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Use of monofilament traces to reduce shark bycatch in commercial demersal longline fisheries: a review

Delegation of Australia

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Abstract

This report summarises the available research on the efficacy of utilising gear modifications such as trace type and hook shape to mitigate catches of deepwater sharks3 in response to the tasking from the 10th Session of the Meeting of Parties (MoP) to the Southern Indian Ocean Fisheries Agreement (SIOFA) 4 in July 2023.

The use of monofilament traces (branch or leaders) in longline fisheries has been widely recommended as an effective tool to reduce bycatch of sharks and improve catch rates of the target species.

There is substantial literature and studies on the use monofilament trace to mitigate shark catches in pelagic longline fisheries. This research is only briefly summarised in this report. This report instead focusses on the limited number of studies available on the effectiveness of the type of leaders or branch lines material (wire or monofilament) in demersal longline fisheries. These studies support the conclusions of the pelagic research suggesting that the use of monofilament traces can be an effective mitigation measure for reducing the bycatch of deepwater sharks in demersal longline fisheries. In particular, one study in the Northeast Atlantic Ocean (Menezes et

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[2] Documents available only to members invited to closed sessions.
[3] The term "sharks" refers to Chondrichthyes (sharks, rays, skates, and chimeras) for the purposes of this report, as defined by the Food and Agriculture Organisation (FAO)
[4] https://siofa.org/

al. 2009) showed that catch rates of Portuguese dogfish (Centroscymnus coelolepis) was almost eliminated with monofilament trace compared to wire trace fishing in the same area. This study also indicated that catches of many other deepwater shark species are reduced with monofilament trace.

Hook shape was not found to have a significant effect on deepwater shark catch rates in the limited studies we found.

Whilst there is a need for further research addressing bycatch mitigation measures for deepwater sharks and identifying efficient strategies, the available literature suggests that the prohibition of wire traces could be effective in reducing the bycatch of the most commonly caught species and genus of deepwater shark in the SIOFA Area.

Recommendations

That SIOFA SC **notes**;

1) That most research on the use of wire or monofilament traces has been focussed on pelagic sharks in tuna fisheries.
2) One study on species similar to those caught in the SIOFA Area in the North Atlantic Ocean showed significant reductions in the catch rates of many shark species through the use of monofilament trace.
3) That line construction can have an influence on shark catch rates and needs to be considered and
4) The use of circle hooks has not been found to have a significant impact on reducing shark catch rates in deepwater fisheries.

That SIOFA SC **RECOMMENDS** to the Meeting of Parties that the prohibition of wire trace has been demonstrated as an effective shark mitigation measure in the North Atlantic Ocean and should be implemented in the SIOFA Area whilst further research is conducted.

Australian Government
Department of Agriculture, Fisheries and Forestry

ABARES

Use of monofilament traces to reduce shark bycatch in commercial demersal longline fisheries: a review

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment, and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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Summary

This report summarises the available research on the efficacy of utilising gear modifications such as trace type and hook shape to mitigate catches of deepwater sharks[5] in response to the tasking from the 10th Session of the Meeting of Parties (MoP) to the Southern Indian Ocean Fisheries Agreement (SIOFA)[6] in July 2023.

The use of monofilament traces (branch or leaders) in longline fisheries has been widely recommended as an effective tool to reduce bycatch of sharks and improve catch rates of the target species.

There is substantial literature and studies on the use monofilament trace to mitigate shark catches in pelagic longline fisheries. This research is only briefly summarised in this report. This report instead focusses on the limited number of studies available on the effectiveness of the type of leaders or branch lines material (wire or monofilament) in demersal longline fisheries. These studies support the conclusions of the pelagic research suggesting that the use of monofilament traces can be an effective mitigation measure for reducing the bycatch of deepwater sharks in demersal longline fisheries. In particular, one study in the Northeast Atlantic Ocean (Menezes et al. 2009) showed that catch rates of Portuguese dogfish (*Centroscymnus coelolepis*) was almost eliminated with monofilament trace compared to wire trace fishing in the same area. This study also indicated that catches of many other deepwater shark species are reduced with monofilament trace.

Hook shape was not found to have a significant effect on deepwater shark catch rates in the limited studies we found.

Whilst there is a need for further research addressing bycatch mitigation measures for deepwater sharks and identifying efficient strategies, the available literature suggests that the prohibition of wire traces could be effective in reducing the bycatch of the most commonly caught species and genus of deepwater shark in the SIOFA Area.

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[6] https://siofa.org/

1 Need

A dedicated deepwater shark workshop was held adjacent to the SIOFA Scientific Committee (SC) 8 in 2023 (SIOFA 2023a), due to concerns about the continuing substantial catch of sharks, despite Conservation and Management Measure for Sharks (CMM 2019/12)[7] prohibiting the targeting of deepwater sharks. The outputs of this workshop were considered by SC8 and a summary of the SC8 advice in relation to these catches is described below (SC8-229) (SIOFA 2023b).

> *The SC noted the high and increasing level of Portuguese dogfish (Centroscymnus coelolepis) bycatch; that they constituted the second highest species of catch among all demersal fish in the SIOFA Area in 2022; that the annual catch of Portuguese dogfish in 2022 was the second highest on record; and that Portuguese dogfish accounted for 75% and 80% of total longline catch in Subarea 2 in 2022 and 2021, respectively.*

The need to mitigate the bycatch of sharks was highlighted at the SIOFA SC 8 meeting and SC8 made the following recommendations about wire trace (SC8 230-231).

> *The SC recommended that the MoP consider implementing measures to ensure Portuguese dogfish is sustainably managed and SC recommended the use of nylon traces for demersal longlines and a catch limit for Subarea 2.*
>
> *Regarding the use of nylon traces, the SC noted that a number of studies have shown their effectiveness as a shark bycatch mitigation measure, including for demersal longline fisheries.*

The SIOFA MoP considered this advice but did not reach consensus on the mandatory use of monofilament nylon trace (hereby referred to as monofilament) or prohibiting wire trace (MOP10–99) (SIOFA 2023c). The MOP tasked SC9 to '*provide further advice on fishing gear options to mitigate the ongoing impact of SIOFA on vulnerable deepwater fisheries*' (MOP10–165) (SIOFA 2023c). This report looks to summarise the available research on the efficacy of utilising other gear types to mitigate catches of deepwater sharks in pursuit of that MoP request.

[7] CMM 12(2023) (Sharks) supersedes CMM 2019/12 (Sharks) https://siofa.org/management/CMM/12%282023%29

2 Background

Many shark and ray species are facing substantial population declines due to overfishing (Dulvy et al. 2021). Bycatch (unintentional catch of non-target species) of sharks can pose a significant challenge for their conservation and management and is a major concern for the sustainability of fisheries (Alverson 1994; Kennelly 2007).

Longline fisheries are a major source of fishing mortality (target and bycatch) of sharks (Oliver et al. 2015; Shea et al. 2023). The need to reduce fishing mortality and bycatch of sharks has been widely recognised in domestic and international fisheries (Dulvy et al. 2021; FAO 1999) and has been recognised by SIOFA in CMM 12 (2023) which prohibits the targeting of deepwater shark species. This has led to a number of bycatch mitigation measures, including the modification of the fishing gear to prevent the capture, or facilitate escape, of the non-target species from fishing gear (Hall, 1996; Gilman 2011; Swimmer et al. 2020; Walker 2005). In longline fisheries, common gear modification strategies that are used to reduce the level of bycatch are trace material, hook type, and bait types (Afonso et al. 2011; Afonso et al. 2012; Ward et al. 2008).

The trace material used for branch or leader lines (lines which connect the hooks to the main longline) can significantly influence the size composition, catchability, retention, and survival of both target and non-target species in longlines (Afonso et al. 2011; Afonso et al. 2012; Branstetter and Musick, 1993; Gilman et al. 2008; Ward et al. 2008). Monofilament traces are used to reduce the number of sharks caught, as the hooked sharks are able to 'bite-off' or break the monofilament leader and swim away, therefore resulting in lower catch numbers of shark being hauled to the boat (Ward et al. 2008). Wire traces are used to prevent the loss of fish with sharp teeth and/or to prevent being cut off with entanglement in the substrate. Wire traces are typically used in fisheries that target and retain sharks (Kumoru 2003; Vega and Licandeo, 2009; Watson et. al. 2005).

Wire trace bans are accepted as a mitigation measure for vessels targeting tuna and/or tuna-like species in the Western and Central Pacific Fisheries Commission (Conservation and Management Measure for Sharks CMM 2022-04; WCPFC, 2022). In addition, Australia, Ecuador, New Caledonia, Papua New Guinea, South Africa, Republic of the Marshall Islands, Cook Islands, and Federation State of Micronesia have prohibited the use of wire leaders in domestic longline fisheries (Lack & Meere 2009; Gilman et al. 2008), and in marine protected areas to reduce shark mortality (Ward-Paige et al. 2017).

The SC8 noted that a number of studies have shown the use of monofilament traces are effective as a shark bycatch mitigation measure, including demersal longline fisheries (SIOFA 2023). Numerous reviews have been conducted on the use of monofilament traces in pelagic fisheries (e.g. Scott et al. 2022; Swimmer et al. 2020). Therefore, the aim of this paper is to synthesise the available literature for demersal longline fisheries, on use of monofilament traces to reduce shark bycatch.

3 Methodology

An academic literature search was conducted using a combination of following keywords in Web of Science, Google Scholar, and OneSearch: “demersal longline”, “demersal fishing”, “bottom fishing”, “bottom longline”, “longline”, “wire trace”, “metal snood”, “steel leader”, “nylon trace”, “monofilament”, “elasmobranch”, “shark”, “ray”. A separate search for grey literature was completed on Google using the same keywords. This review does not include literature that is not in the English language, although this research is acknowledged to contain valuable information. Once papers were collected from searches, references were combed to identify more relevant literature.

Scientific and common names for species referred to in this report are provided in Appendix A.

4 Results and Discussion

Monofilament traces have been widely demonstrated to be effective at reducing bycatch of sharks in pelagic longline fisheries (Afonso et al. 2011; Afonso et al. 2012; Gilman 2011; Santos et al. 2023; Scott et al. 2022; Swimmer et al. 2020; Walker 2005, Watson et al. 2005; Ward et al. 2008). In pelagic longline fisheries, monofilament traces have been demonstrated to reduce the catch rates of sharks by 41%, while maintaining catch rates of the target tuna species (Ward et al. 2008; Scott et al. 2022).

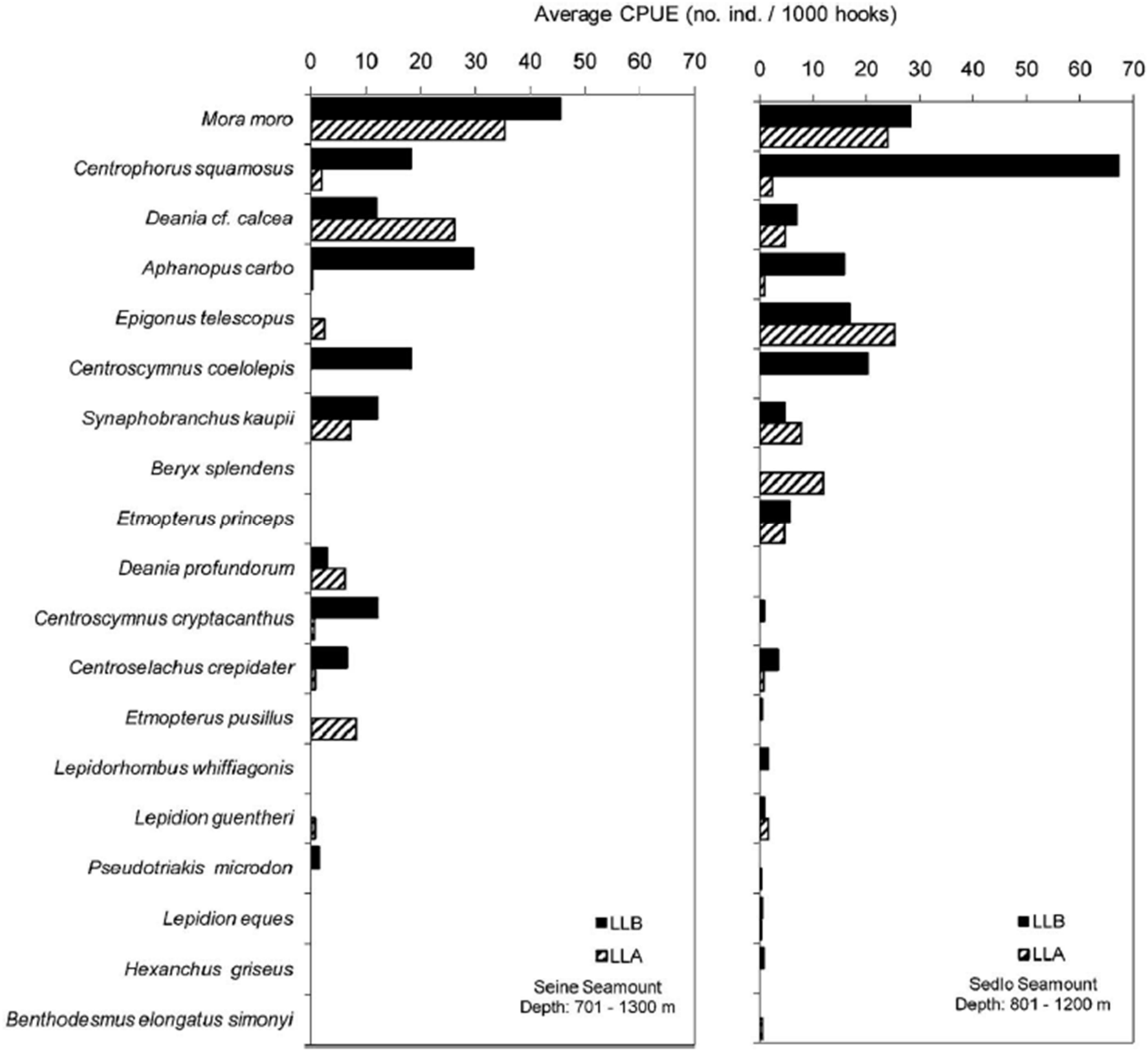
4.1 Demersal longlines

Two studies so far has systematically tested the difference in catches between wire and monofilament leaders for deepwater demersal longlines.

Menezes et al. (2009) conducted fisheries independent research longline surveys at Seine and Sedlo seamounts in the northeast Atlantic Ocean to investigate the deepwater demersal fish assemblages. The surveys used two different gear configurations, longline gear that was identical to commercial fishery operations of the Portuguese Azores bottom longline fishery, with monofilament branch lines (LLA), and longline that had hooks attached to the main line by a steel wire trace (LLB). The depth range of the deployments were 185 to 2000 meters. The deepwater shark species caught in the study were Portugues dogfish, Leafscale gulper shark (*Centrophorus squamosus*), Birdbeak dog fish (*Deania calcea*), Arrowhead dogfish (*Deania profundorum*), Longnose velvet dogfish (*Centroselachus crepidater*), Shortnose velvet dogfish (*Centroscymnus cryptacanthus*), Smooth lanternshark (*Etmopterus pusillus*), Spined pygmy shark (*Squaliolus laticaudus*), Thornback ray (*Raja clavata*), Blackmouth catshark (*Galeus melastomus*), and False catshark (*Pseudotriakis microdon*). Many of these are the same species or genus as those caught in the SIOFA Area and listed as high risk in Annex I and of concern in CMM 2023/12.

Menezes et al. (2009) found that there were significant differences (p<5%) between the catches of the two longline gears at both locations (Sedlo LLB vs Sedlo LLA: ANOSIM global R = 0.276, p-level = 0.3%; Seine LLB vs Seine LLA: ANOSIM global R = 0.403, p-level = 0.1%). The gear with wire trace (LLB) was more efficient in catching deepwater shark species with a higher catch per unit effort (CPUE, number of individuals per 1000 hooks) when compared to the catches with the monofilament trace (LLA) at the same depth range (Figure 1). The longline gear with a wire trace caught higher number of shark species and greater catch by number of individuals caught and by weight. However this trend was not seen for all shark species, where the Birdbeak dogfish had a higher CPUE with monofilament traces, compared to wire traces at the same depth. The Portuguese dogfish was only caught on the wire trace gear at both locations (Figure 1). The authors concluded that the large deepwater sharks and other species with sharp teeth that are abundant in deeper waters were easily able to cut the monofilament traces, leading to reduced catch rates for that gear type.

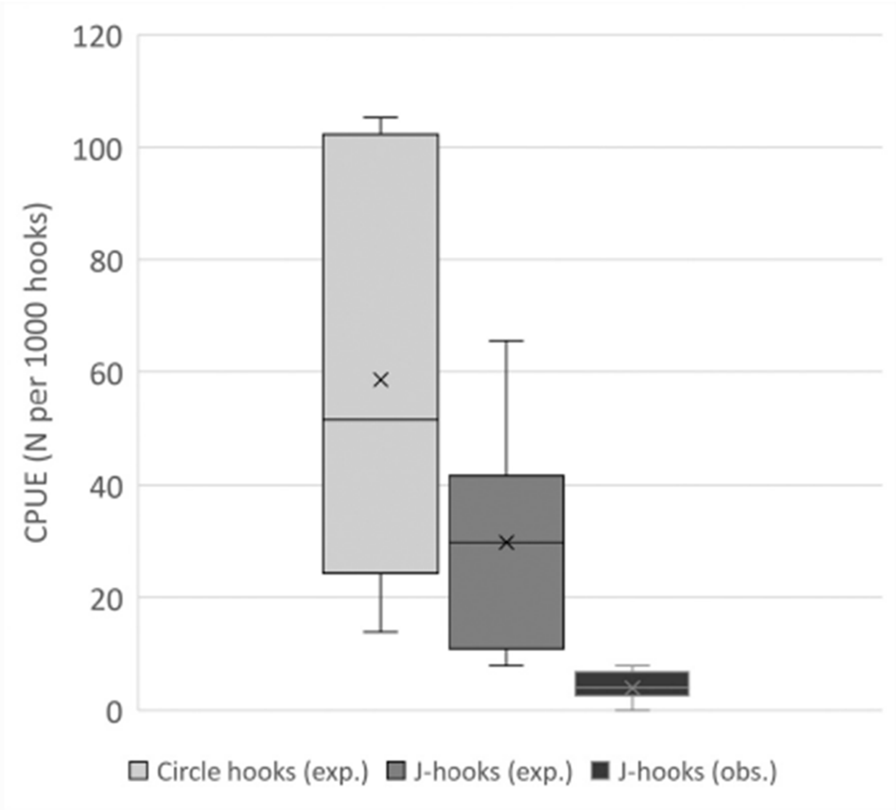
Figure 1 Comparison of catch per unit effort of deepwater species between two longline trace types.



Note: Catch per unit effort (CPUE) refers to the number of individuals per 1000 hooks. LLA refers to the longline gear that used a monofilament trace. LLB refers to the longline gear that used wire traces.
Source: Menezes et al. (2009)

Fauconnet et al. (2024) conducted a study on the hook types as mitigation measures for deep water sharks on commercial longline vessels in the Azores bottom longline fishery. This study used modified fishing gear with a wire traces to reduce the number of shark ‘bite-offs’ in the experiment, instead of the commonly used monofilament leaders in the commercial fishery. The deepwater shark species composition was similar to catch composition in Menezes et al. (2009), and the catch was dominated by birdbeak dogfish, Portuguese dogfish, and longnose velvet dogfish. The study found that the CPUE from j-hooks with wire leaders of deepwater sharks in the experiment were significantly higher than the j-hooks with monofilament leaders used in the commercial fishery at the similar fished depths (Welch t-test (5.09), $p = 0.027$) (Figure 2). Fauconnet et al. (2024) attributed the higher catch rates of deepwater sharks during the study to the use of wire leaders that reduced the number of ‘bite-offs’, when compared to the catch data of the commercial bottom longline fishery that uses monofilament leaders. This further suggests that the leader material may have a significant effect on the catchability of deepwater sharks.

Figure 2 Effect of hook types on the catch per unit effort of deepwater sharks from different data sources.



Note: Exp. refers to the fishing experiment in the study and obs. refers to the onboard observer data from the commercial demersal longline fishery. The boxplot displays the distribution of the data from the minimum to maximum values (whiskers), the first quartiles (lower line), median value (middle line), third quartile (third line) and mean value (cross). Source: Fauconnet et al. 2024.

It must be noted that sharks that avoid capture via 'bite-offs', especially those that are deep-hooked in the gut or throat, may still experience unknown levels of mortality (Afonso et al. 2012; Keller et al. 2020; Scott et al. 2022). However, survival of deepwater sharks that 'bite-off' longlines at depth are likely to be greater than those that are bought to the surface and released due to post-release mortality. Preliminay research from tagging studies suggest that deepwater sharks can experience high levels of post release mortality (proportion of fish released alive but that die in a short-term) (Rodríguez-Cabello & Sánchez, 2017). The post release mortality for deepwater sharks is caused by their biological characteristics, adaptation to depth, impacts and stress of capture, and post-release predation (Davis 2002; Brooks et al. 2015).

4.2 Gear construction

The specific gear construction and thickness of the monofilament trace (i.e. line strength) can have an effect on the level of bycatch of sharks (Branstetter & Musick 1993; Smukall et al. 2021). Double monofilament leaders (3.5mm lines) are commonly used in shark research surveys to reduce the number of shark 'bite-offs' (Branstetter & Musick 1993; Stone & Dixon, 2001). Whereas commercial fisheries tend to use thinner monofilament leaders (2 to 2.4 mm lines) (Stone & Dixon, 2001; Smukall et al. 2021). These thicker leaders that are used in research have been demonstrated to have similar catch rates of coastal shark species to wire traces in shallow waters in the Bahamas (Smukall et al. 2021). It was assumed that the thicker monofilament line could have been more difficult for coastal sharks to bite or break through, similar to the wire traces (Smukall et al. 2021). Therefore, it is important to note and specify the correct line thickness and strength for monofilament traces, as the specific gear construction could impact the catch rates of sharks on demersal longlines.

4.3 Other mitigation measures

Other gear mitigation measures for longlines to reduce shark bycatch include the type of hooks (circle or j-shaped hooks), which affects the position of hooking and catch rates. Circle hooks tend to hook sharks in the corner of the jaw and the trace line tends to be less exposed to abrasion. Where as j-shaped hooks are often embedded in the throat or gut and the trace lines are more exposed to the abrasion against the teeth, resulting in higher rates of ‘bite-off’ (Ward et al. 2008).

Fauconnet et al. (2024) found that the use of circle hooks in a deepwater demersal longline fishery did not significantly reduce the throat or gut hooking of deepwater sharks or improve the overall condition of the captured sharks, compared to the use of j-shaped hooks (Figure 2). The catchability of deepwater sharks on circle hooks (n = 174) was significantly higher than the j-shaped hooks (n = 89) (Welch t-test (5), $p = 0.041$). This was consistent with the results for pelagic and coastal fisheries (Afonso et al. 2011; Reinhardt et al. 2018; Ward et al. 2008). The higher catch rates can result from either (1) the higher probability of a shark being hooked after biting the bait, or (2) a lower probability of escaping the hook after being caught (Afonso et al. 2011; Ward et al. 2008). Circle hooks may not be a suitable measure to mitigate deepwater shark bycatch in the demersal longline fisheries.

5 Recommendations

That SIOFA SC **notes**;

5) That most research on the use of wire or monofilament traces has been focussed on pelagic sharks in tuna fisheries.
6) One study on species similar to those caught in the SIOFA Area in the North Atlantic Ocean showed significant reductions in the catch rates of many shark species through the use of monofilament trace.
7) That line construction can have an influence on shark catch rates and needs to be considered and
8) The use of circle hooks has not been found to have a significant impact on reducing shark catch rates in deepwater fisheries.

That SIOFA SC **RECOMMENDS** to the Meeting of Parties that the prohibition of wire trace has been demonstrated as an effective shark mitigation measure in the North Atlantic Ocean and should be implemented in the SIOFA Area whilst further research is conducted.

Appendix A: Common and scientific names

Table A1 Common and scientific names of species

Common name	Scientific name
Arrowhead dogfish	*Deania profundorum*
Birdbeak dogfish	*Deania calcea*
Black cardinal fish	*Epigonus telescopus*
Black scabbardfish	*Aphanopus carbo*
Blackmouth catshark	*Galeus melastomus*
Bluntnose sixgill shark	*Hexanchus griseus*
False catshark	*Pseudotriakis microdon*
Great lanternshark	*Etmopterus princeps*
Kaup’s arrowtooth eel	*Synaphobranchus kaupii*
Leafscale gulper shark	*Centrophorus squamosus*
Longnose velvet dogfish	*Centroselachus crepidater*
Megrim	*Lepidorhombus whiffiagonis*
Morid cod	*Lepidion guentheri*
North Atlantic codling	*Lepidion eques*
Ribaldo	*Mora moro*
Portuguese dogfish	*Centroscymnus coelolepis*
Shortnose velvet dogfish	*Centroscymnus cryptacanthus*
Simony’s frostfish	*Benthodesmus simonyi*
Smooth lanternshark	*Etmopterus pusillus*
Splendid alfonsino	*Beryx splendens*
Spined pygmy shark	*Squaliolus laticaudus*
Thornback ray	*Raja clavata*

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