PacIOOS

ANIMAL TELEMETRY NETWORK

WORKSHOP SUMMARY REPORT

Identifying Regional Needs and Priorities for Animal Telemetry Observations of Aquatic Species

APRIL 23–24, 2018

INFORMATION TECHNOLOGY CENTER,

UNIVERSITY OF HAWAI'I MANOA,

HONOLULU, HAWAI'I

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Thanks to our planning committee and all who helped to make this workshop a success. Special thanks Helen Worthington for her valuable assistance in preparing this report. We also thank our two breakout group facilitators, Doug Harper and Shannon Lyday Ruseborn, for their excellent work in keeping those sessions focused and on topic.

Report Contents

Workshop participants

Cover photo (and background next page): Hawaiian monk seal. Photo credit: ©James D. Watt / BluePlanetArchive.com

WORKSHOP OUTLINE

As called for in the U.S. Animal Telemetry Network (ATN) Implementation Plan, the PacIOOS (Pacific Islands Ocean Observing System) and the U.S. IOOS (Integrated Ocean Observing System) convened a Pacific Islands regional ATN workshop on April 23–24, 2018. Workshop participants from multiple agencies and organizations, including the National Oceanic and Atmospheric Administration (NOAA), U.S. Navy, U.S. Coast Guard, MarAlliance, the Bureau of Ocean Energy (BOEM), multiple state agencies and universities, and others worked together over the two days to address four objectives.

Objective I. Identify and prioritize regional telemetry stakeholder and research keystone monitoring/observational needs.

Objective II. Review the existing regional telemetry infrastructure and related ocean observing assets.

Objective III. Review existing examples of resource manager and other stakeholder use of telemetry data.

Objective IV. Identify opportunities and challenges for animal telemetry efforts in the Pacific Islands region.

For breakout discussions the participants were organized into two groups, each of which addressed the following two topics:

Topic A

- Identify stakeholder uses of animal telemetry data in the Pacific Islands region and the existing assets in place to collect them.

Topic B

- Identify opportunities and challenges for animal telemetry efforts in the Pacific Islands region.

https://ioos.noaa.gov/project/atn

WORKSHOP HIGHLIGHTS

I. STAKEHOLDER MONITORING/OBSERVATIONAL NEEDS

- Develop consistent, repeatable, and comparable observation methods across gradients of biogeography, environmental conditions, and human impacts.
- Emphasize Western Pacific Regional Fishery Management Council (FMC) pelagic fisheries tagging priorities.
  - Bigeye tuna
  - Striped marlin
  - Opah
  - Monchong (pomfrets)
  - Spearfish
  - Sharks in the Marianas
  - Sharks in Hawaiian longline fisheries
- Evaluate stock boundaries and abundance estimation of false killer whales.

II. EXISTING OBSERVING ASSETS

U.S. Navy

- Pacific Missile Range Facility- Kauaʻi: Humpback whale - 13 animals tagged
  - 2017 - 4 adults, 3 sub-adults
  - 2018 - 5 adults, 1 sub-adult (?)
  - All likely male
  - Tags transmitted from 1.6–12.3 days
  - LIMPET-configured SPLASH10 satellite tags with FastLoc GPS
- Marine Species Monitoring Program - Effects of mid-frequency active sonar (MFAS) on marine mammals
  - Tagging, passive acoustic monitoring – multiple species
- SPAWAR (Space and Naval Warfare Systems Command)
  - Acoustic array in Hawaiʻi

NMFS (National Marine Fisheries Service)

- PIFSC (Pacific Islands Fisheries Science Center)
  - Turtles
  - 110 greens and hawksbills tagged in Marianas (2013-2018)
  - 30 greens tagged in American Samoa (2012-2018)
  - 50 greens and hawksbills tagged in Hawaiʻi (~2000-2018)
  - 2 leatherbacks tagged in Indonesia
  - 6 greens tagged in Philippines
  - 850 tagged throughout the Pacific Islands Region (legacy tags 1992-2016)
  - Sharks: 112 sPAT tags (blue, oceanic whitetip, silky, thresher)
  - Hawaiian monk seals ~160 tagged in Hawaiʻi Archipelago

NOAA/Office of National Marine Sanctuaries (ONMS)/Hawaiian Islands Humpback Whale National Marine Sanctuary

- Large whale entanglement response and monitoring – coordination of 25 GPS/Argos/VHF tags distributed throughout the Hawaiian Islands, West Coast, and Alaska for attaching to gear on entangled animals
- Suction-cup tagging with Hawaiʻi Institute of Marine Biology (HIMB), U.S. Naval Facilities Command (NAVFAC), Moss Landing Marine Labs (MLML), and University of Hawaiʻi-Hilo using Acousonde™, Bprobe, and Dtags collecting sound measurements, movement, depth, temperature, and light
- Remote acoustic monitoring - EARs (ecologic acoustic recorders) and SoundTraps deployed in Maui Nui and Northwestern Hawaiian Islands recording soundscape on a duty cycle during multi-month deployments
- Satellite tracking in partnership with Oregon State University
- Cetabuoy (live-streaming hydrophone on a moored Waveglider platform) with Jupiter Research Foundation to be deployed seasonally during whale season
- Carcass Tags: VHF tags to better track the drift of dead whales

Citizen Science

- Ihu Nui Sportfishing: International Game Fish Association (IGFA) Great Marlin Race, a partnership between IGFA and Stanford University (Barbara Block) that pairs recreational anglers with cutting-edge science to deploy 50 satellite-linked tags on marlin at billfish tournaments around the world each year.

III. STAKEHOLDER USE OF TELEMETRY DATA

- Establish habitat use and movement patterns.
  - Establish basic information for relatively unknown areas or species (Marianas; Hawaiian monk seals).
  - Evaluate high-use areas and home ranges of marine mammals and sea turtles (Hawai'i and Marianas).
- Support improvements to stock assessment models, ecosystem models, and management strategy evaluations with movement patterns from tracked animals and their associations with environmental conditions.
- Assist the protected resources mission by providing information on habitat use, migrations, connectivity, population structure, threats, etc.
- Inform population structure and distribution that can guide appropriate scale for abundance, habitat, threat, and other assessment activities.

IV. OPPORTUNITIES/CHALLENGES FOR TELEMETRY EFFORTS IN THE PACIFIC ISLANDS REGION

- Find ways to leverage Mote stations across multiple research groups in the Pacific Islands.
- Animal-borne sensors will assist in filling the many spatial and temporal gaps in measuring environmental conditions.
- Data warehousing, public accessibility, and data exploration tools are important and needed.
- Telemetry can help answer if whales are going to different feeding/breeding habitats, or are they skipping/shortening their breeding migrations.
- Need standards developed for tag data.

Hawksbill turtle. Photo credit: U.S. Fish and Wildlife Service

WORKSHOP CONCLUSIONS

OBJECTIVE I: Identify and Prioritize Regional Telemetry Stakeholder and Research Keystone Monitoring/Observational Needs.

THEME A: Develop integrated long-term interdisciplinary ecosystem monitoring of abundance, distribution, diversity, condition of: reef fishes, corals, invertebrates, algae, microbes, meroplankton.

THEME B: Determine fish behavioral aspects that influence their catchability, including preferential depth of species with daily/seasonal spatial variability and behavior relative to the fishing gear, especially fish aggregating devices (FADs).

THEME C: Track movement, foraging behavior, and habitat use of Hawaiian monk seals.

FEDERAL AGENCIES AND INTERGOVERNMENTAL ORGANIZATIONS

U.S. Navy

- Cetaceans and sea turtles in Marianas
- Cetaceans and humpback whales off Kaua‘i
- Humpback whales off Maui
- Hawaiian monk seals in Marianas

Bureau of Ocean Energy Management (BOEM)/U.S. Navy/U.S. Fish and Wildlife Service

- Pacific Marine Assessment for Protected Species (PacMAPPS) is a partnership among federal agencies to conduct surveys to assess the abundance of multiple species and their ecosystem (Multispecies Cetacean and Ecosystem Assessment Surveys with a focus on marine mammals and seabirds.

National Marine Fisheries Service/Pacific Islands Fisheries Science Center/Ecosystem Sciences Division (NMFS/PIFSC/ESD)

- Integrated ecosystem observations: Long-term, interdisciplinary ecosystem monitoring of abundance, distribution, diversity, and condition of reef fishes, corals, invertebrates, algae, microbes, and meroplankton.
- Consistent, repeatable, and comparable observation methods across gradients of biogeography, environmental conditions, and human impacts.
- Observations needed to document spatial/temporal variability of environmental conditions in priority essential fish habitats and critical habitats.
- Movement patterns relative to oceanographic features—passive or active movement in features.
- Measures of light/turbidity/ocean color.
- Passive bio-acoustic recordings of soniferous animals, especially species of concern (e.g., bumphead parrotfish, other excavators).
- Optical/acoustic sensors of productivity and/or prey abundance.

NMFS/PIFSC/Protected Species Division

- Track movement, foraging behavior, and habitat use of Hawaiian monk seals.
- Mariana cetaceans: Gain insights into population range and structure.
- False killer whales: Evaluate stock boundaries and abundance estimation.
- Marine turtles

NOAA/Office of National Marine Sanctuaries (ONMS)/Hawaiian Islands Humpback Whale National Marine Sanctuary

- Humpback whales

NOAA/ONMS/Papahānaumokuākea Marine National Monument (PMNM)

- Cetaceans
- Tuna
- Billfish
- Pelagic apex predators
- Sharks
- Hawaiian monk seals
- Seabirds
- Green turtles
- Humpback whales

Pacific Community/Oceanic Fisheries Programme

- Determine fish behavioral aspects that influence their catchability.
  - Preferential depth of species with daily/seasonal spatial variability
  - Behavior relative to the fishing gears (especially FADs)
- Learn about fish movements/influence of the environment.
  - Movements between region, fishing impacts
  - Movement predictions in front of cyclic environment events (e.g., ENSO) or global warming/ocean acidification

Western Pacific Regional Fishery Management Council Tagging Priorities

- Pelagic fisheries
  - Bigeye tuna
  - Striped marlin
  - Opah
  - Monchong (pomfrets)
  - Spearfish
  - Sharks in the Marianas
  - Sharks in Hawai'i longline fisheries
- Bottomfish
  - Onaga
  - Opakapa
  - Uku
- Crustaceans
  - Kona crab (Hawai'i)
- Protected Species
  - Seabirds: Albatross (black footed and Laysan)
- Marine Mammals
  - False killer whales
  - Guadalupe fur seal
- Sea Turtles
  - North Pacific loggerheads
  - Western Pacific leatherbacks
  - Olive ridley turtle

NGO

- Pacific Islands Fisheries Group
  - Striped marlin
- Cascadia Research
  - Cetacean research for both odontocetes and mysticetes species
- MarAlliance
  - Brown spotted grouper

Tagged Tiger Shark. Photo Credit: Mark Royer

OBJECTIVE II: Review the Existing Regional Telemetry Infrastructure and Related Ocean Observing Assets.

FEDERAL AGENCIES AND INTERGOVERNMENTAL ORGANIZATIONS

U.S. Navy

- Pacific Missile Range Facility - Kauaʻi: Humpback whale - 13 animals tagged
- 2017 - 4 adults, 3 sub-adults
    - 2018 – 5 adults, 1 sub-adult (?)
    - All likely male
    - Tags transmitted from 1.6-12.3 days
    - LIMPET-configured SPLASH10 satellite tags with FastLoc GPS
- Marine Species Monitoring Program - Effects of MFAS on marine mammals
    - Tagging, passive acoustic monitoring—multiple species
- SPAWAR
    - Acoustic array in Hawaiʻi

National Marine Fisheries Service

- Pacific Islands Fisheries Science Center
    - Turtles
        - 110 greens and hawksbills tagged in Marianas (2013–2018)
        - 30 greens tagged in American Samoa (2012–2018)
        - 50 greens and hawksbills tagged in Hawaiʻi (~2000–2018)
        - 2 leatherbacks tagged in Indonesia
        - 6 greens tagged in Philippines
        - 850 tagged throughout the PIR (legacy tags 1992–2016)
    - Sharks: 112 sPAT tags (blue, oceanic whitetip, silky, thresher)
    - Hawaiian monk seals: ~160 tagged in Hawaiian Archipelago
    - Bottlenose dolphin: 11 SPOT & SPLASH tags in Marianas
    - False killer whales: 16 SPOT & SPLASH tags in Marianas/Hawaiʻi
    - Melon-headed whales: 15 SPOT & SPLASH tags in Marianas/Hawaiʻi
    - Short-finned pilot whales: 26 SPOT & SPLASH tags in Marianas/Hawaiʻi
    - Killer whales: 5 SPOT tags in Hawaiʻi
    - Sperm whales: 7 SPOT & SPLASH tags in Marianas
    - Spotted dolphin: 6 SPOT & SPLASH tags in Marianas
    - Rough-toothed dolphin: 5 SPOT & SPLASH tags in Marianas
    - Humpback whales: 5 SPOT tags in Hawaiʻi
    - Bryde's whales: 5 SPOT tags in Hawaiʻi
    - 12 VR2W acoustic receivers on FADs off Kona and Windward Oʻahu

BOEM/U.S. Geological Survey

- 2013–2016 - Main Hawaiian Island Seabird Tracking: Distribution and ranging behaviors

NOAA/ONMS/Hawaiian Islands Humpback Whale National Marine Sanctuary

- Large whale entanglement response and monitoring: Coordination of 25 GPS/Argos/VHF tags distributed throughout the Hawaiian Islands, West Coast, and Alaska for attaching to gear on entangled animals
- Suction-cup tagging with HIMB, NAVFAC, MLML, UH-Hilo using Acousonde, Bprobe, and Dtags collecting sound measurements, movement, depth, temperature, and light
- Remote acoustic monitoring: EARs and SoundTraps deployed in Maui Nui and Northwestern Hawaiian Islands recording soundscape on a duty cycle during multi-month deployments
- Satellite tracking in partnership with Oregon State University
- Cetabuoy (live-streaming hydrophone on a moored Waveglider platform) with Jupiter Research Foundation will be deployed seasonally during whale season
- Carcass Tags: VHF tags to better track the drift of dead whales

Pacific Community/Oceanic Fisheries Programme

- More than 1,700 archival tags deployed since 2006 with a total of 26,000 days in their database.
- Sonic tags linked to receiver stations obtain information on fish behavior around the fish aggregating devices (FADs) deployed by the industrial purse seine fishing.
    - 200 anchored FADs in 2006, 2007 in Papua New Guinea
    - 250 drifting FADs since 2014 in the Central Pacific
    - For 2018: 180 sonic tags with 8 receiver stations and 200 archival tags
    - Minipat tags on billfish in Marshall Islands

CITIZEN SCIENCE

Ihu Nui Sportfishing

- International Game Fish Association (IGFA) Great Marlin Race, a partnership between IGFA and Stanford University (Barbara Block) that pairs recreational anglers with cutting-edge science to deploy 50 satellite-linked tags on marlin at billfish tournaments around the world each year.

ACADEMIA

University of Hawai‘i/Hawai‘i Institute of Marine Biology (HIMB)

- 30-50 tags; sharks (tiger, scalloped hammerhead, sandbar, blacktip, Galapagos, blacknose sixgill) and reef fish – Maui, O‘ahu, Northwestern Hawaiian Islands
- 2 Motes – Kaua‘i, Nihau: NAVFAC/HDR
- 5 Motes – 2 Maui, 3 O‘ahu: Holland/Meyer
- 27 VR2W Acoustic Receivers for sharks and reef predators off O‘ahu: Holland/Meyer
- 17 VR2W Acoustic Receivers for sharks and reef predators off Maui: Holland/Meyer
- 30 VR2W Acoustic Receivers for sharks and reef predators in Northwestern Hawaiian Islands: Meyer

Oregon State University

- 25 satellite tags on humpback whales in Maui

NGO

Pacific Islands Fisheries Group

- Minipat tags - Striped marlin off Kona: Clay Tam

Cascadia Research

- 2007–2018: 300 tags, 12 species

Hawai‘i Association for Marine Education and Research

- SPLASH10 tags – manta rays

MarAlliance

- Omnidirectional receiver for spotted grouper in Pohnpei-Micronesia

Background photo: IHU NUI and IHU NUI II; Photo credit: Capt. McGrew Rice, Kailua-Kona

OBJECTIVE III: Review Existing Examples of Resource Manager and Other Stakeholder Use of Telemetry Data.

THEME A: Monitor the effects of U.S. Navy at-sea training and testing actions on marine mammals by linking estimated sonar levels on marine mammals with behavioral responses in combination with U.S. Navy bottom-mounted hydrophone range (Hawai'i); understand habitat use, movement patterns, and population structure.

THEME B: Identify movement patterns from tracked animals and their associations with environmental conditions to support improvements to stock assessment models, ecosystem models, and to guide appropriate scale for abundance, habitat, threat, and other assessment activities.

THEME C: Use soundscapes to study trends in whale occurrence over time and across locations based on chorusing levels by converting decibel levels to approximate number of whales in a defined area.

FEDERAL AGENCIES AND INTERGOVERNMENTAL ORGANIZATIONS

U.S. Navy

- Monitor the effects of U.S. Navy at-sea training and testing actions on marine mammals.
  - Estimate received levels of sonar on marine mammals and behavioral response in combination with U.S. Navy bottom-mounted hydrophone range (Hawai'i).
- Monitor habitat use and movement patterns.
  - Establish basic information for relatively unknown areas or species (Marianas, Hawaiian monk seals).
  - Evaluate high-use areas and home ranges of marine mammals and sea turtles (Hawai'i and Marianas).
- Monitor population structure.
  - Compare to visual survey and genetic data (Marianas).
  - Migration of humpbacks related to distinct population segment.
  - Utility of telemetry observations is complementary to other observations and products, e.g., visual, genetic, behavioral, population trends, density.

BOEM

- Collect data and produce abundance estimates for species of joint management interest (e.g., assess the abundance of cetacean species and their ecosystems).
- Evaluate and monitor potential effects of anthropogenic disturbances.
- Assist with reviews of possible renewable energy site selection plus monitoring of existing sites.

NMFS/PIFSC/Ecosystem Sciences Division

- Movement patterns from tracked animals and their associations with environmental conditions supports improvements to stock assessment models, ecosystem models and management strategy evaluations.
- Animal-borne sensors can provide in-situ observations of:
  - Where essential fish habitats (EFH) and critical habitats (under the Endangered Species Act) are located in time and 3D space,
  - Predator-prey relations – diets, feeding patterns, abundance of forage/prey,
  - Associations/patterns of managed resources and their supporting environmental conditions,
  - Environmental conditions in key habitats (temperature, salinity, oxygen, pH, chlorophyll, nutrients, light, and variability in time and space of the environmental conditions).

NMFS/PIFSC/Protected Species Division

- Support protected marine species recovery and conservation.
- Define essential/critical habitats for Endangered Species Act and Marine Mammal Protection Act species.
- Understand critical baseline behavior/ecology to evaluate effects of anthropogenic disturbances.
- Monk seal basic ecology, fisheries interactions, informing conservation and management, and establishing baseline for changing populations and environment.
- Species and population movements provide information on range and population boundaries that inform population structure and distribution, guiding appropriate scale for abundance, habitat, threat, and other assessment activities.
- Telemetry data can also reveal patterns of behavior and foraging that are otherwise difficult to assess and critical for management.

NMFS/PIRO/Protected Resources Division

- Telemetry data can assist the Pacific Islands Regional Office Protected Resources Division (PIRO/PRD) mission by providing information on habitat use, migrations, connectivity, population structure, threats, etc.

NOAA/ONMS/Hawaiian Islands Humpback Whale National Marine Sanctuary

- Telemetry data can help answer:
  - Are whales going to different feeding/breeding habitats than in the past?
  - Are whales skipping or shortening their breeding migrations?
  - Have energy budgets (e.g., activity levels) changed on the breeding grounds?
- Use soundscapes to study trends in whale occurrence over time and across locations based on chorusing levels by converting decibel levels to approximate number of whales in a defined area.
- Study whale behavior, communication, exposure to noise as well as habitat use.
- Study whale movements between islands and the migration to feeding grounds.

NOAA/ONMS/Papahānaumokuākea Marine National Monument (PMNM)

- Migratory species (e.g., sharks, seabirds, turtles)
- Characterization of habitat range
- Habitat utilization
- Energy flow for management of habitats (e.g., shallow and deep foraging)

Pacific Community/Oceanic Fisheries Programme

- Provide annual stock assessments of the regional tuna resources to the Scientific Committee of the Western and Central Pacific Fisheries Commission to assist them in the management of the commercial tuna fisheries.

CITIZEN SCIENCE

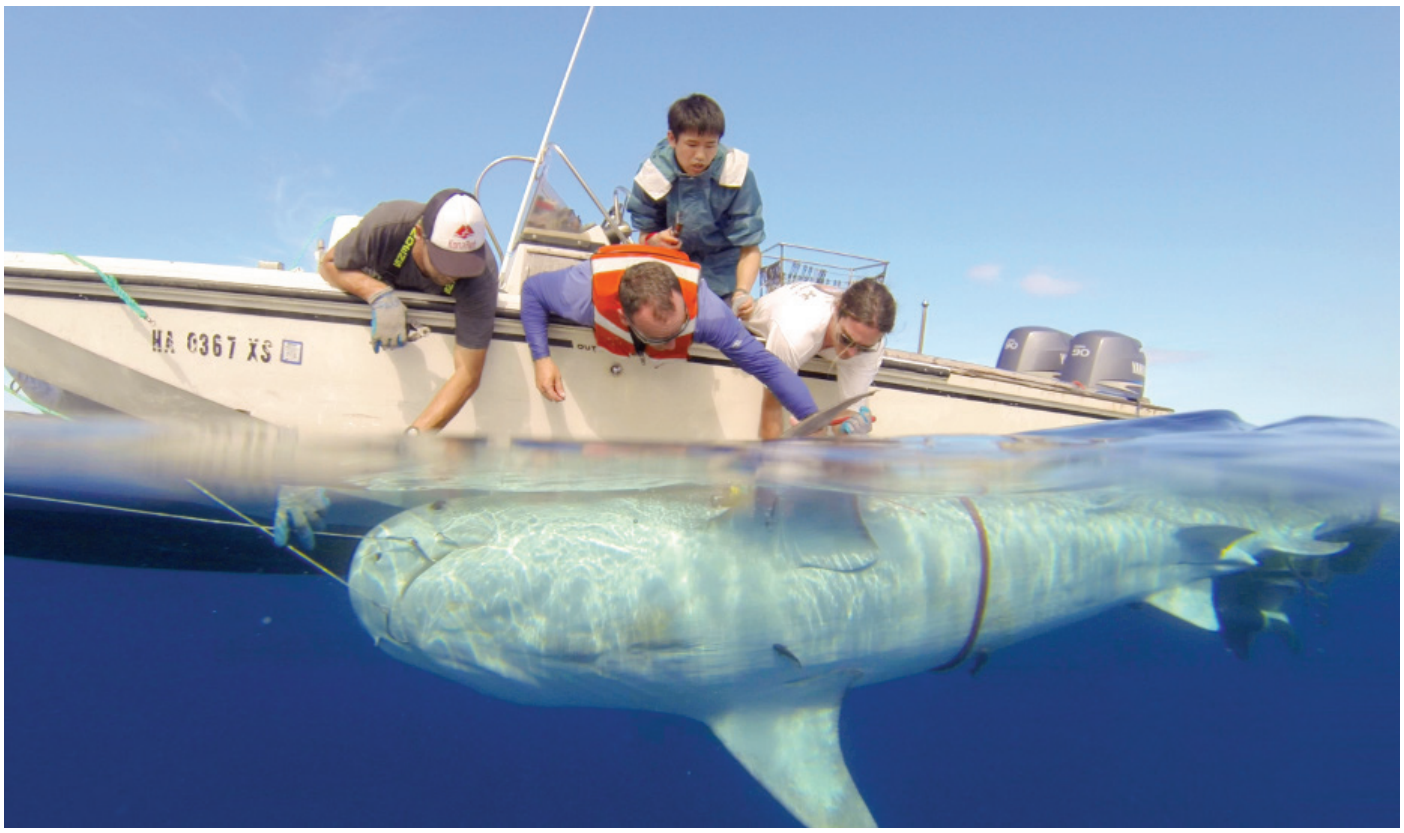
Ihu Nui Sportfishing

- The data collected from tags deployed by the annual IGFA Great Marlin Race participants help to increase understanding of distribution, population structure, and biology of the marlin; this information is made available to resource managers and policy makers who are responsible for long-term conservation.

OBJECTIVE IV. Identify Opportunities and Challenges for Animal Telemetry Efforts in the Pacific Islands Region.

CHALLENGES

- Find ways to improve leveraging Mote stations across multiple research groups in Hawai'i. Groups and projects within the HIMB maintain a network of Motes. A more organized approach for the Central Pacific tagging community is needed.
- Need more options for long-term tag attachments.
- Need improved location accuracy in lower latitudes (trade-offs by using Fastloc?).
- Have challenging federal data archiving issues (PARR). Can the ATN help with them?
- Need an improved process for identifying technology needs from the community.
- Need improved data bandwidth for non-recoverable tags. Is Iridium a solution?
- Need solutions for emergent environmental observations as new species are listed.
- Develop standards for tag data.
- Need longer tag duration (without increasing size/weight) and more frequent tag reporting.
- Need increased bandwidth to enable more data transfer and less data summary/compression (e.g., GSM networks).
- Expand data warehousing, public accessibility, and data exploration tools.
- Commitment to long-term sustained telemetry observations is essential because they need to be able to assess habitat associations and how environmental or anthropogenic perturbations may change habitat use or behavior.
- Limited resources or rarely seen/studied species mean data are acquired slowly (so studies are long).
- Green turtles move over long distances and need international protection.



Experts tag a tiger shark with a tracking device in the waters off Maui. Photo Credit: University of Hawai'i, Hawai'i Institute of Marine Biology

OPPORTUNITIES

- Future telemetry success depends on continued innovation in tag capabilities (physiology tags and oceanography tags). Tagging is still a "cutting edge" science but the only one capable of answering key questions about natural resources.
- Telemetry paired with other sensors (calibrated acoustics, accelerometer, etc.) with medium/long-term attachment would provide significant improvements for behavioral studies.
- Pre-paid satellite charges would be welcome.
- Support acoustic (VEMCO) tag networks in Hawai'i or Marianas/Guam.
- Solutions for emergent environmental observations are needed as new species are listed.
- Ecosystem science to support ecosystem-based management/ecosystem-based fisheries management (EBM/EBFM) would benefit from developing diverse sensor suites to equip large numbers of managed species to document movement patterns, predator-prey relationships, and spatial and temporal variability of environment conditions.
- Animal-borne sensors will assist in filling the many spatial and temporal gaps in measuring environmental conditions.
- Add acoustic or other environmental sensors to the tags. Hybrid acoustic/satellite technologies hold promise (e.g., Business Card tags 2.0).
- The value of baseline telemetry data is that it allows you to determine habitats utilized by species and to further enhance their conservation and protection by maintaining or improving them as well as support protection of the species.
- The importance of telemetry is likely to grow because tuna and associated species behavior around FADs is still poorly understood and documented. Sustainability question of the drifting FAD tuna purse seine fishery has defined a clear need for increasing our knowledge on tuna and associated species behavior.
- A primary goal is to tag large numbers of all tropical tuna species; large-scale acoustic telemetry would be the most valuable approach to achieve that goal.
- It would be ideal for the Pacific community to have their own drifting FADs so they would not have to depend on collaboration with the purse seine fisheries to do their fisheries research.
- Telemetry can help answer:
  - Are whales going to different feeding/breeding habitats than in the past?
  - Are whales skipping or shortening their breeding migrations?
  - Have energy budgets (e.g., activity levels) changed on the breeding grounds?

Humpback whales. Photo credit: HIHWNMS, Ed Lyman, NMFS ESA Permit #782-1719

SPEAKERS

NATURAL RESOURCE MANAGEMENT, FISHERIES CONSERVATION AND MANAGEMENT, AND RESEARCHER PERSPECTIVES

Topics covering perspectives of natural resource management, fisheries conservation and management, and research were presented by invited speakers in three sessions with 30 minutes of panel discussions following each set of speakers.

NATURAL RESOURCE MANAGEMENT PERSPECTIVES

Using Acoustic Telemetry to Improve Management of Marine Protected Areas

Russell Sparks, Aquatic Biologist
Hawai'i Department of Land and Natural Resources
Division of Aquatic Resources

The mission of the Division of Aquatic Resources is to manage, conserve, and restore the state's unique aquatic resources and ecosystems for present and future generations. Their 30x30 Marine Management Goal is to effectively manage 30% of nearshore marine areas by 2030. The Molokini Marine Life Conservation District (MCLD), Hawai'i's second most visited Marine Protected Area (430,000 people/year), is an example of how they are implementing effective management. Because effective management requires collecting information about the local living marine resources, the Division of Aquatic Resources leveraged the existing tiger shark tracking acoustic telemetry receiver array near the MCLD to examine the movement patterns of five common reef predators (Omilu, Ulua, Uku, Whitetip, and Grey reef sharks) to assess the level of protection they receive from the no-fishing zone and to determine if they are displaced from the MCLD during periods of heavy human use and where they go. They determined that there is as much as a 50% displacement of predators when 12 or more vessels arrive at the MCLD. Identifying where they go when displaced allows for better protection by networking managed areas.

U.S. Pacific Fleet Marine Species Monitoring Program Animal Telemetry Network Brief

Julie Rivers, Marine and Natural Resources Program Manager, U.S. Pacific Fleet

Robert Uyeyama, Marine Species Monitoring Coordinator, U.S. Naval Facilities Engineering Command (NAVFAC) Pacific

Since 2008, pursuant to Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) federal requirements, the U.S. Navy's Marine Species Monitoring Program has used field methods (including visual surveys, passive acoustic monitoring from instrumented ranges and autonomous devices, tagging, and biopsy) to investigate occurrence, exposure, response, and consequences to marine species from U.S. Navy training and testing. They use a significant amount of telemetry data in Hawai'i and the Marianas collected by investigators funded by the U.S. Navy and other agencies (PIFSC: Cetacean Research Program-Marianas, Marine Turtle Biology and Assessment Program – Marianas and Hawaiian Monk Seal Research Program (GSM); Cascadia Research Collective: cetaceans off Kaua'i; SPAWAR SYSCEN Pacific: humpback whales off Kaua'i (Argos); Oregon State University: humpback whales off Maui (implant); and, HDR Engineering, Inc.: installed Mote stations at Ni'ihau and Kaua'i (Makaha Ridge). The U.S. Navy also develops products using telemetry data collected by others such as behavioral response and estimated received level of tagged animal of hull-mounted mid-frequency active sonar. Additionally, data from telemetry devices are used in compliance documents, ESA consultations, MMPA authorizations, etc.

Animal Telemetry and Renewable Offshore Energy Development in Hawai'i: A BOEM Perspective

Greg Sanders, Marine Mammal/Sea Turtle Specialist,
Bureau of Ocean Energy Management Pacific Region

The BOEM mission is to manage and regulate development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way. BOEM's primary interest in this region is based on the potential for offshore wind energy development in and around the Hawaiian Islands and the importance of monitoring and evaluating potential effects of anthropogenic disturbances. BOEM, through their PacMAPPS Program and in partnership with the U.S. Navy and the U.S. Fish and Wildlife Service, has joined with the NMFS HICEAS 2017 survey to collect data and produce abundance estimates for species of joint management interest. In particular, PacMAPPS includes rotational surveys throughout the Pacific to assess the abundance of cetacean species and their ecosystems. In addition to funding telemetry studies thorough its Environmental Studies Program, BOEM also uses telemetry data collected by others and may develop products from that data. These products assist with reviewing possible renewable energy site selection and monitoring existing sites.

Using Animals to Collect Ecosystem Observations to Support Management and Conservation of Living Marine Resources in the Pacific Islands

Rusty Brainard, Lead, Habitat and Living Marine Resources Program,
Ecosystem Sciences Division
NOAA Pacific Islands Fisheries Science Center (PIFSC)

The Pacific Islands Region is vast (~1.5 million square nautical miles), remote, and diverse both culturally and ecologically. The vision of the Ecosystem Sciences Division is to fully transform PIFSC scientific activities in the region to build and support ecosystem-based approaches to management of fisheries and living marine resources. The goal is to ensure good governance and reduce the risks for future generations by balancing the tradeoffs between ecological and human well-being. The approach is to conduct field and experimental research to better understand ecosystem function, structure, and processes with particular emphasis on the ecology of protected and managed species and related species interactions and how these might be influenced by climate and ocean change. Although they currently collect/use only limited amounts of marine animal telemetry data, they recognize its value, especially if it was closely aligned and coordinated with other ongoing efforts.

NOAA's Use of Advanced Telemetry Systems in the Research, Conservation and Management of Marine Mammals in the Pacific Islands Region

Charles Littnan, Director. Protected Species Division
NOAA Pacific Islands Fisheries Science Center (PIFSC)

The mission of the PIFSC Protected Species Division is to provide the scientific foundation for the conservation of cetaceans, Hawaiian monk seals, and sea turtles in the vast region of the Pacific Islands, guided by mandates of the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and international agreements. Their work is focused on cetaceans, Hawaiian monk seals, and marine turtles and includes recovery and conservation, defining essential/critical habitats for ESA and MMPA species, and understanding critical baseline behavior and ecology to evaluate effects of anthropogenic disturbances. Animal telemetry data are essential to their mission. Species and population movements provide information on range and population boundaries that inform population structure and distribution, guiding appropriate scales for abundance, habitat, threat, and other assessment activities. Telemetry data can also reveal patterns of behavior and foraging that are critical for management and otherwise difficult to assess. Commitment to long-term, sustained telemetry observations is also essential because it is important to assess habitat associations and how environmental or anthropogenic perturbations may change habitat use or behavior. Limited resources or rarely seen/studied species mean that data are acquired slowly (so studies are long).

Melanie Hutchinson watches the sun come up after a long night of fishing/tagging. Photo Credit: Ali Bayless

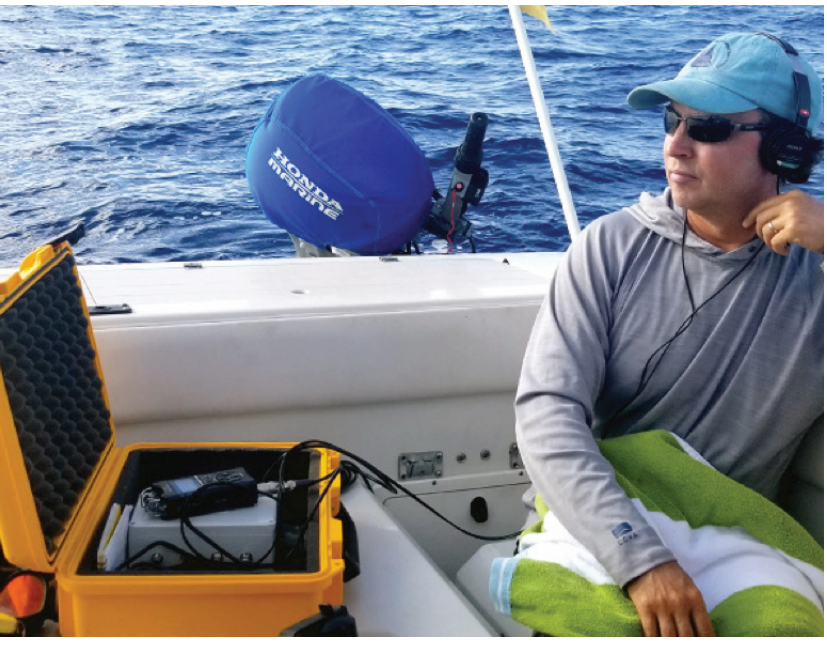
Protected Species Management: Needs and Opportunities

Irene Kelly, Sea Turtle Recovery Coordinator
Protected Resources Division

Andrew Torres, Recreational Fisheries Specialist
Sustainable Fisheries Division
NMFS Pacific Islands Regional Office (PIRO)

The NMFS PIRO works with the PIFSC to integrate cutting-edge science into policy and management decision-making, working together for the conservation and management of domestic and international marine resources. In particular the Protected Resources Division (PRD) is responsible for protecting marine mammals and recovering endangered and threatened species in the region. PRD is the lead office in ESA and MMPA policy coordination, recovery planning, and implementation. They work collaboratively with scientists, fishermen, and industry to develop and implement measures to reduce protected species interactions in commercial longline fisheries. A good example is the integration and application of bycatch reduction technology, management regulations, oceanographic research, and increased fishery awareness to significantly reduce pelagic longline fishery interactions with loggerhead and leatherback turtles.

Guided by the ten National Standards of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the PIRO Sustainable Fisheries Division is responsible for maintaining healthy fish stocks in the region. They are responsible for reviewing, recommending approval or disapproval, and implementing approved fishery management plans for commercial and non-commercial fisheries in the U.S. Pacific Islands Region.



Marc Lammers listens to humpback whale songs off Maui.
Photo Credit: Eden Zang/NOAA

Animal Telemetry for Studying Humpback Whales in Hawai'i: Applications and Needs

Marc Lammers, Research Coodinator

Ed Lyman, National Resource Management Specialist
NOAA/Office of National Marine Sanctuaries, Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS)

The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawai'i. It is administered by NOAA's Office of National Marine Sanctuaries jointly with the State of Hawai'i through the Department of Land and Natural Resources. It is located from the shoreline to the 100-fathom isobath in the four-island area of Maui; Penguin Bank; and off the north shore of Kaua'i, the north and south shores of O'ahu, and the north Kona and Kohala coast of Hawai'i Island. As many as 12,000 whales migrate to Hawai'i each year between November and May, and the sanctuary conducts and supports humpback whale research that aims to increase scientific knowledge about the North Pacific humpback whale population and its habitat. Research efforts include photo identification, population, birth and mortality rates, and whale behavior. A major concern is that after decades of growth, the whale population is declining, suggesting that the population may have reached carrying capacity, and changes in food abundance have led to shifts in distribution and/or reduced breeding effort.

Papahānaumokuākea Marine National Monument Animal Telemetry Data Needs

Jon Martinez, Marine Scientist
NOAA/Office of National Marine Sanctuaries,
Papahānaumokuākea Marine National Monument (PMNM)

The mission of the PMNM is to carry out seamless integrated management to ensure ecological integrity and achieve strong, long-term protection and perpetuation of Northwestern Hawaiian Islands ecosystems, Native Hawaiian culture, and heritage resources for current and future generations. The monument area covers 582,578 square nautical miles and is home to a number of bluewater species (e.g., cetaceans, tuna, billfish, pelagic apex predators), deep sea abyssal scavenging community including sharks, Hawaiian monk seals, seabirds, green turtles and humpback whales. Research to date has been primarily through partnerships and using synthesized data products from telemetry studies. PMNM is still working on a management plan, so they do not yet have a mandate for monitoring. Nevertheless, they believe that there is tremendous value in long-term animal telemetry efforts, especially to understand habitat utilization to generate baseline data for future changes like climate change.

FISHERIES CONSERVATION AND MANAGEMENT PERSPECTIVES

Fish Telemetry and Management of the Western and Central Pacific Commercial Tuna Fisheries

Bruno LeRoy, Fisheries Scientist
Pacific Community/Fisheries, Aquaculture, and Marine Ecosystems Division/Oceanic Fisheries Programme/ Fisheries and Ecosystem Monitoring and Analysis Section

The Pacific Community (PC) is the principal scientific and technical organization in the Pacific region, proudly supporting fisheries development since 1947. It is an international development organization owned and governed by the 26 country and territory members. In pursuit of sustainable development to benefit Pacific people, this unique organization works across more than 25 sectors. They are renowned for their knowledge and innovation in such areas as fisheries science, public health surveillance, geoscience, and conservation of plant genetic resources for food and agriculture.

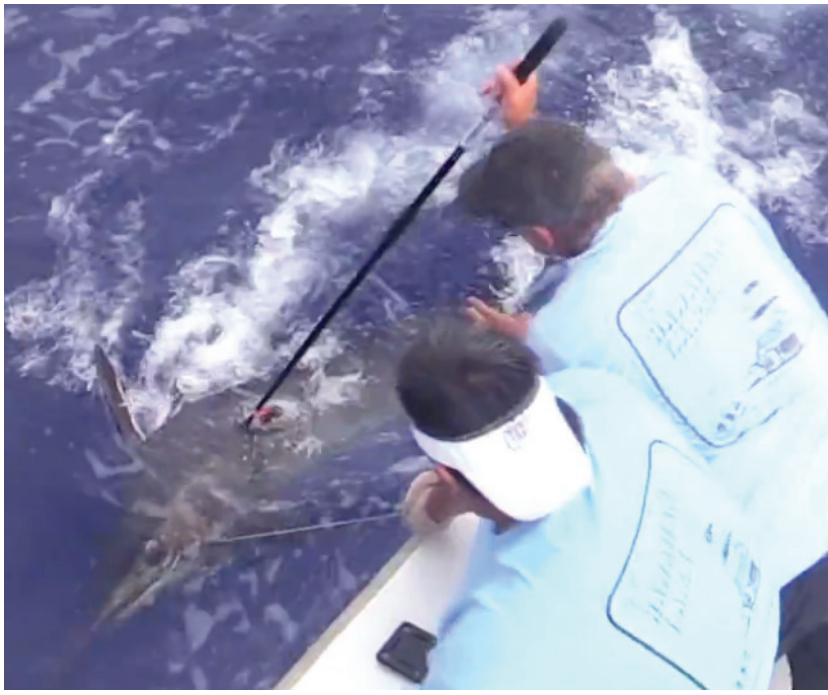
The PC Oceanic Fisheries Program is the service provider to the Western and Central Pacific Fisheries Commission (WCPFC). They report stock assessments for the regional tuna resources annually to the Scientific Committee of the WCPFC. The Fisheries Ecosystem Monitoring and Analysis Section tries to ensure that the right fisheries and ecosystem monitoring data are collected. Some of these data are direct inputs for stock assessment models. The Western and Central Pacific Ocean (WCPO) tuna fisheries are huge and vitally important for the region. Since they started their Pacific Tuna Tagging Program in 2006, they have deployed over 1,700 archival tags and have a total of 26,000 days in their database. They have used sonic tags linked to receiver stations to get information on fish behavior around the fish aggregating devices (FADs) deployed by the industrial purse seine fishing, in Papua New Guinea (about 200 anchored FADs in 2006, 2007), then in Central Pacific on drifting FADs since 2014 (about 250).

> "If you line up one year's catch of WCPO tuna from tail to head, it will stretch beyond the moon!"
>
> *Bruno LeRoy*

Satellite Marlin Tagging in Hawai'i

Captain Frederick McGrew Rice, Charter Boat Captain
Ihu Nui Sportfishing and Western Pacific Regional Fishery Management Council (WPRFMC)

McGrew is Captain of Ihu Nui, the leading world-class Blue Marlin sport fishing charter vessel based out of Kona. He is also an appointed member of the Western Pacific Regional Fishery Management Council, one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976 (now called the Magnuson-Stevens Fishery Conservation and Management Act) to prevent overfishing, minimize bycatch, and protect fish stocks and habitats. For decades, McGrew has been an active enabler of citizen science by using his sport fishing trips to attach satellite tags to fish that they catch and release. He is an active participant in the International Game Fish Association (IGFA) Great Marlin Race, a partnership between IGFA and Stanford University (Barbara Block) that pairs recreational anglers with cutting-edge science to learn more about the basic biology of marlin and how they utilize the open ocean habitat. The goal of the program is to deploy 50 satellite-linked tags on marlin at billfish tournaments around the world each year to increase understanding of distribution, population structure, and biology of the marlin and engage anglers and the general public in the research process. The program can then provide this information to resource managers and policy makers responsible for long-term conservation.



Tagging and releasing in the Great Marlin Race. Photo Credit: Capt. McGrew Rice, Kailua-Kona

Tagging Priorities: Western Pacific Regional Fishery Management Council

Eric Kingma, International Fisheries Enforcement and NEPA Coordinator
Western Pacific Regional Fishery Management Council (WPRFMC)

The congressionally funded Regional Fishery Management Councils in the U.S. are comprised of eight councils that provide primary stakeholders with a substantial role in managing fisheries and resources in their respective areas. The councils prepare Fishery Management Plans and associated federal regulations (e.g., annual catch limits) and create regulations that are implemented by NMFS and enforced by the U.S. Coast Guard and NOAA/Office of Law Enforcement. They are also required to develop five-year research priorities for their regions. The WPRFMC is responsible for a large, regulated commercial fishing area of the U.S. EEZ in the Western Pacific Region with the major fisheries including: Hawai'i longline deep-set (bigeye tuna) and shallow-set (swordfish), American Samoa longline (South Pacific albacore) and Main Hawaiian Islands bottom fish (Deep 7 and uku). Commercial fisheries landings in Honolulu are in the top ten of the U.S. Tagging priorities include pelagic fisheries (7), bottomfish (3), crustaceans (1), seabirds (1), marine mammals (2), sea turtles (3).

Tagging Topics of Interest

David Itano, Independent Fisheries Consultant
Provided written statement

Topics of interest include issues relating to recreational/non-commercial fisheries of the U.S. Pacific Islands Region (American Samoa, Commonwealth of the Northern Marianas Islands, Guam, Hawai'i, and U.S. remote insular areas). David Itano's experience includes duties related to the collection, collation, and analysis of data pertaining to the stock assessment and management of tuna and billfish resources of the western and central Pacific.

The main topic of interest is the behavior and connectivity of pelagic fisheries species, specifically:

- Bigeye tuna range and identification of spawning grounds
- Movements of striped marlin in Hawai'i/central Pacific
- Movements of opah (moonfish)

Future goals embrace the development of physiology tags (to detect spawning) as well as acoustic/satellite hybrid tags.

RESEARCH SECTOR PERSPECTIVES

An Argos Satellite Data Collection and Location System Update

Melinda Holland, CEO
Wildlife Computers, Inc., Redmond, Washington

Since 1984, Wildlife Computers has grown from a core group designing, manufacturing, selling, and supporting custom marine tags to the leading provider of advanced satellite-based wildlife telemetry solutions to the scientific community. Wildlife computer tags transmit their data to shore using the Argos Satellite Data Collection and Location System. Melinda Holland is a strong supporter and a member of the Argos Alliance, a U.S. lobby group promoting recognition of the Argos system, as well as continuity of its operation, particularly on NOAA satellites. Plans are in place for Argos to fly on nano-satellites in the next 4–5 years. In the meantime the U.S. commitment is to maintain the Argos systems on the existing, though aging, NOAA weather satellites, plus provide another on a commercial satellite. Everyone was encouraged to spread the word on how important Argos is to global marine animal telemetry.

Reproductive Movement and Fisheries Vulnerability of Brown-Marbled Grouper, Epinephelus Fuscoguttatus

Kevin Rhodes, Coastal Fisheries Coordinator, MarAlliance, Pohnpei, Micronesia

Kevin Rhodes presented the results of a comprehensive tagging study in April 2009 with colleagues from Curtin University, the Conservation Society of Pohnpei, the University of the U.S. Virgin Islands, and the University of Hawai'i at Hilo in the waters surrounding Pohnpei. Using conventional and acoustic tagging methods, they examined sex-specific patterns of reproductive movement, residency, and seasonality relative to a spawning aggregation site for brown marbled grouper. They aimed to estimate catchment areas with the goal of developing informed management protocols to protect reproductive individuals. A total of 74 fish were tagged, 17 of which were with acoustic tags. The results showed that management can protect reproductive adults with a combination of spatial and temporal measures that include establishing marine-protected areas that encompass the spawning aggregation areas and portions of the corridors, plus implementing seasonal bans on catch and sales covering all possible reproductive periods. Recent research has included similar work with grey reef sharks and manta rays.

Animal Telemetry in the Marianas Islands

Michael Orr, Assistant Professor,
College of Natural and Applied Sciences, University of Guam

Michael Orr presented the work he had previously done with acoustic tagging and tracking of salmon in the inland sea region of Nova Scotia, which investigated the question: "Do salmon complete their life cycle within the Bras d'Or Lakes?" He then gave a brief overview of how he will apply those techniques to pollution/fisheries and MPA efficacy needs in his new position at the University of Guam.

Regional Priorities for Ocean Telemetry: Guahan, USA

Jason Biggs, University of Guam Marine Laboratory/
Scientific Advisor to the Governor of Guam for Oceans

Jason Biggs quoted Guam's Governor, Eddie Baza Calvo: "...To regain our place in history as a hazard resilient island community with plenty of seafood and healthy coral reefs to sustain us, we need to play a more active, rather than adaptive, role in managing our local resources" and emphasized that from the Guam perspective, "the time for telemetry is now." National and local policy continue to emphasize research and perpetuation of natural marine resources. National monuments and CMSP both need telemetry data to achieve effective management and answer the Micronesia Challenge. For Guam, fisheries are an indigenous resource, and they "want to be able to fish forever."

Included in the challenges they face are the management conflicts among the U.S. military, marine animal habitat use, and resource partitioning. This is especially true for turtles, cetaceans, and pelagic fisheries. Telemetry in space and time is slowly being implemented in Guam primarily with "low-tech tags and techniques."

Sea Turtle Tagging in the Pacific Islands Region

T. Todd Jones, Leader
Marine Turtle Biology & Assessment Program,
NOAA Pacific Islands Fisheries Science Center

The NMFS Marine Turtle Biology and Assessment Program conducts research throughout the central and western Pacific Ocean to support the conservation and management of threatened and endangered marine turtle populations. The program works to understand the distribution, abundance, trends, movements, habitat use, and population dynamics of numerous populations of turtles from five species: green, hawksbill, leatherback, loggerhead and olive ridley. The overlap of turtles/habitats with fisheries/threats is also of concern: pelagic longline and near-shore recreational fisheries, residency patterns and durations, plus proximity to discrete or long-term threats. Studies have also been done to evaluate the drag from the satellite tags on turtle behavior. Multiple distinct populations per species are studied over 1.6 million square nautical miles with a mix of various national/international jurisdictions and stakeholders. Currently, there are ongoing tagging programs in Hawai'i, the Marianas, and American Samoa. The ATN can help with storing Pacific-wide datasets and serving data to collaborators/requestors.

Acquiring In Situ Environmental Data from Tagged Fishes

Kim Holland, Researcher, Pelagic Fisheries and Shark Research Groups, Hawai'i Institute of Marine Biology, University of Hawai'i

Most of Kim Holland's research activity is in the Hawaiian archipelago but also includes international waters of the tropical Pacific. Research has been quite constant over the past 30 years (especially acoustic component), largely due to focusing on a variety of species (tuna, sharks) or questions (e.g., MPAs) with high economic or other importance. Archival and satellite tagging have assumed increasing prominence. Funding is moderately good for the foreseeable future. There are exciting new *physiology* and *oceanography* (temperature, pH, chlorophyll, oxygen, salinity profiles) tags already here or on the near horizon which could attract funding. Post-release survival of bycatch remains an important topic.

The two major research emphases at HIMB are physiological ecology and behavior of fishes—usually large predators such as tunas, sharks, and large reef predators—and conceptualization and development (in collaboration with manufacturers) of new tag types and other hardware. These include CHAT tags, Business Card tags, feeding tags, oceanography tags—e.g., temperature and oxygen profiles (salinity soon), and land-based receivers to enhance data throughput. An archipelago-wide network of Motes would be invaluable for satellite telemetry and inter-group collaboration. The future success of telemetry might depend on continued innovation in tag capabilities (physiology and oceanography tags).

New Technology Provides New Insights into Sharks

Carl Meyer, Assistant Researcher, Shark & Reef Fish Research, Hawai'i Institute of Marine Biology, University of Hawai'i

Current research focuses on the ecology and management of sharks and reef fishes with a particular interest in the movement patterns, habitat use, and trophic ecology of sharks and fishes. The research addresses a variety of issues of management concern including impacts of shark ecotourism, shark predation on critically endangered species, effectiveness of the design of Marine Protected Areas (MPAs), spawning migrations and foraging strategies of top predators, impacts of human recreational activities in MPAs, and digestive physiology and navigational abilities of sharks. They use two broad classes of electronic acoustic and satellite tags (transmitters and dataloggers) in their studies. Carl Meyer believes that most tags are good at telling where sharks are going but not so much on what they are doing in the habitat, and we need to know this. For tiger sharks, researchers are acquiring a broader understanding by using tags with new sensors including depth, temperature, speed, accelerometers, and video cameras. It is important to leverage the networks to see what devices are needed so the manufacturers are more likely to develop them.

Using Telemetry Tools to Reduce the Impact of Commercial Fisheries on Pelagic Shark Populations

Melanie Hutchinson, JIMAR Fisheries Bycatch Researcher, International Fisheries Program, Fisheries Research and Monitoring Division, NOAA/NMS Pacific Islands Fisheries Science Center & Affiliate Faculty, Hawai'i Institute of Marine Biology

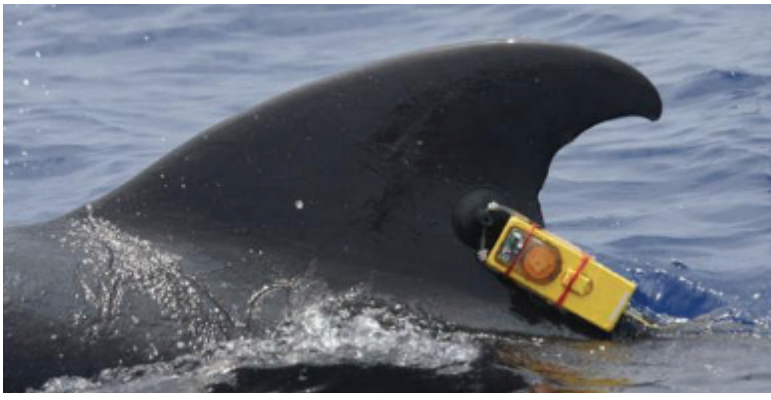
Melanie Hutchinson is interested in shark population biology and ecology and the impacts that longline fisheries in particular have on pelagic shark populations. She has been testing different strategies to mitigate shark bycatch (blue, oceanic whitetip, silky, big eye thresher) in high seas and coastal fisheries using a combination of electronic tags and ID tags to look at their interaction rates with the fishery, as well as quantifying post-release survival to determine best handling practices. She is also working to understand the environmental variables that can predict presence and absence, when they show up and why, and what they are doing there. This is part of her larger study of pelagic shark ecology, habitat use, residence times, and biologically significant areas in this region. She has also engaged with the purse seine fisheries community in a telemetry and social study to reduce mortality to oceanic whitetip sharks around anchored fishing aggregation devices (FADs).

Dtags Reveal Low Energy Expenditure and Resting Behavior of Humpback Whale Mother-Calf Pairs in Sheltered Breeding Areas

Lars Bejder, Director, Marine Mammal Research Program, Hawai'i Institute of Marine Biology, University of Hawai'i

The mission for the University of Hawai'i Marine Mammal Research Programs is to conduct applied and empirical research that facilitates stakeholders (industry, government, NGOs) in fulfilling their environmental, regulatory, and statutory tasks. Their applied and empirical research is focused on facilitation of stakeholders' needs and includes population ecology, abundance estimation and stocks assessments, behavioral ecology, health assessments (individual, population), and acoustics impact assessments. The programs have done a lot of work in Western Australia quantifying important breeding and resting grounds for humpback whales using Dtags (Digital acoustic recording tags). These non-invasive, suction-cup tags provide audio (to record ambient sounds), pitch, roll, heading, depth, and fluke strokes; they have 100 GB of memory, 500 kHz of audio range, a 500 Hz sensor, and are capable of providing 60 hours of data recording. Increasing human activity in that humpback resting habitat is creating concern, and they are currently working with the shipping industry and management on mitigation methods. They are hoping to continue using this technology with Hawai'i's humpback whale population.

Future tagging effort will include: i) Behavioral responses to navy activities (Dtags: 3D responses, measured received levels), ii) island-associated movements of spinner dolphins, iii) humpback whale long-distance migrations, body condition and energetics, iv) marine megafauna habitat use and overlap with marine plastics debris, and v) Dtag development: heart rate monitoring (with Professor Peter Madsen).



A Wildlife Computers Mk10-F satellite tag joined with a Telonics VHF transmitter and Fastloc GPS, mounted on a a short-finned pilot whale in Hawai'i. Photo Credit: Greg Schorr and Robin Baird—NMFS Permit # 731-1744 issued to Robin Baird

Odontocete Satellite Tagging around the Main Hawaiian Islands: Studies of Spatial Use, Behavior, and Overlap with Anthropogenic Activities

Robin W. Baird, Research Biologist, Cascadia Research Collective, Olympia, Washington

Since February 2000, Robin Baird has been coordinating research on cetaceans in Hawaiian waters, focusing on both odontocetes and mysticetes. These studies have covered areas around all the main Hawaiian islands, from the island of Hawai'i in the east to Kaua'i and Ni'ihau in the west, and have focused on a number of species, including false killer whales, bottlenose dolphins, short-finned pilot whales, rough-toothed dolphins, melon-headed whales, pygmy killer whales, pantropical spotted dolphins, Blainville's beaked whales, and Cuvier's beaked whales. Much of this research addresses a variety of conservation and management issues. This work has involved studies of odontocete stock structure, population assessment, and diving behavior/ecology.

Baird uses a variety of tags to conduct his research on toothed whales, including remotely-deployed Low-Impact Minimally-Percutaneous External-electronics Tag (LIMPET) tags (SPOT5/6, SPLASH10-A, SPLASH10A-F). The tags collect data to specifically examine:

- Population structure and population identity (movements in conjunction with association analyses from photo-identification)
- Coordination of individuals with overlapping tag data to inform analyses of social organization
- Spatial use in relation to social variables (e.g., social cluster)
- Spatial use in relation to environmental variables
- Behavior (from Switching State-Space Models) in relation to area and environmental variables
- Diel patterns of diving behavior
- Interactions with longline gear, using tag data in combination with fishery logbook data
- Movements and changes in diving behavior in response to exposure to mid-frequency active sonar

Making Animal Telemetry Data Accessible in the Pacific Islands: PacIOOS Data Management Capabilities and Successes

Jim Potemra, Faculty and Data Management Lead, University of Hawai'i School of Ocean and Earth Science and Technology & PacIOOS

Jim Potemra provided a broad overview of PacIOOS' data management capabilities with a focus on managing and visualizing animal telemetry data in the Pacific Islands region using the main PacIOOS data viewing and mapping platform called Voyager. Voyager includes many data layers, some analysis capabilities as well as data access for some applications. The 'Biology' overlays include trackings, sightings and distributions each with their own unique data layers, e.g., dolphins, seals, sharks, turtles, whales and coral. The tracking component includes various marine organisms that have been tagged with sensors so that their positions can be communicated via satellite (upon breaching the water's surface) and tracked over time. The Voyager visualization shows the path of an individual on the map over a certain time period and can provide insights about its habitat and behavior. The sightings component includes various marine species whose locations have been identified either through satellite tags or direct human observation, and they are visualized by the sighting locations rather than the motion of a single organism. Distributions are similar to sightings except their visualizations are aggregated locations from multiple sources. He also illustrated one of the PacIOOS website project pages that showcases the shark tagging project in collaboration with Kim Holland and Carl Meyer at HIMB.

Architecting the Future ATN Data Assembly Center (DAC)

Rob Bochenek, Information Architect, Axiom Data Science

At the time of the workshop, Axiom Data Science had recently assumed responsibility for the operational implementation of the ATN Data Assembly Center (DAC). Because at this time the DAC was still in the early phase of assembly, this presentation focused primarily on the principles of cyberinfrastructure, the components of a dataset lifecycle and how each is to be managed in the DAC, and a description of the DAC Research Workspace—a unique module that allows researchers to create their own project, upload their data, and coordinate its exchange across networks, group and programs. The module enables metadata entry with an ISO 19110/19115-2 standards compliant editor, allows one to execute server side R and Python numeric workflows (Jupyter) on uploaded data (**and** any data in the IOOS stack [State Space Models and other analyses]), and provides a data archive pathway to DataONE, NCEI, and Datacite DOI Minting. Bochenek also provided some examples/case studies of what will be possible to do within the DAC.

BREAKOUT SESSIONS

The participants were organized into two breakout groups, each of which addressed the following two topics:

Topic A: Identify stakeholder uses of animal telemetry data in the Pacific Islands region and the existing assets in place to collect them.

Topic B: Identify opportunities and challenges for animal telemetry efforts in the Pacific Islands region.

GROUP 1

Facilitator: Doug Harper

TOPIC A – Data Uses and Assets

The telemetry data that is collected and how it is used covers a wide spectrum of applications. Among the applications discussed were to assess the impact of U.S. Navy training on marine mammals, to understand animal movement in the entire Hawaiian archipelago and in particular the connectivity between the Main Hawaiian Islands and the Northwestern Hawaiian Islands, and to evaluate requirements for animal habitats and the threats to them. A special point was made that we must recognize that different needs and observing approaches, both temporal and spatial, exist and are important to consider—especially between coastal and open-ocean studies.

The group provided a broad synopsis of telemetry assets that are currently in the water. These are included in the *Workshop Conclusions*, *Objective II* of this report. Additional discussions centered on expectations and needs for future assets/telemetry projects, including satellite tagging of striped marlin, Indonesian partners tagging leatherback and green turtles in the Philippines, passive acoustic tags for hawksbill turtles in Guam, and 120-day tags on whales off Maui. The U.S. Navy also has an inventory of 10–15 satellite tags planned for deployment off Kaua'i (species yet to be determined).

TOPIC B – Opportunities and Challenges

There was a consensus that a map of existing Motes (direct receivers for satellite tags) and a wish list for additional ones would provide greater opportunities for maximizing data collection by multiple programs. The same is true for acoustic receiver assets. Deploying (Mote-like) receivers on unattended aerial platforms (e.g., drones, blimps) could provide increased opportunities for local Argos coverage. Also, the opportunity for program success and continuity depends greatly on having an identified customer for the data who is willing to be a strong and vocal advocate for its need and value. Opportunities for promoting telemetry efforts are greater when case studies of high priority/impact issues and management questions are used as examples. Exploring and identifying what has been successful in other locations where an ATN data structure exists can also be beneficial. An opportunity for how to build a focused observing program might be to convene a workshop aimed at pulling together data from NOAA's multiple turtle tracking efforts and creating a coordinated approach through the ATN for aggregating, managing, sharing, displaying, accessing, etc., all of that data. The ATN DAC provides the opportunity for researchers to manage their data in their password-protected Research Workspace account, as well as provide DOI minting and archiving for their datasets.

Along with these opportunities there are associated challenges in the Pacific Islands Region that include organizing and managing collaborations and data sharing among the multitude of jurisdictions in the region, concern about the security of isolated Mote locations, plus the relatively small coverage in the equatorial region by the polar-orbiting satellites carrying Argos. Fears of data sharing also exist on a larger scale, such as misuse and misinterpretation of the data, sensitivity of the data collected from threatened/endangered species, and the inevitable concerns regarding public perception about doing anything that could be potentially harmful to the animals.

GROUP 2

Facilitator: Shannon Lyday Ruseborn

TOPIC A – Data Uses and Assets

This group also provided a brief synopsis of telemetry assets that are currently in the water. These are included in the *Workshop Conclusions, Objective II* of this report.

The discussion of data applications and uses in this group centered on management needs as well as the scientific and technical requirements of the community. There was concern expressed about the limited amount of information that exists on protected species. We need a better understanding of how the animals are using areas, as well as improved tagging technology that will better answer the important scientific questions. This can include, for example, incorporating more oceanographic and behavioral sensors into the tags, as well as improving data analysis methods and easily integrating oceanographic data from other instruments into the movement models/tracking data. Longer battery life for accelerometer tags would also provide a better understanding of animal behavior and possibly any effect of the tags on their behavior. There was also advocacy for establishing partnerships with the glider communities with a vision of having a fleet of gliders equipped with acoustic receivers patrolling large areas of the Hawaiian archipelago listening for tagged animals.

On the management side, it was proposed that this type of workshop should be an ongoing collaborative effort that provides continual, face-to-face outreach and collaboration among the scientific, management, and technical portions of the community. This would improve the understanding, integration, and implementation of science efforts and the management questions they address. It could also help to improve the perception of marine animal tagging by showcasing the benefits and utility of our telemetry activities to the public. This would be especially valuable to the management of monuments, sanctuaries, and marine protected areas by illustrating how useful the data can be from animals that are tagged outside the protected areas but freely move in and out of the zones.

TOPIC B – Opportunities and Challenges

The group continued to embrace the idea of maintaining continuity of this type of meeting to improve collaboration among the Pacific Islands tagging community. These meetings enable participants to share experiences, expertise, and best practices, as well as to develop standards and identify what works (and does not work), etc. Ideas included creating a formal network such as a "Hawai'i Biologging Group," or possibly an electronic mailing list. Mechanisms were imagined that would facilitate direct communications with tag manufacturers, as well as allow for deep involvement by the local fishing communities to earn their trust and respect. A documented inventory of existing supplies and capabilities would also be valuable. The notion of PacIOOS providing an equipment loan program for students (e.g., acoustic receivers) was also proposed, along with a possible matching equipment donations program.

Opportunities exist also at the University of Guam (UOG). UOG has a growing and expanding research support facility and has received a $6 million EPSCoR (Established Program to Stimulate Competitive Research) grant from the National Science Foundation. The 5-year grant is focused upon studying the effects of climate change on coral reefs, specifically on a genetic basis.

On the challenges side, a major point was made that having a close relationship with the fishing industry could be potentially challenging should information from a research study lead to a reduced opportunity or even closure of a particular fishery. One of the biggest challenges is also the significant lack of research capacity and resources in the enormously large region outside the Hawaiian Islands.

There is also a perceived lack of consistency in the tagging permitting process. Some staff granting permits are not subject-matter experts, which could lead to over-regulation. Better education and awareness for regulators is needed.

Coordinating acoustic listening stations is a challenge, too. A collaborative data access and sharing network like the one established on the U.S. East Coast would be valuable. Also, while the Mote receivers can provide a significant increase in received transmissions from satellite tags, an investment-versus-benefit analysis needs to be performed before proceeding with installation efforts. Consideration must be given to how to decide priority areas, who pays for and manages the stations, whether there is a registration fee, who maintains them and defines data access rights, and whether a permit is needed to install one.

WORKSHOP PARTICIPANTS

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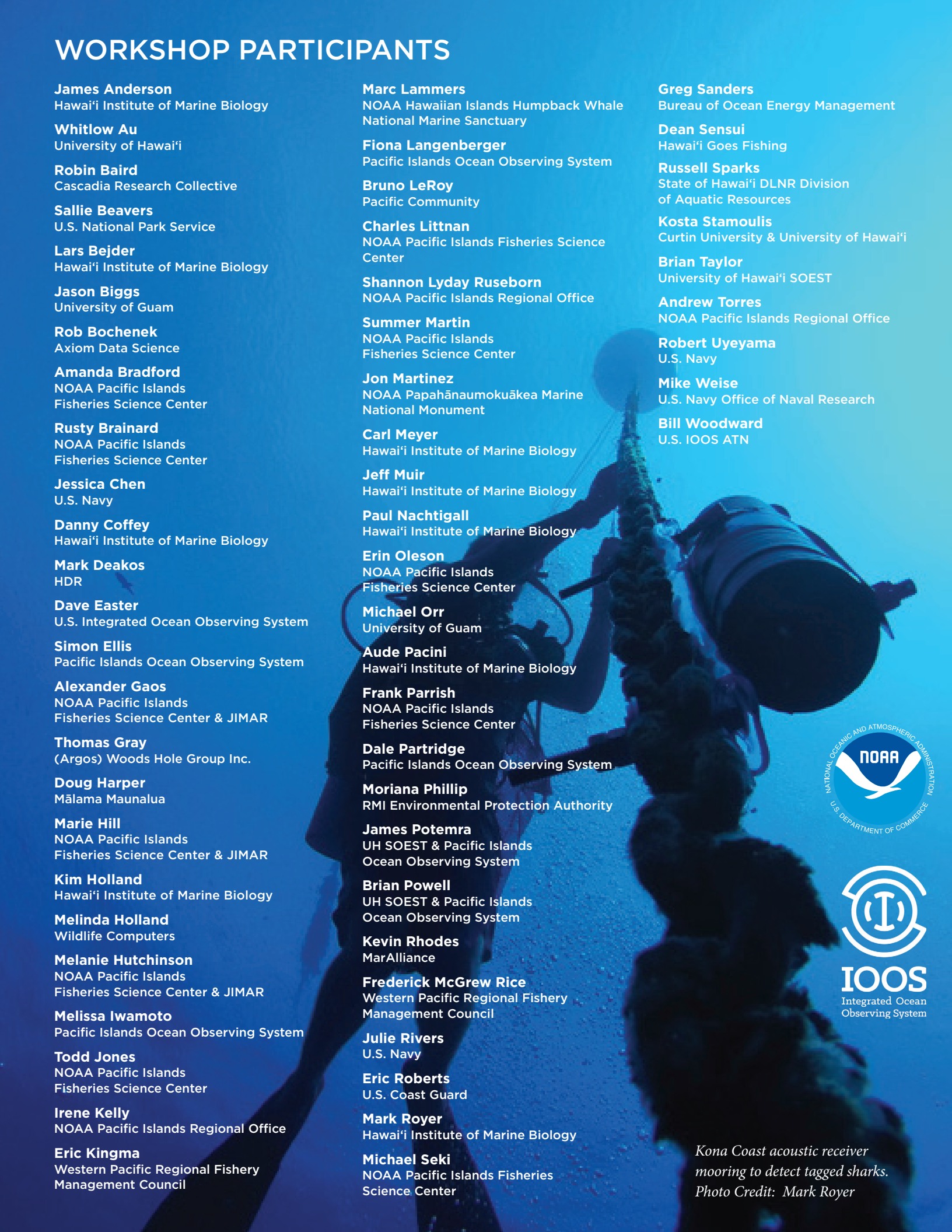

Kona Coast acoustic receiver mooring to detect tagged sharks. Photo Credit: Mark Royer