Review of Yellowfin Tuna Fisheries in the Maldives

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Abstract

Yellowfin tuna (*Thunnus albacares*), in the Maldives, is exploited by the four gears that target tunas; pole and line, handline, longline and trolling. It is the second most important species after skipjack tuna (*Katsuwonus pelamis*). Average catch for the recent 5 years, from all gears were around 50,000 t and contributed between 35 and 43 percent of all tunas landed (SKJ, YFT, BET, FRI, KAW). Pole and line, which used to be the most important gear for yellowfin tunas, exploit surface swimming juveniles, below ~70 cm FL, with 80% of catch between 38 and 63 cm FL. Handline yellowfin tuna fishery lands surface swimming sub adults and adults above ~80 cm FL, with 80% of the catch between 99 and 155 cm FL. The longline fishery also lands similar sized fish (80-168 cm). The historically predominant troll fishery catches tunas from the atoll lagoons and outer atoll reefs. A seasonal troll fishery targeting yellowfin tuna existed in the 1990's. Nominal catch for PL shows the catches to be fluctuating around a mean of 14,500 t, with a declining contribution to total YFT catch. Handline fishery shows clear increasing trend in catch from 189 t to 30,500 t. In terms of catch, handline gear has become the most important for yellowfin tuna in the Maldives. Cessation of licensing foreign or joint venture longliners in 2010 to allow for a fully local fleet, clearly disrupted the catch trend. Landings from the longline fleet remained between 1,100 and 3,100 t prior to cessation of foreign licensing, while the latter period showed catches below 1,200 t. As for marine species of special interest, Maldives implements a number of measures to protect such species. While pole and line, handline and troll fisheries have minimal interactions with endangered, threatened and protected species and have virtually zero bycatch and discards, longline, undoubtedly has bycatch, most important being sharks. However, the ban on shark fishery prohibits sale or use of shark by-catch and are therefore released or discarded at sea. Additionally, longline fishery regulation mandates vessels to implement seabird mitigation measures in adherence to relevant IOTC Resolutions. The Ministry of Fisheries and Agriculture, and the Marine Research Centre implements several programs to improve fisheries data, including those to improve logbook reporting, widen the size sampling program, implement the vessel monitoring system and also efforts to better manage the Maldives marine fisheries.

1. Introduction

Yellowfin tuna (*Thunnus albacares*) the second most important species in the Maldives tuna fisheries and is commonly caught by all 4 gear types that target tunas; pole-and-line, handline, longline and trolling. Average catches in the recent five years (2013-2017) was about 50,000 t, and comprised between 35 and 43 percent of all tuna catches (skipjack tuna; *Katsuwonus pelamis*, yellowfin tuna, bigeye tuna; *Thunnus obesus*, frigate tuna; *Auxis thazard*, kawakawa; *Euthynnus affinis*).

It is the target species in the handline yellowfin tuna fishery and exploits surface swimming adult fish. Juveniles are caught in the pole-and-line fishery, often associated with skipjack of similar size. The longline fishery for bigeye and yellowfin tuna, often catch deep swimming adult fish, which comprise a considerable proportion of the catch. Small scale coastal troll fishery that operated within and outside the atoll rim reefs, target neritic species, but also catches small quantities of yellowfin tuna.

Prior to introduction of the handline fishery in the 1990's, large fish (>80cm FL) were virtually un-exploited within the Maldives waters except by small seasonal handline and troll fisheries that existed in the early 1990s (Adam and Anderson (1995), Adam and Jauharee (2009)) and the foreign licensed longline fleet from late 1980s until 2010. The foreign licensed fleet which operated beyond 100 miles from the atolls, caught an average of 2,300 t between 2004 and 2009.

This paper presents a review of the tuna fisheries that exploit yellowfin tuna, incorporating most recent catch-and-effort and size data. It also discusses bycatch and interactions of the fisheries with Endangered, Threatened and Protected (ETP) species.

2. Material and Methods

Ministry of Fisheries and Agriculture collects catch and effort data from the tuna fisheries through fishery logbooks introduced in 2010. Prior to this, data collection was through island offices reporting to the Ministry on a monthly basis. In 2010 the system was migrated to a logbook system where the fishing vessel captains themselves have to report. With the introduction of the fishery logbooks, the island office data collection system was gradually phased out. The nominal catch and effort data for the period, 2004-2015, was obtained from the Ministry of Fisheries and Agriculture.

The tuna size sampling program implemented by the Marine Research Centre (MRC) since the 1980's collects size data from the tuna fisheries. The initial objective of the program was to provide conversion factors to the Ministry which was needed to convert the catch reported in numbers to weights. More recently, the program collects data as part of the national reporting to the IOTC. Currently, routine data collection is carried out by fishermen samplers who report on their catch and by samplers at the key landing ports. Additionally, size data from the Male' fish market is obtained by a contracted staff.

3. Catch Trends

3.1. Pole and line fishery

Live bait, pole-and-line (PL) is the primary gear targeting tunas in the Maldives, in the catches of which, yellowfin tuna comprise around 20%. Prior to inception of the handline yellowfin tuna fishery, PL contributed the majority of yellowfin tuna catch. The gear exploits juvenile yellowfin tuna, commonly associated with skipjack tuna of similar sizes. Juvenile bigeye tuna (*Thunnus obesus*) also form a small part of the PL yellowfin catches ranging from 2-15% (Anderson (1996), Adam et al. (2014), its presence increasing towards the south of the archipelago.

Nominal catch of yellowfin tuna from PL gear has been fluctuating around a mean catch of 14,500 t in the recent years (2004-2017) (Figure 1Error! Reference source not found.). Lowest catch was reported for 2016 (8,500 t) and the highest catch reported in 2013 (18,800 t) in the data period. Longterm trend (from 1995, when gear specific catch began to be recorded) for PL caught yellowfin tuna also showed similar pattern, without an obvious trend.

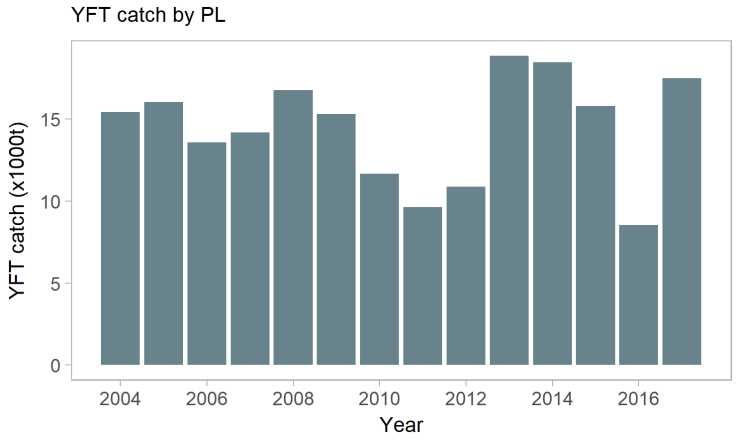

Figure 1. Nominal YFT catch from PL gear.

3.2. Handline fishery

Use of handline as a specific fishery targeting yellowfin tuna began in late 1990 (Adam and Riyaz, 2009), although it was practiced at smaller scales much earlier. Development of the handline fishery was a direct response to opening the private sector engagement in the export of fresh fish. Since the handline fishery does not require expensive gear and modification to the vessel, it was a natural conversion of pole-and-line vessels to target surface swimming large yellowfin tunas. Many of the key PL fishing islands, especially in the central and northern atolls, have recently seen their fleet changed to handline fishery. However, PL still is the main gear for tunas in the southern atolls of the country.

Handline yellowfin tuna fishing is carried out using live bait, of which most commonly used are; fusiliers (*Caesio sp*.), bigeye scad (*Selar crumenophthalmus*) and round scad (*Decapterus macarellus*). Red-toothed triggerfish (*Odonus niger*) is also widely used nowadays. The catch is immediately gilled, gutted and bled on deck and stored in ice. Yellowfin tuna from the handline fishery are exported to Europe, Japan, USA and Sri Lanka, among other destinations.

Nominal catch of yellowfin tuna (all gears combined) has been increasing, in most part due to the handline yellowfin tuna fishery. Catch of 2016 (53,700 t) was the highest on record (1970-2017). Handline catch in the period (2004-2017), has increased from 189 t to 30,500 t. There seems to be a clear distinction between catch reported prior to and post 2010, when logbooks were introduced (Figure 2). Average catch from 2004 to 2010 was about 4,800 t, while that of 2011 to 2015 was about 29,800 t. The observed difference in reported catch could be attributed to the improved reporting from the fleet with the logbook reporting system compared to the previous data collection method. In terms of catch, handline gear has become the most important for yellowfin tuna in the Maldives.

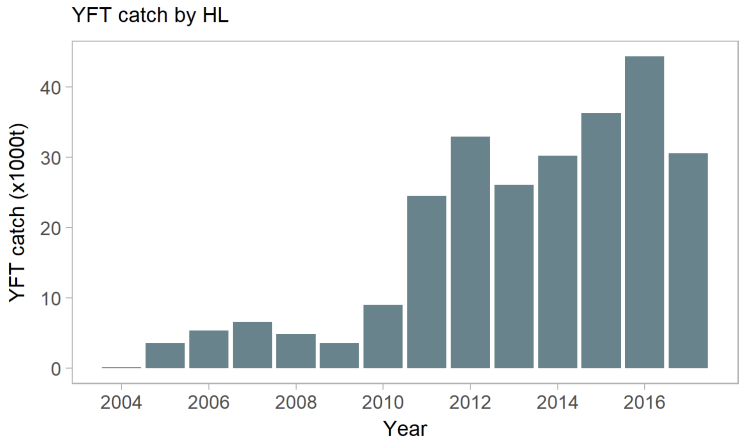

Figure 2. Nominal YFT catch from HL gear.

3.3. Longline fishery

Longline vessels have been licensed to fish within Maldives EEZ since 1985 (Anderson et. al, 1996). Up until 2010, foreign, or joint venture longliners were licensed to operate in the outer waters of the EEZ (from 75 miles from shore) while the inner waters, up to 75 miles was reserved for local fishermen. Although mandatory catch reporting was provisioned in the license agreement, there was poor reporting rates and access to the data was a problem (Adam, 2007), primarily because licenses were issued by the then Ministry of Economic Development. Anderson et. al., speculated that catch from these vessels were under reported and was partly the reason all licenses were terminated in August 1994, and resumed sometime later. In mid of 2010, the Government of Maldives ceased licensing foreign longline vessels to fish from Maldives EEZ. The Ministry of Fisheries and Agriculture resumed licensing in 2011 to fish from 75 miles from shore, within the Maldives EEZ. The Longline Fishery Regulation (No. 2014/R-388) was enacted in 2014, to allow locally owned vessels and businesses to fish from 100 miles from the archipelagic baseline, targeting yellowfin and bigeye tuna. The fishery is highly regulated with a total allowable catch, quota system, mandatory VMS and logbook reporting of catch and effort data.

Catches from the longline fishery have declined by 95% in the data period, from 2,500 t in 2004 to 112 t in 2015, due to cessation of licensing in 2010 (Figure 3**Error! Reference source not found.**). Prior to it, YFT landing from the fleet remained between 3,100 and 1,100 t (2004 – 2009 period). Low catches (~ 1000 t) was reported for 2008 and 09 as licenses were not renewed in this period. The number of active vessels were 13 and 16 for 2008 and 09 respectively. No vessel operated in 2010, and in 2011 and slightly more than 1 t of YFT was reported from longline in these years. Catch from longline appears to be improving as 2017 catch increased from 286 t to 1269 t from the previous year.

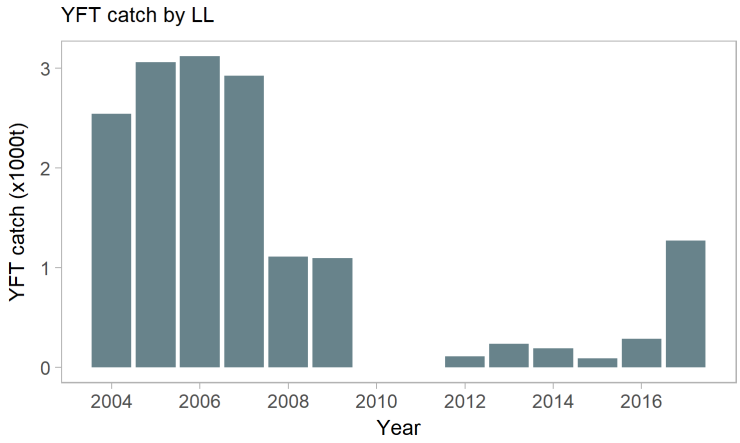

Figure 3. Nominal YFT catch reported from LL gear.

3.4. Trolling

The trolling fleet, which primarily targeted neritic tunas (frigate and kawakawa) and caught small amounts of yellowfin tuna. Yellowfin tuna caught by the trolling fleet were reported to be subadults and adults larger than 70cm FL (Adam and Anderson, 1996). Historically, the fleet constituted a significant proportion of the national tuna fleet. Its importance was highest during the period of transition during the mechanization of the pole and line fleet (1975-1982) (Anderson, Hafiz and Adam, 1996). The recent years have seen catches below 2,000 t except for 2004, when 6,000 t was reported (Figure 4). The reported catch of 2004 is dubious as such a catch has never been reported from the trolling fleet, since 1995 (when gear-wise data began to be collected).

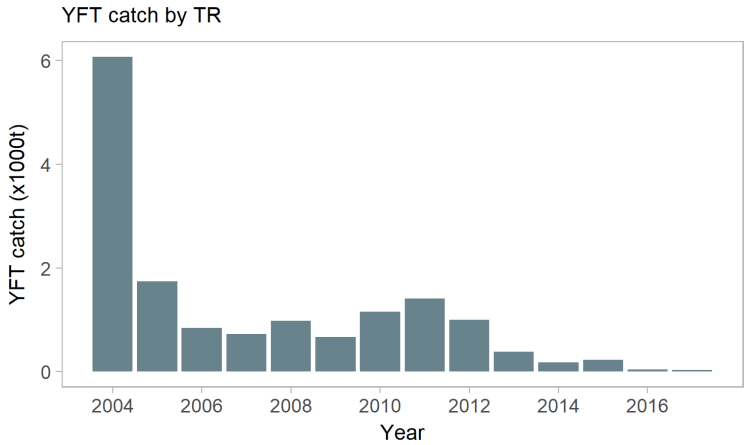

Figure 4. Nominal catch of YFT reported by the trolling fleet.

4. Gear Contribution

Maldives tuna fisheries seems to be in a in a state of flux. Pole and line gear, which used to be the predominant gear for yellowfin tunas has largely been replaced by handline, mostly in the central and northern atolls. Undoubtedly, this shift has contributed to the observed trends in landings from the PL and HL fleets. Contribution of pole and line gear to the total yellowfin catches declined by 44%; from around 60% in 2004 to 35% in 2017. PL contribution peaked at 74% in 2009, and the lowest was recorded at 16% in 2016. In contrast, handline contribution increased from 14% in 2005 to 61% in

2017. Similar to nominal catch, there is a marked difference in proportion of handline caught yellowfin tuna landed between pre and post logbook introduction in 2010 (17% vs 62%). This increase in reported catch and contribution by the handline fleet suggests improved coverage of the fleet with the introduction of the logbooks. It appears that the observed decline in PL contribution is more due to increasing catch from the handline fleet than an actual reduction of PL landings.

Longline contribution to the nominal catch of yellowfin tuna has largely been affected by the licensing scheme of longline vessels to fish from Maldives EEZ. Prior to cessation of foreign licensing in 2010, the longline fleet landed between 10 to 14% of yellowfin tuna (between 2004 and 2007). Somewhere between 25-37 vessels were active during the period. In the following two years, the number of active vessels were 13 and 16 respectively, landing about 5% of all yellowfin tunas. Since, 2011, longline contribution appears to be increasing.

Importance of the trolling fleet, which historically landed significant amounts of neritic species, has tapered in the recent times. Their activity was highest during the transition to mechanized pole and line fleet:1975-1982 (Anderson et. al). In the data period, the trolling fleet contributed less than 10% of all yellowfin tuna landed, except for 2004, when it contributed 25%. In the last five years, (2013-2017), the fleet's contribution has remained below 1%. Figure 5 and Figure 6 below present yellowfin tuna contribution by different gears.

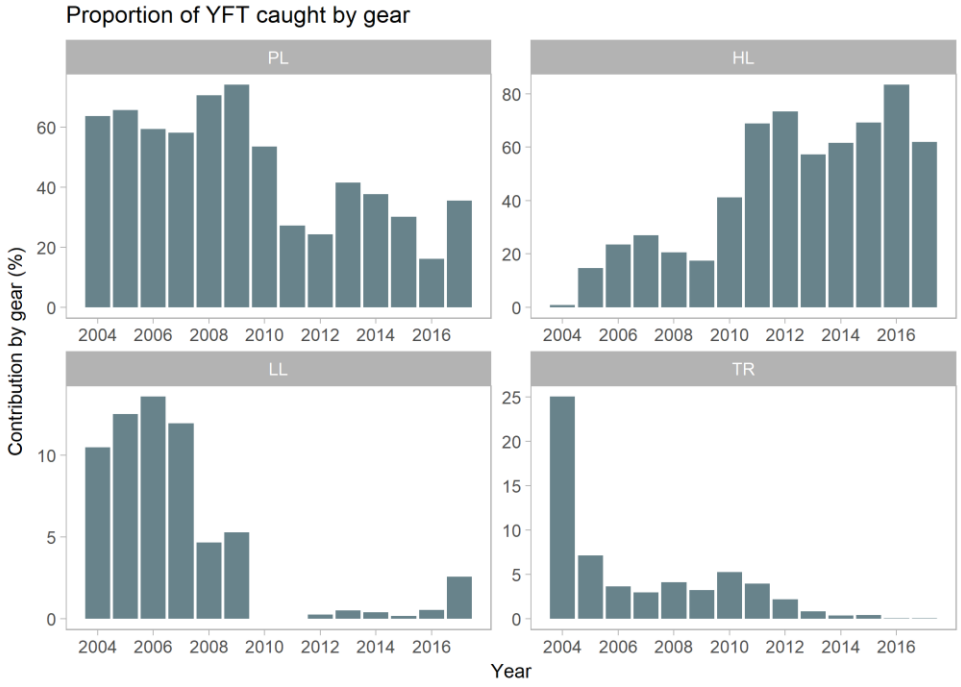

Figure 5. Proportion of YFT landed by different gears.

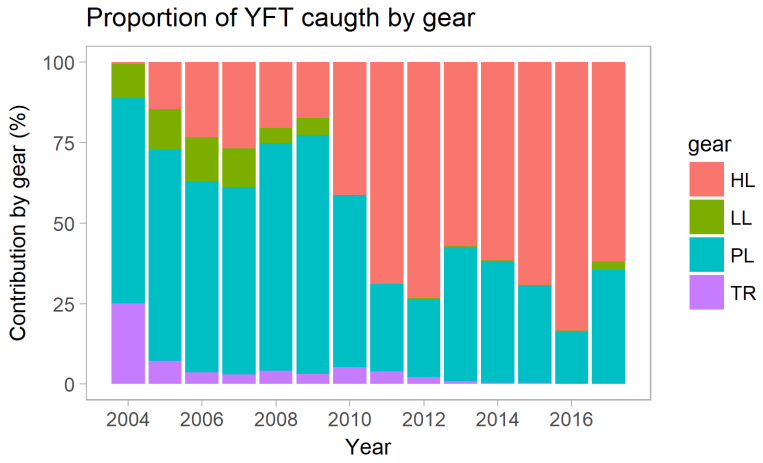

Figure 6. Proportion of YFT landed by different gears.

5. Catch and Effort

Anderson (1986) presented the history of the Maldives catch and effort data collection system. The Ministry of Fisheries (then the Ministry of Home Affairs) initiated catch and effort data collection in 1959 (Anderson, 1986), through island chiefs, to collect total tuna catch by *masdhoni* (tuna fishing vessel) each day. This system of total enumeration proved to be feasible as catches were counted for distribution among the crew and vessel owner. In the coming years, the system expanded in terms of the level of detail. For example, in 1966, number of trolling vessels began to be recorded, along with pole and line vessels and three categories of tuna (large skipjack; small skipjack and yellowfin; frigate and kawakawa). In 1970, five categories of tuna, and catches of all non-tuna species (reef fish) began to be reported. Mechanization of the fleet began in 1974, and in 1979, the Ministry of Fisheries required that catches be reported by vessel mechanization status (i.e. mechanized and non-mechanized vessels).

In the following years, the system expanded to record non-tuna species into three basic groups; Group 1 (large fish such as wahoo and giant trevally), Group 2 (medium sized fish such as trevally, rainbow runner and red snapper), and Group 3 (small fish such as scads). The next major development to the system came in 2010, when logbooks were introduced to the tuna fisheries. In the following years, as the logbook coverage improved, data flow from the previous, island office reported system tapered and no reports were received in 2017. The Ministry officially ceased data collection from island offices in January 2018.

Maldives tuna fishery has always reported fishing effort in number of days fished. This has been practical and feasible as historically, fishing trips did not last more than a single day. However, with mechanization of the fishing fleet and the consequent increase in vessel sizes, fishermen are able to stay out at sea for longer durations. Additionally, the larger vessels required more crew (25-30 compared to ~10) than a traditional vessel, in turn, reducing the total number of vessels and the number of days fished. This is apparent to some degree from the nominal effort for pole and line, which has seen an 84% decline in the data period. Other possible factors which might have exacerbated the observed decline in effort include the switching over of a portion of the PL fleet to the more lucrative handline tuna fishery targeting adult yellowfin tuna. Additionally, the recently

implemented changeover of the fishery data collection system from a total enumeration to logbook reporting is believed yet another contributing factor.

Due to the changing socio-economic conditions and partly for reasons previously mentioned, nominal effort reported for the pole-and-line fleet showed a somewhat remarkable downward trend from 147,700 days to 24,300 days. This trend appears to have stabilized in the last three years probably due to saturation of the factors that caused the downward trend.

Unlike pole-and-line, handline gear did not show such a remarkable trend in nominal effort, and has fluctuated between 20,000 and ~52,000 effort days, except for the year 2004. It is believed that the anomaly in 2004 (4,600 effort days) is more due to data recording/reporting error (possible mis-recording of gear) in the previous data collection system (Ahusan, Medley and Adam, 2017).

Trolling effort showed a steep declining trend from 2004-2006 and 2010-2017. In contrast, effort seems to have increased for the 2006-2009 period. Overall, trolling effort has declined by 99% (from 57,646 days to 299 days) in the data period. Traditionally, troll fishing was carried out on '*Vadhu dhoni*', smaller versions of PL tuna fishing vessels and targeted neritic tunas (frigate and kawakawa), mainly kawakawa, but also caught yellowfin tuna to some extent. After mechanization of the PL fleet, importance of the trolling fleet declined, most probably due to socio-economic reasons (Anderson, Waheed and Adam, 1998). In more recent times, popularity of trolling has picked up again due to the wide availability of small crafts for part time fishing and increased popularity of recreational fishing among locals and tourists. However, these trips mostly target non-tuna species such as sailfish (*Istiophorus platypterus*), wahoo (*Acanthocybium solandri*) and other large fish, for which good markets exist at the tourist resorts or fish processors. As a result, these trips are not expected to be captured in the traditional tuna targeted troll fishery.

Longline fishing effort has largely depended on the number of vessels licensed to fish. Effort has remained between 8,100 and 14,500 days from 2004-2009. The decision to cease licensing foreign vessels meant effectively no longline effort within Maldives EEZ in 2010. The following years (2011 and 2012), the longline effort was around 50 days, as local vessels began to be licensed. From 2014 onwards, the Ministry does not report longline effort in numbers of days.

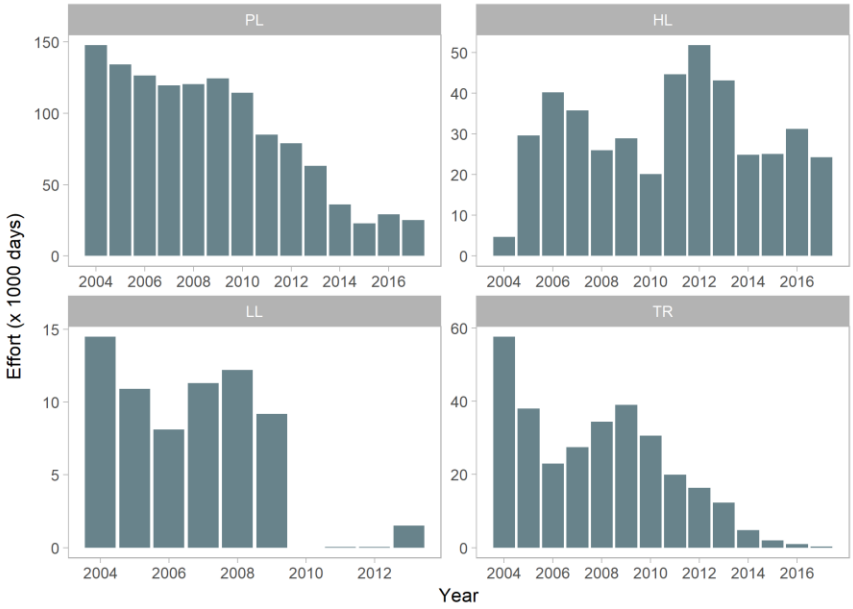

Figure 7. Nominal effort (x 1,000 days) reported for the four gears. Note that no longline vessel operated in 2010. LL effort wasn't reported in number of days after 2013. Longline effort for 2011 and 2012 were too low to be seen in the figure.

6. Length Distribution

The length sampling programme at MRC was described by Ahusan, Adam and Jauharee (2011) and presented the different sampling approaches, funding sources and limitations in the programme. Size data collection from the tuna fisheries has been an ongoing process since mid-1980s. Over the period the quantity and quality of data in terms of reliability and representativeness have varied. To address these issues, the program underwent several modifications through the period. Initially, field officers were contracted at key islands to collect data from the pole-and-line catch landed at the respective islands. As the fishery developed, increasing amount of catch were landed at the exporters' landing sites rather than home islands. As a result, the island-based field officers were replaced by fishermen samplers who reported data from their catch.

The program incorporated handline yellowfin tuna fishery from 2007, when 2 handline fishermen were contracted to sample the catch from their fishing tips. Since then, data from the handline yellowfin tuna fishery has been collected through fishermen samplers or from the landing sites. Prior to 2007, two PL samplers reported handline caught yellowfin tuna, possibly caught during good fishing seasons.

Over the course of the program, MRC has received funding to expand data collection from several NGO's such as the Overseas Fishery Cooperation Foundation (OFCF) of Japan and WWF-Pakistan. Recently, data collection has been widened with assistance from the World Bank through the Sustainable Fisheries Resources Development Project to include both, the commercial and coastal fleets. Table 3 presents a summary of the size data at the MRC database.

Table 1. Summary of size data for yellowfin tuna

Year	Numbers of yellowfin tuna sampled by gear			
	HL	LL	PL	TR
2004	0	0	27,961	0
2005	2,056	0	15,620	0
2006	2,567	0	6,685	0
2007	3,779	0	28,281	0
2008	4,022	0	19,193	0
2009	2,491	0	20,009	0
2010	1,585	0	4,680	0
2011	4,328	0	6,523	0
2012	4,872	0	1,168	0
2013	3,826	0	6,366	0
2014	3,344	163	9,180	0
2015	2,079	189	38,217	23
2016	2,147	38	17,398	0
2017	3,476	99	14,038	0

Figure 8 below presents the fork length distribution of yellowfin tuna caught by the four gears. Pole-and-line lands yellowfin tuna between 20 cm and about 75 cm FL. However, 80% of the catch is between 38 and 62cm FL. As expected, there is a clear separation of catch from PL and HL gears. Handline gear exploits the adult population, between about 80 – 190 cm FL, with 80% of the catch falling between 99 and 155 cm FL. This observation is a bit lower than that reported by Ahusan et al. (2016) for handline caught yellowfin, where 80% of the catch ranged between 102 and 162 cm FL. The difference could be attributed to the differing time spans of the two datasets, where Ahusan et al., used data from 2007-2016 while this paper used data from 2004-2017. It is possible that the fishery has evolved over the years to avoid the relatively smaller sized fish (< 100cm) as these are not purchased by the exporters tend to have a lower quality in general.

Length data from the longline fleet suggests a slightly narrower size range, between 80 and 168 cm with 80% of the data between 113-155 cm FL. The length distribution highlights improper sampling which needs to be addressed. Length data for troll gear was too few to be of any value (n=23). Catch from the trolling fleet has never been adequately covered in the size sampling program, mostly due to limited resources and the need to prioritize more important gears (PL, HL). Adam and Anderson (1996) suggested that the seasonal large yellowfin tuna fishery which existed in parts of the country prior to the commercial handline fishery landed subadults (> 70cm FL). However, it should be noted that the fishery employed both, handline and troll gears and therefore, the reported sizes could not have been only from troll gear.

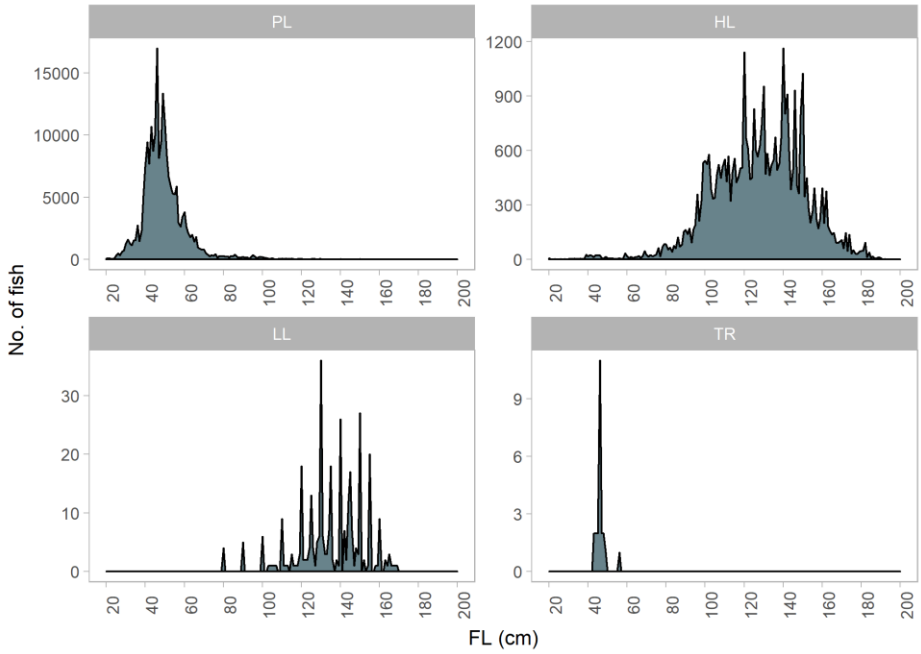

Figure 8. Length distribution of yellowfin tuna for different gears.

7. Bycatch & Discards

Traditional tuna fishing gears, pole and line, handline and troll gear, are known to be highly selective with minimal amount of bycatch. The newly introduced fishery logbooks have provisions to report bycatch and interactions with Endangered, Threatened and Protected (ETP) species to comply with a number of IOTC resolutions and other international requirements.

In pole and line fisheries, four of the tuna species commonly caught in the Maldives (skipjack, yellowfin, frigate and kawakawa) are considered target species, and thus are never discarded. Hence, the levels of discards from the pole-and-line fishery is considered negligible. Most commonly caught bycatch species include rainbow runner (*Elegatis bipinulata*), silky shark (*Carchahinus falciformis*), and dolphin fish (*Coryphaena hippurus*) (MRS, 1996), which are consumed except for shark species. In terms of fishery interactions with Endangered, Threatened and Protected (ETP) species, Miller et. al. (2016), from 106 pole and line fishing trips, observed very low to negligible levels of interactions with ETP species. These comprised of zero interactions with marine turtles and marine mammals; interaction involving 7 silky sharks and 3 seabirds, all released in good condition. Additionally, the authors reported two incidents where sharks were discarded dead.

Association of large yellowfin tuna with dolphins is well known in the Maldives. Over 90% of respondents in a study on the phenomenon reported positive association with dolphins (Anderson and Shaan, 1998). In the handline yellowfin tuna fishery, more than 90% of the schools are estimated to have been located with the help of dolphins (Adam and Jauharee, 2009). Despite such a high degree of association, reports of dolphin bycatch is uncommon. Fishermen tend to avoid hooking dolphins, as it will damage gear and disrupt the fishing operation. Logbook data for 2017 showed 4 incidents involving sharks from the handline fishery, which were released without major damage. As shark fishing is banned, there is no economic incentive to land sharks. It is possible that the actual

number of interactions in the handline yellowfin tuna fishery be higher as the data has not been verified by observers.

A number of regulatory measures are in place to minimize the impact of the longline fishery on the populations of non-targeted and ETP species. The ban on shark fishery and the longline fishery regulation (2014/R-388) ensures that all live sharks caught in the fishery are released and reported. Additionally, the regulation requires setting gear below 60 m to avoid surface sharks. Sea turtles are protected by legislation under the Environmental Protection and Preservation Act (4/93) while the longline fishery regulation requires that vessels carry de-hookers and line cutters to minimize turtle mortalities. Longline vessels are also required to implement at least one seabird mitigation measure in accordance to IOTC resolution 12/06.

Logbook reporting is mandatory for all longline vessels and catches of non-target and ETP species are reported through the logbooks. Data from 2016 and 2017 suggest sharks to be the main by-catch group (Figure 9) with up to 75% reported to have been released alive and 25% released with minimal damage. Less than 1% was reported as being discarded dead. Post-release survival of sharks, and other species in general, is not well understood and depends on a number of factors such as species, soak time, size of the animal and haulback condition. The authors note that release condition and post-release survival of sharks and other bycatch species from the longline fisheries has not been studied in the Maldives.

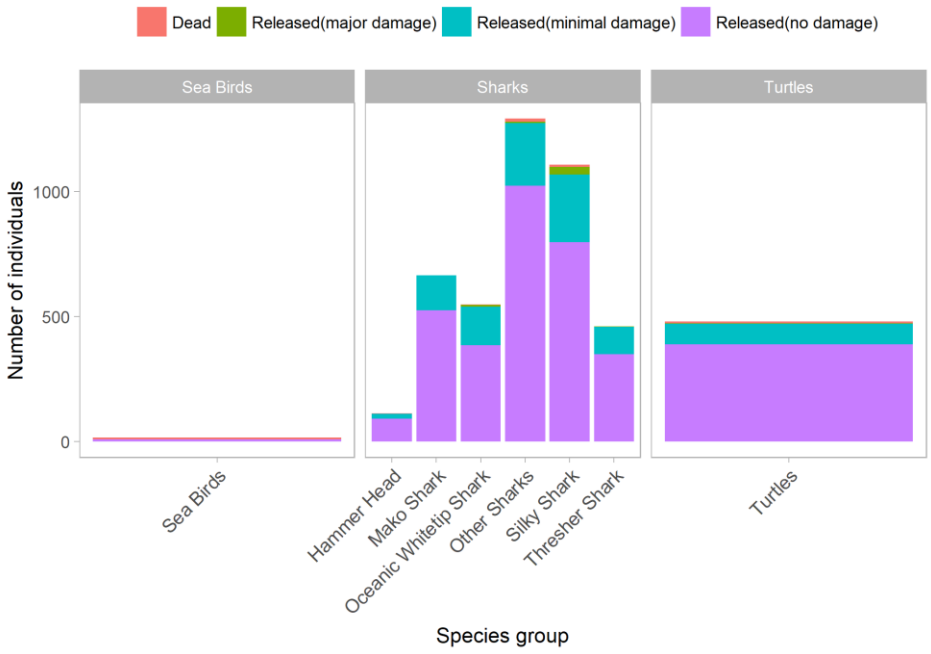

Figure 9. Numbers and fate of the bycatch from the longline fishery as reported in the logbooks (2016 and 2017).

8. Ongoing Efforts at Improving Data

A major change in the acquisition of catch and effort data occurred in 2010 when logbooks were introduced. The old system was phased out in 2015. Since its initial launch, logbooks have undergone at least 2 revisions, partly to harmonize it with IOTC's data requirements. The Ministry exerts

continuous effort to improve reporting rates and timeliness of logbook reporting. In this regard, a mobile app is being developed to electronically report logbook data and is expected to be completed before 2022.

The Fishery Information System (FIS), an online fisheries database, was first launched in 2010, which was used to issue fishing licenses. The system underwent major upgrades in 2014 (incorporation of logbook data) and 2016. The FIS allows tuna exporters to report purchase data in near real-time. Efforts to improve and enhance the system is ongoing, with development of additional modules to enable additional features for the FIS system.

The ongoing World Bank Project, Sustainable Fisheries Resources Development Project, committed financial resources to improve the fisheries management of the country. Specifically, the project would enable the expansion of the VMS coverage, complement observer data collection through e-monitoring systems, improve the size sampling program by contracting additional samplers to cover the coastal and commercial fleet. Additionally, the Ministry has recently revised the terms of commercial fish purchasing and export license, for the parties to provide size data from the purchases. It is expected that these efforts will improve compliance various Conservation and Management Measures adopted by the IOTC.

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