WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

Council Position on the False Killer Whale Take Reduction Plan Modifications As of November 2022

Overview Prepared for the 194th Council Meeting

At the 190th meeting in March 2022 and 192nd meeting in September 2022, the Western Pacific Regional Fishery Management Council considered new information pertaining to the management of false killer whale interactions in the Hawaii deep-set longline fishery under the False Killer Whale Take Reduction Plan (FKWTRP). The FKWTRP is implemented by NMFS pursuant to the Marine Mammal Protection Act (MMPA), based on recommendations from the False Killer Whale Take Reduction Team (FKWTRT). The FKWTRT operates on consensus. The Council has a seat on the FKWTRT, represented by Council staff.

The FKWTRT convened for an in-person meeting Nov 7-10, 2022, to review and consider implications of latest data and studies related to false killer whale interactions, assess effectiveness of current plan and brainstorm potential management and other measures, and identify additional data and analysis needed to support follow-up TRT discussions. Potential changes discussed include the following:

- Modification of the weak hook measure (strengthening branch line and/or using weaker hook);
- Development of a combined fighting line and cutter device to improve potential for straightening weak hook and associated handling;
- Improvements to handling guidelines and training;
- Modification of the Southern Exclusion Zone;
- Development of depredation deterrents;
- Effort controls; and
- Implementation of electronic monitoring.

The FKWTRT formed six work teams to further explore key issues in advance of the next meeting on March 28-31, 2023, at which FKWTRT is expected to reach consensus on recommendations to modify the FKWTRP.

At the 194th meeting in March 2023, the Council will receive an update on the FKWTRT work and any new information available for the TRT's consideration, and will consider providing further direction to staff on the Council's position on the modifications to the FKWTRP in preparation for the FKWTRT meeting.

Council positions on the future direction of the FKWTRP as of November 2022 are outlined below. Information papers reviewed by the Council in the development of these positions are included in the appendix.

1. ***The Council does not support adoption of weaker hooks under the Take Reduction Plan due to the potential economic impacts and lack of clear conservation benefit.***

The Council at the 190th meeting in March 2022 reviewed the results of the 2021 weak hook study that evaluated the impact of a 4.2 mm diameter hook compared to the existing requirement for 4.5 mm diameter hook on catch weight and value. The results indicate that target catch rates were not significantly different between the two hook sizes, but bigeye tuna body length, weight, and value were significantly higher on 4.5mm hooks. The number of straightened hooks recorded during the study was not significantly different between the two hook sizes. The Council's Scientific and Statistical Committee (SSC) found that the 2021 weak hook study does not provide sufficient scientific evidence to support adoption of a weaker circle hook. This finding is further supported by false killer whale interaction outcomes that show low success rates of weak hooks.

Prior to the 2018 in-person meeting of the FKWTRT, the Council had adopted the position that it would not support any changes to gear or additional closures under the FKWTRP until the updated abundance estimates resulting from the 2017 HICEAS survey is available for review by the SSC and Council. The new abundance estimates, published in 2020, indicates that the current best estimate of the false killer whale pelagic stock abundance based on a 2017 survey is 2,086 animals, resulting in a PBR of 16. The assessment also updated the abundance from the previous two surveys conducted in 2002 and 2010, now estimated at 2,086 and 2,144, respectively, although the assessment did not explicitly test for population trend. This suggests that the pelagic stock has had a PBR of around 16 since at least 2002, and the Hawaii deep-set longline fishery likely had not exceeded the PBR in the past.

Based on the results of the recent weak hook study, as well as the updated abundance estimate of the pelagic stock of false killer whales, the Council at its 190th meeting in March 2022 adopted the position that it does not support adoption of weaker hooks under the FKWTRP.

2. ***Priority for the Take Reduction Plan should be placed on developing strategies for reducing trailing gear and finding solutions to reduce depredation, in light of the latest false killer whale abundance estimates, Hawaii deep-set longline fishery's transition to monofilament leaders, and the impact of depredation on the fleet.***

The Council at its 190th meeting in March 2022 adopted the position that the priority under the FKWTRP should be on developing strategies for reducing trailing gear and finding solutions to reduce depredation in light of the latest false killer whale abundance estimates, Hawaii deep-set longline fishery's transition to monofilament leaders, and the impact of depredation on the fleet. A regulatory amendment under the Council's Pelagic Fishery Ecosystem Plan (FEP) prohibited the use of wire leaders (effective May 2022), which had prevented the ability to cut branch lines below the weighted swivel. Further, as described above, weak hooks do not appear to provide meaningful conservation benefit to false killer whales, and a review of mitigation measures included in the SSC's September 2021 False Killer Whale Issues Paper indicate that there is a lack of readily-available alternative mitigation measures that would significantly reduce interactions.

Hawaii longline fishermen are required to remove trailing gear as much as possible from most other protected species, and thus a consistent strategy for false killer whales is likely to be more successful than the current strategy that requires crew to create tension on the line to straighten the weak hook. The replacement of wire leaders with monofilament leaders in the Hawaii deep-set fishery opens up options for new designs of relatively simple line cutting devices compared to a device capable of severing wire leaders. Further, depredation events are more common than interaction events, and are thought to be precursor events to hooking or entanglements. Depredation events are also costly to fishery participants, and strategies for reducing depredation are more likely to be successful due to the greater incentives to fishery participants. Further, measures to reduce depredation are more likely to be adopted by fisheries outside of the U.S., such as foreign longline fleets that operate in high seas areas overlapping with the Hawaii fishery.

These two priority areas were also identified by the FKWTRT in their non-regulatory recommendations adopted in December 2020.

3. ***Crew training should be deferred on weak hooks and tie off strategies that increase stress on the animals to allow industry to cooperatively develop new and more effective strategies to reduce trailing gear.***

The Council at the 190th meeting in March 2022 adopted the position that crew training should be deferred on weak hooks and tie off strategies that increase stress on the animals to allow industry to cooperatively develop new and more effective strategies to reduce trailing gear. This was based on the recommendations included in the SSC's 2021 False Killer Whale Issues Paper that identified the development of strategies to reduce trailing gear as a priority in light of the Hawaii deep-set longline fishery's transition to monofilament leaders. Straightening the weak hook necessitates applying active tension on the line, which is stressful to the animal and crates a dangerous situation for the crew with potential for gear flyback.

4. ***The Southern Exclusion Zone (SEZ) should be considered for removal when the Take Reduction Plan (TRP) measures are revised, noting the tradeoffs of the closure on other protected species interactions and competition with foreign fishing vessels.***

The Council at the 192nd meeting in September 2022 reviewed the analysis conducted by the Pacific Islands Fisheries Science Center (PIFSC) that evaluated the influence of Southern Exclusion Zone (SEZ) on false killer whale depredation in the Hawaii deep-set longline fishery. The SSC at the September 2022 meeting noted the analysis confirms that the SEZ closure displaced fishing effort out of the SEZ and EEZ, while the probability of depredation does not differ substantially between inside and outside the SEZ. The model suggests that the tradeoff to the SEZ closure is effort displacement into areas with higher interaction rates for other protected species (oceanic whitetip sharks, giant manta rays, olive ridley turtles) and areas with higher foreign vessel presence, and further analysis would be warranted to quantify the extent of those tradeoffs.

Prior to the 2018 in-person meeting of the FKWTRT, the Council had adopted the position that the Southern Exclusion Zone should be considered for removal when the FKWTRP measures are revised as it is not necessary to achieve the goals of the FKWTRP. Based on the findings of the SEZ analysis, the Council at the 192nd meeting reiterated its previous recommendation on this matter.

Background Materials

Appendix 1: False Killer Whale Weak Hook Study Implications and Considerations for Council Position on Future Direction for the False Killer Whale Take Reduction Plan (Prepared for the 190th Council Meeting, March 2022)

Appendix 2: SSC False Killer Whale Issues Paper (Adopted by the SSC at the 141st SSC Meeting, September 2021)

Appendix 3: False Killer Whale Take Reduction Measures Briefing Document (Prepared for the 172nd Council Meeting, March 2018)

Appendix 1

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

False Killer Whale Weak Hook Study Implications and Considerations for Council Position on Future Direction for the False Killer Whale Take Reduction Plan

Prepared for the 190th Council Meeting
March 22-24, 2022

Overview

The False Killer Whale Take Reduction Team (FKWTRT) is expected to meet in person during 2022 to discuss the implications of the weak hook study on the False Killer Whale Take Reduction Plan (FKWTRP). The Council at the 190th meeting in March 2022 will consider providing direction on the Council position in preparation for the FKWTRT meeting. This paper provides considerations for the Council in developing its position on the weak hook study implications as well as future direction for the FKWTRP.

The weak hook study was implemented in 2021 to evaluate the impact of a 4.2 mm diameter hook compared to the existing requirement for 4.5 mm diameter hook on catch weight and value. The study results indicated the following:

- Bigeye tuna weight was significantly heavier on stronger hooks (8.5%), exceeding the 5% threshold that industry representatives indicated would be acceptable for supporting gear change.
- The use of the 2.3mm branch lines (instead of the 2.0mm commonly used in the fleet) resulted in longer gear conversion time and greater crimp failure, according to captains who participated in the study, indicating that further evaluation is needed on appropriate combination of hook and branch lines.
- Due to the small difference in breaking strength (29kg) of the hooks used in the study, it is unclear whether 4.2mm wire diameter hooks (compared to 4.5mm) would provide meaningful conservation benefit in reducing serious injury to FKWs.
    - The difference in the number of hooks straightened on 4.2 mm and 4.5 mm hooks during the study was not statistically significant
    - One hook straightened during a FKW interaction on a 4.2 mm hook during the study, but sample size of observed interactions were small

Based on the above, the recommendations identified in the SSC's September 2021 Issues Paper remain relevant for considering next steps for the weak hook and other alternative strategies under the FKWTRP:

- "Weak hook" mitigation strategies should only be mandated after thorough testing of hook and line strength, target catch retention and thorough training of captain and crews under different hooking scenarios. Emphasis should be placed on gears with standardized characteristics.

- The utility of severing the branch line close to the hook to leave a minimal amount of trailing line should be further assessed in relation to post-release condition and serious injury determinations.
- Efforts to develop novel line cutting devices that also protect from gear flyback should be promoted.

The Council and its advisory bodies may consider and provide direction on the following at their March meetings:

- Whether the recent weak hook study provides sufficient evidence to support changes to the existing weak hook requirement by adopting weaker hooks and/or stronger branch lines;
- Whether additional testing for making the hook the weakest point in the gear is warranted;
- Whether future direction for the FKWTRP other than those previously identified and supported by the Council (focus on minimizing trailing gear; removal of Southern Exclusion Zone) should be considered; and
- Whether additional analyses could inform Council's consideration for the above items.

Implications of the Weak Hook Study

NMFS Pacific Islands Regional Office (PIRO) implemented a weak hook study in the Hawaii deep-set longline fishery in 2021 that evaluated target and non-target species catch and value of two hook types. The study compared the effects of a 4.5mm wire diameter circle hook meeting the current regulatory requirement under the FKWTRP, and a 4.2mm wire diameter circle hook. The study also used 2.3 mm monofilament nylon for the branch line and leaders with both hook types, rather than the more commonly used 2.0 mm or 2.1 mm monofilament nylon. The study was conducted in response to FKWTRT discussions and draft recommendations generated at the April 2018 meeting. The draft report was presented to the FKWTRT on October 27, 2021, with discussion focused on clarifications and comments on the draft report. A separate in-person meeting will be scheduled later in 2022 (likely late summer) for the FKWTRT to discuss the implications of the weak hook study for the modifications to the FKWTRP.

This section highlights the key issues related to the weak hook study for Council's consideration in providing direction for the upcoming FKWTRT deliberations. The full weak hook study report is included in the SSC and Council briefing documents.

TRT draft recommendation on threshold for considering weaker hooks

The weak hook study design was based on FKWTRT draft recommendations for modifying FKWTRP measures, as discussed at the April 2018 in-person meeting and subsequent follow-up teleconference meetings. FKWTRT considered potential adoption of a weaker 4.2 mm hook (subject to review of study results) as part of a package of measures, which included voluntary adoption of 2.3 mm monofilament nylon branch lines, suspension or elimination of the Southern Exclusion Zone (SEZ) conditional to additional gear modifications, and crew training. FKWTRT ultimately was not able to come to consensus on recommendations for modifying the measures, but generally agreed that a new weak hook study was needed to evaluate the potential impact of a 4.2 mm diameter hook compared to the existing requirement for 4.5 mm diameter hook. Specifically, FKWTRT members considered a draft recommendation that included a threshold for determining whether the economic value of retained catch would occur:

> *The Team recommends that NMFS undertake a rigorous study that compares 4.2 mm and 4.5 mm wire diameter circle hooks. The goal of the study would be to determine whether there would be a decrease in the economic value of retained catch…if the 4.2 mm hook is implemented in the deep-set fishery.*
>
> *…a decrease in the economic value of retained catch occurs if (i) the* ***ex-vessel weight of bigeye tuna*** *caught on 4.2 mm circle hooks is more than* ***5% less*** *than the ex-vessel weight of bigeye tuna caught on 4.5 mm circle hooks or (ii) the* ***ex-vessel monetary value of total catch*** *landed on 4.2 mm circle hooks is more than* ***5% less*** *than the ex-vessel monetary value of total catch landed on 4.5 mm circle hooks.*
> [draft recommendation version January 27, 2020]

At the FKWTRT teleconference on November 29, 2018, PIFSC reported on a power analysis to determine the sample size needed for the weak hook study. The power analysis indicated that 680 longline sets (approximately 40 trips) would be needed to significantly detect a 5% reduction in bigeye tuna catch rate, whereas 170 longline sets would be sufficient to detect a 10% reduction in bigeye tuna catch rate.[1] PIRO PRD reported that they would be ready to implement a study at the 10% power level with a field season starting in April 2019 (to target summer months when larger bigeye tuna are typically caught).

At the FKWTRT teleconference on April 5, 2019, PIRO PRD indicated that the study would be pushed back until spring 2020 due to unexpected delays in securing both the stronger branch line and 4.2mm hooks needed to carry out the study.

At the FKWTRT teleconference on November 18, 2019, Lynker (PIRO contractor for the weak hook study) presented on the hook study design for team member input. TRT members supported the decision to use 15/0, 4.5mm round circle hook as the control and 15/0, 4.2mm round circle hook as the treatment. Industry representatives reiterated that their threshold for supporting gear change based on the study would be no more than a 5% variance in ex vessel weight and economic value.

The weak hook study final report makes reference to a threshold set by the FKWTRT of less than 10% reduction in price or weight, which appears to be inaccurate based on the review of the FKWTRT deliberations summarized above. While the FKWTRT did not reach consensus on a threshold, the draft recommendations indicate that the FKWTRT had considered a 5% reduction as a threshold.

[1] Bigelow, K. 2018. PIFSC report on sample size considerations for a longline hook study. PIFSC Internal Report IR-18-020

Key findings from the final report

The study was postponed until spring 2021 due to COVID-19, with field trials conducted during March –July 2021, and final report delivered in December 2021. FKWTRT convened October 27, 2021, to review and provide input on the draft report. The key findings from the final report are as follows:

- "Though not statistically significant, catch risk of bigeye tuna was higher on weak hooks but mean body length (3.3 cm) and dressed weight (6.8 lb or 3.1 kg) was significantly larger and heavier on strong hooks, respectively. Bigeye caught on strong hooks also fetched a significantly higher mean price per fish at auction ($52.89) but the analysis did not take into account exogenous (i.e., time spent hooked, temperature, dissolved oxygen) and endogenous factors (e.g., stress, parasites, shark damage, bad gaff placement) known to influence flesh quality. Using a meta-analytic approach synthesizing effect sizes on catch rates, body sizes, dressed weights and prices for species at auction, we demonstrated ex-vessel revenue was virtually similar on the two hook types."
- "On average, bigeye tuna captured on strong hooks were significantly heavier (6.834 lb; 3.10 kg) than those caught on weak hooks. Yellowfin tuna were also heavier on strong hooks (3.222 lb; 1.46 kg) but the difference was non-significant."
- "Bigeye tuna captured on strong hooks averaged significantly more per fish ($52.891) than those caught on weak hooks. Species in the Target subgroup fetched, on average, $12.281 more per fish at auction on weak hooks but the analysis was significantly influenced by the inclusion of swordfish that brought in $408.334 more on weak hooks but the samples were skewed… For all marketable species, ex-vessel gross revenue indicates fish captured on strong hooks brought in $204.45 more than fish caught on weak hooks."
- "Three FKW were captured (2 on 4.5 mm ø hooks and 1 on a 4.2 mm ø hook) and one bottlenose dolphin was caught on a 4.2 mm ø hook."
- "In total, 39 4.5 mm ø hooks and 58 4.2 mm ø hooks were considered straightened by vessel captains (Table 2; Figs. S7-S8)." – difference was not statistically significant

In terms of the 5% threshold of bigeye tuna weight considered in the draft FKWTRT recommendation, bigeye was significantly heavier on stronger hooks with a 8.5% difference between the hook types. In terms of the 5% threshold of ex-vessel value of total catch, the two hook types resulted in similar total value. However, swordfish catch is likely overrepresented in the study results due to one of the vessels fishing north. The number of swordfish caught in the study was approximately 12% of the number of bigeye tuna caught in the study, whereas swordfish catch typically is about 2% compared to bigeye tuna on an annual basis, and less than 5% during the second quarter (April-June).[2] When swordfish is removed, total catch value on the weaker hooks was lower by 4.7% than the stronger hook (Table 1). When considering only the ex-vessel value of the two target species (bigeye and yellowfin tunas), the catch value on weaker hooks was lower by 9.4% (Table 1).

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[2] *See* Pelagic FEP 2020 Annual SAFE Report: https://www.wpcouncil.org/annual-reports/
See also Hawaii longline fishery logbook summary reports: https://www.fisheries.noaa.gov/resource/data/hawaii-and-california-longline-fishery-logbook-summary-reports

Table 1. Total ex-vessel revenue (gross) for species sold at auction and difference by hook type. (Adapted from Table 5 of the weak hook study report)

Species	Stronger hooks (4.5 mm) ($)	Weaker hooks (4.2 mm) ($)	Difference between stronger and weaker hooks	
			Value	Percentage
abacore	426.9	1095.6	668.7	156.6%
bigeye tuna	213406.3	200282.5	-13123.8	-6.1%
blue marlin	2229.3	3271.3	1042	46.7%
blue shark	154	N/A	-154	-100.0%
dolphinfish	4543.51	4713.66	170.15	3.7%
escolar	458.2	609.9	151.7	33.1%
oilfish	3.2	N/A	-3.2	-100.0%
opah	15676.3	18661.3	2985	19.0%
spearfish	1940.6	1721.7	-218.9	-11.3%
sickle pomfret	8267.4	13826	5558.6	67.2%
skipjack tuna	1276.3	560.3	-716	-56.1%
striped marlin	9247.4	8762.1	-485.3	-5.2%
swordfish	21776.9	36709.1	14932.2	68.6%
wahoo	10183.8	11729.5	1545.7	15.2%
yellowfin tuna	63345.1	50388.1	-12957	-20.5%
Grand Total	**$352,935.20**	**$352,331.10**	**-$604.1**	**-0.2%**
Exclude sword	*$331,158.31*	*$315,621.96*	***-$15,536.35***	***-4.7%***
BET & YFT only	*$276,751.4*	*$250,670.6*	***-$26,080.8***	***-9.4%***

Additionally, the following considerations from the weak hook study, identified through the FKWTRT discussions on the draft report and Council review of the report are relevant in considering the management implications:

- Use of 2.3 mm mono (instead of the 2.0 mm commonly used in the fishery) resulted in longer gear conversion time and greater crimp failure, according to captains who participated in the study.
- The Hawaii fleet and other fisheries throughout the Pacific generally experienced anomalously low catch rates during the study period. The current La Nina conditions have persisted longer than normal (2020-2022) and are known to affect the distribution of fish by species and their size distributions. The report did not consider whether catch composition during the study period was representative of a typical year.
- Of the four odontocete interactions observed during the study, the FKW interaction on the 4.2mm hook resulted in the hook partially straightening and released without any trailing gear (see additional details of the four interactions in Table 2).

Table 2. Summary of the four odontocete interactions observed during the weak hook study.

Species	Hook type	Interaction description	Preliminary Injury determination
FKW	4.5mm	The whale surfaced in a tangle of line, and the observer saw the line leading to the whale's mouth. The captain advised the crew to tie off the branch line to the railing, but the whale was struggling as they crew was trying to tie off, and the crimp between the leader and branch line broke. The hook, 1-m leader, and weight remained on the whale.	SI
FKW	4.2 mm	Deck boss had a very heavy pull on the mainline. Observer saw a false killer whale and observed it to be hooked in the lip or jaw – hook was seen near the back left corner of the mouth. The observer did not see any blood or other injuries. The engines were stopped and the crew tied off the line. The whale swam forward and then under the boat, and the **line went slack, and the whale was gone**. The **crew pulled in all the gear including a partially straightened hook**. The whale was not seen again. No gear remained on the animal. The hook was saved, and one other straightened hook was retrieved during the haul.	NSI
FKW	4.5 mm	Crew and observer noticed a whale on the line under water. When they started pulling in the line, the whale started to struggle. It was blowing bubbles when submerged under water. At first, under the captain's direction, the crew wrapped the line around the rail and applied tension by maneuvering the boat. Eventually they stopped, and cut the line, likely due to the amount of time handling was taking (the interaction lasted 10-15 minutes) and amount the whale was struggling. The observer could not see the hook, but could see the hook crimp right outside the mouth. No other marine mammals were sighted. The hook, weight, 1m of leader, and 4 feet of branch line remained on the animal after the line was cut.	SI
Bottlenose	4.2 mm	Dolphin came up in a tangle of line. Crew tied off the branch line to the rail, and waited (for hook straightening) but after about 5 minutes, noticed the hook and leader were ingested. Therefore, the captain cut the line. 4 feet of branch line, weight, leader and hook remained on/in the animal.	SI

SSC Issues Paper Excerpt on Weak Hooks

The SSC's false killer whale issues paper adopted in September 2021 reviewed various mitigation strategies, including the weak hook. The following is an excerpt of the issues paper as it pertains to the weak hook strategy and related issues:

> *The "weak hook" straightening strategy using current gear regulations has not proved useful in releasing bycaught FKW in the Hawaii fishery since the regulated adoption of the weak hook strategy in 2013. In only a handful of cases has the hook straightened to release the animal free of hooks and trailing gear. It has been noted that securing the branchline and applying active tension is highly stressful to the animal and creates a dangerous situation for*

the crew with potential for gear flyback and can contribute to more serious injuries to the whale if the hook is ingested. The debate continues as to whether the health and condition of false killer whales is improved by cutting the leader as close to the hook as possible or by the current strategy to apply tension on the line in an attempt to straighten hooks.

The impact of different amounts of retained or trailing gear on the post release condition of false killer whales needs to be assessed to better inform and update the process for distinguishing serious from non-serious injury of marine mammals. The guidelines currently in place were developed from a 2007 workshop convened by NMFS and published in a set of procedural directives in 2012 that provides the process and criteria for distinguishing human-caused serious from non-serious injury to marine mammals (NMFS 2012). Under the guidelines for small cetaceans, animals with a hook retained in the head, mouth or ingested is assessed as a serious injury. An interaction with a small cetacean released with trailing gear of varying lengths is generally assessed as a serious injury based in part on Anglis and DeMaster (1998). While removal of the hook is desirable, the relative benefit of reducing stress and injury by leaving the hook in place and removing as much gear as possible with a long-handled cutting device should be evaluated. Research on other protected species such as sea turtles and oceanic whitetip sharks have shown that removal of trailing gear can significantly increase post-release survival (Chaloupka, 2004, Hutchinson, 2021). It is recommended that NMFS devote significant agency resources to research the post-hooking condition and mortality of FKWs and similar odontocetes and the impact of retained hooks and trailing gear on the animal's condition.

The replacement of wire trace with monofilament leaders in the Hawaii deep-set fishery opens up options for new designs of relatively simple line cutting devices compared to a device capable of severing wire trace. The development of improved line cutting gear designed to remove line very close to the hook and the weighted swivel while designed to minimize flyback should be promoted in collaboration with fishery participants. One area of development could be for a small device that could be slid down the branchline to sever the monofilament leader when underwater and close to the hook but below the weighted swivel. Gear spring back should be low if the line is cut underwater. Such a device would also be useful for releasing oceanic sharks with minimal trailing gear.

A hook study is being conducted in 2021 to further inform the "weak hook" strategy and is designed to evaluate the economic cost of target catch retention by different hook strengths. It is possible that a different ratio of hook strength to branchline diameter could provide better results from the current situation. However, other mitigation approaches need to be considered. It should be noted that hook strength and straightening characteristics will vary depending on many criteria such as the steel alloy, hook manufacturer model and shank cross-section type (round or flat) (Mclellan et al 2015). The strength of monofilament leader of the same diameter will also vary by make and type. All available hook and line characteristics should be considered and tested when developing gear-based regulations.

Based on the review, the issues paper identified the following recommendations for future direction of mitigation strategies, which remain relevant in light of the weak hook study results:

1. The “move on” strategy where boats travel long distances or wait extended periods after a depredation is inappropriate for a fishery marketing fresh, iced product with limited storage time.
2. Catch shielding gears have many logistical issues related to their storage, potential for tangling and time, and effort required to add or remove gear to mitigate such a rare event.
3. Acoustic deterrents can quickly become ineffective and contribute to the “dinnerbell effect.” However, the identification of key acoustic signals that FKWs use to depredate catch should be identified to make a vessel less detectable than others.
4. “Weak hook” mitigation strategies should only be mandated after thorough testing of hook and line strength, target catch retention and thorough training of captain and crews under different hooking scenarios. Emphasis should be placed on gears with standardized characteristics.
5. The utility of severing the branchline close to the hook to leave a minimal amount of trailing line should be further assessed in relation to post-release condition and serious injury determinations.
6. Efforts to develop novel line cutting devices that also protect from gear flyback should be promoted.

Recommendation 6 has added significance given the replacement of wire trace with monofilament leader by the fishery which will allow simpler, less costly line cutting devices but presents added potential hazard from gear flyback.

Considerations for Future Direction of the FKWTRP

The FKWTRT is expected to meet in person during 2022 to discuss the implications of the weak hook study on the FKWTRP. The Council at the 190th meeting in March 2022 will consider providing direction on the Council position in preparation for the FKWTRT meeting.

The Council previously adopted the following position statements at the 172nd meeting in March 2018, in advance of the April 2018 FKWTRT meeting:

1. The Council finds that minimizing trailing gear on false killer whales may provide greater reduction in impacts than the weak hooks, which have exhibited low success rates in hook straightening. The Council recommends that NMFS increase its efforts to develop gear-based solutions to release false killer whales without hooks and/or with minimal amounts of trailing gear, including development of mechanisms that assist quick and safe removal of trailing gear.
2. The Council will not support any changes to gear or additional closures under the FKWTRP until the updated abundance estimates resulting from the 2017 HICEAS survey is available for review by the SSC and Council.
3. The Council finds that the Southern Exclusion Zone should be considered for removal when the TRP measures are revised as it is not necessary to achieve the goals of the TRP.
4. The Council requests NMFS to forward any TRT recommendations regarding changes to the operation of the fishery (e.g., gear, effort, spatial measures) to the Council for SSC and Council consideration to ensure consistency with the Pelagic FEP and ongoing deliberations of Council actions.

As previously noted, the FKWTRT did not reach consensus on recommendations to modify the FKWTRP at the April 2018 and subsequent deliberations. In lieu of consensus recommendations on management measures, FKWTRT in December 2020 adopted recommendations on non-regulatory aspects focusing on 1) crew training; 2) depredation research; 3) post-hooking mortality research; and 4) data synthesis, which were consistent with the previous Council position statements.

The following sections provide updates and considerations for several key issues that were identified in the Council's previous position adopted in March 2018.

Minimizing trailing gear as a mitigation strategy

The primary impediment to considering trailing gear minimization as a mitigation strategy for false killer whale interactions is the NMFS Serious Injury Determination Policy Directive. Under the current directive, NMFS considers most interactions that result in the animal being released alive with gear remaining in their mouth as a serious injury, which is considered to have the same population impact as a dead animal. NMFS is in the process of reviewing the Serious Injury Determination Policy Directive, which was implemented in 2012 and developed based on a technical workshop convened in 2007.

NMFS recently solicited informal input from FKWTRT members on information to be considered in the review. The Council submitted input in a letter dated January 31, 2022 (Appendix A), which highlighted the following:

- New information is available that would warrant development of a developing SI determination criteria specific to false killer whale interactions in the Hawaii deep-set longline fishery that takes into account gear characteristics, handling methods, and various interaction outcome scenarios based on the latest information, which include:
    - Management measures implemented after the 2007 technical workshop, such as weak circle hooks, associated handling strategies, and transition of wire leaders to monofilament nylon leaders
    - Detailed observer data on false killer whale interactions in the Hawaii deep-set longline fishery, which show that hook is visible around the mouth for a considerable portion of interactions (e.g., 40% in 2021) and suggests that injury could be minimized if tools are available to cut the leader below the weight
- Requested that NMFS review all available literature on odontocete fishery interaction and gear ingestion, as well as all relevant stranding data and necropsy data from Hawaii and worldwide to evaluate the risk of gear ingestion in false killer whales
- Requested that NMFS convene a workshop with the FKWTRT, the Council, and relevant external subject matter experts

Revision of the Serious Injury Determination Policy Directive remains a priority for considering trailing gear minimization as a mitigation strategy for false killer whale interactions.

Updated abundance estimates

At the time of the initial FKWTRT deliberations in 2010, the abundance estimate of the pelagic stock of false killer whales within the EEZ was 484, based on a reanalysis of the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) data. The resulting potential biological removal (PBR) was 2.5, and the mean annual mortality and serious injury (MSI) inside the EEZ was estimated at 7.3.

The 2010 HICEAS resulted in a higher abundance estimate of 1,540 pelagic false killer whales inside the EEZ, resulting in an increased PBR of 9.3. These estimates became available after the initial deliberations of the FKWTRT in 2010 but before NMFS published the final rule to implement the FKWTRP. At the time of the FKW TRP implementation in December 2012, the 5-year mean annual MSI for the pelagic false killer whale stock was 13.6 individuals inside the EEZ, and 11.2 on the high seas. By early 2018, the latest 5-year (2011-2015) mean estimated annual MSI was 7.5, and the mean estimated annual MSI since the TRP implementation (2013-2015) was 4.1, indicating that the current MSI levels of pelagic false killer whale stock had been reduced below the PBR.

The latest HICEAS survey was conducted in 2017. The newest abundance estimates from the 2017 survey, published in 2020, indicates that the current best estimate of the false killer whale pelagic stock abundance based on a 2017 survey is 2,086 animals, resulting in a PBR of 16 (Oleson 2020). The assessment also updated the abundance from the previous two surveys conducted in 2002 and 2010, now estimated at 2,086 and 2,144, respectively, although the assessment did not explicitly test for population trend (Bradford, 2020). This suggests that the pelagic stock has had a PBR of around 16 since at least 2002, and the Hawaii deep-set longline fishery likely had not exceeded the PBR in the past.

Southern Exclusion Zone

The draft FKWTRT recommendations considered at the April 2018 meeting included a suspension clause for the Southern Exclusion Zone (SEZ) for the duration of the weak hook study, and a potential removal of the SEZ if weaker hooks were adopted as a management measure following the study. However, these draft recommendations did not reach consensus, and the SEZ remains in place.

The SEZ trigger was met for the first time in 2018 since its implementation in 2013. The first SEZ closure lasted from July to December 2018, and the second SEZ closure lasted from February 2019 to August 2020 (Table 3). The SEZ trigger of two MSI was revised in December 2020 based on the new PBR, and the current trigger is four MSI.

Table 3. Southern Exclusion Zone closures.

Closure date	Closure FR notice	Reopening date	Reopening FR notice
July 24, 2018	83 FR 33848 (July 18, 2018)	Dec 31, 2018	n/a (automatic reopening)
Feb 22, 2019	84 FR 5356 (Feb 21, 2019)	Aug 25, 2020	85 FR 50959 (Aug 19, 2020)

In 2021, the deep-set fishery met and exceeded the SEZ trigger, with a total of five MSI observed inside the EEZ. The interactions that met and exceeded the trigger occurred in November and December 2021, respectively, but the SEZ did not close during the calendar year because the serious injury determination process was not completed before the end of the year.

At a FKWTRT teleconference held February 3, 2022, to review the 2021 interactions, several FKWTRT members expressed concern regarding the delay in closing the SEZ and the apparent increase in interactions inside the EEZ. It is likely that FKWTRT will discuss SEZ issues further at the 2022 in-person meeting.

Prior to the FKWTRP implementation, the SSC had recommended implementing the SEZ trigger as a simple cumulative sum scheme, in which MSI and PBR would be expressed as cumulative sum values, and the SEZ closure would be triggered if the cumulative MSI exceeds the cumulative PBR in any given year. Based on this concept, the cumulative MSI inside the EEZ since 2013 has not exceeded the cumulative PBR, either in terms of the historical PBR, or assuming the updated PBR of 16 applies retrospectively given the revised historical abundance estimates (Figure 1).

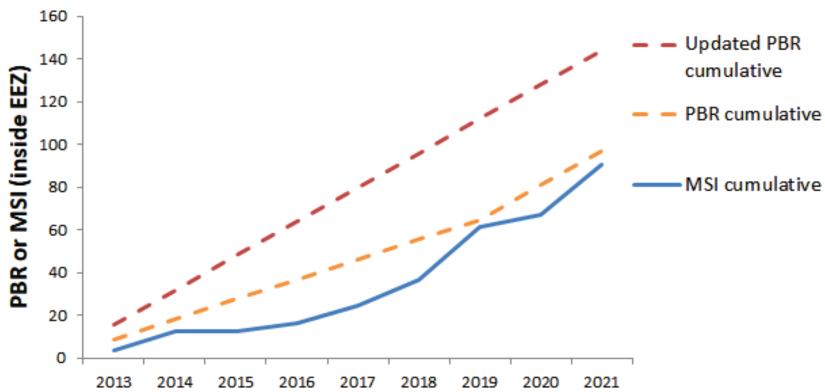

Figure 1. Observed MSI inside the EEZ, historical PBR, and updated PBR expressed as cumulative values since the FKWTRP implementation in 2013.

Western
Pacific
Regional
Fishery
Management
Council

January 31, 2022

Ms. Kristy Long
Office of Protected Resources
1315 East-West Highway
13th Floor
Silver Spring, MD 20910

Dear Ms. Long,

The Western Pacific Regional Fishery Management Council appreciates the opportunity to provide input to the National Marine Fisheries Service (NMFS) on the ongoing review of the Serious Injury (SI) Determination Policy Directive.[1] NMFS solicited input from the members of the False Killer Whale Take Reduction Team (FKWTRT) through a verbal request during a virtual meeting of the FKWTRT convened on October 27, 2021.

As articulated by the Council's representative on the FKWTRT during the October 2021 meeting, we are disappointed that NMFS will not be convening a workshop to review the existing SI Determination Policy Directive. The briefing provided to the FKWTRT was a short update on the process, with no substantial information presented on the review or potential revisions. This falls short of NMFS' commitment to provide opportunities for additional input prior to releasing a draft for public comment for interested constituents through webinars or question and answer sessions.[2] We request that NMFS schedule a webinar or virtual workshop with the FKWTRT, Fishery Management Councils, and relevant external subject matter experts to review the best available scientific information gathered by NMFS staff and discuss potential changes so that meaningful deliberation can take place prior to the release of draft revisions. Broad review and input in the process of revising the SI Determination Policy Directive is warranted given that it has been 15 years since NMFS last convened a technical workshop on marine mammal SI determination in 2007, which provided the basis for the existing policy issued in 2012.

We are also disappointed that NMFS has not prioritized conducting additional research and analyses to improve the understanding of species-specific survival rates of false killer whales following interactions with the Hawaii longline fishery. The FKWTRT identified this need as the second highest priority when it updated the False Killer Whale Take Reduction Plan (FKWTRP) Research Priorities[3] in 2014. FKWTRT again recommended post-hooking mortality research in December 2020, with extensive discussion on this issue at the April 2018 in-person meeting when a draft version of this recommendation was supported by FKWTRT members.

The Council also recommended in 2018 and again in 2019 that NMFS support additional research to obtain scientific information on species-specific post-hooking mortality information to inform revision of the Policy Directive and consider a prorated approach for SI Determination for

[1] Policy Directive 02-038 and Procedural Directive 02-038-01.
[2] Letter from Chris Oliver, NOAA Assistant Administrator for Fisheries, to Council Executive Director, July 10, 2019. *See enclosure.*
[3] https://media.fisheries.noaa.gov/dam-migration/fkwtrt_research_priorities_mar2014_508_opr2.pdf

false killer whales.[4] In response to this recommendation, NMFS indicated that it lacks data to develop prorated outcomes for most small cetaceans, including false killer whales.[5] This response is unacceptable considering that it has been nearly a decade since the FKWTRT prioritized research to evaluate survival of false killer whales and other similar species following fishery interactions.

Notwithstanding the lack of progress in addressing this critical data gap to inform management of false killer whale interactions in the Hawaii longline fishery, we believe that there is sufficient information and expertise available to inform meaningful revisions to the SI Determination Policy Directive. As described below in further detail, NMFS should consider developing SI determination criteria specific to false killer whale interactions in the Hawaii deep-set longline fishery that takes into account gear characteristics, handling methods, and various interaction outcome scenarios based on the latest information that have become available since the 2007 technical workshop. Further we request NMFS to review all available literature on odontocete fishery interaction and gear ingestion, as well as all relevant stranding data and necropsy data from Hawaii and worldwide to evaluate the risk of gear ingestion in false killer whales. These tasks would be best accomplished through a workshop with the FKWTRT, the Council, and relevant external subject matter experts. We would be glad to assist with the coordination of such workshop.

Develop Injury Criteria Considering Gear and Handling Requirements and the Diversity of False Killer Whale Interaction Scenarios in the Hawaii Deep-set Longline Fishery

According to the existing SI Determination Policy Directive, small cetaceans released alive are assigned to SI or non-serious injury (NSI) categories based on the type of injury, amount of gear remaining, and other conditions specific to each interaction. NMFS interprets SI as injury that is more likely than not to result in mortality. Based on this definition, the estimated post-interaction mortality rate for false killer whales that are released alive and the injury level determined to be serious would range between 50 and 100 percent. However, for the purpose of evaluating the impacts of SI against the potential biological removal level, SI is considered 100 percent removal from the population regardless of the injury type and other available information for that interaction, and thus the population-level impact of a SI is considered equivalent to a mortality. It is unlikely that all false killer whales released alive and categorized as SI die from their injuries.

Current guidelines for small cetaceans classify most gear remaining on the animal's head region as SI. Over 90 percent of the interactions since the FKWTRP implementation have resulted in the animal released alive, yet nearly 70 percent of those interactions were categorized as SI and considered to have equivalent impacts to an observed mortality due to varying amount of gear remaining on the animal, mostly in the head region.

The existing SI determination criteria for small cetaceans are limiting development of practical solutions for improving post-hooking survival of false killer whales. For example, if the "weak hook" does not straighten as intended, removing as much gear as possible prior to release to minimize trailing gear that may become wrapped around the body would likely reduce the chances that the animal will die as a result of the injury. However, the policy as currently written provides no incentive to captains and crew members to remove as much gear as possible, because a hook remaining in the mouth (or a hook that is not visible) would likely result in the interaction being categorized as a SI. This concern was echoed by many of the FKWTRT members at its April 2018

[4] Letter from Council Executive Director to Chris Oliver, June 22, 2018; and letter from Council Executive Director to Chris Oliver, April 3, 2019. *See enclosure.*
[5] Letter from Chris Oliver to Council Executive Director, July 10, 2019. *See enclosure.*

meeting. The existing criteria has also hampered development of alternatives to the weak hook strategies for removing as much trailing gear as possible, because the hook would need to be removed from the animal in most cases for an interaction to be categorized as a NSI.

The existing SI Injury Determination Policy Directive was developed based on the technical workshop convened in 2007. At the time, the FKWTRT had not been convened, and interaction details from observer data were limited. As a result, a number of factors specific to the Hawaii deep-set longline fishery that could affect interaction and injury outcomes were not considered during the 2007 workshop. For example:

- The Hawaii deep-set longline fishery has been required to use circle hooks under the FKWTRP since 2013. Circle hooks, compared to tuna hooks previously used in the fishery, are less likely to become hooked in the gut or esophagus, and are more likely to result in mouth hookings.[6]
- The Hawaii deep-set longline fishery uses 15/0 or smaller size circle hooks, which was found to be too small for the gape to hook around the jaw in pilot whales,[7] suggesting that any hook visible around the mouth is likely hooked in soft tissue.
- FKWTRP weak hook requirement necessitates crew to pull on the line to attempt to straighten the hook. The hook may become lodged in the animal's throat or goosebeak as a result of this handling, which may result in a different outcome for the animal compared to if the line was cut close to the mouth without applying tension on the line.
- In 2021, the deep-set longline vessels voluntarily transitioned from wire leaders (0.5-1 meter metal wire placed above the hook and below the weighted swivel) to monofilament nylon leaders. This gear change is also expected to become a regulatory requirement in the near future based on the Council's recommended action,[8] and may facilitate removal of trailing gear from false killer whales. Additionally, ingestion of wire leaders may have different survival outcomes than ingestion of monofilament nylon leaders.

We urge NMFS to convene an expert workshop (including fishery interaction and gear experts) to develop a SI determination criteria specific to false killer whale interactions in the Hawaii deep-set longline fishery that considers gear characteristics, handling methods, and various interaction outcome scenarios based on the latest information including those described above. Particular focus should be placed on cases that currently fall under the "hook(s) in head" (S5a) and "hook(s) confirmed in lip only" categories, which represent most of the false killer whale interactions in the Hawaii deep-set longline fishery, and consider prorated SI categories depending on the handling methods, gear used, or other factors that could increase the animal's chances of survival.

As an example, in six of the 15 observed false killer whale interactions in 2021 (40%), the observer noted that the hook or the crimp located immediately above the hook was visible around the mouth of the animal (Table 1). In all of these cases, the vessels were using 15/0 circle hooks which are likely too small to hook around the jaw, and thus the hook was likely embedded in soft tissue around the mouth. Out of the six interactions, only one resulted in the hook partially straightening and the animal being released without any gear remaining. The remaining five false killer whales were released with trailing gear that could create constricting wraps around the body or could be

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[6] Clarke, S., Sato, M., Small, C., Sullivan, B., Inoue, Y. & Ochi, D. 2014. Bycatch in longline fisheries for tuna and tuna-like species: a global review of status and mitigation measures. FAO Fisheries and Aquaculture Technical Paper No. 588. Rome, FAO. 199 pp.

[7] McLellan, B., Authur, L., Pabst, D.A. Testing hook-tissue interactions in pilot whale mouths. Presentation to the False Killer Whale Take Reduction Team, April 2015.

[8] *See* 87 FR 2742 (January 19, 2022)

dangerous if ingested, resulting in SI determinations. In each of these cases, the animal could have been released with minimal training gear if the handling guidance had been to cut the line as close to the mouth as possible, and a specialized line cutter that travels down the branchline was available on board.[9] Such an approach to handling would also simplify the messaging for captain and crew training and consistent with other large protected species and sharks that cannot be brought on board, which is likely to reduce the chances that crew would cut the line in a manner that leaves long trailing gear, as was the case in two of the interactions. However, such outcomes for false killer whales are not likely to be achieved under the current SI Injury Determination Policy Directive that does not consider these fishery-specific circumstances based on the latest scientific and observer data.

Table 1. Interaction details of the six false killer whale interactions in 2021 for which hook or the crimp above the hook was visible around the mouth. Source: Pacific Islands Regional Observer Program data (2021 interaction summary sent to FKWTRT members)

Interaction date	Interaction details	Amount of gear remaining	Injury determination
6/1/21	Deck boss had a very heavy pull on the mainline. Observer saw a false killer whale and observed it to be **hooked in the lip or jaw – hook was seen near the back left corner of the mouth**. The observer did not see any blood or other injuries. The engines were stopped and the crew tied off the line. The whale swam forward and then under the boat, and the **line went slack, and the whale was gone**. The crew **pulled in all the gear including a partially straightened hook**. The whale was not seen again.	No gear remained on the animal	NSI (preliminary)
6/17/21	Crew and observer noticed a whale on the line under water. At first, under the captain's direction, the crew wrapped the line around the rail and **applied tension by maneuvering the boat**. Eventually they stopped, and cut the line, likely due to the amount of time handling was taking (the **interaction lasted 10-15 minutes**) and amount the whale was struggling. The observer could not see the hook, but could **see the hook crimp right outside the mouth**. No other marine mammals were sighted.	The hook, weight, 1-m leader, and 4 feet of branchline remained on the animal after the line was cut.	SI (preliminary)
8/11/21	The crew notified the observer that a whale was on the line. The mainline was very tangled, but there was only one line (the branchline) leading to the whale, the whale was not entangled, only hooked. The observer could **see the shank of the hook in the lower right of the whale's mouth, either in the jaw or lip**. The crew got the captain at the observer's direction, who came on deck and directed the crew to cut the line. No attempt at handling or straightening the hook was made.	The line was cut with the hook, leader, 45g weight, and 2 meters of branchline remaining on the whale.	SI (preliminary)
8/24/21	A false killer whale was observed on the line. It surfaced twice and then dove as deep as it could based on the length of the branchline. It **appeared to be hooked in the mouth, in the lip or jaw area**. The crew cut the line without permission from the captain.	All of the branchline (approx. 12.5m), leader, weight, and hook, remained on the animal.	SI (preliminary)

[9] Caleb McMahan, Hawaiian Fresh Seafood, under a NMFS Bycatch Reduction Engineering Program award, has developed a line cutter prototype that could accomplish this task. Further development on this prototype is warranted to develop a specialized line cutter suitable for use in false killer whale interactions.

9/13/21	The observer and crew saw the whale on line, **hooked in the lip area**. The observer told the crew to notify the captain, meanwhile, the **crew tied off the line**. When they tied off the line, the whale dove and the line snapped at the sleeve.	The leader (0.6m) and hook remained on the whale.	SI (preliminary)
11/19/21	A false killer whale was observed on the line, **hooked in the mouth**. The crew stopped the vessel and pulled the whale alongside the vessel. The captain directed that the branchline be secured to a floatline, and tied off to the vessel. He then **used the vessel to apply tension to the line**. The **line broke at the swivel** before the hook straightened.	The hook, 0.5m of leader, and the weight remained on the animal.	SI (final)

Review All Available Information on Odontocete Fishery Interactions and Gear Ingestion to Refine Key Injury Criteria Relevant to Longline Fishery Interactions

Most false killer whale interactions in the Hawaii longline fishery result in the animal observed with some amount of fishing gear in the mouth, with the location of the hook often not visible. These interactions fall in the category of S5a (hook in head, regardless of presence of gear) or S5b (hook confirmed in lip only) in the existing policy. Current injury determinations for these categories were based mostly on bottlenose dolphin data, and no species-specific data were available for false killer whales at the time the 2007 technical workshop was convened.

The main source of bottlenose dolphin data considered at the 2007 technical workshop are summarized in Wells et al. (2008).[10] The paper reviews 12 cases of fishing gear ingestion. These cases can be summarized as follows:

- 11 cases from stranded carcasses, 1 case from scarring on a free-ranging animal
- In 7 out of the 12 cases, fishing gear ingestion was considered to be cause of death, and of which:
    - 3 had line wrapped around goosebeak (laryngeal spout)
    - 4 involved hook embedded in the mouth, throat, or goosebeak
- In 2 cases, primary causes of death were a shark attack or a stingray barb in lung, but gear was considered to have contributed to mortality
- In 1 case involving a free-ranging animal, it was first observed with large well-healed scars in the angle of the gape of the mouth at age 36 (suggest either ingestion or gear wrapped around the gape); at age 55 (2008) still observed and had records of reproduction
- In 4 cases, non-embedded small hooks were found in the stomach but not considered to be cause of death, suggesting that if hooks are not embedded in tissue, they may not be fatal
- Line wrapping around goosebeak suspected to occur as a result from attempts at regurgitation of gear (repeated cycle or unsuccessful swallowing followed by regurgitation could lead to wrapping)
- Embedded gear has not been observed in free-ranging dolphins in the study area (only in carcasses), suggesting that hooks embedded in throat or goosebeak are typically fatal
- Ingested gear has never been found in more than 600 veterinary examinations of wild-captured bottlenose dolphins during health assessments (including exam of oral cavity, and in recent years insertion of a tube into the stomach to collect small samples of stomach contents for cytology), suggesting that ingested gear are typically fatal

[10] Wells, R. S., J. B. Allen, S. Hofmann, K. Bassos-Hull, D. A. Fauquier, N. B. Barros, R. E. DeLynn, G. Sutton, V. Socha, and M. D. Scott. 2008. Consequences of Injuries on Survival and Reproduction of Common Bottlenose Dolphins (*Tursiops truncatus*) Along the West Coast of Florida. Marine Mammal Science. 24(4): 774–79.

Considering that it has been 15 years since the last technical workshop, we urge NMFS to conduct an expert workshop to review all available literature on odontocete fishery interaction and gear ingestion, as well as all relevant stranding data and necropsy data from Hawaii and worldwide to evaluate the risk of gear ingestion in false killer whales. Such a review should consider, at minimum:

- Hawaii's false killer whale necropsy data, which includes:
  - An animal stranded on the Big Island that had five fishing hooks ingested but determined to have died from natural causes; and
  - A false killer whale that was retrieved dead on a Hawaii deep-set longline fishery that had was found with fishing gear in its stomach that was not from the Hawaii fishery;
- Whether any stranding data of false killer whales or similar sized odontocetes have shown fishing gear ingestion to be the cause of death or emaciation;
- Whether false killer whales, which are larger than bottlenose dolphins, could swallow some amount of fishing gear without having the line wrapped around the goosebeak;
- The effects of gear handling that may cause a fishing hook to become embedded (e.g., as a result of an attempt to straighten a weak hook), compared to cutting the line as close to the mouth as possible in a manner that minimizes the potential of the hook becoming embedded in its throat or goosebeak;
- Whether any stranding records of odontocetes included fishing line in addition to non-embedded hooks (which could suggest that some amount of line could be swallowed without fatal outcomes)

Conclusions

The Council appreciates this opportunity to provide informal input. However, we request that NMFS hold to its prior commitment to provide a more meaningful platform for input that facilitates deliberation and discussion among relevant experts, including FKWTRT and the Council. Further, we request that NMFS convene an expert workshop to review the latest fishery-specific and species-specific information that has become available since the 2007 technical workshop, to inform development of SI determination criteria specific to false killer whale interactions in the Hawaii deep-set longline fishery. We are prepared to assist NMFS with convening an expert workshop in 2022 to inform the revisions to the SI Determination Policy Directive. Please contact the Council's protected species coordinator, Asuka Ishizaki (asuka.ishizaki@wpcouncil.org) to discuss these comments in further detail.

Sincerely,

Kitty M. Simonds
Executive Director

Enclosures

Cc: Janet Coit, Assistant Administrator for Fisheries
Samuel Rauch, Deputy Assistant Administrator for Regulatory Programs
Michael Tosatto, Regional Administrator, PIRO
Michael Seki, Director, PIFSC
Ann Garrett, Assistant Regional Administrator for Protected Resources, PIRO
Archie Soliai, Chair, WPRFMC
James Lynch, Scientific and Statistical Committee Chair, WPRFMC

Appendix 2

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

ISSUE PAPER

Seeking Consensus under the MMPA - Review of False Killer Whale interaction mitigation strategies in the Hawaii Deep-set longline fishery with recommendations

SSC Working Group on Alternative Approaches to Reduce Impacts to FKWs
Adopted by the SSC at the 141st Meeting

September 16, 2021

1.0 Introduction

Interactions between the pelagic stock of false killer whales (*Pseudorca crassidens*), (FKW) and the Hawaii-based deep-set longline fleet are rare events that continue to be problematic for the sustainability of longline fisheries that primarily target bigeye tuna, both inside and outside the US EEZ around Hawaii. FKW are known to predate on both bait and catch, and they may be able to acoustically track longline vessels during setting and hauling. NOAA National Marine Fisheries Service (NMFS) formed the Take Reduction Team (TRT) in 2010, and the TRT recommended a draft Take Reduction Plan (TRP) in July 2010. NMFS implemented the TRP in 2012. There have been ongoing efforts to achieve consensus and to demonstrate that both the regulatory and non-regulatory measures that have been proposed or tried experimentally can reduce the mortality and serious injury (MSI) estimates to meet the criteria set forth in the Marine Mammal Protection Act (MMPA). Reaching consensus on recommendations to revise regulatory measures by the TRT has been difficult to achieve; however, this is not uncommon for TRTs for other species (Mcdonald 2015). Flexibility in approaches to estimating population abundance, risk and potential biological removal (PBR), and to develop and assess mitigation measures, may be warranted (Rizzardi, 2014).

This contentious issue has plagued the pelagic longline fleet, led to sometimes failed experimental measures, and taken up time and resources on the part NMFS Protected Resources Division (PRD), the Hawaii Longline Association (HLA), the Western Pacific Fishery Management Council (WPFMC) Scientific and Statistical Committee (SSC) to develop mitigation measures. This paper was developed by four members of the SSC who were part of a Working Group formed in 2020 to review and consider alternative measures to the experimental weak circle hook measure that turned out to be ineffective. This Working Group came about as a result of the TRT's inability to reach consensus on effective regulatory measures. The TRT did recommend on-going assessment of non-regulatory measures, and the Working Group considers those recommendations below.

This paper reviews and synthesizes the ongoing efforts to mitigate deleterious interactions between FKW and the Hawaii longline fleet through 2021, and brings together disparate pieces of information scattered in various reports, including previous SSC discussions of this matter. The paper sketches the history of the formation of the FKW TRT, and its efforts to reach consensus on an acceptable suite of mitigation measures, both regulatory and non-regulatory. The paper then reviews the course of events leading up to the TRT's difficulties in reaching consensus on regulatory measures, and evaluates a range of measures and assesses their likelihood of providing a positive impact, offering suggestions for a path forward.

The paper evaluates the types of demographic data that are lacking, but perhaps necessary to make scientifically credible risk estimates for the FKW population of concern. The paper considers PBR as required under the MMPA, and comments on issues surrounding the difficulties in estimating PBR given a lack of adequate population demographic data. The paper concludes by recommending that the serious injury (SI) criteria be re-evaluated, and makes recommendations for future research that would enable such reconsideration.

1.1 Need for Evidence-based Evaluation

Effective, evidence-informed marine fisheries policy-making depends on policy-relevant science. Scientific evidence requirements concern not only the capture species but also protected marine species such as the false killer whale (FKW) that are incidentally caught in the Hawaii deep-set longline fishery. Robust synthesis of the scientific evidence on the exposure of FKWs to pelagic longline fisheries and the demographic consequences of that exposure are needed to better inform bycatch mitigation policy.

Many barriers exist to evidence-informed policy other than evidence synthesis (Rose et al 2018), and some of those barriers relate to advocating the synthesized evidence in the appropriate policy forum and in a way that is meaningful to fisheries management agencies and policy-makers. Given these considerations, the Working Group addresses both (1) the synthesis of the relevant scientific evidence concerning alternative measures to reduce FKW bycatch and (2) what might be the appropriate policy instruments for applying this evidence.

1.2 Overview of PBR and Take Occurring in the Fishery

The 1994 amendments to the MMPA mandate that, as part of the Stock Assessment Reports (SARs), PBR estimates must be developed for each marine mammal stock in U.S. waters. PBR is defined as "the maximum number of animals, not including natural mortality, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (OSP)." In addition, the MMPA specifies that PBR must be calculated as the product of three elements: the minimum population estimate (N_{min}), half the maximum net productivity rate (0.5 R_{max}), and a recovery factor (F_r). Guidance for determining each of these elements is provided in the NMFS Guideline for Assessing Marine Mammal Stocks (GAMMS) (NMFS 2016).

NMFS recognizes three false killer whale stocks in the Hawaii Islands Stock Complex (pelagic, main Hawaiian Islands, and Northwestern Hawaiian Islands stocks), and two additional stocks in the greater Western Pacific (Palmyra Atoll and American Samoa stocks) (Caretta et al 2020). The primary focus of the FKW TRP is the pelagic stock, which is a transboundary stock ranging inside and outside of the U.S. EEZ around Hawaii with an unknown outer extent on the high seas.

False killer whale interactions in the Hawaii deep-set longline fishery are monitored through a federal observer program that provides coverage for approximately 20% of the trips. For interactions that resulted in the animal being released alive, NMFS determines whether the interaction was likely to be a serious injury based on its Serious Injury Determination Policy (Policy Directive 02-238 and Procedural Directive 02-238-01). Under the policy, small cetaceans released alive are assigned to SI or non-serious injury (NSI) categories based on the type of injury, amount of gear remaining, and other conditions specific to each interaction. NMFS interprets SI as an injury that is more likely than not to result in mortality, or any injury that presents a greater than 50 percent chance of death to the animal. For the purpose of evaluating the impacts of SI against PBR, SI is considered 100 percent removal from the population regardless of the injury type and other available information for that interaction, and thus the population-level impact of a SI is considered equivalent to a mortality. Most of the false killer whale interactions in the Hawaii longline fishery result in the animal released alive with varying amounts of trailing gear remaining, which result in the interactions being categorized as SI. The total interactions for the fleet are estimated based on an expansion of these observed interactions Further consideration of these issues is contained in Caretta (2020).

At the time of the initial FKW TRT deliberations in 2010, the abundance estimate of the pelagic stock of false killer whales within the EEZ was 484, based on a reanalysis of the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) data. The resulting PBR was 2.5, and the mean annual MSI inside the EEZ was estimated at 7.3.

The 2010 HICEAS resulted in a higher abundance estimate of 1,540 pelagic false killer whales inside the EEZ, resulting in an increased PBR of 9.3. These estimates became available after the initial deliberations of the FKWTRT in 2010 but before NMFS published the final rule to implement the FKWTRP. At the time of the FKW TRP implementation in December 2012, the 5-year mean annual MSI for the pelagic false killer whale stock was 13.6 individuals inside the EEZ, and 11.2 on the high seas. By early 2018, the latest 5-year (2011-2015) mean estimated annual MSI was 7.5, and the mean estimated annual MSI since the TRP implementation (2013-2015) was 4.1, indicating that the current MSI levels of pelagic false killer whale stock had been reduced below the PBR.

The latest HICEAS survey was conducted in 2017. The newest abundance estimates from the 2017 survey, published in 2020, indicates that the current best estimate of the false killer whale pelagic stock abundance based on a 2017 survey is 2,086 animals, resulting in a PBR of 16 (Oleson 2020). The assessment also updated the abundance from the previous two surveys conducted in 2002 and 2010, now estimated at 2,086 and 2,144, respectively, although the assessment did not explicitly test for population trend (Bradford, 2020)

1.3 Formation and Output of the TRT and TRP

The False Killer Whale Take Reduction Plan (FKW TRP) was implemented in December 2012 to reduce false killer whale interactions in the Hawaii longline fishery. Take reduction plans are required under the MMPA when, among other conditions, the MSI levels of a marine mammal stock exceed the PBR estimated in the MMPA SAR, and the stock interacts with a fishery classified as Category I or II under the MMPA List of Fisheries (LOF).

The Hawaii longline fishery was first classified as a Category I fishery in the 2004 LOF. At the time, the population estimate of the false killer whale stock around Hawaii was 268 for the entire U.S. EEZ around Hawaii, resulting in a PBR of 1.2, and the MSI was estimated at 4.4. NMFS did not convene a Take Reduction Team (TRT) at first due to funding limitations. In the interim, the Council established a Marine Mammal Advisory Committee (MMAC) in 2005 to explore ways to reduce false killer whale interactions in the Hawaii longline fishery. MMAC met over three meetings between 2005 and 2009, generating recommendations for research and assessments needed to fill the information gaps. NMFS established the FKW TRT in 2010, including representation from the Council, State of Hawaii, federal agencies, academic and scientific organizations, fishing industry, and environmental groups. During the TRT deliberations, the abundance estimate of the pelagic stock of false killer whales was 484, PBR was 2.5, and the mean annual MSI inside the EEZ was estimated at 7.3.

The FKW TRT submitted a draft FKW TRP to NMFS in July 2010. NMFS published a proposed rule based on the team consensus plan in July 2011 and published the final rule in November 2012. The goals of the TRP were to reduce the MSI occurring within the U.S. EEZ around Hawaii to less than the stock's PBR within six months, reduce MSI to below 10% of PBR within five years, and to not increase the MSI on the high seas. The main components of the FKW TRP were the required use of "weak" circle hooks intended to allow release of false killer whales without remaining gear, measures to improve captain and crew response to interactions, modification to the MHI longline exclusion zone established under the Council's Pelagic Fishery Management Plan (FMP, currently the Fishery Ecosystem Plan) in 1992, and a triggered Southern Exclusion Zone closure that would prohibit fishing in a portion of the U.S. EEZ around Hawaii if two false killer whale interactions inside the EEZ resulted in a MSI determination in a year.

1.4 History of Measures Implemented and TRT Deliberations

The Working Group finds that the weak hook measure under the current False Killer Whale Take Reduction Plan has not been successful, and that the Southern Exclusion Zone closures have not resulted in further reduction in interactions. The TRT, after a nearly three-year deliberation process, did not reach consensus on alternative approaches to improve the effectiveness of the existing measures. The TRT in late 2020 concluded that consensus could not be reached on recommendations on management measure changes, but agreed to several non-regulatory and research priorities that focused on the following:

- Encouraging NMFS in coordination with HLA to train deck bosses and crew (in addition to owners/operators);

- Recommending that NMFS conduct or support research regarding FKW depredation on longline gear, with the goal of identifying mechanisms to reduce and avoid depredation without causing significant economic impacts to the fishery;

- Recommending that NMFS conduct or support research to quantify and assess post-release FKW mortality; and

- Recommending conducting data synthesis when possible.

Over the past ten years, the SSC has made a number of recommendations for minimizing impacts to false killer whales and improving assessment of population impacts. These recommendations include conducting population viability analysis and developing probability-based serious injury determination criteria. As noted above, formation of the Working Group and development of a comprehensive issues paper was recommended to summarize available information on these issues, and to inform recommendations to the Council on future mitigation measures as well as population assessments.

2.0 Cetacean Avoidance Research and Interaction Reduction Measures

Interaction and depredation of catch and bait by toothed cetaceans is well known in pelagic longline fisheries which may alter cetacean foraging behavior and distribution, financially impact fisheries, and contribute to resource waste and discarding (Gilman 2006). Hamer (2012) lists 32 peer-reviewed publications documenting 20 odontocete species interacting with longline gear and the number has likely increased with time. A wide range of potential solutions to mitigate the impact of these interactions have been attempted and many have been evaluated through applied research (Swimmer 2020). Studies or management approaches to reduce these impacts include the use of acoustic strategies to repel marine mammals from fishing gear or to reduce their ability to locate the gear, improved communication and move on policies to physically separate marine mammals from fishing effort, gear driven deterrents that drop over and mask catch from depredation and release mechanisms to reduce the physical impact of gear interactions (Clarke 2014).

Several methods have been trialed or considered to mitigate fishery impacts during false killer whale interactions including a variety of acoustic studies, “move on” studies, physical encasement around catch, “weakened gear” strategies, and removal of trailing gear. A summary of these studies and management measures more specific to interactions between false killer whales and the Hawaii deep-set tuna longline fishery are described below.

2.1 Acoustic Research

A range of acoustic approaches have been applied to studying and potentially mitigating fishery interactions with marine mammals. A variety of acoustic harassment devices (AHD) have been trialed across several fisheries in an attempt to reduce depredation or entanglement with the gear (McPherson 2003). These devices create underwater sounds deemed noxious to the target species or create a masking effect making the vessel and gear difficult for the cetaceans to locate. Studies have found that odontoctetes species will quickly habituate and adapt to overcome acoustic harassment methods rendering them ineffective (Tixier 2015, Mooney 2009). Pinnipeds and toothed whales are intelligent species and can key in on and be attracted to the signal from AHDs creating a "dinnerbell effect." The FKW TRT has recommended against the use of AHDs to mitigate FKW interactions in the fishery and NMFS has no plans to utilize AHD technology.

The auditory signals and echolocation of false killer whales have been found to be species-specific allowing for the acoustic monitoring of FKW in situ and without verification by human observers (Oswald 2007, 2011, 2013; Bauman-Pickering 2015). FKW depredate both target tuna and finfish bycatch in the fishery and are known to take bait from the hooks as they have been simultaneously recorded with video and acoustic devices (Thode et al. 2016). Passive acoustic monitoring (PAM) in the form of acoustic recording devices attached to commercial deep-set longline gear has been used to document the occurrence and timing of FKW in proximity to longline sets (Bayless 2017). The animals appear to be more present and active near the gear during the haul-back phase of the fishing operation when most depredation events are believed to occur.

2.2 Move-on Studies

Depredation or damage to target longline catch by odontocetes can be significant, prompting vessel operators to move location to avoid the source of the damaging interaction. Often, this may be a movement of only 3 to 5 hours steaming at 9 knots or less due to the desire to commence the next day setting operation to continue the full fishing cycle. This distance is considered inadequate to avoid FKW that can easily cover these distances and catch up with the fishing gear on the next set. Relevant work is being conducted by Fader (in press) that used a modeling approach to examine observer-collected data from the Hawaii deep-set longline fishery to examine patterns in odontocetes depredation by false killer whales.

The study found that in order to achieve a 50% reduction in depredation rate it would be necessary to move about 400 km or wait about 9 days before setting. Waiting 9 days is clearly unrealistic in a fishery where catch is stored fresh on ice, trip lengths are generally between 12 to 20 days and where fish held longer than 10 or 12 days may begin to see diminishing quality, shelf life and value. However, it may be possible to move about 400 km before setting the gear and still have enough total fishing time to complete a profitable trip.

2.3 Catch Shielding Devices

A variety of devices have been tested in longline fisheries that are designed to cover up a hooked fish thus creating a physical, psychological or sensory barrier to depredation (Clarke 2014, Hamer and Childerhouse 2013, Mcpherson and Nishida 2010, Swimmer 2020). These devices are normally attached near the branch line clip to the mainline and when triggered by a hooked fish will descend and deploy around the catch. These devices have included sheaths of fine netting, monofilament streamers, wire streamers, fine steel chains and monofilament cages or cones (Rabearisoa 2012, Hamer 2012, 2015).

Two similar studies carried out in Australia and Fiji tuna longline fisheries and in the Hawaii deep-set tuna longline fishery evaluated anti-depredation shielding devices consisting of monofilament streamers, steel trace streamers, a monofilament cone and a capsule-like plastic pod that contained stainless steel chains (Hamer 2015, 2019). The pod device had the advantage of being small, self-contained and easily attached or removed from a standard branchline with no dangling lines or wires prone to tangling. The pull from a hooked fish releases and opens the pod which deploys two thin chains around the hooked fish. The effect of these devices on CPUE in both studies was broadly similar, especially for the pod equipped branchlines. Significantly higher catch rates were noted for bigeye tuna, pomphret (*Eumegistis illustris*) and eight other frequently caught fish species. Depredation by sharks and in particular, the cookie cutter shark (*Isistius brasiliensis*) was also noted to decrease for gear protected catch. Low numbers of odontocete depredation were noted in the Australia-Fiji study but only on unprotected control branchlines, suggesting the mitigation devices may be having some positive, protective role. However, the rate of odontocete interaction was too low to allow a statistically significant analysis.

The Hawaii study was designed to evaluate the efficacy of a modular, manufactured device (the pod) compared to simple wire or monofilament devices constructed on the vessel of inexpensive materials. These objectives highlight the problems and issues that deploying these gears face. In order to be effective, a catch shielding device will need to be deployed on every branchline unless an observed spillover effect is realized that extends to adjacent branchlines. The gear should ideally be easily constructed or inexpensive to purchase, compact for storage, not prone to tangling, be easily and quickly deployed or removed from the gear, not add greatly to the storage area needed in the branchline baskets and not negatively impact target catch rates. Most of these conditions were not met by the experimental gear that required considerable storage space on already crowded vessels and could cause tangling in the branchline baskets or when deployed.

Some shielding gear slowed sink rates which can increase bait depredation by seabirds while some gears required an extra deck hand to deploy, remove and store the gears creating additional burden to overall costs and accommodation space. Economic losses to the fishery can periodically be high due to depredation but the fishing industry appears at this time to be willing to bear that expense rather than adopt these gear-based solutions to mitigate a relatively rare interaction event.

2.4 Line cutter devices

Hawaii pelagic longline fisheries must comply with numerous federal regulations and conditions to mitigate protected species interactions (50 CFR 665 Subpart F). A suite of gears are required to be carried onboard to deal with hooking or entanglement of sea turtles, including long-handled line clippers and dehooking gear. The deep-set fishery operating north of 23° N latitude is also required to equip branchlines with a 45 g weight within 1 meter of each hook to reduce seabird bait depredation when setting gear. The majority of gear in the deep-set fishery deploys baited circle hooks rigged on a short steel wire trace of < 1m that attaches to a 45 g leaded swivel that attaches to the remaining branchline consisting of monofilament with a diameter/thickness of 2.0 mm or larger.

The long-handled line cutters currently approved for the fishery are not capable of severing wire trace and severing the monofilament above the 45 gram, leaded swivel is not desirable as it releases the animal with the hook, wire trace and weighted swivel still attached, hence the support for a hook-straightening protocol designed to release bycaught cetaceans with no hook or trailing gear. Efforts to develop an improved line cutting device have been supported by the 2019 NMFS Bycatch Reduction Engineering Program (BREP) that funds research to develop technical solutions and improved practices to reduce bycatch impacts on federally managed fisheries. A device has been designed that will clip to and slide down a branchline that is capable of easily severing wire leader used in the fishery. A prototype device was tested on a commercial longline vessel where 14 incidentally caught blue shark (*Prionace glauca*) were released in good condition by severing of wire leader close to the hook (McMahan 2021 pers. comm.). Currently, the device remains in prototype form.

The need for such a powerful device may become unnecessary considering a move by the industry to switch to all monofilament leaders. HLA, which represents the majority of effort in the Hawaii pelagic longline fishery, announced that members will transition to monofilament leaders in 2021 (HLA 2020) (Ayers and Leong 2020). The proposal is non-binding, but efforts to implement this change within a federal regulatory framework are in progress. A shift to monofilament increases the possibility of cutting the leader close to the hook with simple long handled devices but a danger of gear flyback and injury of the crew remains. HLA has noted the importance of this issue and the need to develop gear and release protocols that consider crew safety as a priority.

2.5 Weak circle hooks

The use of "weak circle hooks" paired with relatively strong branchlines have been trialed and used as a strategy to release a larger non-target species of interest (e.g. odontocete) while retaining smaller target species, often bigeye or yellowfin tuna (Clarke, 2014, Swimmer, 2020). The intent is for hooks to straighten and release non-target species that are free of hooks or trailing gear. Longline hook strengths were evaluated in the Atlantic as a means to reduce interaction impacts to Atlantic pilot whales (Bayse and Kerstetter 2010). That study tested 16/0 strong and weak hooks, finding no significant difference in CPUE or weight of yellowfin and bigeye tuna taken by the weak hook type. The weak circle hook strategy was evaluated in the Gulf of Mexico yellowfin fishery to reduce unwanted bycatch of much larger Atlantic bluefin tuna (*Thunnus thynnus*) with promising results. The study found no significant CPUE difference in target yellowfin tuna and most finfish species examined while bluefin tuna catch was significantly reduced by 56.5% with weak hooks (Bigelow et al 2012, Foster and Bergmann 2010). As a result, the use of weak circle hooks is required for domestic pelagic longline vessels operating in the Gulf of Mexico (https://www.federalregister.gov/citation/76-FR-2313).

A similar study in the Hawaii deep-set bigeye tuna fishery evaluated catch rates of "strong" 15/0 circle hooks (4.5 mm wire diameter) against "weak" 15/0 hooks of 4.0 mm wire diameter (Bigelow et al 2012). Catch rates of the targeted bigeye tuna were not significantly reduced on the weak hooks though the sea trials were not conducted during the period when larger bigeye tuna occur in the fishery. Observers engaged in the study collected 76 hooks that had been straightened, of which 6 were strong and 70 of the weak hook type. One strong circle hook was observed to have been straightened by a false killer whale depredating bait during line retrieval resulting in its release. Fish catch were retained on 27 partially straightened weak hooks including 21 bigeye tuna, four blue marlin, one yellowfin tuna and one bigeye thresher shark suggesting the weak hooks were so weak that loss of target catch could become an issue.

Research has examined the pulling force required to straighten different hook types placed in the soft tissue of the dorsal lip area and mandible bone of odontocete cadavers (short-finned pilot whales (*Globicephala macrorhynchus*), Risso's dolphins (*Grampus griseus*), and false killer whales (*Pseudorca crassidens*) recovered from stranding events (Mclellan 2015). Five hook types were evaluated that included 16/0 and 18/0 circle hooks of the same model from two different manufacturers (4 hooks) representing "weak" polished steel and "strong" carbon steel circle hooks. A 9/0 "J" style hook was also evaluated.

The force required to straighten and release the hooks varied considerably by hook size and hook manufacturer, which also correlated with steel alloy type. The 16/0 polished steel circle hooks straightened and released at the lowest forces (51 – 85 kg) while the 18/0 carbon steel circle hooks did not straighten until 132 – 251 kg of force was applied. The polished steel circle hooks straightened along their entire length, exposing the sharpened barb that sliced through the lip tissue to release. The carbon steel circle hooks also straightened along most of their length but the barb often broke off and embedded in the jaw before the hook released. Only the larger 18/0 circle hooks had sufficient gape to encircle and attach to the mandible with pulling force applied to two short finned pilot whales and one Risso's dolphin. Hook straightening and release was achieved at 182 kg and 243 kg but the experiment was suspended in a third trial when straightening and release could not be achieved. In all three trials, bone fractures resulted from the applied force.

The TRP requires the Hawaii deep-set longline fishery to only use "weak" round wire circle hooks with a maximum wire diameter of 4.5 mm paired with a "strong" monofilament branchline with a minimum diameter of 2.0 mm with a point offset of 10 degrees or less. Other materials used in branchline composition must have a minimum breaking strength of 181.4 kg (400 lb.). These gear requirements are supported by training and handling guidelines for the captain to direct the crew to apply "active tension" to the branchline in an attempt to apply sufficient pressure to straighten the hook and release the cetacean without hook or trailing gear. There are also requirements for the captain to be notified and come on deck if an interaction occurs to direct the release attempt (77 FR 71260) (Federal Register, 2012).

The use of weak circle hooks has remained the primary regulatory measure to deal with bycaught false killer whales in the Hawaii based longline fishery since the TRP was developed in 2012. During the eight-year period (2013 to 2020), 55 false killer whale interactions with the deep-set longline fishery have been documented by Hawaii Longline Observer Program (HLOP) observers (Fader et al 2021 to 2018, unpublished TRT presentation update). The gear came free on two occasions (3.6%) or the hook broke on one interaction (1.8%) with two incidents not observed or recorded. The overwhelming majority of interactions ended when the branchlines broke (22 times, 40.0%) or were intentionally cut by the crew (23 times, 41.8%) resulting in the animal being freed with the hook in place and trailing variable but often lengthy sections of gear. The mitigation strategy has succeeded on only five occasions (9.1%) with hooks straightening and releasing the animal without hooks or trailing gear.

2.6 Additional measures considered with recommendations for further study

2.6.1 Acoustic-related studies

A number of acoustic strategies to reduce FKW interaction with longline gear have been proposed that include: 1) underwater signaling devices to mask vessels and vessel activity, 2) broadcasting decoy sounds to occupy and distract cetaceans from fishing vessels, 3) using acoustic devices and sound transmission to interfere with cetacean echolocation, 4) use of sonobuoy transmission to track cetaceans useful for fleet avoidance, 5) identifying the exact source of onboard acoustic generation that cetaceans may be keying in on to identify longline vessels, and 6) investigate the acoustic signature of vessels with historically low cetacean interaction to be replicated by other vessels (Gilman, 2006). Considering the intelligent nature of these animals, the likelihood of these approaches producing lasting positive results is likely to be low.

Acoustic detection and visual detection of false killer whales from longline vessels indicates that the animals are most attracted to the vessels when gear and catch is being hauled and this is likely to be when most depredation events occur. Work continues by NMFS in an attempt to identify what acoustic signals may be most important that false killer whales are focusing on when targeting vessels for depredation. This information may be useful to identifying, masking or eliminating mechanical sounds that increase the likelihood of attracting depredating cetaceans.

2.6.2 Move on studies

The nature of the Hawaii tuna longline fishery that targets sashimi grade bigeye tuna held on ice limits the ability of vessels to make lengthy time/area shifts in their operation. Once the first tuna is landed, cleaned and iced the time clock starts that determines how many additional days of fishing can occur before returning to port with the catch in marketable condition. Waiting to set for several days is not an economically viable solution in this fishery, nor is steaming for great distances. However, it may be worthwhile to steam away from a serious depredation event and lose one or two days of fishing.

2.6.3 Catch shielding gear

Various catch shielding devices that deploy a physical or psychological barrier around catch to deter depredation have been trialed on longline gear with mixed results (Clarke 2014, Hamer and Childerhouse 2013). Some degree of depredation reduction on target catch and deterrence of shark depredation, particularly for cookie cutter sharks has been documented (McPherson and Nishida 2010). These gears are simple, easily constructed and inexpensive but can become bulky and tangle in branchline storage bins or when deployed. The storage of this gear on smaller vessels when not deployed is another issue. Small modular units that store the shielding device until triggered address the storage and tangling issues and can be easily added or removed from longline gear but are costly to produce (Hamer 2019).

In order for shielding devices to be accepted by industry and useful for mitigation of depredation, they will need to be effective, inexpensive, non-tangling, and easily added and removed from longline gear and be compact enough to be stored onboard. The gear should also be easily deployed and not require additional crewmen or overly burden existing crews. Due to issues in meeting these criteria, further trials or research on the efficacy of catch shielding devices have not been proposed or trialed.

2.6.4 Line cutting devices

Further development of a heavy-duty line cutter capable of severing wire trace is likely to be shelved if the Hawaii-based fishery moves to, or is required to adopt, monofilament leader material. If vessels effect this change, severing the leader close to the hook is possible with the required long-handled line cutters that are required to be carried during fishing operations. However, pulling an active false killer whale or other cetacean close enough to cut the line close to the hook will require heavy tension on the line and place the crew in danger from gear flyback when the leaded swivel is cut free. Cutting leader to release bycaught toothed whales is also an issue with the fishery as releasing animals with the hook in the head or mouth and some amount of trailing gear is usually assessed as a mortality/serious injury (MSI) by current NMFS guidelines (NMFS 2012). Cutting the leader in this manner provides little incentive to release cetacean bycatch by cutting the line close to the hook and the issue of gear flyback is also of concern. I n line with TRT recommendations, NMFS will be investigating technical solutions to reducing danger and injury to crewmen from gear flyback when hooks or leaders release under load.

2.6.5 Weak hook mitigation strategy

The CPUE of target and common fish bycatch between "strong" (4.5 mm wire diameter) hooks against "weak" (4.0 mm wire diameter) hooks found no significant reduction in bigeye catch rates with the weaker hook (Bigelow, 2012). However, 70 of the weak hooks tested in the study were retrieved that had been straightened or partially straightened with 27 of these still retaining bigeye tuna or marketable non-target finfish. This suggests that the 4.0 mm wire diameter hook may be too weak and prone to releasing bigeye tuna, particularly since the study did not cover the season when larger bigeye is available to the fishery.

The weak hook strategy currently regulated for the fishery requires the use of a "weak" circle hook of 4.5 mm maximum wire diameter paired with a "strong" branchline (minimum 2.0 mm diameter leader or maximum of 181.4 kg test). This configuration has not proved effective in releasing bycaught false killer whales in the Hawaii deep-set longline fishery. In the period of 2013 to 2020, hooks straightened to release false killer whales during only 5 out of 55 observed interactions (9.1%). The majority of the interactions (81.4%) were terminated when the crew cut the branchline at the rail or the branchline broke when it was secured to the vessel, releasing the animal with various amounts of trailing gear.

NMFS began a study to evaluate circle hook strength in 2021 that is in progress. The study was delayed by two years in part due to issues related to the COVID-19 pandemic. The study is designed to test "strong" circle hooks of 4.5 mm wire diameter against "weak" 4.2 mm wire diameter circle hooks and relatively strong 2.3 mm diameter monofilament branchlines. The study is designed to compare the catch rates and value of bigeye tuna and large, salable finfish taken by the fishery between the strong and weak circle hooks to examine the economic impact of using the weaker hooks. The field trials were timed to occur during months when larger bigeye are available to the fishery. Basically, the study is designed to test the economic impact of adopting a "weaker" circle hook of smaller wire diameter than the currently required 4.5 mm diameter hooks and paired with a stronger branchline.

Fishery participants on the TRT have expressed support for the use of stronger leader and branchline material to facilitate hook straightening, but have opposed any changes to hook strength, while supporting additional crew training, depredation research and examining factors that contribute to serious injury determinations.

2.6.6 Research Discussion

The utility of "move on" studies that recommend lengthy spatial or temporal shifts to avoid FKW interaction are limited due to practical considerations of trip length in relation to catch quality.

Further work with catch shielding devices does not appear promising when considering practical considerations of gear storage, deployment costs and potential for tangling or impacting operations and crew requirements.

The use of acoustic harassment devices is generally regarded as counter-productive due to the dinnerbell effect and promoting targeted depredation. However, there may be some merit in continued research to identify acoustic gear and vessel characteristics or acoustic masking strategies useful to reduce vessel detection and depredation.

The "weak hook" straightening strategy using current gear regulations has not proved useful in releasing bycaught FKW in the Hawaii fishery since the regulated adoption of the weak hook strategy in 2013. In only a handful of cases has the hook straightened to release the animal free of hooks and trailing gear. It has been noted that securing the branchline and applying active tension is highly stressful to the animal and creates a dangerous situation for the crew with potential for gear flyback and can contribute to more serious injuries to the whale if the hook is ingested. The debate continues as to whether the health and condition of false killer whales is improved by cutting the leader as close to the hook as possible or by the current strategy to apply tension on the line in an attempt to straighten hooks.

The impact of different amounts of retained or trailing gear on the post release condition of false killer whales needs to be assessed to better inform and update the process for distinguishing serious from non-serious injury of marine mammals. The guidelines currently in place were developed from a 2007 workshop convened by NMFS and published in a set of procedural directives in 2012 that provides the process and criteria for distinguishing human-caused serious from non-serious injury to marine mammals (NMFS 2012). Under the guidelines for small cetaceans, animals with a hook retained in the head, mouth or ingested is assessed as a serious injury. An interaction with a small cetacean released with trailing gear of varying lengths is generally assessed as a serious injury based in part on Anglis and DeMaster (1998). While removal of the hook is desirable, the relative benefit of reducing stress and injury by leaving the hook in place and removing as much gear as possible with a long-handled cutting device should be evaluated. Research on other protected species such as sea turtles and oceanic whitetip sharks have shown that removal of trailing gear can significantly increase post-release survival (Chaloupka, 2004, Hutchinson, 2021). It is recommended that NMFS devote significant agency resources to research the post-hooking condition and mortality of FKWs and similar odontocetes and the impact of retained hooks and trailing gear on the animal's condition.

The replacement of wire trace with monofilament leaders in the Hawaii deep-set fishery opens up options for new designs of relatively simple line cutting devices compared to a device capable of severing wire trace. The development of improved line cutting gear designed to remove line very close to the hook and the weighted swivel while designed to minimize flyback should be promoted in collaboration with fishery participants. One area of development could be for a small device that could be slid down the branchline to sever the monofilament leader when underwater and close to the hook but below the weighted swivel. Gear spring back should be low if the line is cut underwater. Such a device would also be useful for releasing oceanic sharks with minimal trailing gear.

A hook study is being conducted in 2021 to further inform the "weak hook" strategy and is designed to evaluate the economic cost of target catch retention by different hook strengths. It is possible that a different ratio of hook strength to branchline diameter could provide better results from the current situation. However, other mitigation approaches need to be considered. It should be noted that hook strength and straightening characteristics will vary depending on many criteria such as the steel alloy, hook manufacturer model and shank cross-section type (round or flat) (Mclellan et al 2015). The strength of monofilament leader of the same diameter will also vary by make and type. All available hook and line characteristics should be considered and tested when developing gear-based regulations.

2.7 Recommendations for Action – Operational Measures

Upon review of existing research, the Working Group provides the following recommendations and observations regarding *Odontocete* interactions and fishery impacts:

1. The "move on" strategy where boats travel long distances or wait extended periods after a depredation is inappropriate for a fishery marketing fresh, iced product with limited storage time.

2. Catch shielding gears have many logistical issues related to their storage, potential for tangling and time, and effort required to add or remove gear to mitigate such a rare event.

3. Acoustic deterrents can quickly become ineffective and contribute to the "dinnerbell effect." However, the identification of key acoustic signals that FKWs use to depredate catch should be identified to make a vessel less detectable than others.

4. "Weak hook" mitigation strategies should only be mandated after thorough testing of hook and line strength, target catch retention and thorough training of captain and crews under different hooking scenarios. Emphasis should be placed on gears with standardized characteristics.

5. The utility of severing the branchline close to the hook to leave a minimal amount of trailing line should be further assessed in relation to post-release condition and serious injury determinations.

6. Efforts to develop novel line cutting devices that also protect from gear flyback should be promoted.

3.0 Evaluation of PBR and Serious Injury Determinations as Applied under the MMPA

FKW has a wide geographic range in the Pacific Ocean (Figure 1) and is exposed to anthropogenic hazards such as pelagic fisheries, including the US Hawaii-based deep-set pelagic longline fishery (Anderson, 2020, Fader, 2021). FKWs incidentally caught in U.S. pelagic longline fisheries can die on the gear, or if released alive, sustain serious injuries that might lead to post-release mortality or impaired reproduction (McLellan, 2015, Bradford & Forney 2017). Nonetheless, FKW interactions with U.S. pelagic longline gear in waters around the Hawaiian Archipelago are extremely rare (Figure 2; Anderson 2020). Note, estimates provided are capture estimates and not the MSIs (Bradford and Forney 2017) or so-called “mortality and serious injury” estimate used for PBR risk assessment.

There are three “demographically-independent” FKW populations in Hawaiian waters with limited gene flow between these populations (Caretta 2020, Martien 2019). There are also FKW populations found in U.S. EEZ waters around Palmyra Atoll and American Samoa, which are considered as two separate stocks to the Hawaiian Archipelago stock (Caretta 2020).

There are no demographically based models of FKW population dynamics to help inform bycatch mitigation strategies for any of the 3 FKW “populations” or “management units” exposed to the U.S. Hawaii-based pelagic longline fishery. This is because there is a lack of demographically relevant information available for these FKW populations that hinders the development of evidence-informed bycatch mitigation strategies. Even so, no substantive efforts exist to derive estimates of key demographic parameters such as age class-specific FKW mortality and recruitment rates that are considered essential for the development of risk assessment models for long-lived marine species exposed to anthropogenic hazards in general (Bjorndal 2011) and specifically for marine mammal species (Cáceres and Cáceres-Saez 2013).

This data deficiency is evident not just for FKWs but for cetaceans in general (Baker and Clapham 2004, Mannocci 2012, Cáceres and Cáceres-Saez 2013, Kreb 2020), presumably because of the logistical challenges in deriving robust estimates of key demographic parameters let alone reliable age class-specific abundance estimates.

Given these data deficiencies, the question now exists about how best to address FKW bycatch mortality. Several so-called “sparse-data” methods have been proposed to help determine population-specific bycatch mortality limits for marine mammal species, including: (1) potential biological removal (PBR), (2) depletion-corrected average catch (DCAC), (3) replacement yield (RY), and (4) a metric based on the slope of an observed relative abundance trend (Punt et al

2021a). Punt et al (2021a) concluded that PBR was no worse for use than the other three data-limited methods.

3.1 Potential Biological Removal Concept

The PBR method is commonly used for marine mammal and seabird risk assessments given sparse demographic data (Marsh 2004, Robards 2009, Dillingham and Fletcher 2011, Lonergan 2011, Mannocci 2012, van Der Hoop 2013, Carettta 2020, Kreb 2020, Punt 2020, 2021b). In fact, the PBR method is the approach required by the MMPA for determining the allowable level of human-induced mortality or serious injury for those stocks (populations) subject to management under the US MMPA (Wade 1998, Bradford & Forney 2017).

PBR is a simple form of harvest control rule comprising the product of 3 components: (1) some recent minimum population size estimate (N_{MIN}), (2) an estimate of the maximum intrinsic population growth rate ($0.5*R_{MAX}$), and (3) a recovery factor (F_R) that is assumed in the range $0.1 < F_R < 1.0$ in order to ensure the recovery of any depleted stock (Wade 1998, Punt et al 2020).

Section 118 of the MMPA requires that commercial fisheries "reduce incidental mortality or serious injury of marine mammals to insignificant levels approaching a zero mortality and serious injury rate", where "*insignificant*" has been defined by NMFS as 10% of the species-specific PBR level (50 CFR § 229.2). So, a "*significant*" fishery-related mortality for the stock is then defined as > (0.1*PBR).

Under the MMPA, mammal stocks must be classified as either (1) strategic or (2) non-strategic, where "*strategic*" stocks are those where anthropogenic mortality is "*significant*" or the stock is declining/depleted, or the stock is listed under the ESA. ***Importantly, the mortality levels to be used to define "significant" are supposed to be based on fishery-independent data***.

When the bycatch of a marine mammal population subject to U.S. jurisdiction exceeds PBR, then a TRT is convened to develop a TRP. Further background to the history, development and testing of the PBR concept as prescribed by the MMPA regulatory context can be found in Brandon (2017), Punt (2018) and Punt (2020).

3.2 Estimating a Key Component of PBR

A keystone component of the PBR calculation is an unbiased absolute abundance estimate and its precision to help derive the N_{MIN} (Wade 1998, Punt, 2020). This component is much harder to derive robust unbiased estimates and precision than say the R_{MAX} component that could readily be derived from meta-analytic summary of other studies.

Interestingly, PBR defines the N_{MIN} for the whole stock, not for instance just the adult portion. This is a major deficiency in the model because the immature age classes of long-lived marine mammals or marine turtle species may sustain greater anthropogenic sources of mortality than the reproductive adult portion of the stock (Chaloupka, 2002). The risk depends on the age class- and/or sex-specific exposure to an anthropogenic hazard.

Presumably, to be precautionary, PBR should be calculated for the age class/sex with the greater relative reproductive value. However, the PBR concept assumes all anthropogenic mortality impacts are not age class- or sex-dependent, which is most likely demographically unrealistic in most cases for marine mammals. The question then arises if it is practical to determine age class- and/or sex-specific N_{MIN} even if it isn't an explicit requirement under the MMPA.

Leaving aside the practicality of determining age class- and/or sex-specific, it has been shown recently that age and sex structure of a population can have a significant effect on the PBR level estimate (Punt 2018, Punt 2020), especially if there is sex-biased bycatch mortality (Brandon 2017). Punt (2018) suggests that reducing the recovery factor (F_R) could help account for apparent transient ageclass effects when calculating the PBR but this would be quite an arbitrary application and unreproducible.

Perhaps more practical is the focus on more robust estimates of abundance for each of the three FKW populations exposed to the Hawaii-based pelagic longline fishery. The 2017 NMFS ship-based line-transect sampling efforts were a substantial commitment in this direction for the pelagic and NWHI populations and in the recent 2020 survey for the MHI population as well, although these surveys do not provide age class- or sex-specific estimates of population size.

Importantly, the uncertainty in population size estimates used for the PBR can also bias the PBR level estimate (Punt 2020) further supporting the need for reliable population size estimates to enable application of the PBR concept. In fact, PBR depends on the availability of unbiased and precise absolute abundance estimates, which are often unavailable.

Punt (2021a) have proposed three alternative methods to PBR based on bycatch mortality or so-called "removal" estimates and relative population abundance estimates. However, these methods were found using a simulation-based testing framework to be more affected by parameter uncertainty than PBR and also required precise estimates of bycatch mortality. So, the conundrum continues — PBR and several alternatives depend on either unbiased and precise absolute abundance estimates or precise bycatch mortality estimates. More importantly, PBR does not account explicitly for the long-term population-level consequences of exposure to fishing gear.

3.3 Variations on the PBR Theme

Recent extensions of the PBR method have been proposed such as accounting for indirect bycatch effects (Moore 2013), including depensation effects for depleted populations (Haider, 2017) and application of the PBR concept within a data-quality-dependent tiered system (Brandon 2017).

Punt (2021b) used PBR within a stock assessment framework to evaluate bycatch risk for two species of South American pinniped. Meanwhile, Robards (2009) argued that the PBR concept was not appropriate for risk assessments for the ice-associated pinnipeds such as Pacific walrus in a rapidly changing Arctic environment. Instead, Robards (2009) advocates for consideration of ecosystem-based approaches but readily acknowledge that the MMPA does not make adequate provision for such approaches.

3.4 Marine Mammal Examples of PBR Application

PBR estimates for the Hawaiian FKW populations are provided for instance in Caretta (2020).

Marsh et al (2004) used the PBR concept with empirical estimates of key demographic parameters to assess harvest risk in the Torres Strait (northeast Australia) dugong fishery and concluded that the current harvest rate was unsustainable. Mannocci (2012) used both a deterministic matrix population projection model and PBR to assess common dolphin bycatch risk in the Bay of Biscay (French Atlantic coast) and concluded that estimated bycatch rates posed a significant risk for the long-term viability of these populations.

More recently, Kreb (2020) used PBR to assess the risk of exposure to coastal development (shipping, fishing, oil spillage) on Irrawaddy dolphin populations resident in Balikpapan Bay (East Kalimantan, Indonesia). There was a serious lack of empirical estimates of Irrawaddy dolphin demographic parameters for that study.

3.5 Mortality and Serious Injury Determination

The PBR estimated for each FKW stock exposed to the Hawaii-based pelagic longline fishery comprises not only observed mortalities but also the observed "seriously injured" FKWs (Bradford and Forney 2017). The combined mortality and serious injury metric (MSI) is based on an assumption that FKWs released alive from the longline gear might (1) still die at some later time post-release due to capture-induced injury or (2) suffer ongoing morbidity that could manifest as impaired growth or reproductive capacity.

Post-release mortality (PRM) is a straightforward metric to determine for FKWs captured and released alive from the longline gear as has been done for loggerhead marine turtles exposed to the same fishery (Chaloupka 2004). P RM has not been estimated for any FKW population. PRM is straightforward to estimate but post-release sublethal effects due to various levels of injury are not simple to estimate — and no attempt has been made to derive such estimates for any FKW population. Consequently, current MSI estimates are incomplete, inaccurate and quite vague due to the unreproducible concept of "serious injury" as currently applied. Recently, Punt (2020) using a model-based evaluation of PBR, found that sublethal effects on birth rates in their model scenarios for marine mammals was not likely to impair the recovery of the stock exposed to fishing gear.

Meanwhile, uncertainty in PRM and sublethal effects could be accounted for in FKW PBRs by adjusting the recovery factor (F_R) component of the PBR calculation (Punt 2020). But this is not a principled or reproducible means for accounting for PRM and/or sublethal effects in the determination of the allowable level of human-caused mortality for a FKW population exposed to the Hawaii-based pelagic longline fishery. The SSC previously advised the Council as follows on this issue in 2013:

" … that NMFS consider a team-based determination in the serious injury determination process, especially for data-poor cases, and that NMFS expand the membership of the determination working group to include non-NMFS scientists, cetacean veterinarians, fishery experts and vessel captain and crew, as appropriate, to further improve the clarity and transparency of the process. Furthermore, NMFS should continue to enhance the quality of data collected by observers by improving training to minimize the number of cases that are classified as "unidentified blackfish" or M&SI "cannot be determined (CBD)".

3.6 An Alternative Risk Assessment Framework

As noted above, PBR does not account explicitly for the long-term population-level consequences of exposure to anthropogenic hazards such as pelagic longline gear. A *population consequences of disturbance* (PCoD) conceptual framework has been advocated to assess the likelihood of population-level consequences given marine mammal exposure to anthropogenic hazards (Pirotta 2018). This simple framework comprises a 4-level sequence ranging from observed changes in individual behaviour (level 1) to population-level effects such as impaired reproductive, survival or population growth rates (level 4). Surprisingly, there have been few applications of the PCoD framework to marine mammal risk assessments (Pirotta 2018).

A recent PCoD application is the risk assessment undertaken for the West Australian humpback whale stock exposed to a simulated commercial seismic survey scenario (Dunlop 2021) — they found no evidence that seismic surveys would have an effect on female humpback breeding rates and little evidence that population growth rate would be affected. While not a specific PCoD application, Punt (2021b) nonetheless uses PBR within a simple stock assessment model given data limitations to assess trends in abundance and also population growth rates for 2 pinniped species (level 4 effects).

A PCoD approach to assessing the potential consequences of FKW population exposure to pelagic longline fisheries is needed. Within this conceptual framework, the focus should be on estimating population-level effects on long-term FKW stock viability to better support evidence-informed FKW bycatch mitigation policy. Hence robust and transparent capture-mark-recapture sampling and modelling approaches for the insular FKW population needs to be undertaken to derive reliable estimates of key demographic parameters (survival, breeding, recruitment) and population size. This would support application of rigorous stochastic population dynamic based risk assessment approaches such as proposed by Hilborn and Ishizaki (2013) for the Hawaiian FKW populations (level 4 effects).

3.7 Conformance-based monitoring of FKW captures

PCoD review of the FKW populations is important to derive a robust form of risk assessment. However, it is equally as important to regularly know the long-term status of each FKW population exposed to the Hawaii-based pelagic longline fishery. Conformance monitoring has been advocated at previous SSC meetings as a simple, robust and effective means to monitor and report on protected species bycatch in the Hawaii-based pelagic longline fisheries. Specifically, a statistical process control chart approach using a generalized statistical model for over- or under-dispersed data using the Conway-Maxwell Poisson model (Sellers 2012, Huang 2017) was proposed as shown in Figure 2. The purpose of this device is to:

- identify an anomalous or non-conformance shift or trend in the FKW bycatch time series process (control limits: 2014, 2018)

- help identify an appropriate management response to any bycatch anomalies based on either *k*-sigma- or probability-based control limits

- and to present this information is a simple but robust analytic framework that can be readily updated as new data are acquired sequentially in a comprehensive monitoring program

The process control chart would help to put the annual FKW captures in context with the expected sampling behavior for such a rare event and the current PBR. This could lead to an evidence-informed mitigation response to an identified anomaly. Preferably the control charts would be constructed for specific FKW age classes.

4.0 Summary and Conclusions

Section 118 of the MMPA directs the NMFS to prepare a TRP for each 'strategic' marine mammal stock that interacts with a Category I or Category II fishery. Such plans also may be developed when a Category I fishery has a high level of mortality and serious injury involving one or more marine mammal stocks, even though it does not exceed the PBR of the marine mammal stock.

NMFS uses TRTs to develop recommendations for measures to be included in TRPs, and to monitor the implementation of those plans until NMFS has determined that take reduction goals have been met TRTs are appointed to formulate consensus-based take reduction measures for marine mammals. Since 2018, the TRT formed for FKW has been unable to reach consensus over revised measures to be included in a TRP for the species.

In view of this situation, representatives from the Council's SSC conducted an in-depth review of the best available scientific information to evaluate the status of information pertaining to FKW. Recommendations provided below are intended to help guide future management recommendations made by the Council to NMFS, and to assist parties in formulating measures for inclusion in a TRP for the species.

4.1 Syntheses and Draft Recommendations for SSC

1. FKW are a wide-ranging species in the Pacific Ocean (Figure 1) and are potentially exposed to the risk of capture in pelagic longline fishing gear. FKWs are caught infrequently in that gear (Figure 2).

Recommendation: Develop take reduction measures that recognize the already-low mortality rate of FKW caught in fishing gear.

2. The post-release mortality rate of FKW from fishing gear is presently unknown. Indirect, sublethal effects of capture and release of FKWs that might impair reproductive behavior is also unknown. At-vessel and post-release mortality rates estimates are essential for assessing the risk of FKW expose to the US-based pelagic longline fisheries in the Pacific. Understanding whether there are any meaningful sublethal effects on long-term population viability is also important.

Recommendation: Conduct a post-release study on FKWs using satellite tags or other technology to assess mortality rates and sublethal affects. Develop cost-effective methods to determine robust estimates of sublethal effects attributable to capture and release from pelagic longline.

3. The current risk assessment framework for FKWs caught in the US-based pelagic longline fisheries is based on the PBR. The background to the PBR approach and some recent variants were reviewed. It is clear that the PBR method in any form does not account explicitly for the long-term population-level consequences of exposure to anthropogenic hazards such as pelagic longline gear. It is presently assumed that long-term consequences exist for the FKW populations exposed to longline gear. Available scientific data do not strongly support this assumption. A rigorous risk assessment framework should be established to support an evidence-informed bycatch mitigation policy. Such a framework should assess the demographic consequences of exposing FKW to the longline fishery.

Recommendation: Implement a PCoD, comprised of a 4-level sequence ranging from observed changes in individual behaviour (level 1) to population-level effects such as impaired reproductive, survival or population growth rates (level 4). PCoD review of the FKW populations is important to derive a robust form of risk assessment. However, it is equally as important to regularly know the long-term status of each FKW population exposed to the Hawaii-based pelagic longline fishery. PCoD is a simple, robust and effective means to monitor and report on protected species bycatch in the Hawaii-based pelagic longline fisheries.

4. A stochastic population dynamic-based, risk assessment model does not exist, and could be useful in assessing the applicability of PBR and its variants for bycatch management in the FKW population. PBR is a legal concept provided for under the MMPA. However, the application of PBR to a species such as FKW may not be appropriate, or suffer significant limitations that should be better understood to ensure the results of such analyses are the best available scientific information.

Recommendation: Develop a population dynamic-based model to assess the applicability of PBR for bycatch management. Use the results of such modelling to inform selection of appropriate take reduction measures for the US-based pelagic longline fishery.

5. Management uncertainties and challenges associated with FKW in the US-based longline fishery have not been resolved through a consensus-based TRT process established by NMFS

under the MMPA. Prior scientific recommendations made by the SSC have not been addressed or included in a TRP for FKW.

Recommendation: Make use of the SSC process provided in the Magnuson-Stevens Act to help inform measures considered by the TRT and other parties in formulating a TRP. Subject SSC recommendations and work products to independent scientific peer review in published literature to confirm the validity of such recommendations and work products.

6. It is important to regularly and reliably know the long-term status of each FKW population exposed to the Hawaii-based pelagic longline fishery. Conformance monitoring has been advocated at previous SSC meetings as a simple, robust and effective means to monitor and report on protected species bycatch in the Hawaii-based pelagic longline fisheries. This would lead to an evidence-informed mitigation response to an identified anomaly.

Recommendation: The Council and NMFS should adopt conformance-based monitoring of FKW captures in the Hawaii-based pelagic longline fisheries and report the conformance and any anomalies in the SAFE Report.

7. The economic impacts of current FKW regulatory measures and depredation events on commercial fisheries is not well understood. The costs and benefits of regulatory measures on the commercial fishery should be better understood so that decisionmakers and the public are aware of the impacts of these measures on commercial operations. Conducting baseline economic studies will also help inform future management decisions under the MSA and National Environmental Policy Act.

Recommendation: The Council should undertake a study to assess the economic impacts of FKW regulatory measures on Hawaii-based pelagic longline fisheries and report the results of such studies to NMFS. This study should be updated over time to assess the cumulative impacts of such regulatory measures on commercial fisheries.

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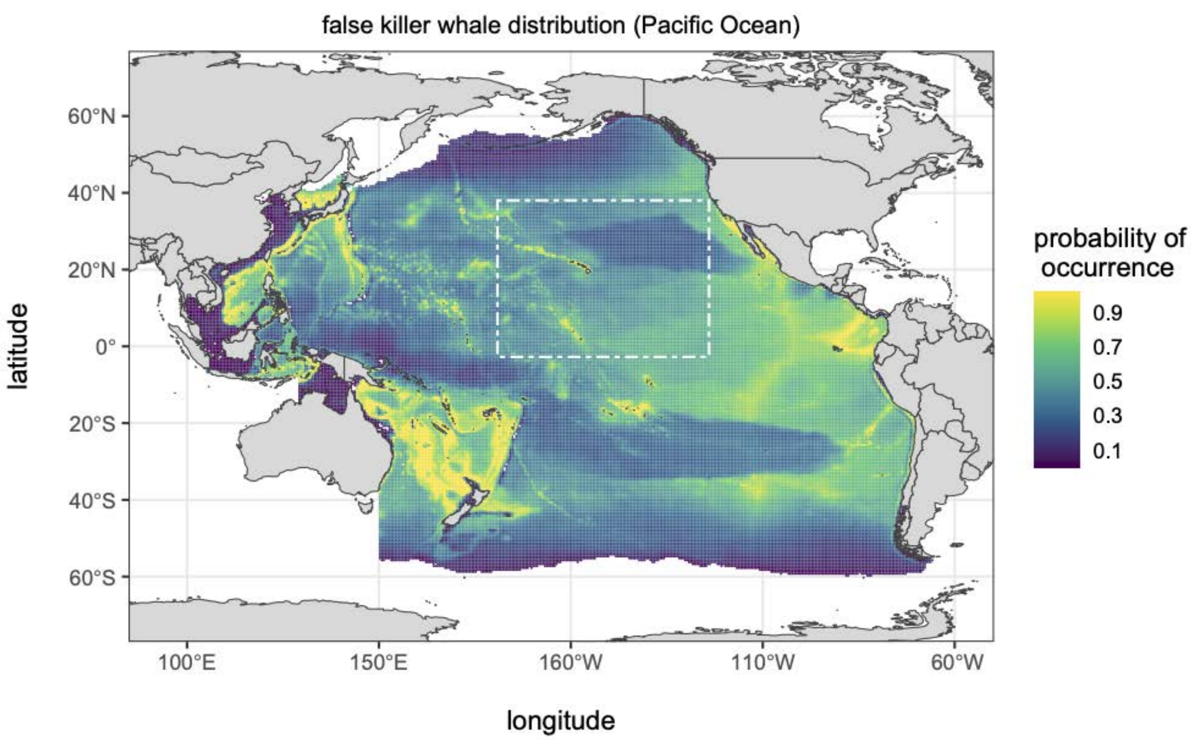

Figure 1 Spatial distribution of the false killer whale in the Pacific Ocean with the probability of occurrence by half-degree cells (data sourced from AquaMaps: Kaschner et al 2006). The white dashed bounding box shows the approximate extent of the Hawaii-based pelagic longline fisheries. It is apparent that FKWs have minimal exposure to the Hawaii-based pelagic fisheries.

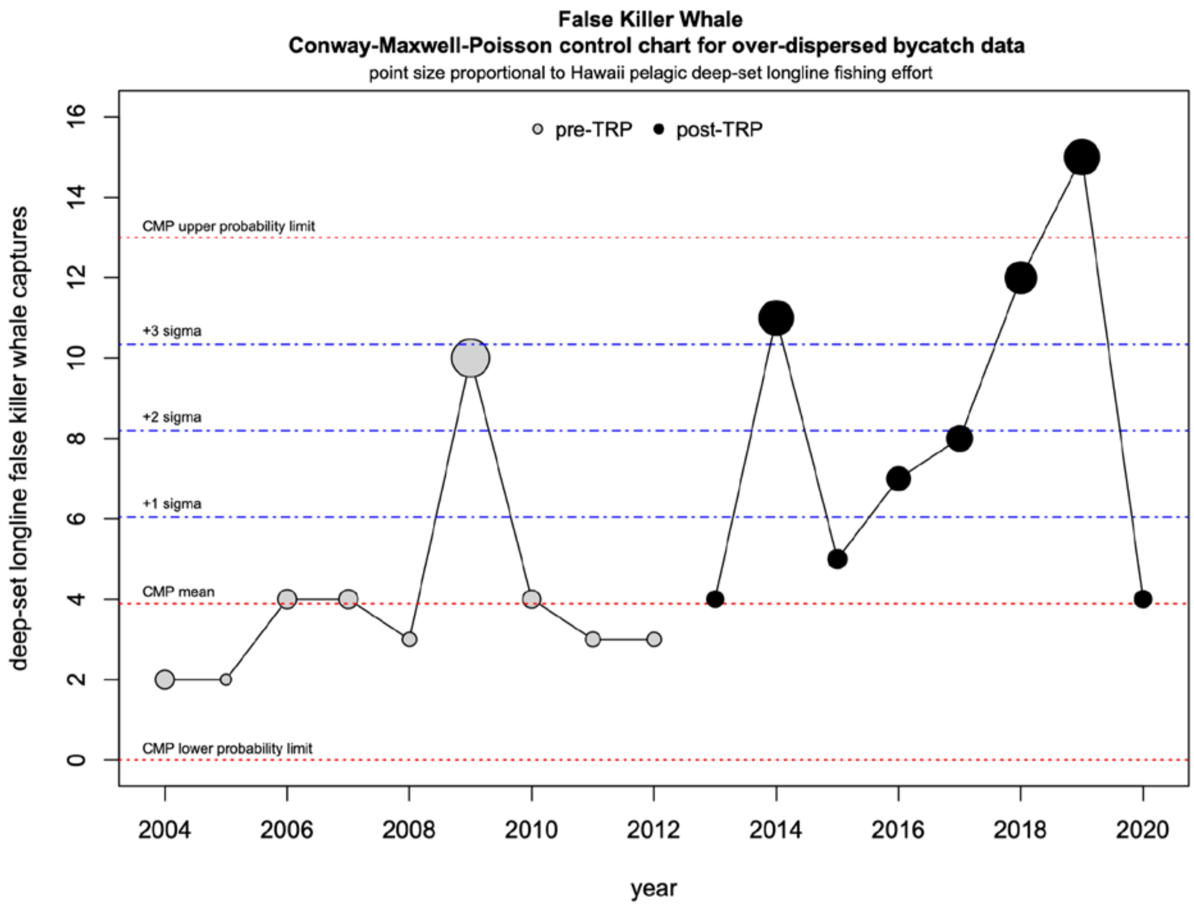

Figure 2 Statistical process control chart for FKW bycatch in the Hawaii-based deep-set pelagic longline fishery (2002 - 2020). Both k-sigma and probability control limits are shown derived from a Conway-Maxwell-Poisson statistical model (Sellers 2012, Huang 2017) fitted to the over-dispersed FKW bycatch time series prior to the TRP (2013). It was apparent that 2014, 2018 and 2019 were anomalous bycatch years based on a 3-sigma control limit while 2019 was an anomalous bycatch year based on an upper probability-based control limit. Those anomalous years were also the years with the highest FKW CPUEs (fishing effort proxy). The expected Conway-Maxwell-Poisson mean estimated for the 2002-2012 or pre-TRP series was ca 4 FKWs per annum. Data sourced from WPRFMC (2019). TRP = Take Reduction Plan.

Appendix 3

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

False Killer Whale Take Reduction Measures

Briefing Document
Prepared for the 128th Scientific and Statistical Committee Meeting and the 172nd Council Meeting

The False Killer Whale Take Reduction Plan (FKWTRP) was implemented in December 2012 to reduce false killer whale interactions in the Hawaii longline fishery. Take reduction plans are required under the Marine Mammal Protection Act (MMPA) when, among other conditions, the mortality and serious injury (MSI) levels of a marine mammal stock exceed the potential biological removal (PBR)[1] estimated in the MMPA Stock Assessment Report (SAR), and the stock interacts with a fishery classified as Category I or II under the MMPA List of Fisheries (LOF).

The Hawaii longline fishery was first classified as a Category I fishery in the 2004 LOF. At the time, the population estimate of the false killer whale stock around Hawaii was 268 for the entire U.S. EEZ around Hawaii, resulting in a PBR of 1.2, and the MSI was estimated at 4.4. NMFS did not convene a Take Reduction Team (TRT) at first due to funding limitations. In the interim, the Council established a Marine Mammal Advisory Committee (MMAC) in 2005 to explore ways to reduce false killer whale interactions in the Hawaii longline fishery. MMAC met over three meetings between 2005 and 2009, generating recommendations for research and assessments needed to fill the information gaps. NMFS established the FKWTRT in 2010, including representation from the Council, State of Hawaii, federal agencies, academic and scientific organizations, fishing industry, and environmental groups. During the TRT deliberations, the abundance estimate of the pelagic stock of false killer whales was 484, PBR was 2.5, and the mean annual MSI inside the EEZ was estimated at 7.3.

The FKWTRT submitted a draft FKWTRP to NMFS in July 2010. NMFS published a proposed rule based on the team consensus plan in July 2011 and published the final rule in November 2012. The goals of the TRP were to reduce the MSI occurring within the U.S. EEZ around Hawaii to less than the stock's PBR within six months; reduce MSI to below 10% of PBR within five years; and to not increase the MSI on the high seas. The main components of the FKWTRP were the required use of "weak" circle hooks intended to allow release of false killer whales without remaining gear, measures to improve captain and crew response to interactions, modification to the MHI longline exclusion zone established under the Council's Pelagic Fishery Management Plan (FMP; currently the Fishery Ecosystem Plan) in 1992, and a triggered

[1] PBR is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The PBR level is the product of the following factors: 1) the minimum population estimate of the stock; 2) one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and 3) a recovery factor of between 0.1 and 1.0.

Southern Exclusion Zone closure that would prohibit fishing in a portion of the U.S. EEZ around Hawaii if two false killer whale interactions inside the EEZ resulted in a MSI determination in a year.

The FKWTRP has been in place for five years. The TRT will meet on April 10-13, 2018 to review the status of TRP implementation and discuss potential modifications to the plan. This document describes the main TRP topics of interest to the Council that is anticipated to be discussed at the upcoming FKWTRT meeting, including topics identified in recent Council recommendations. The Council at its 172nd Meeting will review these topics and provide direction to staff for the upcoming FKWTRT meeting.

Recent Council Actions Regarding the FKWTRP

At its 170th Meeting, the Council directed staff to send a letter to NMFS requesting that it reevaluate the need for the Southern Exclusion Zone (SEZ) closure. In its response correspondence, the Pacific Islands Regional Office (PIRO) indicated that NMFS will fulfill Council's request within the scope of the 2018 TRT meeting through the evaluation of current measures, consideration of alternative measures and review of results from analyses relevant to the SEZ.

At its 171st Meeting, the Council directed staff to work with industry representatives, PIRO and PIFSC to consider alternative approaches to minimize injuries on false killer whales released alive, including considerations for the serious injury determination guideline review, and provide a briefing to the SSC and Council at the March 2018 meeting in preparation for the April 2018 Take Reduction Team meeting. The Council also requested NMFS to consult with the Council in its current serious injury determination guideline review process and requested NMFS to provide a presentation of the review at the March 2018 SSC and Council meeting. The serious injury determination guideline is described in NMFS Policy Directive 02-038 and associated process, which provides the basis for determining whether a marine mammal interaction is counted against the PBR. In their responses, PIRO and the Pacific Islands Fisheries Science Center (PIFSC) indicated that the review of the serious injury determination policy was initiated in 2017 but has been postponed due to staffing changes. NMFS does not yet have a revised timeline for the review, but indicated that it is unlikely that enough progress will have occurred to present on the review at the March 2018 SSC and Council meetings.

Abundance and PBR Estimates of the Pelagic False Killer Whale Stock

NMFS recognizes four false killer whale stocks around Hawaii in the draft 2017 SARs: pelagic, main Hawaiian Islands insular, Northwestern Hawaiian Islands, and Palmyra stocks. The primary focus of the FKWTRP is the pelagic stock, which is a transboundary stock ranging inside and outside of the U.S. EEZ around Hawaii with an unknown outer extent on the high seas.

At the time of the FKWTRT deliberations in 2010, the abundance estimate of the pelagic stock of false killer whales within the EEZ was 484, based on a reanalysis of the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) data. The resulting PBR was 2.5, and the mean annual MSI inside the EEZ was estimated at 7.3.

The 2010 HICEAS resulted in a higher abundance estimate of 1,540 pelagic false killer whales inside the EEZ, resulting in a PBR of 9.3. These estimates became available after the initial deliberations of the FKWTRT in 2010 but before NMFS published the final rule to implement the FKWTRP. At the time of the FKWTRP implementation in December 2012, the 5-year mean annual MSI for the pelagic false killer whale stock was 13.6 individuals inside the EEZ, and 11.2 on the high seas.

According to the draft 2017 SAR, the current 5-year (2011-2015) mean estimated annual MSI is 7.5, and the mean estimated annual MSI since the TRP implementation (2013-2015) is 4.1. These estimates indicate that the current MSI levels of pelagic false killer whale stock are below the PBR.

NMFS also conducted the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) in 2017, which is expected to result in a new abundance estimate and PBR. However, these updated estimates are not likely to be available prior to the April 2018 FKWTRT meeting.

MSI Estimates on the High Seas Portion of the Pelagic False Killer Whale Stock

The FKWTRP primarily focuses on reducing MSI within the U.S. EEZ around Hawaii. The range of the pelagic false killer whale stock extends outside of the EEZ, but there is no abundance estimate for the portion of the pelagic stock on the high seas, and thus PBR is not estimated for the high seas portion of the stock. The FKWTRP included a goal that the incidental MSI of the pelagic stock does not increase above the 2012 level when the plan was implemented (11.2 per year).

The current 5-year mean estimated annual MSI for the high seas portion of the pelagic stock is 15.2 false killer whales, and the mean estimated annual MSI since the TRP implementation in 2013 is 21.2. Given the higher estimated MSI on the high seas compared to 2012, the FKWTRT is expected to discuss this issue at the April 2018 TRT meeting.

The Hawaii deep-set longline fishery has expanded over the past two decades, with increasing effort (hooks set) and expansion of spatial effort to the north and east of the main Hawaiian Islands over time. The MSI estimates in the SAR are based on the number of interactions, and does not consider interaction rate. Given the greater effort on the high seas over time, an analysis to determine the extent to which change in effort has contributed to the higher MSI estimates on the high seas would be warranted.

Southern Exclusion Zone

The SEZ encompasses approximately 132,000 square miles of the southeastern portion of the EEZ around Hawaii, bounded on the east at 154° 30′ W. longitude and on the west at 165° W. longitude (Figure 1). The SEZ closure was initially conceptualized when the abundance estimate of the pelagic stock was 484 and the potential biological removal (PBR) was 2.5 false killer whales per year. At the time, one observed MSI in the EEZ would result in an estimated total MSI of approximately five false killer whales for the fleet (based on approximately 20 percent observer coverage), exceeding the PBR. As such, a contingency plan was considered necessary to minimize the potential for additional false killer whale interactions in the EEZ. The area for the SEZ was selected on the basis that the area contained a higher proportion of false killer whale interactions compared to other areas within the EEZ.

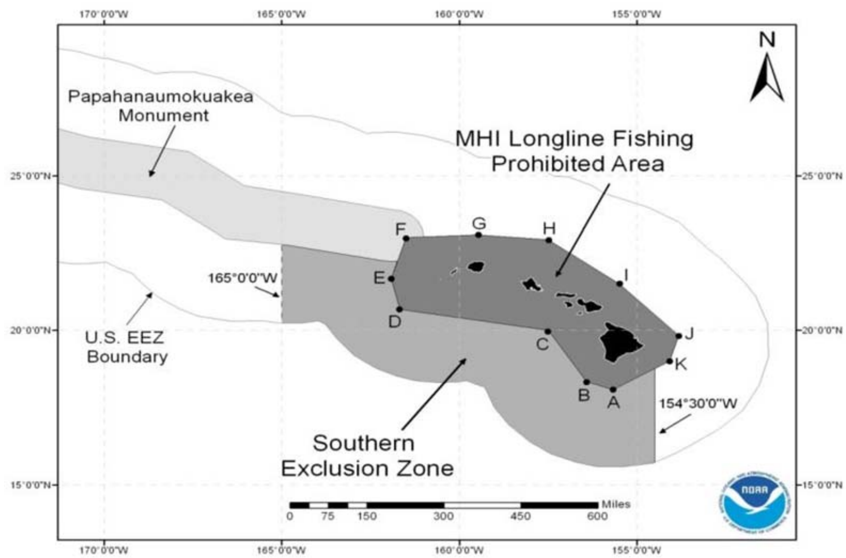

Figure 1. Map of the Southern Exclusion Zone at the time of the TRP implementation in December 2012.

The circumstances surrounding the Hawaii deep-set longline fishery has changed since the initial deliberations of the TRT. The current PBR of the U.S. EEZ portion of the pelagic false killer whale stock is 9.3, based on an abundance estimate of 1,540 resulting from the 2010 stock assessment survey. According to the draft 2017 SAR, the current 5-year (2011-2015) mean estimated annual MSI is 7.5, and the mean estimated annual MSI since the TRP implementation in 2013 is 4.1. These estimates indicate that the current MSI levels of pelagic false killer whale stock are below the PBR.

Additionally, of the 35 false killer whale interactions observed in the Hawaii deep-set longline fishery since 2013, seven were observed inside of the EEZ, of which four resulted in serious injury determinations that counted against the SEZ trigger. These interactions inside the EEZ resulting in MSI determinations occurred in 2013, 2014, 2016, and 2017, with one MSI per year when observed, thus the SEZ closure has not been triggered since the TRP implementation in 2012. Further, of the 35 false killer whale interactions since 2013, only three have been observed within the SEZ area, suggesting that the likelihood of an SEZ closure preventing additional false killer whale interactions within the area is low.

The proportional impact of a SEZ closure on the area within the EEZ open to the Hawaii longline fishery has also changed substantially since the TRP implementation. When the TRP was implemented in December 2012, the SEZ encompassed approximately 18 percent of the 723,000 square miles available to longline fishing within the EEZ. However, the expansion of the Papahanaumokuakea Marine National Monument in 2016 resulted in approximately 70 percent of the U.S. EEZ around Hawaii (approximately 677,000 square miles of the total 958,000 square miles of EEZ) being closed to the Hawaii longline fishery year-round, reducing the area within the U.S. EEZ open to fishing operations without the SEZ closure to approximately 280,000 square miles. This area within the EEZ remaining open to the Hawaii longline fishery without the SEZ closure is less than half of the area that was intended to remain accessible inside the EEZ with the SEZ closure when the TRP was implemented (approximately 591,000 square miles, or 61.7 percent of the EEZ) (Table 1). Further, if the SEZ closure is triggered under the current management scenario with the expanded monument, the area accessible to the Hawaii longline fishery inside the EEZ will be reduced from 29.2 percent to 17.8 percent of the EEZ (Table 1). Additionally, the full extent of the U.S. EEZ around Johnston Atoll was closed to commercial fishing in 2014 with the expansion of the Pacific Remote Islands Marine National Monument, further reducing U.S. EEZ areas where the Hawaii longline fishery can operate without foreign competition.

The FKWTRT has discussed whether the potential for a SEZ closure has influenced fleet behavior, and in particular whether vessels with observers avoid fishing inside the EEZ to avoid triggering the SEZ. PIFSC is currently conducting an analysis to examine the influence of the SEZ measure on the spatial distribution of effort by comparing the proportion of longline effort inside and outside the EEZ for both observer and logbook data. The results of this analysis are expected to be presented at the April 2018 TRT meeting.

Table 1. Areas and percentages of the EEZ around Hawaii remaining open to the longline fishery with the SEZ closure before and after the 2016 monument expansion.

Area	TRP Implementation in 2012	Post-Monument Expansion in 2016
Approximate area within EEZ open to Hawaii longline fishery without SEZ closure	723,000 sq. miles	280,000 sq. miles
Approximate area for SEZ closure	132,000 sq. miles	110,000 sq. miles*
Approximate area within EEZ open to Hawaii longline fishery with SEZ closure	591,000 sq. miles	171,000 sq. miles
Percentage of the EEZ remaining open with SEZ closure**	61.7%	17.8%

* The SEZ area between 163W and 165W overlap with the expanded monument area, which is now permanently closed to the Hawaii longline fishery; thus the effective SEZ closure area after the monument expansion is smaller than the actual SEZ area.
** The total U.S. EEZ area around Hawaii is approximately 958,000 square miles.

Gear and Handling Approaches to Minimize Injury to False Killer Whales

The Hawaii deep-set longline fishery is required under the FKWTRP regulations to use "weak" circle hooks, defined as circle hooks with wire diameter equal to or less than 4.5 mm. The measure also requires that monofilament leaders and branchlines are a minimum of 2.0mm in diameter to ensure that the hook becomes the weakest point in the branchline. The TRP, its implementing regulations, or the associated marine mammal handling and release informational placard do not provide specific guidance on how to handle the gear when a false killer whale is hooked that would maximize the potential for the hook to straighten.

The success rate of a weak hook straightening has been low. Of the 35 observed false killer whale interactions since the implementation of the TRP gear requirements, four interactions resulted in the hook successfully straightening and releasing the animal without remaining gear. Additionally, 10 interactions resulted in the line breaking, and 11 interactions resulted in the line being cut. In the initial years, a large proportion of the observed interactions resulted in the animal released alive with trailing gear due to crew cutting the line without attempting to straighten the hook. In response, the Hawaii Longline Association in collaboration with the United Fishing Agency and the Council produced a short video and implemented an outreach program in 2015 targeting vessel captains. The video emphasized the importance of attempting to straighten the hook and suggested tying off the mainline to a cleat and using the vessel as leverage to create sufficient tension. However, outcomes vary even when crew have tied off the line and created tension using the vessel.

The TRT placed emphasis on removing all gear from the animal as the primary strategy for reducing impacts to false killer whales due to the current serious injury determination guidelines. Serious injury is defined in regulations as any injury that will likely result in mortality, which NMFS interprets in its Policy Directive 02-038 as any injury that is "more likely than not" to result in mortality, or any injury that presents a greater than 50 percent change of death to a marine mammal. The serious injury determination guidelines for small cetaceans specify that any gear remaining in the head region of the animal would be considered a serious injury. In most false killer whale interaction cases, the hooking occurs around the mouth as the interactions are likely a consequence of a failed depredation attempt on bait or catch. At the time of TRT's initial deliberations in 2010, approximately 90 percent of observed interactions since 1994 had been classified as resulting in serious injury. Given that the TRT did not identify a viable technical solution to reduce the number of interactions by preventing hooking events, reducing the proportion of interactions resulting in serious injury determinations became the focus for reducing the MSI levels below PBR.

Potential next steps to further minimize injury to false killer whales through gear and handling approaches are discussed below.

Additional Modification to Gear Requirements

The FKWTRT has discussed further gear modifications to ensure the hook is the weakest point in the gear and to increase the chances of the hook straightening without breaking the line. Examples include the use of stronger monofilament branchlines and specification of hook material. However, the conditions under which the hook straightens depends on a complex combination factors, including hook material, hook strength, branchline strength, gear condition, false killer whale behavior during interaction, and crew response. As such, strengthening the gear alone is not likely to lead to a substantially higher success rate in hook straightening.

Increase Outreach to Captain and Crew on Handling Approaches

The industry-led outreach effort implemented in 2015 targeted vessel captains. This outreach effort could be expanded to crew by making the materials available in the applicable languages and distributing the instructional materials to all vessels. While the 2015 outreach effort recommended tying off the mainline to a cleat and using the vessel to create sufficient tension on the line, crew continue to pull the line by hand in majority of the cases. Thus, additional outreach to crew and a follow-up effort to captains may be warranted. However, as in the case of gear modifications discussed above, crew response and handling alone do not determine the outcome of an interaction and hook may not straighten even when recommended procedures are followed.

Shift Focus to Minimizing Trailing Gear and Reducing Interaction Time

Most of the interactions since the TRP implementation that did not result in the hook straightening or the animal freeing itself has resulted in the animal released with some amount of trailing gear from line breaking or line being cut. In most of these cases, the remaining gear consists of the hook, weight, wire leader, and some length of the monofilament branchline. Due to the emphasis on straightening the hook and the current guidelines that lead to serious injury determinations if the animal is released with any amount of gear remaining, captain and crew have not been instructed to minimize trailing gear. Additionally, the Hawaii deep-set longline fishery uses wire leaders in the terminal gear, making it difficult to cut the line above the hook.

Species-specific post-hooking survival data for false killer whales interacting with longline fisheries are not available. However, it is reasonably likely that the survival rate of false killer whales released with hook only would be higher than those released with trailing gear consisting of a wire leader, weight, and monofilament line. As such, shifting the focus to the development of a mechanism to cut the wire leader above the hook or other mechanism to remove trailing gear may minimize injury to the animal. Further, such a mechanism may also be beneficial in minimizing trailing gear for other species groups that are not retained in the fishery and are not brought aboard the vessel for dehooking, such as sharks and leatherback turtles. A cross-species application of such a mechanism would likely result in high success rate in removing trailing gear from false killer whales, as captain and crew would gain experience cutting the wire on shark species that are more commonly captured in the fishery. A mechanism that would allow quick removal of gear may also reduce interaction time for false killer whales, minimizing the potential for capture myopathy.

A mechanism to minimize trailing gear would need to be implemented with a revised serious injury determination guideline that recognizes the reduced post-hooking mortality rate with the removal of trailing gear. Without a change in the guidelines, captain and crew will have limited incentive to adopt new handling techniques to minimize trailing gear.

Shift Focus to Reducing False Killer Whale Interactions

The FKWTRP focused on reducing the proportion of interactions resulting in serious injury determinations due to the lack of viable technical solutions to reduce the number of interactions by preventing hooking events. Recognizing that false killer whale hooking events are associated with depredation events, the Hawaii Longline Association in collaboration with the Council, PIFSC and other researchers conducted field trials of devices designed to deter catch depredation. Preliminary results indicated that the devices had limited impact on fishery operations and may provide additional benefit by reducing cookie cutter shark damage on catch. Detailed statistical analysis of the field trial data is ongoing. Due to the relatively rare nature of depredation events, the trial in the Hawaii longline fishery did not test the effectiveness of the device in reducing depredation, but previous trials conducted in Fiji showed lower depredation rates on hooks with deterrent devices.

The deterrent devices tested to date are designed to release a chain mechanism triggered by the tension of a caught fish, and the chain surrounds the catch to prevent marine mammal depredation. False killer whales are known to depredate on catch and bait in the Hawaii longline fishery, but a catch-triggered deterrent device is not likely to protect against bait depredation. It is also unknown whether false killer whales become accidentally hooked while depredating on bait or catch. Nevertheless, further development and testing of depredation deterrent devices may be warranted, especially if such devices provide additional incentives to fishermen through reduced catch damage from marine mammals and sharks.