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INTERACTIONS WITH ENDANGERED, THREATENED AND PROTECTED (ETP) SPECIES IN THE MALDIVIAN POLE-AND-LINE TUNA FISHERY

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Cover image: Pole-and-line fishing for tuna in the Maldives © Kelsey Miller & IPNLF

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Abbreviations used in this report

aFAD	Anchored Fish Aggregating Device
dFAD	Drifting Fish Aggregating Device
EEZ	Exclusive Economic Zone
ETP	Endangered Threatened and Protected (species)
FAD	Fish Aggregating Device
IOTC	Indian Ocean Tuna Commission
IPNLF	International Pole & Line Foundation
MRC	Marine Research Centre, Maldives
NM	Nautical Mile

1. Executive Summary

Executive Summary

The Republic of Maldives is one of the top tuna pole-and-line fishing countries in the world. The fishery has changed little over the centuries and targets surface swimming skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*). Over 80% of the pole-and-line catch is skipjack and about 15-17% is yellowfin tuna which school with skipjack in surface waters. Pole-and-line landings in 2014 were 87,101 metric tonnes.

The pole-and-line tuna fishery was certified by the Marine Stewardship Council (MSC) in November 2012 with eight conditions to be met within the first five years, including assessment of the likely impacts on endangered, threatened or protected (ETP) species by this fishery.

To address this condition, the Maldives initiated a directed research program during 2014-2015 with the support of International Pole & Line Foundation (IPNLF), using trained fisheries observers to document ETP interactions in this fishery. Over the course of the research program, observers were deployed on 106 fishing trips. Two categories of interactions were described to assess the impacts on ETP species: Category 1 included interactions with ETP species that were uninjured or sustained minor injuries with a high expectation of survival, Category 2 interactions involved ETP species that sustained serious injuries or mortalities and had a low or no likelihood of survival.

Over the course of 106 observed fishing trips no sea turtles were directly impacted by the fishery. Additionally, zero marine mammals interacted with the fishing gear. Only ten Category 1 interactions were observed: seven silky sharks were caught and released in good condition, and three seabirds (two brown noddies and one lesser noddy) were caught during pole-and-line or trolling operations. Due to the short time on deck, flick off method, and barbless hooks, survival of these individuals is expected to be high. Only two instances of Category 2 (serious injury/mortality) were observed, in which silky sharks (*Carcharhinus falciformis*) were caught and discarded dead following fishing activities.

In summary, very few interactions with ETP species were observed. During 106 trips, a total of 12 interactions were observed, with only two resulting in serious injury or mortality. This research demonstrates that the impacts on ETP species in this one-by-one fishery are low or negligible on both the level of the individual and population. Therefore, the authors conclude that this fishery does not "pose a risk of serious or irreversible harm to ETP species and does not hinder recovery of ETP species."

2. Introduction

Introduction

The Republic of Maldives is a nation with a long tradition of pole-and-line tuna fishing dating back hundreds of years (Adam 1999 and references cited therein). Until the 1980s, the tuna fishery was the mainstay of the Maldivian economy, providing employment and a source of protein for its inhabitants. The country holds the highest per-capita fish consumption in the world (FAO 2014), and much of the social fabric of the country, especially of the outer islands, is still closely linked with tuna fish and fishing. In 2012, the pole-and-line fishery directly supported over 10,000 fishermen, almost ten percent of the country's population (MoFA 2012).

The primary target species of the pole-and-line fishery is skipjack tuna (*Katsuwonus pelamis*), but small amounts (~15-17%) of juvenile yellowfin tuna (*Thunnus albacares*) mixed with bigeye tuna (*Thunnus obesus*, 5-10% of the *Thunnus* component), are also caught and retained (Adam et al. 2014). The Maldivian pole-and-line fishery accounts for roughly one-fifth (~21%) of all of the pole-and-line caught tuna in the world, alongside Japan (~28%) and Indonesia (~25%) as the major fishers (Gillett 2016). In 2014, 87,101 metric tonnes (mt) of tuna were landed by pole-and-line (Adam et al. 2015b), with peak landings in 2006 with a reported catch of 166,000 mt tuna (138,000 mt of skipjack).

The pole-and-line skipjack fishery was certified by the Marine Stewardship Council (MSC) in November 2012 with eight conditions to fulfil within the first five-year cycle of certification (Anderson et al. 2012). Condition 6 (Performance Indicator for the Marine Stewardship Council 2.3.3) concerns impacts on endangered, threatened or protected (ETP) species, including documentation on species likely to be impacted by the pole-and-line method of fishing. The condition requires the Maldives to provide management strategies and information to assess outcomes for ETP species (Anderson et al. 2012). ETP species include those that are protected or recognised by national or international legislation agreements. Four separate categories of ETP species were considered in the initial assessment, and these categories are followed in this report: seabirds, sharks and rays, turtles, and marine mammals. Details on impacts to ETP species in the livebait fishery are provided in a separate report (Jauharee et al. 2015).

The terms "takes," "interactions," "bycatch," and "discards" are frequently used in the literature, but their definitions can be inconsistent and ambiguous. In this paper, following Warden and Murray (2011), we define "interactions" to include only observable in-

teractions, those reasonably expected to be seen following accepted fishery observer protocols, and include both uninjured/minor injuries and serious injuries/mortalities. These two categories of uninjured/minor injuries (with a high expectation of survival) and serious injuries/mortalities (low or no likelihood of survival) will be assessed separately. The objective is to assess impacts on ETP species, but this paper will also document interactions that may demonstrate potential behavioural changes.

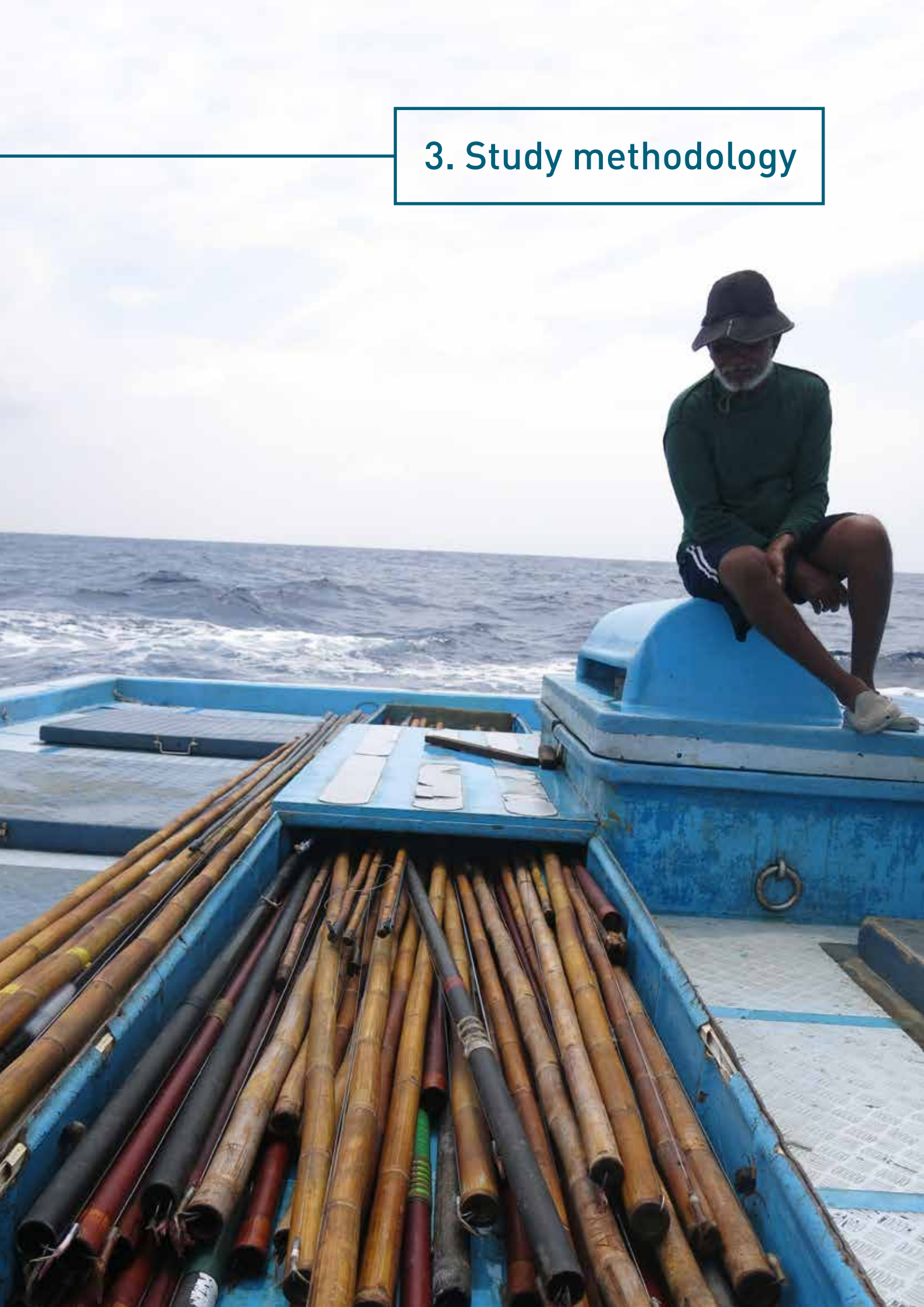
Fishers in the Maldives work together to land a large tuna by pole-and-line

Information on ETP interactions can be collected in several ways. The completion of tuna fishery logbooks by fishermen became compulsory in 2010 throughout the Maldives. In addition to documenting tuna and baitfish catches, fishermen are required to record interactions with any ETP species during fishing activities in their logbooks. Alternatively, fishery observer data can provide robust data on any interactions. Since 2014, the Maldives Marine Research Centre (MRC) has been working in collaboration with IPNLF to conduct a detailed bycatch sampling of the pole-and-line fishery. Finally, structured questionnaires to fishermen can also help assess ETP interaction, although this may be less reliable.

To date, data from 106 observer trips from MRC/IPNLF have been collected, quality checked, and analysed. Detailed observations were made on the pole-and-line fishery's interaction with ETP species. While interactions and impacts on ETP species have been assumed to be low, this is the first study to quantitatively assess this fishery.

The objective of this report is to provide, for the first time, quantitative information on the interaction between ETP species and the Maldivian tuna pole-and-line fishery. This will complement a separate report compiled by the authors on the bait fishing component of this fishery (Jauharee et al. 2015).

3. Study methodology



Study location

The archipelagic atoll chain of the Republic of Maldives is located in the central Indian Ocean, around 73°E. Straddling across the equator, the island chain stretches from 7°N to 1°S (Figure 1). It is comprised of 1,200 islands across 26 natural atolls. Roughly 1,000 tuna fishing boats operate in the country and approximately 60% of the country's fishery landings are caught by pole-and-line, with additional hand-line-caught yellowfin tuna and a small amount of neritic varieties (MoFA 2012). The Maldivian pole-and-line fishery has been in existence for more than 700 years (Adam 2004), and although mechanisation of the fleet and technological improvements have changed over the centuries, the method of fishing remains fundamentally the same.

The fishery consists of two components often conducted on the same vessel, typically within the same fishing trip: catching baitfish and catching tuna. Typically, baitfish are caught inside the atolls at night. The silver sprat or "*rehi*" in local language Dhivehi (*Spratelloides gracilis*) is the most important baitfish, although many others (e.g. blue sprat or "*hondeli*" or *Spratelloides delicatulus*, anchovies, fusiliers, cardinalfish) are also used (Anderson 2009). The baitfish are kept alive in a bait well in the fishing boat (or *dhoni*) which head offshore to target tunas.

Fishing takes place throughout the archipelago. However, pole-and-line fishing is now more concentrated in the southern atolls restricted within 60-70 nautical miles (NM) from the atolls (Adam et al. 2013). Fishermen can either fish at one of

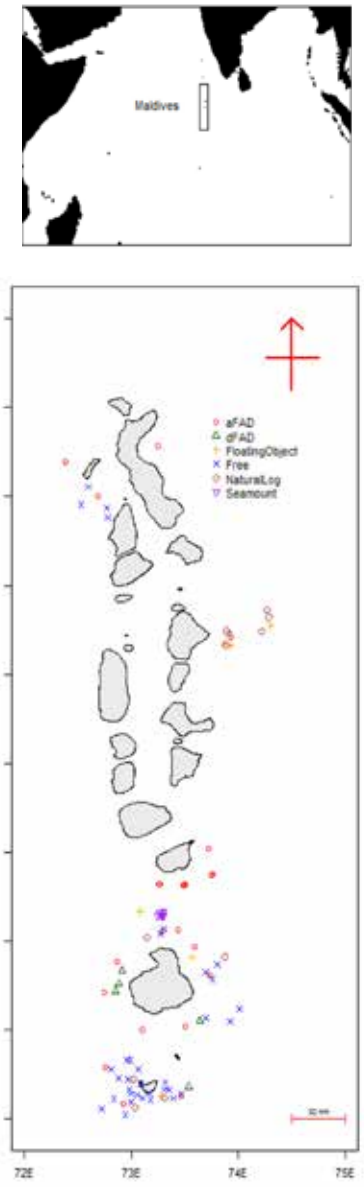


Figure 1. Indian Ocean showing the location of the Maldives, below: location of fishing events by school type observed in Maldivian pole-and-line tuna fishery, FO – Floating (manmade) objects, Free – Free schools, NatLog – Natural floating logs, Seamount – Seamount schools, aFAD – anchored fish aggregating devices and dFAD –drifting fish aggregating devices.

approximately 50 anchored fish aggregating devices (aFADs) deployed and managed by the Ministry of Fisheries and Agriculture (MoFA; Jauharee & Adam 2012) or search for a free swimming school of tuna. Additionally, they may also fish on seamounts or floating objects that they encounter: drifting natural or manmade objects, such as drifting fish aggregating devices (dFADs) released from purse seine vessels operating in the western central Indian Ocean.

When a school of tuna is located, often by the presence of seabirds, water is sprayed from the stern and livebait are thrown to encourage schools into a feeding frenzy. Many fishermen (5-15) stand at the back of the vessel and use non-baited, barbless hooks to catch the tuna and flick them onto the back deck of the boat. Fish are stored on ice and boats typically return to shore to sell their catch the same day.

Field observations

Between August 2014 and November 2015, 106 at-sea trips were conducted. These trips were undertaken by trained fishery observers and represented the spatial and temporal extent of the fishery (Figure 1). The *dhonis* were chosen opportunistically, but trips, vessels, and locations were chosen to best represent the fleet dynamics (size, geography, seasonality). Trips typically included day operations for both bait fishing and tuna fishing. For the purposes of this report, only interactions during tuna fishing and not during baitfishing are reported. A thorough description of observer sampling protocol is available in Miller (2014).

The goals of the fishery observers are to provide independent fishery observation and representative data. The top priorities are to:

- Document the amount and proportion of non-targeted species, and their fate/condition at release
- Document fishery interactions with endangered, threated, and protected (ETP) species
- Document catch composition and size, with site specific detail
- Document fishing effort and fishing effort locations
- Document observations of ETP species
- Improve interaction with fishermen and create awareness on responsible fishing

Trained fishery observers were present on fishing vessels for the duration of a trip, for both bait fishing and tuna fishing activities. Observers collected data on each fishing

event - defined as fishing activity or activities starting from the time gear enters into water, and is separated from other fishing activities by more than ten minutes. In this sense, a single fishing event could also be a series of short fishing activities on a single tuna school. For each fishing event observers collected data on the location, time, number of fishermen, total catch (estimated by species), any interactions or bycatch, and sample the retained catch. All sampled bycatch was: identified to the lowest possible taxa, counted, weighed (if feasible), measured, and sexed if sexually dimorphic. Retained catch was sampled or subsampled (at least 100 fish per fishing event) to provide size estimates and proportion of retained fishes.

ETP interactions

Qualitative notes describing fishing and vessel activities were written daily. ETP species sightings were considered only as observations if they were away from fishing activity and did not interact with fishing gear, targeted catch, or baitfish. ETP species that interacted with fishing gear, catch or baitfish were further assessed and recorded in detail where possible. First, the interaction type was described along with any mitigation techniques used by the fishermen to avoid, reduce, or end the interaction. Secondly, the condition of the animal was classified following the Indian Ocean Tuna Commission (IOTC) and Maldivian observer protocols (IOTC 2010, Miller 2014):

D: Dead
A0: Alive (swam away); conditions not determined
A1: Alive and in good health condition
A2: Alive; minor injuries / stressed high probability of survival
A3: Alive; life threatening injuries / severe stress unlikely to survive
Unk: Condition not observed and unknown

For the purposes of this study, two categories of uninjured/minor injuries (with a high expectation of survival: A1 and A2) and serious injuries/mortalities (low or no likelihood of survival: D and A3) were used to assess the impacts on ETP species.

Within this fishery, there are three potential areas for interaction with ETP species. ETP species may interact directly with a) pole-and-line fishing gear (e.g. being caught as bycatch), b) entanglement with aFADs, or c) their behaviour may be affected (e.g. feeding). Four main taxa of ETP species were considered following Anderson et al. (2012): sharks,

birds, turtles, and marine mammals. However, only those that were observable (primarily Category a, and occasionally Category b) are within the scope of this study. Birds that may feed on baitfish or follow the boat are noted, but not included as an interaction. Potential for entanglement or behavioural changes are mentioned, but not described in detail here.

Fishermen self-reporting

Fishery logbooks became mandatory in 2010, and include a section on both bycatch and ETP species. These are analysed by MRC staff. Additionally, a pilot study of fishermen interviews was conducted to determine if self-reporting provided results consistent with observer data. Ten experienced fishermen provided detailed responses on bycatch and ETP interactions.

4. Results

Results

Of 106 total trips, 87 pole-and-line fishing trips were observed. These included 161 separate fishing events (fishing activities separated from each other by more then ten minutes). A total of 146,593 kg of tuna were caught on these trips (for comparison, this is approximately 0.17% of 2014 pole-and-line landings). Vessels from which observation took place ranged in size from 16-35m (52-117 ft) length overall, with 9-23 crew. Fishing event sampling was spread out across the Maldives, but concentrated in the southern atolls to best represent fishing effort (Figure 1). Three trolling events that targeted tuna were also observed. 55% of the tuna fishing events occurred at aFADs.

As some of the ETP species that were observed interacting with fishing gear are known to be gregarious and typically encountered in groups, both the number of interactions and the proportion of the 87 tuna fishing trips with interactions are considered. As fishing events ranged from five minutes to over four hours, interactions were reported here have been aggregated by trip (i.e. single day). Interactions with sharks and seabirds were seen, but not with turtles or marine mammals (Table 1). However, all four taxa were observed during regular fishing trips (Table 1).

Table 1. Interaction rate with ETP species in pole-and-line tuna fishing with respect to severity of injury.

Taxa	Number of Interactions: Low severity*	Number of interactions: High severity*	Proportion of tuna fishing trips with interactions**	Proportion of trips with high severity interactions*	Number of observations	Proportion of fishing trips with observations
Birds	3	0	2.3%	0.0%	165	72.4%
Sharks	7	2	4.6%	2.3%	25	25.3%
Turtles	0	0	0.0%	0.0%	2	2.3%
Marine Mammals	0	0	0.0%	0.0%	11	11.5%

*Low severity includes fate codes A1: Alive and in good health condition and A2 Alive: minor injuries / stressed high probability of survival. High severity includes D: Dead and A3 Alive; life threatening injuries / severe stress unlikely to survive. ** Includes both low and high severity interaction.

The number of times ETP species were seen, but not interacting with the vessel or fishing gear, was recorded as number of observations (Table 1). Each observation includes any time a single species was observed, regardless of number (e.g. ten brown noddies and five frigate birds would be recorded as two observations).

Seabirds

Seabirds often associate with skipjack schools, frequently feeding on baitfish, and observations were very common. One hundred and sixty-five observations of seabirds (each bird species recorded separately) were recorded. However, it has typically been assumed that interactions, especially harmful interactions, with seabirds from pole-and-line gear are rare (Gillett 2011, Anderson et al. 2012). The most critical interaction is the potential for seabirds to be hooked or entangled in the pole-and-line gear and landed as bycatch. During this study, three seabirds (one lesser noddy, *Anous tenuirostris* and two brown noddies, *Anous stolidus*) were caught on the barbless hooks, but were released or flew away without assistance and in good condition (health condition A1: alive and in good health). Therefore, no high severity interactions were observed. Two of these birds were caught during pole-and-line fishing and one bird was caught while trolling for tuna in between pole-and-line fishing events. The bird species are both considered to be of Least Concern (IUCN 2015). In the Brazilian pole-and-line fishery, seabirds may have been injured by pole-and-line fishermen hitting birds to scare them away (Bugoni et al. 2008), but this practice has not been observed in the Maldives.

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Seabirds observations were very common

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Flying seabirds associate with pole-and-line fisheries but rarely interact with gear

Low severity interactions (non-injuries) may occur if seabird behaviour or feeding habits are modified. Only one instance of birds directly feeding on baitfish thrown from the vessels was recorded; however, it is assumed some amount of the live baitfish thrown from the vessel is consumed by birds. As the birds did not interact with fishing gear or the vessel, this was not included as an interaction (Table 1). Anecdotal reports describe illegal catch of seabirds for trophy pets, but this was not observed during this study. All seabird species in the Maldives are protected under the Environment Protection and Preservation Act 4/93 (Anderson et al. 2012).

Sharks

Nine juvenile silky sharks (*Carcharhinus falciformis*) were caught during pole-and-line fishing on four fishing trips, with five sharks caught at the same location in a single day. The sharks ranged in size from 60-90 cm. Seven of nine juvenile silky shark interactions were classified as low severity (released alive in either good condition or with minor injuries, category A1 or A2). Two sharks were discarded dead; these were the only high severity interaction observed in the entire study. Silky sharks are considered as Near Threatened by the IUCN (IUCN 2015), and to have low resilience in FishBase (Froese & Pauly 2015), and thus are of high importance to assess and monitor. As silky sharks frequently occur in groups, interaction rates are presented as both number of trips with interactions and number of total interactions.

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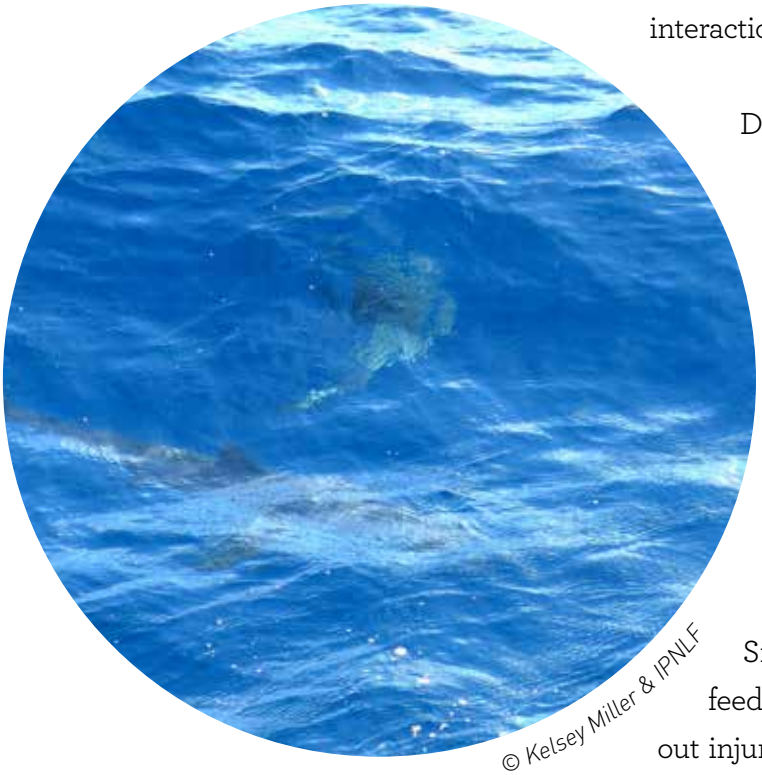
Silky shark swimming with a school of tuna around the fishing vessel



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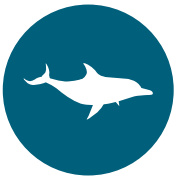
Silky sharks were observed beneath the surface, close to the fishing vessel

Due to strength of line, hook, and fishermen, it is unlikely that larger sharks (e.g. adult silky sharks, oceanic whitetips, etc.) would be caught and brought on board. In general, all bycatch, including small sharks, are expected to have high survival rates due to the combination of short time on deck, flick off method, and barbless hooks (Bailey et al. 1996). However, this warrants further study. All shark species are protected in the Maldives as of 2010. Similar to seabirds, shark behaviour and feeding habits may be affected (although without injury). Most commonly, sharks follow the fishing boats and feed on the tuna, especially tuna that have fallen off of a hook.

Twenty-five separate observations of sharks (one or more sharks present) during tuna fishing were recorded, including silky sharks, whale sharks (*Rhincodon typus*), and oceanic whitetip sharks (*Carcharhinus longimanus*). However, many of these were only seen from the surface, so it is likely that more sharks were unobserved. It is known that skipjack may associate with whale sharks, but pole-and-line fishermen do not interact with whale sharks (Anderson et al. 2012).

Turtles

Pole-and-line tuna fishing gear uses non-baited barbless hooks with only a short line off the back of the vessel. As such, it is highly unlikely that this gear would catch sea turtles. Observers recorded two sighting of sea turtles during tuna fishing activity. Four olive ridley turtles (*Lepidochelys olivacea*) were seen entangled in a ghost net associated with the appendages of a dFAD and one olive ridley turtle was seen resting on a dFAD (not entangled). These dFADs are deployed from purse seine vessels operating in the western Indian Ocean, but when they drift into the Maldivian exclusive economic zone (EEZ) they may be opportunistically fished by pole-and-line vessels. Anecdotal reports have suggested that entanglement on the aFADs (installed by MoFA in Maldivian waters) could occur, but this was not observed in the course of this study. Sea turtles have been protected in the Maldives since 1995 (Directive No: FA-G/29/2005/07).



Marine mammals

There are no known interactions with marine mammals and the pole-and-line fishery, although 11 observations of unassociated dolphins or whales have been noted. Two species of marine mammals, the pan-tropical spotted dolphin (*Stenella attenuate*) and the spinner dolphin (*Stenella longirostris*), frequently associate with schools of yellowfin tuna, but rarely with skipjack (Anderson 2014). Marine mammals have been protected in the Maldives since 1993. Dolphins are frequently observed during bait fishing activities (although without interactions with the vessel or gear), but are not described here.

Fishermen self-reporting

Fishermen are required to document interactions with ETP species in any aspect of fishing (including both bait fishing and pole-and-line) via mandatory logbooks since 2010. However, no data on ETP species have been recorded through these logbooks, suggesting either extremely low interactions, under-reporting, or, most likely, a combination of both.

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The crew and researchers on board the Karavahthaa, following a successful fishing trip, December 2014

Questionnaires were given to fishermen asking about ETP interactions to provide data on a larger number of trips than are observed by a limited observer program. Fishermen self-reporting may not be as accurate as observer data, but it can provide useful information on rare occurrences. Fishermen appeared willing to discuss ETP interactions. Of ten experienced fishermen, all of them reported never catching turtles or marine mammals. One fisherman said that he occasionally catches sharks, and three fishermen reported occasionally catching birds (either tangled in lines or hooked). All said that these species were released alive (low severity interaction). Following this pilot study, further interviews will attempt to discern which species and the frequency of occurrences.

aFADs

While no marine mammals, sharks, or turtles were found entangled in aFADs in this study, entanglement has been noted for dFADs released from purse seine fisheries, that drift into Maldivian waters. Anecdotal information suggest that entanglement may occur on a small scale in the Maldivian aFAD system, but this was not seen

during the course of this study. Silky sharks are at risk of entanglement in dFADs, with evidence suggesting that dFAD entanglement shark mortality is five to ten times that of the known bycatch from the Indian Ocean purse-seine fleet (Filmalter et al. 2013). Given the difference in design and overall numbers of FADs (estimated more than 10,000 dFADs in the Indian Ocean compared to 50 aFADs in the entire Maldives EEZ) the cumulative impacts are likely drastically different (Adam et al. 2015a).

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Pole-and-line fishers sometimes locate tuna schools with the aid of anchored Fish Aggregating Devises (aFADs)

5. Discussion

Discussion

Overall, very low levels of interaction with ETP species were observed in this fishery during this study, mostly from extremely low levels of bycatch with assumed high survivorship (seabirds and silky sharks). Ten low severity interactions with ETP species occurred, and only two high severity interactions in 106 observed fishing trips. While this report presents the first independent assessment of ETP species interactions, there is not sufficient data to determine mortality rates (i.e. survivorship of released individuals). Due to the extremely low encounter rate of ETP species, any extrapolation from rare events may be highly imprecise, and fishery-wide estimates are not provided. Potential impacts, both direct and indirect, are considered to have low to negligible impacts to individuals, and believed to have essentially no impact to populations (Table 2).

As the fishery is pelagic, there are no impacts on habitat for the tuna fishery. The bait fishing inside the atolls is also considered to have minimal impact on ETP species, including both megafauna and habitat (Jauharee et al. 2015).

While this report provides the first analysis of ETP interactions, further studies would be beneficial for assessing the full impacts on these species. Firstly, studies on mortality rates of released bycatch, especially silky sharks, could validate or disprove claims on their assumed high survivorship. Secondly, a dedicated study on the entanglement of marine life in aFADs could better assess the full impacts of this fishery.

Lesser frigatebird (*Fregata ariel*) soars above the tuna schools

Interactions with ETP species in this fishery occur at low to negligible levels. Therefore, this fishery is highly likely to comply with all national and international requirements for conservation (Anderson et al. 2012). As such, no further management on ETP species is considered necessary at this time (Anderson et al. 2012). Pole-and-line tuna fishing is also considered to have one of the lowest levels of discard among all fisheries (Kelleher 2005, Gilman 2011). Based on the low levels of interaction observed, the authors conclude that the Maldivian pole-and-line tuna fishery does not "pose a risk of serious or irreversible harm to ETP species and does not hinder recovery of ETP species," which meets the requirements for MSC certification.

Table 2. Potential direct and indirect effects of Maldivian pole-and-line tuna fishing on ETP species, based on expert opinion and interaction rates as seen in Table 1.

	Potential effects					
	Mortality or injury from hooks or fishing line		Entanglement in aFADs		Change of feeding habits	
Species/taxa	Likelihood of impacts to individuals	Likelihood of impacts to population	Likelihood of impacts to individuals	Likelihood of impacts to population	Likelihood of impacts to individuals	Likelihood of impacts to population
Sea birds	Very low	None	Negligible	Negligible	Low	Negligible
Silky sharks	Low	None	Low	Negligible	Low	Negligible
Other sharks	Negligible	None	Very Low	None	Low	Negligible
Turtles	Very low	None	Low	Negligible	Negligible	None
Marine mammals	Negligible	None	Very Low	Negligible	Very Low	Negligible

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