Hawaii Community Tagging Program Overview

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Background

The Hawaii Community Tagging Program (HCTP) is a working example of cooperation and collaboration between scientists and the local fishing community to solve shark bycatch and depredation problems in small scale fisheries around Hawaii. The HCTP works with fishers to obtain quantitative details during shark interactions (i.e., species-specific catch, depredation, discard methods and mortality rates) and to generate habitat use and movement data from a large scale tagging and telemetry program. Data generated from this project allows us to; understand associative behavior at fish aggregating devices (FAD), devise mitigation strategies for both high seas and local fisheries impacting pelagic shark populations, and to elucidate spatial and temporal hotspots, including areas of biological significance for shark populations, including the listed oceanic whitetip shark, in and around Hawaii. These data may also enhance Hawaii fisheries by identifying times and areas of shark residency when fishers can improve their mitigation practices or avoid certain areas and reduce costs related to depredation.

Overarching objectives of the HCTP:

1. Engage local small boat fishers in this collaborative tagging study to educate fishers on shark population status and conservation priorities, how to identify sharks to species level, and obtain species-specific data during interactions.
2. Collaboratively identify and test bycatch and depredation mitigation strategies.
3. Quantify estimates of shark-fisher interactions, depredation and mortality rates for oceanic whitetip and silky sharks (and other bycatch species) in the Hawaii small boat fisheries.
4. Elucidate FAD associative behavior of oceanic whitetip (OCS) and silky (FAL) sharks to inform bycatch mitigation strategies in the small boat fishery and extrapolate this to the FAD associated purse seine fishery.
5. Identify habitat use requirements of pelagic sharks around Hawaii, including areas of biological significance (with a focus on OCS and FAL).

6. Investigate the stock structure and population demographics of oceanic whitetip sharks around the Hawaiian Islands using photo identification.

Since the inception of the program in 2016, we have conducted eight in-person workshops and trained over 100 fishers (commercial, recreational and charter) and other resource users to tag incidentally captured sharks with electronic (acoustic & satellite) and identification (ID) tags. During the workshops fishers called for educational materials to help them accurately identify the sharks they interact with to species. We created the Offshore Shark Species Identification Guide that is freely downloadable on the www.sharktagger.org website and available as part of the HCTP tag packet training materials provided to anyone interested in participating in the program.

Tagging and Participants

Currently, there are over 130 fishers and resource users participating in the Hawaii Community Tagging Program. We have given out 160 ID tagging packets to interested participants from every Hawaiian Island and Guam. To date, HCTP fishers have deployed 251 tags (138 electronic tags and 113 ID tags) on OCS (n=100), FAL (n=52) and many other species of pelagic and reef sharks around the Hawaiian Islands during fishing interactions while generating detailed information about depredation rates by fishing method. See Table 1 below for the breakdown by tag type and species:

Table 1: All sharks tagged with electronic and ID tags since the HCTP begun in 2016.

SPECIES (FAO Codes)	ID Tag	Acoustic (V16)	MiniPAT	SPAT	Total
AML (Grey reef)	1				1
BLR (Blacktip reef)	5				5
BSH (Blue)	6		4	1	11
BTH (Bigeye thresher)	4		6	1	11
CCA (Bignose)	5		1		6
CCG (Galapagos)	7				7
CCL (Oceanic blacktip)	1	1			2
CCP (Sandbar)	23			1	24
FAL (Silky)	12	20	16	4	52
OCS (Oceanic whitetip)	26	35	33	6	100
PTH (Pelagic thresher)			2		2
RHN (Whale shark)	2				2
SMA (Shortfin mako)	2		3		5
TIG (Tiger shark)	3				3

TRB (Whitetip reef)	5				5
UNID	11	1	3		15
Grand Total	**113**	**57**	**68**	**13**	**251**

Acoustic Tag Data and FAD Association

To elucidate behavioral patterns in residency and seasonal fidelity to FADs, acoustic transmitters (Innovasea™ V16P) are externally attached to the dorsal musculature of sharks. Twenty-six Hawaii state FAD moorings, aquaculture operation sites and a known aggregation site have been instrumented with VR2-W (Innovasea™ Nova Scotia, Canada) acoustic receivers around Oahu and west Hawaii (see Map below, Figure 1). The acoustic receiver array has recently expanded to include all the Oahu FADs.

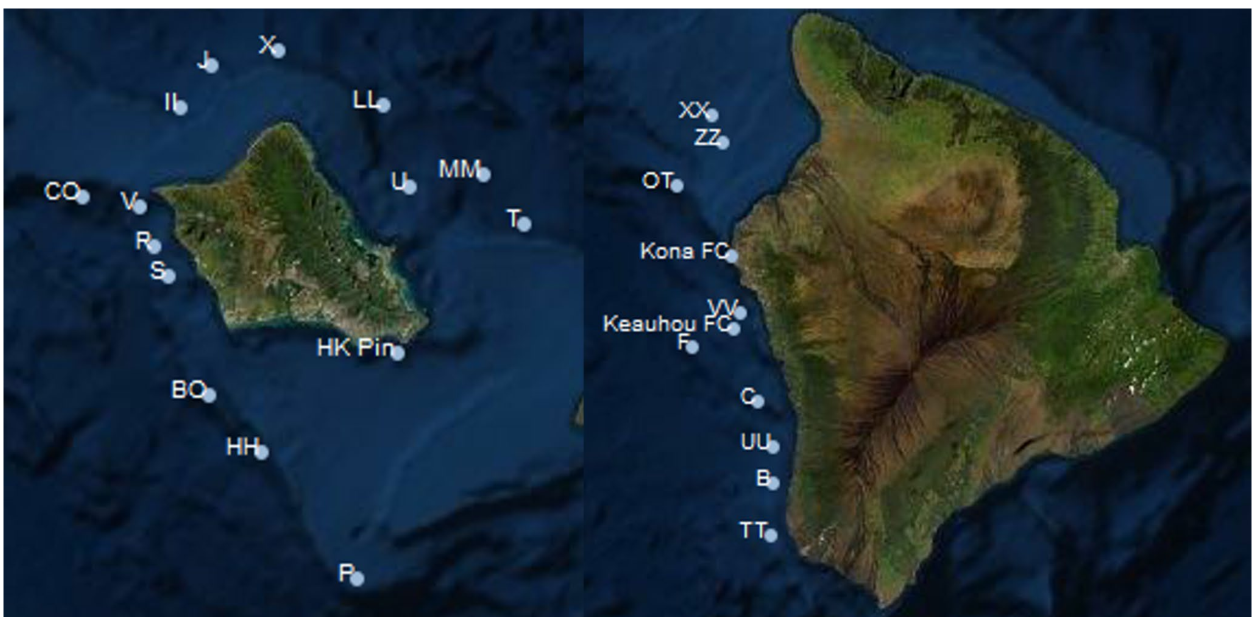

Figure 1: Map of the 26 Hawaii state FAD moorings have been instrumented with VR2Ws..

Of the 57 OCS and FAL that have been acoustically tagged, sixteen sharks have been repeatedly detected at several locations (since receivers were installed in 2017) around Hawaii and Oahu indicating intermittent residency in the Hawaiian Islands and elucidating short term and seasonal FAD association times. Figure 2 below shows all acoustic detections (colored circles, same color is the same individual) by month from OCS (n=35) and FAL (n=20) tagged by fishers participating in the HCTP between mid-2017 - 2021 (x-axis). Receiver stations (y-axis) are the Hawaii state FADs and a commercial aquaculture fish cage (Keauhou Fish Cage) where receivers are mounted. Each panel represents a three-month period corresponding to season.

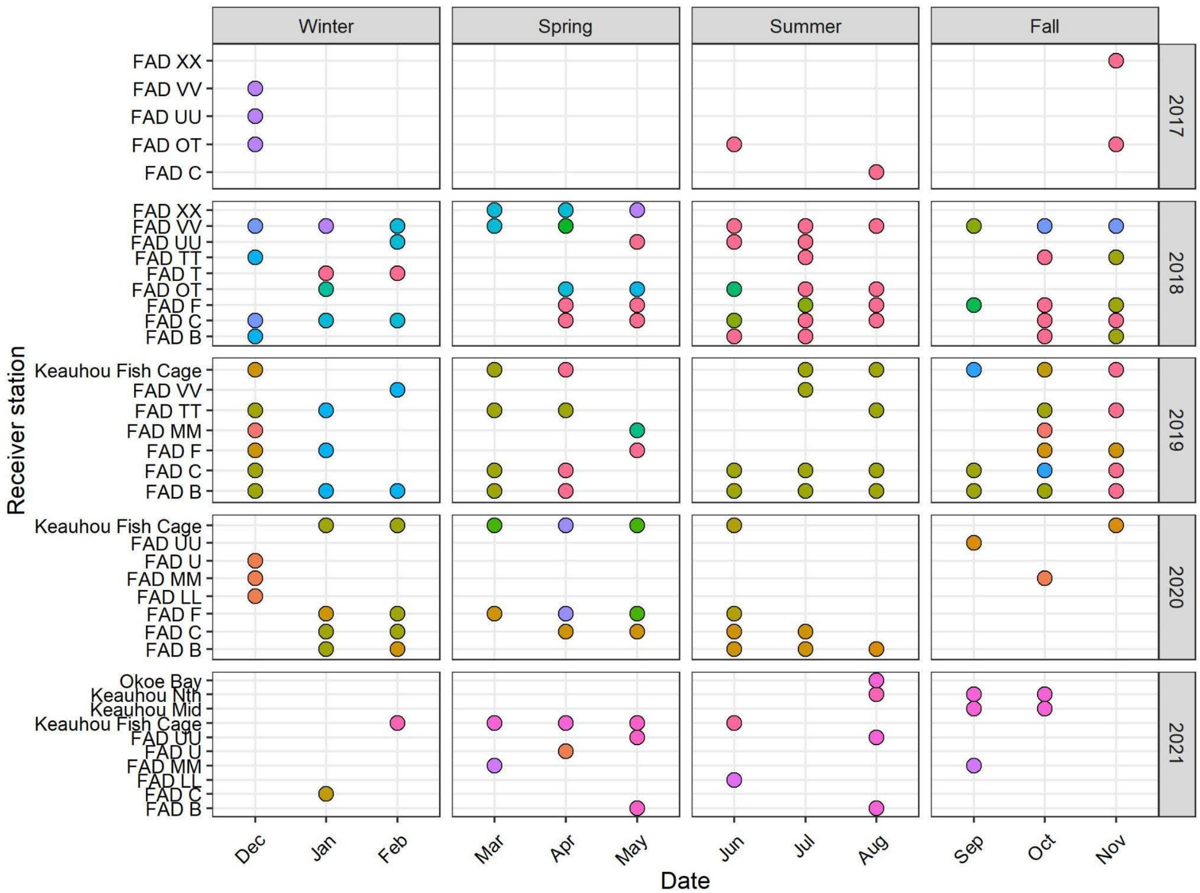

Figure 2: Acoustic detections by season (top) and month (x-axis) across the years 2017 - 2021 (secondary y-axis). Station names are shown on the y-axis. Each colored point represents one acoustically tagged individual, so the same color is the same individual.

In Figure 3 below the same data are shown for animals with repeated detections only. You can see that there are four silky sharks with repeated detections, and ten oceanic whitetips between 2017-2021. The longest acoustic detection period that we have for any of our tagged sharks comes from a 7ft male oceanic whitetip shark tagged in September 2016 (Tag #20958, Figure 3 - double red asterix). He was detected within our array for three consecutive years (and possibly longer since his tag is still live and we still need to download receivers deployed during 2020). The FAD associative behavior in this individual demonstrates seasonal, and short periodic visits to all the FADs along the Kona coast from June 2017 to November 2019, with long absences from the array in between (click here to see the animation in our newsletter). With long-term data sets like this one, we can potentially help fishers avoid shark interactions by identifying patterns in seasonal or temporal FAD association times.

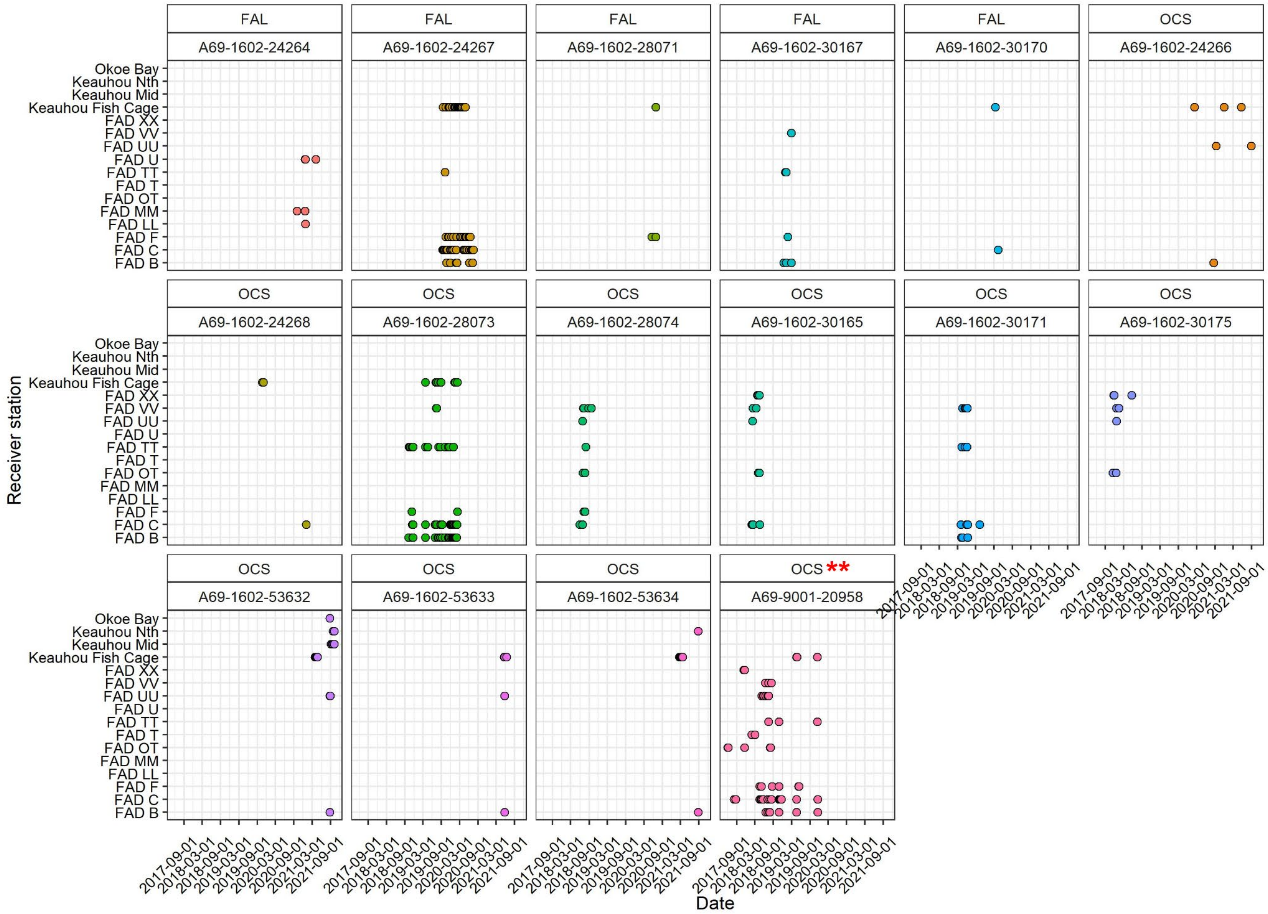

Figure 3: Repeated acoustic detections for 16 sharks (each grid represents one individual), across the years 2017 - 2021 (x-axis). Station names are shown on the y-axis.

Archival Tag Data: Habitat Use and Movement Behavior

Satellite linked, pop-off archival tags (miniPATs. Wildlife Computers, Redmond, Wa.) allow us to elucidate both vertical and horizontal movement behavior of sharks. Transmitted data from miniPATs that have reported, have also shown movements indicative of residential use of the waters surrounding the main Hawaiian Islands (mainly the island closest to their capture). This is particularly evident in FAL, while OCS demonstrate shorter periods of island association followed by large offshore directed trajectories. The map below (Figure 4) shows the tracks from eight of the tagged silky sharks with tags that transmitted data and had deployment periods longer than 10 days. We have also had several recaptures and resights of our tagged animals with a higher rate of recapture for silky sharks than oceanic whitetip sharks. One example is from a 5ft male silky shark tagged by HCTP fishers in August 2019 off Penguin Banks, Oahu was later recaptured by the same fishers in the same location 196 days later. MiniPAT data shows this animal circumnavigating Oahu and Kaua'i and making use of offshore waters (red circles below) prior to returning to its original capture location.

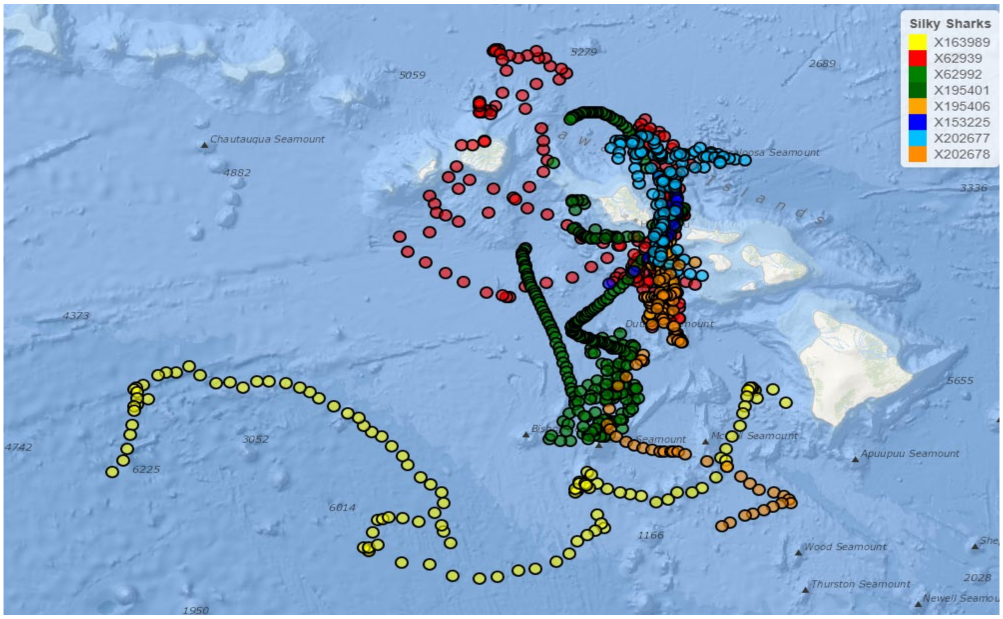

Figure 4: Movement paths of 8 silky sharks tagged with satellite tags since 2017.

The map below (Figure 5) shows the tracks from 13 of the tagged oceanic whitetip sharks with tags that transmitted data and had deployment periods longer than 10 days.

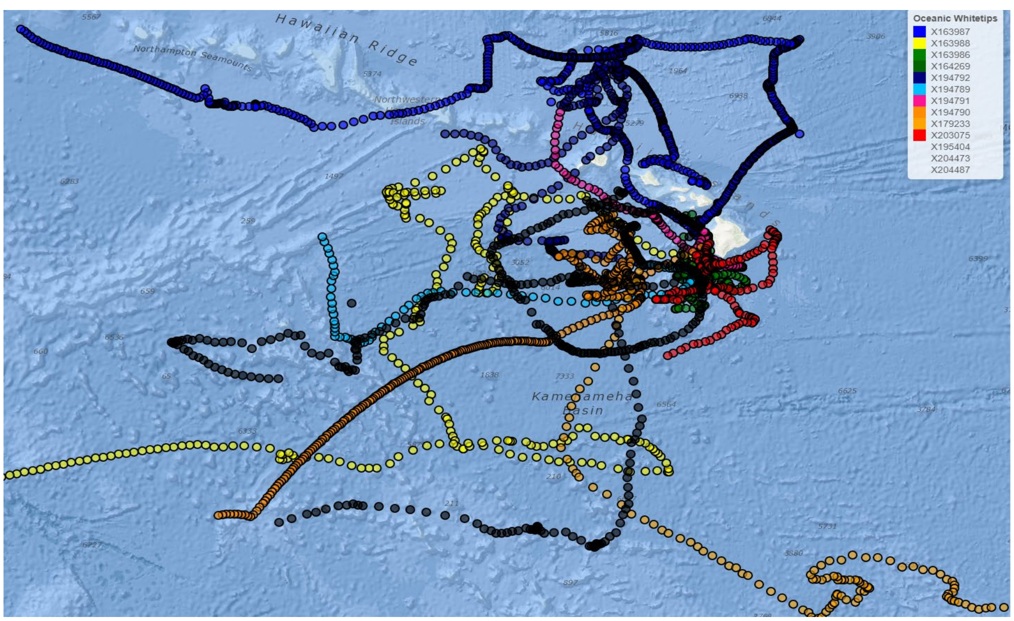

Figure 5: Movement paths of 13 oceanic whitetip sharks tagged with satellite tags since 2017.

Vertical Habitat Use for OCS and FAL

The miniPATs also reveal how tagged animals use the vertical environment. Below are examples of depth and temperature habitat preferences for an FAL (Figure 6) and an OCS (Figure 7).

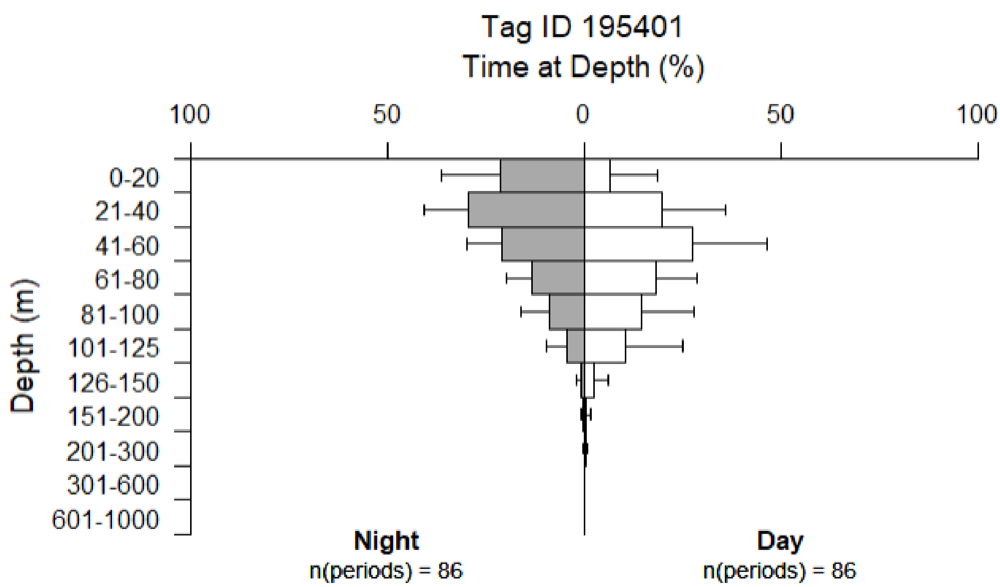

Figure 6: Time at depth histogram by nighttime and daytimes for silky shark (#195401) tagged by a HCTP fisher on April 20, 2020.

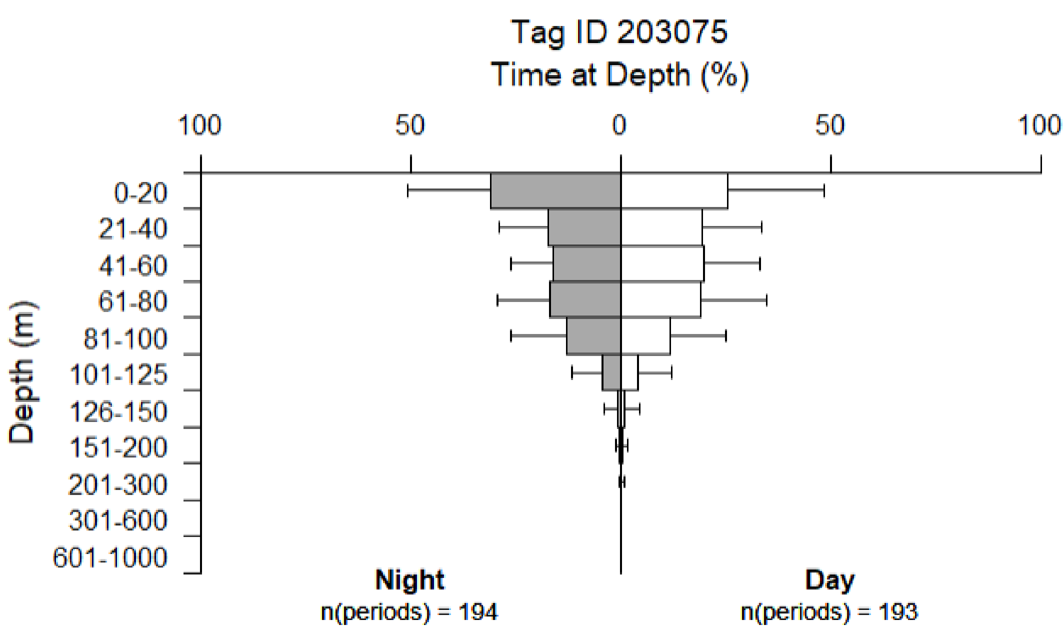

Figure 7: Time at depth histogram by nighttime and daytimes for oceanic whitetip shark (#203075) tagged by HCTP fisher on September 28, 2020.

Figure 8 below shows the same shark's (OCS #203075) depth data colored by temperature over the course of tag deployment. The black line shows the mean depth per day.

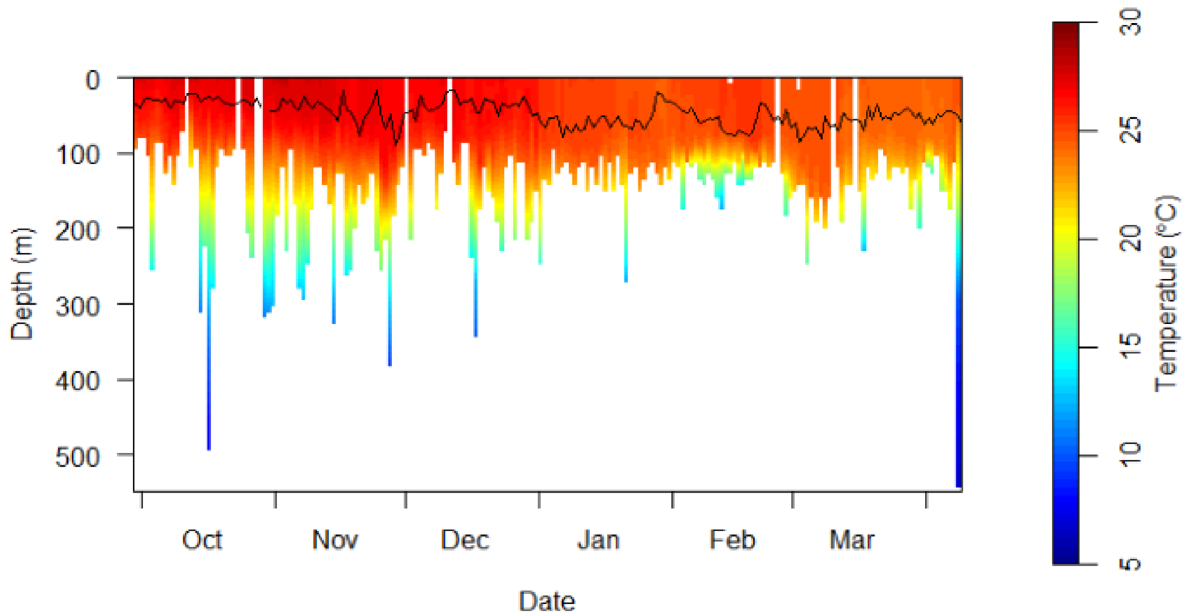

Figure 8: Temperature-depth time series data for OCS #203075

Depredation and Bycatch Mitigation

One of the major objectives of the HCTP is to quantify the impacts that depredation is having on fishers, identify species involved by fishery and location and to come up with potential deterrent strategies. Some of the common themes and feedback that we get from the fishers on the subject are discussed below.

Tagging as a mitigation strategy: During the debrief with fishers after every tagging event we ask the fisher if the shark left the area after tagging. Most fishers tell us that sharks leave the area after tagging ~85% of the time. Many use this as a deterrent strategy.

Jugging: Jugging is a practice commonly used by local fishers to deter depredating sharks from an area. Jugs (e.g. plastic bleach bottle) or other surface float are connected to a hooked animal and set free. Depending on the configuration of the jugged line some sharks may not be able to free themselves from the gear and have been found dead attached to floating jugs. Some fishers were interested in testing galvanic links to see if they were non-lethal and effective deterrents. We provided quick release (2-5 hour) galvanic links and 13 survival pop-off archival tags (SPATs) to three different fishers. Of the 13 SPATs that have been deployed, eight were deployed on four species of sharks (BSH, BTH, OCS, FAL) with quick release jug rigs. Of these eight tags, one tag did not report, one tag had a leaky depth sensor, and the others (n=6) showed the animal surviving until the tags came off between 11-60 days post release.

Deterrents: During tagging workshops and training we always facilitate a conversation about ideas and strategies that different fishers use to deter sharks from their catch. Some fishers let their fish swim while they drive away from the site of high shark activity (i.e., fish pen or FAD), some feed the sharks fish heads at the surface to distract them, some leave a shark hooked while they bring up lines, some have suggested using squirt guns with soap, along with other ideas. Many are interested in trying electrical, magnetic and chemical deterrents. To this end we recently initiated a pilot study in partnership with a local fisher and Sharkbanz® to test magnetic deterrents (Sharkbanz Fishing-Zeppelin) in the bottomfish fishery. We are currently conducting paired trials with one rod in a normal configuration (control) and another rod outfitted with the deterrent devices (Zeppelins) near every other hook. Figure 10 shows the initial results from the paired trials, conducted over three fishing trips to date. Our efforts have resulted in 106 total drops so far, 84 of which caught fish, had a depredation or both. The control rod (i.e., without deterrents) had 13% depredation and 87% no depredation, where the treatment rod (i.e., with deterrent) had only 3% depredation and 97% no depredation. We have funding for 5 more fishing days and will continue to conduct paired trials on one vessel. The pilot study is scheduled to occur during October – December of this year. **With additional funds we can purchase additional deterrents and fishing days to improve sample sizes and statistical significance.**

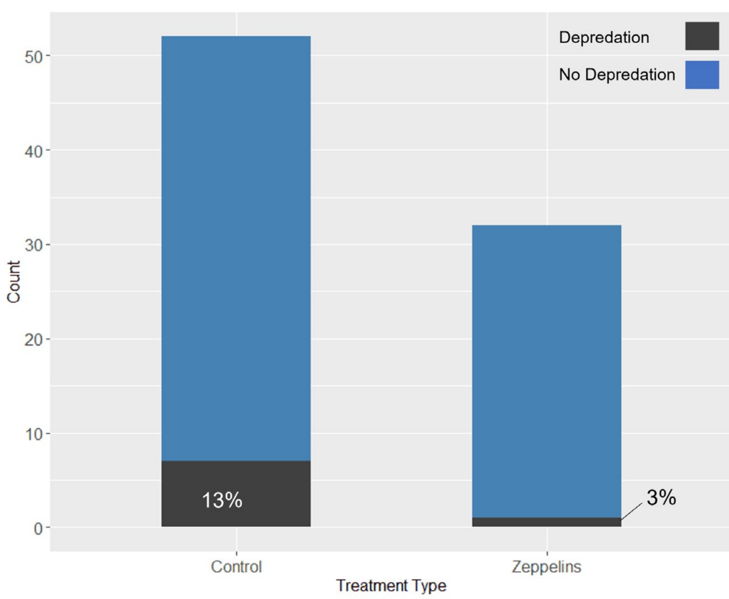

Figure 9: Results from our pilot study testing the effects of shark deterrents on bottomfish gear.

Outreach and Engagement

Outreach and education: Outreach and education are the most important aspects of this project. We continue to expand our outreach capacity via social media, fisher feedback after tagging events and when tags report, and (pre-COVID) by holding intermittent workshops and chartering tagging trips to train fishers on tagging techniques and project objectives. We have found that our outreach and education efforts in local communities about the unique biology, movements, life history characteristics and habitat requirements of OCS, FAL and other pelagic sharks, has been extremely effective in changing fisher attitudes and behaviors about sharks (click here for a link to our fisher interviews).

Engagement: Project scientists continuously engage with the fishing industry; vessel owners, captains, crew, both the State and Federal management agencies and other stakeholders. In addition to direct lines of communication we engage with the local fishing community through regular emails, quarterly e-newsletters, weekly social media updates on our 'SharkTagger' Facebook, Instagram, Twitter profiles, our website and by attending and participating in fishing tournaments. Through these methods we communicate recent results of successful shark tagging events, shark movement patterns, and other up to date research activities we are undertaking. The coconut wireless is still an effective means of disseminating information in Hawaii and has been the quickest way for us to distribute information and engage new fishers in the program thus far. In addition, the project's social component relied heavily on community engagement to synthesize local knowledge and perspectives, aiding the development of outreach strategies and identification of the best fishing/handling practices most likely to be adopted by local fishers. The outcomes of the social engagement study were the basis of a Master's thesis and a recent scientific publication by Mia Iwane.

Partnerships: We have partnered with other agencies including the State of Hawaii, Division of Aquatic Resources, Protected Species Program to assist them in creating their Brown Shark Identification Guide. We are also working with the Hawaii Uncharted Research Collective (HURC) to generate a photo identification library for oceanic whitetip sharks observed around Hawaii. We work with two aquaculture operations raising Kampachi around the Big Island (Forever Oceans and Blue Ocean Mariculture) to monitor tagged shark activity around the fish pens. The shark residency and behavior data around these pens is currently undergoing analysis for publication in partnership with the fish pen operators. The Nature Conservancy and University of Hawaii at Hilo and HIMB along with the State of Hawaii FAD program all work with us to maintain and service the acoustic monitoring array. More recently we have partnered with PacIOOS, Ocean Tracking Network and Animal Telemetry Network to establish a centralized data repository for all acoustic data users in the Pacific Island Region. The Pacific Island Region Acoustic Telemetry (PIRAT) node will greatly enhance data collections for all acoustic telemetry users. A node manager position has been created and successfully recruited so the PIRAT node should be operational in the Spring of 2022.

OCS Photo Identification

The OCS photo identification initiative began in 2018. Since then, we have accumulated over 1000 images from 35 photographers of oceanic whitetip interactions from water users around the Big Island and Oahu. Using dorsal fin markings, coloration, scarring and visible fishing gear (i.e., hooks and lines) from images shared with us by the community, we can establish information on the population structure and demographics around Hawai'i. We also glean important information on inter and intra species interactions including times of mating to parturition and about fishery interactions from trailing gear and other scarring patterns. The image data complements our tagging studies to determine whether there is a resident population of OCS around the Hawaiian Islands, i.e., through re-sightings of the same individual. Over the years the photo ID program has also formed the basis of several student extramural and research credits from the University of Hawai'i at Hilo, Manoa and Hawaii Pacific University. Some of these photos in our growing library date back to 2008, and we have identified 160 unique individuals with several resightings.

Future Directions and Next Steps

This project is ongoing and requires additional time to monitor the arrival and departure times of sharks at the FADs since our acoustic tags have a battery life of 3-5 years. We hope to improve our acoustic dataset with additional tags, extended receiver coverage (to supplement losses that occurred with the 2020 FAD deployments) and longer time series to elucidate FAD association behavior. We will also integrate all the tag and fishing interaction with environmental data to create species distribution models for oceanic whitetip sharks. The models will then be integrated into climate change scenarios to understand how future projections will influence habitat availability and fisheries capture vulnerability for an ESA listed species. Finally, all of the data combined will give us a better understanding of the drivers of interactions and potential mitigation strategies so that we can help fishers avoid sharks and reduce harm to a threatened species.