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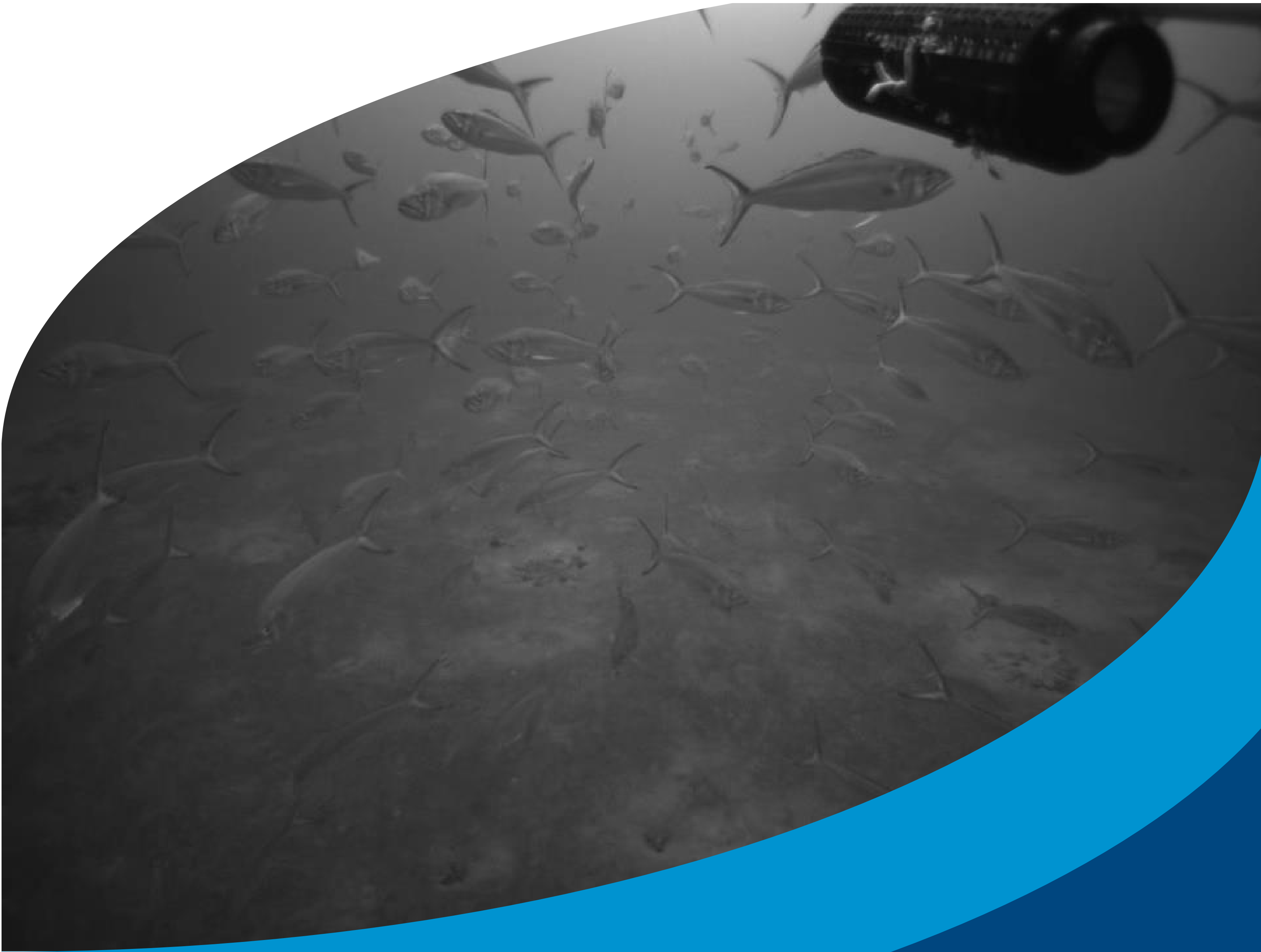
NOAA FISHERIES

PACIFIC ISLANDS FISHERIES SCIENCE CENTER

Report to the Western Pacific Regional Fishery Management Council

March 2022



School of Aphareus rutilans (Photo: 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 list of publications produced during this reporting cycle.

1. Promote Sustainable Fisheries

Factors Related to the Bycatch of Giant Manta in the U.S. Western and Central Pacific Ocean Purse Seine Tuna Fishery

Giant manta (*Mobula birostris*) have been listed as Threatened under the Endangered Species Act (83 FR 2916; January 22, 2018). Understanding the factors that define the complex spatial and temporal interactions that occur between *M. birostris* and fishing vessels can provide insight into characteristics that can be avoided to mitigate interactions. These mitigations may involve avoiding certain spatial locations or oceanographic characteristics such as specific sea surface temperatures. To advance initial investigations, an ensemble random forest (ERF) model (Siders et al. 2019) was applied to the nearly 100% coverage observer data of the U.S. WCPO purse seine fleet from 2010 to 2020 (WCPFC Regional Observer Programme 2021). Models were run for individuals reported to be *Mobula birostris,* as well as for Mobulidae, recognizing that species identification may be challenging. To more fully understand factors that could be influencing interactions, the observer data were aligned with a number of oceanographic characteristics and operational variables (full details in PIFSC Internal Report IR-22-02).

Mobula birostris were recorded in 756 out of 47,316 sets with only 1 individual recorded in 521 sets, but up to 50 individuals reported in a single set. The final ERF model had very good performance with near perfect prediction. Only 27 out of 40,864 sets were classified as false positives; no false negatives were estimated. These results suggest that the ERF model can be used to correctly classify sets that would encounter *Mobula birostris.*

The relative importance of the variables explored indicates a mix of operational and location characteristics that define interactions (Figure 1). Accumulated local effects plots suggest that sets with interactions are in a location farther away from seamounts than expected at random. Also, shorter sets are also more likely to result in *Mobula birostris* interactions. Interactions occur in locations with stronger northern current speeds, higher chlorophyll-a concentrations, less current dynamic energy, during times of a waning moon, moderately closer to SST fronts, in areas of moderate currents, and weaker winds. Set association is also a predictor of occurrence; sets classified as unassociated or feeding on baitfish are more likely to have encounters (supported by the higher-than-expected encounters given the relative frequency of set types). Positive occurrence sets also appear farther away from wind fronts in areas not associated with eddies and in the first and fourth quarters of the year. Similar patterns are observed when all Mobulidae are considered. The general pattern of interaction that emerges from the ERF analysis shows they occur in a localized area (Figure 2) in the WCPO where operations set on smaller, species-rich aggregations of organisms that potentially have fewer target species than anticipated. This suggests that taking greater care in discerning the composition of the aggregations prior to setting within the identified localized area of the WCPO may reduce interactions with *Mobula birostris.*

Ahrens R, Siders Z, Jones TT. 2022. Factors Related to the Bycatch of Giant Manta in the U.S. Western and Central Pacific Ocean Purse Seine Tuna Fishery. PIFSC Internal Report IR-22-02.

Siders Z, Ducharme-Barth N, Carvalho F, Kobayashi D, Martin S, Raynor J, Jones TT, Ahrens R. 2019. Ensemble Random Forest As a Machine Learning Tool to Model Rare Events.

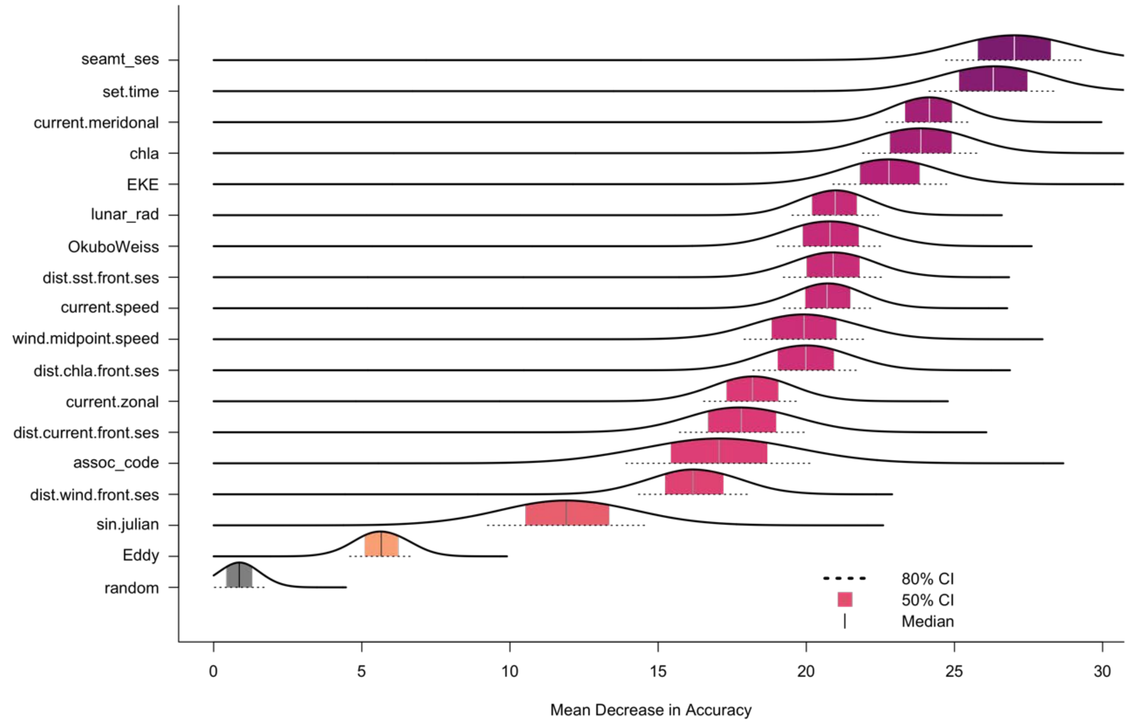


Figure 1. Relative importance of factors considered in the model for Mobula birostris that performed better than a random variable. The distribution for each factor is the distribution of mean decrease in accuracy from 100 individual random forest runs.

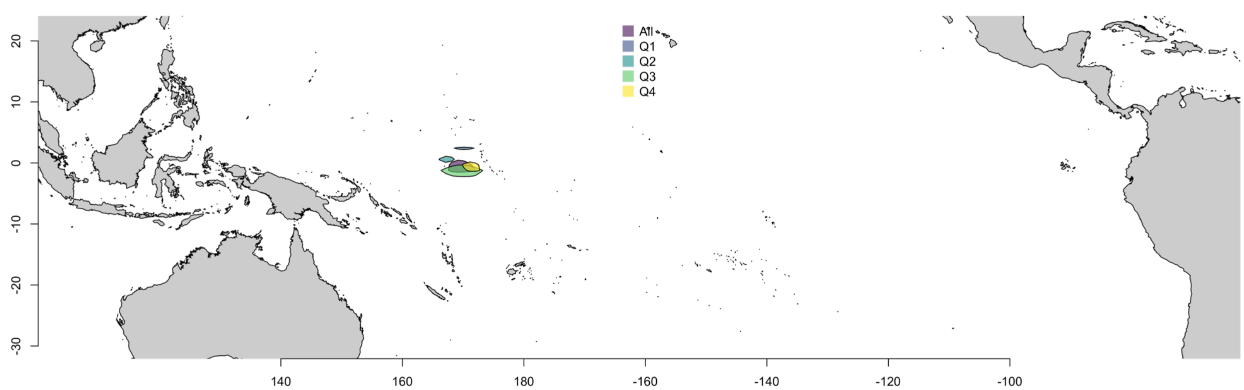


Figure 2. Annual and quarterly polygons indicating the location of the higher (defined as the 80% quantile) Ensemble Random Forest predicted values from sets with interactions after smoothing with a kernel density estimator for Mobula birostris.

Bottomfish Fishery-Independent Survey in Hawai‘i Updates

BFISH 2021 Analysis

*Figure 3. Large Deep 7 school of lehi (*Aphareus rutilans*) around the Hawaiian Islands at a depth of 122.3 m.*

Video annotation and data transcription for MOUSS camera and cooperative research fishing operations conducted during the fall 2021 Bottomfish Fishery-Independent Survey in Hawai‘i (BFISH) are approximately 90% complete. Quality assurance and quality control of these data will take place in February 2022, with formal data analyses slated to begin in March 2022. Primary data analyses products will include species-specific biomass estimates for the associated stock assessment as well as estimations of optimal sampling levels necessary to achieve the target coefficient of variation (15%) for data feeding into the stock assessment.

BFISH 2022

Planning is underway for two separate BFISH operations scheduled for 2022. The first is a spring research and development project scheduled to take place on the NOAA Ship *Oscar Elton Sette* from March 24 to April 4, 2022. This project will have two focus areas:

1. The Life History Program will focus on the collection of juvenile and adult *Pristipomoides filamentosus* for ongoing research investigating (1) using the lens of a fish eye for more appropriate bomb radiocarbon age validation structure than the previously used otoliths and (2) the use of otolith microchemistry to understand recruitment dynamics between juvenile and adult habitats.
2. The Survey and Operations Support Program will test and evaluate new artificial lighting systems for the Modular Optical Underwater Survey System (MOUSS). The goal is to enable MOUSS to collect video data on target species below 250 m water depth. This would primarily increase sensitivity to onaga and other deeper-dwelling species.

The second effort is the annual fall BFISH survey which will include both the NOAA Ship *Oscar Elton Sette* and the Lynker/Pacific Islands Fisheries Group cooperative research fishers. They will deploy hook-and-line as well as camera gear around all eight main Hawaiian Islands under the standard annual survey methodology.

OceanEYEs

OceanEYEs citizen scientists have completed 60% of the final batch of imagery associated with the 2019 BFISH survey. Once this batch is complete, OceanEYEs efforts will switch from annotation of video data for an entire survey to targeted, species-specific imagery needed to improve automated machine learning detection and classification algorithms within the VIAME automated image processing system. To-date, about 13,000 volunteers have completed 2.6 million annotations of 240,000 images. Initial assessments suggest that the accuracy of the majority of these citizen scientist annotations is comparable with PIFSC expert annotations.

2. *Conserve Protected Species*

Winter Update from the Hawaiian Monk Seal Research Program

The Hawaiian Monk Seal Research Program's (HMSRP's) preparations for next season are well underway and other scientific activities have kept us busy. Here are a few highlights of what the program has been up to and what we are preparing for in 2022.

Field Camp Preparations

Conducting assessment and recovery camps in Papahānaumokuākea each season is a year-round effort behind the scenes and packing and hiring for 2022 are in full swing. The HMSRP intends to conduct a full season of monk seal population assessment activities and life-saving interventions in summer 2022. As we did not conduct field camps in 2020 due to the pandemic and had an abbreviated season in 2021, this will be our first full season since 2019. Camps will be deployed at Lalo, Kamole, Kapou, Manawai, and Hōlanikū, with abbreviated surveillance at Kuaihelani in partnership with the U.S. Fish and Wildlife Service.

Toxoplasmosis

Surveillance for and response to sick and injured seals are the cornerstones of the HMSRP's activities. In the main Hawaiian Islands, this includes seals that are affected by toxoplasmosis, a disease caused by a parasite (*Toxoplasma gondii*) that contaminates the environment via cat feces. The 15th known case of toxoplasmosis in Hawaiian monk seals was identified in October 2021. RW22, an adult male, was found stranded on O‘ahu and despite intensive care at the Marine Mammal Center's Ke Kai Ola facility in Kailua-Kona, he succumbed to the disease about 6 weeks later.

Toxoplasmosis is one of the leading causes of death for Hawaiian monk seals in the main Hawaiian Islands. Research led by the HMSRP that examined terrestrial runoff is in review. This investigation showed that land-to-sea flow of *T. gondii* locally is the main source of exposure for Hawaiian monk seals, and local to regional scale efforts to mitigate oocyst deposition and runoff can reduce risk of exposure to this disease. Additionally, a manuscript in preparation uses hydrological modeling and seal movement data to assess the risk of toxoplasmosis to Hawaiian monk seals.

Fisheries Interactions

The most recent life-threatening fisheries interaction with a monk seal occurred in late January 2022 along the Kaiwi Coast of Oʻahu. A juvenile male seal (R7AF) was successfully treated and released to the wild in early February after ingesting a barbed circle hook and wire leader. Removal was conducted at Ke Kai Ola with transport support from the U.S. Coast Guard. The hook was lodged in the esophagus and removed under anesthesia using an endoscope and specialized dehooking tools. R7AF is the fourth monk seal in a row that has been dehooked in this manner, avoiding invasive surgery and facilitating a speedy return to the wild. The gear is being examined more closely and is suspected of being drone-deployed. This makes the third suspected incident of drone-deployed gear affecting seals on the south and east sides of Oʻahu.

Figure 4. Juvenile male Hawaiian monk seal R7AF is released after being dehooked at The Marine Mammal Center's Ke Kai Ola facility.

Hawksbill Nesting in Hawaiʻi: 30-Year Dataset Reveals Recent Positive Trend for a Small, yet Vital Population

Evaluating wildlife population trends is necessary for the development of effective management strategies, which are particularly relevant for highly threatened species. Hawksbill marine turtles (*Eretmochelys imbricata*) are considered endangered globally and are rare in Hawaiʻi. Remnant hawksbill nesting beaches were identified in Hawaiʻi in the late 1980s, and the primary sites have been monitored since that time. In this study we summarize all available hawksbill nesting activity around the Hawaiian Islands between 1988 and 2018, highlighting relevant demographic and geographic data for the species. Because monitoring effort varied substantially across space and time, we implemented a predictive modeling approach that accounted for varying effort to explore potential trends in annual number of nesting females and nests over time. Field monitoring efforts documented an annual average of 14 ±4.3 (range: 5–26) nesting females and 48 ±19.0 (range: 12–93) nests, with a cumulative total of 178 individual nesting females and 1,280 nests recorded across all years. Nesting has been documented on four Hawaiian Islands, with the overwhelming majority of nesting females (78.4%) and nests (86.5%) recorded at four beaches along the southern coast of Hawaiʻi Island. Recent monitoring (2018) at a beach on

Moloka‘i Island revealed numbers similar to the most important beaches on Hawai‘i Island. Despite difficulty discerning obvious trends when looking solely at the raw tabulated numbers from field monitoring, our analysis suggests the numbers of nesting females and nests have been positively trending since 2006. This is supported by a higher percentage (57.1% of annual cohorts) of neophyte (versus remigrant) nesters over the second half of the monitoring time frame. The masking of obvious trends in the tabulated numbers is likely due to decreased overall monitoring effort as a result of reduced funding in recent years, coupled with a shift in focal monitoring effort from the historical primary nesting site of Kamehame to the more recently established nesting site of Pōhue. Although the positive trend is encouraging, our findings highlight the precarious state of hawksbills in Hawai‘i and the need to enhance monitoring across all sites to support more robust population assessments and management decision making.

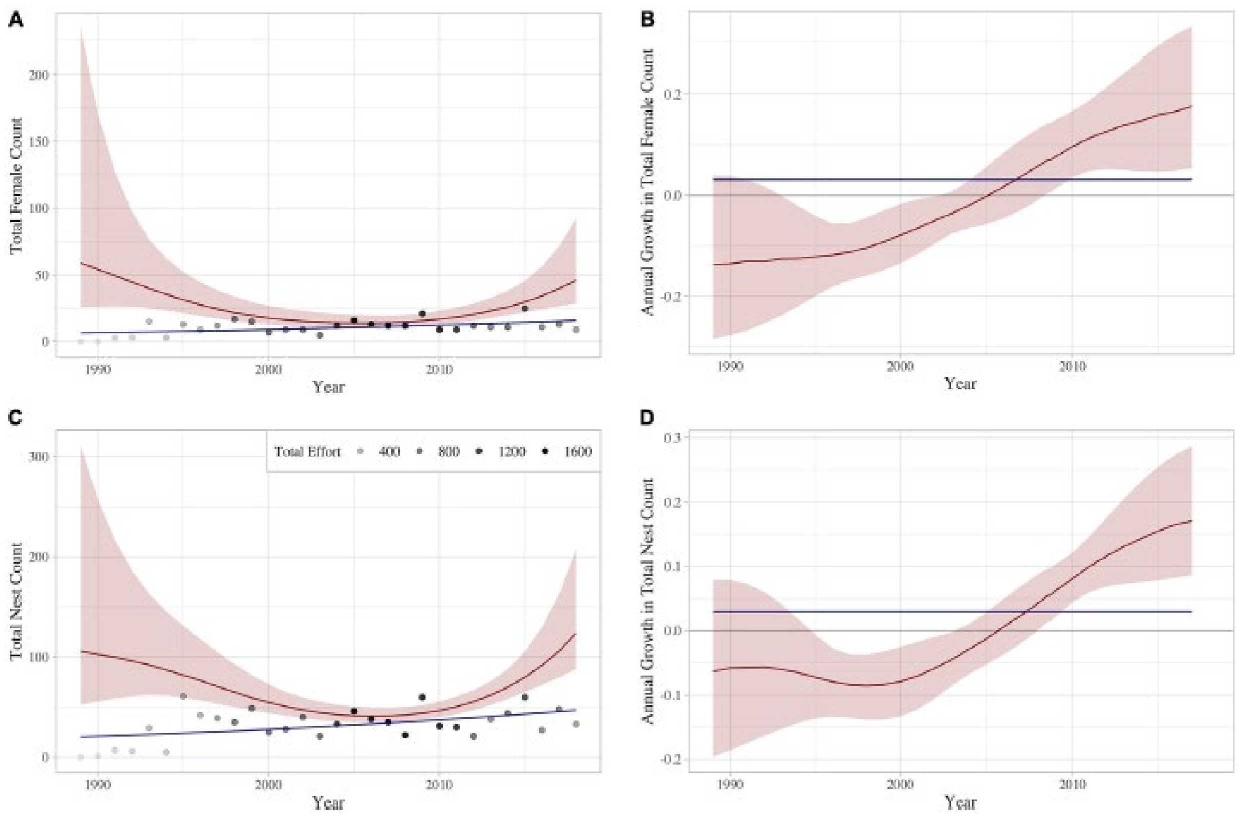


Figure 5. Yearly aggregated prediction of (A) females and (B) nests, as well as associated annual growth rates for (C) females and (D) nests. Solid red curves correspond to the empirical Bayes posterior mean, and the estimated 95% credible bands are shaded in red. Effort levels (shaded dots) are shown in A and B for reference. Total effort is the sum of all night camps and days surveys throughout the year. The blue line represents the constant slope fit for the raw tabulated numbers of (A) and (B), as well as the associated constant yearly growth for tabulated (C) and (D).

Tracking Reproductively Active Adult Green Turtles After the Loss of the Iconic Index Nesting Beach for the Central North Pacific Distinct Population Segment

The PIFSC Marine Turtle Biology and Assessment Program (MTBAP) is gearing up for its fourth season of tracking reproductively active green turtles after significant habitat loss occurred in 2018 from Hurricane Walaka. The focus of this project is to study the adaptive capacity of the population to climate change impacts on habitat. Funding from NMFS Office of Science & Technology has allowed us to purchase 16+ satellite tags for this project. We deployed eight satellite tags in the past 2 years and we hope to put out another 8+ tags in FY22. Preliminary data suggest that Hawaiian green turtles continue to migrate to Lalo for reproduction (Figure 6) and some individuals appear to be able to adapt to climate impacts (loss of nesting habitat) as evidenced by some previously documented East Island baskers/nesters utilizing other islets within the atoll (Figure 7). However, East Island has accreted somewhat since the passing of Hurricane Walaka and some former East Island basking/nesting turtles have continued to use the islet (Figure 7) despite it being smaller and representing suboptimal habitat. East Island previously hosted over 50% of nests laid for the entire Hawaiian green turtle population and this research, coupled with ongoing MTBAP research into the carrying capacity and hatching success of nests deposited on East Island, will help identify how the current suboptimal habitat may impact population trends (i.e., through reduced hatchling production and a loss of overall nesting habitat).

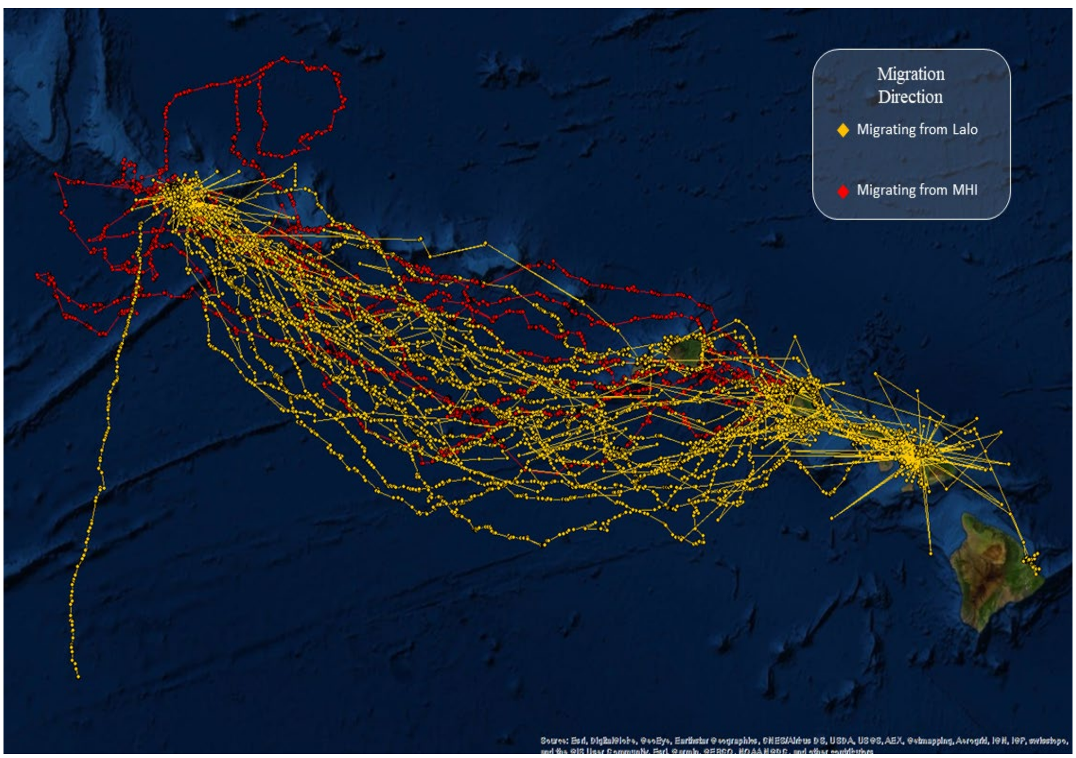


Figure 6. Reproductive migrations of all CNP green turtles that were satellite tagged during 1995 to 2021 (n = 39) that migrated to Lalo from MHI foraging areas (red lines) or from Lalo to MHI foraging areas or Johnston Atoll(yellow lines) (Balazs et al. 2017; NMFS MTBAP unpublished data 2021).

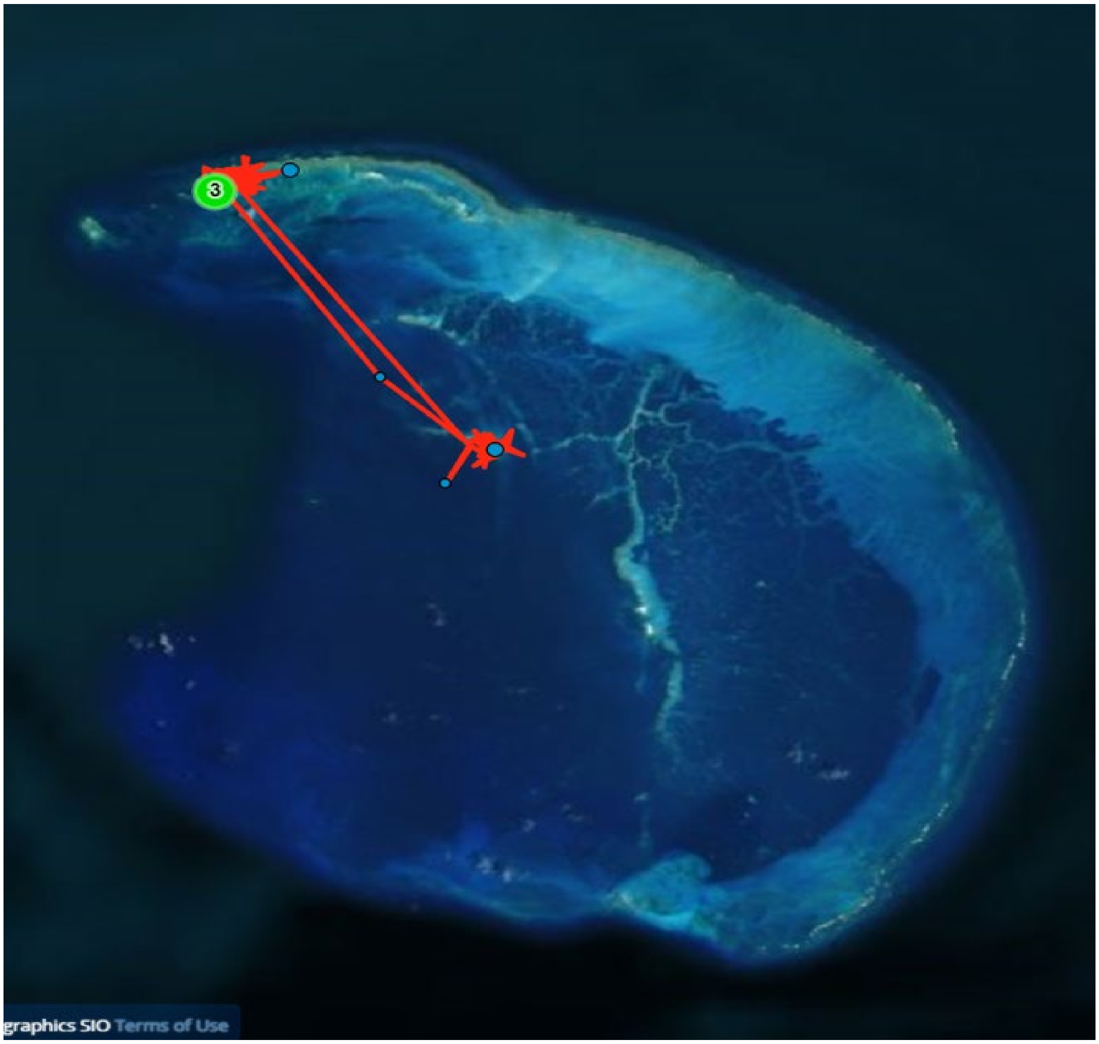


Figure 7. The 2021 season's nesting and basking locations of satellite-tagged Hawaiian green sea turtles in Lalo (French Frigate Shoals Atoll) within the Papahānaumokuākea Marine National Monument, approximately 500 miles northwest of the main Hawaiian Islands.

3. *Research to Support EBFM and Living Marine Resource Management*

Regional Implementation Plan for Human-Integrated EBFM Research Strategy

The increasingly dynamic physical, ecological, economic, and social environment in which we live makes the timely analysis of our human-natural ecosystem more valuable than ever**.** Robust economic and social analyses provide improved management, healthier ecosystems, better seafood, more profitable businesses, innovative interdisciplinary science, and more sustainable communities through more efficient and well informed trade-offs and a better understanding of how Americans value and use our marine resources. We have the opportunity to better integrate social and natural science and management to achieve "Human Integrated Ecosystem Based Fishery Management." During 2021, the NOAA Fisheries' National Economics and Human Dimensions Research Program released the Human-Integrated Ecosystem Based Fishery Management Research Strategy for 2021-2015[1].

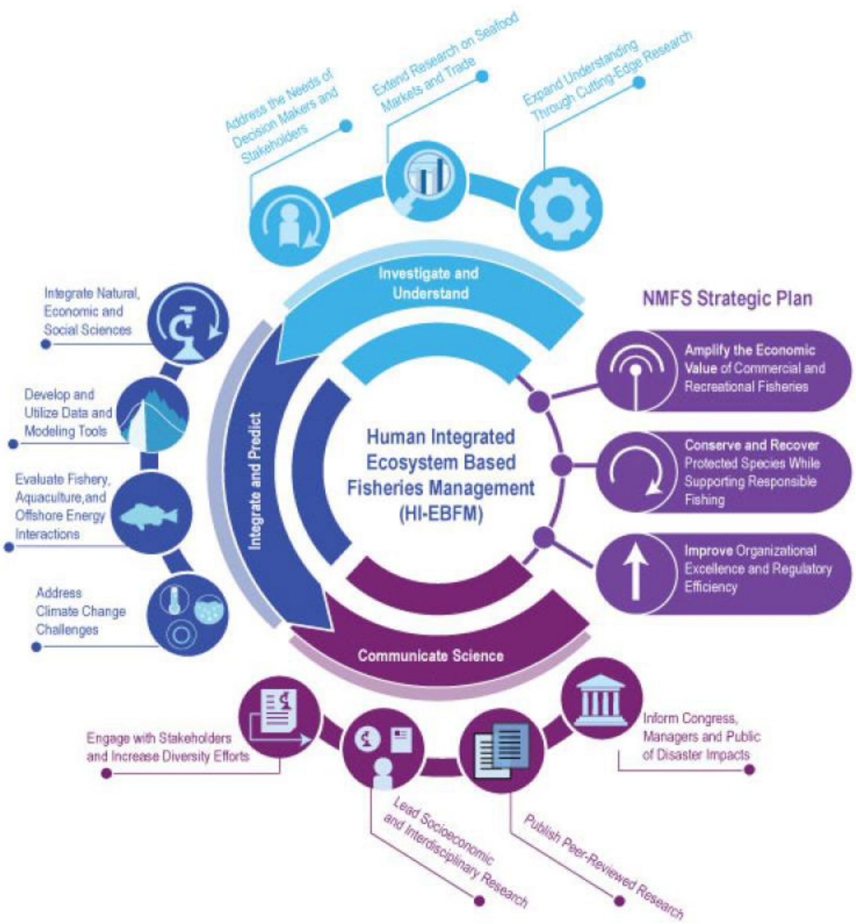


Figure 8. NOAA Fisheries Economics and Social Science HI-EBFM Plan to Achieve NOAA Fisheries Strategic Goals.

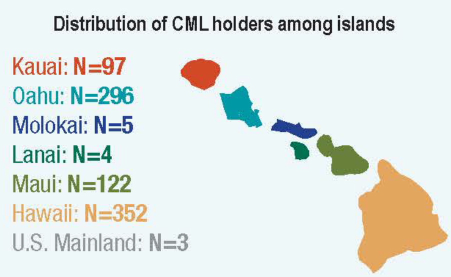
[1] https://www.fisheries.noaa.gov/human-integrated-ecosystem-based-fishery-management-research-strategy-2021-2025-executive-summary

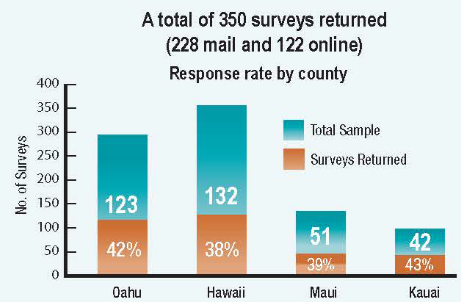
In response to this National Strategy, the PIFSC Social-Ecological and Economic Systems (SEES) Program has recently developed a Pacific Islands Regional HI-EBFM Implementation Plan[2] that maps out a five-year research plan (2021–2025) to advance HI-EBFM for the Pacific Islands Region. Approximately 64 research activities were identified and prioritized through internal SEES working sessions during 2021 and collectively address key HI-EBFM themes of (a) Commercial Fishery Economics, (b) Recreational Fishery Economics, (c) Human Dimensions, (d) Integrated Ecosystem Research (Modeling), (e) Communications and Stakeholder Research. Proposed activities align with the National HI-EBFM Research Strategy, existing WPFMC five-year research priorities, and ongoing PIFSC planning efforts such as EBFM implementation and the Pacific Islands Regional Climate Action Plan. The PIFSC SEES Program looks forward to tackling this ambitious research agenda and will keep the Council updated on implementation progress.

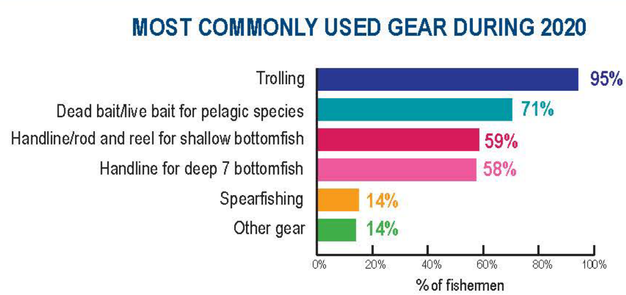
[2] https://docs.google.com/spreadsheets/d/1DYHDFQvVqEgp-GcNsMIZO9xOB2BTAYfj/edit?usp=sharing&ouid=115032476340081705425&rtpof=true&sd=true

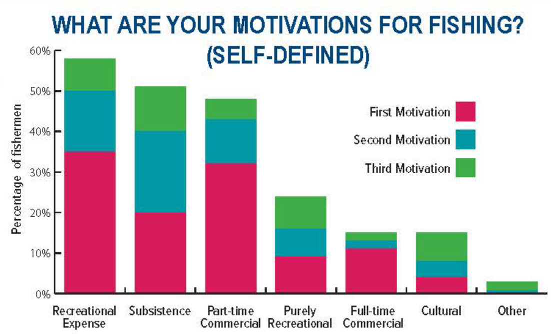
Hawai‘i Small Boat Survey 2021

NOAA’s Pacific Islands Fisheries Science Center conducted the 2021 Hawai‘i Small Boat Survey to better understand the important economic, social, and cultural contributions that small boat fishing provides to the State of Hawai‘i. All commercial marine license (CML) holders who had landed at least one fish in 2020 were eligible to participate in the survey. Fishers had the opportunity to complete the survey online or through a booklet in the mail. Thank you for your support—we received 350 responses out of 879 (40%) surveys sent! For more information about this survey, contact pifsc.socioeconomics@noaa.gov.





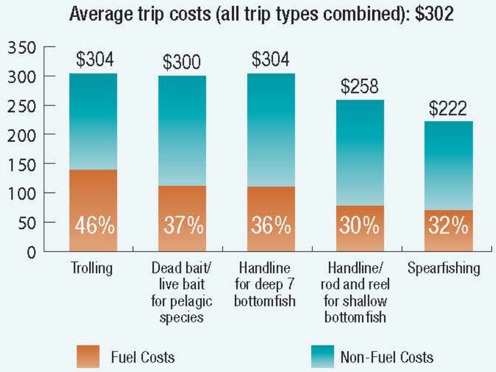




TRIP COSTS BY GEAR TYPE

Trip costs include boat fuel, truck fuel, oil, ice, bait, food & beverages, daily maintenance and repair, gear lost, and other expenses. Average trip costs and the percent of trip costs from fuel are summarized below by gear type.

Average trip costs (all trip types combined): $302



ANNUAL FIXED COSTS

Average annual fishing expenditures increased 27% from 2013 ($5,557) to 2020 ($7,069). Almost all expenditure categories were higher in 2020 (except for loan payments).

Expenditure Category	Annual Fixed Costs in 2020	Annual Fixed Costs in 2013
Boat and trailer repair, maintenance & improvements	$2,337	$1,635
Gear replacement/repair from wear and tear	$1,969	$1,671
Loan payments	$718	$970
Boat insurance	$699	$420
Fees (permit, registration, etc.)	$648	$399
Mooring fees	$629	$414
Financial services	$49	$30
Other expenses	$18	$19
Total	**$7,069**	**$5,557**

Figure 9. Hawai‘i Small Boat Survey infographic.

RICHARD (Rainier Integrates Charting, Hydrography, and Reef Demographics) Mission to the Mariana Archipelago on NOAA Ship *Rainier*

Figure 10. PIFSC NCRMP team approaches Rainier after a day of surveys.

The *Rainier* is currently scheduled to set sail from Honolulu in March, arriving in Guam in early April. Onboard, a team of scientists from across NOAA will simultaneously conduct our dive-intensive National Coral Reef Monitoring Program (NCRMP) long-term coral reef surveys aboard two small boats and high-resolution hydrographic surveys using the *Rainier* and two hydrographic survey launches.

The primary goal of NCRMP is to maintain our long-term time series to report status and trends of U.S. coral reef ecosystems and drivers of ecosystem changes. Other important goals of NCRMP are to deliver high-quality data, data products, and tools to the coral reef conservation community, provide context for interpreting results of localized monitoring, and maintain strong partnerships with federal, state/territory, and academic partners.

The high-resolution bathymetric surveys will produce mapping data to support NOAA's nautical charting products, improve maritime safety, and characterize seabed habitat in areas of the Mariana Archipelago that, in some cases, have not been surveyed in over 80 years, if at all. These data will be integrated with newly acquired topo-bathymetric light detection and ranging (lidar) data to create a seamless map linking terrestrial, nearshore, and offshore areas.

Figure 11. Rainier is equipped with two highly sophisticated hydrographic launches and two dive boats that will all be deployed daily to conduct NCRMP surveys and mapping in the region.

The Pacific Islands Fisheries Science Center's Life History Program will join this expedition for the final leg to conduct important life history research in this region, time permitting. These surveys supplement ongoing bottomfish market sampling efforts in Guam and Saipan by collecting additional biological samples, such as otoliths, gonads, and tissue samples from multiple locations throughout the Mariana Archipelago. The data will directly inform fisheries stock assessments and hence sustainable fisheries management.

4. Organizational Excellence

Journal Articles

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