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NOAA FISHERIES
PACIFIC ISLANDS FISHERIES SCIENCE CENTER

Report to the Western Pacific Regional Fishery Management Council

February 2020

PIFG fishermen aboard the Ao Shibi IV preparing to deploy the MOUSS underwater camera system (Photo: Chris Demarke, NOAA Fisheries)

The Pacific Islands Fisheries Science Center (PIFSC or Center) administers and conducts scientific research and monitoring programs that produce science to support the conservation and management of fisheries and living marine resources. This is achieved by conducting research on fisheries and ocean ecosystems and the communities that depend on them throughout the Pacific Islands region, and by dedicating efforts to the recovery and conservation of protected species. The Center is organized into five major divisions: the Operations, Management, and Information Division (OMI); Science Operations Division (SOD); Fisheries Research and Monitoring Division (FRMD); Protected Species Division (PSD); and Ecosystem Sciences Division (ESD).

PIFSC continues to improve its science and operations through collaboration and integration across divisions, and increased communication, cooperation, and coordination with partners and stakeholders. In 2018, the Center developed a 5-year framework for annual prioritization of research and monitoring activities in order to fully utilize the capabilities of PIFSC and its partners (e.g., NOAA Fisheries Pacific Islands Regional Office (PIRO); Western Pacific Regional Fishery Management Council (WPRFMC)). In 2019, the Center released an updated 5-year science plan. All activity updates and reports herein are organized in accordance with the research themes (per the PIFSC Science Plan 2019–2023) outlined below:

1) Promote Sustainable Fisheries
2) Conserve Protected Species
3) Research to Support Ecosystem-based Fisheries Management (EBFM) and Living Marine Resource Management
4) Organizational Excellence

This report concludes with a listing of publications produced during this reporting cycle.

1. Promote Sustainable Fisheries

Fishery Impacts on Life History Characteristics: Effects of exploitation evident in age-based demography of 2 deepwater snappers, the goldeneye jobfish (*Pristipomoides flavipinnis*) in the Samoa Archipelago and the goldflag jobfish (*P. auricilla*) in the Mariana Archipelago

The Life History Program recently published research on territorial bottomfish with their partners from Samoa, Secretary of the Pacific Community, Hawaii Institute of Marine Biology (HIMB), and PIRO. Life history samples and information were primarily collected during research cruises in the Samoa Archipelago and Mariana Archipelago and were supplemented with data from SPC research cruises and the PIFSC Biosampling Program.

The Samoa and Mariana Archipelagos have remote locations where substantial fishing pressure has not occurred for at least 30 years, providing a rare opportunity to examine the effects of exploitation on the age and size compositions, growth, and mortality of these species. For both species, overall, age-based data reveal a greater effect of fishing pressure than those based on size. We found that there were limited differences in size-based metrics; however, severe age truncation and significant differences in age compositions were apparent between fished and unfished areas. This difference highlights concerns with size-based analyses: when species have protracted asymptotic growth trajectories, the resulting fishing impacts may not be readily apparent in size-based analyses because size and age become decoupled. This decoupling also confounds comparisons of growth among areas with different exploitation levels.

Natural mortality is an important component of stock assessments; however, it is notoriously difficult to estimate. In many deepwater snapper fisheries, natural mortality is typically estimated indirectly by using empirical formulae derived from correlation with life history parameters or maximum age from a collection of species. Because of the lack of life history information, none of these natural mortality estimators were derived by using information specific to tropical deepwater snappers. We tested the accuracy of a maximum age-based natural mortality estimator by comparing these estimates with those of an age-based catch curve for the unfished areas (where total mortality equals natural mortality). The comparison of these methods indicates that the age-based natural mortality estimator is suitable for use in deepwater snapper stock assessments when direct measures of natural mortality are unavailable.

This study's findings also stress the importance of using appropriate life history values as inputs when using natural mortality estimators. Applying the natural mortality estimator to the fished areas led to a very different result, depending on which maximum age was used: estimates were close to three times greater for the fished area maximum age than for the unfished area maximum age. These different estimates of natural mortality contribute to very different exploitation ratios, which may result in inaccurate advice on stock status for fisheries managers. This potential for inaccuracy highlights the need for thoughtful application of natural mortality estimators and reliable estimates of maximum age when using these empirical methods.

O'Malley JM, Wakefield CB, Oyafuso Z, Nichols RS, Taylor BM, Williams AJ, Sapatu M, Marsik M. Effects of exploitation evident in age-based demography of 2 deepwater snappers, the goldeneye jobfish (*Pristipomoides flavipinnis*) in the Samoa Archipelago and the goldflag jobfish (*P. auricilla*) in the Mariana Archipelago. Fisheries Bulletin 117:322–336. doi:10.7755/FB.117.4.5

Cooperative Research Key to the Bottomfish Fishery-Independent Survey in Hawaii (BFISH)

Cooperative research, or the practice of working in close partnership with the local community, resource users, and stakeholders, has been key to the continued success of the Bottomfish Fishery-Independent Survey in Hawaii (BFISH). As part of its efforts to continually improve the data used in its stock assessments, FRMD began research and development for BFISH in 2011. By 2016, due in large part to the efforts of the local commercial bottomfishing community, the survey began collecting data that would be used as a key component of the 2018 Deep-7 stock assessment. The addition of data from the BFISH survey has reduced uncertainty in abundance estimates and allowed for more informed management decisions.

BFISH is a multi-gear survey, comprising both hook-and-line sampling as well as deep-water camera systems. Local commercial bottomfishers have been the driving force behind hook-and-line sampling since the beginning of the survey, while the camera systems have typically been deployed from NOAA ships. While effective, this restriction of the cameras to only the NOAA ships has reduced survey efficiency and results in spatio-temporal clustering of the camera samples.

In an effort to reduce these restrictions, scientists from SOD began working with local bottomfishers to outfit their vessels with the equipment necessary to deploy the BFISH camera systems. One vessel, *Ao Shibi IV*, was fully outfitted and began conducting limited operational camera deployments in 2017. This year a second vessel, the *Ao Shibi Too*, was outfitted. During

a 3-day period in November, these two vessels completed 34 camera deployments; a resounding success. The commercial captains and their crew have proved adept at deploying and recovering

the cameras, are able to complete a greater number of deployments and recoveries each day, and have been excited to actually see the fish community in its natural environment. As the BFISH survey matures, cooperative research and our partnership with the commercial bottomfishing community will remain key to its success.

2. Conserve Protected Species

Hawaiian Monk Seal Research Program

The NOAA Hawaiian monk seal team cares for RO28, an adult female monk seal that stranded in January 2020 with toxoplasmosis. (NOAA permit 18767)

Toxoplasmosis is a disease caused by a protozoal parasite shed into the environment via cat feces. To date, at least 11 seals are known to have died from toxoplasmosis and it is one of the leading threats to the species. The PSD Hawaiian Monk Seal Research Program (HMSRP) organized the ***Technical Workshop on Toxoplasmosis in Hawaiian Monk Seals*** to review current knowledge and gain expert insights on the most severe disease threat impacting Hawaiian monk seal recovery.

Approximately 20 experts from universities, NGOs, and state and federal agencies gathered in Honolulu, Hawaii, for this 2.5-day workshop, Oct 28–30, 2019. The primary goal of the workshop was to identify knowledge gaps and prioritize future research directions based on their ability to inform management approaches and solutions in order to address the threat of toxoplasmosis to Hawaiian monk seals. Overall, participants felt that the existing knowledge base provided a strong foundation for formulating some management options already (e.g., a known definitive host; well characterized infections in seals). Yet, there were several areas in which a greater understanding of the threat, and a more holistic way of characterizing it, could serve useful in the pursuit of threat mitigation options for Hawaiian monk seals (HMS) as well as other marine mammal taxa and native wildlife. Research directions were grouped into *four priority areas*: (1) completing in-progress research and continuing ongoing disease monitoring; (2) fully exploiting current resources, data streams and samples; (3) generating new data streams and/or analyses to address high-impact knowledge gaps for which solutions are realistically achievable and have the greatest potential to

inform management needs; and (4) leveraging partnerships to contribute to research that improves scientific knowledge of Toxoplasma, but may require long-term effort, or have indirect benefit to Hawaiian monk seal recovery.

Two-Month Cetacean and Seabird Ship Survey around the Main Hawaiian Islands is Underway

The PSD Cetacean Research Program (CRP) is conducting a 51-day survey aboard the NOAA Ship *Oscar Elton Sette* searching for whales, dolphins, and seabirds around the main Hawaiian Islands. This project is named the Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey, also referred as "WHICEAS," because it will occur in the winter months (January–March 2020), which provides an opportunity to focus on baleen whales that generally migrate into Hawaiian waters during that period.

A fin whale seen approximately 200 nautical miles north of Maui on November 29, 2017. Photo: NOAA Fisheries/Mark Cotter.

An important related project is named the Hawaiian Islands Cetacean and Ecosystem Assessment Survey, also referred as "HICEAS," which provide the necessary data to update abundance estimates for all Hawaiian cetacean and seabird species. Historically, the HICEAS efforts are conducted in the summer to fall months and survey the waters within the entire Hawaii Exclusive Economic Zone aboard two NOAA ships. Conducting this year's winter effort will allow us to examine the changes in density of species between winter (i.e., WHICEAS 2020) and summer/fall (i.e., HICEAS 2002, 2010, and 2017).

Our primary survey will include traditional cetacean survey methods: visual observations and acoustic detections while traversing along a systematic survey grid. In addition, we will deploy Drifting Acoustic Spar Buoy Recorders (DASBRs). DASBRs passively drift with the currents and collect acoustic recordings throughout the study area, independent of the ship. The extended monitoring period and deeper sensors (DASBR hydrophones descend to 150 m) allow for increased detections of beaked whales and baleen whales, two species groups of great interest due to their typically low sighting rates.

WHICEAS 2020 is the third survey in a multi-agency plan called Pacific Marine Assessment Program for Protected Species (PacMAPPS), a partnership between NMFS, the Bureau of Ocean Energy Management (BOEM), and the U.S. Navy to collect data and produce density estimates for species of joint management interest. PacMAPPS includes rotational surveys throughout the Pacific to assess the abundance of cetacean species and their ecosystems. To date, two rotational surveys have been completed: HICEAS 2017 surveyed waters of the entire Hawaiian Archipelago, and the California Current Ecosystem Survey (CCES) 2018 surveyed offshore of the U.S. West Coast. Following WHICEAS 2020, a survey of the entire Mariana Archipelago is proposed for 2021 and the Gulf of Alaska in 2022.

Drifting Acoustic Spar Buoy Recorders (DASBRs) are deployed to drift with ocean currents and record nearby vocal cetaceans for days to weeks until the ship recovers the instrument. Photo: Schmidt Ocean Institute/Alex Ingle.

Update on Nesting Green Turtle Habitat at French Frigate Shoals

The PSD Marine Turtle Biology and Assessment Program (MTBAP) processed spatial nesting data from the 2019 field season at French Frigate Shoals (FFS) to reveal insights on nesting habitat use. Due to the impact of Hurricane Walaka on East Island in 2018, the field team was only able to conduct night nesting surveys on Tern Island in 2019. A key observation from the season was the dramatic loss of vegetation blocking the turtles' access to the old runway on Tern Island. This change expanded the area available to the females for nesting activities, but came with an increase in failed nesting attempts due to the lack of suitable habitat (e.g., sand too shallow) and an increase in nesting females crossing the sloped runway and becoming trapped on the other side.

The team recorded a GPS location for every confirmed nest and compared the spatial extent of 2019 nests to that of nests in 2018. In 2019, the turtles used a larger nesting area, which was a result of sand shifts and vegetation removal during Hurricane Walaka (see following image for a comparison to 2018). The team also measured sand depth across the newly expanded nesting area to characterize the habitat and determine how much of it appeared to be suitable. Sand depth is important to marine turtle nesting, as it provides temperature stability for incubation. While we do not know the mean nest depth for turtles at FFS, the mean nest depth for green turtles in Costa Rica is 68.1 cm.

Green turtle nest locations on Tern Island in 2019 (pink dots) along with nest locations from 2018 (yellow dots). In 2019, the vegetation blocking access to the old runway was removed by the effects of Hurricane Walaka.

The following image shows the distribution of sand depths in three depth categories (0–20 cm, 20–40 cm, 40–66 cm). Sand depths in the 40–66 cm range (the most optimal of those measured) only covered a subset of the expanded nesting area.

Tern Island sand depth measurements recorded in 2019 by the Marine Turtle Biology and Assessment field team. Mean nest depth for green turtles in Costa Rica is 68.1 cm (Tomillo et al. 2017).

The locations of successful nests observed (this does not represent every nest laid) are overlaid on all confirmed nests in the following and final figure, demonstrating that while the nesting area was substantially larger this year, there is evidence to suggest that successful emergence of nests was limited to a smaller area.

Green turtle nest locations on Tern Island during the 2019 field season. Pink dots indicate locations of nests that were successfully deposited. Black dots indicate locations of hatch craters and thus the successful development and emergence of at least some hatchlings from the nest.

Reference

Tomillo PS, Fonseca L, Paladino FV, Spotila JR, Oro D. 2017. Are thermal barriers "higher" in deep sea turtle nests?. PloS one:12(5).

3. Research to Support EBFM and Living Marine Resource Management

Examining the seascape of compliance in U.S. Pacific island fisheries

Noncompliance is a major threat to coastal and marine ecosystems. Recent noncompliance research has focused on illegal, unreported, and unregulated (IUU) fisheries and capacity shortfalls in marine protected areas (MPAs), but less work has looked at other aspects of noncompliance. Although scholars and managers recognize that noncompliance can cause governance failures, the academic literature on compliance rarely acknowledges the connections between governance processes, compliance activities, and management outcomes. Likewise, scholars often highlight regulatory approaches such as law enforcement tools as solutions, instead of non-regulatory interventions that may encourage voluntary compliance or governance processes that can increase the legitimacy of regulatory programs.

We examined compliance across the United States Pacific islands region, an area of 5.83 million square kilometers that includes Hawaii, American Samoa, Guam, the Northern Mariana Islands, and one of the world's largest marine protected areas. The region includes commercial, subsistence, and non-commercial fisheries, and a diversity of cultures that rely on them. To examine compliance, we used a qualitative research approach. We reviewed historical and archival data sources, analyzed the published academic fisheries management literature in the region, and conducted interviews with compliance or management experts. We found that the academic literature highlighted the importance of enforcement, but our expert interviews mentioned multiple factors that affected compliance, such as capacity, governance processes, and a lack of data.

Although several fisheries may benefit from an increased enforcement presence, we argue that non-regulatory and governance approaches can complement regulatory programs and should be part of an integrated compliance approach in this region and worldwide. Non-regulatory approaches that could strengthen existing compliance efforts include public outreach and education, social marketing, social learning, strategic communication, and persuasion-based behavior change interventions. Non-regulatory approaches may also include market-based solutions such as fishery improvement projects and third party sustainability certification programs. Governance approaches improve compliance through increased participation and involvement in management processes. By increasing participation and involvement in management, regulations are often more fair and legitimate in the eyes of resource users. Regulatory tools such as monitoring and enforcement remain important, but our research shows how non-regulatory and governance approaches can complement regulatory approaches and should improve compliance across the U.S. Pacific islands region.

Ayers AL, Leong K. 2020. Examining the seascape of compliance in U.S. Pacific island fisheries. Marine Policy:103820. https://doi.org/10.1016/j.marpol.2020.103820

Prey-Size Plastics are Invading Larval Fish Nurseries

Many of the world's marine fish spend their first days or weeks feeding and developing at the ocean surface. Larval fish are the next generation of adult fish that will supply protein and essential nutrients to people around the world. However, little is known about the ocean processes that affect the survival of larval fish.

PIFSC and an international team of scientists conducted one of the most ambitious studies to date to learn where larval fish spend their time and what they eat there. The researchers combined field-based plankton tow surveys and advanced remote sensing techniques to identify larval fish nursery habitats in the coastal waters of Hawaii. The study was recently published in the journal Proceedings of the National Academy of Sciences.

The team found that surface slicks contained far more larval fish than neighboring surface waters. Surface slicks are naturally occurring, ribbon-like, smooth water features at the ocean surface. They form when internal ocean waves converge near coastlines in marine ecosystems worldwide. The surface slicks also aggregate plankton, which is an important food resource for larval fish. Larval fish in the surface slicks were larger, well-developed, and had increased swimming abilities. Larval fish that actively swim will better respond and orient to their environment. This suggests that tropical larval fish are actively seeking surface slicks to capitalize on concentrated prey.

Often just weeks old, numerous larval fish had plastics in their stomachs, including mahi-mahi (top left), flying fish (top right), spearfish (middle right), jacks, (bottom right), triggerfish (two sizes, bottom left), and damsels (middle left). Photo: NOAA Fisheries/Jonathan Whitney.

Unfortunately, the team also discovered that the same ocean processes that aggregated prey for larval fish also concentrated buoyant, passively floating plastics. Researchers found that plastics were 126 times more concentrated in surface slicks than in surface water just a couple hundred yards away. There were seven times more plastics than there were larval fish.

The majority of the plastics found in surface slicks were very small (less than 1 mm). Larval fish prefer their prey this size. After dissecting hundreds of larval fish, the researchers discovered that many fish species ingested plastic particles. "We found tiny plastic pieces in the stomachs of commercially targeted pelagic species, including swordfish and mahi-mahi, as well as in coral reef species like triggerfish," said Dr. Whitney. Plastics were also found in flying fish, which apex predators such as tunas and most Hawaiian seabirds eat.

Recent evidence shows that adult fish ingest plastic. This is the first study to show that larval coral reef fish and pelagic species are also consuming plastic, as early as days after they are spawned. Researchers are unsure of how harmful plastic ingestion is to larval fish. In adult fish, plastics can cause gut blockage, malnutrition, and toxicant accumulation. Larval fish are highly sensitive to changes in their environment and food. Prey-size plastics could impact development and even reduce survivorship of larval fish that ingest them.

The researchers measured the size and distribution of the surface slicks using satellites. Even when viewed from space, surface slicks are distinct from the rest of the ocean. The researchers found that surface slicks comprise less than 10 percent of ocean surface habitat. However, they are estimated to contain about 42 percent of all surface dwelling larval fish and nearly 92 percent of all floating plastics.

"Biodiversity and fisheries production are currently threatened by a variety of human-induced stressors such as climate change, habitat loss, and overfishing. Our research suggests we can likely now add plastic ingestion by larval fish to that list of threats," said Dr. Gove.

Gove JM, Whitney JL, McManus MA, Lecky J, Carvalho FC, Lynch JM, Li J, Neubauer P, Smith KA, Phipps JE, Kobayashi DR, Balagso KB, Contreras EA, Manuel ME, Merrifield MA, Polovina JJ, Asner GP, Maynard JA, Williams GJ. 2019. Prey-size plastics are invading larval fish nurseries. Proceedings of the National Academy of Sciences. https://doi.org/10.1073/pnas.1907496116.

Status and Trends Assessment for Land-based Sources of Pollution Impacts on Benthic Reef Communities in Faga'alu Bay and Vatia Bay, American Samoa

This project builds upon prior baseline assessments of benthic communities conducted in 2012 and 2015 at Faga'alu Bay (U.S. Task Force watershed priority site) and Vatia Bay (Territorial priority watershed), respectively, to address national and jurisdictional goals to reduce land-based sources of pollution impacts in coral reef ecosystems.

Between January 13th and 29th, staff from the Joint Institute for Marine and Atmospheric Research completed a total of 60 benthic surveys that will allow scientists to evaluate the changes in the condition and integrity of the coral reef ecosystems in these areas. Faga'alu Bay is of special interest given that in 2014 the Erosion and Sediment Control Plan was implemented at the Samoa Maritime quarry, in the head of the watershed, to reduce terrigenous runoff and

sedimentation into the adjacent reef. The 2020 surveys aim at drawing comparisons with the baseline assessments for benthic community structure; namely, percent cover of coral, coralline algae, and macroalgae, as well as the coral community composition, specifically coral colony densities, condition, and taxonomic richness. This work will enable federal and jurisdictional resource managers to more effectively conserve these coral reef ecosystems and manage ecosystem reserves.

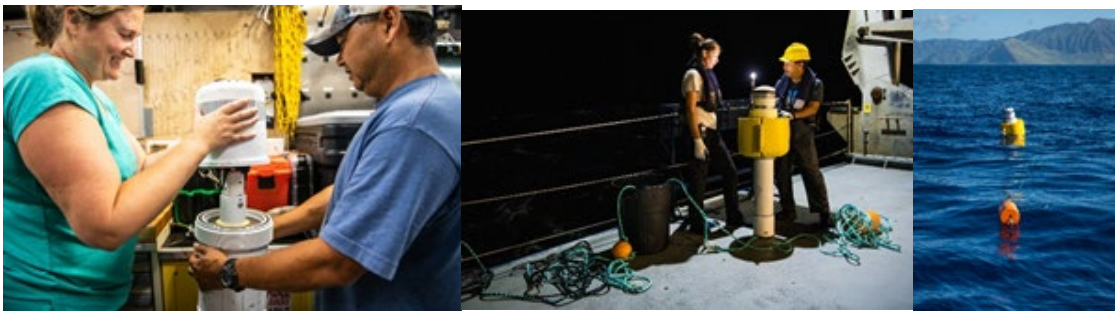
This project also aimed at building local capacity by providing classroom and in-water training for long-term coral reef benthic monitoring to staff of the American Samoa Coral Advisory Group (CRAG) and the National Marine Sanctuary of American Samoa (NMSAS). This work will ensure the continuity of our efforts and the means by which we may quantify the effectiveness of place-based management interventions.

Status and trends assessment for land-based sources of pollution impacts on benthic beef communities in Faga'alu Bay and Vatia Bay, American Samoa. a) Mats of the macroalga Dictyota *overgrowing the benthos in the backreef at Faga'alu Bay. b) Calcifying macroalgae* Peyssonnelia *(red) and* Halimeda *(green) overgrowing the coral* Porites rus *at Vatia Bay. c) The corallimorph* Rhodactis*, invading the coral benthos in Vatia Bay. d) Local partner in-water training; left to right: Morgan Winston, Brittany Huntington, Bernardo Vargas-Ángel (JIMAR), Georgia Coward (CRAG), Hanae Spathias (NMSAS), and Natasha Ripley (CRAG)*

4. Organizational Excellence

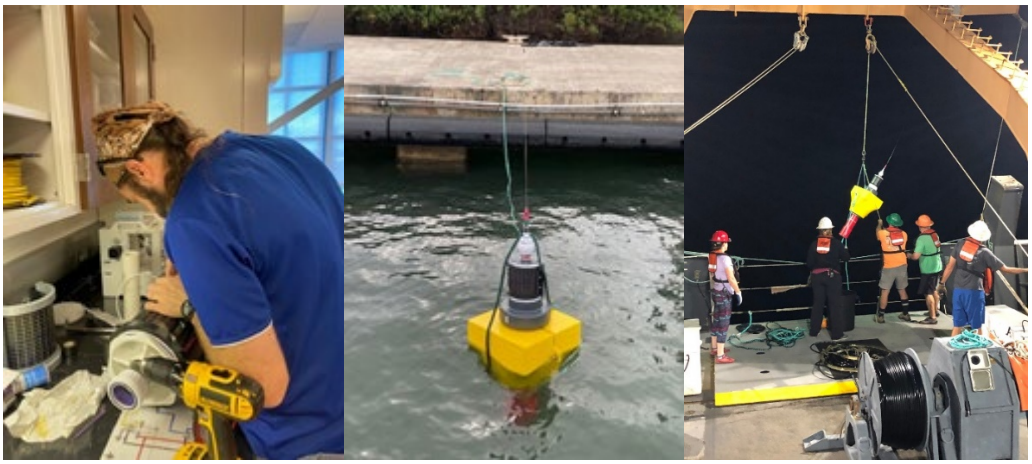
Ruggedizing Drifting Acoustic Spar Buoy Recorder Housings to Support Acoustic Cetacean Research

Over the last year, SOD has been working with PSD's Cetacean Research Program (CRP) to re-design and ruggedize their Drifting Acoustic Spar Buoy Recorder (DASBR) housings. In October of 2019, SOD supported CRP with deployments of these DASBRs aboard the Schmidt Ocean Institute's R/V *Falkor* (FK191021). The research team successfully deployed and recovered three DASBRs at known locations of beaked whales off of Oahu and Maui to record whale vocalizations while water samples for eDNA were collected conducting CTD casts.



From left to right: Jennifer McCullough (CRP) and Kyle Koyanagi (SOD) assembling a DASBR unit on FK191021; Chief Scientist Ann Allen (CRP) and Kyle Koyanagi preparing to deploy a DASBR array on FK191021; DASBR deployed off of Oahu, Hawaii on FK191021.

Since then, SOD continued to work with CRP to develop a second generation DASBR housing prototype (DASBR+) which is currently being tested on the Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (WHICEAS) aboard the NOAA Ship *Oscar Elton Sette* (SE-20-01). The new prototype housing includes automatic identification system capability which allows for easier ship tracking and avoidance, low-light activated LED flashers for small boat avoidance at night, and a battery bank with a solar charging capability to allow for up to 30 days of activity.



From left to right: Jeremy Taylor with SOD wiring up solar panels for new second generation DABR+ prototype; In-water testing of DASBR+ and float system; DASBR + prototype being deployed on the NOAA Ship Oscar Elton Sette *WHICEAS project.*

NOAA Technical Memorandum on Comparison of BotCam and MOUSS Systems

In brief, stereo-camera systems have become integral tools in surveys of bottomfish species in the main Hawaiian Islands. At PIFSC, camera sampling technology has transitioned from an analog system (Bottom Camera Bait Station—BotCam) to a high-definition digital system (Modular Optical Underwater Survey System—MOUSS) to increase sampling efficiency and data yield. To ensure continuity of data streams between camera systems, comparative tests on species richness, relative abundance (MaxN), and length measurements were undertaken. No significant differences were found between BotCam and MOUSS in their ability to detect bottomfish species and in the relative abundance and length data generated by both systems, thus allowing for continuity of videographic data streams. Of the two camera systems, MOUSS generally produced better quality imagery leading to some more precise fish identifications and better measurement accuracy. BotCam, on the other hand, had greater light sensitivity at deeper sampling depths, allowing it to detect some species missed by MOUSS in light-limited conditions.

Misa WXFE, Amin R, Asher JM, Richards BL, Taylor JC, Rollo AK, Miller DR, Demarke CD, Koyanagi KH. 2020. BotCam to MOUSS: Comparative tests on bottomfish relative abundance, length data, and imagery generated by 2 stereo-camera systems during field surveys in Hawaii. NOAA Tech Memo. NMFS-PIFSC-94, 26 p. doi:10.25923/ara7-2w20 Copies of this report

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Weijerman M, Leong KM, Wongbusarakum S. 2019. Second Hawaii Atlantis Ecosystem Model Planning Workshop: Where is the"S" in EBFM? Pacific Islands Fisheries Science Center. PIFSC Administrative Report H-19-05 36 p. https://doi.org/10.25923/bfwa-7084

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