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NOAA FISHERIES

PACIFIC ISLANDS FISHERIES SCIENCE CENTER

Report to the Western Pacific Regional Fishery Management Council

June 2022

NOAA Ship Rainier recovers hydrographic survey launch. (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 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 (PIFSC Science Plan) 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

Uku SE22-02 Leg 1 Life History Program Research Projects

Life History Program scientists aboard the NOAA Ship *Oscar Elton Sette* visited Penguin Bank (southwest Moloka‘i), west Lāna‘i, and the Maui Nui area this spring to conduct three bottomfish research projects in five days.

During the first project, scientists collected juvenile and adult ‘ōpakapaka (*Pristipomoides filamentosus*) eye lenses to explore their use as more appropriate bomb radiocarbon age validation structures than otoliths. A key assumption in bomb radiocarbon research is that the timing and magnitude of ^{14}C should be synchronous between otoliths and the reference ^{14}C chronology. Therefore, it is critical that fishes live in similar water masses to the regional reference chronometers. In Hawai‘i, the reference ^{14}C chronology comes from shallow water corals whereas bottomfish live in deepwater. This spatial discrepancy is being addressed by investigating the use of eye lenses as more appropriate age validation structures. Several notable differences make eye lenses a more appealing biological structure for age validation studies using the bomb radiocarbon chronometer than otoliths. Most importantly, whereas the predominant source of most elements and isotopes to otoliths is dissolved inorganic carbon from the surrounding seawater, eye lenses are derived from 100% metabolic carbon. Because $\Delta^{14}C$ in deep-sea organisms is mainly derived from phytoplankton that inhabit the euphotic zone, eye lens cores would reflect similar $\Delta^{14}C$ values to the reference chronologies established from shallow water corals (and fishes). Otolith cores would be depleted relative to surface water signatures. If deemed suitable, then the eye lens ^{14}C could also be used to extend the current coral reference curves. The eye lens approach to bomb radiocarbon age validation is a budding area of research that PIFSC’s life history program (LHP) is actively pursuing by examining not only ‘ōpakapaka from Hawai‘i but also gindai (*P. zonatus*) from Guam.

Juvenile ‘ōpakapaka were also targeted during the survey from the areas surrounding Penguin Bank. These fish spend the first few years of their lives in shallow water before migrating to deeper water habitats. How far they are willing to travel to adult habitats is currently unknown. This project is exploring the origin of adult ‘ōpakapaka at Penguin Bank. Currently, LHP is examining the variability in the microchemistry of juvenile otoliths collected throughout Hawai‘i to develop an ‘elemental map’ that delineates specific nursery areas. The natal microchemistry composition is conserved in the core of adult otoliths, so when it is compared to the microchemistry of juveniles, we will be able to determine an individual’s nursery area of origin. While we collected juvenile fish from a variety of locations around Penguin Bank during the survey, we also thanked fishermen, such as Roy Morioka who continue to collect juvenile ‘ōpakapaka for this project.

The final project investigated fish reproduction. Researchers examine fish gonads (fish reproductive organs) to determine the size and age at which fish mature, important information for stock assessments regardless of the methods used. Typically, researchers collect the gonads from fish, preserve them in formalin, and then affix them to microscope slides. They then examine the slides to ascertain whether the fish is mature or not. However, some characteristics of mature fish also appear in the gonads of juvenile fish that were poorly preserved (such as frozen, or kept at room temperature or on ice for too long). This can result in a misclassification of maturity and may potentially bias the size and age at maturity estimates. During the survey, gonads from developing and spawning capable bottomfish were collected and preserved at several different times after catch that mimic poor preservation conditions to test how this impacts maturity estimates. These samples are currently being processed into histology slides and comparisons will ensue.

Although the field sampling took place over an extremely short time period (five days), sufficient samples were collected to continue advancing this research. The three projects highlighted here are examples of the research LHP conducts to advance life history information for stock assessments and sustainable fisheries management.

Photo: LHP staff fishing for bottomfish and processing them for otoliths, eye lens, and gonads during SE22-02 Leg 1.

Uku Essential Fish Habitat Level 2 Dynamic Modeling Approach

Aprion virescens (Hawaiian name ‘uku’, common name ‘green jobfish’) is a large reef-associated snapper and the only shallow bottomfish species in Hawai‘i within the Bottomfish Management Unit Species complex. While the adult stage essential fish habitat (EFH) for *A. virescens* is broadly designated from the shoreline to offshore down to 240 meters deep, there are no empirical studies quantifying the species’ density (EFH level 2 criterion) in shallow water (0–30 m). More information on the species’ habitat connectivity from offshore to nearshore could inform refinement of the species’ EFH designations in the main Hawaiian Islands (MHI). We developed a statistical EFH modeling framework employing a combination of in situ *A. virescens* density data enhanced by various satellite data sets to estimate the species’ abundance in shallow

MHI waters (Figure 1, Figure 2). This statistical EFH modeling framework can predict the localized changes in the distribution of target species density in relation to relevant dynamic environmental variables (e.g., sea surface temperature and chlorophyll-a concentration), which can be used as a proxy for species abundance (Figure 3). This is the first study to use a large, fishery-independent database as a source of data for analysis and prediction of the habitat distribution of *A. virescens* along the nearshore coastal area in the MHI region. This study will be subject to a Tier 1 Western Pacific Stock Assessment Review process scheduled from July 12–14, 2022. The results of this study provide information on the spatial distribution of *A. virescens* which fishery managers can use to distinguish the species' EFH and apply enhanced management strategies.

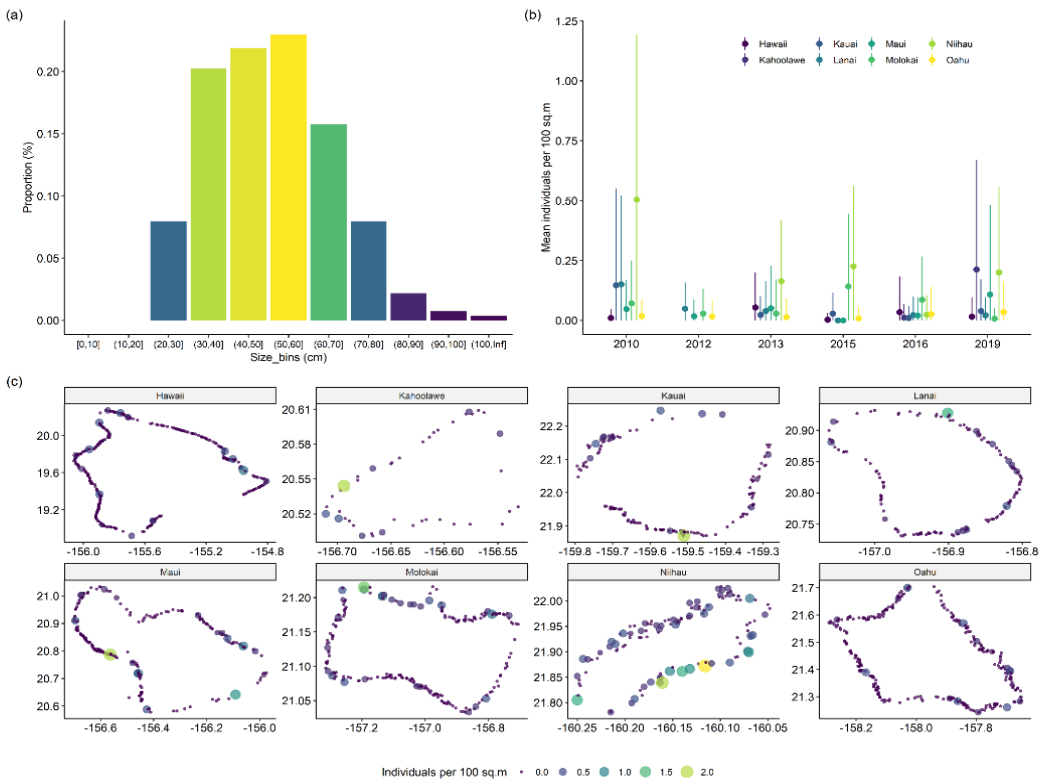

Figure 1. Fishery-independent (a) size compositions, (b) mean densities, and (c) spatial density distributions of Aprion virescens in the shallow main Hawaiian Islands waters (0–30 m) for the 2010–2019 period. Data were drawn from the National Coral Reef Monitoring Program.

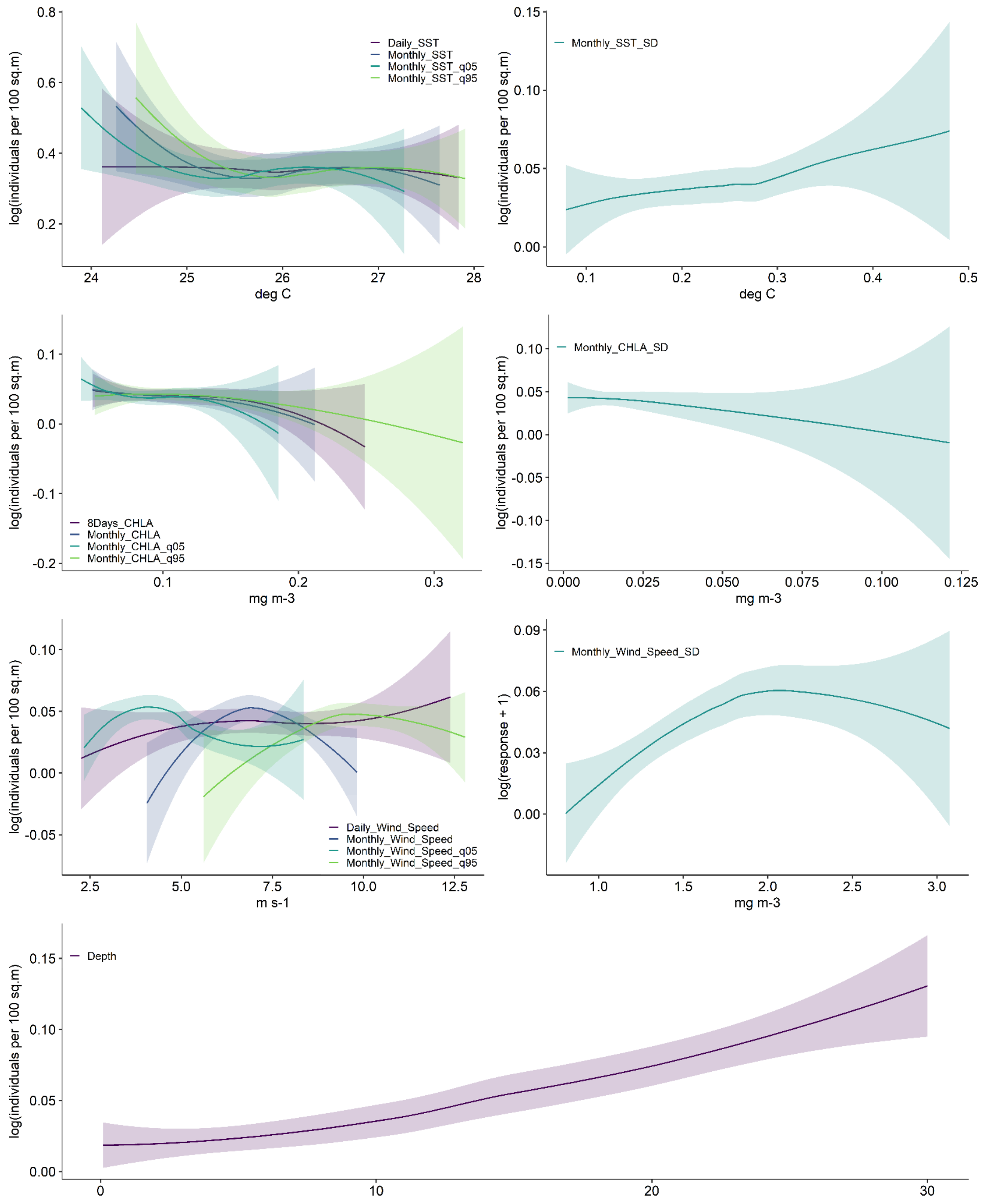

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Figure 2. Relative effects of the fixed environmental effects (x-axis) illustrating differences in relative Aprion virescens density (y-axis) in shallow waters (0-30 m). Lines represent means and shaded ribbons represent 95% CI.

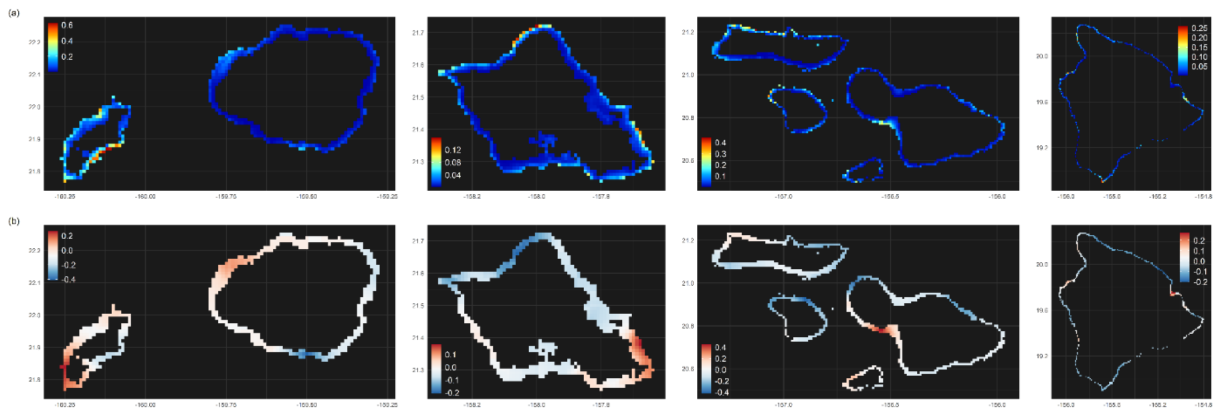


Figure 3. Model predicted spatial and temporal patterns of Aprion virescens density across the Main Hawaiian Islands; (a) spatial distribution of mean density (individuals per 100 sq.m) over 2010–2019, (b) predicted local trend (slope coefficient of log density) over 2010–2019. First column: Ni'ihau-Kaua'i. Second column: O'ahu. Third column: Moloka'i-Lana'i-Kaho'olawe-Maui. Fourth column: Hawai'i.

Updates on Longline Tagging Bycatch Reduction

Satellite tagging of loggerhead sea turtle bycaught in HI SSLL fisheries

Reducing loggerhead and leatherback sea turtle bycatch in the Hawai‘i longline fisheries includes the development of species distribution models and ecosystem-based fisheries management (EBFM) tools aimed at establishing spatio-temporal regions of potential high sea turtle bycatch. To refine and improve upon species distribution models (i.e., EBFM tools), there is a need to deploy satellite tags on loggerhead sea turtles that interact with the Hawai‘i longline fisheries. Although satellite tags have been previously deployed on North Pacific loggerhead turtles, these tags were deployed on turtles that were primarily 1) released in the western North Pacific Ocean, 2) raised in captivity, or 3) deployed 15+ years ago.

As a result of these conditions, newer, more recent movement data are needed to inform our contemporary models. To address this gap, in 2021 PIFSC researchers (PSD and FRMD) in close collaboration with the NOAA Fisheries Observer program organized, developed, and implemented a post-hooked sea turtle satellite tag deployment project. These efforts included a tag deployment training module for fishery observers and the deployment of satellite tag kits for loggerhead sea turtles to the observers of the Hawai‘i SSLL fisheries.

To date, a total of 20 satellite tags have been deployed on loggerhead sea turtles bycaught in the Hawai‘i shallow set longline fishery. Over 25 observers have been trained on the deployment of satellite tags and during Q4 of 2021 and Q1 of 2022, and 94% of the shallow set longline fishing trips included a trained observer with a satellite tagging kit.

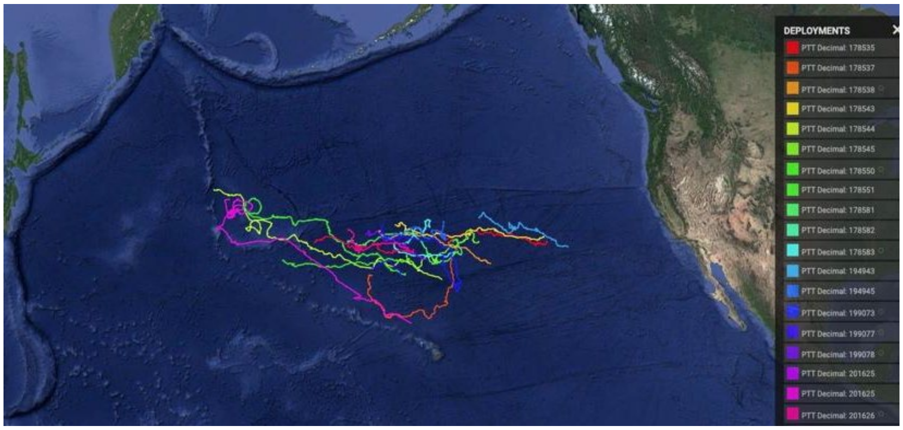


Figure 4. Post-hooking movement patterns of 20 loggerhead sea turtles bycaught in the HI SSLL fisheries, 2019-2022.

This satellite tagging effort has helped generate critical, fundamental movement data needed to improve the accuracy of the Protected Species Ensemble Random Forest (PSERF) model. Further efforts to increase the deployment of satellite tags on post-hooked turtles in the Hawai‘i SSLL fisheries will help facilitate increased movement data collection and PSERF model accuracy.

Designing tagging technologies for the direct attachment of satellite tags onto leatherback sea turtles.

As with loggerhead sea turtles, reducing leatherback sea turtle bycatch in the Hawai‘i longline fisheries also includes the development of species distribution models (e.g., PSERF) for ecosystem-based fisheries management (EBFM). Unlike hardshell turtles, techniques to attach satellite tags require boating leatherback sea turtles which is not practical in a fishery setting. In response to this significant difference, PIFSC researchers in collaboration with NOAA OPR’s marine turtle veterinarian, the Western Pacific Regional Fishery Management Council, and Wildlife Computers (a leading wildlife telemetry solutions company) designed new tagging technologies to enable vessel-side tagging of bycaught leatherback sea turtles.

Two main components for tagging leatherback sea turtles in this manner include: 1) a tag head (i.e., tag anchor) designed specifically to safely implant in leatherback sea turtle carapaces and 2) a deployment device that results in the precise implantation of the tag head into the turtle’s carapace. A testing mechanism was developed to determine the force necessary to implant tag anchor designs into leatherback carapaces (carapace samples were collected from freshly dead leatherback turtles (Figure 5: A, B)). These carapaces were then sent back to NOAA veterinarian laboratories where computed tomography (CT) scanning (Figure 5c) and gross dissection (Figure 5) showed that implanting tag anchors imposed a limited degree of trauma and very localized effects with no substantial fractures within the carapace (Figure 5c). Initial results indicated that it is achievable to design tag anchors for leatherback sea turtles that results in only limited injury to the carapace.

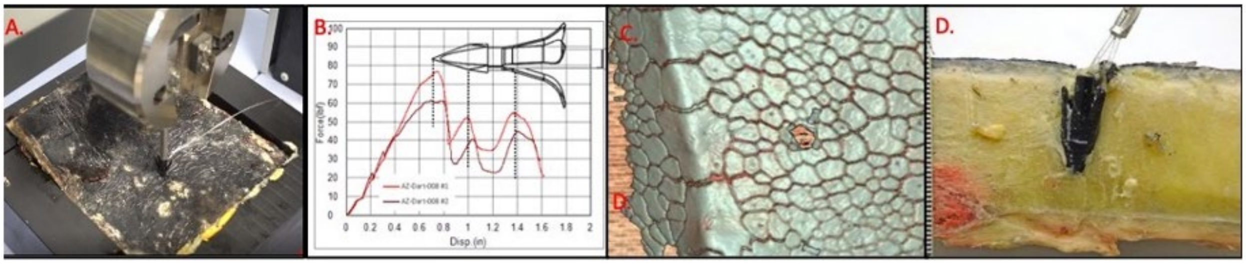
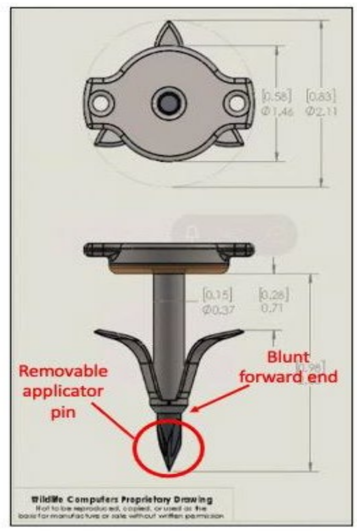


Figure 5. A. Motorized load cell that measures the forces needed to penetrate and implant various tag anchor designs in a leatherback carapace sample (provided by NOAA from freshly dead turtles). B. Graph of force and displacement overlayed on features of the tag anchor. C. Subsequent 3-D computer tomography (CT) scans of the carapace showing only localized damage to the mosaic osteoderms that comprise the carapace of the leatherback. D. Cross sectional dissection of the carapace showing the embedded tag anchor within the fibrous adipose layer. (Figures A, B from Wildlife Computers, Inc. Figures C, D from Dr. Brian Stacy).



The prototype tag anchor for leatherback turtles has been refined leading to minimizing the size of the anchor while incorporating safety elements such as a cushioned stopper plate to ensure a maximum depth penetration well within safety margins. Another safety feature is the use of a removable applicator pin that leaves only a blunt forward end of the tag anchor in the fibrous adipose layer of the carapace which further minimizes migration of the tag toward the coelomic membrane. By incorporating these safety elements into the tag design, concerns likely to come up during the animal welfare and experimental permitting processes are being preemptively addressed.

Development of a power-assisted pole deployment device needed to precisely imbed the above designed tag anchor into a leatherback carapace is ongoing. The goal is to make a device that allows a bycaught leatherback to be brought alongside a fishing vessel so that a tagger can use the pole to reach down to the animal (sometimes 2–4 m below, depending on the vessel's freeboard) to implant the tag.

Research article:

John Wang of the PIFSC Fisheries Reporting and Bycatch Program recently published a paper on the use of net illumination to reduce bycatch, particularly sea turtle bycatch, in coastal gillnet fisheries (Senko et al. 2021). Though it has been shown to decrease bycatch of sea turtles, sea birds, small cetaceans, elasmobranchs and, in this report, overall bycatch biomass, net illumination does not decrease target catch or catch value. By demonstrating that it actually increases fishing operational efficacy, adoption of the technology may expand. This research article was widely cited in various lay press outlets, including Economist, Forbes, Smithsonian, Bloomberg, NPR-Weekend Edition, Wildlife Conservation newsletter, National Geographic Magazine (planned for June 2022).

Table 1. Published studies examining net illumination as a bycatch reduction technology.

Fishery and testing location	Light source	Bycatch reduction	Target catch	Number of bycatch animals in study	Reported fishing effort	Citation
Sea turtle bycatch studies						
Baja, MX experimental gillnet	Green lights	60% reduction-green sea turtles	No difference	115 sea turtles	12 net sets	Wang et al. 2010
Baja, MX experimental gillnet	Green LEDs	40% reduction-green sea turtles	No difference	187 sea turtles	30 net sets	Wang et al. 2010
Baja, MX experimental gillnet	UV LEDs	40% reduction-green sea turtles	No difference	332 sea turtles	22 net sets	Wang et al. 2013
Peruvian bottom set gillnet fishery	Green LEDs	64% reduction-green sea turtles	No difference	194 sea turtles	228 net sets	Ortiz et al. 2016
Italian bottom set gillnet fishery	UV LEDs	100% reduction-loggerhead turtles	No difference	16 sea turtles	669 net panels	Virgili et al. 2018
Peruvian gillnet (drift net and bottom set) fisheries	Green LEDs	70–74% reduction - mixed species of sea turtles (green, olive ridley, and loggerhead sea turtles)	No difference	131 sea turtles	864 net sets	Bielli et al. 2020
Ecuadorian drift gillnet fishery	Violet LEDs	93% reduction–mixed species of sea turtles (olive ridley, green, and leatherback sea turtles)	No difference	32 sea turtles	146 net sets	Darquea et al. 2020
Ghanaian gillnet fishery	Green LEDs	81% reduction–mixed species; 88% reduction of leatherbacks, 81% reduction of olive ridleys	No difference	222 sea turtles	9,761 net sets	Allman et al. 2020

Fishery and testing location	Light source	Bycatch reduction	Target catch	Number of bycatch animals in study	Reported fishing effort	Citation
Indonesian drift gillnet fishery	Green LEDs	61% reduction–mixed species.	No difference	33 sea turtles	140 net sets	Gautama et al. (in review)
Other bycatch taxa studies						
Peruvian bottom set gillnet fishery	Green LEDs	85% reduction–guanay cormorants	No difference	45 cormorants	228 net sets	Mangel et al. 2018
Peruvian gillnet (drift net and bottom set) fisheries	Green LEDs	70–66% reduction–mixed species of cetaceans	No difference	53 cetaceans	864 net sets	Bielli et al. 2020
Baja, Mexico bottom set gillnet fishery	Green LEDs	63% reduction–total bycatch biomass; 48% reduction in finfish bycatch; 95% reduction in elasmobranchs bycatch.	No difference	2273 kg of bycatch biomass	56 net sets	Senko et al. 2022

2. *Conserve Protected Species*

Hawaiian Monk Seal Research Program

The Hawaiian Monk Seal Population Estimate Surpasses 1,500!

Photo: A Hawaiian monk seal rests on the beach under a rainbow. NMFS permit 848-1695.

After an unprecedented pause in our field research activities due to the pandemic in 2020, the Hawaiian Monk Seal Research Program resumed many of its core population assessment and enhancement activities in 2021. This included deploying field research teams at key subpopulation sites in the Northwestern Hawaiian Islands. Over the last few months, the HMSRP has been evaluating the data from our remote field efforts as well as the data we receive from the public and partners across the main Hawaiian Islands. We are pleased to share the results of population research and enhancement efforts from 2021 as we reached a new milestone!

The HMSRP estimates that the total number of monk seals throughout their entire range was 1,570 in 2021. This is a considerable increase since the most recent estimate of 1,435 in 2019, and it is the first time the population has exceeded 1,500 seals in more than two decades. The population has grown on average at 2% per year from 2013–2021.

Positive trends were seen throughout four of the six subpopulation sites in the Northwestern Hawaiian Islands and the population trends at the other two sites remained the same as in 2019.

In the main Hawaiian Islands, despite some unfortunate losses to human-related causes in 2021, population growth remained strong.

With this good news, there are also areas we will closely monitor in 2022 and beyond. Some Northwestern Hawaiian Islands subpopulations have shown low pup survival for a year or more, which is an important indicator of future trends. Also, the loss of island habitat at Lalo due to climate change heightens concerns about the long-term viability of the mostly low-lying islands that monk seals inhabit throughout most of the Northwestern Hawaiian Islands. Fortunately, our 2022 field teams are being deployed in May for another year of research and life-saving interventions to monitor and support seal survival in the face of these challenges. In the main Hawaiian Islands, there is a growing emphasis on human-seal coexistence, and we will continue to work with communities and partners to keep that momentum strong.

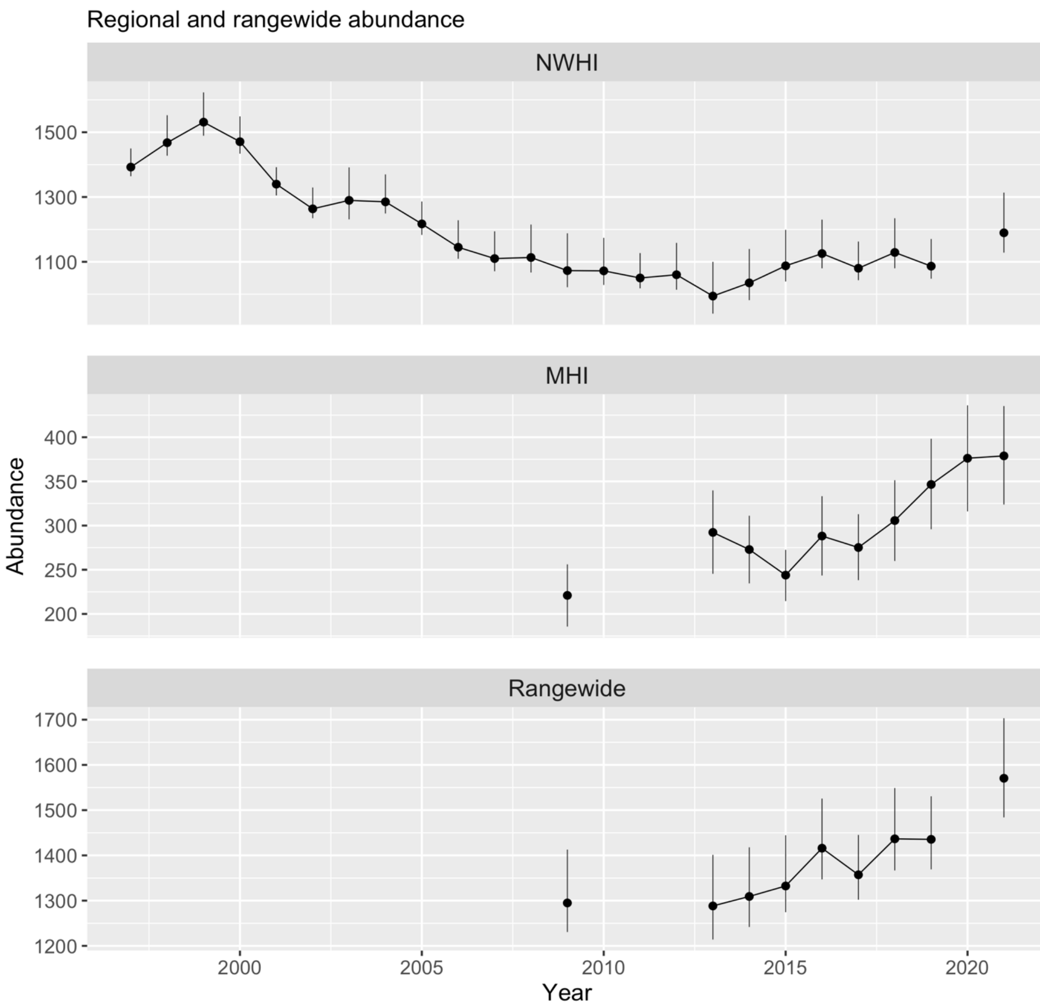


Figure 6. Trends in estimated number of Hawaiian monk seals in the Northwestern Hawaiian Islands (NWHI, top panel), the main Hawaiian Islands (MHI, middle panel), and range-wide (bottom panel). The solid circles indicate the best estimate, and the vertical lines span the 95% confidence intervals (reflecting uncertainty about the estimates). Note that estimates in the MHI (and consequently, for the entire range) are only available beginning in 2009. Partners supplied enough data to estimate MHI abundance in 2020, but the number of seals in the NWHI was not estimated that year. Credit: NOAA Fisheries

Protected Species Assessment and Recovery Camps Deploy in May 2022

Photo: A Hawaiian monk seal and Hawaiian green sea turtle resting on the beach at Manawai (Pearl and Hermes Reef). Credit: NOAA Fisheries/Sarah Glover (NMFS Permit #22677, PMNM Permit 2021-015).

On April 28, 2022, a team of field scientists bound for Papahānaumokuākea Marine National Monument departed Honolulu on the NOAA Ship *Oscar Elton Sette*. Field teams of 3–7 people will spend the next 4 months conducting research on endangered Hawaiian monk seals and Hawaiian green sea turtles at Lalo (French Frigate Shoals), Kamole (Laysan Island), Kapou (Lisianski Island), Manawai (Pearl and Hermes Reef), and Hōlanikū (Kure Atoll). Surveys will also be conducted at Nihoa, Mokumanamana, and Kuaihelani (Midway Atoll) from the ship. We are excited about deploying a shared NOAA-USFWS camp this season at Kapou to maximize our resources and capacity while minimizing our collective footprint in this special place. Field research teams will conduct life-saving interventions including rescuing turtles and seals from entrapment and entanglement, treating injured seals, rescuing malnourished pups, reuniting mother-pup seal pairs, and more. Assessing the resilience of these species to climate change remains of paramount importance to our research, and this is especially true at Lalo. The loss of habitat there further threatens nests of Hawaiian green sea turtles after losing their primary nesting site, East Island, in 2018. It also increases the vulnerability of Hawaiian monk seal pups at some Lalo islets to Galapagos shark predation and has important implications for the seals' ability to access foraging grounds. Population monitoring, instrument deployment, and preventive actions like monk seal vaccinations are all tools that will help shield these species against the growing threats they face.

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

Update on RICHARD Mission in the Mariana

The RICHARD (Rainier Integrates Charting, Hydrography, and Reef Demographics) mission got underway from Hawaiʻi on March 26, stopping for one day at Wake Island to deploy and recover high frequency acoustic recording packages (HARPs) used for long term monitoring of cetaceans in the Pacific Islands Region before continuing to Guam. Once in Guam, PIFSC scientists embarked on the NOAA Ship *Rainier* and began the National Coral Reef Monitoring Program (NCRMP) surveys. The achievements of the recently completed first leg, as well as extensive mapping around Guam and Saipan (see map) are listed below. The next leg, led by Chief Scientist Tom Oliver, began on May 9 (ChST) with a focus on benthic surveys. We are working with our local NOAA liaisons and partners in the region to plan outreach events in both Guam and Saipan in July and August.

Summary of Leg 1 NCRMP accomplishments:

- Fish team:
    - 108 SPC surveys
    - 98 photoquad site surveys
    - 85 SfM belt surveys
    - 55 CTD + water samples
    - 226 dives
- OCC team:
    - 39 CTD + water samples
    - 43 STRs deployed / 41 STRs recovered
    - 70 CAUs deployed / 66 CAUs recovered
    - 40 BMUs deployed / 35 BMUs recovered
    - 12 SfM fixed site surveys
    - 36 photoquad site surveys
    - 1 diel suite deployment
    - 165 dives

Photo: Rainier recovers hydrographic survey launch while NCRMP dive boats stand by.

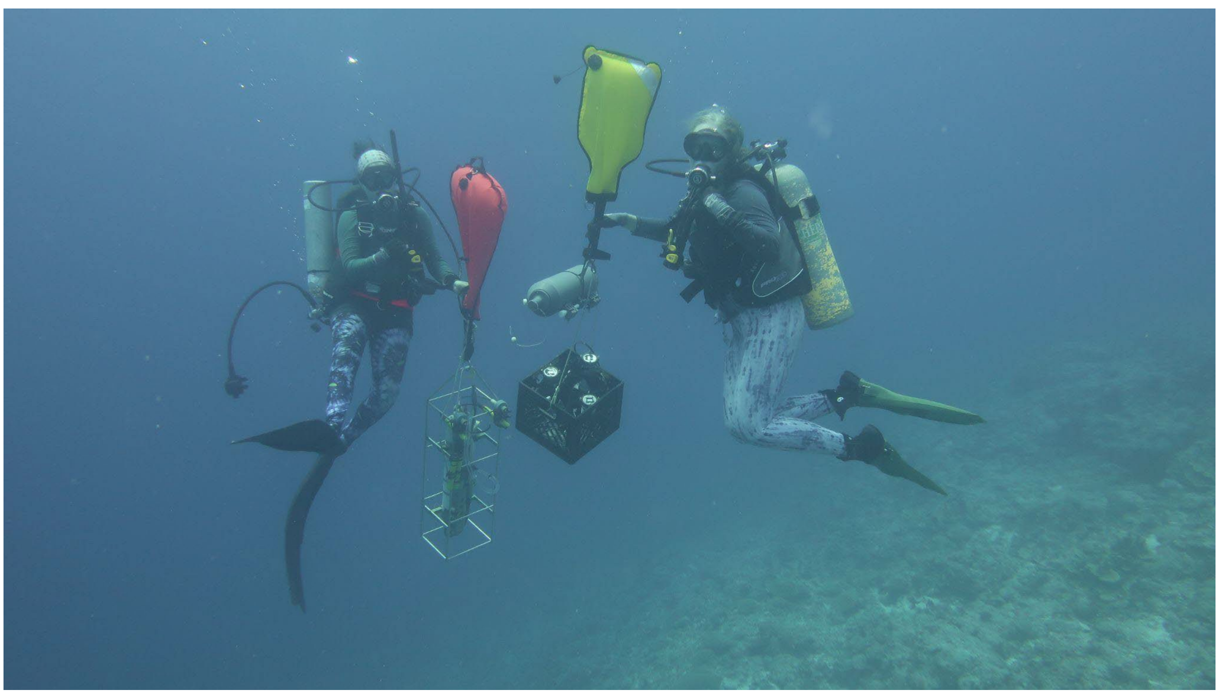


Photo: PIFSC Diver Rebecca Weible and Candace Alagata conduct lift bags operations to recover the water sampling diel suite in Saipan.

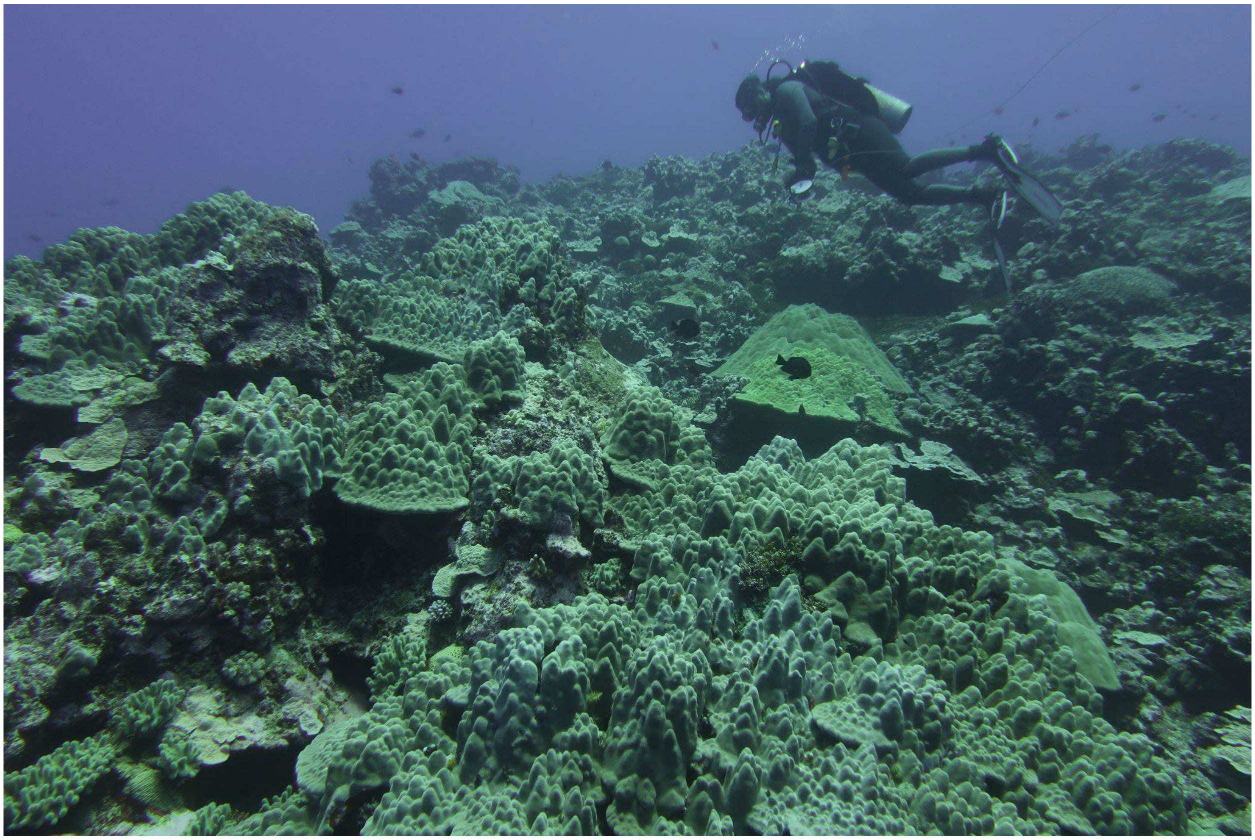


Photo: The coral reef in Aguijan.

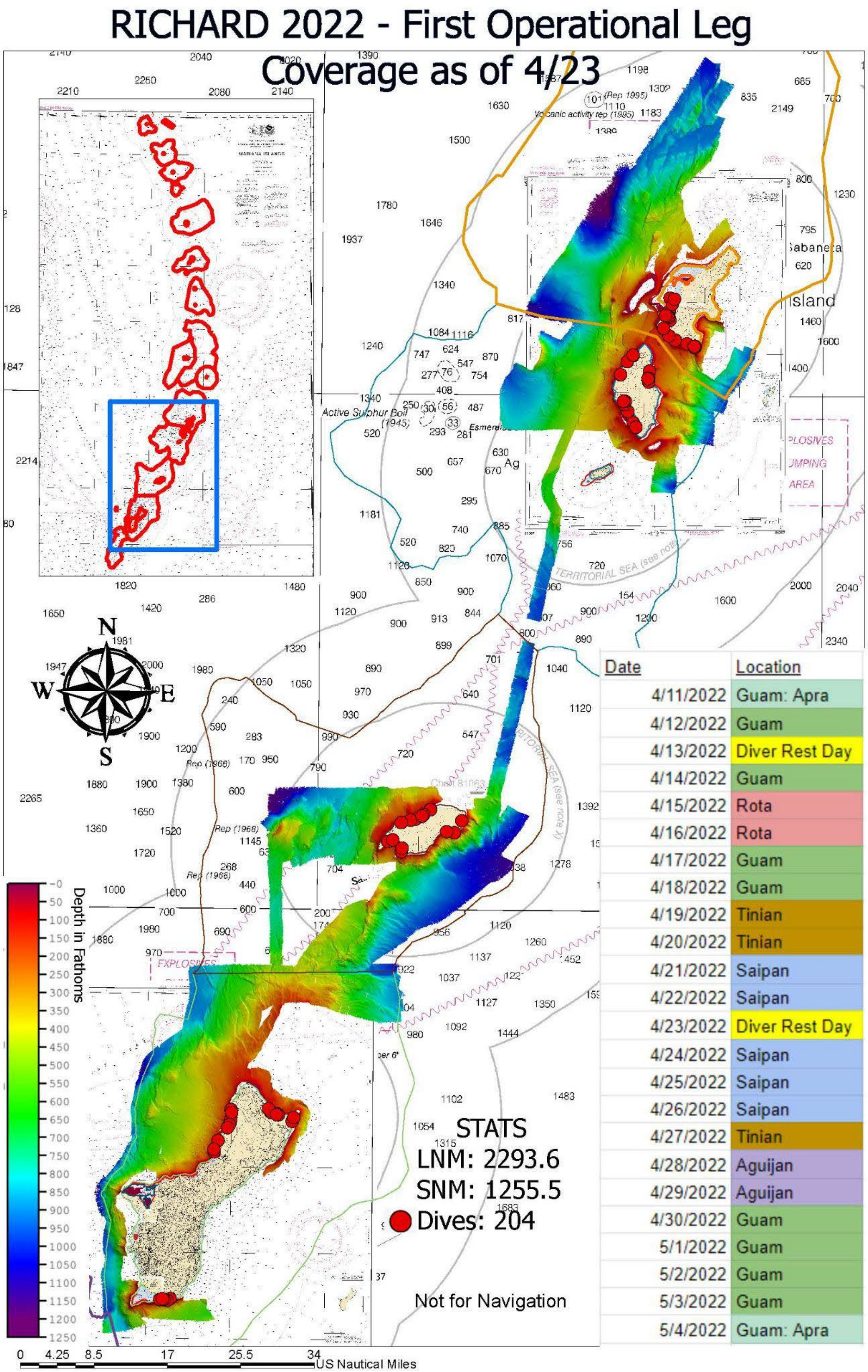


Photo: A representation of the hydrographic and NCRMP survey coverage as of May 1, 2022.

4. *Organizational Excellence*

Administrative Reports

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Data Reports

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