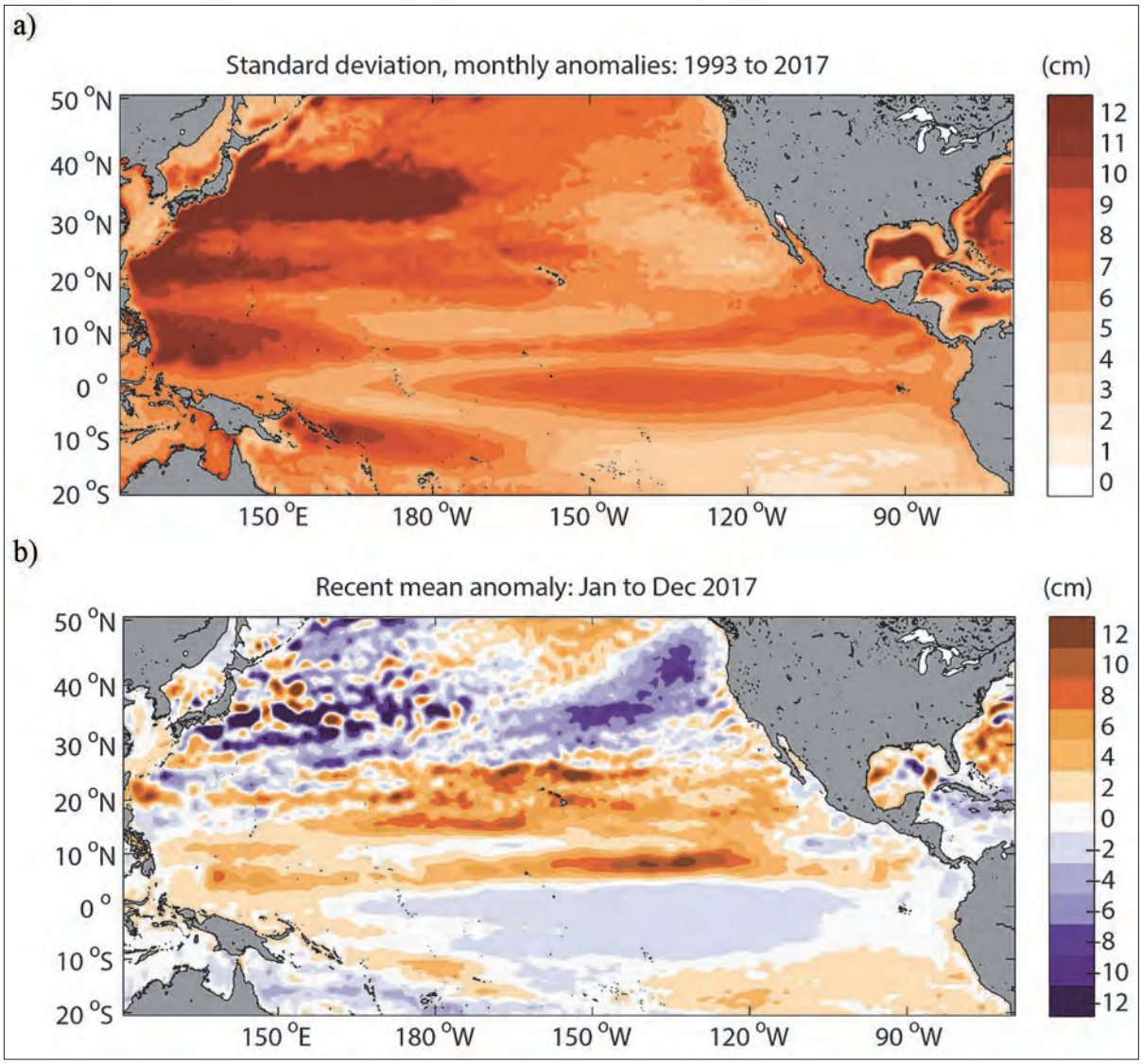

Figure 1. Observed standard deviation of monthly sea level variability (a; 1993–2017) and the average of monthly anomalies during 2017 (b). Sea level anomalies are computed from AVISO/CMEMS gridded satellite altimetry plus dynamic atmospheric correction with respect to the 1993–2017 climatology. The long-term (1993–2017) linear trend has been removed.

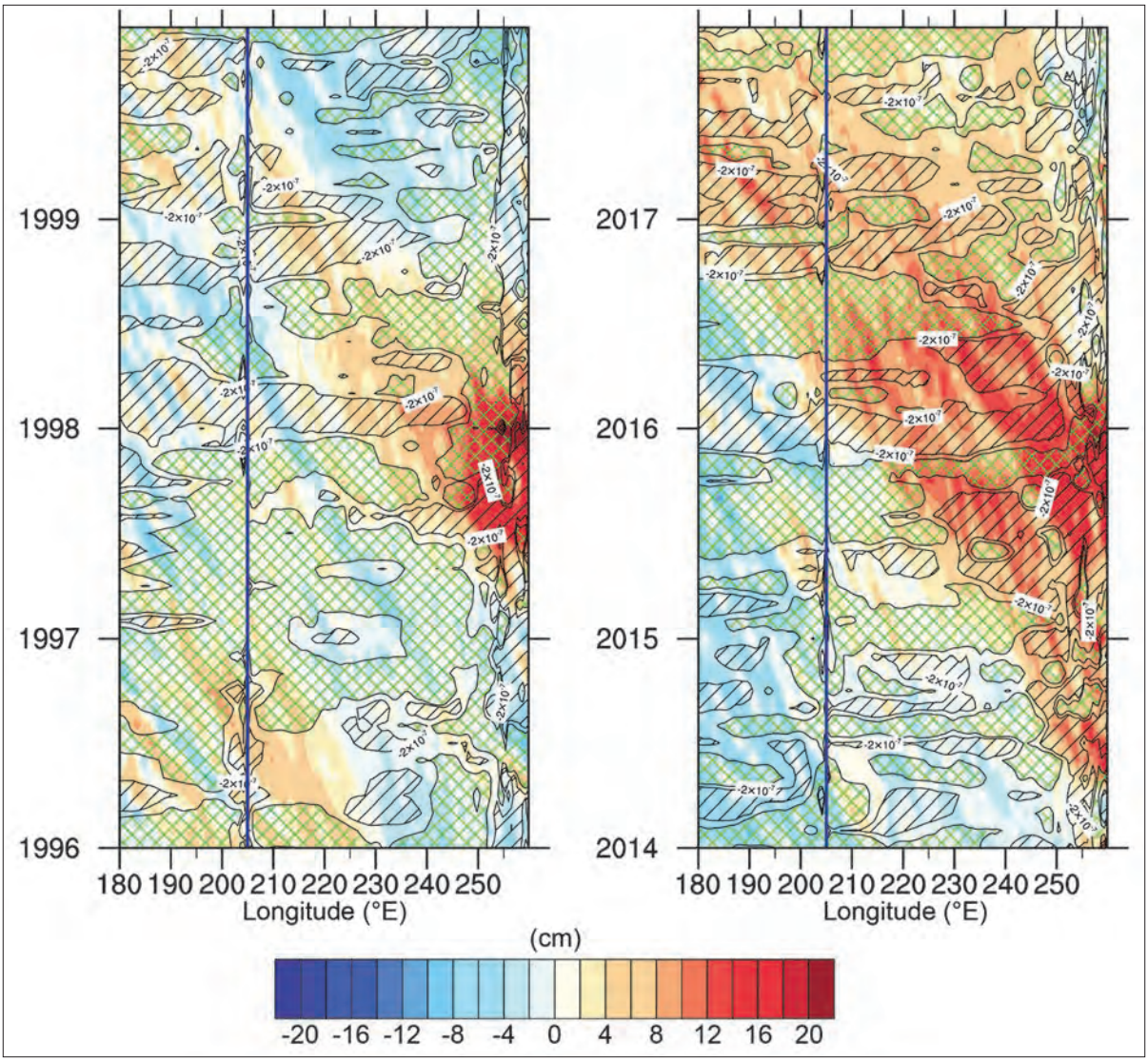

Figure 2. Longitude-time plots of observed monthly sea level anomalies (shading) and windstress curl (black: negative-anticyclonic-Ekman pumping; green: positive-cyclonic-Ekman suction) in the tropical northeastern Pacific (14°N–23°N). The long-term linear trends are removed. Conditions before and after the recent two strongest El Niño events are shown (left: 1996–1999; right: 2014–2017). The longitude of Hawaii is indicated (blue line).

were not especially distinct (1998/99 vs. 2016/17 averages; not shown). The long duration of the recent high sea levels, which began during the weak 2014 El Niño, is another distinction that is being explored as it may relate to the high sea levels that occurred two years later around Hawaii.

The observed sea level variability around Hawaii was successfully simulated using an ocean-only GCM (POP2 model, which is the ocean component of the NCAR CESM1 model that will be used to conduct seasonal forecasting experiments) with prescribed atmospheric forcing (1979–2017). Recent simulation years are shown in Fig. 3 (left) as a longitude-time cross section of the tropical northeastern Pacific. Success of the control experiment (all momentum and heat fluxes from the atmosphere included) at simulating the timing of observed high sea levels (Figs. 2-right versus 3-left), which began in 2016, is a non-trivial result itself. Simpler models (e.g., resolving oceanic planetary wave dynamics but not thermodynamics) do not simulate the sea level variability around Hawaii well, which suggests that multiple processes are involved.

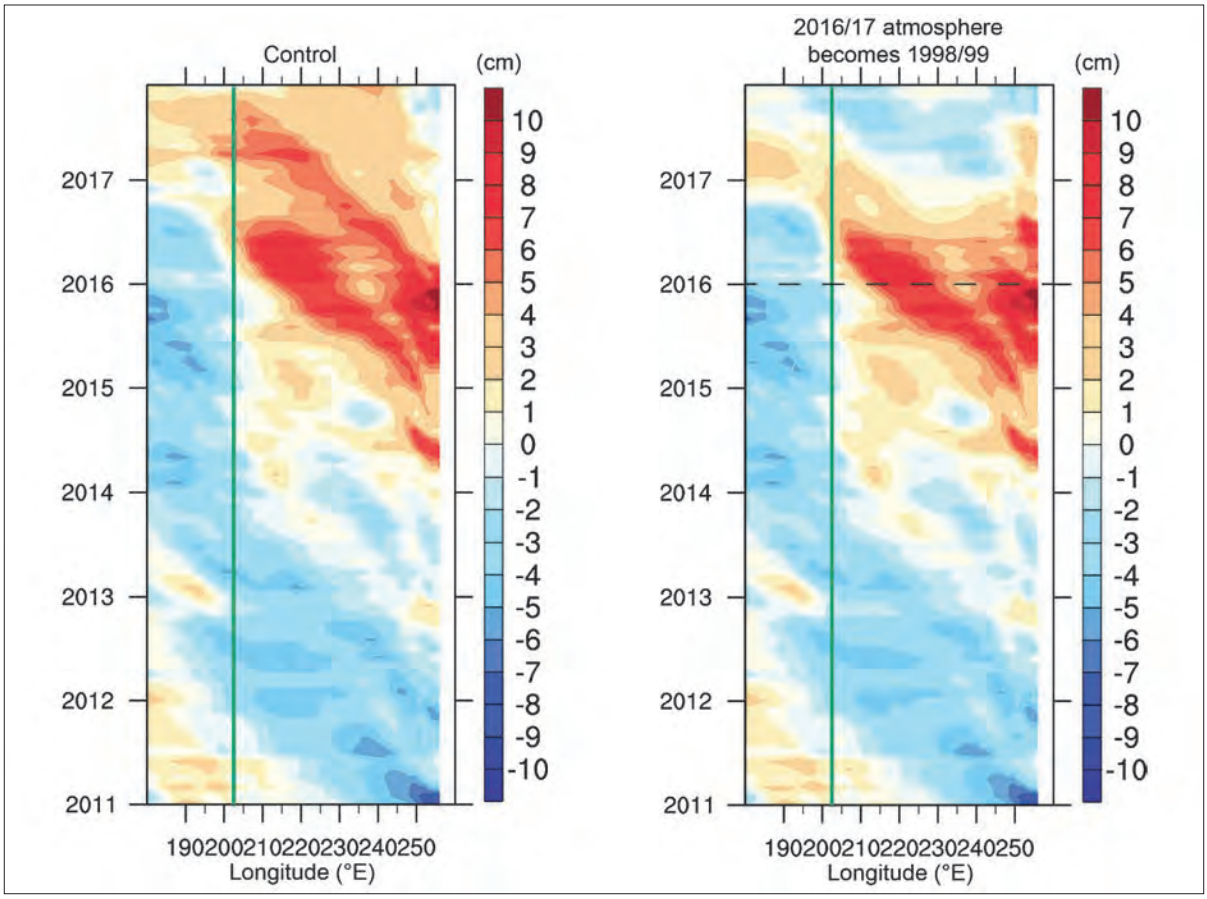

Figure 3. Longitude-time plots of simulated monthly sea level anomalies in the ocean-GCM (POP2 model) for the tropical northeastern Pacific (14°N–23°N) with prescribed atmospheric conditions from before and after the recent strong El Niño event (left). On the right, the atmospheric forcing is changed after the peak of El Niño (dashed line: 2016–2017 becomes 1998–1999). The longitude of Hawaii is denoted by the green lines.

Using the ocean-GCM, a series of sensitivity experiments were performed by changing the atmospheric forcing during specified times and regions. One key result is that the 2017 Hawaii high sea levels are almost entirely diminished when the 2016/17 atmosphere is replaced with 1998/99 conditions (Fig. 3, right). The project is currently quantifying the relative roles of momentum (e.g., more Ekman suction during 1998) and thermodynamic (e.g., less evaporative cooling during 2016) fluxes in determining the regional sea level. Clearly, the atmospheric conditions after El Niño seem important in determining the extent and magnitude of high sea levels in the tropical northeastern Pacific. The understanding of the sea level variability mechanisms is being used to design assessments of the proposed multi-model seasonal prediction system.

In real-time, as part of the multi-model seasonal forecasting for tropical Pacific islands product, CFSv2 was found to be able to correctly forecast many aspects of the Hawaii high sea level event (Fig. 4). CFSv2 did especially well forecasting the large-scale prolonged high sea levels, which could be attributed to the model resolving the westward-propagating oceanic Rossby wave. CFSv2 did less well depicting month-to-month variability, which near Hawaii, is strongly influenced by mesoscale oceanic eddy activity.

Note that CFSv2 performed poorly during 2015 and early 2016 (when sea level was first rising around Hawaii). CFSv2 had a cold bias in the tropical Atlantic Ocean during that time (Fig. 4), which NOAA-CPC attributed to a bug in the coupling procedure after ocean-data assimilation. The bug seems to have negatively affected forecast performance as far away as the central Pacific. Building a multi-model ensemble (Objective #2) should help to buffer the seasonal sea level forecasts against any such future individual model errors, although careful real-time monitoring will continue to be necessary.

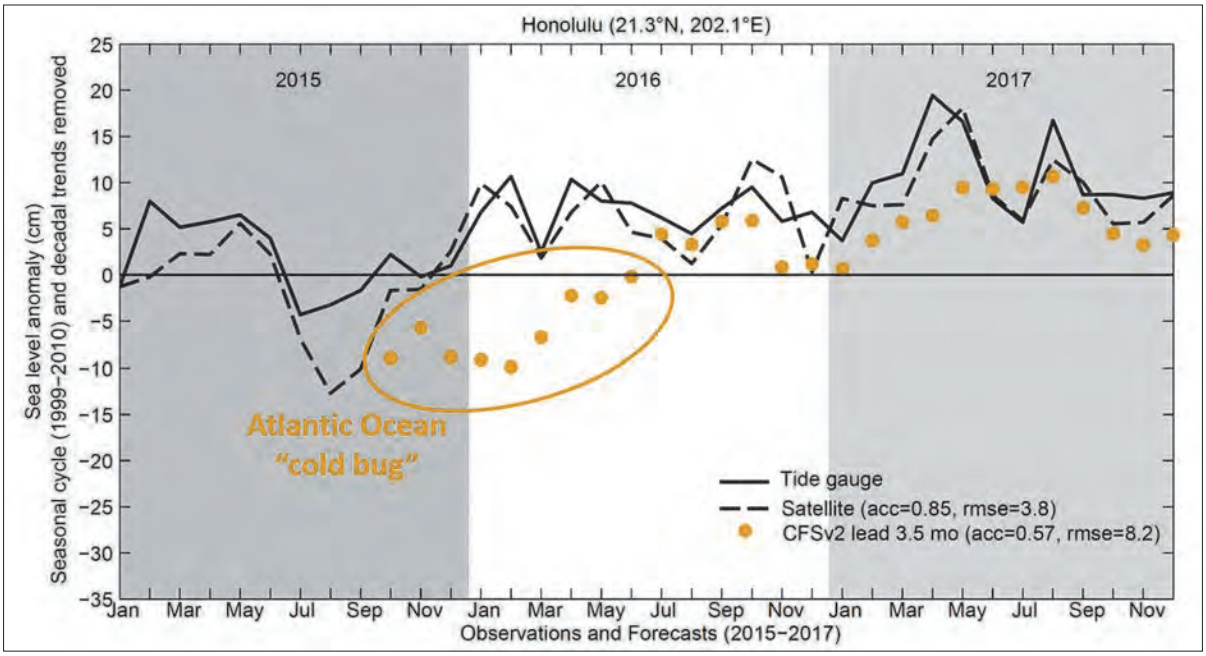

Figure 4. Observations (black: tide gauge and regional satellite altimetry average) and real-time forecasts (orange: CFSv2, 3 month lead) of monthly sea level anomalies around Honolulu, Hawaii. Statistical post-processing is applied to remove long-term model drift (Widlansky et al. 2017). The forecasts that may be negatively affected by a cold bias in the tropical Atlantic Ocean are circled.

Forecasting system developments

Developing a prototype ensemble seasonal prediction system for coastal sea level anomalies (Objective #2) is a two-part process—utilizing experimental GCM simulations as well as operational forecasts—both of which have begun. Developing the GCM experimental approach is primarily a technical challenge (i.e., testing computing configurations). Archiving output from operational forecast systems is mainly a logistical challenge (i.e., coordinating with multiple modeling groups to obtain sea surface height output).

The Coupled Ocean-Atmosphere GCM (CESM1) was configured to run on a High Performance Computer at UH. Shared (free) computing time has so far been sufficient for testing purposes, although a dedicated multi-core computing node will be leased to run the many planned retrospective forecasts. For horizontal resolutions, the proposed design (~1° latitude x longitude ocean, 2° atmosphere) was followed, which is proving efficient (~7 model years per 1 wall-clock day). Initially, an ocean anomaly assimilation approach will be used, following previous successful seasonal-to-decadal prediction efforts (Chikamoto et al. in preperation). The modeling configuration also permits ocean-only simulations with targeted forcings, which is an addition to the proposed research. Such experiments have already been used to diagnose the mechanisms of seasonal sea level variability around Hawaii.

The project archived sea surface height output from six models participating in the North American Multi-Model Ensemble (Table 1). Monthly mean data from each retrospective forecast and for all available leads (typically 10 to 12 months) has been obtained. A preliminary retrospective skill assessment of each model considered individually was completed (e.g., Fig. 5). It was found that forecast skill varies amongst models, regions, and target seasons although, in general, Pacific sea levels are better predicted than in the Atlantic. In some regions, monthly sea level anomalies are highly persistent (e.g., tropical northeastern Pacific). The archive is configured to support a forthcoming multi-model assessment (e.g., varying how much each model is weighted, either temporarily and/or spatially).

Assessment of the sea level variability along the U.S. Gulf of Mexico and East Coasts, as resolved by GCMs with ocean-data assimilation (Fig. 6), suggests that the models capture some aspects of the large-scale pattern, although major biases exist. The modeling deficiencies that will need to be addressed were discussed in the proposed research plan. For example, the correlation between monthly sea level anomalies recorded by the Key

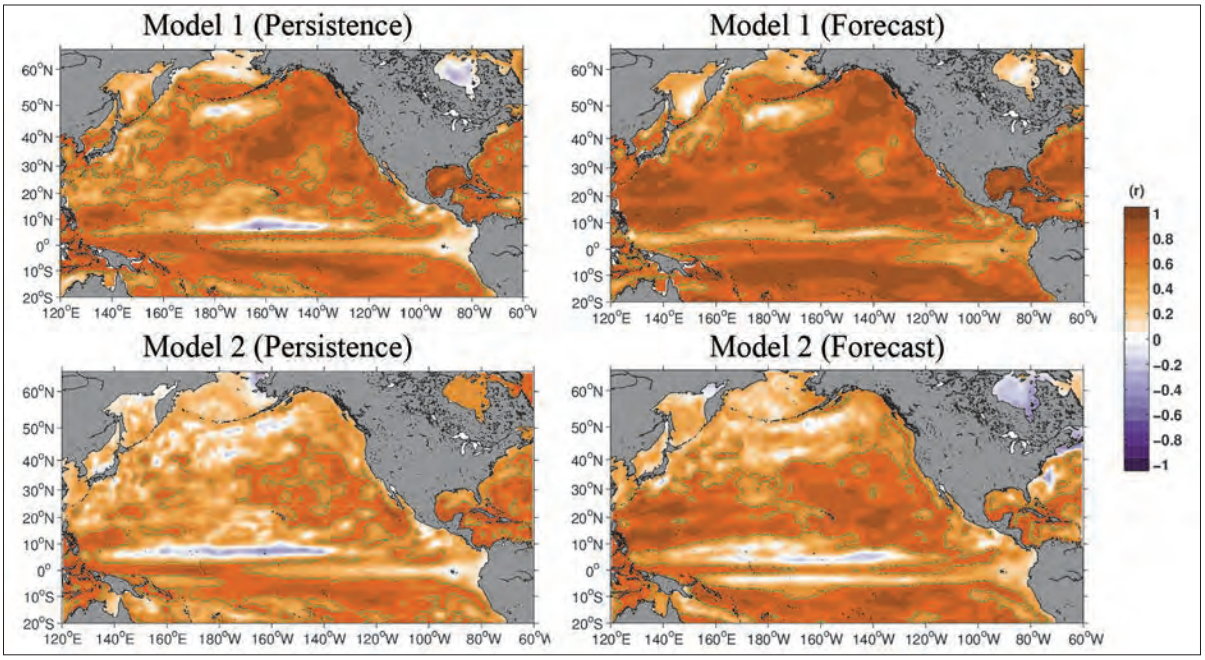

Figure 5. Persistence (left) and retrospective (right) forecast skills from two models participating in the NMME project as measured by anomaly correlation (r) at a 3-month lead for January start times (1982–2014). The forecasts are compared to sea surface height from the model assimilation run with the long-term linear trend removed. The r = 0.6 contour (36% variance explained) is outlined.

Table 1. List of archived models and retrospective forecasts of monthly sea surface height (> 2 TB of data).

Model	Years	Starts per month	Lead (months)
CanCM3	1981–2012	10	12
CanCM4	1981–2012	10	12
CCSM4-UM	1982–2015	10	12
CESM1	1980–2010	10	12
CFSv2	1981–present (real-time forecasts)	~24, 4×daily pentad (~120, 4×daily)	10
GFDL-FLORB01	1980–2014	10	12

West tide gauge, compared to the CFSv2 analysis (lead 0), is negative; suggesting a systematic bias or error affecting simulation of the nearby Gulf Loop Current. Yet, the CFSv2 model resolves how sea levels along the East Coast vary in-phase with those around Key West; a pattern mostly similar with satellite altimetry measurements although there are clearl model errors in the Gulf of Mexico and Caribbean Sea (Fig. 6). Consistent large-scale spatial correlation patterns are promising in regards to supporting the proposed statistical transformations from coarse resolution simulations to high-resolution observations (Objective #3), which seems be a critical need to produce useful sea level predictions for the Atlantic, Gulf of Mexico, and Caribbean Coasts.

Communication and outreach

The project has actively shared results with scientists, stakeholders, students, and the general public via interactive dialogues, presentations, and journal manuscripts.

Forming the Marine Prediction Task Force (MPTF; lead PI Merrifield; via NOAA-MAPP) has helped generate a communication framework for exchanging research methods and results among investigators engaged in seasonal ocean prediction science. The MPTF uses monthly teleconferences, virtual meetings, and emails as the primary communication mechanisms. After the initial organizational activities and terms of reference for MPTF were completed, the primary activity during Year 1 was hosting introductory presentations from the eight teams

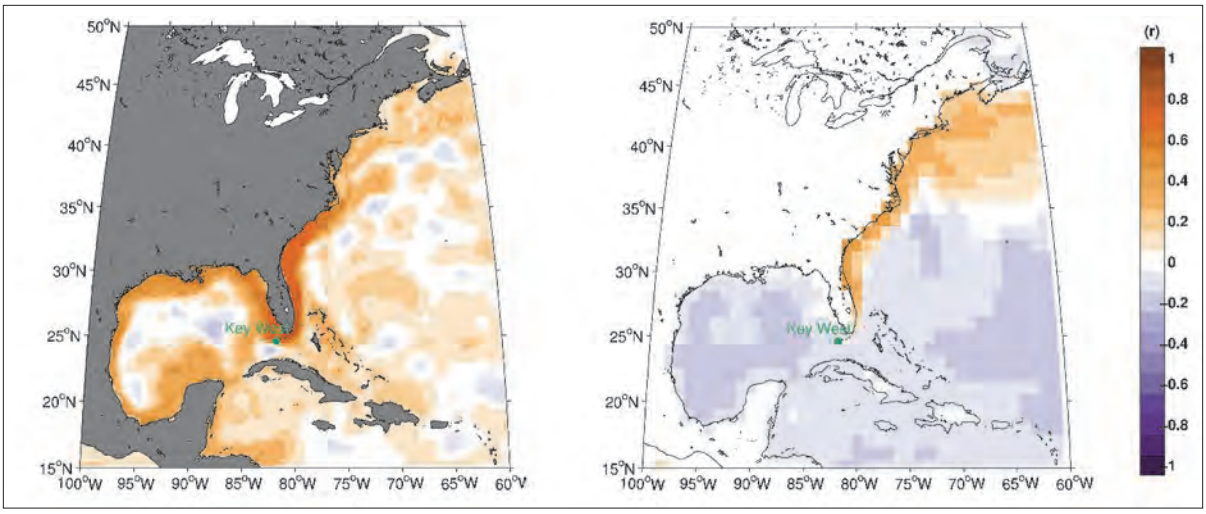

Figure 6. Maps of the anomaly correlations between monthly tide gauge data (Key West, Florida) and satellite altimetry (left) or CFSv2 at lead 0 (right). The long-term linear trends are removed.

on the task force. The MPTF has begun efforts to draft a manuscript on seasonal prediction for marine ecosystem applications and will also be co-organizing a session at the Ocean Obs'19 conference.

The project has actively sought collaborations with seasonal forecasting groups outside of the MPTF as well. Specific collaborations being developed include: 1) requests for real-time ocean forecast output from modeling groups participating in the NMME (NOAA-MAPP), S2S (WWRP/WCRP), and SubX (NOAA-MAPP) projects; 2) a partnership at USF with a complimentary project aimed at interannual to decadal prediction of coastal sea levels (NASA); 3) sharing of CFSv2-IITM forecast output (higher-resolution atmosphere compared to CFSv2-NOAA; co-PI Annamalai visited India during April–May 2018 to foster collaborations); and 4) assessments of sea surface height output from the SINTEX-F (JAMSTEC) seasonal forecast system as well as from other international seasonal forecasting groups (e.g., UKMO and AUS BoM). The objective in seeking these collaborations is to increase the ensemble size of seasonal forecast ocean model output.

The primary outreach activity was leading a NOAA webinar (Pacific Island Sea Level Forecast tool; January 2018) to inform on using seasonal sea level forecast products, which the project is producing in real-time for tropical Pacific Islands. Webinar participants were asked to explore the product website (https://uhslc.soest.hawaii.edu/sea-level-forecasts/) and come prepared with suggestions for improving communication of the sea level forecasts. Feedback from NOAA scientists (e.g., communication of forecast performance and uncertainty metrics should be improved) and Pacific Island stakeholders (e.g., additional regions and simplified products are needed) will be considered as the project's prototype seasonal forecast product for sea levels along the U.S. Coast is designed.

Co-PI's presented results at the following conferences and workshops: AMS Annual Meeting symposium on the coastal environment (Widlansky, Sweet); UFORIC meeting on coastal flooding (Marra, Thompson, Widlansky); AGU Ocean Sciences session on contemporary sea level variability (Widlansky, Thompson); and AOGS Annual Meeting sessions on seasonal climate predictability and advances in oceanic data assimilation (Widlansky and Postdoc). Sea level variability diagnostic results from this project were discussed in the "2017 State of the Climate Report" (Thompson et al. in press) and conveyed to NOAA scientists (NCEP, NOS, NESDIS, NCEI, and NWS). Mitchum (Lead-PI, USF) has been actively communicating the research scope to the Saint Petersburg, FL Mayor's Office along with other small cities vulnerable to sea level variability. The project has supported operational activities at the UH Sea Level Center (NOAA-OOMD) by providing seasonal sea level outlooks (Pacific-focus so far) to aid technicians in planning tide gauge maintenance activities. The project also engaged with K–12 educational activities via the UH Sea Level Center and contributed to media outreach activities via the UH Sea Grant College Program concerning sea level variability.

Highlights of accomplishments

- The project is leading the new Marine Prediction Task Force (NOAA-MAPP).
- Presented a NOAA webinar informing about the seasonal sea level forecasts that we are producing in real-time for tropical Pacific islands.
- Collaborated writing the sea level variability section in the "2017 State of the Climate Report" (Thompson et al. in press; Yoon et al. in press).
- Configured a coupled ocean-atmosphere GCM to run on the UH High Performance Computer, which we are using to explore processes responsible for recent observed sea level variability (Long et al. in preparation).
- Built an in-house archive of monthly sea surface height from retrospective forecasts (six models) participating in the NMME project (NOAA-MAPP), which we are using to conduct skill assessments of the predictions compared to observations.

Transitions to applications

The project is issuing experimental seasonal sea level forecasts on a monthly basis for islands in the tropical Pacific, including Hawaii, via a UH Sea Level Center (NOAA-OOMD) web product (https://uhslc.soest.hawaii.edu/sea-level-forecasts/) and email group (sea-level-forecastgrp+subscribe@hawaii.edu). Included in the product are maps of recent monthly sea level anomalies and future forecasts out to six months, along with island-region averaged time series of observations and multi-model forecasts. A substantial amount of post-processing is done to remove individual model biases and then to combine data from multiple observations and models into a seasonal sea level outlook (Widlansky et al. 2017). Each month, the forecasted sea level anomaly is added to the respective island's astronomical tide prediction, thus delivering a future water level alert calendar as an applied product.

Estimate of current technical readiness level of work

Table 2 outlines the technical readiness of project deliverables that are under development.

Table 2. List of deliverables worked on during Year 1, which are categorized by the three project objectives (#1 Understanding sea level variability processes, #2 Developing an ensemble seasonal sea level prediction system, and #3 Providing monthly sea level outlooks), their associated Technical Readiness Levels (RLs) according to NOAA's Administrative Order on Transition, and action items for Year 2.

Deliverable	Objective	RL	Action items
Improved understanding of the oceanic and atmospheric mechanisms that explain seasonal sea level variability. Year 1 focus was on the recent (2016–2017) extremely high sea levels in Hawaii.	1	2	• Complete manuscript. • Expand process-based assessment to other regions (e.g., U.S. East Coast) and events (e.g., high sea levels in Miami, Florida).
Multi-model seasonal sea level forecasts. Year 1 focus was on continuing efforts for tropical Pacific islands.	2 and 3	6	• Add models. • Assess forecasting procedure feasibility for the U.S. Coast.

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Towards Advancing the MJO and 1-30-day Weather Forecasting in the Fully Coupled NGGPS
Cooperative Agreement No. NA16NWS4680019
Reporting Period 10/01/2017–03/31/2018

P.I.: Joshua Xiouhua Fu

Collaborators: Yuejian Zhu, Xiaqiong Zhou, Wei Li, Celelia Deluca

Purpose of the Project

The purpose of the project is to collaborate with NOAA scientists at NCEP/EMC to improve the forecasting of the MJO and SST in the fully-coupled NGGPS.

Progress during FY 2018

As a continuing effort to improve the Madden-Julien Oscillation (MJO) and sea surface temperature (SST) in the coupled NGGPS, we have comprehensively evaluated the impacts of various cumulus parameters, stochastic physics schemes and SST conditions on MJO forecasting in the atmospheric component of the NGGPS (i.e., the NCEP GFS) and conducting in-depth diagnostics to understand the involved physical processes. The sensitivity experiments include three variants of Arakawa-Schubert cumulus schemes (SAS2, RAS, SAS and updated SAS), different stochastic physics schemes (e.g., Stochastic Total Tendency Perturbation-STTP; Stochastic Perturbed Physics Tendency-SPPT; Stochastic Humidity Perturbation-SHUM; and Stochastic Kinetic Energy Backscatter-SKEB) and more than five different SST conditions (e.g., climatology, NCDC, TMI, RTG, and CFS-forecasted etc.). The project also analyzed the downstream impacts of different MJOs on tropical Pacific and Atlantic basins in boreal summer. Major findings are as follows.

Quantify the effects of SST-feedback and atmospheric internal dynamics on the MJO

To what degree SST-feedback and atmospheric internal dynamics, respectively, contribute to the MJO is still a controversial issue. The simple direct estimate with observations suggests that SST-feedback only plays a minor role. The evaporation increase from positive intra-seasonal SST anomaly accounts for less than 10% of the intra-seasonal precipitation variability (e.g., Shinoda et al. 1998); the surface convergence directly driven by SST gradient accounts for about 10-25% of the total convergence in association with the MJO convection (e.g., Maloney and Kiel 2002; Hsu and Li 2012). Using a hybrid coupled model developed at University of Hawaii, Fu et al. (2003) and Fu and Wang (2004) found that active air-sea coupling enhances the intra-seasonal intensity by about 50% measured with wavenumber-frequency spectrum. This study revealed that the total effect of SST-feedback on the MJO involves two processes: direct contribution to surface evaporation and convergence disturbances and positive feedback between surface convergence and elevated heating. The latter contribution has been neglected in previous estimates with observations. Taking advantage of the hindcasts carried out with the NCEP GFS, a new method has been developed (Fu et al. 2018) to quantify the respective contribution of SST-feedback and atmospheric internal dynamics. It is found that during certain periods (e.g., mid-2 October: before and during the Oct-MJO active phase) atmospheric internal dynamics plays a dominant role (Fig. 1). During other periods (e.g., early November: before and during the Nov-MJO active phase), the contribution from SST-feedback is significantly stronger than that from atmospheric internal dynamics. Averaged over the DYNAMO IOP, the contributions from atmospheric internal dynamics and ocean-feedback are about half and half. This finding highlights the importance to include ocean-feedback into 1-30-day weather forecasting systems.

Impacts of different stochastic physics schemes on MJO forecasting skills

Four sets of 35-day hindcasts with the NCEP GFS under different configurations have been carried out, which are initialized every five days from May 1st, 2014 to May 26th, 2016. The configurations of four experiments are given in Table 1.

The overall intra-seasonal forecasting skills measured by the Anonymous Correlation Coefficient (ACC), Root-Mean-Square-Error (RMSE), and intensity (standard deviation) of the four experiments with lead times of 1-30-day are given in Fig. 2. For all three variables (OLR, U850 and U200), the run with STTP stochastic physics and climatological SST has the lowest ACC skill, highest RMSE and intensity when compared to other three

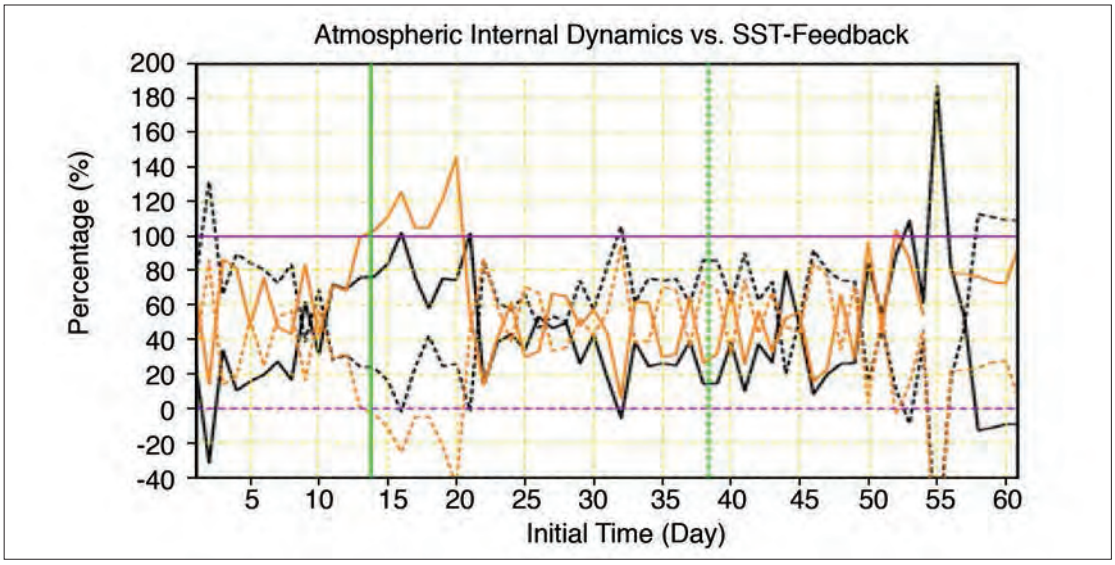

Figure 1. Relative contributions of atmospheric internal dynamics (solid lines) and SST feedback (dashed lines) on the Oct- and Nov-MJOs during the DYNAMO IOP as a function of initial times (the abscissa: covering 61 days from Oct. 1st, 2011 to Nov. 30th, 2011). The black and orange lines represent the precipitation and surface convergence, respectively. The negative values of the orange dashed lines during day-15 and day-20 and around day-55 indicate that ocean coupling makes the result worse than that of the uncoupled case during these periods.

Table 1: Configurations of Four Sensitivity Experiments

Label	Stochastic Physics Scheme	SST	Cumulus Scheme
STTP	STTP	Relax to Climatology	SAS
SPs (SPSA)	SPPT+SHUM+SKEB	Relax to Climatology	SAS
SPs+CFSBC (SPSB)	SPPT+SHUM+SKEB	Initial analysis+ bias corrected CFS forecast	SAS

runs. Replacing the STTP with SPs stochastic scheme increases ACC skill, reduces RMSE and the intensity too. Introducing CFS forecast SST anomaly into the boundary condition significantly increases ACC skill after 15 days but has little impact on the RMSE and intensity. Further replacing the operational SAS cumulus scheme with the updated version (Han et al. 2017) leads to a systematic increase of ACC skills from the first week to day-30 but has little impact on the RMSE and intensity. This result indicates that the last configuration (SPs stochastics and CFS forecast SST anomaly plus updated cumulus scheme) leads to best MJO skills in terms of ACC and RMSE, however, the area needed to be further improved is MJO intensity, which drops very fast as lead-time increases.

Impacts of different stochastic physics schemes on the mean states

In order to untangle the physical processes responsible for the systematically weak MJO in the NCEP GFS and that lead to skill changes under different configurations, the project evaluated the mean states in four experiments at lead times of 1-30-day (Fig. 3). It is found that even with the best configuration (SPSC in table 1), the model mean states are systematically drier than the observations (second row of Fig. 3). The dry environment will limit the development of organized convection associated with the MJO, thus leading to systematically weak MJO in the GFS. This problem is most severe in the STTP case. Both the updated SAS cumulus scheme and SPs stochastic scheme lead to wetter mean states than that with STTP stochastic scheme and operational SAS scheme (third and five rows of Fig. 3). The inclusion of CFS forecast SST anomaly also helps a little bit during later lead times (fourth row of Fig. 3). This finding points out that the latest GFS needs to further moisten its troposphere in order to intensify model MJO.

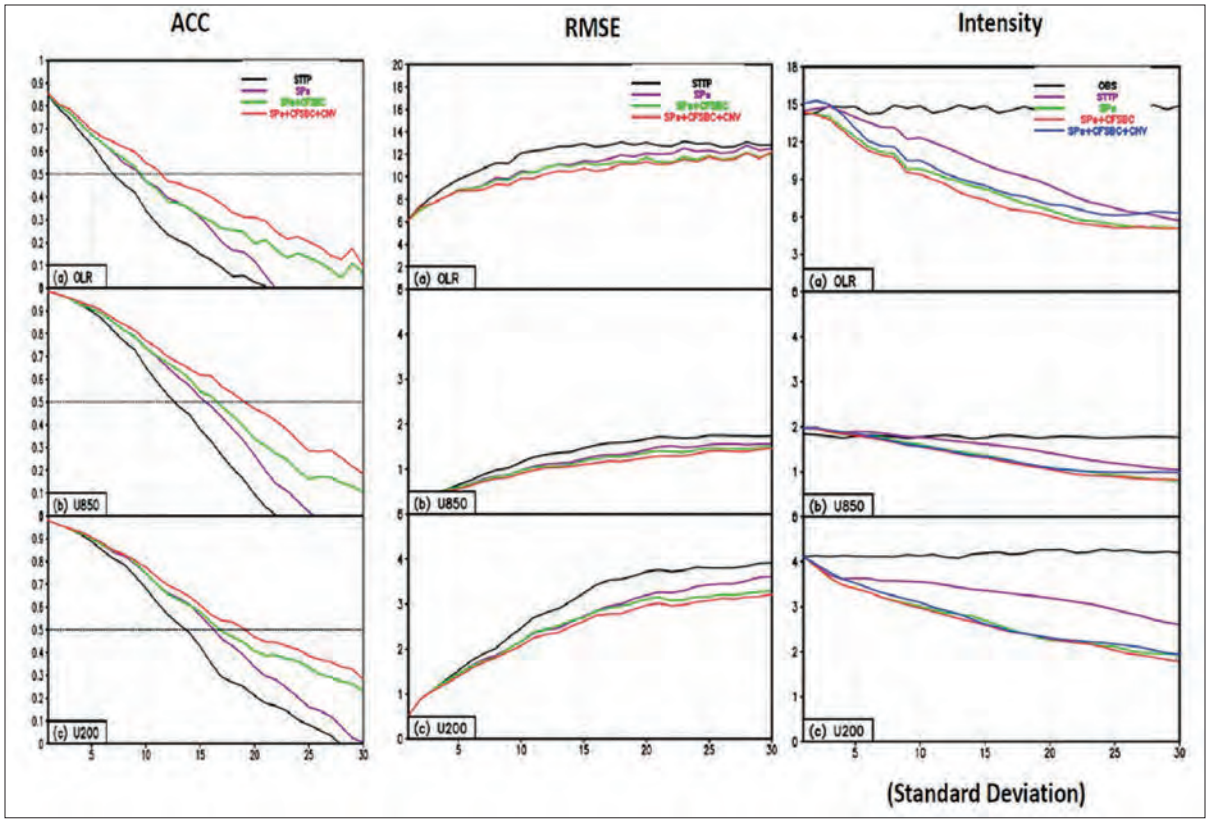

Figure 2. The Anonymous Correlation Coefficient (ACC, left column) and Root-Mean-Square-Error (RMSE, middle column) of STTP, SPs, SPs+CFSBC, and SPs+CFSBC+CNV and their intensities (Standard Deviation, right column). More details on experimental designs are given in Table 1.

Progress on testing, summary of evaluation and/or verification of proposed improvements

Through collaboration with scientists at NCEP EMC and CPC, the project conducted many hindcasts with NCEP GFS under various model configurations: e.g., cumulus schemes, stochastic physics schemes and SST conditions. The impacts of these factors on MJO forecasts are comprehensively evaluating on various aspects. The associated underlying physical processes are revealed. Some of the results have been published on peer-reviewed journals. The findings on the roles of cumulus schemes, SST-feedback and stochastic schemes on MJO forecasting offer valuable insights for the further improvements of MJO simulations and forecasts in the GFS (NGGPS) and community models.

Interactions with scientists at EMC, other NCEP centers, NOAA labs, and/or NOAA testbeds

The project closely collaborated with EMC scientists (e.g., Yuejian Zhu, Wei Li, and Erik Sinsky, and Xiaqiong Zhou, et al.) and CPC scientist (e.g., Wanqiu Wang et al.) to conduct various tests, evalutions and verifications intending to improve the extended-range forecasting of MJO and US weather in the GFS and the coupled NGGPS. Additionally, the project had some interactions with other scientists at EMC and ESRL (e.g., Suranjana Saha, Vijay Ballaragged, Mark Iredell, and Cecelia Deluca et al.) on the progresses of the fully coupled NGGPS system.

Progress against milestones/schedules in proposal

The project is are making steady progress toward the proposed goal: in collaboration with NCEP scientists to improve the MJO and SST in the fully coupled NGGPS.

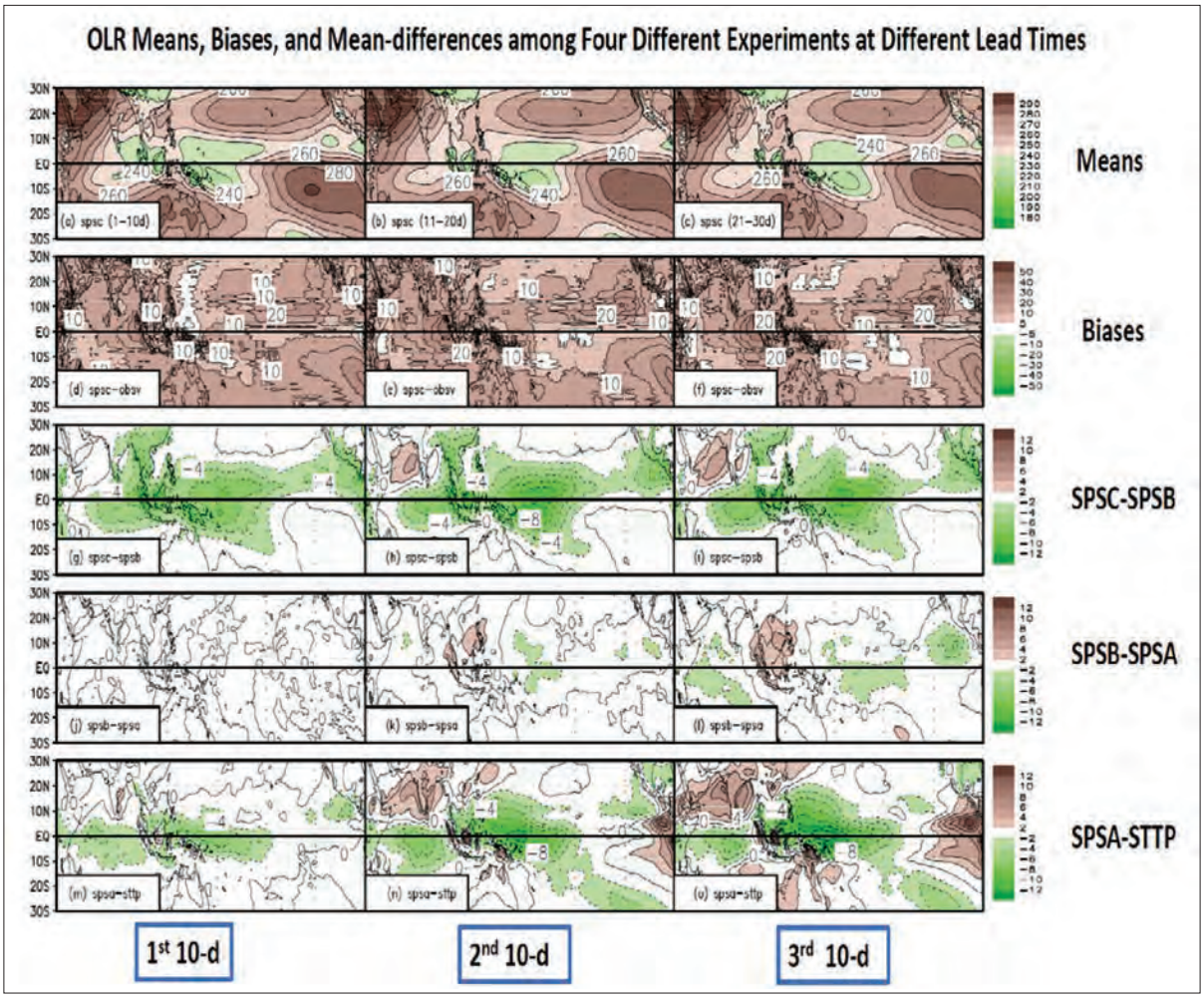

Figure 3. Mean OLR (first row), biases (second row), differences between SPSC and SPSB (third row), differences between SPSB-SPSA (fourth row) and differences between SPSA-STTP (fifth row) at lead time 1-10-day (left column), 11-20-day (middle column), and 21-30-day (right column). The detailed experimental designs can be found in Table 1.

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Conference Presentation

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