WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

Oceanic Whitetip Shark Working Group Findings Report

March, 2021

Viable Options to Address MSA 304(i) Requirements

Working Group Overview and MSA 304(i) Obligations

The Council at the 182nd Meeting in June 2020 established a working group to develop a roadmap for generating analyses and measures for oceanic whitetip sharks regarding requirements to address the obligations under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 304(i). The working group was tasked to develop draft recommendations to the Pelagic Plan Team.

The Western and Central Pacific (WCPO) oceanic whitetip shark (OCS) stock was assessed under the Western and Central Pacific Fisheries Commission (WCPFC) in 2019. The WCPFC 15th Science Committee determined that the stock was overfished and experiencing overfishing. On May 4, 2020, the Council was notified by NMFS of the overfished and overfishing status based on best scientific information available and of its obligations to take action within one year of that notice, pursuant to the MSA.

The purpose of this document is to propose options for consideration by the Pelagic Plan Team and options for consideration by the Council to develop recommendations on: 1) Domestic regulatory actions to address the relative impact of fishing vessels of the United States on the WCPO OCS to satisfy requirements under MSA Section 304(i) and any non-regulatory domestic measures; 2) International recommendations to the Department of State or Congress; or actions that will lead to ending overfishing and rebuild the WCPO OCS stock, taking into account the relative impact of vessels of other nations and vessels of the United States on the stock per MSA Section 304(i)(2)(B). The OCS WG may continue to investigate further management and mitigation measures not presented in this document, noting this findings report was in response to a one-year statutory requirement under MSA 304(i).

The OCS WG comprised of the following members:

- PIFSC: T. Todd Jones, Keith Bigelow (Chair), Rob Ahrens, Felipe Carvalho, Donald Kobayashi, Melanie Hutchinson
- PIRO: David O’Brien, Joshua Lee, Brett Schumacher, Colby Brady, Valerie Post, Chelsey Young
- State of Hawaii: Ryan Jenkinson

- Non-Governmental Experts: Clay Tam, Eric Kingma, John Myking, Sean Martin, Joel Rice
- Council Staff: Mark Fitchett, Asuka Ishizaki

<u>Relative Impact of US Fisheries on WCPO Oceanic Whitetip Shark Stock</u>

The WCPFC 14th Science Committee published estimates of bycatch of oceanic whitetip sharks in the WCPO by fishery. Since the WCPFC enacted CM-2011-04 to prohibit retention of oceanic whitetip sharks in 2013, preliminary estimates of average catch of this species from 2013 through 2017 are 566 individuals per year in purse-seine fisheries (Peatman et al. 2018a), 16,920 individuals in shallow set fisheries, and 36,020 individuals in deep-set fisheries (Peatman et al. 2018b). For fisheries under Council jurisdiction, estimated average annual catch over this period in the American Samoa longline fishery was 617 individuals, or 1.7 percent of deep-set catch in the WCPO. In the Hawaii deep-set longline fishery, catch was 1,725 individuals, or 4.8 percent of the deep-set catch in the WCPO. In the Hawaii shallow-set longline fishery, catch was 26 individuals, or 0.15 percent of shallow-set catch in the WCPO (WPFMC 2019). These figures for the Hawaii-based sectors likely overrepresent the impact of those fisheries on the WCPO stock, since estimates of OCS from US fisheries out of Hawaii include total annual estimates in the eastern Pacific (EPO) delineated by 150W along with those estimates within the WCPO. However, most fishing effort (84%-93%) by the Hawaii-based longline fleet is within the WCPO, or WCPFC Convention Area.

With the caveat that accurate catch statistics for OCS are unavailable or unreliable in many countries due to historical non-reporting of OCS (and other sharks), the impact of a fishery can be approximated by examining estimates of the fisheries catch to estimates of the total catch. The relative impact of the US longline (LL) fisheries, including the American Samoa LL fishery, the Hawaii based deep-set LL (HW DS LL) fishery and shallow-set fishery (herein the US LL fisheries) vary depending on the total catch assumed, and the most recent assessment used six catch time series to characterize the uncertainty in the catch estimation for the WCPO. The estimates of the US longline fisheries total interactions with OCS are available from the PIFSC Data Reports (McCracken 2018, 2019, 2019b), and total approximately 2,400 individuals with significant interannual variability. {insert text on why these are biased upwards} These values are based on the total US LL catches, which would be subject to a total mortality rate of 42.23%. The total estimate of the mortalities due to US LL fisheries is therefore 1,014 (= 2,400 * 0.4223), of which 721 is estimated as due to the HW DS LL fishery. For comparison, two estimates of total catch for 2016 in the WCPO longline fleet are 34,000 and 80,000 individuals for the median and high estimates associated with a discard and post release mortality (PRM) totaling 43.75%. These values translate to US LL fisheries having between 1% and 3% of the total catch of the WCPO OCS shark stock. Recent work (Rice et al. 2021, in prep) modeled the future impact of the US LL fishery on the stock as a whole, using projections based on the most recent assessment (Trembley Boyer et al. 2019). The 2019 assessment model was projected with the 2016 (status quo) catch, and compared to status quo projections without the estimates of the US LL catch as a whole. A separate suite of model runs without estimates of the HW DS LL catch was also run. Estimates of the biomass and spawning potential ratio (a proxy for exploitation via fishing mortality) are compared after approximately one generation time (2024) to show hypothesized impact of the US LL fleet over the near term. Omitting the US LL catches resulted in a negligible effect on the biomass in the first few years, but over time scenarios without the US LL catch lead to lower exploitation rates as fewer sharks are removed.

Domestic US Options to Satisfy MSA 304(i) requirements

A. *The OCS-Working Group (OCS-WG) endorses the Hawaii Longline Association (HLA) proposal to end the use of wire leaders in Hawaii LL fisheries and recognizes this as a potentially significant means to reduce catch of the species, reduce trailing gear, and reduce post release mortality.*

Rationale

US longline fisheries have ceased the use of shark lines and the practice of shark finning since 2001, predating the WCPFC non-retention measure. Since 2013, US longline fisheries have utilized circle hooks.

The prohibition of wire leaders is a step to reduce fishing mortality of OCS in US longline fisheries. Reductions in mortality could be partly due to the fact that sharks can more easily bite through monofilament line, with likelihood of bite-off possibly contingent on hook type, leading to early release and less trailing gear. Additionally, crews can efficiently cut through monofilament leaders and release sharks with less trailing gear. There is also scientific evidence that oceanic whitetip sharks have higher post-release mortality (2-4%) when caught and released on wire leaders as compared to caught and released on monofilament leaders (Table 1). Post-release mortality is reduced 25% on wire and 28% on monofilament leaders when trailing gear is reduced from 14 m to 0 m, after 360 days post-release (Table 1, Hutchinson et al, 2021). However, due to difficulties of cutting through wire from a vessel's rail height, efficient gear removal at the hook using mono leaders is expected to have at least a 5% greater conservation benefit to OCS as compared to releases of OCS with 1.8 meters of wire leader and weighted swivel intact and a 30% increased survivability than if individual was released with the full branchline length (Table 1, Hutchinson et al, 2021).

- *Using a Monte-Carlo simulation, Harley et al. 2015 found that replacing wire trace leaders reduced catchability, which resulted in a reduction in fishing mortality of 23.3% for the oceanic whitetip shark. Circle hooks are reported to reduce gut hooking which may increase survival; use of circle hooks had only a very small benefit (reduction- 2.9% silky, 3.3% oceanic whitetip) as improvements in survival through lip-hooking were possibly offset by increases in mortality associated with less shark being able to bite-off the line - and therefore being retained by the gear. This study did not have data specific to bite-off rates.*
- *Oceanic whitetip sharks showed lower mean mortality per unit effort (MPUE) when using nylon vs. wire (0.35 (±0.79) vs (0.71 (±1.21), respectively; n= 11) (Afonso et al. 2012)*
- *Afonso et al. (2012) found that wire leaders caught more blue shark, and all sharks combined, while noting that if bite-offs were assumed to be undetected sharks, differences in shark catchability between leader types disappear. Their study also found significantly higher CPUEs of bigeye tuna and all target species combined (n = 286) observed on nylon leaders compared to wire leaders, while the CPUEs of blue sharks and all sharks*

combined (n = 171) were higher on wire leaders. However, they found 54% of the shark catch was alive (N = 86) on wire leader. Wire leaders caught twice as many live sharks as nylon leaders, while the number of dead sharks was similar (40 and 37, respectively). Results suggest that the effect of wire leaders is mostly to increase the CPUE of live sharks, and longline gear equipped with nylon leaders and J-hooks will lead to more underestimation of shark catch and mortality rates than longline gear equipped with wire leaders or circle hooks.

- *Shark bite-off on nylon leaders is thought to be more frequent on J-hooks or tuna hooks due to their tendency of throat or gut hooking, compared to circle hooks which are more likely to result in mouth or jaw hooking (Afonso et al. 2012; Ward et al. 2008). However, bite-offs are still likely to occur with circle hooks (Afonso et al. 2012). A controlled experiment conducted on a pelagic longline vessel evaluated the influence of hook type (circle vs J-hook) and leader material (nylon vs wire) on catch and mortality rates of target and bycatch species (Afonso et al 2012). Of the 37 bite-offs included in the analysis, all but one occurred on nylon leaders, and 68% (25 cases) occurred on J-hooks, while the remaining 32% (12 cases) occurred on circle hooks.*
- *Ward et al. (2008) noted that transitioning from wire tracers to nylon-based materials for leaders would reduce catchability of billfishes and sharks considerably - specifically a 69% reduction in catchability for oceanic whitetip sharks based on experimental trials. The study did have a relatively small sample size of sets with interactions. The study found 83% of sharks observed were alive, with fewer animals released alive on wire leaders. Bite-off rates ranged up to 53.3% per longline operation (for nylon), with few bite-offs for wire, while catch for eight of the ten species of sharks tracked were significantly higher for all species combined.*
- *Santos et al. (2017) found that blue sharks have a slightly increased amount of gut-hooking with wire leader, and a slightly increased mouth or jaw hooking with mono leader. Use of monofilament leaders trended toward lower catch rates of sharks, particularly blue sharks. Circle hooks primarily embed in the corner of the jaw and J hooks are more likely to be swallowed, causing deep hooking in the throat or gut. · Larger mean sizes of sharks were caught on wire leaders. Blue, silky, and oceanic whitetip shark sharks had significantly higher relative mortality at haulback with J-style hooks than with circle hooks. Their analysis estimated that banning wire trace lead to increased bite-offs which resulted in the greatest reductions in fishing mortality of mitigation measures considered – 17.6% and 23.3% for silky shark and oceanic whitetip shark respectively.*
- *Harley and Pilling (2016) estimated that overall median mortality rate (deaths/catch) for silky shark status-quo (wire trace) was 34%, and 26% reduced with no wire trace.*
- *Gilman et al. (2016) found that mouth and jaw-hooked sharks are less likely to be able to bite through a monofilament leader (their teeth cannot reach the monofilament leader) when circle hooks are used. Wire leaders resulted in higher catch rates and possibly lower haulback survival for most shark species susceptible to capture in pelagic longline fisheries. They determined that monofilament leaders could be one solution to elasmobranch bycatch if it is determined that there are lower shark mortality rates for escapees than for those caught on wire and other durable leader materials*
- *Caneco et al. (2014) found that catch rates of oceanic whitetip sharks in Fiji longline sets were significantly higher in the presence of wire trace. Tables provided in this study did*

not indicate significant differences in catch rates of oceanic whitetip sharks with wire trace in analyses of the Hawaii fishery, but the authors did note "Catch rates of OCS and BSH were significantly higher in the presence of wire-trace."

- *Favaro and Cote (2015) investigated a variety of BRD gear, noting that two poorly studied classes of BRD gear (i.e. raised demersal longlines, and monofilament nylon leaders), represent promising directions for future research. Monofilament nylon leaders were 58% less likely to catch sharks and rays than wire leaders, but the reduction was not statistically significant owing to the large confidence interval predicted by their model. However, the effect size of the single study that tested monofilament nylon leaders is significant when calculated on its own (i.e. not as part of their meta-analysis).*

Analyses

PIFSC and PIRO staff in collaboration with the OCS-WG conducted a literature review to objectively evaluate the potential effects of the use of monofilament and steel leaders in longline fisheries. The OCS-WG compiled the following categories of data to be considered for review: 1) study, 2) geography, 3) fishery type (deep or shallow set), 4) species of interest (target species, shark and other incidental species of value), 5) hook type (circle or tuna J-hook), 6) total number on wire, 7) total number on mono and 8) statistical significance or lack thereof, and 9) shark condition at retrieval, among other categories. These results are found in Appendix 1.

B. OCS-WG has noted the critical importance of further reducing or removing extraneous trailing gear for increasing oceanic whitetip survival and the implementation of an effective line-cutting process through existing crew training and additional outreach is urgent. The OCS-WG recognizes the HLA proposal includes crew training on proper OCS handling and gear removal, with attention to innovations that further safety at sea, to promote post-release OCS survivability.

Rationale

Proposed crew training for cutting the leader closest to the hook, would further reduce post-release mortality of OCS. Monofilament leaders would facilitate the use of linecutter devices already in use in US longline fisheries.

- *Hutchinson et al. (2019) suggests that reducing the amount of trailing gear (e.g., <1 body length, or 0.5 meters) left on sharks increases post-release survivorship*
- *This can be accomplished by bringing the shark close to the vessel while still in the water, and using a line cutter to cut the line as close to the hook as possible or by using a long handled dehooker. Use of sliding linecutters could potentially result in poor handling when the animal is entangled in gear, which they often are from the soak. It is more preferable in these situations to bring the animal to the rail and use a long-handled line cutter, than a sliding apparatus, which would just leave the animal to die in gear entanglements*
- *Hutchinson et al. (2021) looked at the effects of branchline leader material and trailing gear on post-interaction survival of tagged OCS using a Bayesian hazard model. The model revealed that over a time duration of 360 days, switching from wire leader material to monofilament has a small improvement in survival rates while trailing gear*

length has a much larger impact on survivorship (see Table # below for survival probabilities over time by leader material and trailing gear length).

Analyses

- *Kaplan-Meier survival and Cox Proportional Hazards analyses were conducted to determine the effects of several parameters on post release survival rates (Hutchinson & Bigelow 2019).*
- *A Bayesian hazard survival modeling approach with additional tag data is currently underway and results will be available in the coming months. (Hutchinson et al. 2021)*

Table 1. Individual survival of oceanic whitetip sharks at five time points (in days (d)) after interaction with the HIDS fishery on two types of branchline leader material and with various lengths of trailing gear remaining on the animal after release from the fishing gear. The median shark survival is given with the 90% credible interval provided in the parentheses.

Leader material	Trailing gear (m)	1 day	30 days	60 days	180 days	360 days
Wire	0	1 (1–1)	0.98 (0.95–0.99)	0.96 (0.9–0.99)	0.89 (0.72–0.96)	0.79 (0.52–0.93)
Wire	1.8	1 (1–1)	0.98 (0.94–0.99)	0.95 (0.89–0.99)	0.87 (0.7–0.96)	0.76 (0.49–0.92)
Wire	3	1 (1–1)	0.97 (0.94–0.99)	0.95 (0.88–0.98)	0.86 (0.69–0.95)	0.74 (0.47–0.91)
Wire	5.15	1 (1–1)	0.97 (0.93–0.99)	0.94 (0.87–0.98)	0.84 (0.65–0.94)	0.7 (0.42–0.89)
Wire	10	1 (1–1)	0.96 (0.9–0.99)	0.92 (0.81–0.97)	0.78 (0.52–0.92)	0.6 (0.27–0.85)
Wire	14	1 (0.99–1)	0.94 (0.84–0.98)	0.89 (0.71–0.97)	0.71 (0.36–0.91)	0.51 (0.13–0.82)
Mono	0	1 (1–1)	0.98 (0.94–0.99)	0.97 (0.89–0.99)	0.9 (0.7–0.97)	0.81 (0.48–0.95)
Mono	1.8	1 (1–1)	0.98 (0.94–0.99)	0.96 (0.88–0.99)	0.89 (0.67–0.97)	0.79 (0.45–0.94)
Mono	3	1 (1–1)	0.98 (0.93–0.99)	0.96 (0.87–0.99)	0.88 (0.65–0.96)	0.77 (0.42–0.93)
Mono	5.15	1 (1–1)	0.97 (0.92–0.99)	0.95 (0.84–0.99)	0.86 (0.6–0.96)	0.74 (0.36–0.92)
Mono	10	1 (1–1)	0.96 (0.88–0.99)	0.93 (0.77–0.98)	0.8 (0.45–0.95)	0.64 (0.2–0.9)
Mono	14	1 (0.99–1)	0.95 (0.81–0.99)	0.91 (0.66–0.98)	0.74 (0.29–0.94)	0.56 (0.082–0.88)

International Options to Satisfy MSA 304(i) requirements

C. ***The OCS-WG noted the need for increased observer coverage and/or electronic monitoring (EM) in areas with high vulnerability of OCS capture. OCS-WG members noted that increased fishery monitoring is a critical point, and there is a reasonable argument to increase coverage to at least 10% in equatorial waters (10°S northward to 10°N). Furthermore, EM technology could potentially be a more cost effective monitoring tool for fisheries with insufficient resources to develop or expand human observer monitoring infrastructures.***

Rationale

Well-monitored fisheries will provide indicators from interaction rates and will track population trajectories and health of rare species populations, because knowledge on fishery-dependent removals through time from catch reporting alone (usually only reporting landings or retentions) will not be sufficient. This recommendation focuses specifically on equatorial waters for two reasons: 1) it is the core habitat of OCS, and 2) the majority of international longline fishing effort is deployed in these areas.

- *Peatman and Nicol (2020) displayed that the proportion of longline effort with observers was generally lower in WCPO waters from 10°S to 10°N as compared to to the northeast sectors of WCPFC Convention Area where the US fleet operates.*
- *Augmenting monitoring requirements with electronic monitoring (EM) can reduce cost prohibiting constraints on monitoring interactions with rate and protected species, such as oceanic whitetip sharks.*
- *Improving handling and at-sea operations to improve detection in EM is critical. At-sea observers still maintain higher veracity in species reporting and monitoring.*

Analyses

- *In WCPO waters from 10°S to 10°N, Peatman and Nicol (2020) indicated higher uncertainty in catch estimates of rarer, non-target species, such as sharks and rays with non-retention measures. This report also indicated higher estimates of catch of most sharks and rays in these waters.*
- *Misidentification and detection rates of rarer species needs improvement.*

D. ***OCS-WG noted trailing gear impacts analyses and noted the critical importance of reducing trailing gear in international fleets to increase survivability. The OSC-WG finds the reduction of wire leader usage and the use of circle hooks in international longline fisheries to be important steps to reduce fishing mortality.***

Rationale

- *See rationale presented under Domestic Options* ***A*** *and* ***B****.*

Analyses

- *See analyses presented under Domestic Options **A** and **B**.*

E. The OCS-WG noted that existing handling guidelines are currently non-binding for sharks, which could progress into internationally binding measures to appreciably reduce mortality of those species.

Rationale

- *Hutchinson et al. (2019) suggests that leaving sharks in the water and cutting as much trailing gear away from the animal as possible (e.g., <1 body length, or 0.5 meters) increases post-release survivorship.*
- *The WCPFC Workshop on Joint Analysis of Shark Post-Release Mortality Tagging Results (WCPFC-SC15-2019/EB-WP-01) recommended minimizing the length of trailing gear left on released sharks as this was found to be a significant factor in determining PRM for both shortfin mako and silky sharks. This can be accomplished by bringing the shark close to the vessel while still in the water, and using a line cutter to cut the line as close to the hook as possible. The workshop also found that although the WCPFC study provided no data showing that hauling sharks on deck contributed to PRM, it did show that injured sharks are less likely to survive, and it considered that the probability of injury is higher when sharks are hauled onboard.*
- *IATTC adopted Resolution C-16-05 on the management of shark species, with handling requirements, but only relevant and binding for purse seine vessels. Handling requirements could be expanded to longline fisheries*
- *Resolution C-16-05 also banned longline fisheries targeting tuna and swordfish in the Convention Area from using shark lines.*

Analyses

- *Kaplan-Meier survival analyses and Cox Proportional Hazards were conducted to determine the effects of several parameters including handling (Gear removal versus cutting the line) on post release survival rates (Hutchinson & Bigelow 2019;WCPFC-SC15-2019/EB-WP-01). A Bayesian exponential survival modeling approach with additional tag data is currently underway and results will be available in the coming months.*

Other Measures Not Considered Under MSA 304(i)

Area and zone-based management actions were not explored because the US fishery does not operate largely in areas with highest density, largely 10S northward to 10N in the Western and Central Pacific Ocean.

Operational and gear modifications, aside from wire leader removal, were not yet considered. Analyses are pending from PIFSC, utilizing the Monte Carlo approach from Harley et al (2015), which examines a suite of longline mitigation measures, including gear modifications and operational characteristics, that could potentially reduce interactions and mortality of OCS and other species.

Updates on Research Activities Since Fall 2020 Report

Ecosystem-Based Fishery Management (EBFM) Project

The EBFM Project, categorizes the oceanographic features that predict fishery interactions with protected, by-catch, and target species through the use of a machine learning ensemble approach the Ensemble Random Forest. Using a suite of oceanographic products at a weekly temporal resolution and static physical features the EMFM projects produces the 1) spatial distribution of expected interaction over tie time period (2005-2019) of the data (Figure 1), the quarterly contours of the expected probability of interaction over the time series (Figure 2), the annual average interaction probability (Figure 3), the relative importance of features in classifying interaction (Figure 1), and the Accumulated Local Effects (ALE) of the features (Figure 4) which, for a given feature, show the relative influence of that features across its observed range of values.

ERF modeling indicates that fishery is the primary determinate of interaction with ASLL and SSLL having higher interaction rates. Interaction rate increases sharply at sea surface temperatures (SST) >25°C, peaks at low to increasing east current speeds and areas of increasing current deformation and rotation. OCS interactions have a negative seamount standardized effect size indicating seamount association. Increased interactions are also associated with increasing eddy kinetic energy, peak full moon, weak north-south currents and increasing resultant current speed. Area of the highest interaction over the time series is to the south west of the main Hawaiian Islands.

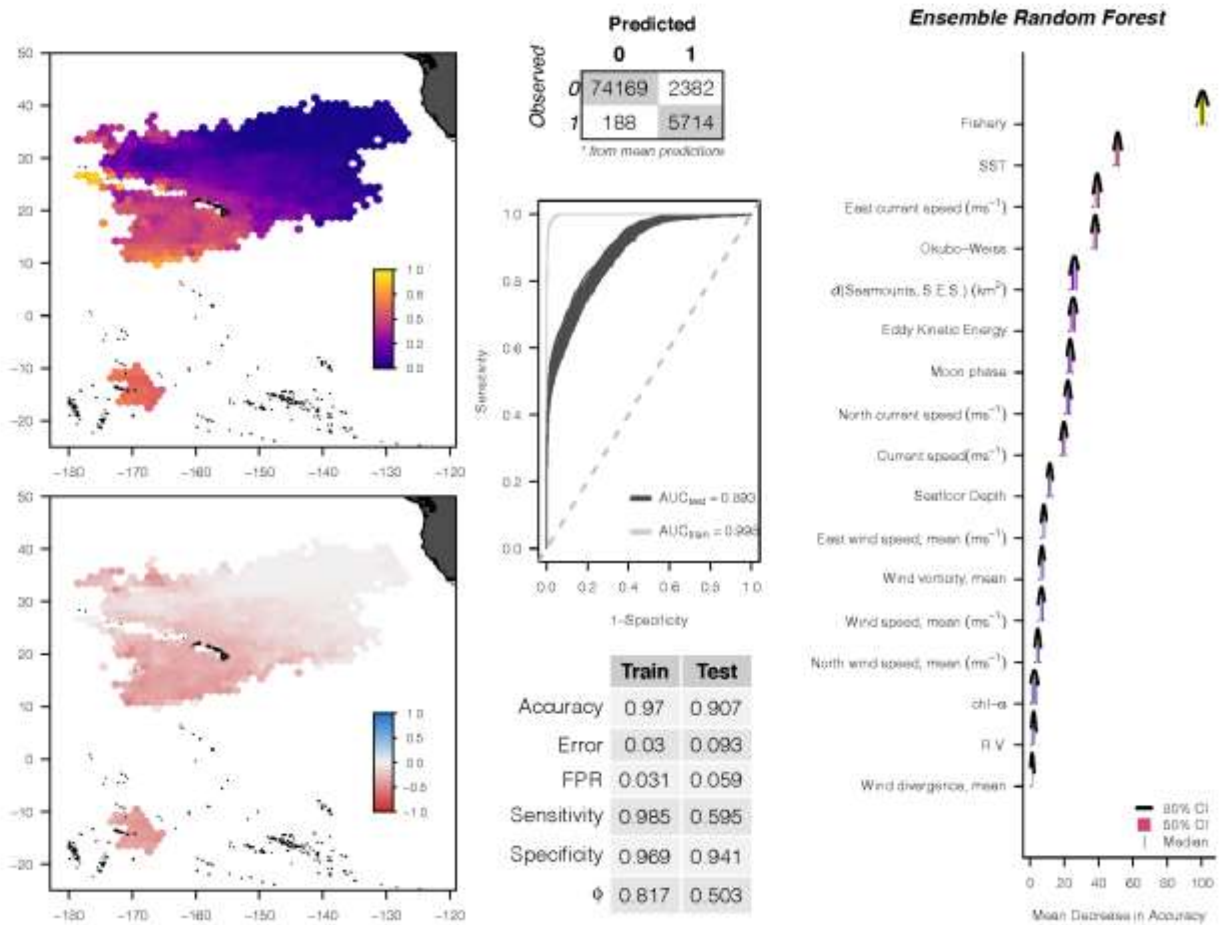

Figure 1. Summary plot for the Ensemble Random Forest output and performance metrics. Top left is the expected probability of interaction over the time series. Bottom left are the residuals. Middle top is the confusion matrix. Middle middle is the Area Under the Curve performance metric for the train and test data. Middle bottom are additional model diagnostics, Right hand side are the relative ranking of features.

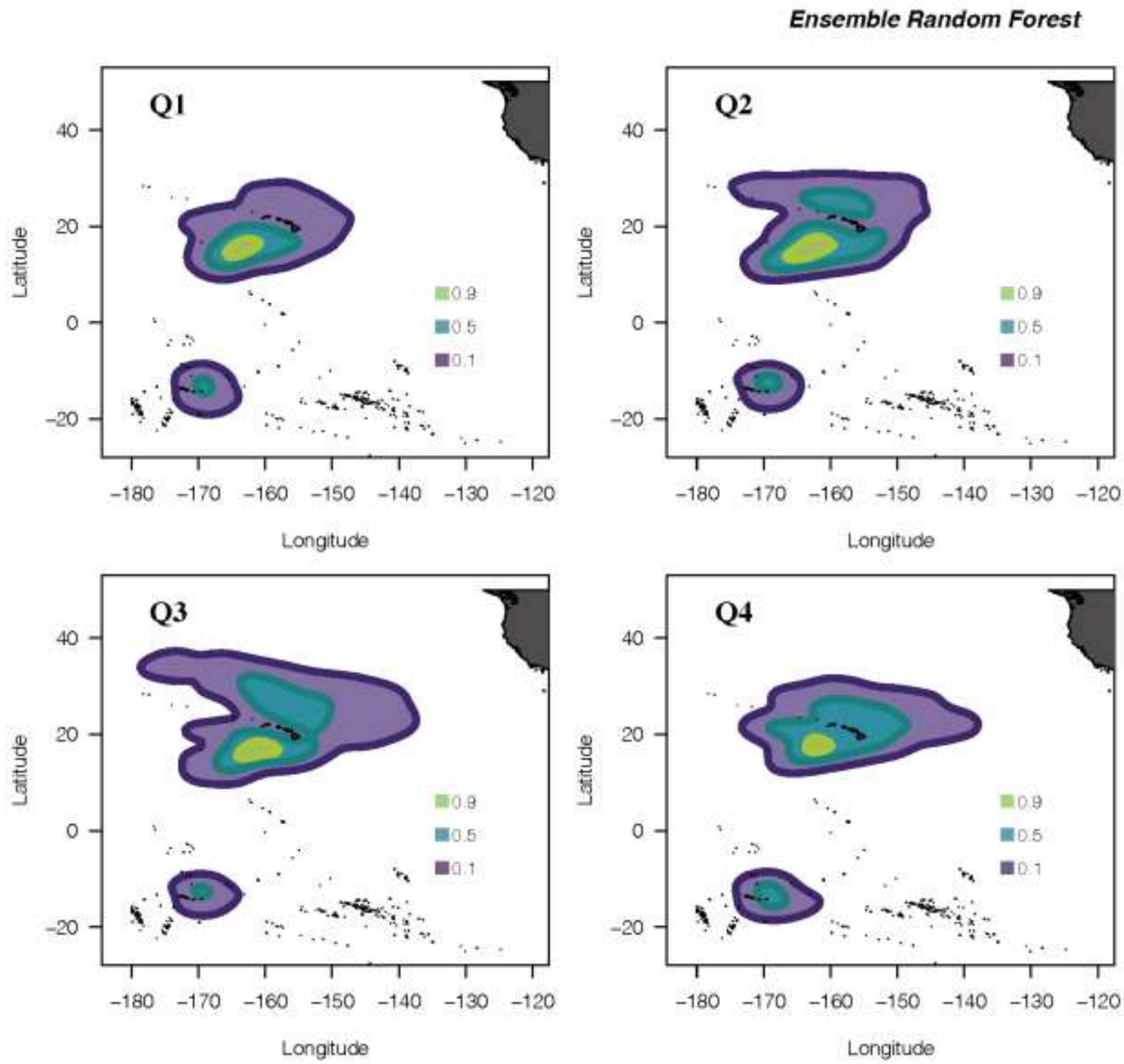

Figure 2. Quarterly contours of the probability of interaction over the 2005-2019 time series.

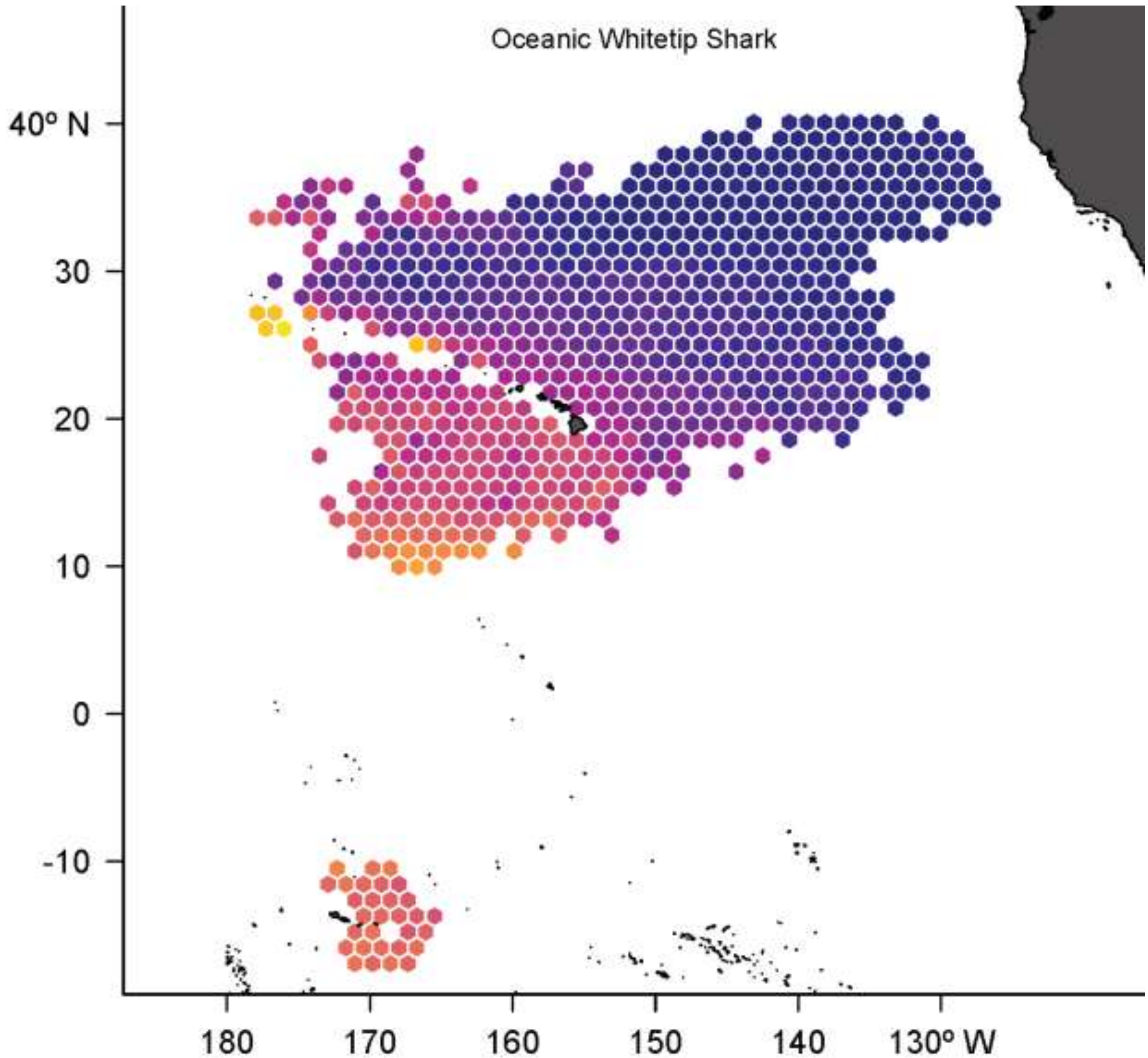

Figure 3. Average annual probability of interaction.

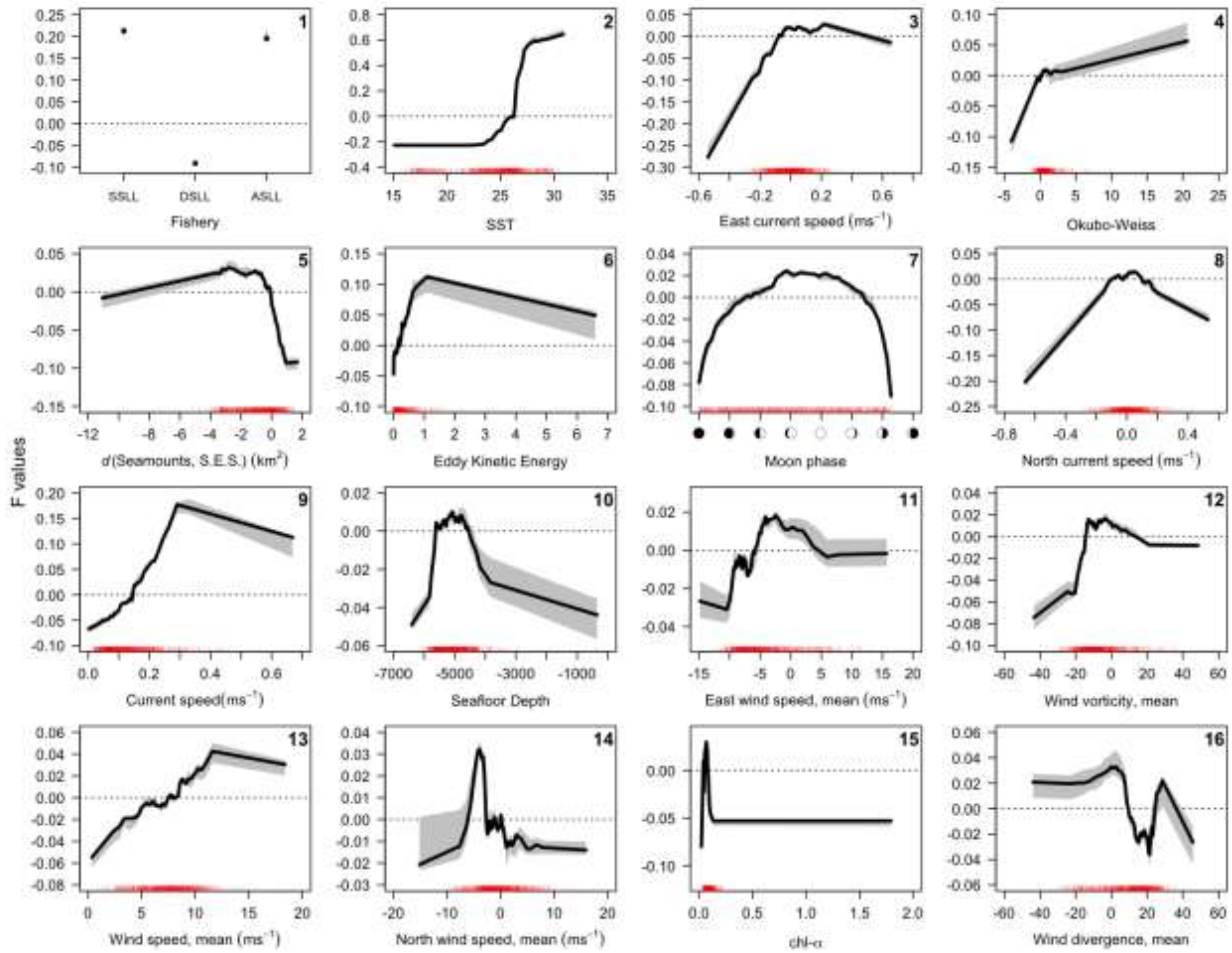

Figure 4. Accumulated local effects

Monte Carlo Analyses of Longline Management and Mitigation

PIFSC is analyzing USA and international longline observer data with covariates such as Year, Month, Region, SST, latitude, longitude, hook type (Circle, J and Tuna) and leader material (Wire and Mono). Models will consider:

1) Condition (alive or dead) upon longline retrieval,
2) Catchability effects, and
3) Catch reductions by removal of hooks near the longline float.

Parameter estimates will be used to conduct a Monte Carlo analysis similar to Harley et al. 2015 to illustrate possible measures to reduce longline impacts on oceanic whitetip shark.

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Ward, 2008. Empirical estimates of historical variations in the catchability and fishing power of pelagic longline fishing gear. Rev Fish Biol Fisheries 18:409-426.

Appendix 1 - Literature Review and Summary of Longline Gear Modification and Efficacy to Reduce OCS Interactions

Source		**Santos et al., 2017**. Effects of leader material on catches of shallow pelagic longline fisheries in the southwest Indian Ocean. Fish. Bull. 219-232 (2017).	**Gilman et al., 2016**. A cross-taxa assessment of pelagic longline by-catch mitigation measures: conflicts and mutual benefits to elasmobranchs. Fish and Fisheries, 2016. 17. 748-784.	**Afonso et al., 2012.** Shark bycatch and mortality and hook bite-offs in pelagic longlines: Interactions between hook types and leader materials. Fisheries Research 131-133 (2012) 9-14	**Afonso et al., 2011**. Fishing gear modification to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. Fisheries Research 108 (2011) 336-343.	**Ward et al., 2008.** Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers. Fisheries Research 90 (2008) 100-108.
Study Type (Field, Review, Observer Data, Meta-analysis, Other)		Field	Review, Meta-analysis	Field	Field (pelagic longline & bottom longline)	Field
Pelagic **Fishery Typ**e (Deep, Shallow, Other- non pelagic)		Shallow	Deep, Shallow	Shallow	Two gears tested: Deep, & Other- non pelagic (coastal bottom longline- data not included in this summary table)	Deep
Geographic Location		Southwest Indian Ocean	n/a, Various	Southwestern equatorial Atlantic (~ 0–4◦S latitude and 34–37◦W longitude)	Northeast Brazil (pelagic longline sets 30-35° W long., 0-5° S lat.)	Small area of the western Coral Sea outside the Great Barrier Reef
Species of Interest (*Catch Rate, 1000 hooks*)	Tuna	Wire (0.6), Mono (0.6)	n/a, Various	Bigeye = 1.88 Wire; 2.47 Mono	n/a	Wire (32), Mono (33)
	Shark	Wire (11.5), Mono (8.9)	Various (expressed as ≥ 1 record of a sign. increase to # with decrease)	Oceanic whitetip = 0.71 (Wire), 0.35 Mono; Silky = 1.06 (Wire, Mono)	Circle (25.8), J-hook (10.7)	Wire, (1), Mono, (3)
	Billfish	Wire (12.8), Mono (13.3)	n/a, Various	Swordfish = 6.59 Wire; 7.41 Mono	n/a	Wire, (4), Mono, (4)
	Other, Teleosts	Wire (5.7), Mono (4.3)	n/a, Various	Various	n/a	Wire, (19), Mono, (11)
Total Sets Observed		82 Sets	n/a, Various	17 Sets	Phase 1 (384 Sets J-hooks only). Phase 2 (224 alternating circle/J hooks), 650 hooks per set	177 Operations (assumed sets)

Source		**Santos et al., 2017**. Effects of leader material on catches of shallow pelagic longline fisheries in the southwest Indian Ocean. Fish. Bull. 219-232 (2017).	**Gilman et al., 2016**. A cross-taxa assessment of pelagic longline by-catch mitigation measures: conflicts and mutual benefits to elasmobranchs. Fish and Fisheries, 2016. 17. 748-784.	**Afonso et al., 2012.** Shark bycatch and mortality and hook bite-offs in pelagic longlines: Interactions between hook types and leader materials. Fisheries Research 131-133 (2012) 9-14	**Afonso et al., 2011**. Fishing gear modification to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. Fisheries Research 108 (2011) 336-343.	**Ward et al., 2008.** Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers. Fisheries Research 90 (2008) 100-108.
Total Hooks Observed		~82,656 (41,328 of each leader type; Wire, Mono)		17000 Hooks, 1200 hooks (experiment encompassed 1000 hooks per set)	7.800 hooks (alternating circle versus J-hook)	75,101 hooks (37,422 Wire, 37,679 Mono)
Hook Type	**Circle**	No	Investigated (circle versus J hook, see below), Various	(17/0, 10° offset)	Yes (circle, 18/0, 0° offset)	No
	Tuna, J-hook	Yes, J-hook		68% greater bite offs than Circle (10/0, 10° offset)	Yes (J-hook, 9/0, 10° offset)	Yes, tuna-hook (55 mm total length, 28mm bite, 27 mm gape, 10° offset)
Total number spp. on **wire**		~41328	Investigated (Wire versus Mono), Various	54% of the shark catch was alive (N = 86), 40 dead sharks caught.	n/a (circle versus J hook)	Sharks, 103. Tuna, 1,208.
Total number spp. on **mono**		~41328		34% of the shark catch was alive (N= 56), 97% of bite offs on Mono, 37 dead sharks caught.	n/a (circle versus J hook)	Sharks, 44. Tuna, 1,279.
Statistically significant (yes, no, meta-analysis)?		Yes; varying spp. significance. Only Blue shark bycatch CPUE significant (31% increase on wire; 95% CI 14%-52%)	Various (expressed as ≥ 1 record of a significant increase to decrease) of elasmobranch spp.: Circle vs J-hook (4:1) with haulback survival rate (3:0); Wire vs. Mono (7:3) with haulback survival rate (1:2).	Yes, J-hooks showed a significantly higher proportion (68%) of bite-offs than circle hooks. Blue shark CPUEs between leader types found significant differences only in J hook treatments. Catch rates were significantly influenced by the type of leader.	Yes. CPUE for night, blue, silky, and oceanic whitetip significantly greater with circle hooks. Haulback mortality for blue, silky, and oceanic whitetip shark sharks higher with J-style hooks than circle hooks. Significant differences on hook location/type for night, blue, silky, & oceanic whitetip (J > gut, Circle > external)	Yes (0.05)

Source		Santos et al., 2017. Effects of leader material on catches of shallow pelagic longline fisheries in the southwest Indian Ocean. Fish. Bull. 219-232 (2017).	Gilman et al., 2016. A cross-taxa assessment of pelagic longline by-catch mitigation measures: conflicts and mutual benefits to elasmobranchs. Fish and Fisheries, 2016. 17. 748-784.	Afonso et al., 2012. Shark bycatch and mortality and hook bite-offs in pelagic longlines: Interactions between hook types and leader materials. Fisheries Research 131-133 (2012) 9-14	Afonso et al., 2011. Fishing gear modification to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. Fisheries Research 108 (2011) 336-343.	Ward et al., 2008. Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers. Fisheries Research 90 (2008) 100-108.
Shark condition upon retrieval tracked?		Condition at haulback (alive or dead)	Various, elasmobranch haulback survival rate investigated (see above)	Yes (dead or alive), at-vessel mortality-per-unit effort (MPUE), as # of dead individuals caught per 1000 hooks. Blue shark emerges as the most impacted elasmobranch species when considering MPUE, followed by silky shark.	Yes, individual (alive or dead) in relation to hook type. Hook location recorded for each individual (external, internal/swallowed, entangled)	Yes, 83% of sharks alive (wire + mono)
Bite offs tracked?		Yes	No (not among meta-analysis variables tracked in review)	Yes, only bite-offs <20 from hook included, & bite-offs assumed as caught sharks (~33% of shark catch; mostly on Mono leaders (97%)). Differences between CPUE of all sharks combined on the two leader types disappear if bite-offs assumed sharks.	No, encourages tracking "bite-offs" in future studies	Yes
Terminal Gear Picture Provided?		Yes (figure, not photo)	n/a, Various	Circle and J hook pictures only, see hook type, above	Yes (figure, not photo)	Yes
Terminal Gear Description	Leader Material	2.5 mm mono leader (or treatment 1.2 mm multifilament stainless wire leader, 3 strands, 0.65 m long) with hook at terminal end.	Investigated (Wire versus Mono), Various	Mono (0.2 m length, 1.2 mm diameter); Wire multifilament, stainless steel (similar dimensions)	~3.6 m leader length	Wire (30 cm, stainless steel, six-strand wire cable, 38 g swivel 5 m from hook); Mono (no weighted swivel, 2 mm diameter, 250-300 kg strain)

Source		**Santos et al., 2017**. Effects of leader material on catches of shallow pelagic longline fisheries in the southwest Indian Ocean. Fish. Bull. 219-232 (2017).	**Gilman et al., 2016**. A cross-taxa assessment of pelagic longline by-catch mitigation measures: conflicts and mutual benefits to elasmobranchs. Fish and Fisheries, 2016. 17. 748-784.	**Afonso et al., 2012.** Shark bycatch and mortality and hook bite-offs in pelagic longlines: Interactions between hook types and leader materials. Fisheries Research 131-133 (2012) 9-14	**Afonso et al., 2011**. Fishing gear modification to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. Fisheries Research 108 (2011) 336-343.	**Ward et al., 2008.** Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers. Fisheries Research 90 (2008) 100-108.
	Dimensions (Remaining Branchline)	Total branchline length 18.6 m length, 2.5 cm snap with 4 sections (S). S1- 2.5 mm mono (11.85 m long), swivel (4.5 cm). S2- 0.7 m weighted rope (50 g), terminal loop. S3- 2.2 mm mono (5.4 m long). S4- (see above leader description).	n/a, Various	See configuration, below	~18 m branchlines from snap to leader start	16 m nylon, 2 mm diameter, 250-300 kg strain
	Configuration	Fishing gear and practices standardized (gear placement, setting time, light color, bait size, hook) standardized along the 2 trips.	n/a, Various	Mono mailine (3.5 mm diameter, ~32 m length), 1200 nylon monofilament branch lines (2.0 mm diameter and ~32 m length) equipped with an 80 g swivel, leader & hook; 8 sections and each section contained 30 floats with 5 hooks	30 hook sections between float lines	9-10 branchline between buoys, 170 m max depth, 500 hooks per set
	Deployment/ Retrieval Description	Hook # constant per set & same for each treatment; 504 hooks of each leader type, depth 2050 m, deployment ~1730 h, haulback ~0600.	n/a, Various	4 treatments with 250 branch lines each	650 hooks per set (1000 hook CPUE description for clarity); Circle, J-hook	2 h deployment, 7 h drift/soak

Source		Santos et al., 2017. Effects of leader material on catches of shallow pelagic longline fisheries in the southwest Indian Ocean. Fish. Bull. 219-232 (2017).	Gilman et al., 2016. A cross-taxa assessment of pelagic longline by-catch mitigation measures: conflicts and mutual benefits to elasmobranchs. Fish and Fisheries, 2016. 17. 748-784.	Afonso et al., 2012. Shark bycatch and mortality and hook bite-offs in pelagic longlines: Interactions between hook types and leader materials. Fisheries Research 131-133 (2012) 9-14	Afonso et al., 2011. Fishing gear modification to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. Fisheries Research 108 (2011) 336-343.	Ward et al., 2008. Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers. Fisheries Research 90 (2008) 100-108.
Confounding Variables	Bait (different, same)?	Squid only (all similar size)	n/a, Various	Squid, Illex sp. (~70 g)	skipjack (*Katsuwonus pelamis*)	Sardine and Squid (randomly deployed)
	Different hook Types?	No, J-hook only, stainless 10°	n/a, Various	One circle type, one J-hook type, see Hook Type, above	Yes (circle versus J hook)	No
	Branchline Configuration; Different leader types in Study?	Alternating sections; Wire, Mono (84 hook sections)	n/a, Various	2 Mono types, 2 Wire types; (circle + nylon; circle + wire; J-hook + nylon; J-hook + wire), branchlines randomly arranged throughout each set	Alternating (Phase 2); Circle, J-hook	Randomly deployed; Wire, Mono, for 80 of 86 longline operations
	Lightsticks	Green battery flashlight attached to S2/S3 loop	n/a	n/a (unspecified)	n/a	~9% of branchlines (2 m above hook)

Source		**Shelton Harley and Graham Piling, 2016.** Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05, WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016).	**Shelton Harley, Bruno Caneco, Carl Donovan, Laura Tremblay-Boyer and Stephen Brouwer, 2015.** Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02, Rev 2 (30 July 2015).	**B. Caneco, C. Donovan and S. Harley, 2014.** Analysis of WCPO Longline Observer Data To Determine Factors Impacting Catchability And Condition On Retrieval OF Oceanic Whitetip, Silky, Blue, and Thresher Sharks. WCPFC-SC10-2014/EB-WP-01.	**Don Bromhead, Joel Rice, and Shelton Harley. 2013.** Analysis of the potential influence of four gear factors (leader type, hook type, "shark" lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02 rev1.	**Brett Favaro and Isabelle M. Cote', 2015**. Do by-catch reduction devices in longline fisheries reduce capture of sharks and rays? A global meta-analysis. Fish and Fisheries, 2015, 16. 300-309.
Study Type (Field, Review, Observer Data, Meta-analysis, Other)		Observer & Other (effort).	Observer & Other (effort).	Observer Data	Observer Data	Meta-analysis
Pelagic **Fishery Typ**e (Deep, Shallow, Other-non pelagic)		Deep (likely predominantly; unspecified pelagic longline)	Deep (likely predominantly; unspecified pelagic longline)	Deep	Deep	Various (hook-based gear; pelagic longline, demersal, hook-and-line)
Geographic Location		Western and Central Pacific	Western and Central Pacific	Micronesia/Marshall Is. (FSM/RMI), Fiji, American Samoa (AS), Hawaii (HI)	Hawaii DSLL model results predominantly included in this table (study also provided model results for Fiji, Micronesia/Marshall Is.)	Various (field-based contributing studies, global)
Species of Interest (C*atch Rate, 1000 hooks*)	Tuna	n/a	n/a	n/a	n/a	n/a
	Shark	Variable (deaths/catch), mortality reduction per 100 hooks (90 percentile) if no wire leader used: Silky	Variable (deaths/catch), modeled mortality per 100 hooks (90 percentile) if no wire leader used: Silky	Positive and significant, Wire is key catchability variable (reduced 'bite offs'), set-level per 100 hooks (spp.	Mean predicted catch estimates, results not significant for HI DSLL model, 2005-2009 dataset (catch	Mono leaders 58% less likely to catch sharks; see total spp, below

Source		**Shelton Harley and Graham Piling, 2016.** Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05, WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016).	**Shelton Harley, Bruno Caneco, Carl Donovan, Laura Tremblay-Boyer and Stephen Brouwer, 2015.** Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02, Rev 2 (30 July 2015).	**B. Caneco, C. Donovan and S. Harley, 2014.** Analysis of WCPO Longline Observer Data To Determine Factors Impacting Catchability And Condition On Retrieval OF Oceanic Whitetip, Silky, Blue, and Thresher Sharks. WCPFC-SC10-2014/EB-WP-01.	**Don Bromhead, Joel Rice, and Shelton Harley. 2013.** Analysis of the potential influence of four gear factors (leader type, hook type, "shark" lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02 rev1.	**Brett Favaro and Isabelle M. Cote', 2015**. Do by-catch reduction devices in longline fisheries reduce capture of sharks and rays? A global meta-analysis. Fish and Fisheries, 2015, 16. 300-309.
		(13%), Oceanic whitetip (21%)	(0.32), Oceanic whitetip (0.27)	by region): Oceanic White-tip (Fiji), Blue (Fiji)	rate per 1,000 hooks)	
	Billfish	n/a	n/a	n/a	n/a	n/a
	Other, Teleosts	n/a	n/a	n/a	n/a	Multifilament nylon leaders reduced the relative risk of teleost capture (exp(^b8) = 0.443, 95% CI = 0.281 to 0.698).
Total Sets Observed		n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	16,272 (HI DSLL model, 2005-2009)	n/a, variable
Total Hooks Observed		n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a	n/a, variable
Test Branchline Configuration (Alternating types, Random, Sections)		n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a, variable
Hook Type	**Circle**	Unspecified, likely same model assumption and treatment regarding circle hooks as Harlet et al., 2015	Impact/benefit model assumed only circle hooks were used; mortality reduced by 2.9% (silky), & 3.3%	Circle hooks result in higher catch rates in all 3 fisheries it was examined	5,279 observed sets, *Circle, & Circle Offset, Wire + Mono* (HI DSLL model, 2005-2009)	Circle hook increase risk of elasmobranch capture (7.6%, nonsignificant); propensity to promote jaw

Source		**Shelton Harley and Graham Piling, 2016.** Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05, WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016).	**Shelton Harley, Bruno Caneco, Carl Donovan, Laura Tremblay-Boyer and Stephen Brouwer, 2015.** Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02, Rev 2 (30 July 2015).	**B. Caneco, C. Donovan and S. Harley, 2014.** Analysis of WCPO Longline Observer Data To Determine Factors Impacting Catchability And Condition On Retrieval OF Oceanic Whitetip, Silky, Blue, and Thresher Sharks. WCPFC-SC10-2014/EB-WP-01.	**Don Bromhead, Joel Rice, and Shelton Harley. 2013.** Analysis of the potential influence of four gear factors (leader type, hook type, "shark" lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02 rev1.	**Brett Favaro and Isabelle M. Cote', 2015**. Do by-catch reduction devices in longline fisheries reduce capture of sharks and rays? A global meta-analysis. Fish and Fisheries, 2015, 16. 300-309.
			(Oceanic).			hooking, improving post-release survival
	Tuna, J-hook				10,993 observed sets, *Tuna, Tuna Offset, J-hook, J-hook Offset Wire + Mono* (HI DSLL model, 2005-2009)	J-hook propensity to promote gut-hooking
Total number spp. on **wire**		Mortality reduction per 100 hooks (90 percentile) if no wire leader used: Silky (13%), Oceanic whitetip (21%), See Harley et al., 2015 & catch rate above	Model assumed shark lines removed and Wire leaders switched to Mono; mortality reduced by 17.6% (silky), 23.3% (oceanic)	n/a (variable, fishery-dependent)	14, 709 Total Wire sets, Total Species # n/a.; 4589 Circle Wire (Circle_Wire + Circle_offset_Wire), 10,120 Tuna/J (J_Wire, Tuna_Offset_Wire, Tuna_Wire)	Mono leaders 58% less likely to catch sharks and rays than Wire leaders (nonsignificant)
Total number spp. on **mono**				n/a (variable, fishery-dependent)	1,483 Total Mono sets, Total Species # n/a. ; 690 Circle Mono (Circle + Circle_offset), 793 Tuna/J (Tuna,	

Source	**Shelton Harley and Graham Piling, 2016.** Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05, WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016).	**Shelton Harley, Bruno Caneco, Carl Donovan, Laura Tremblay-Boyer and Stephen Brouwer, 2015.** Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02, Rev 2 (30 July 2015).	**B. Caneco, C. Donovan and S. Harley, 2014.** Analysis of WCPO Longline Observer Data To Determine Factors Impacting Catchability And Condition On Retrieval OF Oceanic Whitetip, Silky, Blue, and Thresher Sharks. WCPFC-SC10-2014/EB-WP-01.	**Don Bromhead, Joel Rice, and Shelton Harley. 2013.** Analysis of the potential influence of four gear factors (leader type, hook type, "shark" lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02 rev1.	**Brett Favaro and Isabelle M. Cote', 2015**. Do by-catch reduction devices in longline fisheries reduce capture of sharks and rays? A global meta-analysis. Fish and Fisheries, 2015, 16. 300-309.
				Tuna_Offset)	
Statistically significant (yes, no, meta-analysis)?	Yes (90 percentile, see catch rate, above)	Yes (90 percentile, see catch rate, above)	Yes (significant results provided, see above-catch rate, and see below-condition)	Yes (for Fiji only). Wire has positive relationship for Silky shark catches in Fiji, but no significance estimates able to be determined for Hawaii or RMI.	Yes, in single study; No, in meta-analysis due to large confidence interval predicted by model. See Mono/Wire.
Shark condition upon retrieval tracked?	Unspecified, likely same condition model assumptions and treatment as Harley et al., 2015 (modeled in developing mortality estimates, see above)	Yes (modeled in developing mortality estimates, see above)	Positive and significant, Wire is key condition/retrieval variable, set-level per 100 hooks (spp. by region): Silky (FSM/RMI), Blue (FSM/RMI, Fiji)	Mean predicted condition estimates, results not significant HI DSLL model, 2005-2009 dataset (catch rate per hooks unspecified)	n/a, variable
Bite offs tracked?	Yes (modeled in developing mortality estimates, see above)	Yes (modeled in developing mortality estimates, see above)	Somewhat, see above (catch rate)	No	n/a, variable
Terminal Gear Picture Provided?	n/a (variable,	n/a (variable,	n/a (variable,	n/a (variable, within	n/a, variable

Source		Shelton Harley and Graham Piling, 2016. Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05, WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016).	Shelton Harley, Bruno Caneco, Carl Donovan, Laura Tremblay-Boyer and Stephen Brouwer, 2015. Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02, Rev 2 (30 July 2015).	B. Caneco, C. Donovan and S. Harley, 2014. Analysis of WCPO Longline Observer Data To Determine Factors Impacting Catchability And Condition On Retrieval OF Oceanic Whitetip, Silky, Blue, and Thresher Sharks. WCPFC-SC10-2014/EB-WP-01.	Don Bromhead, Joel Rice, and Shelton Harley. 2013. Analysis of the potential influence of four gear factors (leader type, hook type, "shark" lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02 rev1.	Brett Favaro and Isabelle M. Cote', 2015. Do by-catch reduction devices in longline fisheries reduce capture of sharks and rays? A global meta-analysis. Fish and Fisheries, 2015, 16. 300-309.
		fishery-dependent)	fishery-dependent)	fishery-dependent)	Hawaii, 2005-2009 dataset)	
Terminal Gear Description	Leader Material	Wire, Mono (variable, various fishery-dependent)	Wire, Mono (variable, various fishery-dependent)	Wire, Mono (variable, various fishery-dependent)	n/a (variable, within Hawaii, 2005-2009 dataset)	n/a, variable
	Dimensions (Remaining Branchline)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, within Hawaii, 2005-2009 dataset)	n/a, variable
	Configuration	n/a (variable, fishery-dependent), shark lines in some fisheries in which data was used	n/a (variable, fishery-dependent), shark lines in some fisheries in which data was used	n/a (variable, fishery-dependent)	n/a (variable, within Hawaii, 2005-2009 dataset). Hawaii DSLL gear requires 20 m floatlines, no lightsticks, and 15 branchlines between float, 45 g lead weight within 1 m of hook.	n/a, variable
	Deployment/Retrieval Description	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, within Hawaii, 2005-2009 dataset)	n/a, variable
Confounding Variables	Bait (different, same)?	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, within Hawaii, 2005-2009	n/a, variable

Source		**Shelton Harley and Graham Piling, 2016.** Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05, WCPFC-SC12-2016/EB-WP-06 REV 1 (21 July 2016).	**Shelton Harley, Bruno Caneco, Carl Donovan, Laura Tremblay-Boyer and Stephen Brouwer, 2015.** Monte Carlo simulation modelling of possible measures to reduce impacts of longlining on oceanic whitetip and silky sharks. WCPFC-SC11-2015/EB-WP-02, Rev 2 (30 July 2015).	**B. Caneco, C. Donovan and S. Harley, 2014.** Analysis of WCPO Longline Observer Data To Determine Factors Impacting Catchability And Condition On Retrieval OF Oceanic Whitetip, Silky, Blue, and Thresher Sharks. WCPFC-SC10-2014/EB-WP-01.	**Don Bromhead, Joel Rice, and Shelton Harley. 2013.** Analysis of the potential influence of four gear factors (leader type, hook type, "shark" lines and bait type) on shark catch rates in WCPO tuna longline fisheries. WCPFC-SC9-2013/EB-WP-02 rev1.	**Brett Favaro and Isabelle M. Cote', 2015**. Do by-catch reduction devices in longline fisheries reduce capture of sharks and rays? A global meta-analysis. Fish and Fisheries, 2015, 16. 300-309.
					dataset)	
	Different hook Types?	Circle, J-hook (variable, various fishery-dependent)	Circle, J-hook (variable, various fishery-dependent)	Circle, J-hook (variable, fishery-dependent)	Circle, J/Tuna hook (variable, fishery-dependent)	n/a, variable (investigated in meta-analysis, see hook type above)
	Branchline Configuration; Different leader types in Study?	Deep (variable, various fishery-dependent)	Deep (variable, various fishery-dependent)	Deep (variable, fishery-dependent)	Deep (hook and leader type variable within Hawaii, 2005-2009 dataset)	Variable, see Wire/Mono leader above
	Lightsticks	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	n/a (variable, fishery-dependent)	No light sticks allowed (within Hawaii, 2005-2009 dataset)	n/a, variable

Source		Ward, 2008. Empirical estimates of historical variations in the catchability and fishing power of pelagic longline fishing gear. Rev Fish Biol Fisheries 18:409-426.	Branstetter and Musick (1993). Comparisons of shark catch rates on longlines using rope/steel (yankee) and monofilament gangions. Marine Fisheries Review, 55 (4-9).
Study Type (Field, Review, Observer Data, Meta-analysis, Other)		Review	Field
Pelagic **Fishery Typ**e (Deep, Shallow, Other-non pelagic)		Deep, Shallow	Other- non pelagic (semi-demersal survey)
Geographic Location		Pacific Ocean (tropical)	U.S. mid-Atlantic coast
Species of Interest (C*atch Rate, 1000 hooks*)	Tuna	Bigeye tuna significantly higher on Mono	n/a
	Shark	Sharks significantly lower on Mono than Wire	Wire (352 shark:5,725 hooks), Mono (
	Billfish	Blue marlin significantly lower on Mono, references (Stone and Dixon, 2001) in Mono catchability for swordfish double that of multifilament	n/a
	Other, Teleosts	n/a	n/a
Total Sets Observed		n/a, variable	71 Sets
Total Hooks Observed		n/a, variable	10,641 (6,975 wire-steel gangions, 3,666 Mono)
Test Branchline Configuration (Alternating types, Random, Sections)		n/a, variable	n/a
Hook Type	**Circle**	References (Yokota et al. 2006), no significant difference between blue shark catchability between circle/J hook types	Semi-demersal: 9/0
	Tuna, J-hook		352 sharks/5,725 hooks
Total number spp. on **wire**		Sharks significantly lower on Mono than	288 sharks/3,308 hooks

Source		**Ward, 2008**. Empirical estimates of historical variations in the catchability and fishing power of pelagic longline fishing gear. Rev Fish Biol Fisheries 18:409-426.	**Branstetter and Musick (1993).** Comparisons of shark catch rates on longlines using rope/steel (yankee) and monofilament gangions. Marine Fisheries Review, 55 (4-9).
Total number spp. on **mono**		Wire	Catch rates (all shark spp.) in offshore waters slightly higher on Wire/steel gear
Statistically significant (yes, no, meta-analysis)?		Yes (see significance in catch rates, hook type, # Wire/Mono, above)	No
Shark condition upon retrieval tracked?		No	Yes, "Bite-offs" averaged about 5% of the hooks per set (Mono).
Bite offs tracked?		References (Ward et al., 2007) Wire/Mono catchability bite-off variability: 0.62 mako, 0.51 blue marlin, 1.14 bigeye tuna, 0.96 yellowfin tuna, 1.71 skipjack tuna	No
Terminal Gear Picture Provided?		No, n/a, variable	Semi-demersal: Wire/steel (1-2 m of 1.6 mm CI16-inch) 7X7 stainless steel wire)
Terminal Gear Description	Leader Material	n/a, variable	Quick-snap with 8/0 swivel, 2-3 m of 3 mm e/s-inch) tarred hard-laid nylon line, an 8/0 swivel connecting
	Dimensions (Remaining Branchline)	n/a, variable	Semi-demersal: 6.4 mm Cf4-inch) tarred hard-laid nylon mainline anchored at both ends with 3-5 m gangions spaced about 20 m apart. Buoys on the mainline at 20-gangion intervals.
	Configuration	n/a, variable	100 steel gangions set as a continuous unit with 50 monofilament gangions placed at one end of the line.

Source		**Ward, 2008**. Empirical estimates of historical variations in the catchability and fishing power of pelagic longline fishing gear. Rev Fish Biol Fisheries 18:409-426.	**Branstetter and Musick (1993).** Comparisons of shark catch rates on longlines using rope/steel (yankee) and monofilament gangions. Marine Fisheries Review, 55 (4-9).
	Deployment/Retrieval Description	n/a, variable	Cut mackerel, whole menhaden; random
Confounding Variables	Bait (different, same)?	n/a, variable	No (9/0 J-hook)
	Different hook Types?	Variable, see circle/J hooks above.	Two sizes of mono leader (1.6 mm and 2.4 mm, both 500 lb. breaking strength)
	Branchline Configuration; Different leader types in Study?	Variable, see Wire/Mono leader above	No (assumed, unspecified)
	Lightsticks	n/a, variable	No (assumed, unspecified)