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2ND CIRCLE HOOK WORKSHOP

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SEA TURTLE BYCATCH MITIGATION AND CIRCLE HOOK WORKSHOP REVIEW DOCUMENT

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EXECUTIVE SUMMARY

This document provides background information for fulfilling the recommendations of the 1st and 2nd Ecosystem and Bycatch Working Groups (EBWG) to the Inter-American Tropical Tuna Commission (IATTC) to conduct a second sea turtle bycatch mitigation and circle hook workshop to address mandates in Resolution C-19-04. The Reoslution which requires shallow-set longline vessels to adopt one of three bycatch mitigation measures: using large circle hooks, using only finfish bait, or implementing an alternative measure approved by the Commission requires clarification on the minimum size of what qualifies as a large circle hook. Here we review the results and stated next steps from the previous workshop for lessons learned, provide updated data towards understanding the cross taxa impacts of circle hooks of different sizes, provide a thorough review of alternative mitigation measures for sea turtle bycatch, and improve the best handling and release practices guidelines for vessels fishing in a shallow-

set manner (<100m).

INTRODUCTION

This document aims to provide the background information to successfully meet the recommendations of the 1st and 2nd Ecosystem and Bycatch Working Group (EBWG) that requested a second sea turtle bycatch mitigation and circle hook workshop be conducted to fulfill the mandates of Resolution C-19-04 paragraph 3(d)(i) – (iii):

"Require owners/operators of longline vessels fishing in a shallow-set manner (<100m) to employ at least one of the following mitigation measures:

i. Use only large circle hooks

ii. Use only finfish bait, OR

iii. Another mitigation measure to reduce sea turtle bycatch that has been approved by the Commission. A proposal for such a measure shall be submitted to the Bycatch Working Group at its meeting in the year prior to desired implementation, for review and potential recommendations to the Scientific Advisory Committee (SAC) and approval of the Commission."

And 4(c) which states:

"The Bycatch Working Group shall prioritize the identification and assessment of new scientific information regarding sea turtle bycatch mitigation and recommend, if needed, additional measures to the Commission that would strengthen this resolution. By 2021, the Bycatch Working Group and SAC shall analyze scientific information regarding different circle hooks sizes and their effectiveness at mitigating sea turtle bycatch (decreasing catch and increasing post-release survival) and provide a recommendation to the Commission for a minimum hook size as well as a schedule for implementing this recommended minimum hook size through a revision to this resolution."

To meet these recommendations, the 2nd Sea Turtle Bycatch Mitigation and Circle Hook Workshop aims to review the best available scientific information regarding different circle hook sizes and their effectiveness at mitigating bycatch and optimizing target species catch rates with the overarching goal of identifying and recommending a minimum circle hook size to complete Resolution C-19-04, paragraph 4.c. The workshop plans to build upon the results of the first workshop for CPCs to consider potential adjustments to Resolution C-19-04, while also evaluating their durability across manufacturers, exploring additional mitigation measures, and improving the best handling and release practice guidelines for shallow-set longline fisheries. This document seeks to support the workshop in their effort to establish clearer guidelines and practical solutions to enhance bycatch mitigation while maintaining sustainable fishing practices in the eastern Pacific Ocean (EPO) by reviewing all relevant data to the workshops objectives.

Per IATTC process, results from this workshop will be shared at the third EBWG meeting in May 2025. Ideally, the EBWG and the SAC will provide a recommendation to the Commission for a minimum hook size, potentially through a revision to Res C-19-04. With regards to the need to identify a schedule for implementation, this will not be addressed at this workshop, but rather will be discussed at the upcoming meeting of the EBWG in 2025.

1.1. Summary of the 1st Circle Hook Workshop

The 1st Circle Hook Workshop was hosted by the IATTC Bycatch Working Group Co-Chairs (Yonat Swimmer and Manuel Correia) and held by videoconference in March 2022. The workshop aimed to provide overviews of ecosystem-level concerns and potential trade-offs regarding expanded use of circle hooks in longline fisheries, as well as to investigate potential impacts of gear types on various taxa. In addition, the goal was to agree upon an adequate minimum width for the 'large' circle hook size designation that would meet the goals of the Resolution, which was not met.

The Workshop included extensive summaries and literature sources regarding the impacts of different hook types on both bycatch and target species. Presentations were made to include impacts on vulnerable taxonomic groups such as elasmobranchs (sharks and rays), seabirds and sea turtles. Overall, the conservation benefits of a large circle hook for all taxa were discussed, including the difference in interaction rates of sharks, which were offset by biteoffs, increased rates of at-vessel and post-release survival. Concerns were raised over the loss of target species catch particularly in small-scale, mahi mahi (dorado) fisheries, and that efforts should be taken to identify a hook or best handling and release practices to minimize negative impacts to commercial operations in the Eastern and Pacific Ocean (EPO). Overall, a recommendation was made to encourage the use of larger circle hooks where possible, yet more work was required to identify a means to minimize the economic impacts that use of large circle hooks may pose on small-scale fisheries and a minimum width recommendation was not made.

As stated in the Chair's Report of the workshop summarized text, "Conservation measures should seek to strike a balance between the objective of protecting sea turtles, seabirds and sharks and the socioeconomic needs of the fishing industry. For example, larger hook sizes may impede the effective capture of target species in certain fisheries (e.g., dorado/mahi mahi), for which a more targeted or differentiated approach to management would be appropriate". Much of the motivation for the current workshop is generated from this need. In addition, the role of training fishers in best handling and release practices is also highly valuable and with significant conservation gains. As such, summarized text indicates: "Use of best practices and trainings with industry should be encouraged and supported. For all vulnerable species, use of best handling practices is critical to increase an animal's probability of survival after a fisheries interaction. In particular, safely removing hooks, and where hook removal is not possible, removing as much of the line as practical, are important to reduce severity of injury and improve animal's likelihood of survival."

1.2. Objectives for the 2nd Sea Turtle Bycatch Mitigation and Circle Hook Workshop

The 2nd Workshop aims to identify a path forward in our efforts to balance conservation and exploitation of marine resources, including reinforcing the role of best handling and release practices. In addition, this will provide an opportunity to discuss potential for a more targeted or differentiated approach to management, including the idea of a potential "carve out" or exemption for certain target species or fisheries. Based on discussions and presentations from the first workshop, the specific objectives for this second workshop as requested by the EBWG2 are as follows:

I. Define the size characteristics that qualify as a 'large' circle hook (Resolution C-19-04, Paragraph 3(d)(i)).

II. Review of the impacts of fishing operations on the form and structure (i.e., longevity and integrity) of circle hooks of various sizes and from different manufacturers.

III. Develop a third mitigation measure as described in Paragraph 3(d)(iii) of Resolution C-19-04 for small coastal multi-species vessel fleets

IV. Update best handling and release practice guidelines for shallow-set fisheries

2. DATA REVIEW TO ACHIEVE WORKSHOP OBJECTIVES

This section summarizes the available information on sea turtle bycatch mitigation strategies for pelagic longline fisheries. The review covers circle hook size studies, hook configuration and longevity, and provides a thorough review of potential 'third' bycatch mitigation measures besides the use of large circle hooks or finfish bait. Draft best handling and release practice guidelines for incidental sea turtles captured in the shallow-set fisheries are also provided.

2.1. Workshop Objective I. Definition of a 'large' circle hook

2.1.1. Circle hook measurement standardization

The current working definition of a large circle hook as adopted by the Commission in Resolution C-19-04 is: *'defined as a hook with the point turned perpendicularly back to the shank to form a generally circular or oval shape, and the point of the hook not offset more than 10 degrees.'* For the purpose of this Workshop and completion of the Resolution, the aim is to identify a 'large' size, which is best defined by the minimum width and it's associated manufacturer identifier (eg. 16/0). It is well known that hooks can vary slightly in dimensions by manufacturer, and thus we suggest using a standardized measurement convention, as shown in Figure 1A. Table 1 gives standard sizes for circle hooks along with their corresponding approximate minimum width. Hooks may also differ in degree of offset, type of eye, as well as the casting of metals and forging. Figures 1B and 1C illustrate the differences between an unforged (1B: round) and forged (1C: flattened or hammered) hook, which may also play a role in capture rates of varying species, largely as a result of differences in hook breaking-strength (Scott et al. 2022a).

TABLE 1. Circle hook sizes and minimum width dimensions.
TABLA 1. Tamaños de anzuelos circulares y dimensiones de ancho mínimo.

Circle Hook Size	Minimum Width (~cm)
13/0	3.5
14/0	3.8
15/0	4.0
16/0	4.4
18/0	4.9

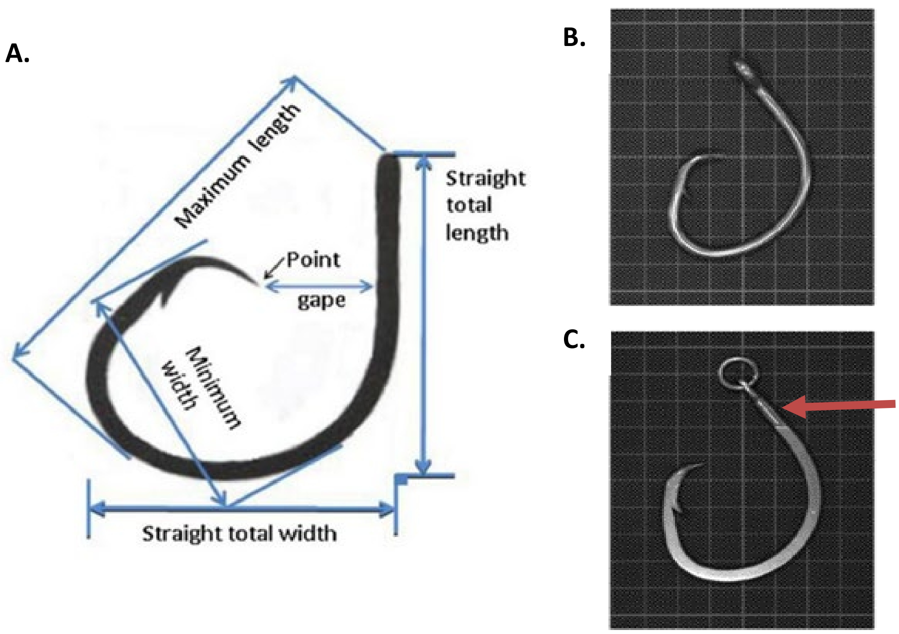

FIGURE 1. Hook anatomy diagram and examples. A. Circle hook measurements diagram identifying where minimum width is measured (From Mituhasi, T., & Hall, M., 2011). B. Image of a round or 'unforged' circle hook. Shank thickness = 4.4 mm, Minimum width = 41 mm, Standardized size = 3 for this hook manufacturer. C. Image of a 'forged' or flattened circle hook. Shank thickness = 5.1 mm, Minimum width = 50 mm, Standardized size = 18/0. Note the round portion of the shank under the hook eye (red arrow) - this is where the shank (wire) diameter is measured for US Pacific Longline regulatory purposes. Below this mark the hook has been flattened (forged) to increase the strength of the hook. B &C From Yokota et al. (2006).

FIGURA 1. Diagrama de la anatomía de un anzuelo y ejemplos. A. Diagrama de las medidas de un anzuelo circular que identifica dónde se mide el ancho mínimo (Mituhasi, T.,y Hall, M., 2011). B. Imagen de un anzuelo circular redondo o "no forjado". Grosor de la caña = 4.4 mm, ancho mínimo = 41 mm, tamaño estandarizado = 3 para este fabricante de anzuelos. C. Imagen de un anzuelo circular "forjado" o aplanado. Grosor de la caña = 5.1 mm, ancho mínimo = 50 mm, tamaño estandarizado = 18/0. Nótese la parte redonda de la caña debajo del ojo del anzuelo (flecha roja): aquí es donde se mide el diámetro de la caña (alambre) para fines reglamentarios de la pesquería palangrera de Estados Unidos. Debajo de esta marca, el anzuelo fue aplanado (forjado) para aumentar su resistencia. B y C de Yokota *et al.* (2006).

2.1.2. Circle hooks and Sea Turtles

The 1st Circle Hook Workshop focused on discussing the benefits and trade offs of circle hooks for sea turtle bycatch mitigation. The presentations highlighted extensive research indicating the two main benefits of circle hook use in longline fishing: they reduce interactions with sea turtles and they reduce the mortality of incidentally-captured turtles (see Serafy et al. 2012, Andraka et al. 2013, Gilman et al. 2017). This reduction in mortality is due to the increased likelihood of mouth-hooking when using a circle hook, while J hooks are often ingested, causing internal injuries and damage and make removal of ingested hooks more difficult and injurious (Parga et al. 2015, Gilman et al. 2017). The general consensus was that the larger the circle hook, the greater the reduction in sea turtle bycatch and an increased likelihood that, if captured, turtles would be hooked externally and survive the interaction. The Gilman et al. (2017) review paper in particular, found improved bycatch outcomes for sea turtles for circle hooks of size 15/0 or greater, with most studies showing positive effects using 16/0 and 18/0 circle hooks, including multiple field studies conducted in the EPO (Largacha et al. 2005, Andraka et al. 2013, Parga et al. 2015 see Table 2). Additionally, studies have found that the use of finfish bait alone, but especially coupled with circle hook use reduces sea turtle bycatch and increases the likelihood of mouth-hooking and in combination have the greatest conservation benefits (Andraka et al. 2013, Parga et al. 2015, Gilman et al. 2017). An earlier version of Table 2 compiling the extensive research on circle hooks (across their size ranges) and their effects on sea turtle bycatch and level of injury, was presented during the 1st Circle Hook Workshop by Wallace, B. (2021). The table (Table 2) below builds on the results presented by Wallace (2021) to include studies published after the 1st circle hook workshop.

TABLE 2. SUMMARY OF STUDIES ON CIRCLE HOOK SIZE AND THEIR EFFECTS ON SEA TURTLES.
TABLA 2. RESUMEN DE ESTUDIOS SOBRE EL TAMAÑO DE LOS ANZUELOS CIRCULARES Y SUS EFECTOS EN LAS TORTUGAS MARINAS

Hook Size	Minimum width (cm)	References	Decrease sea turtle bycatch	Increase post release survivability and/or decrease in injury severity	Study location
13/0	3.5	Parga et al. (2015)		X	East Pacific Ocean
14/0	3.8	Parga et al. (2015)		X	East Pacific Ocean
15/0	4.0	Andraka et al. (2013)	X		Ecuador
		Pacheco (2013)		X	Panama
		Parga et al. (2015)		X	East Pacific Ocean
16/0	4.4	Andraka et al. (2013)	X		Panama, Ecuador
		Bolten and Bjorndal (2002)	X	X	Azores
		Clark, S. (2017)	X	X	WCPO
		Piovano et al. (2010)	X		Mediterranean
		Parga et al. (2015)		X	East Pacific Ocean
		Lima et al. (2023)	X	X	Azores
17/0		Santos et al. (2012)	X		Equatorial South Atlantic
		Santos et al. (2013)	X		Equatorial South Atlantic
18/0	4.9	Andraka et al. (2013)	X		Costa Rica
		Largacha et al. (2005)	X		Ecuador

Hook Size	**Minimum width (cm)**	**References**	**Decrease sea turtle bycatch**	**Increase post release survivability and/or decrease in injury severity**	**Study location**
		Watson et al. (2005)	X		USA (Atlantic)
		Foster et al. (2012)	X		USA (Atlantic)
		Swimmer et al. (2017)	X		USA (Atlantic) USA (Hawaii)
		Pacheco et al. (2011)	X		Equatorial South Atlantic
		Stokes et al. (2012)		X	USA (Atlantic)
		Brazner and McMillan (2008)	X		Canada (Atlantic)
		Epperly et al. (2012)	X		USA (Atlantic)
		Parga et al. (2015)		X	East Pacific Ocean
		Lima et al. (2023)	X	X	Azores

2.1.3. Circle hook impacts on target and other bycatch species

Here we review the available information on the cross-taxa impacts of circle hooks versus other hook types on catch rates of different vulnerable taxa and tuna and tuna-like species.

2.1.3.a Elasmobranchs

For shark species, study results have been mixed where multiple studies found that using circle hooks increases shark catch rates as compared to J hooks or tuna hooks. This effect may be offset by the finding that the use of circle hooks reduces injury and mortality in most shark species (see review in Reinhardt et al. 2018). Many papers also discuss the potential for confounding effects of the "bite off" phenomenon in which a shark is able to bite through the fishing line or leader and self release prior to haul-back. This leads to uncounted interactions that may artificially inflate the catch rates with circle hooks, as bite offs are thought to occur more often when hooks are ingested and the leader crosses the teeth, such as occurs with J hooks, while circle hooks are more likely to embed in the corner of the mouth and the leader material is not as exposed to the teeth (Gilman et al. 2008, Afonso et al. 2011, Godin et al. 2012, Reinhardt et al. 2018, Scott et al. 2022, Lima et al. 2023). A few studies have looked at the specific effects of circle hooks on other (non-shark) elasmobranch species. Piovano et al. (2010 & 2017) found that larger J hooks, and especially 16/0 circle hooks significantly decreased pelagic stingray bycatch and manta ray bycatch.

2.1.3.b Seabirds

The effect of circle hooks on seabird bycatch is inconclusive, with no clear advantage or disadvantage with circle hook use. Li et al. (2012) found that 16/0 or 18/0 circle hook use decreased the probability of seabird capture. However, other studies indicate no differences between hook types and seabird bycatch rates (Domingo et al. 2012 and Gilman et al. 2016b). There is a possibility that circle hooks decrease the rate of deep hooking as it does for other species, which would increase the probability of post capture survival, but this has not yet been empirically studied.

2.1.3.c Tuna and other target species

Many studies have investigated the effects of hook shape and size on target species (i.e., tuna, dorado and billfish) with variable results across studies (Table 3). In general, for tuna species, many studies found circle hooks increased catch rates, some found no difference and there were two papers where catches decreased (see Table 3 below).

For marlin, data is limited but the few studies that have been conducted suggest that circle hooks reduce post capture mortality (Kerstetter et al. 2006, Graves et al. 2010). Some studies found swordfish catch rates decrease with the use of circle hooks (Carruthers et al. 2009, Sales et al. 2010, Coelho et al. 2012, Fernandez-Carvalho et al. 2015, Swimmer et al. 2017, Lima et al. 2023, Ochi et al. 2024). While others demonstrated an increase in swordfish catch rates with circle hooks (Kim et al. 2006, Kim et al. 2007, Curran and Beverly 2012, Huang et al. 2016). However, some studies have shown that circle hooks reduce the probability of at haul-back mortality for target species (Ochi et al. 2024), which has the potential to be translated into higher quality catch at market (Santos et al. 2023). This factor may help compensate for the possibility of a decrease in the catch rate found for swordfish in certain studies. Additionally, the use of fish bait on circle hooks has been shown to increase the swordfish catch rates (Watson et al. 2005, Gilman et al. 2006). For dorado, results are mixed with some studies finding a decrease in catch rates with circle hooks and others finding no significant difference in catch rates between circle hooks and J hooks (Largacha et al. 2005, Rodriguez-Valencia et al. 2008, Andraka et al. 2013).

TABLE 3. Example list of studies researching the impacts of hook shape on tuna and other target species catch rates.
TABLA 3. Lista de estudios que han investigado los impactos de la forma de los anzuelos en las tasas de captura de atunes y otras especies objetivo.

Taxa and catch rates	References
Increases catch rates	
Bigeye tuna	Kim et al. 2007; Carruthers et al. 2009; Sales et al. 2010; Pacheco et al. 2011; Huang et al. 2016
Yellowfin tuna	Reinhardt et al. 2017
Albacore tuna	Ward et al. 2009; Sales et al. 2010; Domingo et al. 2012; Reinhardt et al 2017; Santos et al. 2024
Bluefin tuna	Reinhardt et al 2017; Santos et al. 2024
Swordfish	Kim et al. 2006; Kim et al. 2007; Curran and Beverly 2012; Huang et al. 2016 (circle hooks + fish bait: Watson et al. 2005; Gilman et al. 2006)
No difference in catch rates	
Bigeye tuna	Curran & Bigelow 2011; Domingo et al. 2012
Yellowfin tuna	Kim et al. 2006; Sales et al. 2010; Pacheco et al. 2011; Domingo et al. 2012
Albacore tuna	Pacheco et al. 2011
Bluefin tuna	Gambie et al 2012
Dorado	Andraka et al. 2013 – Costa Rica
Decreases catch rates	
Bigeye tuna	Kim et al. 2006
Albacore tuna	Huang et al. 2015
Swordfish	Carruthers et al. 2009; Sales et al. 2010; Coelho et al. 2012; Fernandez-Carvalho et al. 2015; Swimmer et al. 2017; Lima et al. 2023; Ochi et al. 2024
Dorado	Largacha et al. 2005; Rodriguez-Valencia et al. 2008; Andraka et al. 2013 - Ecuador

2.1.4. Recent studies on circle hook effects on sea turtle bycatch, target and non-target catch rates

The topic of hook shape and size impacts on target and bycatch species (including sea turtles) was extensively review during the 1st circle hook workshop. Here we summarize the results from new studies on circle hooks sizes and target and non-target catch rates, published after the first circle hook workshop. Generally, these recent studies support the findings mentioned above and discussed during the first circle hook workshop. Most studies confirm that larger circle hooks reduce sea turtle bycatch, with mixed results for target species and other bycatch species (See Appendix 1 Gilman et al. 2024). Multiple studies found that sea turtles were more likely to be hooked in the mouth with circle hook use leading to lesser injuries as opposed to swallowing the hook with J hook use. A reduction in haulback (at-vessel) mortality rates was also found by multiple studies for both sea turtles and other target and non target species with circle hook use. It is difficult to summarize effects on other species, as the various studies had disparate target species and gear configurations as well as varying bycatch species. The Vannucci et al (2024) study analyzed hook occurrence in stranded[1] sea turtles and hook effects on the prognosis of the individual. This study is also consistent with the findings that J hooks are more likely to be ingested and cause internal damange to the individual, potentially leading to death. A detailed summary of findings from each of the recent studies is below

TABLE 4. Studies published on circle hooks since the 1st Circle Hook Workshop in 2022.
TABLA 4. Estudios publicados sobre anzuelos circulares después del 1er taller sobre anzuelos circulares en 2022.

Reference	Effort & variables considered, experimental details	Relevant results
Ochi et al. 2022	306 sets from 2002 to 2010 J hook vs. Small and large circle hooks Small circle hook defined as “less than 68 mm straight total length and less than 80 mm maximum total width”	Circle hooks: -small circle hooks increase cath rates of blue shark, bigeye tuna, dolphinfish and escolar -Catch per unit of effort (CPUE) for turtles was smallest with squid bait + circle hooks Finfish bait: -no sea turtle mortality -decrease bigeye tuna and blue sharks catch (more pronounced effect when using fish bait and circle hooks) -increase dolphinfish, escolar, and shortfin mako catch (more pronounced effect when using fish bait and circle hooks) Hooking location: -increase in sea turtle mouth hooking with large circle hooks -increase in mouth hooking with small circle hooks for shortfin mako and swordfish -decrease in hook swallowing and at haul-back mortality with both size circle hooks for blue sharks
Carbonara et al. 2023	7 sets J hook vs. Circle hook	-blue shark at-haulback condition was significantly better with circle hooks -no other significant differences were found -small sample size
Lima et al. 2023	343 sets from 2000 to 2004 J hook, tuna hook[3], 16/0, 16/0 offset,	Sea turtles: -16/0, 18/0 and 18/0 offset reduced bycatch and are less likely to capture smaller individuals -probability of deep hooking decreases with hook size -larger individuals more likely to be deeply hooked -tuna hook increased bycatch by 136%

Reference	Effort & variables considered, experimental details	Relevant results
	18/0, 18/0 offset	Sharks: -blue shark catch higher for all circle hooks (especially for smaller sharks) and for wire leaders -lower probability of deep hooking with circle hooks for blue shark -probability of deep hooking increases with blue shark size -no differences in catch between circle, J, or tuna hook types for shortfin mako -18/0 circle hook least likely to capture shortfin mako Swordfish: -decrease in catch rates with all circle hooks (18/0 most reduction), except smaller individuals more likely to be captured with 18/0 -lower probability of deep hooking with circle hooks
Santos et al. 2024	40 experimental sets from 2005 to 2022	Circle hooks: -decrease sea turtle and pelagic stingray bycatch -increase tuna catch -decrease marlin and swordfish catch -increase crocodile shark bycatch At haul-back mortality with circle hook use: -decrease for tuna, marlin, and swordfish -decrease for shortfin mako, scalloped hammerhead, and blue sharks -increase for bigeye thresher sharks Fish bait: -decrease sea turtle and sailfish bycatch -decrease tuna catch At haul-back mortality with finfish bait use: -increase for shortfin mako and blue sharks -no significant decrease for other species
Vanucci et al. 2024	Meta analysis: Sea turtle strandings[1] from 2015 to 2020	Hook characteristics: -2.5% of strandings were hooked in some way, majority were J hooks -increase in hooking during spring and summer Location of hooks: -majority were internal Internal hooking characteristics: -majority were in esophagus -66% had lesions from esophagus hooking -51% had fibrous tissue deposits from esophagus hooking

Reference	Effort & variables considered, experimental details	Relevant results
		Fishing line characteristics: -all stranded sea turtles with stomach trauma from hooking was found dead -majority had plication and mucosal lesions -43% of deaths could be directly attributed to fishing line fragments in intestines -38% had fishing line fragments coming out of their cloaca Body score characteristics: -almost 50/50 split good condition and thin -5% underweight
Yan et al. 2024	Meta analysis: 13 controlled experiments from Bycatch Mitigation Information System (bmis-bycatch.org)	-circle hooks reduce loggerhead, olive ridley and leatherback bycatch (no effect for green) -no significant effects on sharks or tuna for circle hooks -circle hooks reduce swordfish catch by 17% -circle hook + fish bait have greatest reduction in sea turtle bycatch -circle hook and finfish bait more effective in Pacific than Atlantic

[1] A stranding is when an individual is found either on land or in the water to be either unhealthy or deceased

[2] This was defined by the study as a subjective body condition of either excellent/good, thin, or cachectic.

[3] A tuna hook is different from a J hook in that it is designed specifically to withstand hooking of large, fast fish and typically has a shorter shank than J hooks.

2.2. Workshop Objective II: Hook longevity and integrity over time

The 2nd EBWG requested that advice be provided by this workshop on the 'impacts of fishing operations on the form and structure (i.e., longevity and integrity) of circle hooks of various sizes and from different manufacturers'. While the sizes and hook types used across the various small-scale fleets of the EPO has previously been described in Mituhasi & Hall (2011), and investigated by the IATTC Shark Sampling Program in Central America (ABNJ tuna phase 1), and Mexico, Ecuador and Peru (ABNJ tuna phase 2), data on the manufactures, makes and or models of the hooks used in these fleets is not available. These data would be required to conduct a review of manufacturer specifications and to investigate the longevity and integrity of the hooks over time. Properties like hook shape, hook size and mechanical strength of the hook bend have a direct influence on fishing performance and corrosion rates of the hook. The fishing hooks available throughout the region are not uniform in their physical and mechanical properties and a

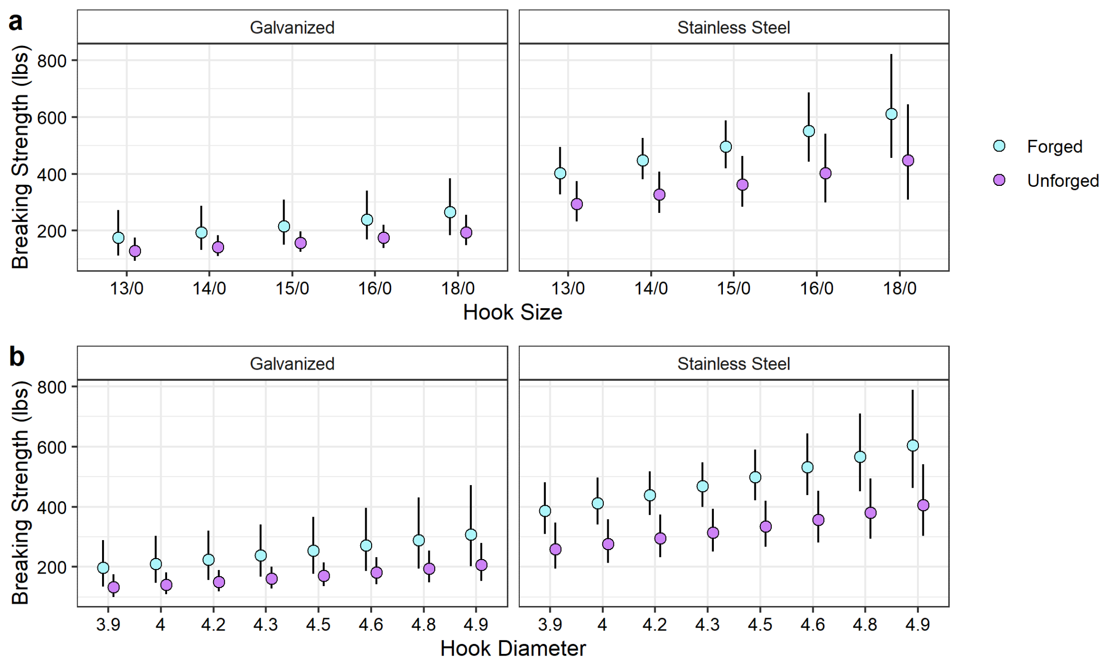

FIGURE 2. From Scott et al. (2022a. Fig. 7) Shows the mean breaking-strength (lbs) of soaked galvanized (left panel) and stainless steel (right panel) hooks across increasing sizes* (x-axis) and forging; forged (blue circles) and unforged (purple circles). Black vertical lines represent the 95% confidence intervals around the mean. Note that 'hook diameter' here is measured as the diameter of the round portion of the shank of the hook under the hook eye (see red arrow in Fig 1.C.). Thus hook diameter in this study is different from the hook diameter used throughout the rest of this document.

FIGURA 2. De Scott *et al*. (2022a. Fig. 7) Se muestra la resistencia promedio a la rotura (lb) de anzuelos galvanizados en remojo (panel izquierdo) y de acero inoxidable (panel derecho) en tamaños crecientes* (eje 'x') y forja; anzuelos forjados (círculos azules) y no forjados (círculos morados). Las líneas verticales negras representan los intervalos de confianza del 95% alrededor del promedio. Nótese que el "diámetro del anzuelo" se mide aquí como el diámetro de la parte redonda de la caña del anzuelo bajo el ojo del anzuelo (ver flecha roja en la Fig. 1.C.). Por lo tanto, el diámetro del anzuelo en este estudio es diferente del diámetro del anzuelo utilizado en el resto de este documento.

high degree of variation is seen between different brands. These variations could be attributed to differences in the steel wire used in the hook manufacturing process (Edappazham et al. 2008). For example, in a study where no significant variation was observed among total length, hook wire diameter, gape and bite of five hooks from different manufacturers, the chemical compositions of the hooks varied and significant variation was noticed in their unbending force (breaking strength) (Edappazham et al. 2008). Another factor complicating the assessment requested above is that many manufacturers do not disclose the exact composition of metals used in their products, forging processes and or when these may change, and thus, completing this task accurately or successfully is extremely challenging.

However, some data exists in the scientific literature that assesses corrosion rates, and breaking strengths of a few hook makes, models, and metal compositions and these results can be cautiously applied across hooks from different manufacturers to facilitate discussion on how form and structure may be impacted by fishing.

One relevant study was conducted in Hawaii by Scott et al. (2022a,b.), where they investigated how long it took for the gear used in the Hawaii and American Samoa small-scale, shallow-set and deep-set longline fisheries to break apart. They were specifically focused on understanding how long bycatch species, discarded by cutting the line, would be burdened with the trailing gear. To address this question the authors conducted multiple experiments, including a year long study where all the gear configurations employed in those fisheries were soaked and embedded in ballistic gel and placed in a flow-through sea water flume. Weight changes were measured monthly and at the end of the year the breaking strengths of the soaked hooks and the same hook types when new were tested. The breaking (tensile) strengths of the hooks tested in the study were affected by hook forging (forged vs. unforged; see Figure 1B & C for examples of forged vs. unforged hooks), metal type (galvanized vs. stainless steel), size (14/0 - 18/0) and wire/shank diameter (3.8 - 4.9 mm, as measured at the top of the shank where the wire is round and unforged). There was a positive relationship between breaking strength, hook size, and hook diameter. However, hook forging was the strongest predictor, where forged hooks had consistently higher breaking strengths than unforged hooks. For example, larger, forged, stainless steel hooks required up to 612.35 ± 188.5 lb (mean ± SD) of force to open or break them compared with 175.05 ± 192.35 lbs required to open or break smaller, unforged galvanized hooks (Figure 2). Interestingly, breaking strength differed markedly for similar sized hooks (i.e., 15/0) of different manufacturers and diameters. For example, the average breaking strength of a 15/0, forged, 4.2 mm, stainless steel hook was 415.17 ± 217.9 lb (mean ± SD) while the average breaking strength of a 15/0, unforged, 4.4 mm hook was 324.63 ± 212.74 lb (mean ± SD) (Scott et al. 2022a). Hook corrosion over time, measured as weight loss in the Scott et al. (2022a.) experiments, were also observed where larger, galvanized hooks lost up to ~11.5 % ± 2.9 % of their original weight compared with stainless steel hooks that lost ~1.2 % ± 0.8 % of their original weight after one year. Breaking strength of soaked hooks across the 12 different hook configurations (excluding leader material) varied between 1 - 654.2 lbs (398.6 ± 136.15, mean ± SD) and the breaking strength of the unsoaked (i.e., new) hooks varied between 325.6 - 824.8 lb (582.0 ± 117.9 mean ± SD) indicating that hooks that had been soaked for 360 days had a substantially lower breaking strength (up to 178 lb less on average) than their identical unsoaked counterparts ($t = -5.10$, $p < 0.001$).

In addition to fabrication material, both coating and leader material have been shown to affect corrosion rates. A separate laboratory experiment comparing hook corrosion rates between two surface coatings (blued vs. tinned) in India, showed losses of 106.3 vs. 26.9 millimeters per year respectively (Edappazham et al. 2010). Thus, surface coatings are also an important factor in hook longevity. Leader material have also been shown to affect corrosion rates where hooks rigged with wire leaders versus monofilament or nylon corrode faster (Edappazham et al. 2022; Scott et al. 2022b.).

2.3. Workshop Objective III: Identification of a third mitigation option (besides finfish for bait)

Resolution C-19-04 3.d. *Requires owners/operators of longline vessels fishing in a shallow-set manner to employ at least one of the following mitigation measures: i Use only 'large' circle hooks ii. Use only finfish for bait, OR iii. Another mitigation measure to reduce sea turtle bycatch that has been approved by the*

Commission. A proposal for such a measure shall be submitted to the Bycatch Working Group at its meeting in the year prior to desired implementation, for review and potential recommendation to the Scientific Advisory Committee (SAC) and approval of the Commission.

This workshop has the opportunity to discuss and identify other mitigation options for sea turtle bycatch mitigation to provide guidance to the SAC. In this section we summarize information on sea turtle bycatch mitigation techniques that have been tested in global longline fisheries to facilitate these discussions. A thorough evaluation of potential sea turtle bycatch mitigation techniques and their cross taxa impacts – including their impacts on target species in pelagic longline fisheries was previously conducted by Gilman et al. (2024). The results of this work were compiled in a table and is available as Appendix 1 in this document. Most of the strategies reviewed in Gilman et al. (2024) do not affect catch rates, although some effects are not yet known for certain mitigation measures. When conducted correctly both from both a technical standpoint as well as incorporating stakeholder involvement, time and area closures showed the best promise in reducing sea turtle and other bycatch, yet this may not be the preferred mitigation option from a practical point of view in that it will require extensive outreach to inform fishers and will be difficult to monitor and enforce. Dynamic ocean management (when adaptive and flexible spatial management measures are applied over specific areas identified as biologically important through satellite tracking, oceanographic models, acoustic sensors and other technologies tracking data in near real time (Hazen et al. 2018)) and other emerging methodologies for predicting species presence also show promise as highly effective management tools. In addition, the use of finfish for bait either alone or in combination with large circle hooks, reducing gear soak times, banning light sticks, using a minimal hook offset (<10 degrees), and having a branchline that exceeds the length of the float line all have positive effects on reducing sea turtle bycatch mortality rates while having minimal effects on other species interactions (Table A.1).

Other mitigation techniques that have been explored but were not successful or are considered not feasible in reducing sea turtle bycatch and or fishing mortality are summarized in Table 5. This table largely includes experimentation with sea turtle sensory cues such as smell and vision, which has not resulted in a viable mitigation option. A table (Table 6) reviewing the sea turtle bycatch mitigation measures adopted in the other tuna RFMOs (t-RFMOs) has also been produced. This summary table shows that currently, for other mitigation measures, t-RFMOs only encourage or require the use of best handling and release practices and require vessels to have line cutters and other tools for proper manipulation of sea turtles. One exception is the International Commission for the Conservation of Atlantic Tunas (ICCAT), that also requires the use of one of the following mitigation option: alternative/new gear types/modifications, time area fishing restrictions/closures, gear markings detectable by sea turtles, or modifications in fishing behavior/strategy. These options are stated in the text of the recommendation but do not include detailed guidance on how to implement them.

TABLE 5. Non-viable mitigation measures for sea turtle bycatch.
TABLA 5. Medidas no viables de mitigación de la captura incidental de tortugas marinas.

Mitigation Measure	Why not Viable	References
Repellant bait: bait treated with a chemical deterrent (either natural or manmade)	No difference in response between control and treatment, many compounds have been studied.	Swimmer et al. 2006
Blue Dyed Bait: shown in seabirds to reduce bycatch rates due to reduction in visual perception of the bait	Although differences were found in the laboratory study, no difference in response between control and treatment were found in the field	Swimmer et al. 2005
Predator shaped decoy*: plastic cut out of shark placed on gillnet set while fishing	Deterrent for both target species and sea turtles	Southwood et al. 2008, Wang et al. 2010
UV light decoy*: Visual range for sea turtles includes UV light, while teleost fish visual range does not. Decoy placed near fishing set to deter sea turtles away from net	Although it decreased sea turtle bycatch and had no effect on target catch, UV light use poses a human safety issue	Virgili, et al. 2018
Predator shaped UV plastic decoy: suggested by Southwood et al. study on sea turtle visual acuity, as UV light is not in teleost fish visual range	Not tested but UV light use poses a human safety issue	Southwood et al. 2008

*only studied in gillnets

TABLE 6. Sea Turtle Bycatch Mitigation options adopted in IATTC and other t-RFMOs.
TABLA 6. Opciones de mitigación de la captura incidental de tortugas marinas adoptadas en la CIAT y otras OROP atuneras.

Conservation and Management Measures in the t-RFMOs*				
IATTC Consolidated Resolution on Bycatch C-04-05 (Rev 2)	**IATTC** Resolution C-19-04 Sea Turtles	**WCPFC** Resolution 2018/04: Conservation and Management Measure of Sea Turtles	**IOTC** Resolution 2012/04: Conservation of Marine Turtles	**ICCAT** Recommendation 22-12: Recommendation by ICCAT on the Bycatch of Sea Turtles Caught in Association with ICCAT Fisheries
Mitigation measures: -Encourage the release, when practicable, of sea turtles entangled in FADs and other fishing gear. -Take measures, including providing assistance, necessary to ensure that longline vessels carry on board the necessary equipment (e.g. de-hookers, line cutters and scoop nets)	**Mitigation measures:** -carry on board, and employ when appropriate, safe-handling tools (e.g. de-hookers, line cutters, and dip nets). -follow handling and release guidelines -For vessels fishing shallow-set; Use only large circle hooks, OR ii. Use only finfish for bait, OR iii. Another mitigation measure that has been approved by the Commission	**Mitigation measures:** -carry line cutters and de-hookers -follow handling guidelines -Use one of the following: large circle hook with <10° offset, finfish bait, or another conservation measure -record turtle interactions -urged to undertake research trials	**Mitigation measures:** -carry line cutters and de-hookers -follow handling guidelines -encourage use of finfish bait -record turtle interactions	**Mitigation measures:** -Use one of the following: use only large circle hook with <10° offset, finfish bait, or another conservation measure -Use one of the following: alternative/new gear types/modifications, time area fishing restrictions/ closures, gear markings detectable by sea turtles, modifications in fishing behavior/ strategy --carry line cutters, de-hookers, and dip nets -follow handling guidelines -bring aboard comatose/inactive turtle -ensure fisherman are aware/ use proper handling techniques -urged to undertake research trials

*CCSBT adopts relevant resolutions from area of competence in other tuna RFMOs

2.4. Workshop Objective IV: Best Handling and Release Practice Guidelines for 'shallow-set' (<100m) longline fisheries

The use of best handling and release practices (BHRP) for incidental sea turtle interactions has the potential to greatly improve post release survival (PRS) rates of discarded animals (see review in EB-01-01). Particularly because most sea turtles are alive at haul-back (Andraka et al. 2013). The 2[nd] EBWG requested that this workshop investigates the use of BHRP as a potential ‘third’ mitigation option. While the use of BHRP for incidental sea turtles cannot be considered an interaction mitigation option since they do not reduce catch rates, we can consider the appropriate use of BHRP as a ‘mortality mitigation’ option. Animals that are in good condition at the vessel and handled in the appropriate manner, with all gear removed and no internal injuries, have demonstrated high PRS rates (Mangel et al 2011; Swimmer et al. 2006).

However, hook position, trailing gear and other handling effects can significantly reduce PRS rates of sea turtles , where animals that are hooked deeper in the gut often have higher mortality rates (34-65%) than those hooked in the upper esophagus or mouth (8-18%) (Casale et al. 2008; Chaloupka et al. 2004; Sasso & Epperly 2007; Swimmer et al. 2014). While the highest probability of acute mortality is believed to occur when hooks are ingested (as often occurs with J hooks) and puncture the stomach, lower esophagus, heart, or lung, lines left trailing on the embedded hooks are by far the most dangerous part of the gear. Data from stranding centers and necropsies confirms that the presence of trailing gear on the hook actually has the largest impact on PRS rates (e.g. Parga, 2012; Vanucci et al. 2024) where entanglement of the flippers in trailing line can lead to infection or amputation, and if the line is ingested mortality occurs after several weeks to months due to intestinal plication, twisting, intussusception, and fecalomas (Alessandro & Antonelli 2010; Di Bello et al. 2013; Lima et al. 2022; Parga 2012; Swimmer & Gilman 2012, Vanucci et al. 2024).

Poor handling practices can also lead to or increase the severity of injuries, mostly occurring when fishers retrieve the animals towards the vessel, haul the animals on board without using a net (i.e. by the line and/or by the flippers), or during gear removal (see Table 7). If the operation is not conducted in a careful way, tension on the line can embed the hook deeper and cause extensive lesions and even long tears at the point where it is lodged (Parga 2012). Animal handling and gear removal all carry different risks to the post release condition of the animals and they vary across hook types (see the review in Table 7; Stacy & Parga 2024). Thus fishers must be made aware of the risks present across all scenarios and informed on the decision criteria for when to bring an animal on board or when to leave it in the water and when to remove a hook or when it should be left in place. Fishers must also be educated and trained on the minimum standards for BHRPs (as required in Resolutions C-04-07 and C-19-04), which should include these general elements (Appendix 2): (1) cutting the line as close as possible to the hook if the hook is not removed, (2) always hauling turtles onboard with the aid of a net and or by supporting the weight of the animal with the carapace, (3) only removing hooks that are visible, (4) taking care of the fragile structures in the mouth when attempting to remove a hook, (5) training of fishers on the BHRP, how to correctly use dehooking devices, and proper resuscitation techniques (Parga 2012, Swimmer & Gillman 2012).

Appendix 1 of Resolution C-19-04 does contain BHRP recommendations for longline fisheries, including instructions for resuscitation of non-responsive sea turtles. While these recommendations are inline with the Food and Agriculture Organization (FAO) recommendations that are referred to in Resolution C-19-04 there is room for improvement and this is an opportunity to develop BHRP that are more specific to the coastal small-scale EPO fisheries. Draft BHRP guidelines for the small scale shallow-set longline fisheries are available in Appendix 2 of this document for the workshop participants' review. These BHRP guidelines, which would need to be tailored for each fleet segment and their specific characteristics, are based on advice from wildlife veterinary doctors (see Table 7, generated through a qualitative approach driven by expert opinion to assess risk of injury using different gear configurations and handling practices), sea turtle biologists, reviews conducted in EB-01-01, reviews of existing BHRP guidelines across IATTC CPCs and other regions as provided by members in response to Memo 0601-410, and subject to expert (identified by members in response to Memo 0601-410) opinion and review and input and testing by fishers. Table 7 shows that generally, circle hooks lower many of the risks associated with being hooked, and emphasizes the importance of understanding the risks and benefits of each potential action before making the choice of whether to remove the hook or cut the line. The draft BHRP guidelines in Appendix II provide a decision tree that balances the risks and benefits of different actions when handling a hooked turtle. The draft BHRP show that if possible, it is best for the sea turtle's survival to bring the sea turtle onboard for safer handling and if the hook is visible, it is best to remove it, and if it is not visible it is important to cut as much of the line as possible.

2.5. Overarching Objective: Drafting workshop outcomes and recommendations

The overarching goal of the 2nd Sea Turtle Bycatch Mitigation and Circle Hook Workshop are to provide the EBWG, the SAC, and ultimately the Commission, with draft recommendations that could inform an update of Resolution C-19-04. Ideally this workshop will identify the critical measurements of a circle hook, specifically that the point faces inward toward the shank (Figure 1) and a minimum width measurement that can be considered "large". In an attempt to fulfill C-19-04 so that it effectively reduces the impacts of fishing on sea turtles in the IATTC Convention Area, this measurement could be added to the Resolution, as mentioned in paragraph 4c of Res. C-19-04. In addition, third potential mitigation options (Res C-19-04, 3.d.iii) will be evaluated including updated best handling and release practice (BHRP) guidelines for sea turtles captured in small coastal multi species vessel fleets. The results of the current workshop will be reported to the 3rd EBWG with the intention of streamlining the process within the EBWG to make Recommendations to the SAC and the Commission with regards to completing C-19-04.

TABLE 7. This table is intended as a tool to aid evaluation and discussion of different fisheries interaction scenarios involving sea turtles. It is based on veterinary opinion and compares the relative risk of circle hooks with J-hook and tuna (T) hooks associated with three key aspects of incidental capture, A) retrieval of bycaught turtles to the fishing vessel, B) removal of the gear, and C) and D) release of turtles with various amounts of gear remaining on them. A core assumption in these comparisons is that circle hooks in use in longline fisheries include those of larger sizes or shapes that are less likely to be swallowed (please see footnote related to smaller circle hooks). Relative risk (column 2) is assigned a score of low (1), medium (2), or high (3) by hook type and an additional score of low, medium, high (same scale) to express degree of confidence (column 4) based on supportive evidence. A subtracting score of low (-1), medium (-2), or high (-3) is applied for any mitigation measures with an additional subtracting score applied (same scale) reflecting the degree of confidence in the efficacy of the stated mitigation measure. For example, high relative risk that is highly mitigatable with high degrees of confidence would have a total score of 0. The difference in the sum of all scores (Δ) by hook type is provided in column 9 as an absolute value indicating a lower relative risk of injury (and resulting mortality) for the hook type shown in parentheses: somewhat lower (1); moderately lower (2); much lower (3). For example, “2 (Circle)” indicates that circle hooks have a moderately lower risk for the given action/circumstance. A non-difference of zero reflects a similar degree of perceived risk based on available information. Prepared by Brian Stacy, DVM, PhD, DACVP (NOAA Fisheries) and Mariluz Parga, DVM, MSc (SUBMON), 2024.

TABLA 7. Esta tabla pretende ser una herramienta para ayudar a evaluar y discutir diferentes escenarios de interacción de la pesca con tortugas marinas. Se basa en la opinión de veterinarios y compara el riesgo relativo de los anzuelos circulares con los anzuelos J y los anzuelos de atún (T) en relación con tres aspectos clave de la captura accidental: A) recuperación de las tortugas capturadas incidentalmente hacia el buque pesquero, B) retirada de las artes de pesca, C) y D) liberación de tortugas con diversas cantidades de arte de pesca en ellas. Un supuesto básico en estas comparaciones es que los anzuelos circulares utilizados en la pesquería palangrera incluyen los de mayor tamaño o forma, que tienen menos probabilidades de ser ingeridos (ver la nota a pie de página relativa a los anzuelos circulares más pequeños). Al riesgo relativo (columna 2) se le asigna una puntuación de bajo (1), medio (2) o alto (3) por tipo de anzuelo y una puntuación adicional de bajo, medio, alto (misma escala) para expresar el grado de confianza (columna 4) basado en pruebas de respaldo. Se aplica una puntuación de sustracción baja (-1), media (-2) o alta (-3) para cualquier medida de mitigación con una puntuación de sustracción adicional aplicada (misma escala) que refleja el grado de confianza en la eficacia de la medida de mitigación. Por ejemplo, un riesgo relativo alto que es altamente mitigable con altos grados de confianza tendría una puntuación total de 0. La diferencia en la suma de todas las puntuaciones (Δ) por tipo de anzuelo se proporciona en la columna 9 como un valor absoluto que indica un menor riesgo relativo de lesión (y mortalidad resultante) para el tipo de anzuelo mostrado entre paréntesis: algo menor (1); moderadamente menor (2); mucho menor (3). Por ejemplo, "2 (Circular)" indica que los anzuelos circulares tienen un riesgo moderadamente inferior para la acción/circunstancia dada. Una no diferencia de cero refleja un grado similar de riesgo percibido basado en la información disponible. Preparado por Brian Stacy, DVM, PhD, DACVP (NOAA Fisheries) y Mariluz Parga, DVM, MSc (SUBMON), 2024.

1. Action/ hook type	**2. Relative risk**	**3. Benefit/risk assessment rationale**	**4. Confidence in relative risk assessment**	**5. Degree affected by mitigation action?**	**6. Mitigation assessment rationale**	**7. Confidence in mitigation efficacy**	**8. Life stage / taxa considerations**	**9. Score (Δ)**
A. Retrieval to boat (injury primarily results from trauma caused by line tension and penetration or laceration of anatomical structures surrounding the hook location)								
Circle hook	Low	Hook locations involving the oral cavity[1] pose less risk of fatal injury because of relative resiliency of the associated anatomy.	High. Injury resulting from swallowed hooks under tension well-evidenced from necropsy data (e.g., from recreational fishing interactions).	Low (Safe handling)	Some benefit, but safety during retrieval is inherent to hook location.	High. Measure doesn’t rely on additional mitigation.	Risks higher for larger, heavier turtles. Less disparity in risk between hook types for foul-hooked interactions (e.g., leatherbacks).	2 (Circle)[1]
J-hook	High	Greater risk of penetration or laceration of blood vessels or respiratory tract or major trauma to esophagus / stomach.		High (Safe handling)	Can reduce injurious actions, such as lifting animals by line, boarding with nets, etc.	Low. Efficacy of implementation difficult to confirm, especially without concurrent robust observer programs.		
T-hook	High	Same as for J-hooks.		High (Safe handling)	As for J-hooks.	Low. As for J-hooks		
B. Gear removal – complete removal of both hook and line (injury primarily results from trauma caused by penetration or laceration of anatomical structures surrounding the hook location)								

1. Action/ hook type	2. Relative risk	3. Benefit/risk assessment rationale	4. Confidence in relative risk assessment	5. Degree affected by mitigation action?	6. Mitigation assessment rationale	7. Confidence in mitigation efficacy	8. Life stage / taxa considerations	9. Score (Δ)
Circle hook	Medium	Hooks that are not swallowed are more accessible and easier to remove without trauma to delicate or vital anatomy, but can injure the mouth or upper airway.	High. Injury resulting from traumatic removal of swallowed hooks well-evidenced from necropsy data (e.g., from recreational fishing interactions.	Medium (Safe handling)	Larger hooks are more difficult to cut and remove without injury, even with instruction.	Low. Efficacy of implementation difficult to confirm, especially without concurrent robust observer programs.	Less disparity in risk between hook types for foul-hooked interactions (e.g., leatherbacks).	0[2] (None) 1[3] (Circle)
J-hook	High	Greater risk of penetration or laceration of blood vessels or respiratory tract or major trauma to esophagus / stomach during removal.		High (Safe handling)	Improved safe handling can allow effective removal of non-swallowed gear and help avoid further injury by swallowed gear.			
T-hook	High	Same as for J-hooks.		Medium (Safe handling)	Mitigation lower due to greater difficulty in safe removal associated with greater hook thickness and larger barbs.			
C. Gear left in place – hook only or with attached line ≤ carapace length (ongoing trauma, secondary infection, internal encapsulation, or shedding of the hook)								
Circle hook	Medium	The rate of hook degradation, even for ferrous materials, is slower than rate of injury, infection, healing of structures of the mouth required for feeding and respiration.	Low. Hooks within the oral cavity and swallowed have substantial, but somewhat different risks that are difficult to qualify based on available data. There is minimal data on long-term fate of oral hooks left in place.	Low (Safe handling)	There is no significant mitigation for hook ± short line left in place as risk largely occurs post-release.	High. No Post-release mitigation	Low risk with both hook types for foul-hooked interactions (e.g., leatherbacks).	0[2] (None) 1[3] (Circle)
J-hook	Medium	Some published observations in hooks naturally shed from the digestive tract and observations of encapsulated hooks without fatal complication in some proportion of cases.						
T-hook	High	Higher risk based on their larger barb size and potential injury when left in place.						

1. Action/ hook type	2. Relative risk	3. Benefit/risk assessment rationale	4. Confidence in relative risk assessment	5. Degree affected by mitigation action?	6. Mitigation assessment rationale	7. Confidence in mitigation efficacy	8. Life stage / taxa considerations	9. Score (Δ)
D. Gear left in place – hook with line ≥ carapace length (persistent risk of entanglement and ingestion resulting in Gastro-Intestinal injury/obstruction)								
All hook types	High	Higher frequency of delayed mortality attributed to fishing line as compared to hooks.	High. No obvious difference in hook type due to greater risk attributed to fishing line.	Low (Safe handling)	There is no significant mitigation for hook with lengthy line left in place as risk largely occurs post-release.	High. No post-release mitigation	None	0 (None)

[1]Risk during retrieval to the boat is considered greater for any hooks or shapes that can be swallowed and penetrate visceral anatomy, as determined by the specific hook characteristics and morphology of the turtle species and size caught. For swallowed circle hooks, relative risk and confidence would be the same as for J- and T-hooks (score (Δ) of zero).
relative risk and confidence may be amended to “medium” and would result in a score (Δ) of zero.
[2]Circle hook vs J-hook comparison.
[3]Circle hook vs T-hook comparison.

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5. APPENDIX

5.1. Appendix 1. Compilation of ‘other’ sea turtle bycatch mitigation options and cross taxa effects

Table A1. Sea turtle bycatch mitigation strategies and the strategies’ effects on other species. Adapted from the International Seafood Sustainability Foundation’s 2024 technical report *Inputs for Comprehensive Bycatch Management Strategy Evaluation in Tuna Fisheries* (Gilman et al. 2024).

TABLA A1. Estrategias de mitigación de la captura incidental de tortugas marinas y efectos de las estrategias sobre otras especies. Adaptado del informe técnico de 2024 de la International Seafood Sustainability Foundation: Inputs for Comprehensive Bycatch Management Strategy Evaluation in Tuna Fisheries (Gilman et al. 2024).

Key

▲ = reduces catch or fishing mortality risk
— = no effect
▼ = increases risk
? = inconclusive/unknown
V = response is variable
O = offset residual bycatch mortalities that could not be avoided, minimized and remediated

Method	Cetaceans	Turtles, hard-shelled	Turtles, leatherback	Rays	Seabirds	Sharks, epi-pelagic	Sharks, meso-pelagic	Teleosts	Citations
Deeper fishing: Deeper (all hooks soak >100m) daytime fishing as compared to shallower nighttime fishing (some or all hooks soak < 100m)	▲	▲	▲	▲	▼	▲	▼	V	Polovina et al., 2003; Ward et al., 2004; Beverly et al., 2009; Musyl et al., 2003, 2011; Monaghan et al., 2024
	—	▲	▲	—	—	▲	▲	▲	
Time area management: spatial closure, season closure, dynamic ocean management Results vary, depending on how closure is managed, with dynamic providing the best results.	V	V	V	V	V	V	V	V	Kobayashi et al. 2005, Grantham, et al. 2008, Lewison et al. 2015, Hazen et al. 2018
	V	V	V	V	V	V	V	V	

Method	Cetaceans	Turtles, hard-shelled	Turtles, leatherback	Rays	Seabirds	Sharks, epi-pelagic	Sharks, meso-pelagic	Teleosts	Citations
Stingray bait instead of finfish bait	?	▲	?	?	?	▲	?	—	Echwikhi, et al. 2010
	?	?	?	?	?	?	?	?	
Ban light sticks	▲	▲	▲	—	?	?	▲	V	Hazin et al., 2002; Murray and Griggs, 2003; Poisson et al., 2010; Afonso et al., 2021; Monaghan et al., 2024
	—	—	—	—	—	—	—	—	
Light emitting device characteristics: Light emitting devices that have wavelengths and a flicker rate that reduce detection by marine turtles	—	—	▲	?	—	?	?	?	Swimmer and Brill, 2006; Crognale et al., 2008
	—	—	—	—	—	—	—	—	
Branchline and floatline relative lengths: Branchline longer than floatline	—	▲	▲	—	—	—	—	—	Gilman et al., 2006
	—	—	—	—	—	—	—	—	
Floatline material: Monofilament nylon (polyamide) instead of polypropylene float lines to reduce entanglements	—	—	—	—	—	—	—	—	Hall, 2008
	—	▲	▲	—	?	—	—	—	
No bait threading: Single baited instead of threaded bait on hook	?	▲	?	?	?	?	?	▲	Stokes et al., 2011; Richards et al., 2012; Gilman et al., 2016b
	—	—	—	—	—	—	—	—	
	?	▲	?	—	?	▲	?	V	Swimmer et al., 2010

Method	Cetaceans	Turtles, hard-shelled	Turtles, leatherback	Rays	Seabirds	Sharks, epi-pelagic	Sharks, meso-pelagic	Teleosts	Citations
Hook with wire appendage: projection posterior from the hook eye at a 45° angle to the shank, to form a physical barrier to ingestion by extending the hook's width dimension.	?	—	?	—	?	—	?	—	
Minimum hook offset: the degree to which the hook point is bent away from the shank's plane, recommended to be <10°	? ?	▲ ▲	▲ ▲	? ?	? ?	▲ ▲	▲ ▲	▼ ?	Watson, et al. 2005, Gilman et al. 2006, Swimmer et al. 2014
Hook shielding devices: Such as the HookPod and Smart Tuna Hook	— —	? —	? —	— —	▲ —	— —	— —	— —	Baker et al., 2016; Sullivan et al., 2012, 2018; Goad et al., 2019; ACAP, 2023
Reducing gear soak time	? ?	▲ ▲	— —	? ?	? ?	? ?	▲ ▲	— —	Watson et al. 2005
Lasso: Hookless branchline with artificial bait for entangling SWO. New gear type with no research or data on catch rates.	?	?	**?**	?	?	?	?	**?**	Unpublished data

5.2. Appendix 2. Draft Best Handling and Release Practice Guidelines for Sea Turtles Captured in Pelagic Shallow-set (<100m) Longline Fisheries

In general, the removal of all fishing gear from the animal is preferred and this is usually safer for the animals if the sea turtle is brought onboard the vessel. There are several considerations that fishers must be made aware of prior to handling sea turtles because many lethal injuries to bycaught sea turtle occur during handling; during retrieval to the boat (injury primarily results from trauma caused by line tension and penetration or laceration of anatomical structures surrounding the hook location), while bringing sea turtles onboard and during hook removal. The bones and ligaments of sea turtle flippers have been shown to be extremely fragile, incapable of supporting their weight out of water and subject to breakage when animals are lifted or manuevered by the flippers. For this reason, sea turtles should not be manipulated or maneuvered by their fins/flippers. Thus, when animals are brought on board for gear removal, fishers must support the weight of the animal by the carapace and or the use of a net if the free-board of the vessel is too high or the animal is too heavy to bring it on board manually. If vessels cannot safely bring the turtle onboard (either the animal is too large, there's no net or the vessel free board is too high to bring turtles up manually) fishers must ensure that the line is cut at the hook at the mouth and this is advised over removing the hook (Parga 2012; Barria and Valerio in press; pers comm. Andraka and Parga). Additionally, if hooks have been ingested and are not visible, hook removal is not recommended. There are several structures in the esophagus (gullet) of a sea turtle that are fragile, have many blood vessels, and severe damage to these is likely during removal of ingested hooks.

Draft BHRP Guidelines

If a sea turtle is hooked or entangled in fishing gear, owners and operators of longline vessels must use the required mitigation gear to release it in a manner that minimizes injury and promotes survival using the guidelines provided below.

5.2.1. Tools Required:

Vessels with freeboard[1] of 1 meter or less must carry:

- Line clippers capable of cutting fishing line or leaders within 5 cm of the eye of an embedded hook, and
- Wire or bolt cutters capable of cutting through any of the hooks on the vessel.
- Net
- At least two of the following mouth openers and gags:
    - Block of hard wood
    - Hank of rope
    - Large bird mouth opener (avian oral speculum)
    - Two rope loops covered with hose
    - Four PVC splice couplings
- Old tire or block or something for elevating sea turtles during hook removal and resuscitation (see section 5.2.3 below)

Vessels with freeboard more than 1 meter must have the following turtle handling/dehooking gear on board:

[1] Freeboard is the distance between the vessel's deck and the sea surface.

- Long-handled line clipper capable of cutting fishing line or leaders within 5 cm of the eye of an embedded hook
- Long-handled net
- Long-handled dehooker
- Short-handled dehooker
- Long-nose or needle-nose pliers
- Wire or bolt cutters capable of cutting through any of the hooks on the vessel
- At least two of the following mouth openers and gags:
    - Block of hard wood
    - Hank of rope
    - Two rope loops covered with hose
    - Old tire or block or something for elevating sea turtles during hook removal and resuscitation (see section 5.2.3 below)

5.2.2. When a sea turtle is seen entangled in fishing gear or hooked on a line:

All fishers must:

i. Bring the vessel to a stop and slow the hauling of the gear. (Prevents further injury).

ii. Slowly manuever the vessel towards the animal.

iii. Determine whether or not the animal can safely be brought onboard for gear removal. (Ideally animals will be brought onboard to remove all fishing gear).

- An animal can 'safely' be brought on board either by using a net to support its weight or manually by supporting its weight on the carapace. **Do Not** haul animals onboard using the line they are hooked on or entangled in. **Do Not** haul animals onboard using their head, tail, fins or flippers.
- If a sea turtle is too large or hooked in such a manner as to preclude safe boarding without causing further damage/injury to the turtle, line clippers should be used to clip the line as close to the hook as possible and removing as much line as possible (< 5 cm of trailing gear) prior to releasing the turtle.

iv. Determine whether or not the hook should be removed and remove as much gear as possible. (The decision tree in A2.1 can help make this determination along with the guidance below.)

- If the hook is visible and the animal was brought onboard the vessel:

    a. Use a dehooker or pliers to remove the hook without injuring the fragile tissues in the mouth and esophagus. Do not rip an embedded hook out – back the hook out. Ideally the barb and point of the hook will be cut and the hook can be backed out. If the hook point cannot be cut, depress the barb prior to backing the hook out. If the hook cannot be removed, cut all trailing gear off the hook and cut any portion of the hook that can be cut off the animal.

- If the hook is visible and the animal cannot be safely brought onboard the vessel:

a. Use a dehooker to remove externally embedded hooks from the animal.

b. If the hook cannot be removed using a dehooker, use longhandled line cutters to cut the line as close to the hook as possible, leaving no more than 5 cm of trailing gear on the hook.

- If the hook is in the mouth or has been partially swallowed but is visible and the animal was brought onboard the vessel:

  a. Using the tools available to open the mouth (listed above), have one crew member pry the mouth open while the another assess whether the hook can be removed without further injury. If it can be backed out of the esophagus this is ideal. If it cannot, cut as much line off the hook as possible.

- If the hook has been swallowed and the animal cannot be brought on board safely:

  a. Cut the line as close to the mouth as possible – leave no more than 5 cm of trailing gear.

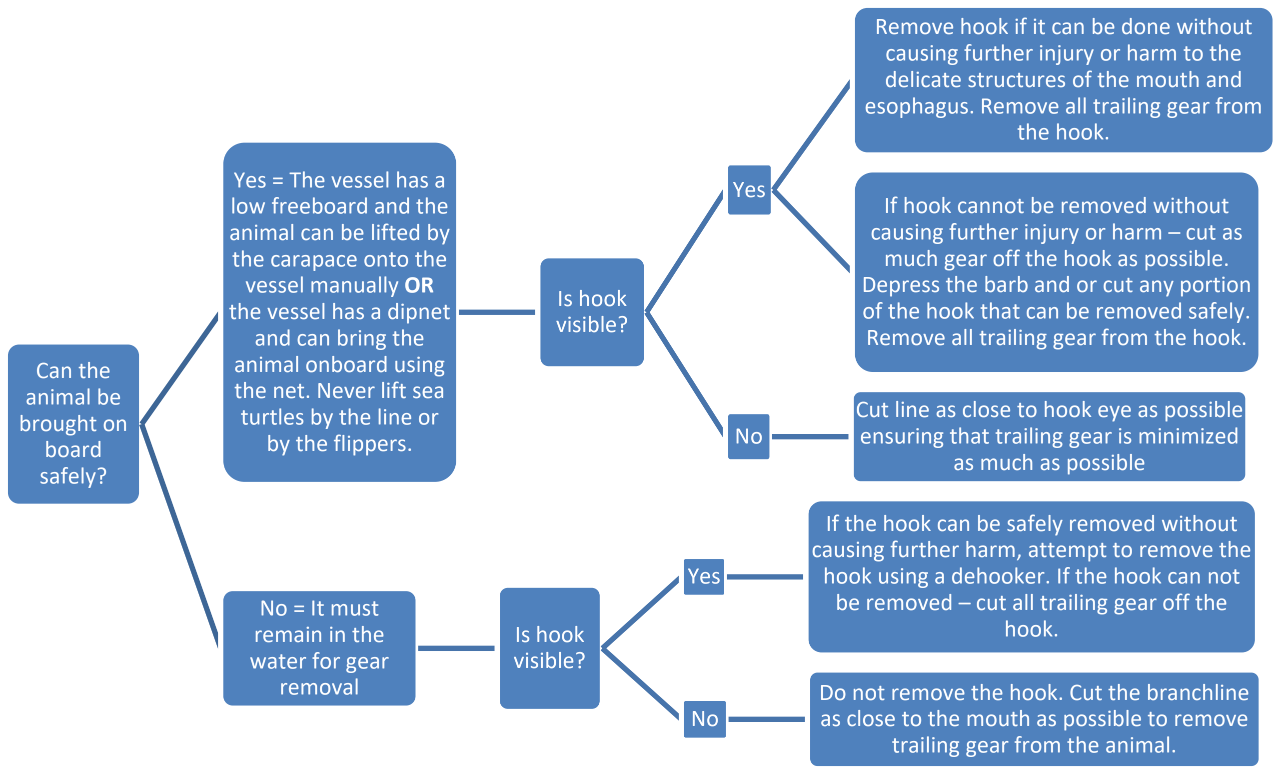

FIGURE A2.1 Hook removal decision tree. May depend on the specific hooks and materials used in each fishery.
FIGURA A2.1 Árbol de decisión para la extracción de anzuelos. Es posible que dependa de los anzuelos y materiales específicos utilizados en cada pesquería.

5.2.3. Resuscitating a sea turtle:

If a sea turtle appears dead, comatose, or otherwise inactive, fishers must take the following actions:

- Bring the animal onboard safely by supporting its weight manually on the carapace or by using a net.

- Place the turtle on its belly and elevate its hindend at least 6 inches or 15 cm. Elevation of hindquarter allows for water in the lungs to drain.
- Occasionally rock the turtle gently side to side by holding the outer edge of the shell and lifting one side about 3”, then alternate to the other side.
- Administer a reflex test at least once every 3 hours or until the turtle is moving. Perform this test by gently touching the eye and pinching the tail of the turtle in order to determine if it is responsive and potentially recovering.
- In warm weather (over 24°C), keep the turtle shaded and moist with a wet towel on the shell and flippers.
- Attempt resuscitation for at least 4 hours. Effort can be stopped it there are no signs of life after 24 hours on deck, or if the muscles are stiff and/or the flesh has begun to rot. If there is an eye reflex, give it more time.
- Return a revived turtle to the sea after it becomes active. Turtles that fail to revive must also be returned to the sea in the same manner as if they were alive. Turtles that appear alive or active when captured should be released as soon as it is safe to do so after fishing gear has been removed.

5.2.4. Releasing a sea turtle:

After removal of fishing gear return the animal to the sea. When a sea turtle is released into the ocean, fishers must:

- Place the vessel engine in neutral gear so that the propeller is disengaged and the vessel is stopped.
- Release the turtle away from any deployed fishing gear.
- Observe that the turtle is safely away from the vessel before engaging the propeller and continuing operations.