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NOAA FISHERIES

PACIFIC ISLANDS FISHERIES SCIENCE CENTER

The Pacific Islands Fisheries Science Center (PIFSC) conducts research in a wide variety of programs that may be of interest to the Western Pacific Fishery Management Council (Council). This report is organized around the research divisions of the PIFSC as a series of highlights.

Photo - Kevin Lino, PIFSC

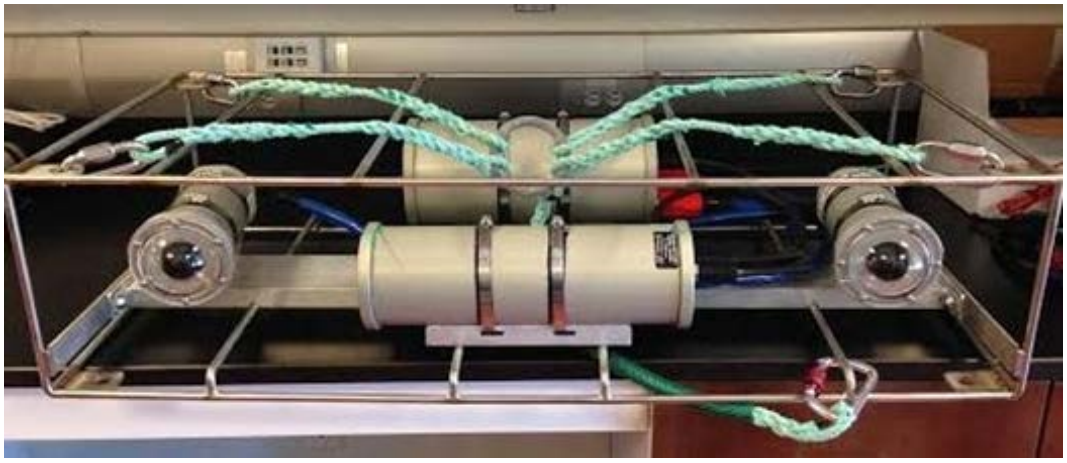
Report to the Western Pacific Fishery Management Council

October 2015

SCIENCE OPERATIONS DIVISION (SOD)

Operationalizing the Modular Optical Underwater Survey System (MOUSS) for the HA-16-01 Main Hawaiian Islands Bottomfish Survey

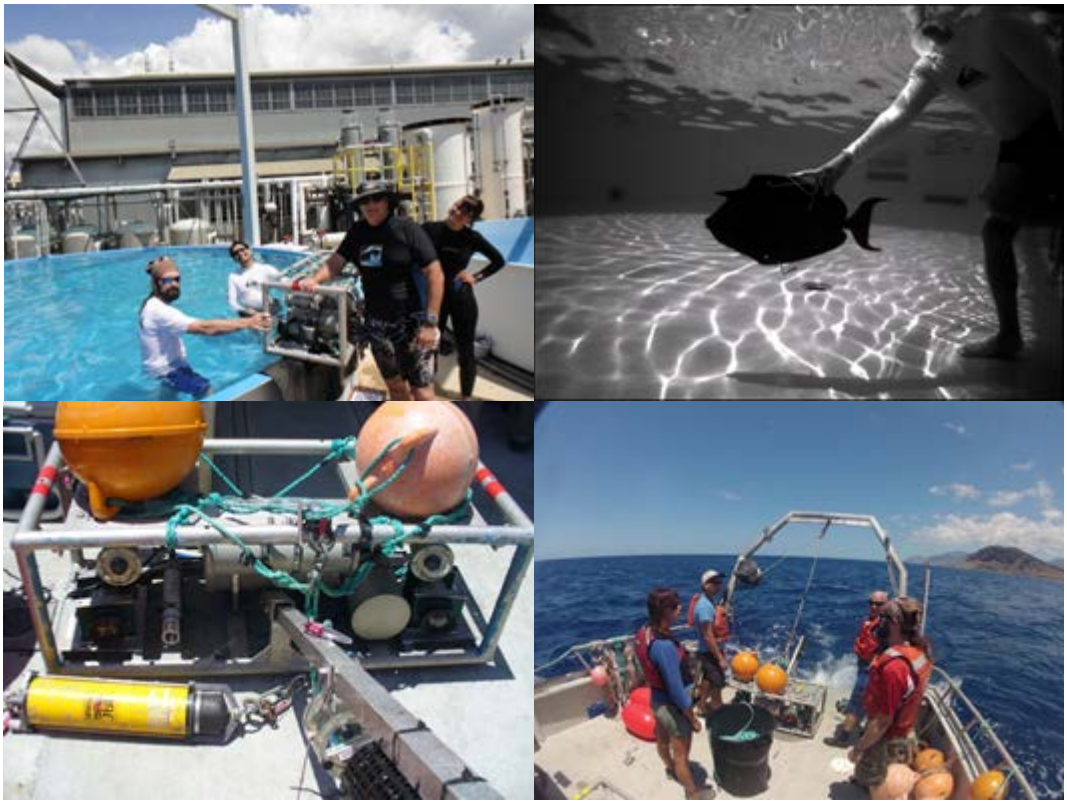
The Advanced Sampling Technologies and Survey Program (ASTSP) has continued to develop and refine the Modular Optical Underwater Survey System (MOUSS) in preparation for the HA-16-01 bottomfish research expedition aboard the NOAA Ship *Hi'ialakai* in October of 2015. The MOUSS is a modular autonomous stereo-video camera system designed for in-situ visual sampling of fish assemblages to aid in bottomfish population assessments. In-situ stereo-video camera systems are increasingly being used by scientists to generate non-extractive, high-resolution, and species-specific size and abundance estimates. Such methods are desired to supplement the fisheries-dependent methods presently being used for stock assessment. Refining the MOUSS includes testing of camera resolution (pixel binning) and frame rate (frames per second - fps) to find the optimal range of these settings for use in gathering bottomfish count and length data. MOUSS cameras are being tested at 2-bin, 3-bin, and 4-bin resolutions and at 8 fps, 12 fps, and 16 fps frame rates. Optimum camera settings should produce MOUSS recordings that are able to capture bottomfish characteristics and motion without overtaxing the data transfer capacity of the MOUSS computers.



Modular Optical Underwater Survey System (MOUSS)

Additional efforts include operationalizing the MOUSS for HA-16-01 to be deployable from small-boat platforms like the PIFSC 19' SAFEBOAT. This includes designing and constructing equipment that meet program needs and NOAA Small Boat requirements.

Standard Operating Procedures (SOP) are also being developed and tested for MOUSS small-boat deployment and recoveries to conduct safe and effective operations.



MOUSS photo resolution testing was conducted in shoreside tanks at the NOAA Inouye Regional Center (top). Comparative tests of MOUSS and BotCam were carried out at sea (bottom).

The MOUSS builds and improves upon previous fishery-independent assessment trials conducted with the Baited Stereo-Video Bottom Camera System (BotCam) which has been effectively used to collect similar data. To measure the effectiveness of the newer and smaller MOUSS units, comparative MOUSS-BotCam tandem system tests were conducted in May 2015. The preliminary analysis of the comparative MOUSS-BotCam video show the MOUSS units successfully provided high quality recordings that matched or exceeded BotCam resolution and video quality. These tests also concluded that the field of view generated by both systems was comparable which should allow for continuity of data streams between the BotCam and MOUSS systems. Preparations are also being made to continue MOUSS-BotCam tandem testing during HA-16-01 using the NOAA Ship *Hi'ialakai* deck equipment.

National Environmental Policy Act Update

In compliance with the National Environmental Policy Act (NEPA), PIFSC currently conducts research under a collection of programmatic environmental assessments (EA). EAs apply specifically to: the Marine Turtle Research Program (MTRP), the Marine Turtle Assessment Program (MTAP), Research Activities Conducted by the Coral Reef Ecosystem Division (CRED), Elasmobranch Bycatch Reduction in Domestic and International Fisheries, Research to Support Reduction of Sea Turtle Bycatch in Domestic and International Fisheries, Research and Enhancement of Hawaiian Monk Seals (HMSRP), and Cetacean Research in the Pacific Ocean (CRP). These documents are available on the PIFSC internet site at http://www.pifsc.noaa.gov/nepa/documents.php.

PIFSC has also started writing a new programmatic EA that will include all fisheries research and fisheries-related ecosystem research activities. This EA is part of a national initiative, which is being directed by the NMFS Office of Science and Technology. This EA would support an application and consultation under the Marine Mammal Protection Act and Endangered Species Act, respectively, for the potential incidental take of protected species. As a result of this initiative, each Science Center in each of the regions in the nation would have a comprehensive incidental take authorization for fisheries and fisheries-related ecosystem research activities. In the Pacific Islands Region, this EA would primarily include research that is conducted in the Fisheries Research and Monitoring Division (FRMD) and Ecosystem Sciences Division (ESD) at PIFSC. This EA would not include directed take research activities on endangered species or marine mammals, such as with the Hawaiian monk seal. The draft EA and LOA application will be made available for public review and comment in approximately October 2015.

Rose Atoll Marine National Monument and American Samoa Archipelago Ecosystem Science Implementation Workshop Held in Utulei, American Samoa from May 26-27, 2015

PIFSC staff members convened a 2-day workshop in Utulei, American Samoa in May 2015 to gain insight from local scientists and managers on marine ecosystem and fisheries research needs within the American Samoa Archipelago. Participants included over 60 people representing a broad spectrum of organizations in American Samoa, including resource managers, scientists, and local community members. Following a series of background presentations by scientists and others, workshop participants identified key topics for research that could be implemented in the next 5 years. They assembled a wide-ranging list of research priorities including threats to coral reefs from Crown of Thorns starfish (COTS) outbreaks, environmental contaminants, land-based

nutrients, and coral bleaching; effectiveness of Marine Protected Areas (MPAs); larvae seeding/spillover; occurrence, location, and seasonality of spawning aggregations; mapping of shallow near-shore marine environments using LiDAR and other technologies; and more.

Participants in the Utulei workshop included resource managers, scientists, and local community members.

An Administrative Report was written synthesizing the workshop information and findings. The report provides details on the discussions and the results of the research prioritization process. This report was reviewed by local participants and was submitted to PIFSC Editorial for review.

Marianas Trench Marine National Monument Pilot Mapping Project

To make scientific data collected and maintained by PIFSC accessible in a simple and easy to user interface, the Marianas Trench marine National Monument Pilot Mapping Project has created a cloud-based data portal. The portal provides access to a collection of interactive, thematic map viewers that contain datasets related to marine mammal surveying, coral reef ecosystems, fisheries research and NOAA ship operations in the Mariana Archipelago. Users can display and download the data.

The portal applications contain several interactive features that allow users to explore the data in more detail than can be obtained from a static map. These features include layer controls for turning on/off the various data types, pop-up windows that provide additional information about selected objects and locations, a query tool for filtering the data (e.g. by species or date), a timeline that allows users to step through the data on a year-by-year basis, and a print tool that can be used to create custom map products (Figure 1). Users are able to view the attribute tables for each of the map layers, and thereby access all of the underlying information associated with each of the features being displayed on the map (Figure 2). Users also are able to access metadata for the datasets included in the applications and download data in a number of standard GIS file formats.

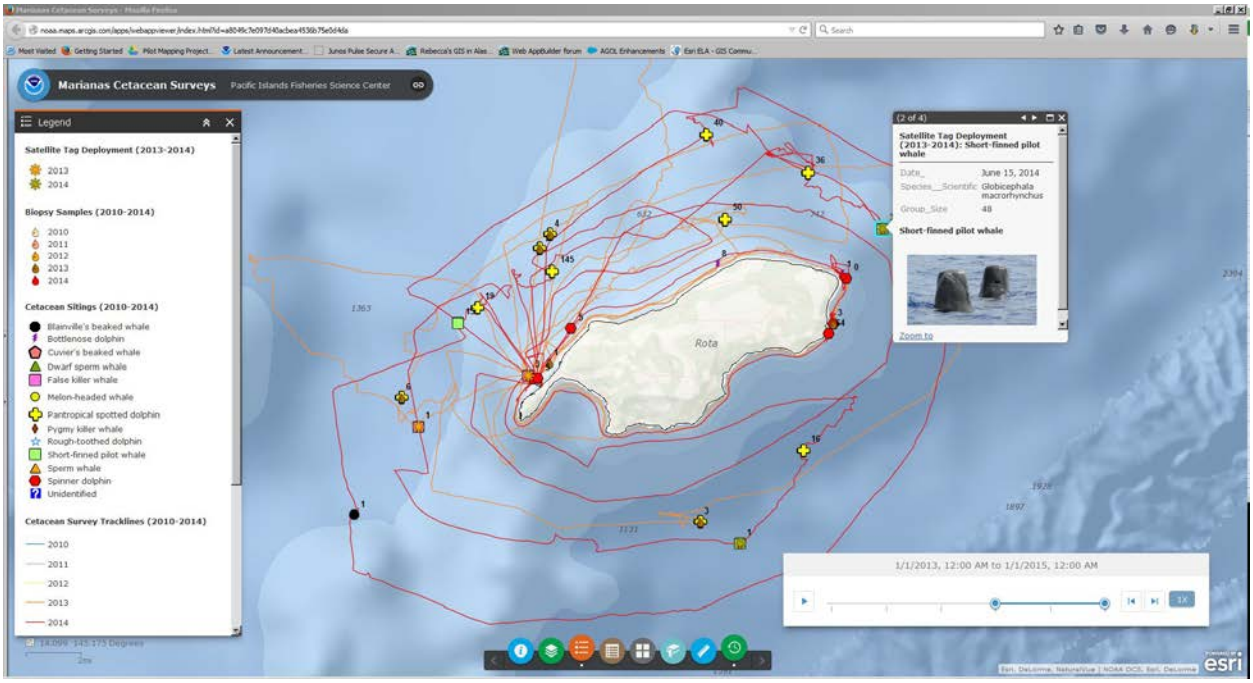


Figure 1. Map application interface for the Cetacean Surveys data viewer, displaying survey tracklines and locations of species observations, biopsy samples and satellite tag deployments.

In addition to providing easy access to PIFSC data holdings, the project has provided a unique opportunity to collaborate across divisions within PIFSC and work with other line offices at the NOAA Inouye Regional Center (IRC). By working closely with scientists and data owners within the PIFSC and throughout IRC, the project team has been able to obtain the wide range of data types included in the map products and ensure that the data are presented in a way that is accurate and meaningful. The PIFSC IT Services office has been involved with the portal project from the beginning to provide guidance and support to ensure that the tool will integrate well with the Center's IT infrastructure and is in compliance with the security requirements. The project has taken advantage of additional outside funds that became available recently to bring in a programmer from

the National Ocean Service, Office of National Marine Sanctuaries office located at IRC. The programmer has JavaScript expertise that will allow us to do further customize and enhance the map's interface and capabilities.

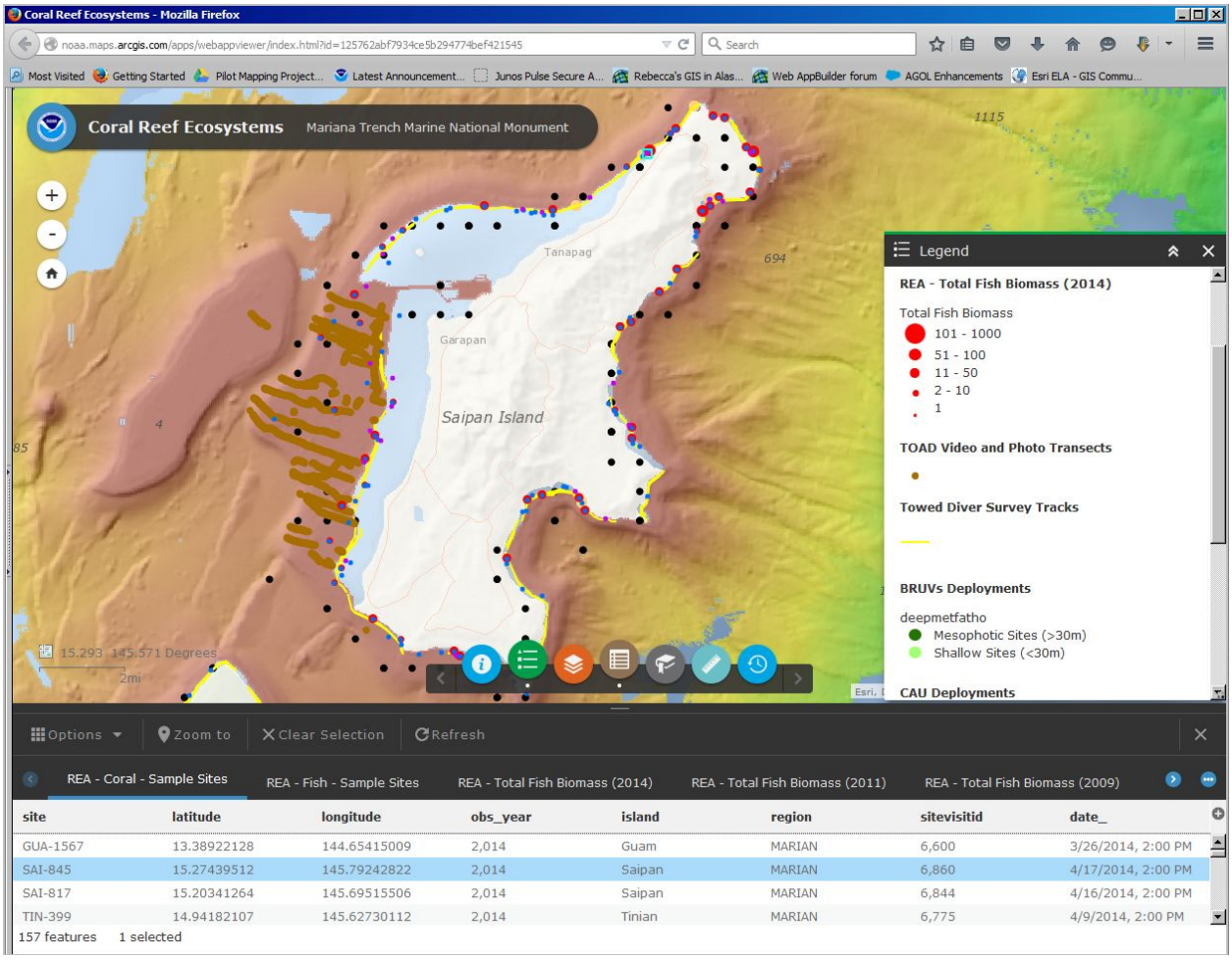


Figure 2. Screenshot of the Coral Reef Ecosystems data viewer showing PIFSC data collection sites around the island of Saipan. The bottom of the window contains a table view providing access to the underlying information associated with each site displayed in the map.

The project is now in the final development phase, which involves obtaining stakeholder feedback and making refinements to the data and tools to ensure data is being accurately represented and that the tools are intuitive and easy for a general audience to use. We have organized several demos and presentations to share the project with PIFSC and other NOAA line offices and are currently compiling this information, and will use it as a guide for potential future directions for this project. The pilot phase of the project will be wrapping up later this year, at which time the applications and data will be publically accessible via the PIFSC Marine National Monument website currently under

development. Future plans for the project are to incorporate feedback from partners to improve the tool and to include additional data sets and potentially other regions.

American Samoa Field Office Assists with Rain Garden Installation

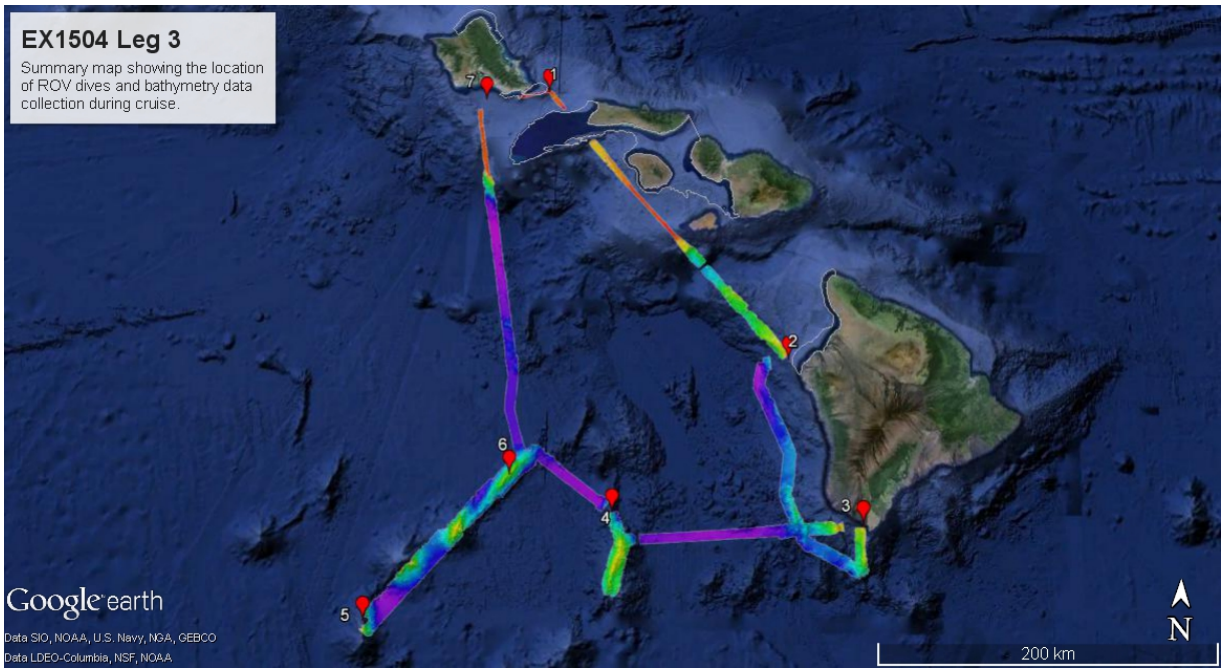
The PIFSC American Samoa Field Office Liaison (FOL) works with various departments of the local government, federal agencies, community groups, private affiliates, and fisheries industry partners on collaborative fisheries efforts. The PIFSC FOL also provides coordination between the people of American Samoa and visiting NOAA scientists and helps with issues of language, culture and tradition. Recently, the PIFSC FOL assisted with local high school and elementary level Science Fairs and a Science Technology Engineering and Mathematics (STEM) Expo. The PIFSC FOL also assisted the NOAA Coral Reef Conservation Program's project to install 10 test-bed Rain Gardens throughout American Samoa, including one at Faga'alu. The project focuses on the installation of rain garden systems to reduce or eliminate the flow of pollutants such as oil, animal and human waste, excess fertilizer, and other sediment and pollutants that storm-water carries to beaches, ponds, and groundwater sources.

Collaborators from the American Samoa government, Horsley & Witten Group, and NOAA celebrated completion of the Faga'alu Rain Garden.

Okeanos Explorer Studies Deep Corals Around the Main Hawaiian Islands

NOAA Ship *Okeanos Explorer* pulled into Pearl Harbor on Thursday, September 3, 2015, bringing Leg 3 of the Hohono Moana: Exploring Deep Waters off Hawai'i expedition to a close. Funded by the NOAA Deep Sea Coral Research and Technology Program, the 7-day mission conducted 24/7 operations to collect data on deep sea coral and sponge communities offshore of Oahu, the Big Island and on three

previously unexplored seamounts in the Geologists Seamounts group. Expedition scientists conducted daytime ROV dives and overnight mapping operations.



During the recent NOAA Ship *Okeanos Explorer* expedition, bathymetric mapping and ROV dives were conducted at several locations around the main Hawaiian Islands.

A preliminary snapshot of the mission accomplishments and highlights includes:

- Completed 6 of 7 ROV dives as planned, from 379 m to 2,700 m deep.
- Observed at least 189 types of animals. These included 16 animals that were potential new species or records for the region, including 2 animals that were recorded during the previous cruise leg.
- Mapped 6,400 square kilometers of seafloor – an area the size of Kauai, Oahu, Maui, Molokai, Ni'ihau, Molokai and Kahoolawe combined.
- Collected 12 TB of data and just under 70 hours of video.
- Live streamed 24-hour video of operations to NOAA's Ocean Explorer website and other venues that received approximately 42,000 views during the 7 day cruise.

Thirty-one scientists participated in the expedition, including 11 from NOAA (4 NMFS, 3 NOS, 2 OAR, 1 OMAO, 1 NCEI) and three from the Department of Interior's Bureau of Ocean Energy Management, U.S. Geological Survey, and Smithsonian Institution. Media outlets covering the expedition included CBS news, CNN, and the Huffington Post.

PROTECTED SPECIES DIVISION (PSD)

External Program Review for Protected Species Science

The PIFSC held an External Program Review of Protected Species Science from July 27th-July 31st. Public presentations of PIFSC marine mammal and marine turtle research activities were held from July 27th-30th. The goal of the review was to evaluate current scientific programs of the NOAA Pacific Islands Fisheries Science Center (PIFSC) established to provide information relative to the conservation and management of marine mammals, endangered or threatened wildlife, and species of concern under NMFS jurisdiction. In addition, the review assessed the extent to which current science programs are focused on information needs identified by NOAA Fisheries Pacific Islands Regional Office (PIRO) managers.

Protected species-related science programs addressed in the review included the Hawaiian Monk Seal Research Program (HMSRP), the Cetacean Research Program (CRP), the Marine Turtle Biology & Assessment Program (MTBAP), and research on protected species bycatch conducted by the Fisheries Research and Monitoring Division (FRMD). The species under study included some associated with substantial amounts of data to others where data and information are limited. It is recognized that there are a variety of other protected species science programs within NOAA Fisheries (e.g., marine mammal health).

The focus of this exercise was for reviewers to provide PIFSC with observations and recommendations on the direction and quality of the Center's data collection and assessment programs. In preparing their presentations or conducting their evaluations, the scientists and panelists, respectively, were asked to emphasize the following five points:

1. Do current and planned protected species scientific activities fulfill mandates and requirements under the Endangered Species Act and Marine Mammal Protection Act, and meet the needs of the regulatory partners, PIRO and the NMFS Office of Protected Resources (OPR)?
2. Are the collaborations that are in place effective? What other opportunities should being pursued?
3. Are the protected species scientific objectives adequate to meet the long-term and short-term goals?
4. Are the protected species studies being conducted properly (survey design, statistical rigor, standardization, integrity, peer review, transparency, confidentiality, etc.)?
5. Are advances in protected species science and methodological approaches being incorporated into PIFSC research? Is PIFSC active in advancing protected species science? Are these advances communicated and applied in NMFS broadly?

Members of the external expert review panel reported their preliminary findings on July 31st. Within three months of the end of the review, the Panel Chair's summary, the panelists' individual reviews, and the response from PIFSC will be completed and posted on our website: http://www.pifsc.noaa.gov/do/peer_reviews/program_review_of_protected_species_science_2015.php

Surveys Expand Knowledge of Cetaceans in the Mariana Islands

From May 8 to June 6, 2015, PIFSC's Cetacean Research Program (CRP) conducted surveys for cetaceans in the waters surrounding Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The purpose of the study was to further develop a record of cetacean occurrence in the region and to gather photos and biopsy samples for population studies. The Mariana Archipelago Cetacean Survey (MACS) was led by Dr. Erin Oleson and in coordination with most of the CRP staff and researchers from the University of Hawaii (UH) and Southeast Fisheries Science Center (SEFSC). They were joined by an undergraduate student in Natural Resource Management from Northern Mariana College.

Melon-headed whales. NOAA photo by Andrea Bendin.

Working aboard the NOAA Ship *Oscar Elton Sette*, the team surveyed for cetaceans throughout the archipelago over a 30-day period, conducting systematic surveys within 50 nmi of the archipelago, as well as focused near-island work at each of the islands north of Saipan. The survey team searched for cetaceans using 25x mounted binoculars ("big-eyes") as well as with a towed hydrophone array.

CRP has been conducting near-shore small-vessel based surveys for cetaceans near the southern islands of the archipelago (Guam, Rota, Tinian, and Saipan) since 2010. As part of that work they have encountered several tropical and sub-tropical species and have built photo-identification catalogs of spinner, bottlenose, and rough-toothed dolphins, and short-finned pilot, false killer, and pygmy killer whales. They have also collected several hundred biopsy samples from these species and others, including sperm whales and humpback whales, and deployed several dozen satellite tags on short-finned pilot and false killer whales to examine animal movements. Each year the team re-sights some of the same individual dolphins and whales resulting in a preliminary assessment of animal movements and population structure within the southern portion of the archipelago. Genetic analysis of the tissue samples also suggests finer-scale population structure. The primary goal of the MACS expedition was to extend this work to the northern islands to better understand how animals there may fit into the structure observed in the southern islands.

The survey team on the NOAA Ship *Oscar Elton Sette* used hand-held binoculars and pedestal-mounted "big-eyes" to search for cetaceans. NOAA photo by Andrea Bendin.

During MACS there were 42 cetacean visual sightings of 9 species, including spinner, rough-toothed, bottlenose, and Risso's dolphins, melon-headed, false killer, and sperm whales, Blainville's beaked whales, and Bryde's whales, as well as groups of dolphins, whales, and beaked whales that could not be identified to species. Photographic and tissue-sampling operations were carried out in conjunction with most sightings, resulting in more than 6600 individual identification photos and 51 biopsy samples collected from spinner, rough-toothed, and bottlenose dolphins, and melon-headed, false killer and sperm whales. A single satellite telemetry tag was deployed on a false killer whale near Asuncion Island. A total of 45 acoustic detections occurred, including acoustic detection of nearly all visual sightings, as well as detection of 2 groups of beaked whales and 2 groups of unidentified dolphins not observed by the visual survey team.

In addition to surveys, since 2010 CRP has maintained two acoustic recorders for collection of long-term observations near Saipan and Tinian. These recorders provide information on species occurrence and behavior throughout the year, and allow for examination of seasonal presence and relative abundance of a variety of vocal cetacean species. The recordings have proven particularly enlightening for species that the visual survey team rarely encounters, such as beaked whales and baleen whales. As part of the MACS expedition both of the existing recording instruments were recovered and redeployed with new batteries and hard drives, enabling another year of monitoring. In addition, the team deployed a new recorder near Pagan to listen for migratory baleen whales farther north in the archipelago. That recorder is intended to be left in place for 2 years before recovery.

ECOSYSTEM SCIENCES DIVISION (ESD)

Survey Gathers Data on Reef Fish Populations of Main Hawaiian Islands

From June 14 to July 3, 2015, PIFSC personnel from the Coral Reef Ecosystem Program (CREP; formerly known as CRED), fellow PIFSC staff members from the Fisheries Research and Monitoring Division (FRMD), and partners from University of Hawaii, Hawaii Division of Aquatic Resources, and Papahānaumokuākea Marine National Monument, participated in a Main Hawaiian Islands Reef Fish Survey on board the NOAA Ship *Hi'ialakai.* The team conducted reef fish visual surveys using SCUBA at 294 sites around Oahu, Maui, the Big Island, Kauai, Molokai, Lanai, and Niihau Islands. The survey methods and sampling design used were consistent with those implemented for NOAA's long-term Pacific Reef Assessment and Monitoring Program across the U.S. Pacific islands, which allows multiple data sets to be readily combined and easily compared.

The survey was designed primarily to improve the ability of PIFSC and partners to generate an accurate picture of the status and trends of coral reef fishes around the main Hawaiian Islands. However, because the overall dataset is highly consistent and widely representative of reef areas across the region, it is being used for multiple purposes and is also contributing to large-scale scientific research by NOAA and external researchers. In addition the data contribute to stock assessments and to the process used by the Western Pacific Regional Fishery Management Council (WPRFMC) to generate annual catch limits (ACLs) for reef fishes.

A novel aspect of the *Hi'ialakai* expedition was that for the first time, CREP divers experimented with the operational use of closed-circuit rebreathers (CCR) for fish surveys. Seventy-nine sites were surveyed using both CCR and SCUBA. In contrast to the open-circuit SCUBA (OC) commonly used for underwater visual surveys, divers using CCRs do not release bubbles upon exhalation of air. Therefore, divers using CCR have a quieter and less intrusive presence in the survey area. By conducting reef fish surveys using both CCR and SCUBA, we are able to examine the potential biases posed by divers using conventional SCUBA. Preliminary results indicate small overall differences between the gears in fish counts for most targeted and non-targeted reef fish families and lower counts of some mid-water planktivores by divers on SCUBA. Research on this topic is ongoing. In partnerships with University of Hawaii and Papahānaumokuākea Marine National Monument we will compare the performance of divers on SCUBA and CCR among survey areas at varying levels of human presence and fishing pressure.

A school of unicornfish (Naso unicornis) at a survey site in Maui. Photo by Kevin Lino.

Micronesia Challenge's 2nd Socioeconomic Measures Workshop

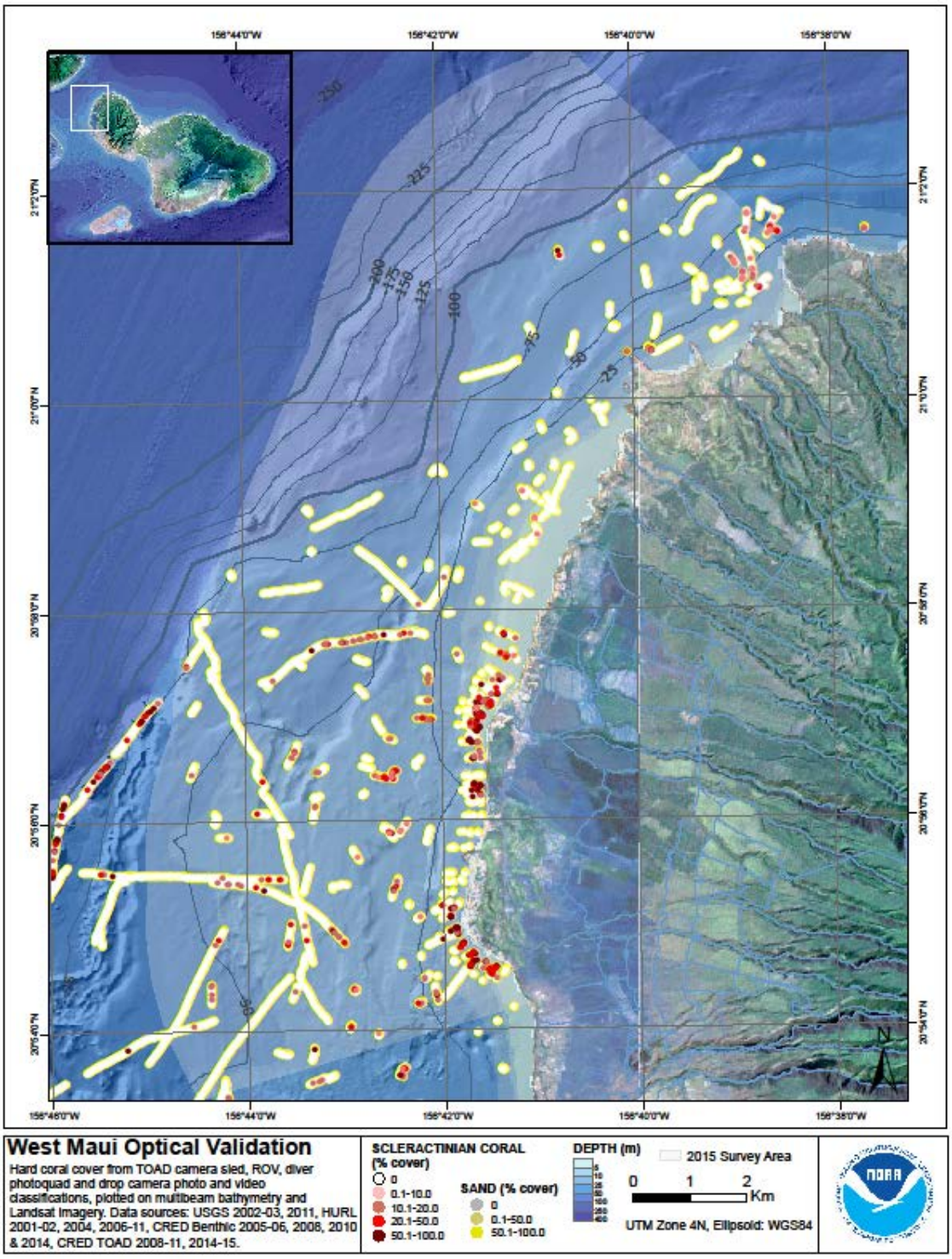
The Coral Reef Ecosystem Program participated in the Micronesia Challenge's 2nd Socioeconomic Measures Workshop, held in Guam from June 10 to June 12, 2015. Workshop facilitation and resource expertise was provided by CREP staffer Supin Wongbusarakum, Brooke Nevitt of the Micronesia Islands Nature Alliance, Michael Lameier of the NOAA National Marine Fisheries Service's Habitat Conservation Division, and Berna Gorong of The Nature Conservancy. The workshop brought together staff members of national, regional and local government agencies and representatives of non-governmental organizations and potential funding agencies. Workshop attendees came from Guam, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, Palau, and the Republic of the Marshall Islands.

Workshop participants reviewed previous and current socioeconomic monitoring efforts in the region and then identified information gaps and steps to improve and sustain monitoring at all levels in Micronesia. They also initiated a discussion on how to integrate socioeconomic and biological monitoring to better understand the impacts of conservation and natural resource management. To underscore and support their unanimous agreement on the importance of socioeconomic monitoring in the region, they established a "Core Micronesia Socioeconomic Monitoring Team" with representatives from all jurisdictions.

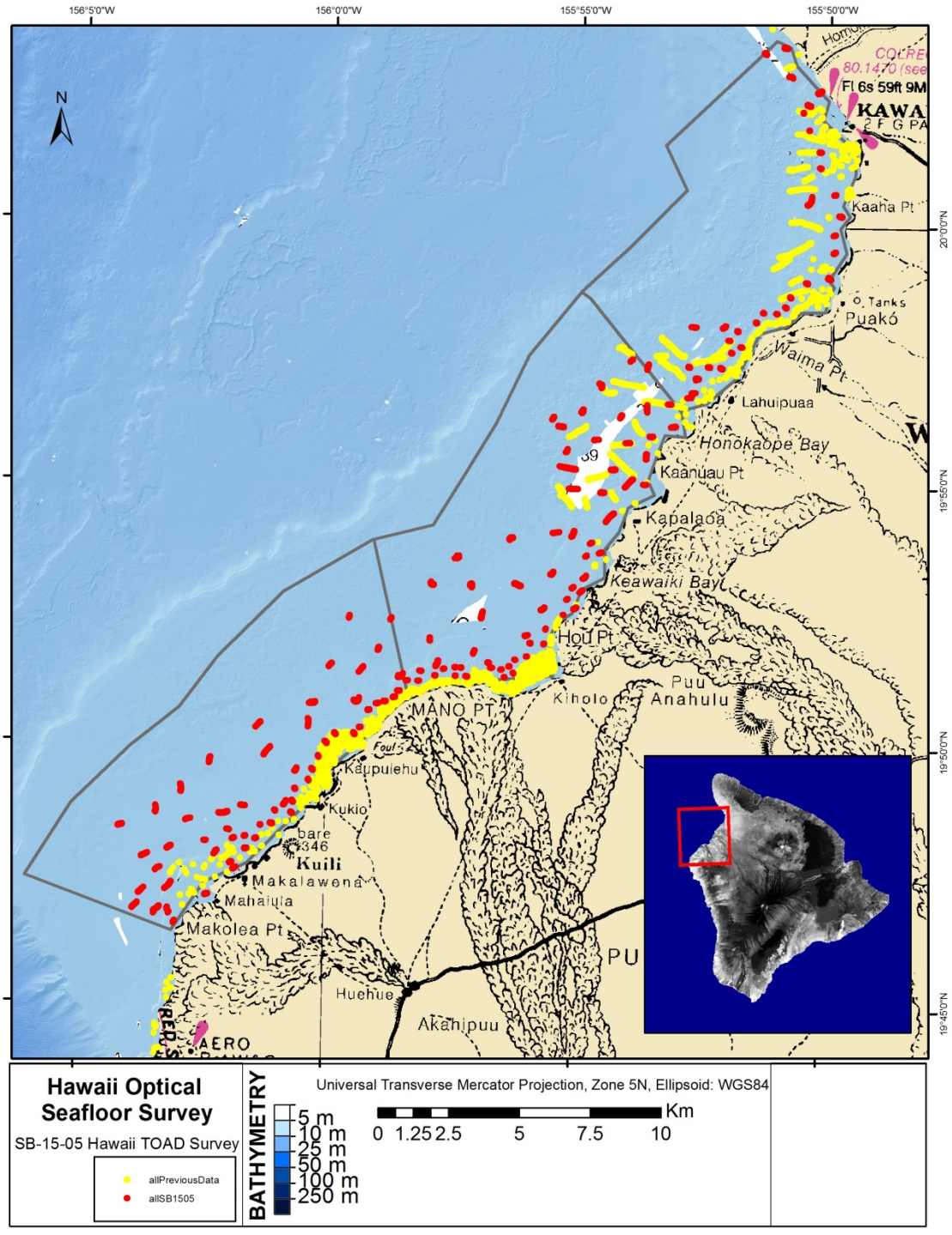
The importance of socioeconomic monitoring for coastal management and conservation is becoming increasingly acknowledged around the world. Without understanding impacts on people and communities that depend on natural resources, the effectiveness of conservation programs can easily be questioned. The team will reconvene from September 21 to October 3, 2015 to further build the group's social science knowledge and training skills and to initiate development of socioeconomic monitoring plans for selected sites in Micronesia.

Seafloor Mapping Missions off Maui and the Big Island

In May 2015, ESD staff conducted missions to map seafloor composition and coral cover on the west side of Maui between Ka‘anapali and Honolua Bay, and on the west side of Hawaii Island south of Kawaihae Harbor. Both sites designated as priority areas by the State of Hawaii Division of Aquatic Resources and the NOAA Coral Reef Conservation Program and are within the waters of the Hawaiian Islands Humpback Whale National Marine Sanctuary. The West Hawaii site is also a NOAA Habitat Blueprint focus area.



Survey results from May 2015 and previous PIFSC and partner surveys from West Maui, showing the percent cover of corals and coverage of sand (which precludes settlement and growth of corals.) The area highlighted in light blue-grey is the Hawaii Division of Aquatic Resources/ NOAA Coral Reef Conservation Program priority site.



Survey tracks from May 2015 and previous PIFSC and partner surveys from West Hawaii; data are still being analyzed. The outlined area is the NOAA Habitat Blueprint Focus Area, which largely overlaps with the NOAA Sentinel Site and includes the other Hawaii Division of Aquatic Resources/NOAA Coral Reef Conservation Program priority site.

During the surveys, imagery was gathered using the Towed Optical Assessment Device ("TOAD"). The TOAD is an underwater camera sled designed to take photographs and video of the seafloor and is typically deployed from a vessel moving at a speed of about one knot.

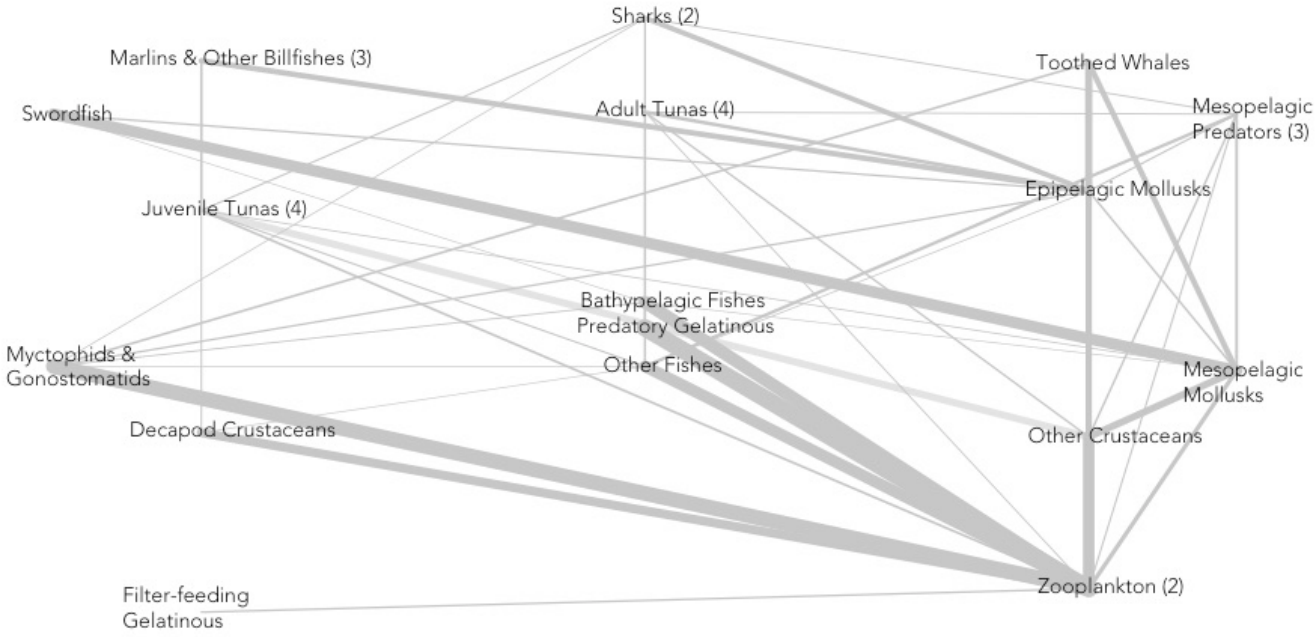
Photos taken by the TOAD are used for mapping the distribution of key benthic organisms, such as hard corals, as well as providing ground-truthing data to integrate with acoustic multi-beam, bathymetric LiDAR (a remote sensing method), and other data for habitat mapping. Partner agencies that provided additional ground-truthing data for this project include the Division of Aquatic Resources, the U.S. Geological Survey, The Nature Conservancy, the U.S. Army Corps of Engineers, the Hawai'i Institute for Marine Biology, and the NOAA Biogeography Program.

The data collected on the survey will be used to create seafloor maps that will assist watershed and marine resource managers in understanding the distribution of coral reef and associated habitats and enhance the scientific foundations for actions to improve the health and resilience of local coral reef ecosystems.

Updated Pelagic Ecosystem Energy Flow

Post-doctoral researcher Dr. Anela Choy, with ESD's Ecosystems and Oceanography Program, updated the PIFSC central North Pacific pelagic ecosystem Ecopath model. She incorporated the results from the most recent diet studies to expand the representation of the lesser-known non-target fish species (e.g., lancetfish, opah, snake mackerel) and defined nine mid-trophic micronekton functional groups. The model framework Ecopath with Ecosim was used to construct an energy budget for the ecosystem and to simulate how changes in the various micronekton functional groups affected apex predator production. Model results indicate that while micronekton fishes represented about 50% of the micronekton biomass they accounted for only 26% of the micronekton production within the ecosystem. By contrast, crustaceans represented 27% of the biomass and accounted for 47% of the production. Gelatinous and mollusk functional groups represented 12 and 11% of the biomass, respectively, and provided 17 and 11% of the production, respectively. Simulated ecosystem changes resulting from changes to micronekton food web components demonstrated that crustacean and mollusk functional groups are the most important direct trophic pathways to the top of the pelagic food web. Incidentally, these micronekton functional groups may be especially sensitive to changes in ocean chemistry resulting from climate change. Other micronekton groups appear to comprise relatively inefficient pathways that are loosely coupled to top of the food web (e.g., filter-feeding gelatinous animals and some fishes) such that biomass declines in these functional groups result in increased

biomass at the highest trophic levels by increasing pelagic energy flow through more efficient pathways. The accompanying figure provides a schematic of the ecosystem energy flow with the width of the lines proportional to the upward energy flow between groups. The dominant trophic pathways from zooplankton to apex species are shown on the right hand side via the three micronekton groups, other crustaceans, mesopelagic mollusks, and epipelagic mollusks, leading to tunas, sharks, billfish, and toothed whales. By contrast on the left-hand side very little of the energy flowing to bathypelagic fishes, predatory gelatinous organisms, other fishes, decapod crustaceans, and myctophids reaches the apex species.

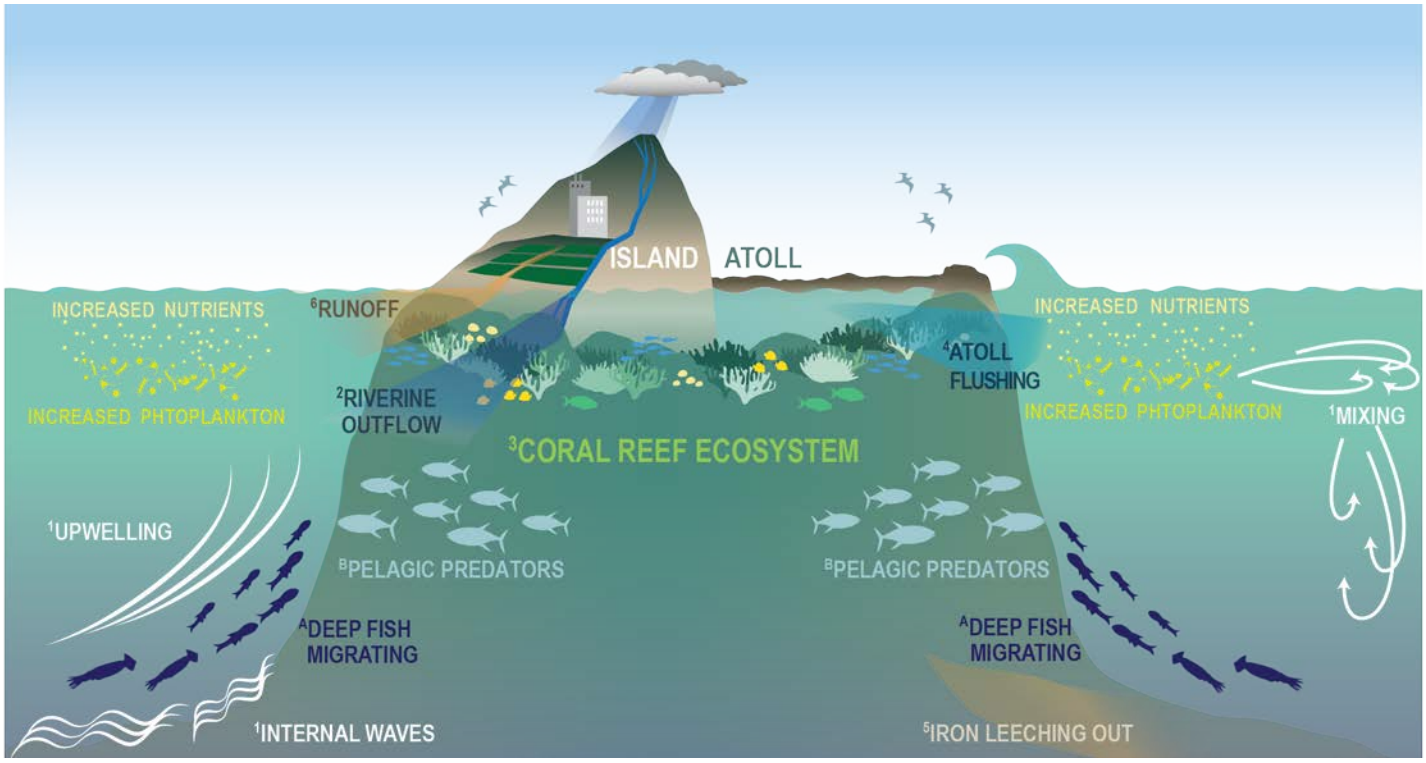


Schematic pelagic ecosystem energy flow with the width of the lines proportional to the energy flow between the groups.

Ocean Oases: Near-island Biological Hotspots in Barren Ocean Basins

The increase in phytoplankton biomass proximate to island-reef ecosystems known as the Island Mass Effect (IME) was documented over a half century ago. Much of our current knowledge of the IME, however, stems from a small number of locations in geographically confined areas. Thus, whether the IME is a pervasive phenomenon across broad gradients in oceanic conditions has historically remained unknown. Furthermore, the relative influence of natural *versus* anthropogenic drivers of the IME and the magnitude of its effect has remained a mystery. Dr. Jamie Gove of ESD's Ecosystems and Oceanography Program recently led the first basin-scale investigation

of the 60-year-old IME hypothesis. The study was a collaborative effort of PIFSC staff and colleagues at the University of Hawaii. The research used 35 coral reef islands and atolls that spanned 43° of latitude and 60° of longitude and crossed multiple gradients in oceanography, geophysical attributes, reef-community organization, and local human impacts. The work quantified the prevalence of the IME across the tropical Pacific and identified key biogeophysical drivers of its occurrence. The researchers found that nearshore phytoplankton enhancement is a long-term, near-ubiquitous feature among Pacific coral reef islands and atolls. Moreover, they found the magnitude of nearshore phytoplankton enhancement differed among island- and atoll-reef ecosystems owing to variations in key biophysical drivers, namely reef area, bathymetric slope, geomorphic type (atoll *versus* islands), and the presence of human habitation. They also found that individual coral reef islands and atolls were capable of increasing the nearshore standing stock of phytoplankton biomass by up to 86% over background oceanic conditions, representing important biological hotspots across an otherwise barren ocean landscape.



The Island Mass Effect

Ecosystem services essential to human societies, for example fisheries production, coastal protection, and ocean-related tourism, are intrinsically linked to the nearshore phytoplankton enhancement associated with the IME. Further modeling focused on the biogeophysical processes that underpin the IME and impending climate-related influences would provide valuable insight to understanding future nearshore

phytoplankton production at the ~4,000 island and atoll coral reef ecosystems across the Pacific Ocean and the millions of people they support.

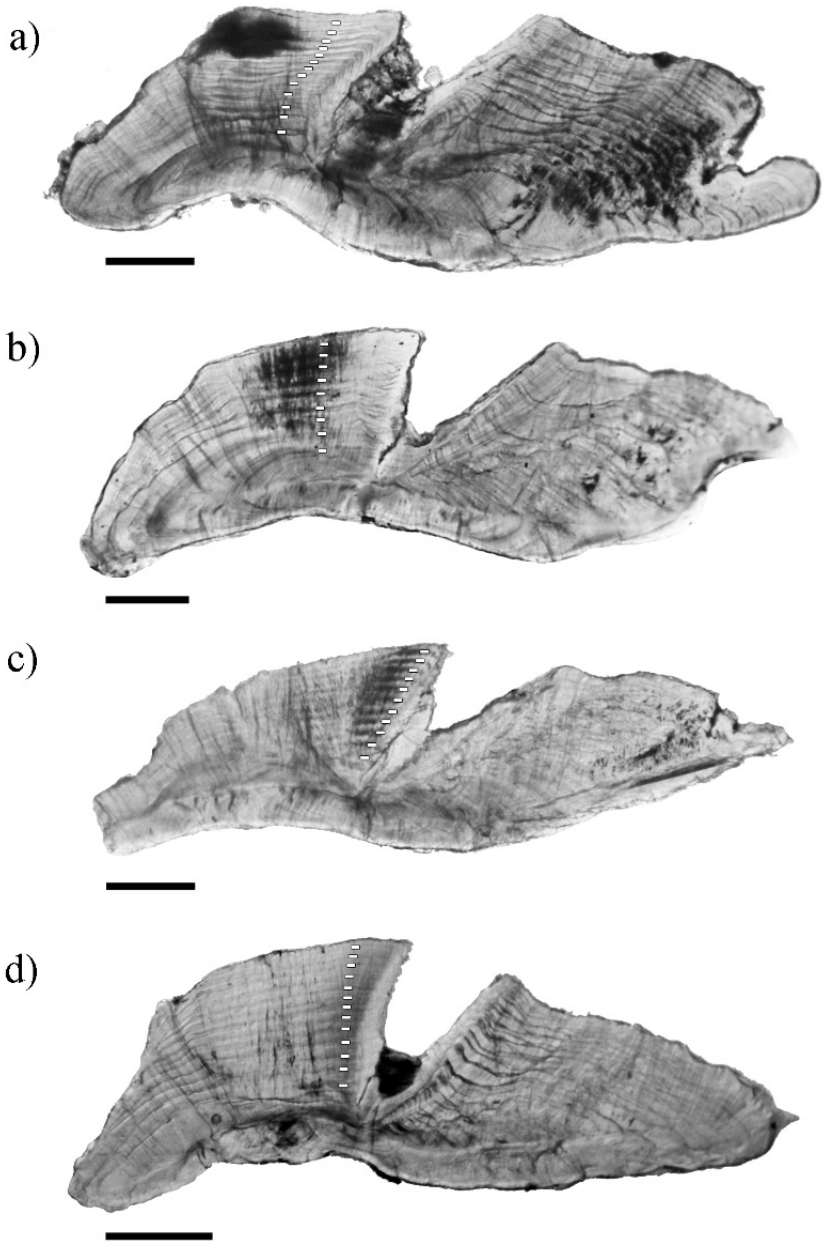
Localized increases in productivity near islands and atolls – 'Island Mass Effect' – may be the result of several causative mechanisms that enhance nearshore nutrient concentrations, including: 1) Current-bathymetric interactions that can drive vertical transport of water masses such as upwelling, eddies and mixing, and internal waves; 2) On islands, precipitation and outflow from rivers can mobilize and transport sediment and other terrigenous material laden with increased nutrients; 3) In coral reef ecosystems from sources such as nitrogen fixation, decomposition and from animal waste products such reef-associated fishes; 4) The outflow of coral reef lagoonal waters in atoll environments; 5) The geochemical make-up of a location may provide essential production-limiting micronutrients such as iron; 6) Human habitation and associated land use, agricultural run-off and wastewater input.

Enhanced nearshore primary productivity can influence food-web dynamics and elicit a biological response in higher trophic groups, for example: A) Diel horizontal and vertical migration patterns in squids, fishes, and other micronekton (collectively referred to as the 'mesopelagic boundary layer community') that move nearshore at night to feed on increased food resources; B) Inshore migration of pelagic predators, such as tuna, to feed on the island-associated micronekton community.

FISHERIES RESEARCH AND MONITORING DIVISION (FRMD)

Comprehensive Review of Parrotfish Life History Traits

FRMD's Life History Program, in collaboration with researchers from Australia and New Zealand, has completed the most comprehensive review of parrotfish age-based demography to date. The review focuses on variation in life history traits (for example, growth, life span and sex change) between different species of parrotfishes (family Labridae; tribe Scarinae) as well as variation within individual species, spanning from regional to global scales. Parrotfishes represent a major reef-associated fishery resource in the U.S. Pacific Islands and in most tropical nations globally. However, the review of demographic information highlights the scarcity of age-based work that has been completed for this group, work that would directly inform fisheries management across many scales. Techniques for conducting age-based studies of parrotfishes are well-developed and otolith sections from various regions globally provide reliable and easily-derived age estimates for individuals (images below).



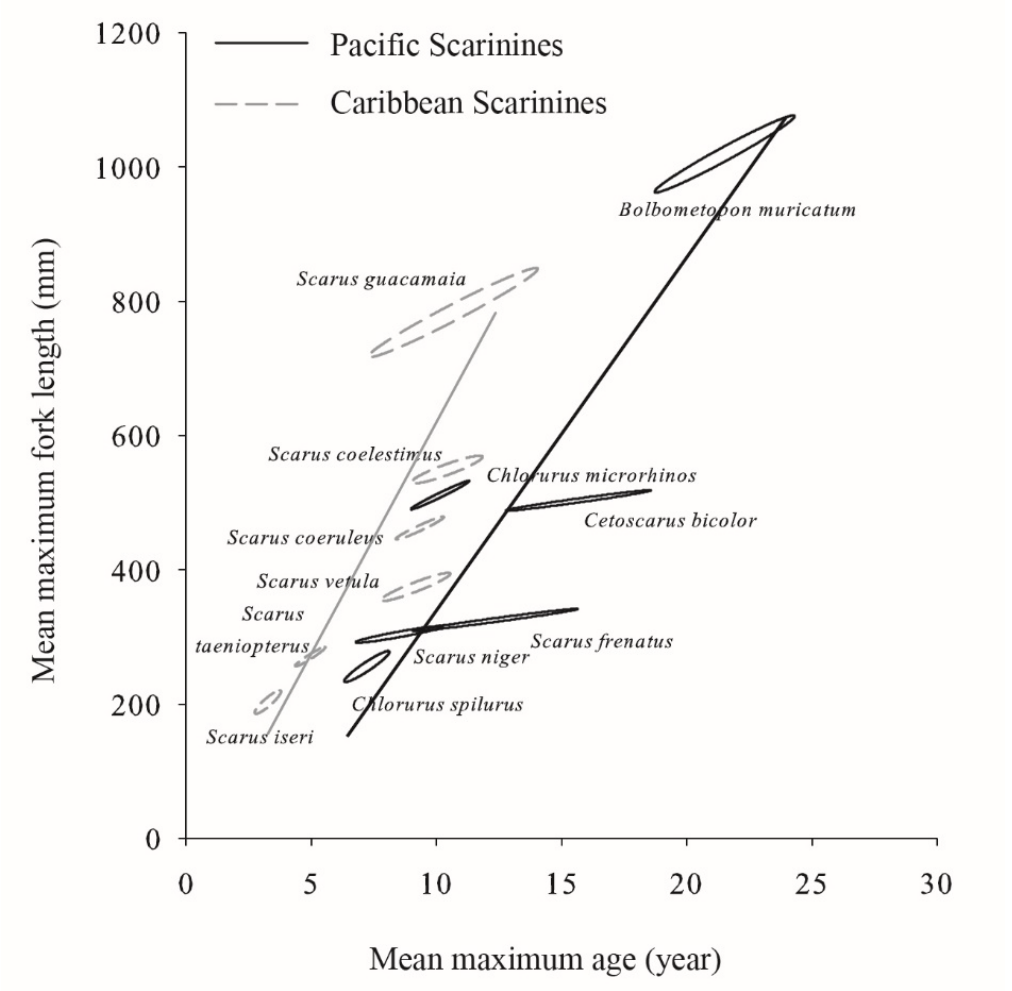
Examples of transverse sections of parrotfish sagittal otoliths, displaying annual increment patterns (denoted by white marks).

Species:

- **a)** ***Cetoscarus bicolor*** **(Red Sea, Saudi Arabia)**
- **b)** ***Chlorurus microrhinos*** **(Great Barrier Reef, Australia)**
- **c)** ***Hipposcarus harid*** **(Red Sea, Saudi Arabia)**
- **d)** ***Scarus frenatus*** **(Yap, Micronesia).**

Scale bars are 500 µm.

Investigation of spatial patterns from available data demonstrated strong and predictable effects on life history trait values resulting from ocean-basin history (large spatial scale), changes in water temperature and seasonality across latitudinal gradients (intermediate scale) and unexpected patterns across small spatial scales driven by habitat, ocean productivity and density-dependent processes. Striking patterns were uncovered among ocean basins, where geologically young basins yielded lower lifespans relative to body length compared with species that evolved in larger, older oceans. This pattern is demonstrated by comparing maximum length and age across species between the Pacific Ocean and Caribbean Sea (chart below). However latitude (proxy for water temperature) underlies these trends by playing a strong role in determining demographic rates of parrotfishes, whereby maximum length and age increase considerably at higher latitudes.



Relationship between mean maximum age and mean maximum length across Pacific and Caribbean Scarinine parrotfishes. Species from the Pacific tend to have longer life spans for a given maximum body size.

Given the multi-scale variability in demographic trends of parrotfishes, a key message that emerges is that fishing pressure alone should not be the default hypothesis for explaining observed differences in parrotfish life history, abundance or community structure. Although fishing has clearly demonstrable impacts, these emerge at relatively local scales and are highly context dependent. However, from a management perspective at localized scales, potential concerns are the long-term 'Darwinian' effects of fishing on parrotfish traits and directional changes in assemblage structure over time. The first is driven by selective mortality, which is amplified in parrotfishes because male individuals are typically much larger than females and therefore much more intensely targeted. The second concern is driven by the high diversity in life-history traits values among the numerous species, leading to very different levels of species-specific vulnerability to fishing pressure. Further studies of parrotfish demography are warranted, covering many regions globally. This will require enhanced coordination and collaboration between fisheries researchers.

Sample Size Requirements by Gear Type for Island Area Creel Surveys

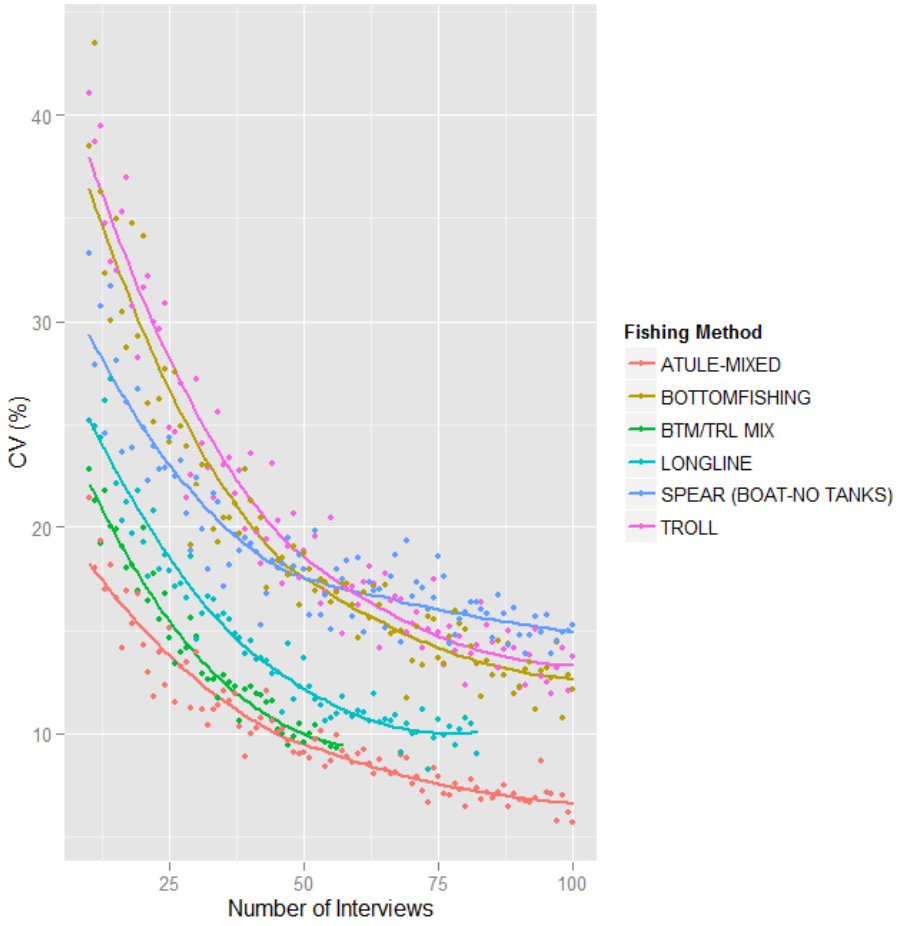
FRMD's Insular Fisheries Monitoring Program (IFMP), Territorial Science Initiative (TSI) aims to increase the volume and quality control of catch data from the fisheries of American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), and Guam.

A main component of the fisheries monitoring programs for each of these three territories is boat- and shore-based creel surveys. These gather data to estimate total catch by combining gear-level fishery participation (effort) data with gear-specific catch per unit effort (CPUE) data collected via fisherman interviews. Though the expansion process used to calculate total catch is complex, having a greater number of interviews increases the precision of CPUE estimates, which in turn improves total catch estimates. But increasing the number of interviews requires additional time and funds. The balance between increased precision and greater cost involves a trade-off.

One common request from territorial fisheries managers is to provide benchmarks for the number of interviews to aim for, such that total catch estimates for the territory will be of greater use at the lowest possible cost (surveyor time and grant funding). To satisfy this request, TSI analyst Toby Matthews has written computer programs for each island area to estimate interview count requirements by gear type for the boat- and shore-based surveys. These six programs (one each for boat- and shore-based fishing in American Samoa, the CNMI, and Guam) were written using R 3.1.2, a free

programming software that some territorial creel survey workers have expressed an interest in using.

Each computer program accepts .csv versions of the participation, interview, and other necessary data as formatted in the databases maintained by the Western Pacific Fisheries Information Network (WPacFIN). Additional program inputs include: 1) the range of years from which to draw interview and participation data, and 2) parameters to customize bootstrapping and graphics procedures.

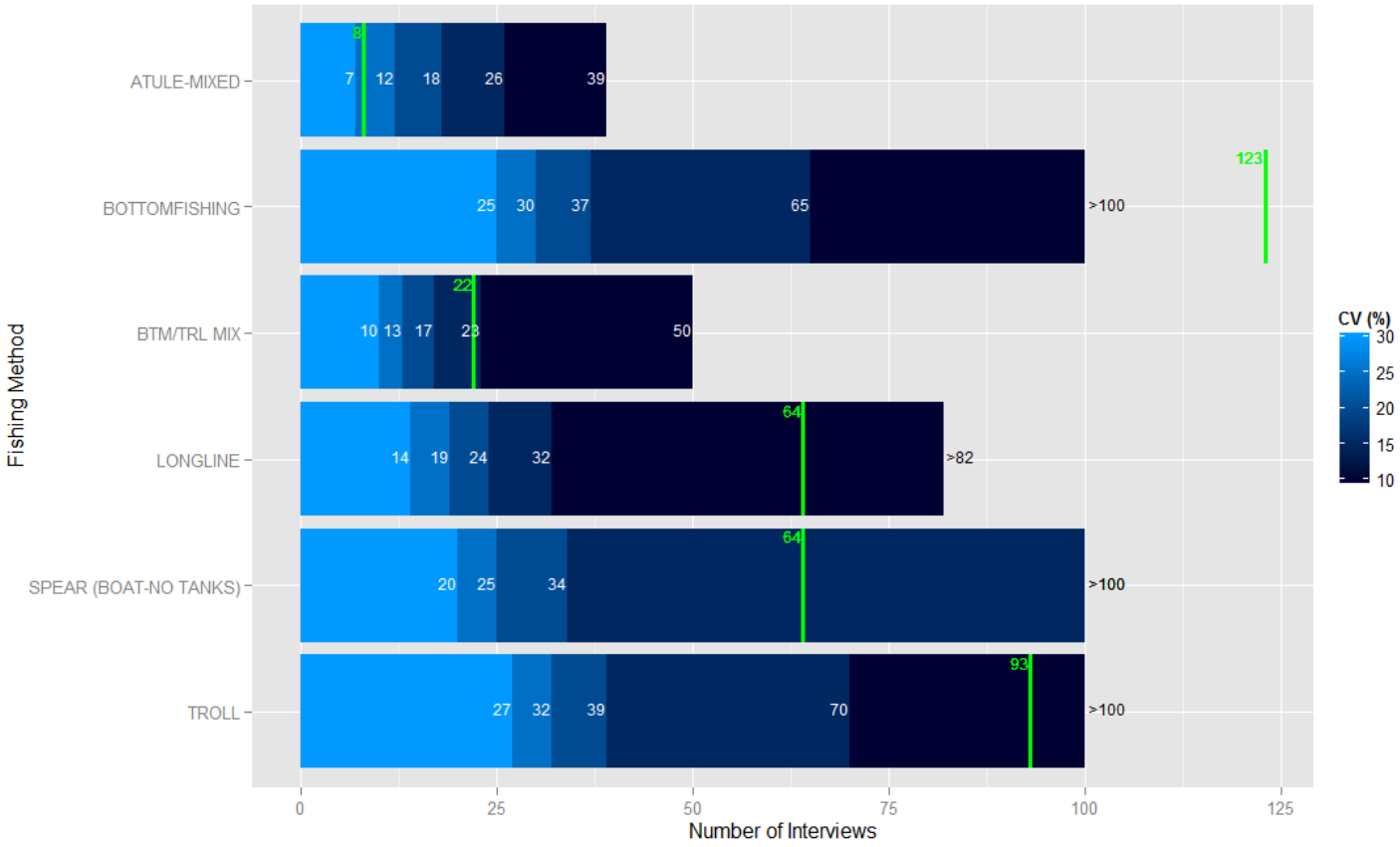


Example of first plot produced by the computer program: Relationship between CV[total catch] and number of interviews using data from the American Samoa boat-based creel survey program. Individual points represent average CV estimates from bootstrap replications, and lines are computed using the LOESS regression procedure.

For each gear type, the programs estimate the coefficient of variation (CV) for total annual catch using varying numbers of interviews. This is done by a bootstrapping procedure, with random subsamples of all available interviews for a gear being drawn and used with the expansion procedure to estimate total annual catch. The expansion

procedure used in these programs very closely mirrors that used in the WPacFIN Visual FoxPro programs, with minor simplifications (to be detailed in the associated PIFSC metadata and administrative report). Future versions of this software will fully implement the WPacFIN data expansion algorithms.

Two plots are produced by each of the programs. The first is a line graph that shows how the CV for total annual catch decreases with increasing numbers of interviews. Separate lines are drawn for each gear type. These plots generally illustrate diminishing returns, in terms of decreases in the CV, once a certain number of interviews are gathered. As such, they can be used to guide creel survey managers in instructing their field technicians what gear types to focus on during interview surveys. The second plot produced is a bar graph that shows approximately how many interviews are needed to attain certain CV levels, as well as where the current number of interviews lies with



Example of second plot produced by the computer program: Number of interviews needed to achieve specified CV[total catch], by fishing method, using data from the American Samoa boat-based creel survey program. Different shades of blue correspond to fixed CV cutoffs (10, 15, 20, 25, and 30% in this example), as specified by the user. White numbers indicate the number of interviews needed to attain the approximate cutoff CV, and green lines and numbers indicate the number of interviews gathered for that fishing method in a chosen year.

respect to these cutoffs. Again, each gear type is plotted separately. Though the same data are used to construct this plot as the first one, this second plot is better suited to inform creel survey managers of their progress toward attaining specific levels of precision in total annual catch estimates.

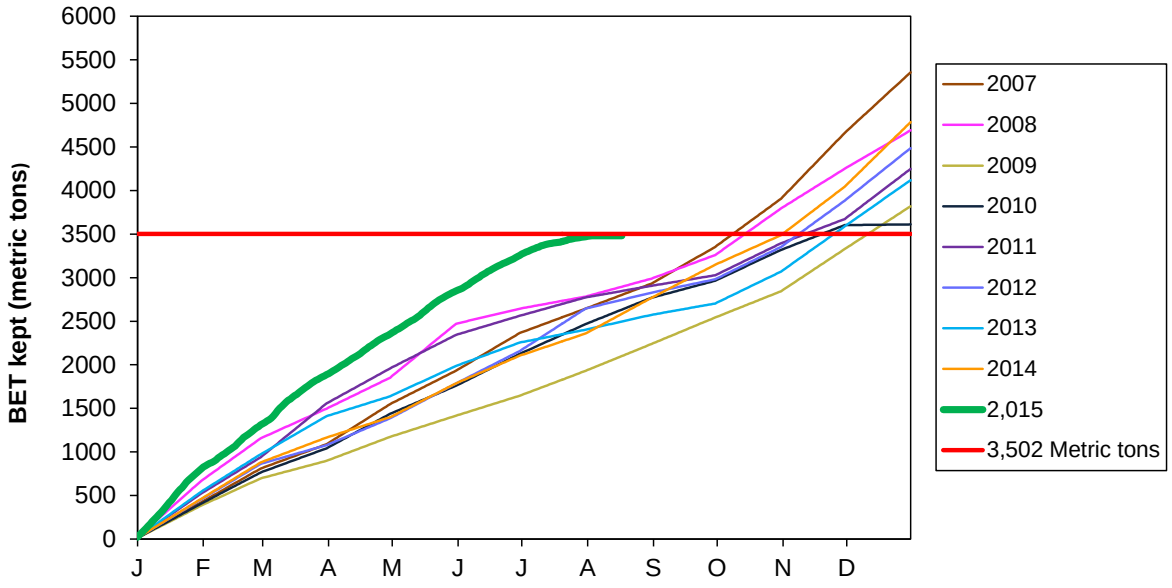
Tracking U.S. Longline Bigeye Tuna Catch Towards Catch Limits in 2015

To provide fishery managers and fishermen with early and actionable information on U.S. longline catches subject to catch limits, PIFSC conducted bigeye tuna “fast-track” monitoring, and circulated updates of estimated catch from May through August, 2015. “Fast-Track” refers to rapid, weekly compilation of the kept catch (number of bigeye) as reported in logbooks submitted at the completion of fishing trips by Hawaii longline vessel operators. Within-year average weights per fish, contained in 2015 data from the State of Hawaii Division of Aquatic Resources Dealer Reporting System, were multiplied by catch in numbers to estimate total weight of kept catch. For the most part average fish weights were specific for each fishing trip (or else a 2015 overall average was used). The fast-track reports are preliminary, being derived before validation of the 2015 database. The most recent, but still preliminary summaries presented here are based on logbooks turned in through September 3, 2015.

Fast-Track reporting in 2015 focused on bigeye tuna catches in the Western and Central Pacific Fisheries Commission (WCPFC) Area; and in the eastern Pacific Ocean area of the Inter-American Tropical Tuna Commission (IATTC). See this link: http://www.fpir.noaa.gov/SFD/SFD_regs_6.html for a description of the 3,502 metric ton (mt) U.S. longline BET catch limit in the WCPFC Area, a link to the WCPFC Bigeye and Yellowfin Tuna Conservation Measure, and a link to the Compliance Guide that describes what catches are subject to the catch limit. See this link: http://www.fpir.noaa.gov/SFD/SFD_regs_4.html for similar information on the 500 mt US longline BET catch limit in the IATTC Area for vessels greater than or equal to 24 meters (m) in length.

Along with summaries of the recent catch, forecasts of when the WCPFC Area catch limit would be reached were provided to managers and the longline industry in a regularly-updated Internal Report (IR-2015-022) entitled "Advice on U.S. Longline Bigeye Tuna Catch in Relation to Limits in Effect for 2015". The catch forecast date for reaching 3,502 mt in 2015 was estimated by adding projected average values for future monthly catches to the most current cumulative catch. Estimates of future monthly catches were based on the average catches observed for those months during the previous 8 years (Figure 1).

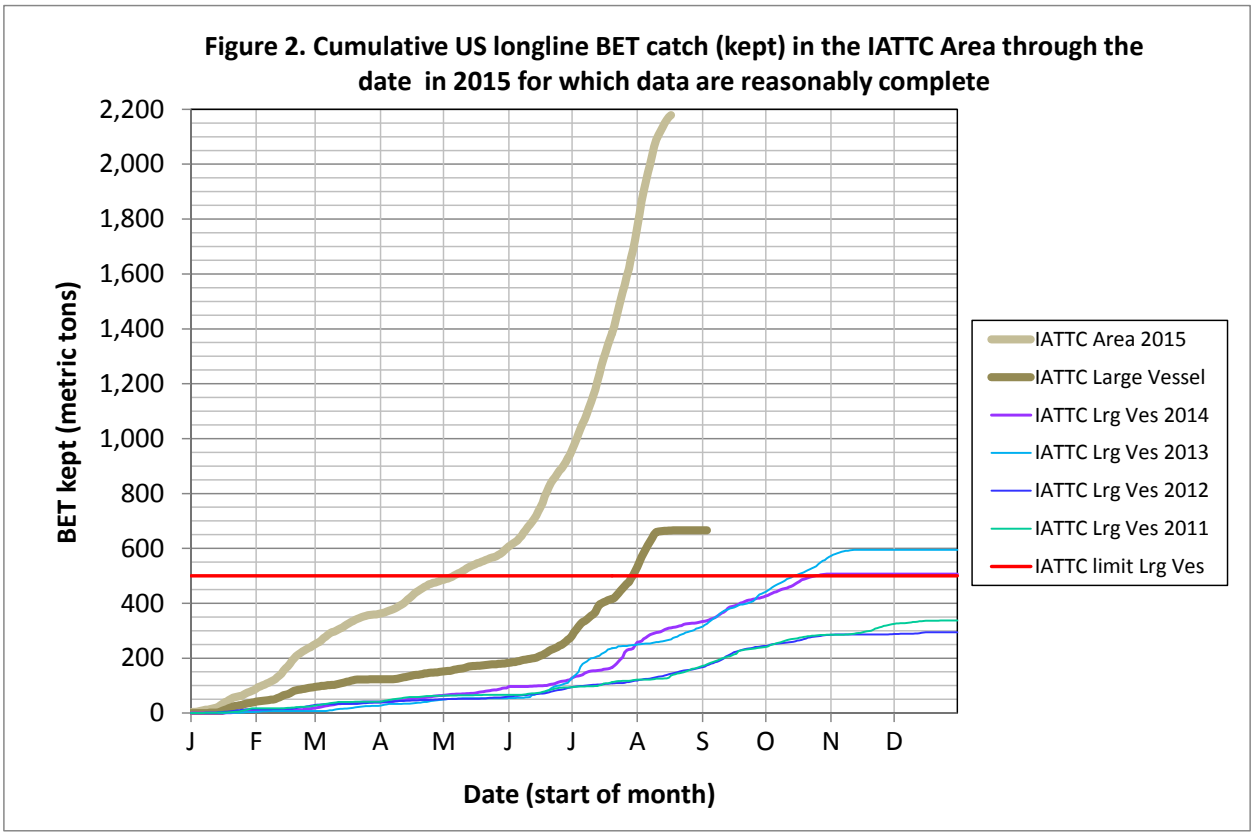
Figure 1. Cumulative Hawaii longline BET catch (kept) in the WCPFC Area for 2007-2015



In 2015, the U.S. bigeye tuna catch in the Western and Central Pacific Fisheries Commission (WCPFC) Area was record-breaking. The much higher than average catch was due to a catch rate per-unit-of-fishing-effort (CPUE) that was much higher (by ~44% for the first half of the year) than in any of the previous eight years. The amount of fishing effort (number of sets) in the first half of the year was only a little (~5%) above the average for the previous eight years. Forecasting indicated the WCPFC Area catch limit would be reached much earlier than in prior years. Based on the forecasts, managers closed the fishery subject to the 3,052 mt catch limit on August 5, 2015. This action succeeded in preventing the catch limit from being exceeded. In the years 2011-2014 the catch limit was a little higher (3,763 mt) and fishing continued after the limit was reached, with catches in excess of the limit being attributed to U.S. Territories. No arrangement for such attribution was in effect when the fishery was closed in 2015.

The catch by U.S. Territories, and catch in the Eastern Pacific Ocean (EPO) outside the WCPFC's area of competence are not subject to the WCPFC catch limit. Catches landed in Hawaii caught outside the U.S. Exclusive Economic Zone around Hawaii by dual permitted vessels with both American Samoa longline permits and Hawaii longline permits reached 286 mt, based on logbooks received through September 3. These catches were not counted towards the U.S. catch limit. Estimates for 2015 are not yet available for vessels actually fishing from, and landing catch in American Samoa.

In the Inter-America Tropical Tuna Commission (IATTC) area in the eastern Pacific Ocean bigeye tuna catches were also very high due to a much higher than average CPUE. Catches by large U.S. longline vessels (>24 m overall length) in the IATTC area, subject to a 500 mt annual limit, could not be accurately forecast, and the report did not predict any specific date for reaching the IATTC area limit. Instead, the updates provided a graphical illustration of IATTC area catch over time. Using this information, U.S. fishery managers took action to close the fishery by large vessels in the IATTC area on August 12, 2015. Due to the very early and rapid increase in catch compared to prior years, the catch exceeded the limit prior to this date (Figure 2).



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