MALDIVES FISHERIES CHARACTERIZATION

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Fisheries Characterization: Maldives

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1. Introduction

Maldivians are highly dependent on the fisheries and tourism sectors for their livelihoods, which, in turn, rely on healthy coastal and reef ecosystems. For example, in 2019, 4.2% of Maldives' GDP was attributed to fisheries (the sum of both the primary and secondary fisheries sector contributions) and 23.6% was attributed to tourism (Maldives Bureau of Statistics, 2021). In 2017, there were an estimated 17,589 employed fishers in the Maldives (no estimates in 2018, 2019) (National Bureau of Statistics, 2018, 2020) and fisheries products made up roughly 96% of the total value of exports in 2018. Our report provides an overview of publicly available datasets, key species and their biological status, and fleet characteristics of the Maldives' fisheries. We organize our report around the species/species groups with published fishery management plans and discuss the characteristics of each fishery individually. The eight fisheries included in this report are tuna and associated live baitfish, billfish, diamondback squid, grouper, general reef, marine aquarium, sea cucumber, and lobster. For each fishery, we provide an overview of: data availability and limitations, targeted or commonly caught species, gear types, the structure of the fleet, catch, and the economic importance of each fishery. Where applicable, we also discuss fishery bycatch and its implications for sustainability. We additionally summarize existing aquaculture production by species group, as well as any aquaculture efforts in development. The report concludes with a synthesis of the multi-jurisdictional fisheries management in the Maldives and key measures from each fishery management plan.

Information and data presented in this report were compiled from Fisheries Management Plans developed by the Ministry, peer-reviewed publications, gray literature, government and NGO reports, and interviews with regional fisheries experts, with sources referenced throughout. This is meant to be a living document which will be updated to reflect recent research, insights and knowledge as they become available. In cases where there is a recent report that already synthesizes information on a topic relevant to this report, it is cited, and it is recommended that the source be consulted directly for detailed information.

2. Tuna and live baitfish fisheries

Overview

The tuna and livebait fisheries have been a core component of the Maldives' history for hundreds of years (Ahusan et al., 2020). The tuna sector is the main source of employment and protein for local communities, and tuna products are the most valuable export commodity (Ahusan et al., 2020; Government of Maldives, 2019). The five primary tuna species caught by the Maldivian tuna fisheries are skipjack, yellowfin, bigeye, frigate, and kawakawa (Ahusan et al., 2020). Pole-and-line, handline, trolling, and longline are the four gear types deployed to catch tuna in the Maldives (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Only domestic Maldivian-flagged vessels are permitted to fish within the EEZ of the Maldives. Foreign vessels flagged to Distant Water Fishing Nations (DWFN) and other neighboring countries in the Indian Ocean previously participated in a longline fishery within the EEZ limited to the zone 75 nautical mile (nm) and further from the coast (Barclay & Parris, 2013). This practice was suspended in 2010 by the Maldivian government in favor of developing a domestic longline fishery. However, regulations around the use of longline gear have evolved over time, and the Maldives longline fishery was most recently suspended in 2019 (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Tuna landings in the Maldives grew steadily after the switch to mechanized vessels in the late 1970s to early 1980s until they hit a peak of roughly 167,000 mt in 2006, roughly 25% higher than present-day landings (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Still, tuna fishing by Maldivian vessels makes up a significant portion (~9% in 2019, 4th highest volume by flag) (IOTC, 2021b) of tuna fishing in the Indian Ocean today. The country ranks second highest in yellowfin tuna catch, third highest in skipjack tuna, and tenth highest in bigeye tuna for catch among the member nations of the Indian Ocean Tuna Commission (IOTC) (Nizar et al., 2019).

The livebait fishery is essential in supporting the activities of the pole-and-line and handline fisheries in the Maldives, as they require large amounts of live bait to operate (FAO, 2009). Baitfishing in the Maldives is carried out by the same vessels that will later utilize the bait, making it a prerequisite for almost every tuna fishing trip (Jauharee et al., 2015). Searching for and landing livebait is a time and energy intensive activity for tuna vessels. For example, 2017/2018 daily logbooks from the handline fleet indicate that over one-fifth of all effort days involved catching livebait with no additional tuna fishing carried out (Ahusan et al., 2019). Different sizes and species of livebait are used by the tuna fisheries. While the livebait stocks are generally believed to be in good health and resilient due to their fast generation times, their true status cannot be formally discerned due to a lack of monitoring and data collection processes.

Data availability and limitations

Fishery independent data

Regional data describing the status of tuna stocks in the Indian Ocean is publicly available through IOTC stock assessments and monitoring.

Fishery dependent data

Catch data is available from the Maldives Bureau of Statistics or by request from the Ministry of Fisheries, Marine Resources and Agriculture (MoMFRA). No comprehensive dataset of livebait catch in the Maldives is available as livebait are caught at sea, utilized, and never landed. Tuna export data is hosted by the Maldives Custom Services (MCS) and publicly accessible. Yearly weight and value export data are available for tunas by export destination.

Target species and status

The tuna fisheries of the Maldives have historically targeted three tropical tuna species: skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and bigeye tuna (*Thunnus obesus*), and two neritic tuna species, frigate tuna (*Auxis thazard*) and kawakawa (*Euthynuss affinis*) (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Skipjack tuna comprises the majority of domestic landings by volume (66% in 2019) and is the primary target species of the pole-and-line fleet (Figure 1; (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h)). Almost all of the remaining tuna landings are yellowfin tuna (33% in 2019) which is caught by the handline, pole-and-line, and (to a lesser extent) trolling fleets (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The contribution of yellowfin tuna to the national tuna landings has increased in the last decade alongside the growth of the handline tuna fishery, where yellowfin tuna are predominantly caught (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Bigeye made up roughly 1% of recorded landings by the domestic tuna fleet for 2015-2019 (Ahusan et al., 2020). Bigeye tuna was the primary target species of the longline fleet before it was suspended first in 1994 and most recently in 2019, and is also caught by the pole-and-line fleet in extremely small quantities as part of mixed schools with yellowfin tuna at anchored fish-aggregating devices (aFADs) (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Currently, the two neritic tuna target species, frigate tuna and kawakawa, are primarily caught in the pole-and-line fishery (Ministry of Fisheries,

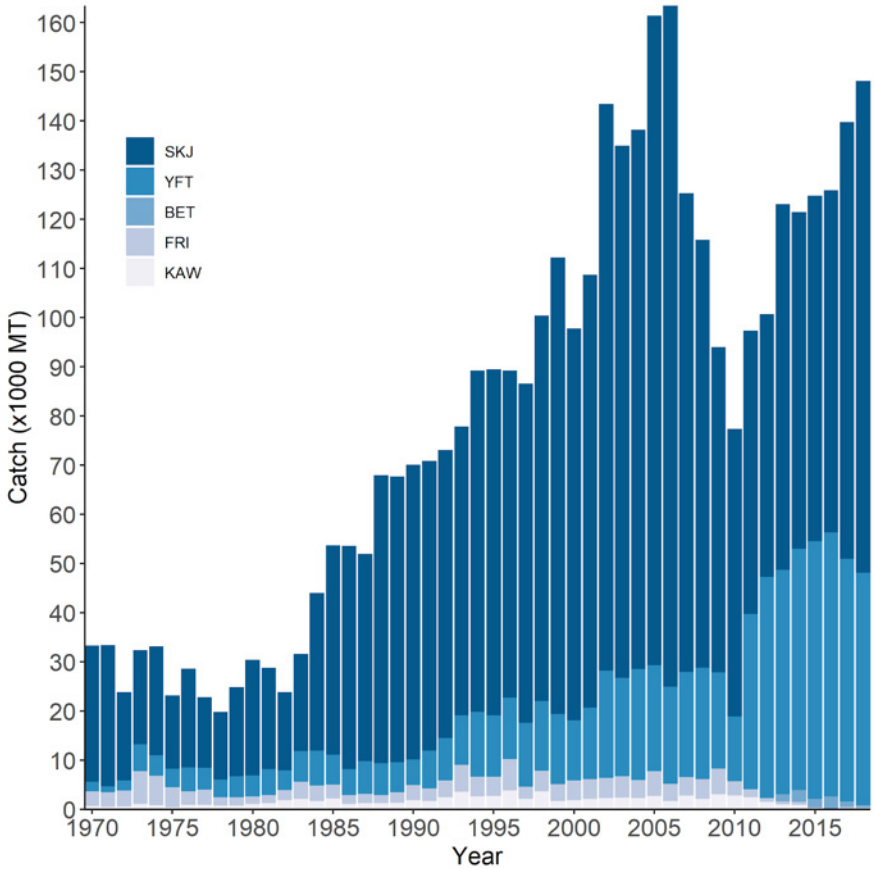

Figure 1. Catch of the five target species of the Maldivian tuna fisheries: skipjack (SKJ), yellowfin (YFT), bigeye (BET), frigate (FRI), and kawakawa (KAW). Figure from the Ministry of Fisheries, Marine Resources and Agriculture (2020h).

Marine Resources and Agriculture, 2020h). Historically, these two species were targeted by the trolling fleet, but the rise to prominence of the tropical tuna fleet has decreased the importance of both the trolling fleet and these two species to national fisheries production (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Currently, the highest volume of kawakawa and frigate tuna is taken incidentally/opportunistically by pole-and-line vessels (Ahusan et al., 2020). Together, these species have made up less than 1% of the national tuna landings over the last five years (National Bureau of Statistics, 2020). Total catch of both species was 178 metric tons (mt) in 2019 from all gear types (Ahusan et al., 2020).

The Indian Ocean stocks of skipjack, yellowfin, bigeye, frigate, and kawakawa are all monitored under the IOTC mandate (Table 1). Skipjack tuna, the most important species in terms of catch volume, is neither overfished or subject to overfishing (IOTC, 2020d). Notably, the primary abundance index dataset used as input in the IOTC assessment of skipjack tuna is from the Maldives (IOTC-SC23, 2020). However, there are concerns about the overexploitation of the yellowfin which is both overfished and currently subject to overfishing (IOTC, 2020d). Bigeye is classified as not overfished but subject to overfishing, which has been linked to increasing fishing pressure in the region from purse seine vessels flagged to other nations (IOTC, 2020d). In contrast to the other tuna stocks, frigate tuna and kawakawa stocks are both data-poor. The kawakawa stock was recently classified as not overfished with no overfishing occurring based on data-limited assessment methods (IOTC, 2020b). No quantitative assessment has been carried out for frigate tuna by the IOTC (IOTC, 2020a). Both kawakawa and frigate tuna are listed as species of least concern at the global scale by the IUCN (Froese & Pauly, 2021).

Table 1. Species commonly fished in the Maldives tropical tuna fishery and their stock statuses for the Indian Ocean as indicated by the Maldives Tuna Fisheries Management Plan (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). F/F_{MSY} and SSB/SSB_{MSY} were taken from IOTC stock assessments for the species covered in the IOTC agreement and color coded according to estimated stock status: green (not overfished and not subject to overfishing), yellow (overfished but not subject to overfishing), orange(not overfished but subject to overfishing), and red(both overfished and subject to overfishing). IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible (Froese & Pauly, 2021).

Species Scientific Name	Species Common Name	IUCN Listing (Year Assessed)	$F_{(year)} / F_{MSY*}$	$SSB_{(year)} / SSB_{MSY*}$	Vulnerability	Resilience
Auxis thazard	frigate tuna	Least concern (2010)	-	-	Low-moderate	Medium
Euthynnus affinis	kawakawa	Least concern (2009)	0.98 (2020)	1.13 (2020)	Moderate	Medium
Katsuwonus pelamis	skipjack tuna	Least concern (2010)	0.48 (2019)**	1.99 (2019)	Moderate	Medium
Thunnus albacares	yellowfin tuna	Near threatened (2011)	1.20 (2017)	0.83 (2017)	Moderate-high	Medium
Thunnus obesus	bigeye tuna	Vulnerable (2011)	1.20 (2018)	1.22 (2018)	High	Medium

*These metrics are only available for stocks formally assessed by the IOTC.
** Skipjack tuna is referenced to annual harvest rate (E) as opposed to fishing mortality (F).

Over 40 species of livebait are caught by the pole-and-line fleet, but only ~12 species are core components of the livebait catch (R. C. Anderson, 2009). The silver sprat (*Spratelloides gracilis*) is the most important species by volume with other important species or groups of fish being (in approximate order of catch magnitude): fusiliers (Caesionidae), shorthead anchovy (*Encrasicholina heteroloba*), cardinalfishes (Apogonidae), a few species of *Chromis*, and the blue sprat (*Spratelloides delicatulus*) (R. C. Anderson, 2009; Jauharee et al., 2015). Livebait catch composition varies widely based on season, region, and time of day (see *Table 2* on pp. 7 of (R. C. Anderson, 2009) for a breakdown), but livebait catch in the southern atolls contains more species in general (R. C. Anderson, 2009). Anchovies are more prevalent in the south, whereas the silver sprat is most abundant in the northern and central atolls (R. C. Anderson, 2009).

The primary livebait species utilized by the handline fishery differ from pole-and-line bait, and are primarily bigeye scad (*Selar crumenopthalamus*), round scad (*Decaptenus macarellus*), red-tooth triggerfish (*Odonus niger*), and fusiliers (Caesionidae) (R. C. Anderson, 2009). Fusiliers are caught as live bait in both fisheries, but pole-and-line fishers typically use smaller juveniles while handline fishers use adults (R. C. Anderson, 2009). Bigeye scads, mackerel scads, and redtoothed triggerfish are the most commonly utilized baitfish by the billfish fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020a).

It is difficult to assess the status of livebait stocks in the Maldives due to the lack of robust data collection programs in place (Gillett et al., 2013). In general they are believed to be in good health due to their underlying biological characteristics (i.e., short generation times and high population growth rates), making them hard to overexploit (Ahusan et al., 2020). An analysis of available livebait catch data included in logbooks from 2011-2014 showed no consistent trends across species or regions, suggesting that any variation in catch was probably due to localized depletion or natural inter-annual variability as opposed to general trends in the population status of livebait (Jauharee et al., 2015).

While the livebait populations of the Maldives are not believed to be overexploited, the lack of data also makes it difficult to parse out any true population trends over time due to fishing pressure (Gillett et al., 2013). Fishers will occasionally note difficulty catching sufficient livebait, especially in the southern atolls (Gillett et al., 2013). The current demand for livebait is believed to have increased due to modern higher-capacity tuna vessels as well as more efficient baitfishing techniques, such as the use of night lights or scuba gear (Jauharee et al., 2015). Other fisheries, including the reef fish fishery, are also reliant on livebait and some livebait species like sprats are also caught for subsistence purposes (Jauharee 2013). Finally, there is significant waste of livebait by the fishery due to rough handling techniques that lead to higher livebait mortality (Gillett et al., 2013).

Gear types

The four relevant gear types used by the domestic tuna fisheries are pole-and-line, handline, trolling, and longline. Pole-and-line gear consists of a barbless, unbaited hook and line attached to a fishing rod whereas handline fishing involves a barbed, baited hook and a line that is not affixed to a rod. Baited lines employ live bait caught at the start of each fishing trip to target tunas. Trolling involves a lured line that is towed behind a moving vessel. The longlines used by Maldivian vessels consist of a series of hooked lines attached to a mainline suspended at depth by floats which are allowed to "soak" for a period of time before being collected.

Pole-and-line gear was the main gear type used by tuna fishers historically and remains the dominant contributor to national tuna landings presently. The modern pole-and-line fleet emerged in the late 1970s/early 1980s with the shift from sailing to mechanized fishing vessels (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Trolling also increased during this time period, with a peak in the number of active vessels in 1982 (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). A handline fleet developed in the late 1990s/early 2000s and now makes up the second

largest percentage of national tuna landings by volume (~27%) (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Handlines are also the most common gear type employed by fishing vessels from central and northern atolls (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). As the proportion of overall tuna catch attributable to the pole-and-line and handline fleets grew with the expansion of the export market for tuna, the proportion of catch from trolling decreased (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The Maldives longline fishery was established in 1985, but all licenses were terminated in 1994 partly due to noncompliance with data submission requirements. Longline licensing resumed in 1997 with a US$1/kg tariff placed on catch, then ceased again in 2010 to prioritize the development of a fully local fleet. Following the resumption of licensing in 2011, it was most recently suspended in 2019 because it did not result in substantial local employment as well as data reporting compliance concerns (Ministry of Fisheries, Marine Resources and Agriculture, 2020h; Ministry of Fisheries, Marine Resources and Agriculture, personal communication, 2022).

Historically, baitfishing occurred in the early morning. Rectangular lift nets were used alongside attractants (fish paste) or with crew members in the water to herd fish into the net (R. C. Anderson, 2009; Jauharee et al., 2015). This method was replaced over time with baitfishing at night with the aid of light attractants, which became the dominant targeting practice throughout the country by the mid-to-late 1990s (R. C. Anderson, 2009). Based on field observations, this more efficient method accounts for over 90% of all livebait used by the handline fleet (Jauharee et al., 2015). However, targeting methods differ by species. For example, while the bigeye scad is caught by handline vessels using night lights and during the day, the red-toothed triggerfish is only caught during the day (Ahusan et al., 2020). Sprats and anchovies have become a larger portion of catch for pole-and-line as they are most attracted to night lights (R. C. Anderson, 2009). These species are less hardy than other bait species, requiring fresh catch to be made every night (R. C. Anderson, 2009).

Fleet structure

As of March 2022, there were 633 mechanized *masdhoni* licensed, on which pole-and-line, handline, or both gears are used (Ministry of Fisheries, Marine Resources, and Agriculture, 2022).

Several events in the 1970s/1980s led to the expansion and technological advancement of the pole-and-line fleet. First, a shift from traditional wooden-hulled sailing vessels, called *masdhoni*, to mechanized vessels (Ministry of Fisheries, Marine Resources and Agriculture, 2020h) increased fishing efficiency, and by 1984, nearly 99% of all tuna landings were being caught by mechanized *masdhoni* (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Second, expanded infrastructure and opportunity via the installation of an aFAD network, the opening of canneries in the Maldives, and the growth of an export market all served to greatly expand the fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Many mechanized *masdhoni* were outfitted for handline fishing during the rise in popularity of the handline fishery around the turn of the 21st century (Ahusan et al., 2020). Currently, tuna fishing licenses are not categorized by gear, hence gear switching is commonly practiced by ~38% of vessels (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Those vessels that do switch between gears are typically fishing in the northern atolls where handline fishing is more common (Edwards et al., 2020). This geographic difference may be explained by differences in infrastructure: the southern atolls are further from the international airport in Malé and have fewer frozen product processing facilities, making the export of yellowfin tuna from handline fishing more costly and difficult (Hohne-Sparborth et al., 2015).

Traditionally, trolling took place on vessels similar to those used in the pole-and-line and handline fisheries but smaller, called *vadhu dhoni* (Ahusan et al., 2020). Trolling was most prominent prior to the mechanization of the *masdhoni* fleet, from a peak of 3,482 vessels in 1982 to 713 in 2010 (Ministry of Fisheries, Marine Resources and Agriculture,

2020h). The decline of the trolling fishery has been linked to the rise of the tropical pole-and-line and handline fisheries and the more lucrative financial prospects offered by those fisheries and their export-based end markets (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). However, trolling may be gaining popularity once again as a recreational fishing activity with the widespread availability of small fishing vessels, available markets to sell catch, and the increased popularity of recreational fishing in general (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The target species of recreational trolling are larger non-tuna species such as billfish and wahoo (Ahusan et al., 2020).

Prior to the closure of the foreign longline fleet, roughly 30-40 foreign vessels were licensed to fish in the Maldivian EEZ during the fishery's peak (Ahusan et al., 2020). Nineteen domestic longline vessels were licensed in 2011 and began operating in 2012 outside of 75 nm. The Longline Fishery Regulation of 2014 (No. 2014/R-388) effectively overhauled the fishery with a series of regulations including: implementing a total allowable catch and quota system, imposing gear restrictions to reduce the ecological impacts to non-target species (described below in Tuna Management Plan section), mandating VMS and logbook data-reporting requirements, and moving the fishery to the high seas and further than 100 nm offshore within the EEZ to conserve space for pole-and-line and handline fishing activity (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Longline fishing was halted for a third time in 2019 - again due to low compliance and irregularities with data reporting - but may resume in the future (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h, personal communication, 2021). There were 28 longline vessels in operation in 2019 prior to the fleet's suspension (Ahusan et al., 2020).

Catch

The Maldives reported 134,300 mt of national tuna landings in 2019 (Ahusan et al., 2020). Total effort (in days) by pole-and-line, handline, and trolling vessels (longline effort is measured in hooks) ranged between roughly 50,000 and 80,000 days per year over the last five years and was 58,909 days in 2019 (Ahusan et al., 2020).

Pole-and-line is the dominant gear type used to target tuna, with 72% of the Maldives' national tuna landings caught by pole-and-line between 2014-2018 (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Skipjack (82%) and yellowfin (16%) tuna make up nearly all of pole-and-line landings by species, with bigeye tuna, frigate tuna, and kawakawa comprising the remainder (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Skipjack catch by the pole-and-line fleet has been on the order of 67,000-100,000 mt since 2014, but the roughly 88,000 mt caught in 2019 was an 11% decrease from the previous year (Ahusan et al., 2020). For context, this magnitude of skipjack catch constitutes roughly one-fifth of the total global supply of pole-and-line caught tuna and about 16.5% of the total skipjack catch from the Indian Ocean (IOTC, 2021a). All of the pole-and-line catch is landed at domestic ports where it is either processed or exported for processing (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The pole-and-line fleet was granted a Marine Stewardship Council (MSC) certification in 2012 after a model-based stock assessment was conducted with the IOTC that found the skipjack stock to be healthy (Edwards et al., 2020).

Pole-and-line fishing vessels operate primarily close to shore, targeting both free-swimming schools of tuna and fish surrounding aFADs (Ahusan et al., 2020; Jauharee et al., 2015). A network of roughly 50 aFADs - anchored approximately 12-20 nm from shore - is installed, managed, and maintained exclusively by the Maldivian Government - Ministry of Fisheries, Marine Resources and Agriculture (2020). Pole-and-line fishing trips typically last only one to two days, but may be extended in times of low tuna or bait abundance (Ahusan et al., 2020; Edwards et al., 2020). Furthermore, multi-day fishing trips have become more common with the mechanization of the *masdhoni* pole-and-line

fleet (Ahusan et al., 2020).

Catch from the handline fishery constituted 27% of national tuna landings from 2014-2018 and has grown in prominence since its initial expansion in the late 1990s/early 2000s (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Its growth was aided by the ease of outfitting pole-and-line vessels with handline gear, the promising financial prospects of accessing export markets, and the increased availability of ice (Ahusan et al., 2020; Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The handline fleet is highly selective in targeting yellowfin tuna (>70 cm fork length) (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Logbook data from 2017/2018 indicate that handline fishing trips last 9 days on average, but may range anywhere from 1-23 days (Ahusan et al., 2019). It is now believed to be the most common fishing activity in the central and northern atolls based on numbers of fishers and vessels (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Handline fishing effort is concentrated relatively close to shore around the north and central atolls (Ahusan et al., 2020). Yellowfin tuna caught by the handline fleet is primarily landed and processed at facilities near the economic center of Malé (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

The trolling fleet's estimated cumulative landings from 2014-2018 were roughly 1,100 mt, less than 0.2% of all tuna landings for that time period (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). It reported approximately 114 mt in landings in 2018, ~40% of which was kawakawa (IOTC, 2021b). The fleet operates both inside and outside of atolls and is more active in the northern atolls where the target species are more abundant (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Total catch from the longline fleet was reported to be 564 mt in 2019 prior to its suspension and was primarily composed of yellowfin tuna (479 mt) and bigeye tuna (83 mt) (Ahusan et al., 2020). The remainder (~5 mt) of the catch was composed of other tuna species and billfishes (Ahusan et al., 2020). Longliners operated further than 100 nm from shore within the EEZ and in the high seas per regulations (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Livebait are caught from within atoll lagoons and reefs and are kept alive within the flooded hull of the fishing vessel (R. C. Anderson, 2009; FAO, 2009). A comprehensive dataset of livebait catch in the Maldives does not exist, likely because livebait are caught at sea, utilized, and never landed. Previously, mechanized *masdhoni* effort has been used as a predictor of livebait catch such that the 25% reduction in *masdhoni* effort from 2003-2008 would correlate to a 25% reduction in predicted livebait catch (R. C. Anderson, 2009). Field surveys conducted in 2014 estimated that an average of 148 kg of bait was caught to support each tuna trip (Jauharee et al., 2015). Using tuna catch data from that year, Jauharee et al. (2015) extrapolated a total livebait catch of just over 10,000 mt, which represented a tuna to livebait catch ratio of approximately 11.8 kg of tuna for every 1 kg of bait utilized. This figure was lower than a previous annual estimate of 15,000 mt in the mid-2000s by Gillett et al. (2013).

Foreign-flagged longline vessels are not licensed to fish within the Maldivian EEZ; however, a substantial amount of the Maldives' fisheries resources are illegally caught by foreign vessels. Ten to fifteen thousand tonnes of fish are estimated to be poached from the EEZ annually (Ministry of Fisheries, Marine Resources and Agriculture, 2020e). Based on vessel-tracking satellite data provided by Global Fishing Watch (GFW), 35 foreign longline vessels actively fished for roughly 1,000 hours within the EEZ in 2020 (Figure 2). This illegal fishing activity took place inside the EEZ boundary and across the center of the EEZ (Figure 2). A two-year MoFMRA study published in 2017 reported that over 400 foreign fishing vessels operate illegally within the EEZ each year, and a number of Sri Lankan fishing vessels have been seized for illegal fishing (Maldives Independent, 2017).

Longline fishing effort by DWFN and regional foreign-flagged vessels is concentrated to the east and west of the Maldivian EEZ, with a notable build-up of observable fishing effort along the

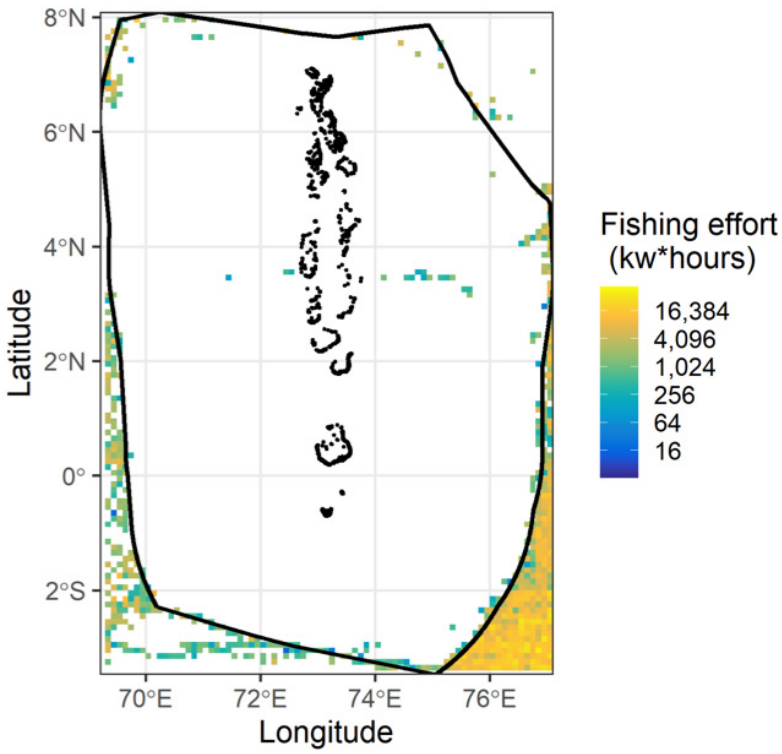

Figure 2. The spatial distribution of observed illegal fishing effort by Sri Lankan longline vessels within and around the EEZ of the Maldives (outlined in black) in 2020. Effort data are displayed in "kilowatt hours" (kw*hours), a unit of fishing effort that captures both the duration of fishing (hours) and the vessel's engine power (kilowatts) as a proxy for fishing capacity, downloaded from Global Fishing Watch (2021).

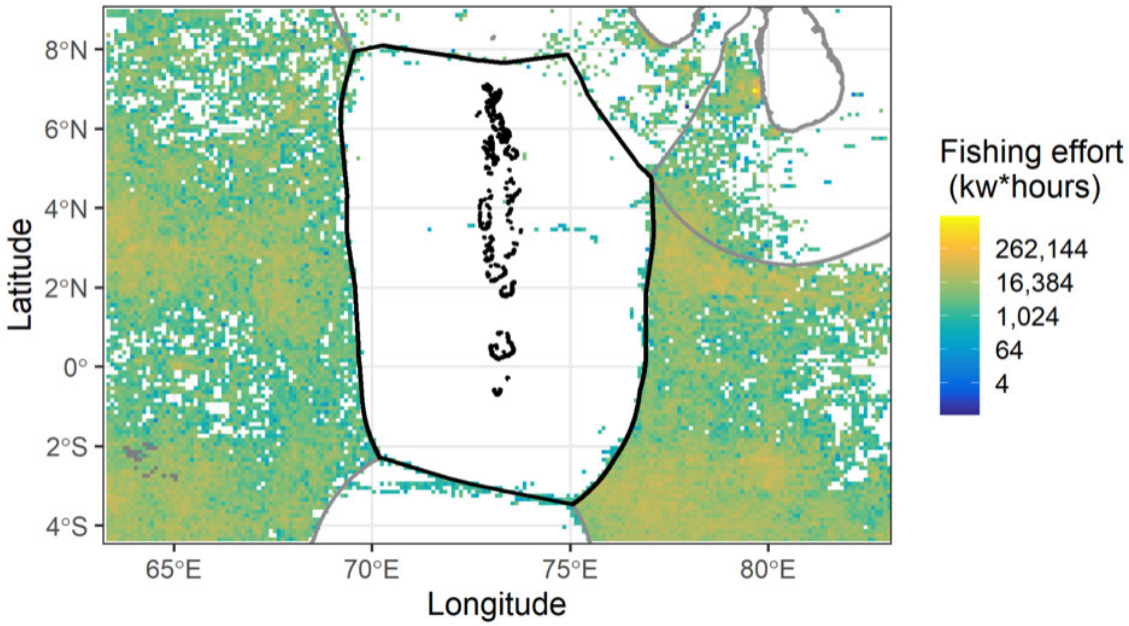

Figure 3. The spatial distribution of observed fishing effort by all vessels around the EEZ of the Maldives (outlined in black) in 2020. The EEZs of India and Sri Lanka lie to the north and northeast while the EEZ of the Chagos Archipelago is to the south (all outlined in grey). Effort data are displayed in "kilowatt hours" (kw*hours), a unit of fishing effort that captures both the duration of fishing (hours) and the vessel's engine power (kilowatts) as a proxy for fishing capacity, downloaded from Global Fishing Watch (2021).

EEZ's eastern border (Figure 3), primarily by the Sri Lankan, Chinese, and Taiwanese DWFN fleets. The concentration of effort along the outside of an EEZ boundary (Figure 3) can be an indication that fish biomass is accumulating inside the EEZ and then spilling over into fishable high seas waters, though this effect may be minimal with regards to highly migratory stocks such as tunas. It should be noted that GFW data is limited to those vessels equipped with automatic identification system (AIS) technology and therefore may not capture all vessel activity.

Bycatch and sustainability

Tuna in the Maldives are caught with highly selective gear with minimal impact on the ecosystem, a low discard rate, and little catch/interactions with bycatch/non-target species (Ahusan et al., 2020; Edwards et al., 2020). A study of 161 pole-and-line fishing events reported that 0.65% of total catch was bycatch by weight (Miller et al., 2017). Individuals of target species that are too small or low quality to be sold are generally consumed locally by the fishermen or their community (Edwards et al., 2020). Finally, tuna fishing in the Maldives has a low rate of gear loss and a low fuel intensity (fuel used per catch) due to "collector vessels" that gather and transfer catch from fishing grounds to landing sites (Edwards et al., 2020).

When in operation, the longline fleet targeting bigeye tuna commonly caught billfish as bycatch (~40% of 2018 catch) and had a higher rate of interaction with non-target and associated species (Ahusan et al., 2020; IOTC, 2021b). All five species targeted by the billfish fishery (see below) were also caught by the longline fleet, however swordfish comprised >50% of all billfish bycatch landings of the longline fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). With the longline fleet now suspended, the tuna fisheries of the Maldives currently have minimal impact on non-target species (Ahusan et al., 2020).

Targeted shark fishing was banned in 2010 but the bycatch of sharks was unavoidable by the longline fleet prior to its suspension (Ahusan et al., 2020). Measures are in place to minimize shark bycatch (see the Tuna Management Plan section below) and all shark bycatch is released or discarded at sea and reported via logbooks and the IOTC database (Ahusan et al., 2020). Shark species and genera with which the fishery formerly interacted include hammerhead sharks, thresher sharks, mako sharks, and oceanic whitetip sharks (Ahusan et al., 2020) (Table 2).

Interactions with other non-target species of special interest (seabirds, sea turtles, marine mammals) by the tuna fisheries are minimal. The Tuna Management Plan (see below) has measures to reduce the incidental catch or interaction with vulnerable species and fishers are required by the IOTC to record interactions with non-target species in logbooks (Table 5). In 2018 and 2019 (prior to suspension), there were fewer than 5 reported

Table 2. Total number of sharks by species/species group that were released or discarded by the Maldivian-flagged vessels within the IOTC area of competence. All interactions shown below are attributed to longlining vessels. Table from Ahusan et al. (2020).

Year	Hammerhead (Sphyrnidae)	Thresher (Alopiidae)	Mako (Lamnidae)	Oceanic whitetip (Carcharhinidae)	Other sharks
2014	18	822	875	1525	1763
2015	14	44	72	221	264
2016	78	374	534	464	1964
2017	34	86	141	86	457
2018	0	6	5	3	5
2019	0	23	14	1	38

Table 3. Number of individuals caught as bycatch by Maldivian longliners for special interest species groups. Table from Ahusan et al. (2020).

Year	Seabirds	Marine turtles	Marine mammals
2014	-	22	0
2015	0	53	0
2016	15	424	0
2017	1	56	0
2018	0	4	0
2019	0	5	0

longline interactions with sea turtles each year and none reported for seabirds or marine mammals (Table 3) (Ahusan et al., 2020).

In contrast, the livebait fishery is known to interact with multiple endangered, threatened, and protected species (Edwards et al., 2020). Possible impacts of the livebait fishery on the ecosystem as a whole include the removal of juvenile reef fish, physical destruction of habitat while anchoring, and interactions with endangered, threatened, or protected (ETP) species (Gillett et al., 2013). However, interactions between ETP species and the livebait fishery have not been observed to result in mortality. While entanglement of ETP species does occur during baitfishing, most species are able to be released without any harm with exception of sharks and rays which occasionally suffer non-fatal injury on release (Jauharee et al., 2015).

Economic importance

The pelagic fisheries, especially the tuna sector, are a very important source of national income and livelihoods in the Maldives. Historically, the position of the Maldives along international trade routes in the Indian Ocean allowed for the export of tuna products to neighboring countries; now tuna products are exported by air to markets around the globe (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The tuna sector alone accounts for roughly 4-12% of the national GDP, 11% of the national labor force, 67% of total exports, and 85% of total protein consumed by Maldivians (Edwards et al., 2020).

As a whole, the harvest sector of the tuna fisheries employed 8% of the national labor force in 2016 with 40% of those jobs being held by individuals aged 18-24 (Edwards et al., 2020). The pole-and-line fishery employed an estimated 10,800 fishers in 2019 when both commercial and non-commercial vessels were considered and is believed to directly and indirectly support approximately 30,000 jobs overall (Edwards et al., 2020). *Masdhonis*, the tuna vessels that support pole-and-line and handline fisheries in the Maldives, are built, owned, and operated by Maldivian citizens. Ownership of these vessels is often hereditary and crew members are typically sourced from the same locality as the captain (Edwards et al., 2020). Direct employment in the pole-and-line fisheries is financially attractive, with fishers making an average monthly income twice that of the national average of US$1,500 (Edwards et al., 2020). However, seasonal fluctuations in the fishery can lead to volatile wages, with monthly wages dipping as low as US$400 in less productive times of year (Edwards et al., 2020).

Skipjack tuna caught by the pole-and-line fishery (roughly two-thirds of all tuna catch) can travel along various product pathways once landed. Fishers typically sell their catch either to the local community or to processors directly or through an intermediary collector vessel operated by the

processing facility (Edwards et al., 2020; IOTC, 2021b). Catch that is not sold to industrial processors can either go to small scale processors creating dried fish products, local community markets, or directly to consumers (Edwards et al., 2020). Yellowfin tuna caught by the handline fleet that is destined for export is typically landed directly at processing facilities (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

The government-owned Maldives Industrial Fisheries Company (MIFCO) is the dominant processor of skipjack tuna in the Maldives (Edwards et al., 2020). Edwards et al. (2020) reports that the post harvest sector provides 2,350 jobs in the formal industrial processing industry with additional individuals engaged in small-scale processing activities that create dried fish products. Unlike the primary fishing activity, women play a substantial role in the post harvest sector and hold roughly 25% of industrial processing jobs (Edwards et al., 2020). Furthermore, the government has invested in several island-based cooperative societies centered around processing activities with majority women membership such as the Gemanafushi Cooperative Society and Naifaru Cooperative Society to amplify the role of women in the fisheries value chain (Edwards et al., 2020). Also of note, MIFCO has worked to expand cold storage infrastructure on remote islands and atolls, increasing accessibility to export markets throughout the Maldives (Edwards et al., 2020).

Tuna exports from the Maldives in 2020 totalled nearly 103,000 mt worth 1.4 billion MVR (Figure 4; (Maldives Customs Service, 2020)). The majority

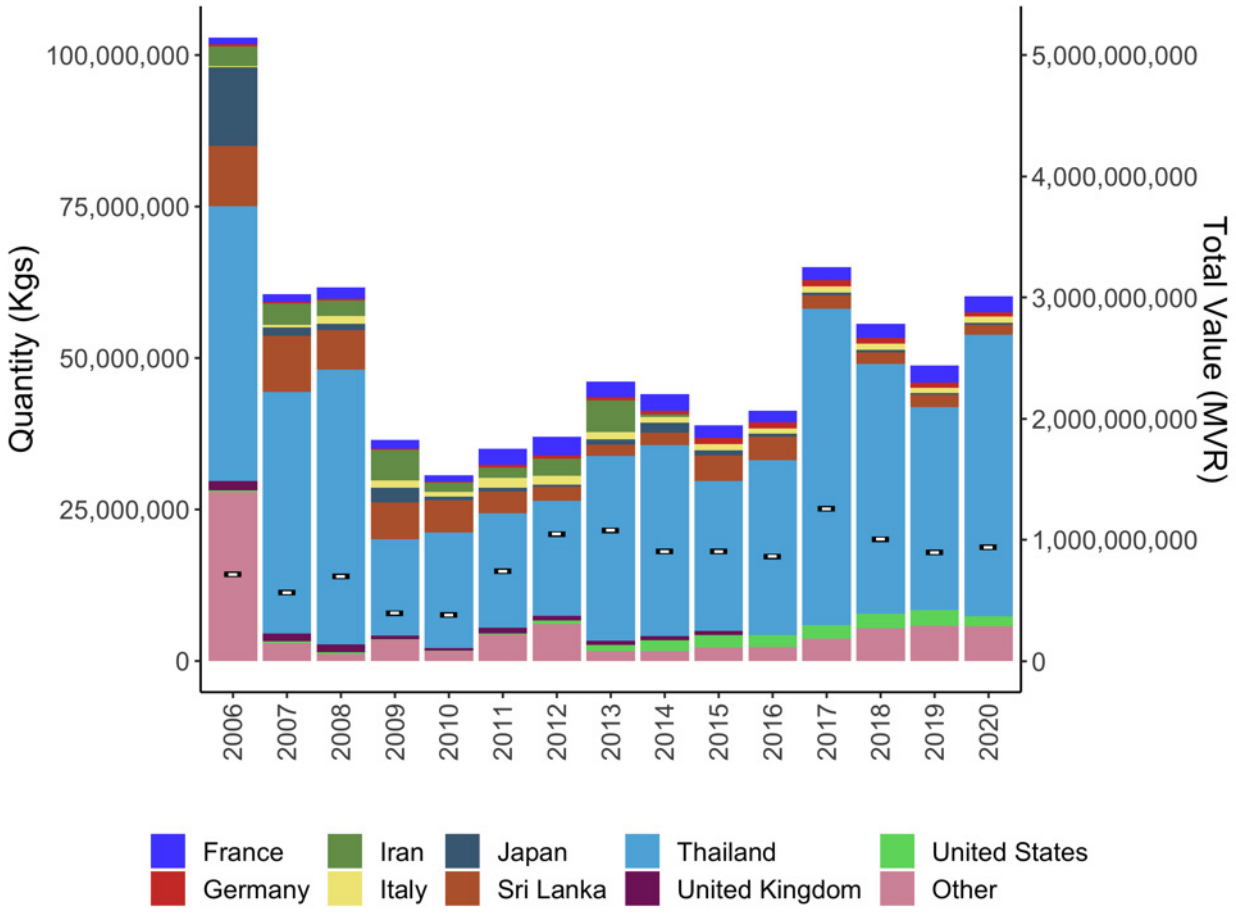

Figure 4. Export data from the Maldives Custom Services of tunas that were exported from 2006 to 2020. Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year (Maldives Customs Service, 2020).

of these exports (~77% of total mass and ~58% of total value) were frozen products destined for Thailand, predominantly skipjack tuna. Roughly 50% of all skipjack catch is exported to Thailand for processing (Government of Maldives, 2019). Processed yellowfin tuna from the handline fleet are typically exported to foreign markets such as the Japanese sashimi market and European markets as fresh, chilled, or frozen products (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

The economic importance of the livebait fishery is that it underlies the production of the pole-and-line and handline tuna fisheries and to some extent, the general reef fishery. Please refer to the "Economic importance" sections of those fishery profiles for further information.

3. Billfish fisheries

Overview

A small artisanal fishery targeting billfish has existed in the Maldives for a long time but increased demand from the tourism industry and ease of access to export markets has led to the commercialization of the fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020a).

Data availability and limitations

Fishery independent data
Regional data describing the status of billfish stocks in the Indian Ocean is available through IOTC stock assessments.

Fishery dependent data
There are presently no catch reporting requirements in the billfish fishery. However, an integrated data collection system will be implemented to collect logbook data from licensed fishing vessels beginning in early 2022. Some billfish catch is currently reported through reef fishery logbooks. Similarly, no mechanism currently exists to record catches from the recreational billfish fishery.

Export data is hosted by the Maldives Custom Services (MCS) and publicly accessible. Yearly export data are available for billfish by export type (dried or salted, fresh/chilled, frozen) as weights and value.

Target species and status

Five species are targeted by the commercial billfish fishery: striped marlin (*Kajikia audax*), black marlin (*Makaira indica*), Indo-Pacific blue marlin (*Makaira mazara*), Indo-Pacific sailfish (*Istiophorus platypterus*), and swordfish (*Xiphias gladius*) (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). Of them, the most commonly caught species in the targeted billfish fishery is the Indo-Pacific sailfish (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). These billfish species are highly migratory species found throughout the Indian Ocean, and management is shared at the regional level by the IOTC. The status of these five species is shown below in Table 4. The most recent assessment of the Indian Ocean swordfish stock concluded that it was healthy and not in danger of becoming overfished in the next ten years under current fishing pressure (IOTC, 2020c). Both the striped marlin and blue marlin stocks were classified as being overfished and subject to overfishing (IOTC, 2020c). Current catch levels of striped marlin are below maximum sustainable yield (MSY) but overexploitation over the last two decades have left the stock severely depleted (IOTC, 2020c). The blue marlin stock had previously been classified as being subject to overfishing but not overfished, however increasing catch levels in the Indian Ocean from 2015-2017 and an improvement in data quality has led to the stock now being estimated as overfished as well (IOTC, 2020c). The statuses of black marlin and Indo-Pacific sailfish in the Indian Ocean are uncertain due to data limitations, but current catch levels of both stocks are above their respective MSY estimates and their catch limits mandated by the IOTC (see the "Regional" heading of the Management section below) (IOTC, 2020c). Furthermore, Indian Ocean catches of both species have been elevated in recent years attributed to developing coastal fleets like the one found in the Indian Ocean region (IOTC, 2020c).

In addition to the commercial billfish fishery, a big game recreational fishery has developed in which both tourists and locals participate. The common target species are sailfish (Makaira spp.), marlins, wahoo, and even some larger yellowfin tuna (Ahusan et al., 2020).

Table 4. Species commonly fished in the Maldives pelagic billfish fishery as indicated by the Maldives Billfish Fisheries Management Plan. F/F_{MSY} and SSB/SSB_{MSY} were taken from IOTC stock assessments and color coded according to estimated stock status: green (not overfished and not subject to overfishing), yellow (overfished but not subject to overfishing), orange (not overfished but subject to overfishing), red (both overfished and subject to overfishing), gray (not assessed/uncertain). IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible.

Species Scientific Name	Species Common Name	IUCN Listing (Year Assessed)	$F_{(year)} / F_{MSY*}$	$SSB_{(year)} / SSB_{MSY*}$	Vulnerability	Resilience
Istiompax indica	black marlin*	Data deficient (2009)	0.96 (2017)	1.68 (2017)	Very high	Medium
Istiophorus platypterus	Indo-Pacific sailfish**	Least concern (2010)	1.22 (2017)	1.14 (2017)***	Very high	Low
Kajikia audax	striped marlin	Near threatened (2011)	1.99 (2017)	0.37 (2017)	Moderate	Low
Makaira mazara	blue marlin	Not evaluated	1.47 (2017)	0.82 (2017)	Very high	Low
Xiphias gladius	swordfish	Endangered (1996)	0.60 (2018)	1.75 (2018)	Very high	Medium

*The results of the black marlin's assessment are uncertain and should be treated with caution
** The status of the Indo-Pacific sailfish stock was estimated using data poor techniques and was determined to be formally classified as uncertain
*** The Indo-Pacific sailfish stock assessment uses biomass (B) as a reference point instead of spawning-stock biomass (SSB)

Gear types

Two main gear types are employed by the billfish fishery: trolling and drifting droplines (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). When trolling, a vessel may deploy up to five lines at once using a hookless lure (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). The dropline method uses a baited barbed hook and up to 10-15 lines may be used at a time (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). Billfish vessels, especially the smaller ones, will frequently switch between gear types and favor trolling, the more efficient gear type, during the early months of the Southwest monsoon (April-May) when billfish are easier to catch (Ministry of Fisheries, Marine Resources and Agriculture, 2020a) A third gear type used more prominently in the past, *heymas helun*, is unique to the Maldives and is still in use in parts of the country to this day (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). This gear type is composed of a baited stick and gaffe that is used to spear a fish and a length of attached rope to retrieve the catch.

Fleet structure

There are approximately 850 vessels active in the billfish fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). These vessels are not exclusive to the billfish fishery and often switch between trolling and reef-based fisheries. Billfish fishers will commonly fish in groups of 3 or 4 using relatively small boats (10-15 ft in length).

Billfishing occurs outside of atolls and a typical fishing trip lasts between 4-6 hours (Ministry of Fisheries, Marine Resources and Agriculture, 2020a).

Catch

Beginning in February 2022, all commercial billfish vessels will be legally required to have a license and report their landings. There are presently no reported landings and not all billfish that are landed are exported, so the total magnitude of catch in the Maldives is currently unknown (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). The estimated billfish landings in Maldives is around 2,300 mt annually (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). Typically, billfish catch is sold to third-party billfish processors, but some fishers will process their catch directly (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). Most of the exports consist of salt dried products which are primarily destined for Sri Lankan markets (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). However, there is rising interest in the creation of frozen and fresh/chilled billfish products due to their higher price. These products are both sold domestically and exported to international markets in Europe, North America, and Asia (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). Bycaught billfish from the longline fleet used to be a dominant source of frozen and fresh/chilled billfish export products.

Economic importance

The billfish fishery employs roughly 1,300 fishers, but there are no data regarding the percentage of these jobs that are full-time or part-time (Ministry of Fisheries, Marine Resources and Agriculture, 2020a).

Catch is typically sold to dedicated billfish processors, although fishers will do the processing themselves on some islands (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). In the late 1990s, all billfish products were salt dried and exclusively exported to Sri Lanka. Before the longline fleet was suspended, fresh, chilled, and frozen products were primarily produced from the billfish landed as bycatch by the longline fleet (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). At that time, the export market expanded to include Europe, North America, and Asia and frozen billfish filets were increasingly popular due to the higher price point they fetch (Figure 5; (Ministry of Fisheries, Marine Resources and Agriculture, 2020a). However, billfish exports in 2020 were limited to 43.5 mt of salt dried products worth roughly 695,000 MVR (Maldives Customs Service, 2020), which can most likely be attributed to the suspension of the longline fleet. From 2016-2020, the breakdown of billfish export volume by disposition was roughly: frozen (70%), salt dried (19%), and fresh/chilled (11%) (Maldives Customs Service, 2020).

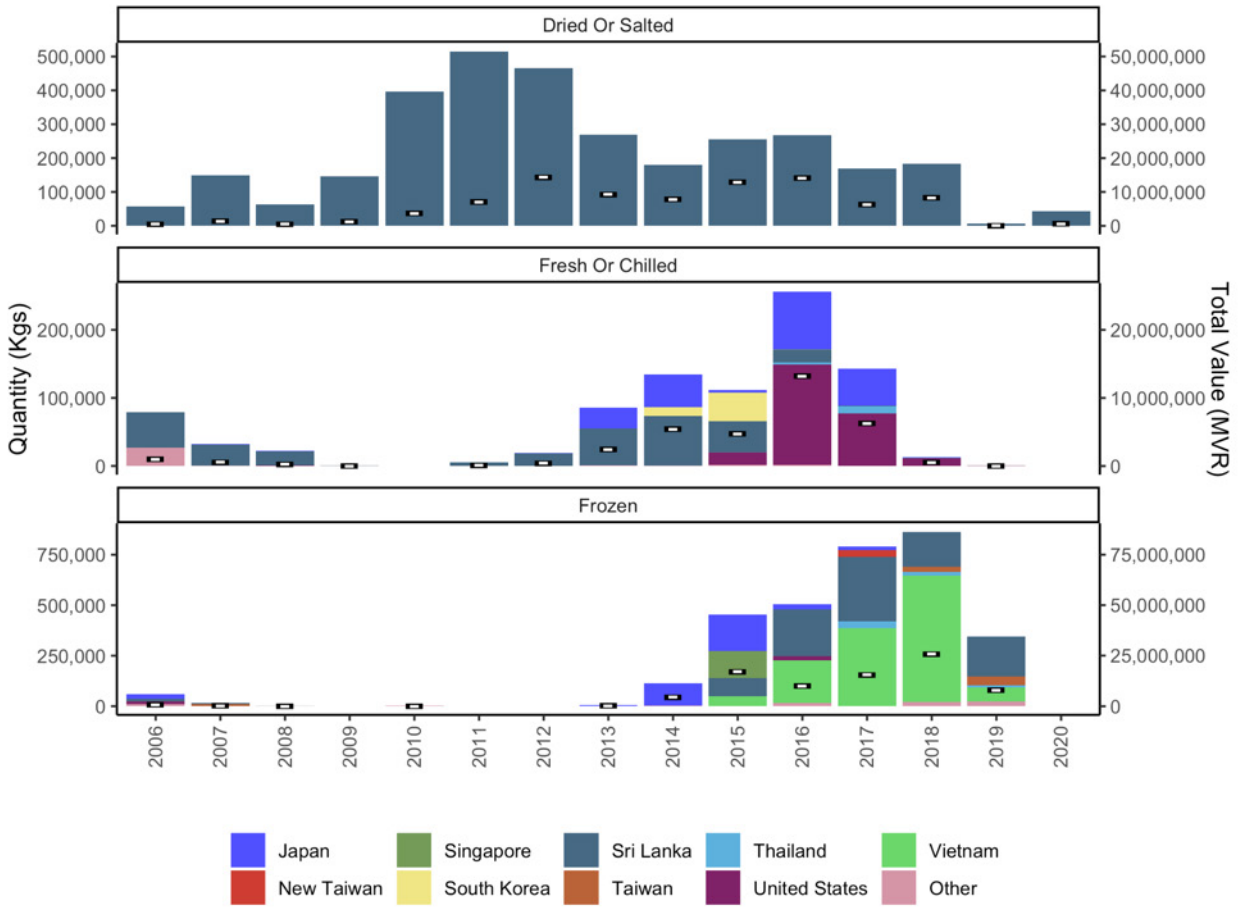

Figure 5. Export data from the Maldives Custom Services (2020) of billfish products that were exported from 2006 to 2020, broken out by disposition. Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year.

4. Diamondback squid fishery

Overview

Prior to the emergence of the diamondback squid fishery, deep sea fishing was not a common activity in the Maldives (Ministry of Fisheries, Marine Resources and Agriculture, 2020b). The government chartered research to investigate the commercial viability of a fishery for diamondback squid in 2015 and started a pilot fishery program in 2019 in an attempt to diversify fisheries products in the Maldives (Ministry of Fisheries, Marine Resources and Agriculture, 2020b).

Data availability and limitations

Fishery dependent data

Data describing this new fishery are not yet collected. However, as regulations for the diamondback squid fishery go into effect, reporting of commercial landings will be required according to the Fishery Management Plan (Ministry of Fisheries, Marine Resources and Agriculture, 2020b). Information on exports will also be collected.

Target species and status

The target species of the emerging deep-sea fishery is the diamondback squid, *Thysanoteuthis rhombus*. These short-lived cephalopods have a high reproductive potential and split their time between living at depth (600 - 800 m) during the day and migrating up to the surface at night to feed and reproduce (Ministry of Fisheries, Marine Resources and Agriculture, 2020b). Despite being considered a species of "Least Concern" by the IUCN, diamondback squid are thought to have a high vulnerability according to their biological characteristics (Cheung et al., 2005). There is no information regarding the resilience of this species.

Gear types

The gear type used in the fishery is a free-floating dropline which consists of a 500 meter line suspended vertically in the water column with a float at the top, squid jigs at the bottom, and a light attractant secured to the main line (Figure 6; (Ministry of Fisheries, Marine Resources and Agriculture, 2020b)).

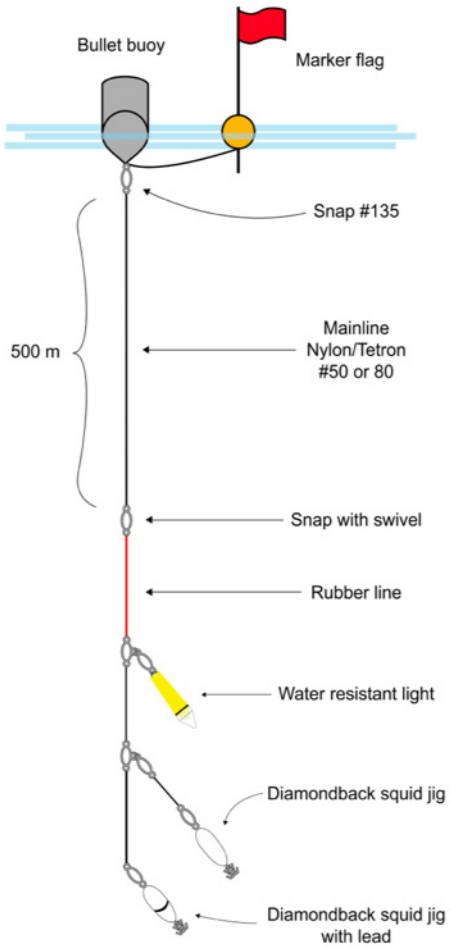

Figure 6. A diagram of the dropline gear used in the diamondback squid fishery. Figure from the Ministry of Fisheries, Marine Resources, and Agriculture (2020b).

Fleet structure

The fishery is still small at present, with roughly 13-15 active vessels (Ministry of Fisheries, Marine Resources and Agriculture, 2020b).

Catch

There is no available estimate of the catch of this fishery. Diamondback squid are currently processed at a single commercial tuna processing facility in the Maldives and all processed catch is sold locally to restaurants and markets (Ministry of Fisheries, Marine Resources and Agriculture, 2020b; MMRI, personal communication, 2022).

Economic importance

Presently, there is no data collected regarding the number of jobs, value of catch, or the economic importance of this emerging fishery besides the limited information presented above. While no catch is exported currently, the meat of diamondback squid is typically valued at US$8-10 per kg and can be as high as US$20-30 in premium markets like Japan (Ministry of Fisheries, Marine Resources and Agriculture, 2020b).

5. Grouper fishery

Overview

The Maldivian grouper fishery has always been export based, but expanded in the 1990s to meet export demands posted by Asian markets (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). Most exports come from 26 of the 40-45 grouper species found in the Maldives (Appendix Table E5). Some groupers are known to form spawning aggregations during the full moon (Domeier & Colin, 1997; Frisch et al., 2016; Hamilton et al., 2012; Ministry of Fisheries, Marine Resources and Agriculture, 2020c) and are monondric protogynous hermaphrodites that mature as females but can change into males when it is reproductively favorable (related to, amongst other factors, the sex ratio at aggregation sites; (Frisch et al., 2016; Ministry of Fisheries, Marine Resources and Agriculture, 2020c; Shapiro et al., 1993). Therefore, high fishing pressure at aggregation sites can have undue impact on grouper populations.

This export-based fishery primarily exports large-bodied grouper as live or fresh/chilled. As such, the value of fresh and chilled grouper exports in the Maldives in 2020 was over 3x greater than all 2020 exports from other reef fish used for consumption and nearly 6x greater than all 2020 exports of cucumbers (Maldives Customs Service, 2020).

Data availability and limitations

Fishery independent data

Fishery independent data are publicly available through ReefCheck's Global Reef Tracker (Figure 7).

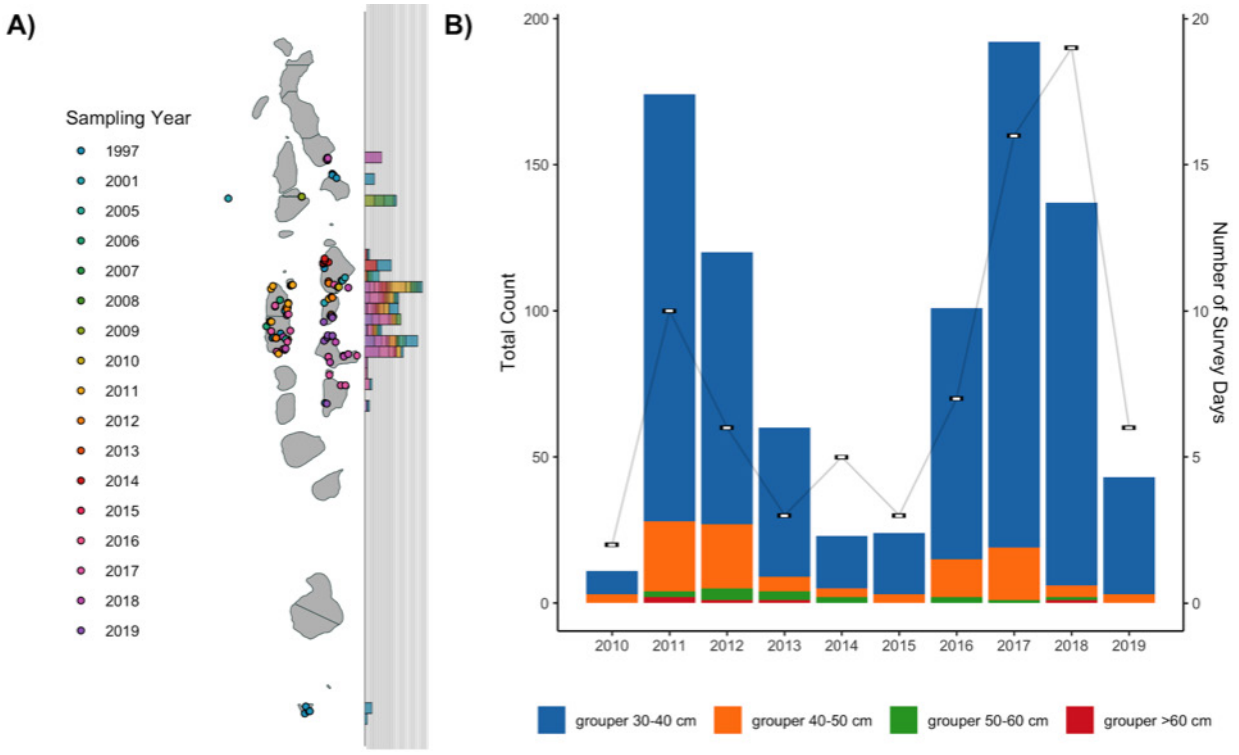

Figure 7. A) Locations of ReefCheck reef surveys that span from 2010-2019. B) Total counts of different sizes of grouper species from all surveys throughout 2010-2019. The black outlined boxes represent the total number of reef survey days within that particular year. Data accessed via Global Reef Tracker by ReefCheck.

ReefCheck expeditions consist of volunteer-based SCUBA surveys of the coral reefs in 26 atolls of the Maldives, where divers identify the presence of several reef species, including groupers, and further estimate the sizes of groupers that have been sighted. In addition, the Maldives Marine Research Institute (MMRI), in collaboration with the World Bank through the Sustainable Fisheries Resource Development Project, has conducted several in-water surveys to monitor two grouper aggregation sites. This project is still ongoing, but data and reporting findings are expected to be available once analysis and reporting is complete. MMRI has also conducted exploratory and baseline assessment surveys at some of the protected grouper aggregation sites in 2013 (BOBLME, 2015). Several other independent surveys and research projects are likely to have taken place in the Maldives over the years and be summarized in reports and presentations, but no raw data sources appear to be available for public consumption at this time.

Fishery dependent data

Fishery dependent data have been collected for the grouper fishery from a variety of projects. The Maldives Underwater Initiative (MUI) is a marine conservation team located at the Six Senses resort in Laamu and works with the Blue Marine Foundation (BMF) on several citizen science projects. Additional projects through collaborations between BMF and MMRI (previously known as Marine Research Center) have also been carried out. Working with fishers, BMF and MMRI have helped to validate the size at maturity for two grouper species, the camouflage grouper *(Epinephelus polyphekadion)* and the squaretail coral grouper (*Plectropomus areolatus*) and have identified areas for grouper protection by surveying 100 independent fishers. Through the Sustainable Fisheries Resource Development Project, the MMRI has also completed maturity studies for four grouper species and has maturity studies for six additional species underway. The Darwin Reef Fish Project also developed an electronic logbook system to collect catch and effort statistics that were being trialed in 2013. Today, the Ministry of Fisheries continues to collect grouper catch logs, but the data are limited by few submissions by fishers. While reports that summarize the above datasets are available, raw datasets are not publicly accessible.

Additional fishery dependent datasets that are publicly accessible include export data hosted by the MCS. Yearly export data dating back to the mid-1990s are available for groupers by export type (frozen, fresh/chilled, live) as weights (for frozen, fresh/chilled exports), number (for live exports), and value (for all exported products). Additional fisher information, such as a licensed fishing vessel list, and fisher feedback, such as a yearly Fishermen's Forum that is held by the Ministry of Fisheries are also important resources that can help inform the current level of fishing taking places within the grouper fishery.

Target species

The majority of grouper species that are exported from the Maldives are fresh or chilled and mainly composed of low-valued species that are kept in exporter holding facilities (i.e., cages) prior to export (Figure 8; Table 5; (Sattar et al., 2011)).

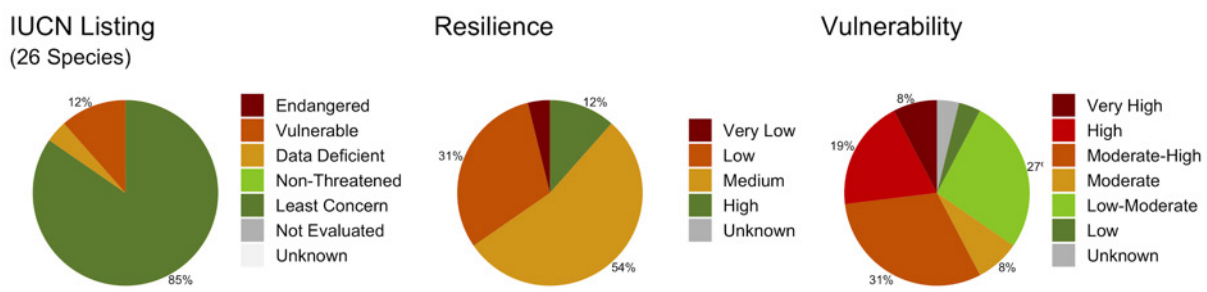

Figure 8. Threat classifications for the grouper species in the Maldives, as identified by their IUCN status, and their resilience and vulnerability categorization.

Table 5. Grouper species primarily targeted in the Maldives based on fishing trip and cage surveys and their IUCN listing, resilience and vulnerability scores. Fishing trip information was derived from observed trips in Vaavu and Alifu Alifu atolls in 2010-2011 (Sattar et al., 2011). Cage presence information was derived from grouper cage surveys conducted in Vaavu, Faafu, Kaafu, and Gaafu Dhaalu atolls in 2010 (Sattar et al., 2011). Cage survey results may be biased towards low-valued species because fishers were notably hesitant to show surveyors move vulnerable, high-value species (Sattar et al., 2011). Primary export types (FC = fresh/chilled, live) and export value per individual are reported by Sattar et al. (2011). Export values are derived from data provided by exporters which limit their accuracy; sometimes exporters group several species together and report them as single species. These limitations lead to unknown export values for some species.

Scientific name	Common name	IUCN listing	Resilience	Vulnerability	Presence on Fishing Trips	Presence in Cages	Export Value (MVR)	Export Type
Aethaloperca rogaa	Redmouth grouper	Least Concern	Medium	Moderate-High	Moderate-High	High	28.5	FC
Anyperodon leucogrammicus	Slender grouper	Least Concern	Low	Moderate-High	Moderate	High	24.2	FC
Cephalopholis argus	Peacock hind	Least Concern	Medium	Moderate-High	High	Highest	40.7	FC
Cephalopholis leopardus	Leopard hind	Least Concern	High	Low	No Data	Low	No Data	No Data
Cephalopholis miniata	Coral hind	Least Concern	Low	Very High	Moderate-High	High	24.6	FC
Cephalopholis sexmaculata	Sixblotch hind	Least Concern	Medium	Low-Moderate	Low	Low	No Data	No Data
Cephalopholis sonnerati	Tomato hind	Least Concern	Medium	Moderate	Low	Low	No Data	No Data
Cephalopholis urodata	Darkfin hind	Least Concern	High	Low	No Data	Low	No Data	No Data
Epinephelus areolatus	Areolate grouper	Least Concern	Low	Moderate	No Data	Low	32.9	FC
Epinephelus caeruleopunctatus	Whitespotted grouper	Least Concern	Low	Moderate-High	Low	Low	No Data	No Data
Epinephelus fasciatus	Blacktip grouper	Least Concern	Low	Moderate-High	Low	Low	81	FC
Epinephelus flavocaeruleus	Blue and yellow grouper	Least Concern	Low	High	Low	Low	48.5	FC
Epinephelus fuscoguttatus	Brown-marbled grouper	Vulnerable	Medium	High	Moderate	Moderate	25.7 (FC) 94.5 (Live)	FC Live
Epinephelus lanceolatus	Giant grouper	Data Deficient	Very Low	Very High	No Data	No Data	747.9	Live
Epinephelus macrospilos	Snub nose grouper	Least Concern	Medium	Moderate	Low	Low	31.9 (FC) 77.1 (Live)	FC Live
Epinephelus merra	Honeycomb grouper	Least Concern	High	Low-Moderate	Low	Low	9.7	FC

Table 5 continued.

Scientific name	Common name	IUCN listing	Resilience	Vulnerability	Presence on Fishing Trips	Presence in Cages	Export Value (MVR)	Export Type
Epinephelus multinotatus	White-blotched grouper	Least Concern	Medium	Moderate	Low	Low	No Data	No Data
Epinephelus ongus	White-streaked grouper	Least Concern	Medium	Low-Moderate	Low	Low	No Data	No Data
Epinephelus polyphekadion	Camouflage grouper	Vulnerable	Medium	Moderate-High	Low	Low	8.3	FC
Epinephelus spilotoceps	Four saddle grouper	Least Concern	Medium	Low-Moderate	Low	Moderate	36.4 (FC) 31.4 (Live)	FC Live
Epinephelus tauvina	Greasy grouper	Data Deficient	Low	High	No Data	Low	No Data	No Data
Gracila albomarfinata	Masked grouper	Least Concern	Medium	Low-Moderate	No Data	Low	No Data	No Data
Plectropomus areolatus	Squaretail coral grouper	Vulnerable	Low	Moderate	Moderate-Low	Low	56.8	FC
Plectropomus laevis	Blacksaddled coral grouper	Least Concern	Medium	High	Moderate-High	Moderate-High	54.7 (FC) 80.1 (Live)	FC Live
Plectropomus pessuliferus	Roving coral grouper	Least Concern	Low	High	Moderate	High	45 (FC) 66.2 (Live)	FC Live
Variola albimarginata	White-edged lyretail	Least Concern	Low	28.91	Low	Low	27.5	FC
Variola louti	Yellow-edged lyretail	Least Concern	Medium	Moderate-High	Moderate	Moderate-High	39.8	FC

Gear types

Historically, groupers were targeted using weighted and baited handlines from vessels, but now visually aided hand lines, where snorkelers spot grouper and sink a baited line to attract it, are most commonly used (Ministry of Fisheries, Marine Resources and Agriculture, 2020c; Sattar et al., 2011). The harvested grouper are collected and placed in floating baskets that are tethered to the fisher. Gears that resemble flying gaffs are also increasing in popularity when fishers are attempting to capture groupers from large aggregations (*Plectropomus areolatus* and *Epinephelus fuscoguttatus*) at night. Freedivers spot an aggregation of groupers using flashlights, then hook the groupers with a gaff and slowly ascend to the surface (Marine Research Centre, Maldives & Marine Conservation Society, UK, 2011; Ministry of Fisheries, Marine Resources and Agriculture, 2020c). The most recent version of the Grouper Fisheries Management Plan does not allow fishers to use SCUBA, gaffs, or lights to target groupers (Ministry of Fisheries, Marine Resources and Agriculture, 2020c).

Once captured, groupers are transported to exporter holding (cage) facilities. Grouper cages (~ 12 ft long x 12 ft wide and 15 ft deep) are placed in

the water. Exporter grouper holding facilities can house several different sizes ("baby," small, medium, large, extra-large fish) and species of grouper (*Plectropomus spp., Epinephelus spp., E. macrospilos, V. louti*) in separate cages (Sattar et al., 2011). Groupers are exported either live, fresh/chilled, or frozen. Once ready for export, groupers are placed in styrofoam boxes (with anesthetic for live exports) for transport via sea freight or air freight to Hong Kong, Taiwan, and Thailand (Sattar et al., 2011).

Fleet structure

Over time, the locations fished, vessels used, and trip durations for grouper fishing have all increased (Table 6; Figure 9). In general, most fishers are aware of and target the locations and timing of grouper aggregations, which typically occur during the full or new moon (Domeier & Colin, 1997; Frisch et al., 2016; Hamilton et al., 2012; Ministry of Fisheries, Marine Resources and Agriculture, 2020c). Juvenile grouper can fetch the same price as adults, but inhabit nearshore habitats with seagrass beds and coral clumps, while adult grouper are associated with stony and coral environments up to 200 m depth (Frisch et al., 2016; Ministry of Fisheries, Marine Resources and Agriculture, 2020c; Shapiro et al., 1993).

In 2018, an estimated 146 vessels and 730 fishers were engaged in the fishery and were distributed across 21 islands and 13 atolls. However, 7 islands are responsible for the majority of fishing pressure (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). The fleet size has remained relatively stable since 2011, when an estimated 149 vessels operated across 25 islands and 10 atolls (but primarily Faafu) (Sattar et al., 2011). Household surveys indicate that approximately 1.2% of households and approximately 8.4% of fishers are involved in the grouper fishery (Sattar et al., 2014).

Catch

Grouper fishing vessels that trade with exporters are required to obtain fishing licenses and report catch data via logbooks (Regulation No. 2013/R-41; (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). While the most recent Grouper Fisheries Management Plan requires all commercial vessels to fill out logbooks, historical catch information can be inferred from export data. Between 2011 and 2018, average annual grouper exports were estimated at 869,000 kg, but increased in 2019 to 1,538,000 kg (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). Surveys conducted on fishing vessels estimate an average catch rate of 90 groupers per fishing day, which is an increase in catch estimates reported in 2005 (40-50 groupers per day per vessel; (Sattar & Adam, 2005)) and may be explained by a shift towards smaller individuals of high-value species, or a shift towards targeting more abundant species (Sattar et al., 2011). These values are still lower than the catch rates recorded when the fishery began in the 1990s; in 1994, fishers reported capturing between 100-170 groupers per day per vessel (Sattar et al., 2011; Shakeel, 1994). Once collected, species are

Table 6. The evolution of the grouper fishery in terms of fishing pressure, vessels used, and trip durations (Sattar et al., 2011; Sattar & Adam, 2005; Shakeel, 1994). Refer to Figure 9 for specific locations fished across time.

Year	Fishing Location	Vessel Type	Trip Duration
1990	Central atolls where fishers lived (Faafu, Meemu)	Rowing/sailing boats, mechanized trolling boats	Day trips
2005	Inter-island fishing	Mechanized boats	Days to weeks
2011	Throughout Maldives	Mechanized boats	Weeks to months

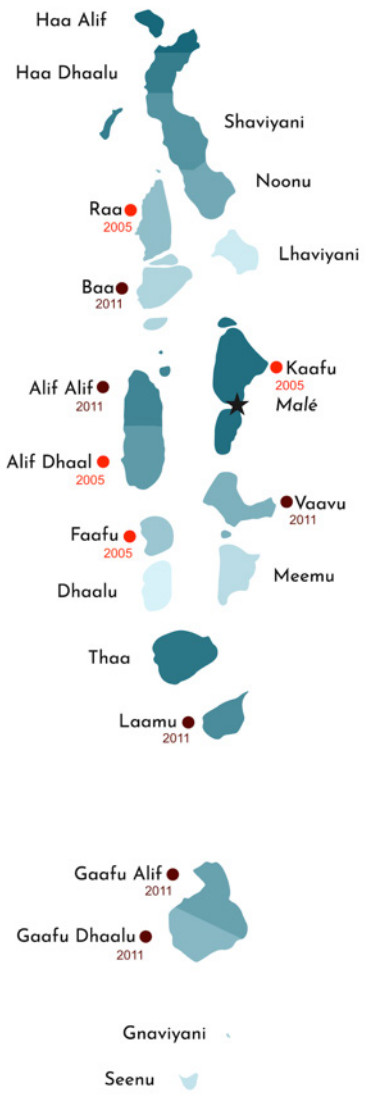

Figure 9. Distribution of islands and atolls where grouper fishing began to occur in 2005 (red dots) and where fishing expanded to by 2011 (dark purple dots; (Sattar et al., 2011; Sattar & Adam, 2005; Shakeel, 1994)). The underlying map courtesy of WorldAtlas, with shaded breaks to indicate different administrative atolls.

primarily exported to Hong Kong, Taiwan, and Thailand (Sattar et al., 2011).

Surveys of fishing trips at Vaavu and Alifu Alifu atolls in 2010 indicate the majority (70%) of caught grouper are below the theoretical length at maturity, regardless of if they were collected for live or fresh/chilled exports (Table 7, with data from (Sattar et al., 2011)). This value has increased since 2005, when only 43% of individuals were below the theoretical length at maturity (Sattar and Adam 2005). However, the most recent Grouper Fisheries Management Plan enforces size limits that are primarily above these lengths and should help to correct this problem (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). The 2010 surveys also indicated a significant decline in the mean lengths of targeted grouper species since 2003, which may be exacerbated by exporters who are willing to pay fishers adult-prices for juveniles of high-value species (*Plectropomus spp, Epinephelus spp*; Table 7; (Sattar et al., 2011).

Table 7. Mean lengths of commonly caught grouper species from surveys of commercial fishers in 2010 and compared to results from surveys in 2003 and length at maturity estimates (calculated as 50% of the maximum length of the species reported in FishBase, (Sattar et al., 2011; Sattar & Adam, 2005). Length at maturity estimates with asterisks were generated from the max lengths recorded in surveys, as they were greater than those indicated on FishBase.

Species	Length at Maturity (cm)	Mean Length Captured > Length at Maturity	Proportion Captured as Immature	Δ Mean Length (2003 - 2010)
Cephalopholis argus	30	X	79.7%	↓
Aethaloperca rogaa	30	X	74.3%	↓
Anyperodon leucogrammicus	32.5	Equal	51.5%	↓
Cephalopholis miniata	22.5	✓	8.5%	↓
Variola louti	41.5	X	88.9%	↓
Plectropomus pessuliferus	60	X	99%	↓
Epinephelus fuscoguttatus	60	X	96.4%	↓
Plectropomus areolatus	39.5*	X	70%	↓
Epinephelus spilotoceps	22*	✓	13.4%	↓
Plectropomus laevis	62.5	X	98.9%	↓

Economic importance

Annual quantities and values of exported species can change significantly, due to species misidentification, or because exports were dominated by a single exporter or a single, large shipment (Sattar et al., 2011). Most grouper exports (65%) are fresh/chilled low-value species, although transportation by freights have increased the demand for exporting live, high-value species (Sattar et al., 2011). Exports are primarily delivered to Taiwan (~97%), Hong Kong (~3%), and Thailand (~0.5%), but prior to 2005, Hong Kong received most of the grouper exported by the Maldives (Sattar et al., 2011). Since 2003, the value of fresh and chilled grouper has decreased, despite increases in the quantities exported, which may indicate that smaller, low-value species are being sold (estimated in 2010 by Sattar et al., 2011).

Alternatively, the value of live grouper may be incentivizing fishers to collect individuals before they have reached sexual maturity, as some exported are paying fishers the same prices for baby and small individuals as they do for adults, particularly for Plectropomus and Epinephelus species (Sattar et al., 2011).

A total of 12 export companies exist in the Maldives (Ministry of Fisheries, Marine Resources and Agriculture, 2020c), but 7 companies are considered the main exporters (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). Established grouper cage systems from the main exporting ompanies are established across 8 areas in the Maldives and cover 10,000 square feet. The majority of cage systems are around Malé (Ministry of

Fisheries, Marine Resources and Agriculture, 2020c). When the fishery first began, grouper cages would roam with the fishers and facilities were located on just a handful of atolls, but in 2011 cages were present in locations in Haa Dhaalu, Shaviyani, Baa, Kaafu, Vaavu, Faafu, Gaafu, and Shaalu Atolls (Sattar et al., 2011).

Exports were estimated to be 869,000 kg in 2011-2018, with 10-17% of exports being live groupers (Figure 10; (Ministry of Fisheries, Marine Resources and Agriculture, 2020c)). In 2019, estimated exports increased to 1,538,000 kg, 44% of which were live groupers (Ministry of Fisheries, Marine Resources and Agriculture, 2020c). In 2020, 98,150 live grouper (2,834,911 MVR; US$184,710.16) and 778,941 kg (31,028,283 MVR; US$2,021,664.53) of fresh or chilled grouper were exported from the Maldives (Maldives Customs Service, 2020).

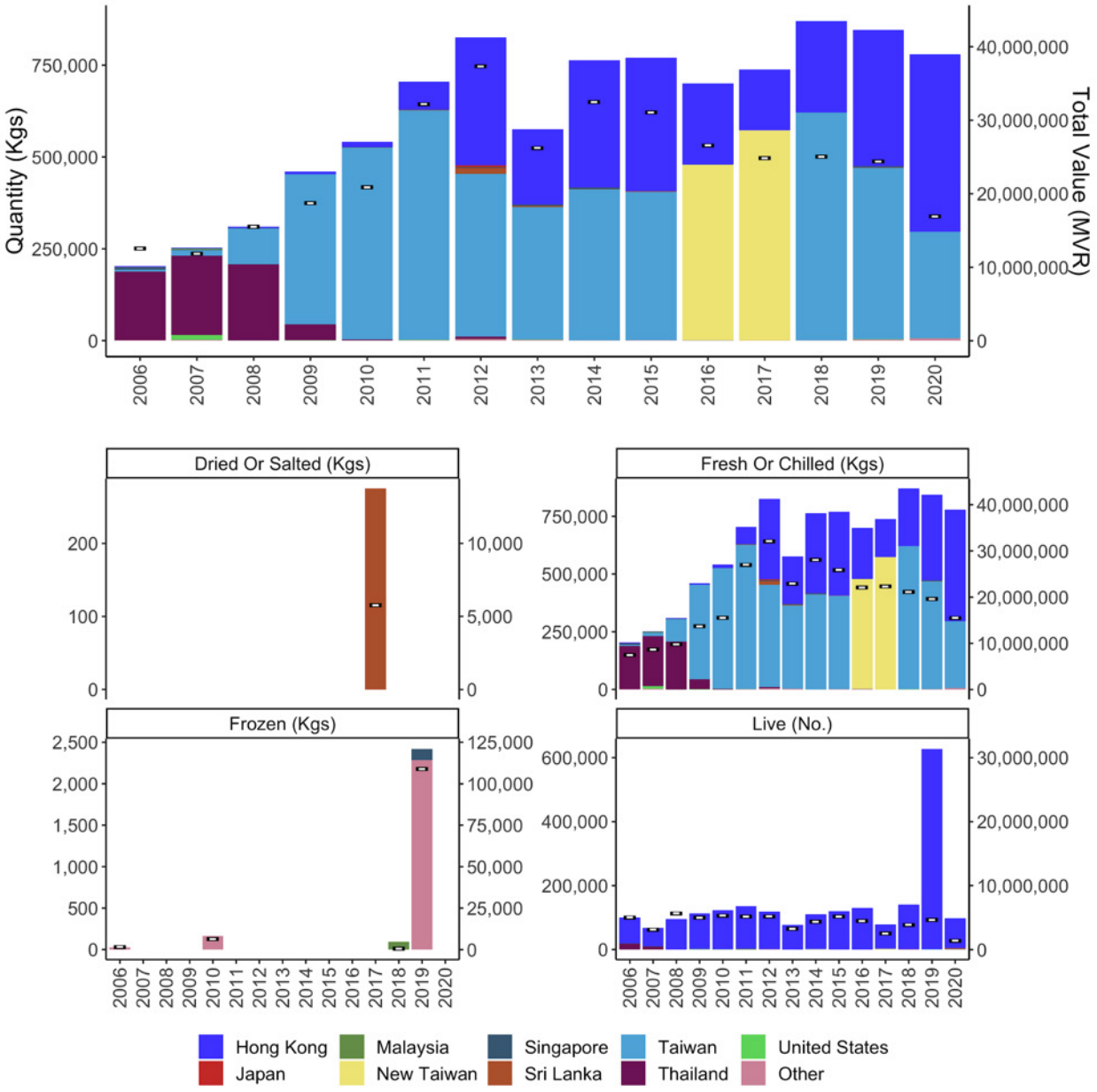

Figure 10. Export data from the Maldives Custom Services (2020) of groupers that were exported from 2006 to 2020 (top), and broken out by disposition (bottom; dried or salted, fresh or chilled, frozen, or live). Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year. The absence of bars and black boxes indicate no data collected during that year; exports for frozen and dried/salted grouper are negligible.

6. General reef fishery

Overview

The Maldivian general reef fishery is primarily defined by the reef-associated species that are economically and ecologically significant, including snappers (Lutjanidae), Emperors (Lethrinidae), jacks (Carangidae), and groupers (Serranidae). The small-scale general reef fishery in the Maldives has likely existed since the islands were inhabited (Adam et al., 1997), but reef species were not commonly targeted or consumed in the Maldives until after the 1980s alongside a burgeoning tourism industry (Ministry of Fisheries, Marine Resources and Agriculture, 2020f). Today, fishing pressure is primarily driven by commercial fishers selling catch to resorts; reef fish exports make up less than 5% of the total marine export value (Ministry of Fisheries, Marine Resources and Agriculture, 2020f; Sattar et al., 2014). Recreational and subsistence fishing also apply fishing pressure to species targeted by the general reef fishery but are not managed under any fisheries management plans. The gears used in this fishery are widely dependent on the locations fished and the species targeted, and fishers are known to frequently switch between gear types and targeting methods (Ministry of Fisheries, Marine Resources and Agriculture, 2020f).

Data availability and limitations

Fishery independent data

Several fishery independent data sources provide information on overall reef health in the Maldives and stem mainly from ecological coral reef research surveys. The MMRI maintains a web-enabled database (CoralDatabase), which facilitate citizen science data collection and management of coral reef monitoring data according to set protocols. The majority of these projects focus on coral propagation and sea turtle movements via satellite tracking, but a notable exception is the Maldives Underwater Initiative (MUI) based at the Six Senses Laamu resort. In collaboration with the BMF, MUI has developed a code of conduct that requires catch reporting by fishers from whom they buy seafood. Other resorts also have equivalent codes of conduct and best practices for recreational fishing operations. The majority of datasets from these sources are available as summaries in online reports, web graphics, or infographics, but the raw data are not publicly available for download.

Fishery independent data are publicly available through ReefCheck's Global Reef Tracker (Figure 11). Additional survey programs such as the Darwin Reef Fish Project and the 100 Island Challenge compile additional fishery independent datasets; however, neither are publicly available for download. Several other independent surveys and research projects are likely to have taken place in the Maldives over the years and summarized in reports, but no raw data sources appear to be available for public consumption at this time.

Fishery dependent data

Self-reported fishery dependent data collected for reef fishes date back to 1970, when data collection began to expand from tuna species to billfishes, sharks, and reef fishes grouped by size category (small, medium, and large). Fishers voluntarily reported the number of fish caught daily to the Island Offices, which compiled these data into monthly reports shared with the MoFMRA. The voluntary nature of data collection led to sporadic catch and effort data among fisheries. Country-specific export data for all fisheries dating back to the mid-1990s is available from the MCS. Data are reported by general species or species grouping and export type (prepared/preserved, canned, dried, salted, frozen, fresh/chilled), where applicable. Additional reports compile data on exports, number of fishers and registered vessels, as well as number of fish caught by non-vessel means (i.e., beach seining). Voluntary logbooks for reef fish were officially introduced in 2010, and became the dominant form of reporting in 2017. Logbooks became mandatory with the publication

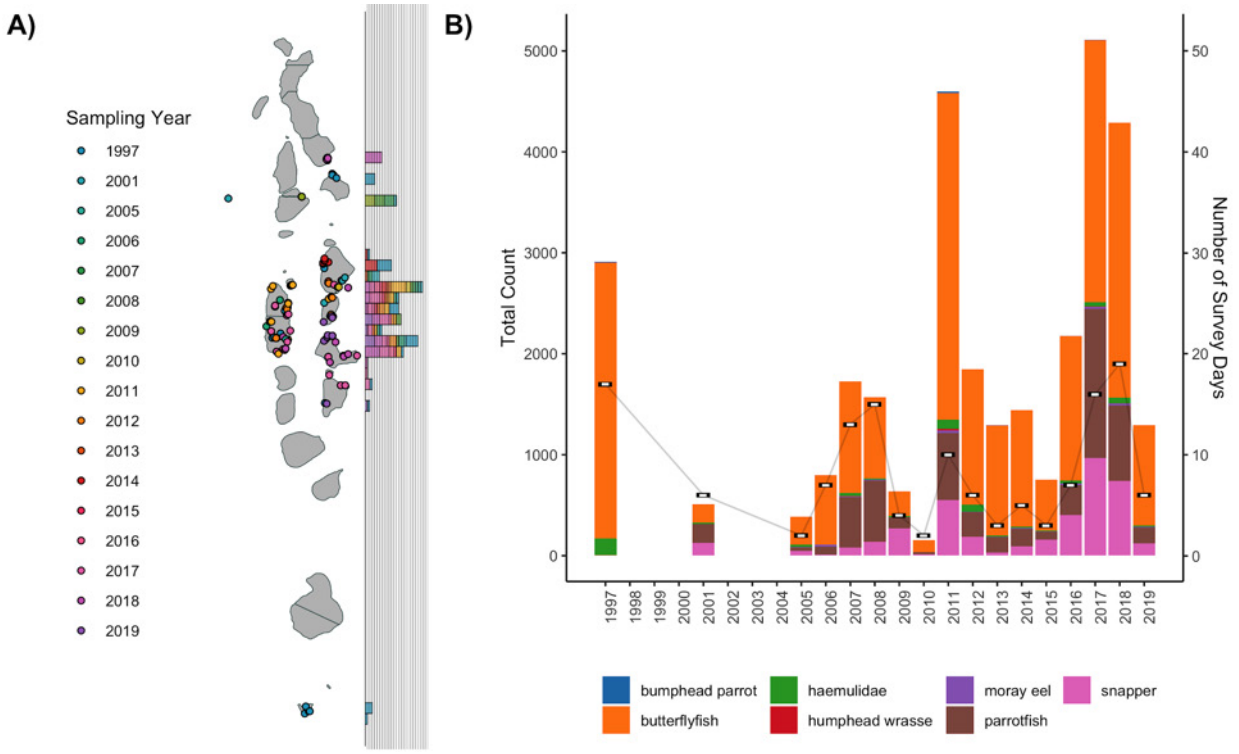

Figure 11. A) Locations of ReefCheck reef surveys that span from 1997-2019. B) Total counts of different reef fish species throughout all surveys in a particular year. The black outlined boxes represent the total number of reef survey days within that particular year; the absence of boxes indicates no data collected during that year. Data accessed via Global Reef Tracker by ReefCheck.

of Fisheries Management Plans in 2020-2021 and are used to collect data on the reef and reef-associated fish species. In addition, in collaboration with the BMF, MUI has developed a code of conduct that requires catch reporting by fishers from whom they buy seafood.

Target species

Maldivian reefs are home to approximately 90 species that are susceptible to fishing pressure (Figure 12, Appendix Table F6). The species that are most commonly caught differ across islands and atolls. For commercial landings, species information can be gleaned from resort purchase records (Table 8; (Sattar et al., 2014)). Though several livebait species are captured throughout the reef, all catch is used as live bait in pelagic fisheries and considered an extension of this fishing sector.

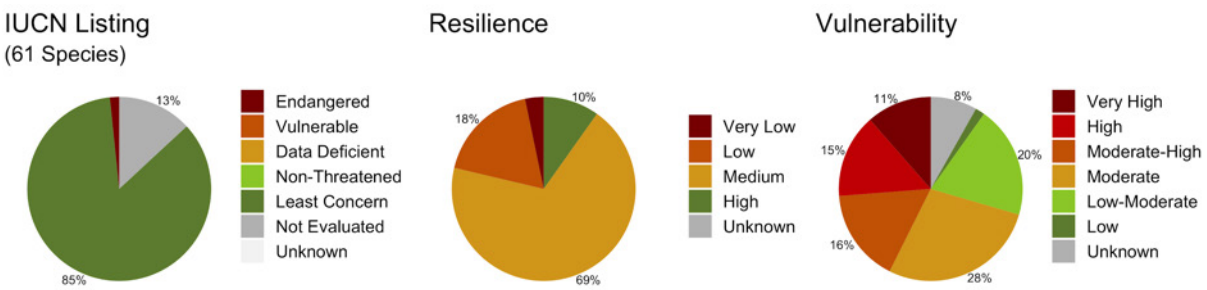

Figure 12. Threat classifications for the reef species in the Maldives, as identified by their IUCN status, and their resilience and vulnerability categorization.

Table 8. Principal/key general reef fishery species and their IUCN listing, resilience and vulnerability scores (see Appendix for full list of general reef fishery species) according to Sattar et al., 2014. The columns for the commercial fishery and fishes purchased by resorts reflect species that are most commonly caught or purchased by these sectors (Sattar et al., 2014); all species have the potential to be caught or purchased by each sector.

Scientific name	Common name	IUCN listing	Resilience	Vulnerability	Commercial Fishery	Purchased by Resorts
Aprion virescens	Green jobfish	Least Concern	Medium	High	✓	✓
Lutjanus gibbus	Humpback red snapper	Least Concern	Medium	Low to Moderate	✓	
Lutjanus bohar	Two-spot red snapper	Least Concern	Medium	Very High	✓	✓
Caranx melampygus	Bluefin trevally	Least Concern	Medium	High	✓	✓
Caranx sexfasciatus	Bigeye trevally	Least Concern	Medium	Moderate to High	✓	✓
Elagatis bipinnulata	Rainbow runner	Least Concern	Medium	High	✓	✓
Gymnosarda unicolor	Dogtooth tuna	Least Concern	Low	Very High	✓	
Carangoides fulvoguttatus	Yellow spotted trevally	Least Concern	Low	Very High		✓

Gear types

The gears used for capturing fish within the Maldivian general reef fishery depends on the species that are being targeted. For example, although commercial fishers primarily use hand lines or baited hand lines with weights, fishers sometimes switch between trolling or pole-and-line fishing, and sometimes use fish pieces, lures, or fish waste instead of live bait (Table 9; (Sattar et al., 2014)).

Fleet structure

Reef fishing takes place year-round in the Maldives and the majority of known fishing pressure comes from commercial fishers, on either a part-time or full-time basis (Ministry of Fisheries, Marine Resources and Agriculture, 2020f). General reef fishing trips are typically single-day trips, but occasionally can last up to 2-3 days (Ministry of Fisheries, Marine Resources and Agriculture, 2020f). Fishing effort data collected by field officers over a period of 7 months in 2012 indicate that the duration of fishing trips are dictated by the gears used and locations fished (Table 10; (Sattar et al., 2014)) The Ministry of Fisheries conducted surveys in 2017 and 2018 and estimated a fleet size of 1,400 vessels and 5,000 fishers (Ministry of Fisheries, Marine Resources and Agriculture, 2020f).

Table 9. The most common gear types used by the general reef fishery, as defined in the Reef Fishery Management Plan (Ministry of Fisheries, Marine Resources and Agriculture, 2020f).

Gear Type	Description
Hand Lines (most common)	Single baited fishing line with a single hook, no weights, held by hand
Weighted handline	A single baited fishing line with a single hook and a lead weight attached as a sinker
Drop Lines	Single weighted line attached to a baited hook and left to float with a buoy; set in multiples
Trolling	Long nylon wires with lures and a hook, set out from the side of the boat and trailed behind the boat. Sometimes the lines are deployed with floaters attached

Table 10. The most common gear types used by the general reef fishery, as defined in the Reef Fishery Management Plan (Ministry of Fisheries, Marine Resources and Agriculture, 2020f).

Island (Atoll)	Number of Trips Observed	Average Trip Duration (hours)	Gears Used	Bait Used	Market
Maarandhoo (Haa Alif)	31	11	Handline without weights, handline with weights	Live bait, fish pieces	Not specified
Kudarikilu (Baa)	30	16	Handline without weights, handline with weights	Live bait	Resorts
Gaafaru (Kaafu)	48	16.5	Handline without weights, handline with weights, pole-and-line	Live bait	Resorts
Rasdhoo (Alif Alif)	16	Not specified	Handline without weights, handline with weights, pole-and-line	Live bait	Resorts
Ukulhas (Alif Alif)	24	12	Handline without weights, handline with weights	Live bait, fish pieces	Ukulhas Atoll, fish processors, resorts
Guraidhoo (Kaafu)	56	8	Handline with weights, trolling, pole-and-line	Live bait	Resorts, Island Centre for people with special needs
Mahibadhoo (Alif Dhaal)	24	14.5	Handline without weights, handline with weights	Live bait	Resorts

Table 10 continued.

Island (Atoll)	Number of Trips Observed	Average Trip Duration (hours)	Gears Used	Bait Used	Market
Fulidhoo (Vaavu)	48	16	Handline without weights	Live bait	Resorts
Feeali (Faafu)	32	13.5	Handline without weights, handline with weights, trolling	Live bait	Feeali Island, Malé
Kolhufushi (Meemu)	8	12	Handline without weights, handline with weights	Live bait	Not specified
Dhaandhoo (Gaafu Alif)	16	3.5	Handline without weights, handline with weights, trolling	Lure, fish waste	Resort
Hithadhoo (Seennu)	42	7	Handline without weights, handline with weights, trolling, pole-and-line	Lure, fish waste	Hithadhoo Island, Resorts

Catch

The total annual catch across the entire Maldivian general reef fishery was estimated in 2012 to be between 10,400-29,145 mt (Sattar et al., 2014). Since 2012, annual catch rates of reef fish species are expected to have increased significantly. Although the Maximum Sustainable Yield (MSY) of the general reef fishery was estimated at 30,000 mt by Anderson et al (2006), methodological and species composition differences make it difficult to directly compare the estimated MSY to catch estimates reported by (Sattar et al., 2014). However, 72% of 102 surveyed commercial reef fishers indicated a decrease in the amount of fish caught during their time in the fishery (mean = 17 years of experience; (Sattar et al., 2014).

The distribution of total catch and species composition varies across atolls and islands within the Maldives. Commercial catch surveys conducted in 2012 found the highest catch rates (reef fishes per trip) in Rasdhoo (Alif Alif Atoll, n = 16 surveys) where Jacks were predominantly caught and the lowest catch rates in Hithadhoo (Laamu Atoll, n = 42 surveys) and Maarandhoo (Haa Alif Atoll, n = 32 surveys) where catch was dominated by Emperors and Snappers, respectively (Figure 13; (Sattar et al., 2014)). The majority of data was collected from Baa, Alifu, and North Malé Atolls, where an estimated (1,554 mt; 5.91 mt/km^2 of reef area), 3,575 tonnes (6.48 mt/km^2), and 1,011 tonnes (2.32 mt/km^2) of reef fish were caught, respectively (Sattar et al., 2014).

With the exception of *L. gibbus*, length-frequency data from 2012 indicate that the majority of reef fishes that are collected in the Maldives are less than their theoretical size at maturity and that mean lengths of fishes caught decreased between 2006 and 2012 (Table 11; (Sattar et al., 2014)). Specific size distributions differ across islands, with the largest fishes observed in Maarandhoo (Haa Alif Atoll), and the smallest fishers observed in

Kolhufushi (Meemu Atoll) and Rasdhoo (Alif Alif Atoll), where high rates of fishing pressure had been previously reported (Figure 13; (Sattar et al., 2014)). Despite these trends, only 34% of 102 surveyed commercial reef fishers reported a decrease in the size of individuals caught during their time in the fishery (mean = 17 years of experience; (Sattar et al., 2014)).

In 2018, it was estimated that 7,962 mt of reef fish were purchased by resorts, assuming a value of 0.84 kg purchased per bed per night (Ministry of Fisheries, Marine Resources and Agriculture, 2020f). Fish not sold to resorts are sold at local markets or are exported to Sri Lanka after being salted and dried.

Table 11. Mean lengths of commonly caught species from surveys of commercial fishers, resort purchases, and resort night fishing expeditions in 2012 compared to results from 2006-2007 surveys and length at maturity estimates (calculated as 50% of the maximum length of the species reported in FishBase; (Sattar, 2008; Sattar et al., 2014)). NS = not significant via t-test.

Species	Length at Maturity (cm)	Commercial Fishers	Purchased by Resorts	
		Mean Length > Length at Maturity	Mean Length > Length at Maturity	Δ Mean Length (2006/2007 - 2012)
Aprion virescens	56	X	X	NS
Lutjanus gibbus	25	✓	✓	↓
Lutjanus bohar	45	Equal	Equal (towards X)	↓
Caranx melampygus	58.5	No data	X	No data
Caranx sexfasciatus	60	No data	X Two size classes (46 cm, 60 cm)	NS
Elagatis bipinnulata	90	X	X	NS
Gymnosarda unicolor	124	X	No data	No data

For a more comprehensive overview of results from the 2012 surveys, please refer to Sattar et al. (2014).

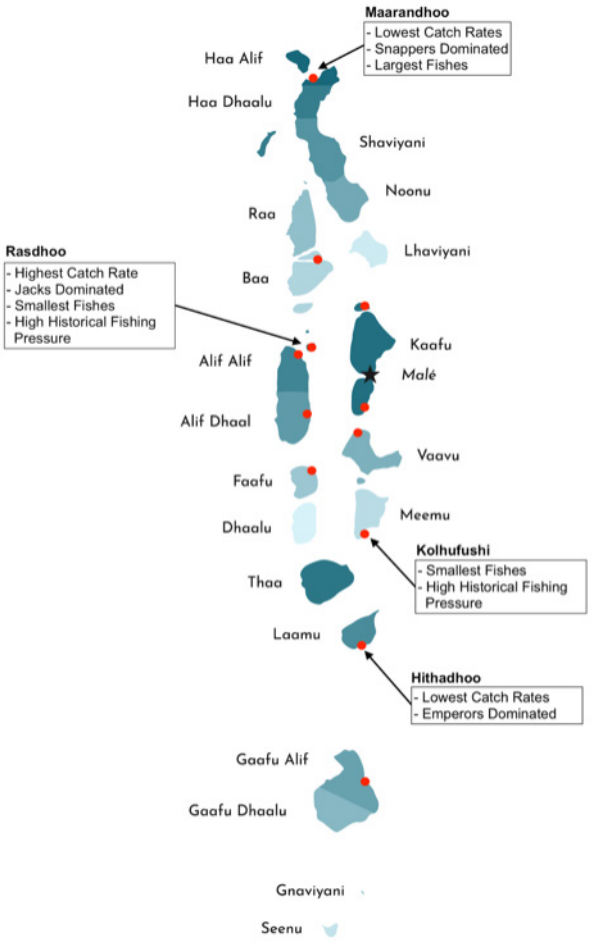

Figure 13. Distribution of islands and atolls sampled by Sattar et al., (2014) for commercial fisher catch information. Sampling locations are represented by red dots. From north to south, the dots lie on Maarandhoo - Atoll: Haa Alif, Kudarikilu - Atoll: Baa, Gaafaru - Atoll: Kaafu, Rasdhoo - Atoll: Alif Alif, Ukulhas - Atoll: Alif Alif, Guraidhoo - Atoll: Kaafu, Mahibadhoo - Atoll: Alif Dhaal, Fulidhoo - Atoll: Vaavu, Feeali - Atoll: Faafu, Kolhufushi - Atoll: Meemu, Hithadhoo - Atoll: Laamu, Dhaandhoo - Atoll: Gaafu Alif. The underlying map courtesy of WorldAtlas, with shaded breaks to indicate different administrative atolls.

Economic importance

The Maldivian general reef fishery is close to shore and the costs to enter and participate in the fishery are low (i.e., low investment in a small-scale fishing vessel, low operational costs), which encourages the participation of youth and novice fishers and facilitates knowledge transfer from experienced fishers to newcomers (JICA et al., 2018).

Fisher consultations in 2012 indicate that 54% of reef fishers consider reef fishing their sole income, while 47% earned income from other avenues (Sattar et al., 2014). The average income for full-time reef fishers is estimated to be 1900 MVR (US$122.93) per person per week (Sattar et al., 2014).

Commercial fishers primarily sell their catch to resorts where they can fetch a higher price compared to fish processors or other buyers; resorts are estimated to pay between 15-60 MVR (US$0.97-US$3.88) per kg (mean 35 MVR [US$2.26] per kg) of reef fish (Sattar et al., 2014). While an estimated total of 185,000,000 MVR (US$119,77,246) of reef fish was purchased by resorts in 2012, the same value of reef fish was purchased by resorts in 2006 when fewer fish were sold, which indicates that the value of commercially caught reef fishes are increasing despite lower catch rates (Sattar et al., 2014).

Local markets are estimated to be the second most important market for commercial fishers. The majority of Maldivian households spend 1-50 MVR (US$0.06-$3.23; mean = 25 MVR [US$1.62]) on reef fish per week (Sattar et al., 2014). Households are estimated to consume more reef fish now compared to 10 years ago, but reef fish consumption is still low compared to tuna consumption rates; nearly 25% of households surveyed reported that they consumed tuna each day, while nearly 20% of households reported that they consumed reef fishes one day per week (mean of 5 fish consumed per week; (Sattar et al., 2014)).

A small export market is also available to reef fishers, with reef fish comprising just 0.24% of income from all marine exports from the Maldives in 2012. In recent years, the volume of fish exported has fluctuated greatly, spanning between 267,000 and 559,000 kg exported between 2012 and 2019 (Figure 14; (Ministry of Fisheries, Marine Resources and Agriculture, 2020f)). In 2020, 409,269 kg of reef fishes (9,401,229 MVR; US$612,542.15) were exported from the Maldives. The majority of exported products were salted and dried (88.9% of total reef fish export weight; 92.6% total reef fish export value) or frozen (9.3% of total reef export weight; 5.6% of total reef fish export value) (Maldives Customs Service, 2020).

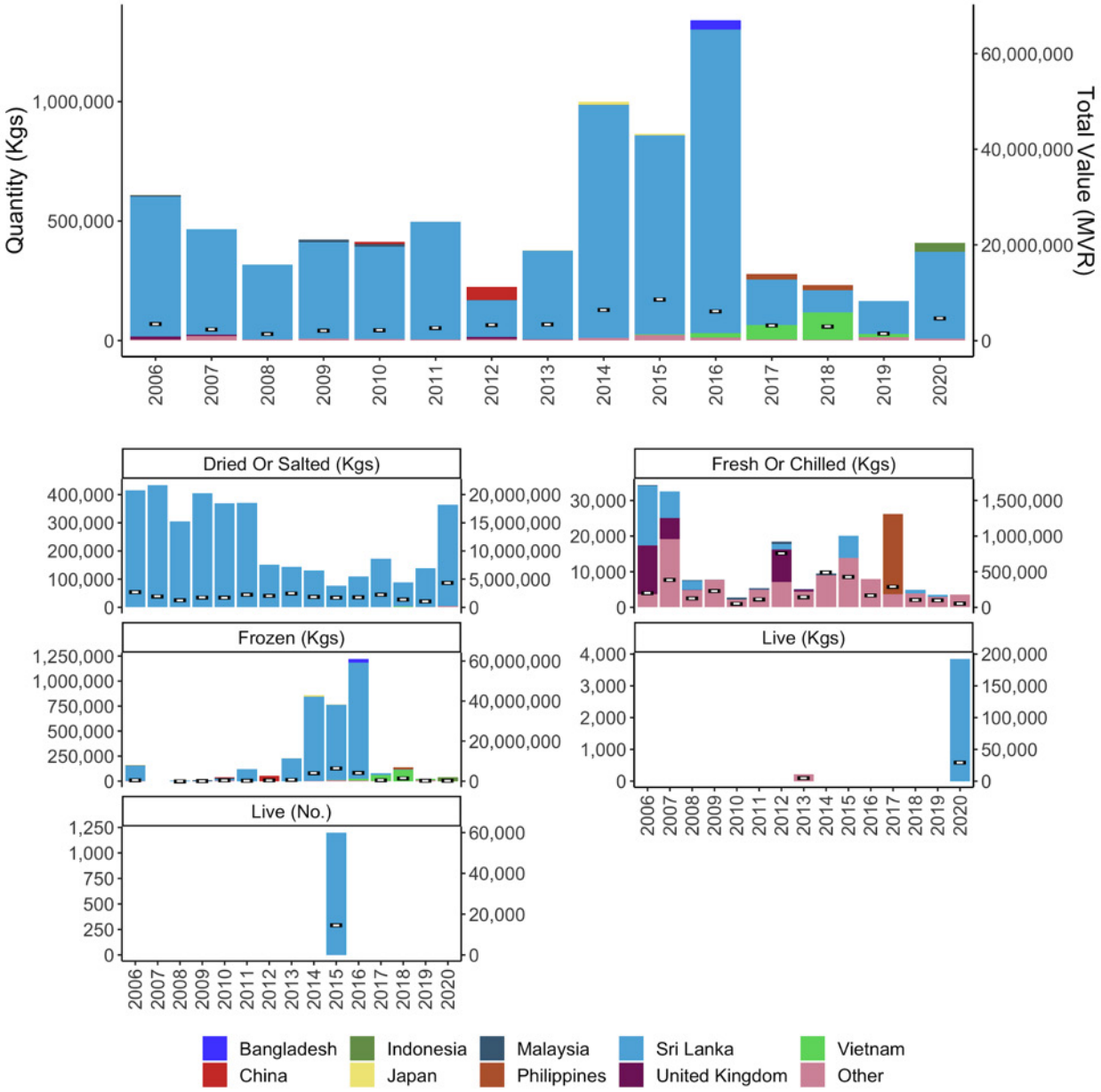

Figure 14. Export data from the Maldives Customs Service (2020) of reef fishes that were exported from 2006 to 2020 (top), and broken out by disposition (bottom; dried or salted, fresh or chilled, frozen, or live). Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year. The absence of bars and black boxes indicate no data collected during that year.

7. Marine aquarium fishery

Overview

The Maldives marine aquarium fishery began in the late 1970s and has continued to make up only a small percentage of the total value of marine exports in the Maldives (0.27% in 2017) (Ministry of Fisheries, Marine Resources and Agriculture, 2020e). Species that are typically targeted by this fishery are driven by consumer demands by the primary export market in the UK, and several species exports have exceeded sustainable yield estimates (Wood et al., 2014).

Management efforts within this fishery began in 1988, when the government employed aggregate quotas for exports of coral reef fish and invertebrates that capped the number of exports to 100,000 individuals per year (Dee et al., 2014). Since then, a species-based quota system has been developed based on a "fuzzy logic" system developed globally. The species-based quota system consists of three categories: Category A, designated for 17 species that do not survive well in captivity or are locally rare and are therefore banned from export, as well as hard corals other than *Tubipora musica* (exported for pharmaceutical purposes to India; (Wood et al., 2014), Category B, with 66 species that have individual quotas (assessed via surveys that were conducted in June 2008 across Baa, North and South Malé, and Vaavu atolls; (M. Saleem & Islam, 2008), and Category C, which allows 300,000 organisms across 71 species to be exported by the Maldives each year (Wood et al., 2014). However, a new quota system is expected to be introduced in 2021 (see Management section).

Data availability and limitations

Fishery independent data

Several ecological surveys, such as the MMRI CoralDatabase and ReefCheck's Global Reef Tracker (see the Grouper and General reef fish fishery sections for complete descriptions), are also relevant for aquarium fishes, as they provide insight about general reef health and fish abundance.

Fishery dependent data

Because the marine aquarium fishery relies on consumer demand, the majority of data available for marine aquarium species are from fishery dependent sources. Although there is currently no catch reporting system required for the Maldivian marine aquarium fishery, aquarium fish exporters submit a Proforma export dataset consisting of species and numbers exported at the time of export (M. R. Saleem & Adam, 2004; Wood et al., 2014). The most recent Fisheries Management Plan requires licensed collectors and holding facilities to submit purchase reports to the Ministry on a monthly basis (Ministry of Fisheries, Marine Resources and Agriculture, 2020e). While the raw data from these sources are not publicly available at this time, export data from the MCS are readily available. In addition, licensed vessel lists, Fishermen's Forum Reports, and public presentations and reports are accessible and may contain useful information for this fishery.

Target species

The species included within the marine aquarium fishery vary and depend primarily on market demand, but approximately 98% of the species exported are fish (Figure 15; Table 12; (Ministry of Fisheries, Marine Resources and Agriculture, 2020e)). Several species that are exported are keystone species or schooling species that are highly associated with coral reefs (Wood et al., 2014) and most are relatively abundant; 44% of 194 exported species examined by Guy Stevens (unpublished data, 2004) were abundant or frequent, 26% were occasionally abundant, and 18% were rarely or very rarely present (Wood et al., 2014).

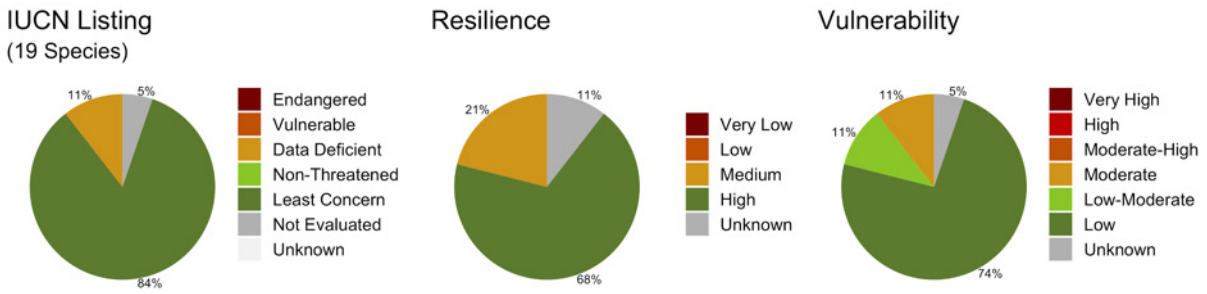

Figure 15. Export data from the Maldives Customs Service (2020) of reef fishes that were exported from 2006 to 2020 (top), and broken out by disposition (bottom; dried or salted, fresh or chilled, frozen, or live). Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year. The absence of bars and black boxes indicate no data collected during that year.

Table 12. Aquarium species primarily targeted in the Maldives (Ministry of Fisheries, Marine Resources and Agriculture, 2020e) and their IUCN listing, resilience and vulnerability scores. Quota categories are Category A (banned from export), Category B (individual quotas established), and Category C (total annual quota of 300,000 individuals across all species within the category) as of 2003 (M. R. Saleem & Adam, 2004).

Scientific name	Common name	IUCN listing	Resilience	Vulnerability	Quota Category
Pseudanthias squamipinnis	Sea goldie	Least Concern	High	Low	C
Labroides dimidiatus	Bluestreak cleaner wrasse	Least Concern	Medium	Low	B (6,000 individuals)
Pseudanthias evansi	Yellowback anthias	Least Concern	High	Low	C
Acanthurus leucosternon	Powderblue surgeonfish	Least Concern	Medium	Moderate	C
Nemateleotris magnifica	Fire goby	Least Concern	Unknown	Low	B (10,000 individuals)
Macropharyn-godon bipartitus	Rare wrasse	Least Concern	High	Low	B (2,000 individuals)
Pseudanthias parvirostris	Sunset anthias	Least Concern	High	Low	C
Nemanthias carberryi	Threadfin anthias	Least Concern	High	Low	C
Blenniella chrysospilos	Red-spotted blenny	Least Concern	High	Low-Moderate	C

Invertebrates make up the remaining 2% of exported species and most species are not typically identified to the species level. Exports are primarily composed of red starfish (unknown species but likely from the *Fromia* genus) and pink starfish (unknown species but likely from the *Echinaster* genus; (Wood et al., 2014). Sea anemones and nudibranchs are also sometimes exported (Sattar et al., 2014). No studies to date have examined the abundances of these genera in Maldivian waters.

Gear types

The marine aquarium fishery primarily consists of SCUBA and free divers that use small (< 10 cm diameter) and large (> 75 cm diameter) hand-held nets to collect free-swimming species (Ministry of Fisheries, Marine Resources and Agriculture, 2020e; Wood et al., 2014). Moxy nets, which were introduced by Sri Lankan fishers who would drape the nets over coral heads and capture fish as they attempted to flee, were banned in 1997 due to habitat damage and high rates of stress-related death in captured fishes (Wood et al., 2014).

Once captured, fish are kept in plastic bags (SCUBA divers) or in a container with holes that floats at the surface of the water (freedivers). Fish with swim bladders are deflated using a hypodermic needle through the anal opening (Wood et al., 2014). Fish are then transported to holding facilities with flowing seawater and are kept for up to a few days without food. Fish are not fed up to 48 hours before packing to ensure no fouling of the bags during transport (Wood et al., 2014). A mortality rate of approximately 10-20% occurs during transport (M. R. Saleem & Adam, 2004).

Fleet structure

Fishing for the aquarium trade began on Kaafu atoll in the 1980s, but is thought to have expanded to several islands across the Maldives by 2016, although exact fishing locations cannot be verified (Figure 16; (Ministry of Fisheries, Marine Resources and Agriculture, 2020e; M. Saleem & Islam, 2008)). To date, an estimated 11-15% of the reef area in North and South Malé is being fished for the aquarium trade, which corresponds to a total of 49.7 km^2 (0.011%) of the total Maldives reef area (4,493.85 km^2) (Wood et al., 2014). There are no areas designated for the collection of aquarium species, but species cannot be fished from resort house reefs or across the established 54 Marine Protected Areas in effect in 2020 (M. Saleem & Islam, 2008). A full map of all established Marine Protected Areas in the Maldives can be found on the Marine Protection Atlas website (Marine Conservation Institute, n.d.).

Catch

There is currently no catch reporting system required for the Maldivian marine aquarium fishery, so catch rates are inferred from export data. Similarly to the grouper fishery, significant changes in exports across years may be attributed to a single exporter or a single, large shipment given the relatively low volume of the fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020e). Even though the species and quantities exported are primarily driven by consumer demand as opposed to species abundances, the annual export quantities of several species in 2011 exceeded sustainable yield estimated by (Table 13; (Wood et al., 2014)).

Average annual exports from 2005-2014 were 325,473 individuals (range: 300,000-350,000) but increased to 409,717 individuals by 2019 (Ministry of Fisheries, Marine Resources and Agriculture, 2020e; M. Saleem & Islam, 2008). Fewer anemones have been exported in recent years, likely due to decreases in consumer demand. Sri Lanka has been the primary destination for exports since 1989 (Ministry of Fisheries, Marine Resources and Agriculture, 2020e; M. Saleem & Islam, 2008).

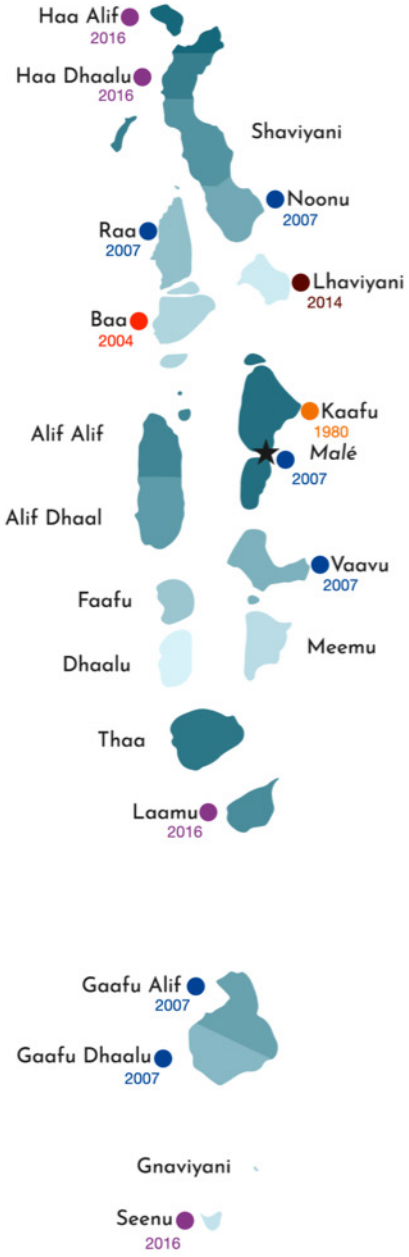

Figure 16. Distribution of islands and atolls where aquarium fishing began to occur in 1980 (orange dot), and where fishing expanded to by 2004 (red dot), 2007 (blue dots), 2014 (dark orange dot), and 2016 (purple dots; (M. Saleem & Islam, 2008)). The underlying map courtesy of WorldAtlas, with shaded breaks to indicate different administrative atolls.

Table 13. Species for which survey data exist, either from 1987-1990 surveys in Malé (virgin abundance estimates), 2008 surveys conducted by the IUCN/MRC (included areas protected against fishing), or surveys conducted in 2010-2013 by FishWatch (included areas protected against fishing). Wood et al. (2014) calculated country-wide density estimates from these survey data and estimated the sustainable yield of aquarium fish within the estimated 4,972 hectares used for collection of aquarium species to compare to 2011 export trends. Estimated sustainable yields were standardized by species vulnerability scores, where 20% of the stock could be safely harvested for species with low vulnerability and 5% of the stock could be safely harvested for species with high vulnerability (Wood et al., 2014). Only 11 of the 20 species listed in the Aquarium Fisheries Management Plan had prior density data for comparison.

Species	Reported Density in Surveys	Estimated Sustainable Yield (% of stock)	2011 Exports	2011 Exports < Sustainable Yield Estimates
Pseudanthias squamipinnis	Malé 1987-1990: 1,045/ha	Malé 1987-1990: 1,039,148 (20%)	57,138	✓
Pseudanthias evansi	Malé 1987-1990: 808/ha	Malé 1987-1990: 803,475 (5%)	9,343	✓
Macropharyngodon bipartitus	IUCN/MRC 2008: 14/ha Malé 1987-1990: 3/ha	IUCN/MRC 2008: 10,441 (15%) Malé 1987-1990: 2,237 (15%)	11,228	X
Labroides dimidiatus	IUCN/MRC 2008: 106.8/ha Malé 1987-1990: 118/ha	IUCN/MRC 2008: 106,202 (20%) Malé 1987-1990: 117,339 (20%)	20,141	✓
Acanthurus leucosternon	IUCN/MRC 2008: 18.1/ha Malé 1987-1990: 318/ha	IUCN/MRC 2008: 8,999 (10%) Malé 1987-1990: 158,110 (10%)	18,062	X
Nemateleotris magnifica	Fishwatch 2010-2013: 13.9/ha IUCN/MRC 2008: 11/ha Malé 1987-1990: 13/ha	Fishwatch 2010-2013: 13,822 (20%) IUCN/MRC 2008: 10,938 (20%) Malé 1987-1990: 12,927 (20%)	12,958	X
Nemateleotris decora	Fishwatch 2010-2013: 0.35/ha IUCN/MRC 2008: 1.5/ha	Fishwatch 2010-2013: 348 (20%) IUCN/MRC 2008: 1,492 (20%)	10,566	X
Halichoeres leucoxanthus	IUCN/MRC 2008: 5.4/ha	IUCN/MRC 2008: 5,370 (20%)	6,541	X
Ecsenius midas	IUCN/MRC 2008: 0.4/ha	IUCN/MRC 2008: 199 (10%)	4,623	X
Cirrhilabrus exquisitus	Fishwatch 2010-2013: 123.42/ha IUCN/MRC 2008: 181.3/ha	Fishwatch 2010-2013: 91,942 (15%) IUCN/MRC 2008: 135,214 (15%)	1,960	✓
Pseudocheilinus hexataenia	IUCN/MRC 2008: 41.5/ha Malé 1987-1990: 75/ha	Malé 1987-1990: 74,580 (20%)	7,513	✓

Economic importance

The monthly income for employees in the marine aquarium fishery is estimated to be 10,000-12,000 MVR (US$647-US$779), but can be as high as 15,456 MVR (US$1000) per month (Wood et al., 2014).

In 2007, 7 registered companies (~90 employees) were participating in the trading of 140 species of fish and 5 species of invertebrates, with a single company contributing 54% of the exports and 66% of total revenue (M. Saleem & Islam, 2008). By 2011, the same company was responsible for 70% of exports from the Maldives (Wood et al., 2014). A total of 358,378 aquarium fish were exported from the Maldives in 2007 and comprised up to 0.55% of the total value of marine exports (7,529,266 MVR [US$590,530]; Figure 17; (M. Saleem & Islam, 2008)). In 2017, this value had decreased; the marine aquarium fishery made up only 0.27% of all marine exports in the Maldives (Ministry of Fisheries, Marine Resources and Agriculture, 2020e). However, since the 1980s, the value of fishes and invertebrates exported has increased from 2,374,004 MVR (US$153,598) to 8,059,763 MVR (US$521,466). In addition, the value of the marine aquarium fishery exports reflects the quality of exported species; for example, Nemateleotris magnifica from the Maldives costs more than Indonesia because of its superior quality (Wood et al., 2014). In 2020, 352,301 live aquarium species (6,056,120 MVR; US$394,589.77) were exported from the Maldives (Maldives Customs Service, 2020).

The gear used in the fishery (e.g., handheld scoop nets, holding equipment) are subjected to high import duty taxes of up to 25-100% of the value of the product itself, making it difficult to ensure quality while offsetting production costs (Ministry of Fisheries, Marine Resources and Agriculture, 2020e).

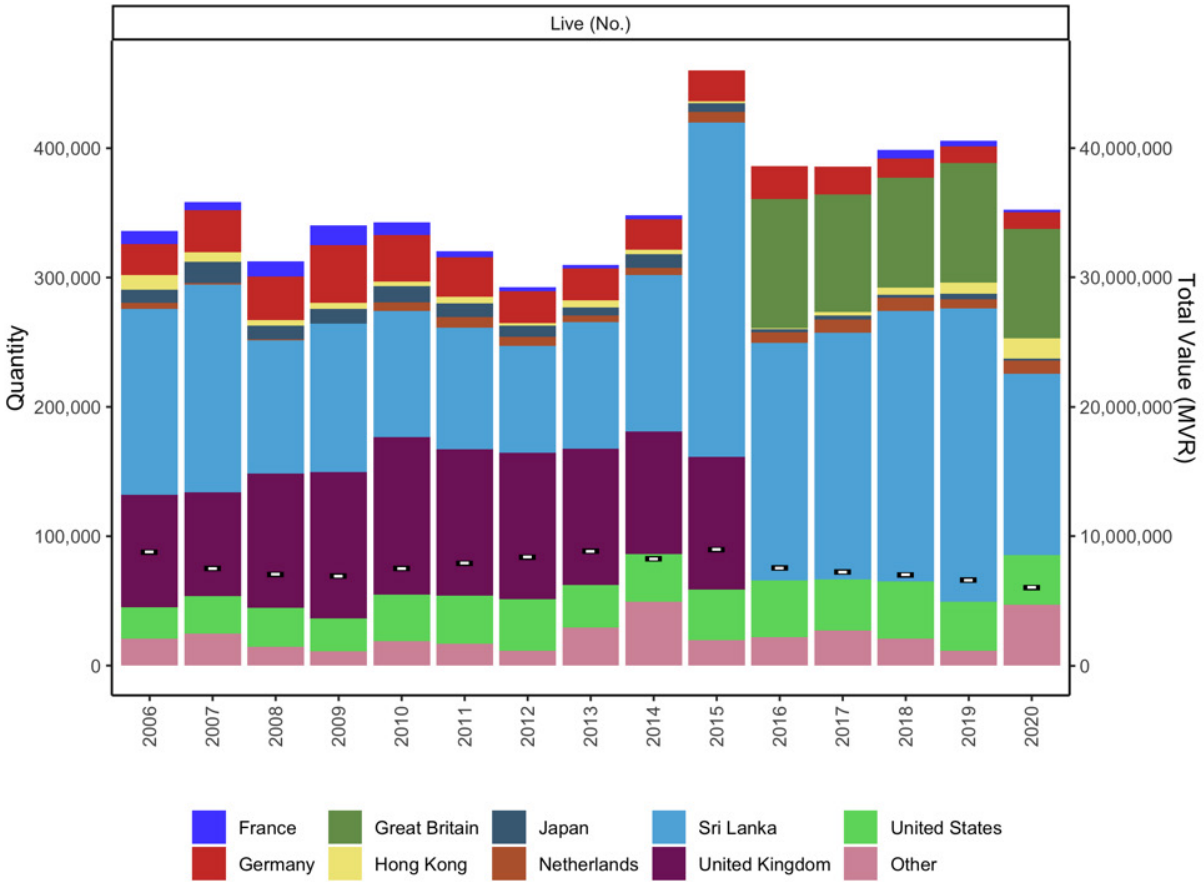

Figure 17. Export data from the Maldives Custom Service (2020) of aquarium fishes that were exported from 2006 to 2020. Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year.

8. Sea cucumber fishery

Overview

The Maldivian sea cucumber fishery was first developed in 1985, when high-value sea cucumbers were abundant in shallow waters and fishing primarily occurred in northern atolls (Hudha Ahmed & Saleem, 1996; Joseph, 1992). By 1987, the abundances of high-value species had declined and the fishery expanded to include several low-valued species across the islands (Hudha Ahmed & Saleem, 1996; Ministry of Fisheries, Marine Resources and Agriculture, 2020g).

Post harvest processing is unique in the sea cucumber fishery with nearly all catch dried and exported. The extensive drying and cleaning procedures carried out by women near lagoons on their home islands has raised concerns about the potential for negative impacts to the livebait fishery (Nizar et al., 2019). Sea cucumbers are cleaned, boiled in water for 30 minutes, and often salted to speed up the cooking process. Once cooked, cucumbers are buried in sand for 12-18 hours before the remaining innards are removed using an incision on the dorsal surface. Cucumbers are then boiled for another 30 minutes to remove any salt before being sun dried. Finally, the cucumbers are boiled a third time to straighten the body before they are transported for export (Ministry of Fisheries, Marine Resources and Agriculture, 2020g).

Data availability and limitations

Fishery independent data

In addition to collecting survey data for reef fish species, ReefCheck Maldives has also logged the presence of invertebrates, including edible sea cucumbers, in their surveys spanning from 1997-2019 (Figure 18). Additional fishery independent data are expected to have been collected over the years, but do not appear to be publicly available at this time.

Fishery dependent data

Due to the export-based nature of the Maldivian sea cucumber fishery, the majority of data available are from fishery dependent sources. Export data for sea cucumbers dating back to the mid-1990s are publicly available for download from the MCS. While catch and effort data are not currently collected from sea cucumber fishers in the Maldives, additional data sources that are available for download, such as licensed fishing vessel lists and fishermen's forums hosted by the Maldivian Ministry of Fisheries, or research presentations from symposiums, such as the Maldives Marine Science Symposium may have useful information about this fishery, in addition to other fisheries within the Maldives.

Target species

At the start of the fishery, catches were primarily composed of high-value species, such as *Thelenota ananas* (prickly redfish). However, these populations quickly declined by 1998, forcing fishers to target lower-value species instead, like *Holothuria atra* (lollyfish; FAO, 2013). Most recently, there are ten species that are most commonly exported, including species that are still considered high-value species within the fishery (Table 14; Figure 19) (Ducarme, 2015; FAO, 2013).

The majority of high-value species have not been reported in the most recent fishery-independent sea cucumber surveys, which may be attributed to low abundances or the misidentification of species (e.g., *H. nobilis* as *Holothuria fuscogilva* [white teat]; Table 14; (Ducarme, 2015, 2016)). Throughout these surveys, low-valued species, including *Pearsonothuria graeffei* (blackspotted sea cucumber, sightings at 92% of surveyed sites), *Holothuria edulis* (pinkfish), and *H. atra* were the most abundant (Ducarme, 2015). Concerns about

the health of sea cucumber populations within the Maldives and the greater Southwest Indian Ocean were listed as a priority for future research (Southwest Indian Ocean Fisheries Commission, 2019). In addition, *H. fuscogilva* and *H. nobilis* were added to CITES Appendix II in 2019 and can no longer be exported (Ministry of Fisheries, Marine Resources and Agriculture, 2020g; Nizar et al., 2019).

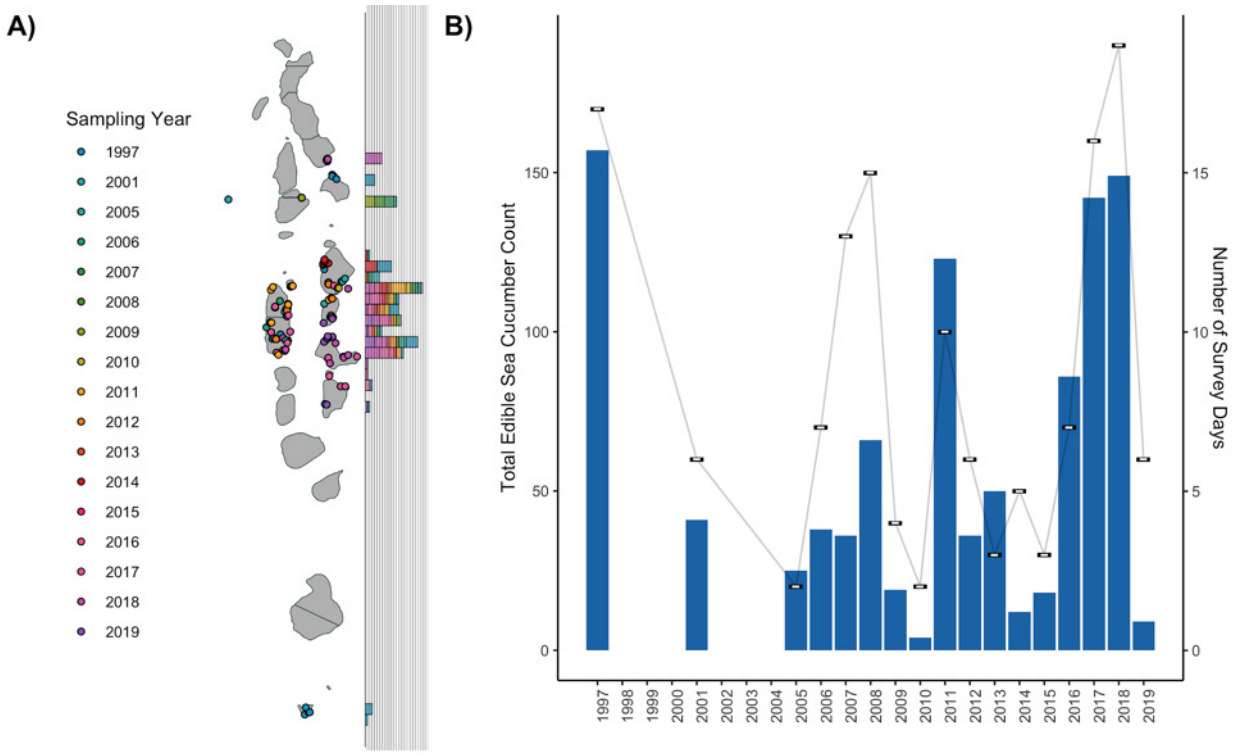

Figure 18. A) Locations of ReefCheck reef surveys that span from 1997-2019. B) Total counts of edible sea cucumbers throughout all surveys in a particular year. The black outlined boxes represent the total number of survey days within that particular year; the absence of boxes indicates no data collected during that year. Data accessed via Global Reef Tracker by ReefCheck.

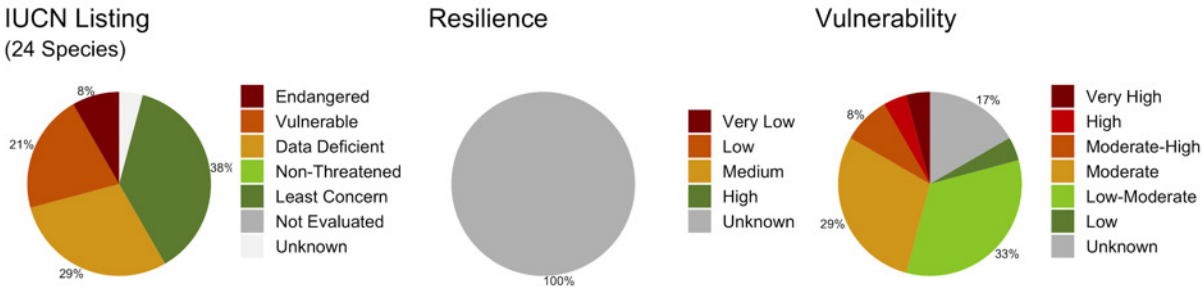

Figure 19. Threat classifications for the sea cucumber species in the Maldives, as identified by their IUCN status, and their resilience and vulnerability categorization.

Table 14. Principal/key sea cucumber species, their IUCN listing and vulnerability scores, and the last year the species was reported either by fishery-independent scientific surveys or, if more recently, anecdotally by fishers. Anecdotal reports that are included were referenced in Ducarme (2015). The most recent scientific surveys were conducted by Ducarme (2016).

Scientific name	Common name	IUCN listing	Vulnerability	Value	Year Last Reported (Location)	Sources
Holothuria nobilis	Black teatfish	Endangered	Moderate	High	Scientific Surveys: 2005 (Malé Atoll)	Ducarme 2015, Muthiga 2008
Thelenota ananas	Prickly redfish	Endangered	Moderate-High	High	Scientific Surveys: 2009 (Baa Atoll) Fishers: 2014 (Baa Atoll)	Payri et al 2012, Ducarme 2015
Holothuria fuscogilva	White teeth	Least Concern	Low-Moderate	Low	Scientific Surveys: 2009 (Baa Atoll)	Payri et al 2012, Ducarme 2015
Actinopyga mauritiana	Surf redfish	Vulnerable	Low-Moderate	High	Scientific Surveys: 2009 (Baa Atoll)	Payri et al 2012, Ducarme 2015
Holothuria fuscopunctata	Elephant trunkfish	Least Concern	Moderate-High	Low	Scientific Surveys: 1994 (Malé and Laamu Atolls) Fishers: 2014 (Baa Atoll)	Ducarme 2015, Reichenbach 1999
Holothuria atra	Lollyfish	Least Concern	Moderate	Low	Scientific Surveys: 2015 (Ari Atoll)	Ducarme 2016
Stichopus chloronotus	Greenfish	Least Concern	Low-Moderate	Low	Scientific Surveys: 2015 (Ari Atoll)	Ducarme 2016
Thelenota anax	Amber fish	Data Deficient	High	Low	Scientific Surveys: 2015 (Ari Atoll)	Ducarme 2016
Bohadschia marmorata	Chalky cucumber	Data Deficient	Low-Moderate	Low	Scientific Surveys: 2009 (Baa Atoll)	Payri et al 2012, Ducarme 2015
Actinopyga echinites	Deepwater redfish	Vulnerable	Low-Moderate	High	Scientific Surveys: 1994 (Malé and Laamu Atolls)	Ducarme 2015, Reichenbach 1999
Actinopyga lecanora	White-bottomed sea cucumber	Data Deficient		Low	Scientific Surveys: 2015 (Ari Atoll)	Ducarme 2016
Actinopyga miliaris	Hairy blackfish	Vulnerable	Low	Low	Scientific Surveys: 2005 (Malé Atoll) Fishers: 2014 (Baa Atoll)	Ducarme 2015, Muthiga 2008
Bohadschia argus	Leopard fish	Least Concern	Moderate	Low	Scientific Surveys: 2009 (Baa Atoll)	Payri et al 2012
Bohadschia vitiensis	Brown sandfish	Data Deficient	Low-Moderate	Low	Scientific Surveys: 2015 (Ari Atoll)	Ducarme 2016
Stichopus herrmanni	Curryfish herrmanni	Vulnerable		Low	Scientific Surveys: 2014 (Baa Atoll)	Ducarme 2015

Gear types

Although originally hand-picked during the low tide, the rapid decrease in sea cucumber abundances in shallow waters led to the development of more sophisticated gears for collecting sea cucumbers at greater depths (Table 15; (Ministry of Fisheries, Marine Resources and Agriculture, 2020g)). A survey conducted in 2012 noted that freediving and SCUBA diving were used for sea cucumber fishing operations in the Maldives, despite SCUBA diving being banned from use in 1993 (FAO, 2013).

Fleet structure

A phone survey in 2017 found that approximately 1,200 fishers participated in the sea cucumber fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020g). Many participants are tuna fishers who collect sea cucumbers during non-tuna fishing seasons (FAO, 2013).

Catch

From 2002 to 2017, limited data for sea cucumber catches were provided to Island Offices to generate Monthly Fishing Reports (Figure 20; (Ministry of Fisheries, Marine Resources and Agriculture, 2020g)). While there is currently no required system for catch reporting in the Maldives sea cucumber fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020g), working groups of local fishers have expressed concerns regarding the stability of sea cucumber abundances within the Maldives, noting that it has become more difficult to find sea cucumbers in shallow waters or lagoons (FAO, 2013; Nizar et al., 2019).

Nearly all collected sea cucumbers are processed (dried) and exported, so it is expected that exports mimic trends in catch. Most exports are sent to Singapore, Sri Lanka and Hong Kong, with Hong Kong dominating the export market in more recent years (FAO, 2013; Nizar et al., 2019). Exporting directly to China has become a burden due to additional documents that are required for export, which have become exacerbated due to language barriers and translation issues (Nizar et al., 2019).

Table 15. Gears used in the Maldives sea cucumber fishery over time (Ministry of Fisheries, Marine Resources and Agriculture, 2020g).

Gear Used	Description	Depth (m)	Restrictions
Hand-picked via sea wading	Captured during the low-tide in shallow lagoons and the intertidal regions	< 1	None
Metal spear	Metal spear fixed to long wooden poles	< 3	None
Hand-picked via snorkeling	Captured using snorkel equipment	15 - 25	None
Fishing Hook	Fish hook fixed to a block of lead and attached to a fishing lure, often paired with snorkel equipment	15 - 25	None
Hand-picked via SCUBA	Captured using SCUBA equipment	Anecdotally > 25	Banned in 1993, but poorly enforced

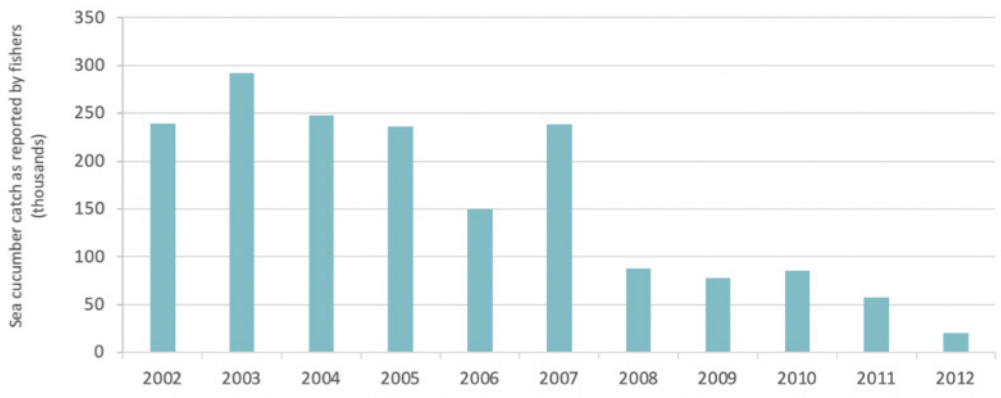

Figure 20. Sea cucumber catch rates from 2002-2012 as reported by islands. Figure from the Ministry of Fisheries, Marine Resources, and Agriculture (2020g).

Economic importance

A survey in 2012 found that most sea cucumber fishers were men participating in freediving and SCUBA diving for collection (FAO, 2013). However, several women are engaged in the fishery to process (dry) sea cucumbers that are collected on their home island before they are exported. The drying process is extensive and time consuming; drying times are species specific and can require drying until the animal is anywhere between 1/5 and 1/20 of its landed weight (Nizar et al., 2019). Despite the amount of work required to find and prepare sea cucumbers, working groups of fishers have expressed concerns that the benefits from the sea cucumber fishery no longer flow directly to the fishing communities (FAO, 2013; Nizar et al., 2019).

Export volume for sea cucumbers peaked in 1990, when 745,000 kg (valued at 31.5 million MVR; US$2.04 million) of sea cucumber were exported, and has since declined steadily over time (Ministry of Fisheries, Marine Resources and Agriculture, 2020g). Overall revenue was highest in 2003 at 43.2 million MVR (US$2.87 million). Data from the MCS spanning 2015-2020 indicate a relatively stable export of dried or salted sea cucumbers to Hong Kong and Sri Lanka, but a decrease in frozen and an increase in fresh or chilled sea cucumber exports in recent years (Figure 21). In 2020, 102,427 kg of sea cucumber (5,255,872 MVR; US$342,449.18) were exported from the Maldives. The majority of exported products were salted and dried (97.6% of total sea cucumber export weight; 98.5% total sea cucumber export value) (Maldives Customs Service, 2020).

Customs records indicate that dried sea cucumbers cost US$3 per kg, but Nizar et al. (2019) indicates that this valuation is an underestimation of overall costs and that the true market value of the fishery is not well represented within the GDP. Furthermore, evidence suggests that tigerfish (*Bohadschia atra*) are sold at rates from 90-100 MVR per kg (US$5.82-$6.57), but the prices of different species can vary drastically (2-650 MVR / US$0.13-US$42.05 per kg) (Nizar et al., 2019).

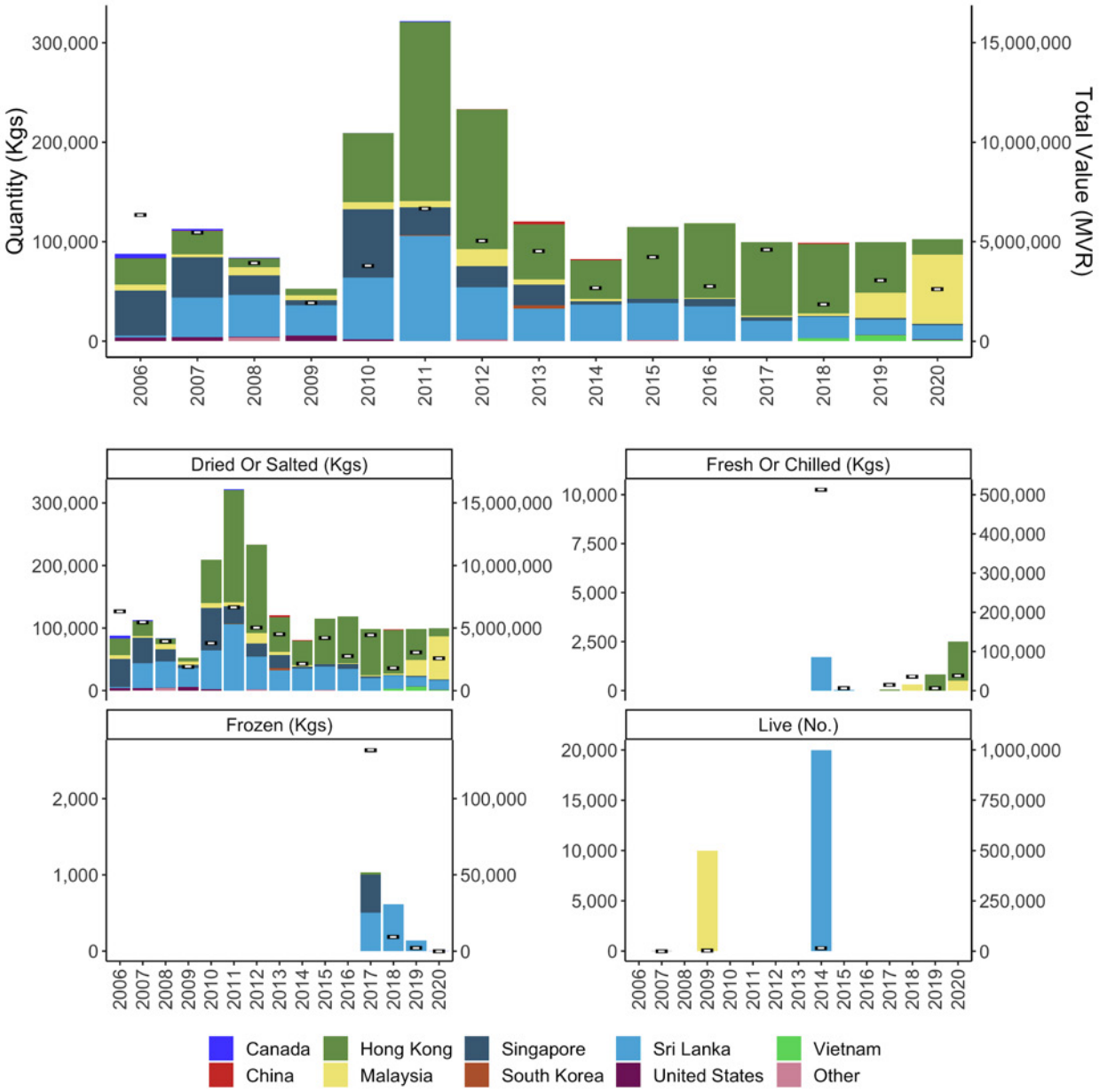

Figure 21. Export data from the Maldives Custom Services (2020) of sea cucumbers that were exported from 2006 to 2020 (top), and broken out by disposition (bottom; dried or salted, fresh or chilled, frozen, or live). Bars are colored based on the destination country. The black outlined boxes represent the total value (MVR) of the exports within that particular export group and year. The absence of bars and black boxes indicate no data collected during that year.

9. Lobster fishery

Overview

The lobster fishery is opportunistic in nature and is generally limited to shallow reef areas that can be accessed via wading or free diving. Historically, the lobster fishery peaked during the northeastern monsoon season, when tourists are abundant and the water is calm (R. Anderson et al., 1992). Lobsters are banned from exports, and the most recent estimate for the value of Maldivian lobsters was published in 1996 (Hudha Ahmed & Saleem, 1996).

Data availability and limitations

Fishery independent data

In addition to collecting survey data for reef fish species, ReefCheck Maldives has also logged the presence of invertebrates, including lobster, in their surveys spanning from 1997-2019 (Figure 22). Additional fishery independent data are expected to have been collected over the years, but do not appear to be publicly available at this time.

Fishery dependent data

Since lobsters are often opportunistically collected during fishing activities for other species and lobsters are banned from export, there are few known fishery dependent datasets. However, lobster purchase data, including numbers and weights of key species, were self-reported by resort purchasers in 2013 as part of the Darwin Reef Fish Project. Raw data are not publicly available.

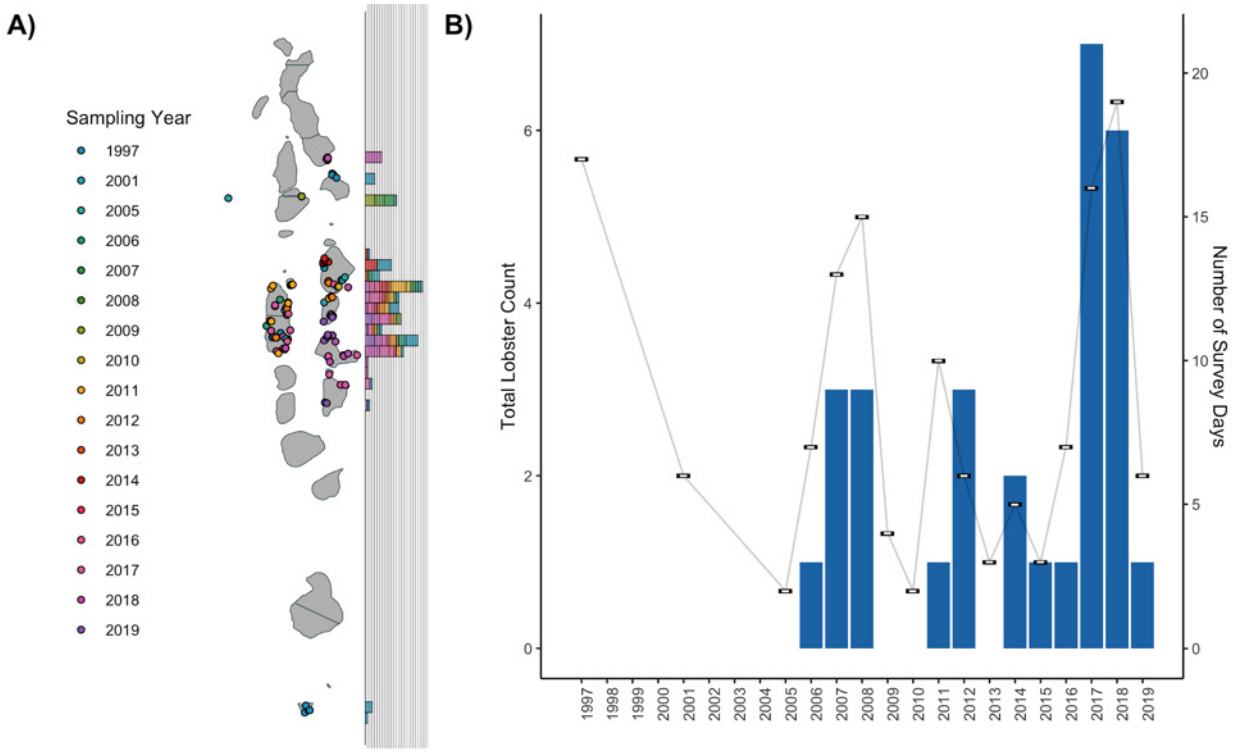

Figure 22. A) Locations of ReefCheck reef surveys that span from 1997-2019. B) Total counts of lobster throughout all surveys in a particular year. The black outlined boxes represent the total number of survey days within that particular year; the absence of boxes indicates no data collected during that year. Data accessed via Global Reef Tracker by ReefCheck.

Target species

Several species of spiny lobsters (Palinuridae), slipper lobsters (Scyllaridae) and reef lobsters (Enoplometopidae) are present along Maldivian reefs, but only spiny lobsters are actively caught (Table 16; Figure 23; (Ministry of Fisheries, Marine Resources and Agriculture, 2020d)).

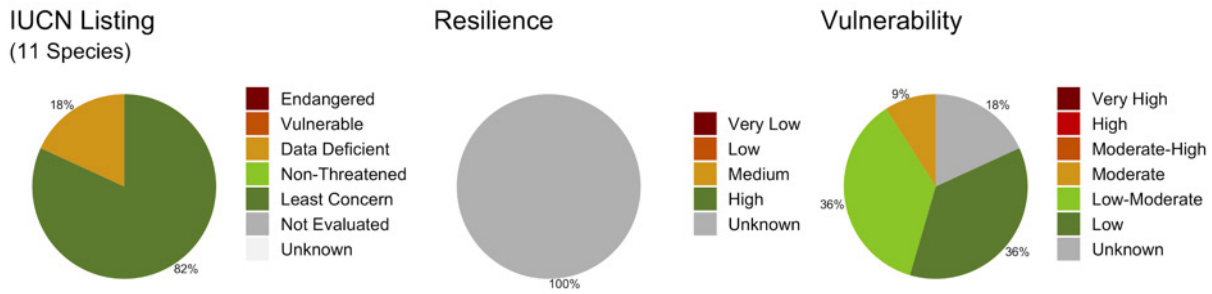

Figure 23. Threat classifications for the lobster species in the Maldives, as identified by their IUCN status, and their resilience and vulnerability categorization.

Table 16. Principal/key lobster species caught in the Maldives and their depth preferences, IUCN listing, and vulnerability scores.

Scientific Name	Common Name	Depth (m)	IUCN Listing	Vulnerability
Palinustus unicornutus	unicorn blunthorn lobster	205-390	Least Concern	
Panulirus femoristriga	stripe-leg spiny lobster	15-35	Least Concern	
Panulirus japonicus	japanese spiny lobster	1-15	Data Deficient	Low
Panulirus longipes	longlegged spiny lobster	1-122	Least Concern	Low
Panulirus ornatus	ornate spiny lobster	1-50	Least Concern	Moderate
Panulirus penicillatus	pronghorn spiny lobster	> 200	Least Concern	Low-Moderate
Panulirus polyphagus	mud spiny lobster	3-90	Least Concern	Low-Moderate
Panulirus versicolor	painted spiny lobster	> 900	Least Concern	Low-Moderate

Gear types

Lobsters are opportunistically caught during sea cucumber fishing trips and are collected by hand while diving or sea-wading, often with the help of lights at night (Ministry of Fisheries, Marine Resources and Agriculture, 2020d). Fishers are not allowed to use SCUBA equipment when collecting lobster (Ministry of Fisheries, Marine Resources and Agriculture, 2020d). Once collected, lobsters are kept alive and sold directly to resorts (Anderson et al. 1992).

Fleet structure

Surveys conducted by the Ministry of Fisheries in 2017-2018 estimate that approximately 200 vessels and 1,100 fishers engage in the lobster fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020d).

Catch

In the 1970s, fishers began voluntarily reporting daily catches to Island Offices as contributions to Monthly Fishing Reports that were forwarded to the Statistics and Data Management section of the Ministry (Figure 24; (Ministry of Fisheries, Marine Resources and Agriculture, 2020d)). However, the lobster catch rates depicted in the reports are not a true representation of total lobster landings and when logbooks were officially introduced in 2010 for pelagic fisheries, there was no longer a method for reporting lobster catch (Ministry of Fisheries, Marine Resources and Agriculture, 2020d). There is currently no required system for catch reporting in the Maldives lobster fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020d).

Export of lobsters is prohibited. Catch is sold domestically to the tourism industry, restaurants, or local markets (Ministry of Fisheries, Marine Resources and Agriculture, 2020d).

Economic importance

The limited data for the lobster fishery paired with the export bans make it difficult to track the economics of this nearshore fishery sector. The most recent estimated value of lobster comes from a 1996 estimate of between 80 MVR (US$5.18) and 150 MVR (US$9.70) per lobster (Hudha Ahmed & Saleem, 1996).

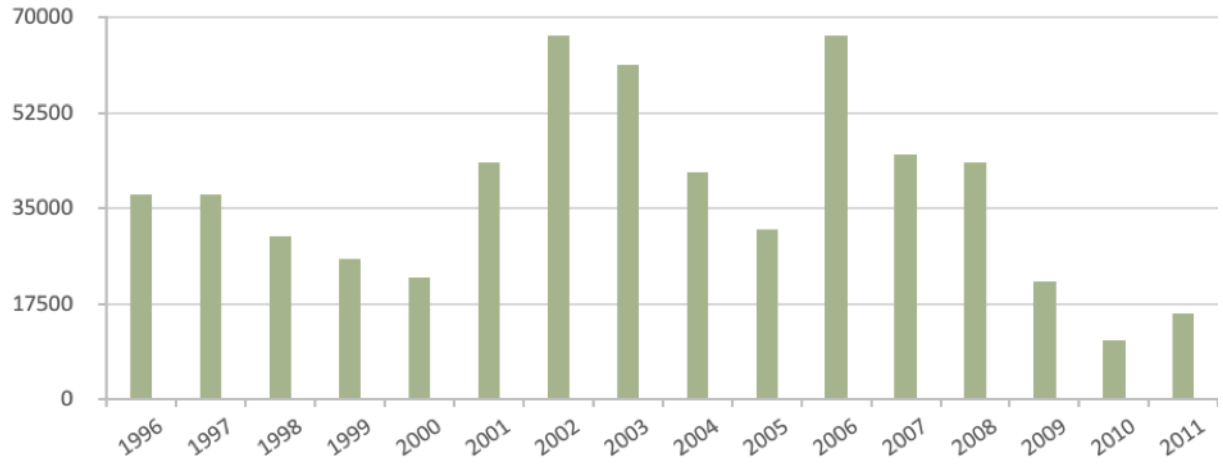

Figure 24. Lobster landings reported (numbers; y-axis) from islands from 1996-2011. Figure courtesy of the Maldives Lobster Fishery Management Plan.

10. Established aquaculture

Groupers

Aquaculture research and development projects have been carried out, and are still ongoing for the seed production (production of eggs or fry at quantities and qualities suitable for aquaculture) of brown-marbled grouper, *E. fuscoguttatus*, in the Maniyafushi Field Station of the Maldives Research Centre with the hopes to export to Chinese markets (JICA et al., 2018).

Additional developments in this sector have begun as part of the Sustainable Fisheries Resource Development Project (SFRDP) funded by the World Bank (MMRI, personal communication). The support infrastructure has been completed for a multispecies hatchery in Maangala island, North Huvadhu (Gaafu Alif) atoll for the seed production of groupers (*E. fuscoguttatus*), sea cucumbers, and baitfish (MMRI, personal communication). The design, build, and operational contract for this hatchery is still underway (MMRI, personal communication). A mariculture research and demonstration facility on Maniyafushi Island, South Male Atoll is also in development and will be the key facility for future work that builds human resources within the mariculture sector while also serving as a satellite hatchery (a hatchery that nurses and grows juvenile fish) to provide fingerlings (juvenile fish 10-15 cm in length, FAO) to pilot farmers (MMRI, personal communication). The infrastructure for this facility is complete and preparation for training is underway (MMRI, personal communication). The SFRDP has also facilitated the collaboration among 19 farmers from four islands of South Ari Atoll (Mahibadhoo, Omadhoo, Dhigurah, Dhan'gethi) in a pilot project to test commercial production of groupers for export (MMRI, personal communication). The farmers are provided with sea cage systems, feed, and fingerlings and are trained on fish husbandry and small business management (MMRI, personal communication). The infrastructure for an Aquatic Animal Health Facility was also completed as a part of the Mariculture Enterprise Development Project which was funded by the International Fund for Agricultural Development (MMRI, personal communication). Through the SFRDP, MoFMRA will equip laboratories for diagnostic services for aquatic animals and train local staff to build in-house capacity for diagnostic services and quarantine services for limited quantities of imported seed stock for starting aquaculture (MMRI, personal communication). Finally, MoFMRA is working on the selection criteria to engage members of the private sector with the SFRDP developments (MMRI, personal communication).

Sea cucumbers

Aquaculture efforts for *Holothuria scabra* (sandfish) were carried out by a single, private group since 2007 in Shaviyani Atoll, with seed production in tanks on land and grow out in enclosed lagoons (MMRI, personal communication, MoFMRA, personal communication). Although this particular establishment is no longer in operation, a commercial aquaculture facility in Laamu Atoll uses shallow lagoons for both the seed production and grow out of *H. scabra* (Ministry of Fisheries, Marine Resources and Agriculture, personal communication, 2021; MMRI, personal communication, 2022). Additional startup culture facilities for *H. scabra* are located in Shaviyani, Noonu, and Male Atolls (MMRI, personal communication, MoFMRA, personal communication). High rates of survival and growth for hatchery-produced *H. scabra* show promise for the aquaculture of other sea cucumber species (Ahmed et al., 2017). Other aquaculture research and development projects have been carried out for sea cucumber cultures for *Holothuria fuscogilva* and *Thelenota ananas* in Laamu Atoll, and a second facility that uses the artificial seeds (fertilized eggs or fry) from the farm in Laamu Atoll has been established in Shaviyani Atoll (JICA et al., 2018). MMRI also conducts culture trials on a local variety of sea cucumber, but trials

for *H. fuscogilva* have been paused until the completion of a mariculture research and demonstration facility on Maniyafushi Island, South Male (MMRI, personal communication, MoFMRA, personal communication).

Additional developments in this sector have begun as part of the Sustainable Fisheries Resource Development Project (SFRDP) funded by the World Bank (MMRI, personal communication) and are more thoroughly described in the aquaculture section for Groupers.

11. Aquaculture in development

Baitfish

The development of livebait aquaculture has been proposed as one way to enhance the accessibility of livebait resources year round, reduce fishing pressure on wild livebait stocks, and limit environmental impacts on coral reef ecosystems (United Nations, 2017). In 2017, MoFMRA is in the process of developing aquaculture of milkfish (*Chanos chanos*) as an alternative source of live bait, to cater to periods of low bait availability. The use of cultured milkfish as bait is likely to be trialed in 2023. Cultured milkfish has been deployed successfully as livebait in the pole-and-line fisheries of Kiribati and Indonesia (United Nations, 2017).

12. Fisheries management in the Maldives

The Maldives' fisheries are managed by MoFMRA. Wide-ranging tuna and tuna-like species are further managed at multiple scales by several regional groups. The overlap of regional and national jurisdiction creates a layered management system that relies upon international cooperation and implementation of regulations at the national scale. In this section, we briefly describe the most relevant entities and management authorities at each geographical scope (regional, national) and the measures that affect the management of Maldivian fisheries, particularly tuna and billfishes. We also summarize key measures from the management plans developed for each of the Maldives' fisheries.

Regional

The regional management of the Maldives' tuna and billfish fisheries are overseen and informed by several different regional fisheries management organizations (RFMOs), intergovernmental organizations (IGOs), and nongovernmental organizations (NGOs). Here, we profile several such entities and describe their interaction with fisheries management in the Maldives. We included organizations that are either explicitly referenced in the Fishery Management Plans described above or whose data generating programs are included in the 2020 National Report to the Indian Ocean Tuna Commission.

Indian Ocean Tuna Commission (IOTC)

The IOTC is an RFMO that was established in 1993 with the mission to promote cooperation between parties fishing in the Indian Ocean, to conserve the status of relevant fisheries stocks, and to encourage the optimal utilization of said stocks to ensure the sustainable development of fisheries reliant upon them (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). In practice, this is accomplished through four key functions: the collection, analysis, and dissemination of key fisheries data; the coordination of research and development activities among member parties; the adoption of Conservation and Management Measures (CMMs) to promote the sustainable utilization of the target stocks, and the tracking of socio-economic dimensions of the relevant fisheries with an eye to their impact on the economic well-being and livelihoods of developing coastal States (IOTC, 2021c). These functions are carried out by the Compliance Committee, who tracks reporting obligations of the participating nations each year, and the Scientific Committee, who coordinates cooperative research in support of IOTC activities, assesses the status of relevant stocks, and delivers evidence-based recommendations to the Commission with regards to policy and procedural changes. Analytical and technical tasks are further delegated to groups called Working Parties, which serve to support the Scientific Committee primarily by conducting stock assessments and evaluating possible management actions (IOTC, 2022). At each annual Session of the Commission, CMMs may be adopted concerning the management of tuna and tuna-like species as well as the fisheries which target them. Subject to review and revision at the Commission Session, these proposals are adopted either as Resolutions or Recommendations. Resolutions are legally binding, unless a member officially files an objection, and are passed by consensus or by voting. Recommendations are not legally binding but rely on voluntary implementation. There are currently 30 full members of the IOTC, referred to as Contracting Parties, 22 of which are coastal States and 8 of which are distant water fishing nations (Sinan et al., 2021). In addition, there are two Cooperating Non-Contracting Parties, Senegal and Liberia, who follow the same regulations as the Contracting Parties but do not have full voting rights.

Stocks are managed through the binding CMMs adopted by the Commission with a two-thirds consensus of the Contracting Parties (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). As of October 2021, there are 59 active

CMMs, 56 of which are full binding Resolutions with the remaining 3 being Recommendations which rely on voluntary implementation by the cooperating parties. A few of the most pertinent CMMs to the Maldives are described below (IOTC, 2021d):

- CMM 3/09 requires observer coverage on at least 5% of all fishing effort
- CMM 21/01 sets differing catch limits for yellowfin tuna relative to 2014 catch levels based on amount caught in 2014. A 21% reduction is mandated for parties that caught more than 5000 mt of yellowfin tuna in 2014
- CMM 21/03 sets harvest control rules for the catch of skipjack tuna
- CMM 18/05 sets overall catch limits for four billfish stocks in the Indian Ocean: striped marlin, black marlin, blue marlin, and Indo Pacific sailfish. Additionally, it sets a minimum size limit and details mandatory data reporting requirements for these species
- CMM 15/03 mandates satellite-based vessel monitoring system (VMS) to be installed on all vessels greater than 24 meters in length targeting IOTC species of interest in the IOTC area of competence and those vessels less than 24 m who are fishing outside of their respective EEZ

The Maldives became a full Contracting Party of the IOTC in 2011, in part due to a condition placed on the certification of the pole-and-line skipjack fishery by the MSC (Edwards et al., 2020). Prior to 2011, unlike other RFMOs, the IOTC did not use precautionary principles to set harvest limits (Edwards et al., 2020). However, in pursuing MSC certification, the Maldives successfully lobbied the IOTC to adopt a more precautionary approach and helped lead the first model-based assessment of the skipjack tuna stock, which concluded the stock was healthy in 2013 (Edwards et al., 2020). Since then, the IOTC has agreed upon reference points for the stock and adopted a handful of harvest control rules, important conditions of the MSC certification (Edwards et al., 2020). The harvest control rules established in 2016 do not restrict pole-and-line fishing currently but outline a series of management actions to be taken if the stock status drops below a management reference point (Edwards et al., 2020). Table 9 of the 2021 National Report to the IOTC outlines the progress made towards implementing IOTC resolutions and recommendations made by the Scientific Committee of the IOTC and Table 8 in that same document details four major research programs currently in progress at the national level that support enhanced collection and reporting of fisheries data mandated by the IOTC.

Southwest Indian Ocean Fishery Commission (SWIOFC)

The SWIOFC is an RFMO established in 2004 under the Fisheries and Agricultural Organization (FAO) to coordinate the sustainable management and development of pelagic and nearshore marine resources in the southwest Indian Ocean and whose area of competence includes the southern portion of the EEZ of the Maldives (FAO Fisheries & Aquaculture, 2021b). The current members of the SWIOFC include Comoros, France, Kenya, Madagascar, Maldives, Mauritius, Mozambique, Seychelles, Somalia, South Africa, United Rep. of Tanzania, and Yemen. The summary report of the Tenth Session by the Scientific Committee of the SWIOFC reported that 56% of the assessed stocks could be considered sustainably exploited in 2019, a slight decrease from the 60% reported for the previous year (Southwest Indian Ocean Fisheries Commission, 2019). The report identified two fisheries in the Maldives as priorities for future research in the Southwest Indian Ocean: the handline tuna fishery (1st priority) and the sea cucumber fishery (Southwest Indian Ocean Fisheries Commission, 2019).

The Bay of Bengal Programme Inter Governmental Organization (BOBP-IGO)

The BOBP-IGO is tasked with enhancing the cooperative management of marine resources within the Bay of Bengal region with a focus on small-scale and artisanal fisheries (FAO Fisheries & Aquaculture, 2021a). The IGO oversees the areas within and between the EEZs of its four member states: Bangladesh, India, the Maldives, and Sri Lanka. The organization hosts workshops and trainings on the management of highly migratory

species, stock assessments, and monitoring, control and surveillance among other topics (Bay of Bengal Programme, 2021). In 2019, the BOBP-IGO worked in close collaboration with the FAO to publish the "Safety at sea for small-scale fishers" manual which outlines proper safe operating procedures for fishing vessels less than 12 m in length.

The Asia-Pacific Fishery Commission (APFIC)
The APFIC works to promote the sustainable management of marine resources throughout the Pacific and Indian Oceans and works to enhance cooperation on fisheries issues across the region (FAO, 2021). While the Maldives is not a formal member state of the APFIC currently, the APFIC has overlapping interests and jurisdiction with the coastal states of the Bay of Bengal and the addition of the Maldives as a full-time member has been identified as a step in the effective functioning of the organization (FAO, 2021).

The International Pole & Line Foundation (IPNLF)
The IPNLF works to ensure the development of environmentally responsible pole-and-line and handline fisheries around the world. Originally the IPNLF worked closely with the Maldives to obtain MSC certification for its pole-and-line tuna fishery and now continues to support the sustainable development of that fishery through programs such as a bycatch sampling program. Member organizations of the IPNLF based in the Maldives include but are not limited to: the Maldives Fishermen's Association, Maldives Industrial Fisheries Company Limited (MIFCO), Dhiveni Masverin (Maldives Fishermen), the Maldives Seafood Processors and Exporters Association (MSPEA), and the processing company Horizon Fisheries (IPNLF, 2021).

The World Bank
The World Bank supports fisheries management in the Maldives through a Sustainable Fisheries Resources Development Project (SFRDP) that began in 2017. The project has three components: 1) enhancing the government's ability to effectively monitor the fisheries sector, 2) supporting the development of mariculture production systems and supporting infrastructure, and 3) building the administrative and technical capacity of MoFMRA (World Bank, 2021). A port sampling program, overhaul of the VMS system, and implementation of EM systems are currently being funded by the SFRDP in support of the first project component.

National

At the national level, the Ministry of Fisheries Marine Resources and Agriculture (referred to as the Ministry in this report) is the primary government authority with regard to the sustainable management and development of fisheries (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The Ministry is composed of three branches that oversee management, compliance, and research relevant to fisheries, respectively: the Fisheries Management Section, the Fisheries Compliance Section, and the Maldives Marine Research Institute (MMRI; formerly the Marine Research Center) (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). MoFMRA has the power to establish and administer regulations for the use and conservation of living marine resources, including fisheries and other threatened species under the Ministry's mandate (Shakeel, n.d.). MoFMRA implements projects to help improve fisheries management and development, develop and document fishing vessels, encourage new fishing methods, install and document FADs, conduct fisheries research, and improve fish processing (Ministry of Fisheries, Marine Resources and Agriculture, 2022a, 2022b). MMRI is MoFMRA's research arm and provides research support on fisheries and marine research, management and development (MMRI, 2022). Specifically, MMRI undertakes collaborative research to generate new knowledge on marine resources, conducts monitoring and assessments of fishing activities and harvested stocks, non-target species and ecosystems, ensures sustainable fishing activities are managed in a way that can be maintained, identifies critical habitats for conservation, and assists MoFRMA by providing expert knowledge for national marine and fisheries resource policies (MMRI, 2022).

Traditionally, atolls in the Maldives were governed under the Vaaru system (Hunter, 1996), where

islands were largely autonomous and resources were shared within communities and the state (Hunter, 1996). Within this system, there were a variety of local traditional practices for sustainable use of natural resources (i.e., gear used, temporal and spatial fishing closures), and rights to fish reefs by locals and outsiders were granted by chiefs and sultans (Hunter, 1996). Due to shifts in the political system and focus on tourism in the Maldives in the 1970s, control of local natural resource management and regulations were centralized by the national government. However, following the passage of the Act of Decentralization of the Administrative Divisions of the Maldives (Law no. 7/2010), which empowers island and atoll councils to adopt their own regulations and policies, there has been a focus on decentralized governance in natural resource management (Hunter, 1996; Ministry of Fisheries, Marine Resources and Agriculture, 2020h; Shakeel, n.d.; Techera & Cannell-Lunn, 2019).

The main national fisheries laws/regulations relevant to the Maldives' fisheries are:

- Fisheries Act of the Maldives (Law No. 14/2019), which repeals the 1987 law and effectively ensures proper management and regulation of fishing activities in the Maldives' EEZ. This law covers a variety of aspects of fisheries within the Maldives from the development and implementation of fisheries management plans to the requirements and terms-and-conditions for licensing, and regulations for fishing activity within and outside of the EEZ.
- Maldives General Fisheries Regulations (2020/R-75), which provides specific rules related to the Maldives' marine fisheries. These include a wide breadth of regulations, including those relating to inshore fishing within island lagoons, FADs, fisheries observers, and determination of protected species, among others.

In this section, we outline the programs and measures administered by the Maldivian government that pertain to data collection, supply chain transparency, and the post-harvest sector, particularly for tuna and billfishes.

Catch enhancement programs

The Maldivian government has installed, and maintains and manages a network of aFADs to enhance local catch, especially during seasons of poor fishing (Edwards et al., 2020). Only pole-and-line fishing vessels are permitted to fish within 3 nm of FADs and installation or use of other personal or private FADs are prohibited (Ministry of Fisheries, Marine Resources and Agriculture, 2021). A list of current FAD positions is maintained by the Ministry and updated monthly if there are changes to the FAD network. In response to sustainability concerns in the markets about the tuna industry reliance on aFADs, the Maldivian government partnered with the International Pole and Line Foundation (IPNLF) to develop a vessel concept that incorporated bird radar and fish sonar to help identify the location of free-swimming tuna schools. According to Edwards et al. (2020), two pole-and-line vessels have begun using these systems.

Protected species

Shark fishing has been banned in the Maldivian EEZ since 2010. The Tuna Management Plan permits fishermen to land sharks caught dead as bycatch with fins attached, but all sharks (alive and dead) are released or discarded at sea in practice (Ahusan et al., 2020). Turtles and their eggs are protected under a stipulation of the Environment Protection and Preservation Act (4/93) that came into effect in 2016 (Ahusan et al., 2020). Whale sharks and all cetaceans are explicitly protected by the fisheries law in the Maldives (Ahusan et al., 2020). A list of marine species that are protected from being harvested or killed in the maritime zones of the Maldives under the fisheries law is provided in Table 17. In addition to the harvest-banned species, some marine species are prohibited from being exported (Table 18). These include baitfish species, eels, (*Anguilliformes spp.*), pufferfishes (*Tetraodontidae*), oysters (*Pteriidae*), silver-mouthed turban (*Turbo argyrostoma*), and octopus (*Octopoda*), among others.

Table 17. Protected marine species that cannot be harvested or killed in Maldivian waters.

English Name	Scientific Name
1. Cetaceans	Infraorder: Cetacea
2. Berried lobsters	Infraorders: Astacidea and Achelata
3. Lobsters with carapace smaller than 7.6cm in length (length measured from the rear of the eye socket to the rear of the carapace on a line parallel to the centre line of the body shell)	Genus: Panulirus
4. Giant Clam	Genus: Tridacna
5. Sharks	Super order: Selachimorpha
6. Rays	Super order: Batoidea
7. Corals	Phylum: Cnidaria, class: Anthozoa
8. Parrotfishes	Family: Scaridae
9. Napoleon Wrasse	*Cheilinus undulatus*
10. Sea Turtles and their eggs	Superfamily: Chelonioidea
11. Black Coral	Order: Antipatharia
12. Whalesharks	Family: Rhinocodontidae
13. Triton Conch	*Charonia tritonis*

Table 18. Marine species that are prohibited from export in the Maldives, in addition to the harvest-banned species listed above, which are also export-banned.

English Name	Scientific Name
1. Lobster and lobster meat	Infraorders: Astacidea and Achelata
2. Top shells/ Trochus shells	Fenus: Trochus
3. Corals and sea anemones	Phylum: Cnidaria, class: Anthozoa
4. Eel	Order: Anguilliformes
5. Pufferfish	Family: Tetraodontidae
6. Oysters	Family: Pteriidae
7. All types of fish used as bait in fishing	
(a) Silver Sprat	*Spratelloides gracilisi*
(b) Blue Sprat	*Spratelloides delicatulus*
(c) Cardinal fishes	Apogonidae
(d) Anchovy	*Encrasicholina heteroloba*
(e) Fusiliers	Caesionidae
(f) Bigeye Scad	*Selar crumenophthalmus*
(g) Chromis	*Chromis sp*
8. Big Shells	
(a) Chiragra spider conch	*Harpago chiragra*
(b) Spider conch	*Lambis lambis*
9. Silver-mouthed turban	*Turbo agyrostomas*
10. Octopus	Order: Octopoda

Data collection programs

Data on the tuna fishery have been collected since 1959 in the Maldives with vessel-specific catch and effort data available back to 1995 (Ahusan et al., 2020). Mandatory fisheries logbooks were introduced in 2010 to improve data reporting and collection partially in response to new requirements set forth by a European Union regulation to prohibit the trade of illegal, unreported, and unregulated (IUU) fishing products (Edwards et al., 2020). Furthermore, the logbook data collection program includes spatial data reporting requirements that adhere to IOTC standards (Ahusan et al., 2020).

The government introduced a web-enabled fishery information system, "Keyolhu", in 2016 to help capture and analyze all fishery data (Ahusan et al., 2020; Edwards et al., 2020). In addition to being an improved fisheries database, Keyolhu includes functionality to issue vessel and processing licenses, track fish purchases, and issue catch verification certificates that must accompany all fisheries exports (Ahusan et al., 2020).

Satellite-based vessel monitoring systems (VMS) are mandatory for all Maldivian longline vessels and are also implemented on some pole-and-line and handline vessels (Ahusan et al., 2020). At the time of reporting for the 2020 national report to the IOTC, 121 vessels were outfitted with VMS technology. By the end of 2021, all tuna vessels are expected to be outfitted with a revamped VMS

pursuant to IOTC Resolution 15/03 "On establishing a vessel monitoring system (VMS)" (Ahusan et al., 2020).

The National Observer Program was established in 2015 but was suspended due to issues with cost and high staff turnover (Ahusan et al., 2020). A bycatch sampling program supported by the MMRI and the IPNLF collects bycatch information to adhere to IOTC reporting requirements, but it is not able to place observers on a sufficient number of fishing trips to meet minimum coverage requirements per the IOTC (Ahusan et al., 2020). In response to the logistical and financial difficulties of placing human observers aboard fishing vessels, a World Bank funded project has begun installing electronic monitoring (EM) systems on Maldivian vessels. Fourteen vessels have been equipped with EM technology, enabling the Maldives to satisfy the minimum 5% IOTC coverage threshold once the EM data collection begins (Ahusan et al., 2020).

A comprehensive port-sampling system to monitor artisanal landings and length frequency is not in place but size sampling of catch takes place at three of the primary ports where pole-and-line tuna is landed (Ahusan et al., 2020). Additionally, a new update to the commercial processing license mandates that all facilities processing fish for the export market must record length frequency data to help meet IOTC reporting requirements (Ahusan et al., 2020).

Transshipment

Transshipment at sea is prohibited within the Maldivian EEZ and Maldivian-flagged vessels do not transship catch within the IOTC operating area (Ahusan et al., 2020).

Transparency and catch certification

Each tuna product to be exported must be accompanied by a catch certificate issued by the Ministry, which can now be expedited via Keyolhu (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Furthermore, Keyolhu functions as an online transparency tool and allows EU authorities to verify catch certificates directly (Edwards et al., 2020).

Price control measures

The price of skipjack tuna exports from the Maldives is set by MIFCO relative to the international price of skipjack tuna landed in Bangkok (Edwards et al., 2020). A constant price premium that is not affiliated with any certification program is added on top of the variable Bangkok price (Edwards et al., 2020). The government also provides loans and grants to the state-owned processing facilities to ensure steady demand and stable income to the pole-and-line vessels supplying the export markets (Edwards et al., 2020). Additionally, the government dictates the minimum price of tuna supplied to the domestic market pursuant to the Regulation on Minimum Price for Sales and Purchase of Fish (2020/R-93).

Subsidies

The government provides subsidies to Maldivian fishers in the form of duty exemptions on the purchase of fuel. Total fuel subsidies amounted to US$6.5 million in 2013 (Hohne-Sparborth et al., 2015). The subsidy program is administered through a recently released mobile app, Fahi Hakatha, to ease fishers in making their claims (Government of Maldives, 2019). In addition to fuel subsidies, the government also provides loans to small-to-medium enterprises (SMEs) in the fisheries sector (Government of Maldives, 2019).

Management plans

Management plans for the tuna, billfish, and diamondback squid fisheries were drafted in 2020 by MoFMRA and set to be reviewed at different yearly intervals depending on the fishery: tuna (3), billfish (5), or diamondback squid (6). MoFMRA developed fisheries management plans in 2020-2021 for all commercial fisheries, including grouper, sea cucumber, marine aquarium fish, lobster, and general reef fish. These management plans and their associated regulations are currently being gazetted. The plans for all fisheries share a similar set of overall objectives which can be generalized as:

1. Ensure that the harvesting, processing, and trading of target species is carried out through the application of principles

of sustainability, ecosystem-based management, and the Precautionary Approach
2. Prioritize evidence-based policymaking through the collection of biological and socio-economic data on the fishery and associated resources
3. Implement a Monitoring, Control, and Surveillance (MCS) mechanism and strengthen data collection and data reporting mechanism for the fishery and trade
4. Ensure equitable benefits to all Maldivians and improve their livelihoods through decentralized development of the fishery and trade
5. Increase education and awareness on billfish and associated resources amongst stakeholders and the general public

A synthesis of key components of these management plans can be found below in Table 20.

Tuna and livebait fisheries

Spatial closures

Any form of tuna fishing is prohibited in the following areas (Ministry of Fisheries, Marine Resources and Agriculture, 2020h):

- Grouper spawning aggregation sites as outlined by the Grouper Management Plan
- MPAs as designated under the Environmental Act 4/93
- Within the spatial jurisdiction of resorts as per the Resort Boundary Regulation 2012/R-7
- Within 3 miles of a FAD unless fishing for tuna with pole-and-line gear
- Within one mile of a data buoy
- Additionally, longline fishing is prohibited within 100 nm of shore according to The Longline Fishery Regulation of 2014 (No. 2014/R-388)

Licensing

All commercial tuna vessels are required to procure a fishing license to operate within the Maldivian EEZ (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Foreign fishing vessels are not issued fishing licenses and are not permitted to fish within the EEZ (Chapter 6 Section 36 of the Fisheries Act) (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). All vessels licensed for pole-and-line fishing are also permitted to be licensed for handline fishing (Edwards et al., 2020). Additional restrictions are placed upon vessels obtaining a longline fishing license including: a requirement to use VMS and logbooks, the installation of an electronic monitoring system (more details below), and an obligation to purchase an Individual Transferable Quota (ITQ) of the minimum amount specified in the Tuna Fisheries Management Plan (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Longline vessels are the only Maldivian vessels permitted beyond the EEZ on the high seas, but must fish outside of 100 nm when within the EEZ (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). The license fee and duration for the different types of tuna fishing are described below in Table 19.

Quotas

Prior to the suspension of the longline fleet, a national ITQ system was in place for the domestic longline fishery (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Vessels were required to purchase a minimum annual quota for bigeye tuna to participate in the fishery that varies with their gross tonnage and unused quota was not rolled over to the following year (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Each year the quota system was active, MoFMRA set a total allowable catch (TAC) based upon the Longline Development Plan submitted to the IOTC (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). When quota demand was greater than the TAC, an ITQ auction was held with a minimum price of US$250 per 5 mt (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). No vessel or fishing company was allowed to bid for more than 15% of the initial total ITQ (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). While catch of all species was counted against the quota amount, a minimum 60% of the catch was mandated to be bigeye tuna (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). Quotas were allowed to be traded with the authorization of MoFMRA, and 15% of the sale revenue was debited

Table 19. Licensing types, durations and fees for different types of tuna fishing (Ministry of Fisheries, Marine Resources, and Agriculture, unpublished).

License type	Duration (Months)	Fee (MVR)	
		<15m LOA	>15m LOA
Pole-and-line tuna fishing only	12	500	1500
Handline tuna fishing only	12	500	1500
Dual pole-and-line and handline tuna fishing	12	1000	2000
Trolling vessels that sell their catch to exporters/export markets	24	250	500
Tuna fishing vessels that sell their catch to the domestic market (including trolling vessels)	24	250	500

to the Maldivian Government (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Bycatch reduction

The Tuna Management Plan sets forth measures to reduce the unintended catch of different groups of bycatch and non-target species by longline fishing vessels, summarized below:

Sharks and sea turtles: Longlines must be set at least 60 feet below the surface at minimum. All living sharks and sea turtles must be released without additional harm. Vessels are mandated to carry line cutters and de-hookers to facilitate this process. If sharks are dead upon retrieval of the longline, they must be landed whole with fins attached and declared to a fisheries ranger or an observer of the Ministry. Any interaction with sea turtles or sharks must be recorded in the logbooks and reported.

Seabirds: Longline vessels must employ at least one of the following measures adopted from IOTC Resolution 12/06 to reduce the bycatch of seabirds: 1) deploying longline sets at night with minimal deck lighting, 2) employing bird-scaring lines with conspicuous streamers, and/or 3) using line weighting techniques.

Marine mammals: Offal must be discarded away from active fishing in time and/or space to reduce the attraction of marine mammals to fishing gear. Any marine mammal or ETP caught incidentally must be released immediately while minimizing additional harm and all interactions with such species must be recorded in the logbook.

Labor

Only two foreign nationals are allowed to work aboard a pole-and-line or handline vessel at a time and are limited to such jobs as housekeeping, cook, or security (Ministry of Fisheries, Marine Resources and Agriculture, 2020h). All crew members on longline fishing vessels must be Maldivian with the exception of a trained captain, engineer, or master and trolling vessels are not permitted to carry any foreign nationals as crew (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Monitoring, control, and surveillance

All commercial tuna fishing vessels are required to maintain standardized fisheries logbooks. In response to issues with compliance, as of March 2019 it is mandatory to submit completed logbook data to purchasing or processing facilities prior to landing the catch (Ahusan et al., 2020). Additionally, all commercial tuna vessels greater than 24 m in length are required to have operational VMS technology onboard and active at all times (Ministry of Fisheries, Marine Resources and Agriculture, 2020h).

Proposed management of the livebait fishery

The livebait fishery of the Maldives has a long history of limited regulation (Gillett et al., 2013). The Tourism Act of 2012 placed several restrictions upon baitfishing activities, but these were motivated by the protection of tourism and local consumption and not directed at ensuring sustainable fishing practices within the fishery itself (Gillett et al., 2013). Other spatial restrictions are enforced as part of other management measures; the Tourism Act requires divers to avoid areas where fishers are engaged in baitfishing, and the President's Office Decree in 1990 banned coral mining on major baitfishing reefs (Gillett et al., 2013), though coral mining is now banned throughout the country. In addition, the export of livebait species has been banned since 1993 (Gillett et al., 2013).

A management plan for the livebait fishery was proposed in 2013 in response to the limited history of regulation within the fishery, the unknown status of livebait stocks, and the lack of awareness for the benefits of management in the face of the commonly-held perception of a limitless livebait resource. It was developed to build awareness among fishers of the benefits of regulation, despite limited resources available to support monitoring and enforcement (Gillett et al., 2013). This management plan was not formally drafted into a specific regulation, although some of the proposed management measures have been implemented across various regulations. The Plan is currently being reviewed and revised as per the new Fisheries Act of the Maldives.

There are six main objectives for management within the fishery, two of which are considered the highest priority (Gillett et al., 2013).

1. Protect livebait resources to assure their continued availability for the pole-and-line fishery and reduce the risk of depletion (highest priority).
2. Create an awareness among bait fisheries of the need for and benefits of fisheries management (highest priority).
3. Reduce negative reactions between the fishery and tourism.
4. Reduce livebait waste during fishing operations.
5. Reduce negative impacts of baitfishing on the ecosystem and physical environment.
6. Reduce negative impacts of baitfishing on endangered, threatened, or protected species.

To meet the objectives of the 2013 Management Plan, several management measures were proposed and can be categorized into the following groups: spatial management, gear restrictions, data collection, and market bans. There is no indication that these measures have yet been implemented or are currently enforced:

- *Spatial management:* expansion of no baitfishing zones around resorts to 1500m, prohibition of baitfishing within established dive sites and MPAs, temporary closures of atolls to baitfishing
- *Gear restrictions:* requiring MMRI approval of new gear types (e.g. purse seines, beach seines), empowering local authorities to impose restrictions on number/intensity of light attractants, net sizes, the use of scuba gear, and livebait-related activities that have been shown to damage coral reefs
- *Data collection:* development of an improved monitoring strategy to collect data on a haul-by-haul basis at the atoll level to meet the data requirements that allow for annual reporting and incorporating on-board observer programs to collect bycatch data
- *Market bans:* ban on the sale of livebait species for food

Billfish and diamondback squid fisheries

The management plans for the billfish and diamondback squid fisheries share many similar stipulations with the exception of the size limits imposed on vessels targeting billfishes. As such, the primary management measures contained in both are discussed generally below.

Licensing

All commercial fishing vessels targeting billfish or diamondback squid will be required to procure a fishing license once the relevant regulations for each fishery come into effect (Ministry of Fisheries, Marine Resources and Agriculture, 2020a, 2020b).

Monitoring

Licensed billfish and diamondback fishing vessels must maintain up-to-date logbooks which detail important fishery statistics such as catch composition, spatial fishing effort, and fuel usage (Ministry of Fisheries, Marine Resources and Agriculture, 2020a, 2020b). Furthermore, the catch certification process (described above in the "National" management section) will be expanded to include all billfish and diamondback squid export products (Ministry of Fisheries, Marine Resources and Agriculture, 2020a).

Size limits (Billfish Management Plan only)

In accordance with IOTC CMM 18/05, the retention of a billfish individual of any species that has a Lower Jaw Fork Length (Figure 25) < 60 cm is prohibited (Ministry of Fisheries, Marine Resources and Agriculture, 2020a).

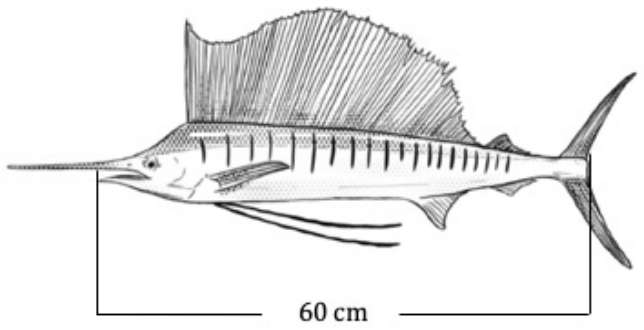

Figure 25. A visual guide to the measurement of lower jaw fork length from the Ministry of Fisheries, Marine Resources, and Agriculture (2020a).

Precautionary measures

The management plans highlight several other management measures that are not currently in place, but which could be implemented in the future to ensure the sustainability of the offshore stocks. They include spatial closures, species bans, adjusting size limits, and implementing catch or export quotas (Ministry of Fisheries, Marine Resources and Agriculture, 2020a, 2020b).

Sea cucumber, general reef fish, lobster, grouper, and marine aquarium fisheries

Generally, the fishery management plans call for similar management measures across the sea cucumber, reef fish, lobster, grouper, and marine aquarium fisheries (Ministry of Fisheries, Marine Resources and Agriculture, 2020g, 2020f, 2020d, 2020c, 2020e). These management measures include:

Advisory Council

An Advisory Council, composed of different stakeholders (fishers, the government, industry, research/science and NGO representatives), will be established for each fishery and meet annually. Their primary goals are to monitor the implementation of the respective fishery's management plan, review reports related to the fishery, and advise on management measures and implementation and review of the fishery management plan.

Licensing

Across all fisheries, licenses are required by all commercial fishing vessels operating within the respective fishery. Licenses are required for all commercial parties involved in processing of sea cucumber, grouper, and reef fish species, and third-party traders that are involved in the export and reselling of reef fish and grouper. The Ministry will maintain a database of license holders.

Data collection and management

The Maldivian government will establish an integrated data collection system with information from licensed fishing vessels, processing facilities/processors, third party traders, and exporting parties. Licensed vessels are required to report catch composition, fuel usage, fishing location, and other trip details for each individual fishing trip in logbooks. When applicable, fishery-associated processors, exporters and third-party traders are required to submit purchase reports for fishery products.

Precautionary measures

The Ministry may implement the following measures to protect the fishery stock: establish no-take zones/area closures, prohibit the capture, processing and exporting of specific species within a fishery, implement harvest/export size requirements for specific species within a fishery, implement species specific catch/export quotas, and impose other restrictions on activities that

may affect the health of fishery stocks.

Catch certification

In hopes of better regulating the fishing and improving catch traceability within each fishery in the Maldives, the Ministry is establishing a catch certification scheme for the sea cucumber and general reef fisheries. This scheme will require the inclusion of all commercial fisheries exports, excluding lobster, which is export-banned, and require that a catch certificate be submitted for any exported products. These catch certificates will include details on the fishing vessel, date of catch, as well as information on the processing facility in order to ensure product traceability and in accordance with applicable laws and regulations.

Table 20. Summary of key management measures instituted through the fisheries management plans and associated regulations. Additional information about these measures can be found in the relevant fishery management plan.

Management Plan	Review period	Licensing	Harvest restrictions	Quotas	Gear restrictions[1]	Spatial or temporal closures
Tuna fisheries	3 years	Required for: • All commercial fishing vessels targeting tuna • All commercial tuna processing facilities • All commercial fishery related activities	Regulated pursuant to IOTC resolutions	Yes, ITQ system in place for longline fishery and yellowfin tuna fishery	Longline fishing was halted in 2019	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear 1 nm of data buoy
Billfish fishery	5 years	Required for: • All commercial fishing vessels • All commercial parties that perform any form of processing of billfish	Size limits: Minimum lower jaw fork length (60 cm) set for all billfish species	No, but the Ministry may establish a catch/export quota to protect and manage the stock if necessary.	None	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear 1 nm of data buoy

[1] In addition to measures established in the Fisheries Act of the Maldives.

Table 20 continued.

Management Plan	Review period	Licensing	Harvest restrictions	Quotas	Gear restrictions[1]	Spatial or temporal closures
Diamondback squid fishery	6 years	Required for: • All commercial fishing vessels • All commercial parties that perform any form of processing of DBS	None	Yes, a total of only 30 licenses will be issued at a given time.	None	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear 1 nm of data buoy
General reef fishery	3 years	Required for: • All commercial fishing vessels • All parties exporting and reselling to resorts as a third-party trader • All commercial parties involved in fish processing	Forbidden to: • Harvest, trade, import or export parrotfishes, giant clams, and Napoleon wrasses • Export all lobster, Trochus sea snails, corals, anemones, all baitfish, eels, big shells (Chiargra spider conch; spider conch), silver-mouth turban, pufferfishes, oysters, and octopus	No, the Ministry may establish a quota and quota system to protect and manage stocks	Use of nets, spear guns, and other trigger-operated gears is prohibited. All new types of fishing gear require authorization from the Ministry before use.	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear 1 nm of data buoy
Lobster fishery	6 years	Required for: • All commercial fishing vessels	Size limits: Minimum carapace length (7.6 cm) set for the following lobster species: • *P. japonicus* • *P. longipes* • *P. ornatus* • *P. penicillatus* • *P. polyphagus* • *P. versicolor* Forbidden to: • Harvest berried lobsters • Export all species of lobsters	No, the Ministry may establish a quota and quota system for specific species if there is a risk of overfishing.	Prohibited to use SCUBA	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear 1 nm of data buoy

[1] In addition to measures established in the Fisheries Act of the Maldives.

Table 20 continued.

Management Plan	Review period	Licensing	Harvest restrictions	Quotas	Gear restrictions[1]	Spatial or temporal closures
Marine aquarium fishery	5 years	Required for: • All commercial fishing vessels • All commercial holding facilities	None	Yes, total allowable export quotas are to be set for all marine aquarium fishery species exported, and allocated amongst exporting parties.	Use of moxy nets is prohibited.	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear, 300 meters of a FAD regardless of gear 1 nm of data buoy
Sea cucumber fishery	4 years	Required for: • All commercial fishing vessels • All parties involved in the processing of sea cucumbers	None, but the Ministry may implement size limits/requirements for export and harvest.	No, the Ministry may establish total allowable catch/export quotas and a quota system for specific sea cucumber species.	Prohibit-ed to use SCUBA	Fishing is prohibited within: Grouper spawning aggregation sites MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear, 300 meters of a FAD regardless of gear 1 nm of data buoy

[1] In addition to measures established in the Fisheries Act of the Maldives.

Table 20 continued.

Management Plan	Review period	Licensing	Harvest restrictions	Quotas	Gear restrictions[1]	Spatial or temporal closures
Grouper fishery	5 years	Required for: • All commercial fishing vessels • All middle men trading grouper species to exporters or markets • All commercial grouper processing facilities	Size limits: Minimum harvest and export size limits have been established for select grouper species; see Appendix Table E5	No, the Ministry may establish total allowable export or catch quotas and a quota system for specific grouper species.	Use of SCUBA gear and gaffs in association with lights to target groupers is prohibited. Spearfishing and the use of gaffs to target grouper spawning aggregations is prohibited. Fishing within 300 meters around FADs is prohibited.	5 spawning aggregation sites will continue to be protected from all activities for an additional 10 years as of 2020. Sites are rotated after 5 years. Fishing within these sites is prohibited. Fishing is also prohibited within: MPAs Resort boundaries 3 nm of a FAD unless fishing with pole-and-line gear, 300 meters of a FAD regardless of gear

[1] In addition to measures established in the Fisheries Act of the Maldives.

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Appendix

A. Data availability

Appendix Table A1. A non-exhaustive list of relevant fishery independent data sources found for Maldives fisheries. Information about the organization, dataset, and public availability (***X*** not publicly available; ✓ publicly available; ~ some data are publicly available to view or download) of datasets found in the Maldives using a web search.

Organization	Description	Dataset Type	Dataset Name	Data Description	Public Download
Indian Ocean Tuna Commission (IOTC)	An intergovernmental organization responsible for the management of tuna and tuna-like species in the Indian Ocean	Ecological Indicators	Fisher-reported catch data	Stock assessments and monitoring of tuna stocks in the Indian Ocean	✓
100 Island Challenge + Blue Prosperity Coalition	A collaboration between the 100 Island Challenge, based at Scripps Institution of Oceanography and the Blue Prosperity Coalition to describe the variation in coral reefs across the globe	Ecological Indicators	Fish Biomass Data	Data collected from surveys during a reef assessment expedition in Jan 2020 on the western side of the northern and central atolls. Data include the biomass of target species, biomass by site, biomass by trophic level, and layers of human activity and use of marine areas	***X***
Coral Database	A part of the National Coral Reef Monitoring Framework in the Maldives	Ecological Indicators	Coral Database	Theoretically has 15 permanent sites of 5 atolls to monitor reef fish populations via ReefCheck Monitors	~
Maldives Marine Research Institute	Research division of the Ministry of Fisheries and Agriculture	Ecological Indicators	Fish Surveys	MMRI, in combination with the World Bank, has conducted several in-water surveys to monitor two grouper aggregation sites. Data is still being collected but will be available once analysis and reporting is complete	~
		Ecological Indicators	Fish Surveys	MMRI, as part of the Bay of Bengal Large Marine Ecosystem Project, Exploratory and baseline assessment surveys at protected grouper aggregation sites in 2013	✓

Appendix Table A1 continued.

Organization	Description	Dataset Type	Dataset Name	Data Description	Public Download
Darwin Reef Fish Project	Funded by the UK Darwin Initiative and organized by the Marine Conservation Society to establish a long-term monitoring and evaluation program for the development of a management plan for Maldives coral reef fisheries in 2009-2013	Ecological Indicators	Fish Surveys	Timed swim surveys for fishes and sharks as part of the Fishwatch and Sharkwatch programs	*X*
Maldives Marine Science Symposium	Presentations of emerging science in the Maldives	Unknown	Unknown	Although the topics presented in the Symposium are unknown, the data that are presented are available to participants at the Symposium or are publicly accessible when the data are published in marine or fisheries journals	~
Maldives Underwater Initiative	Marine conservation team at the Six Senses Laamu in collaboration with the Blue Marine Foundation	Reef Health	Coral Reef Ecology	Bi-annual surveys of reefs around Six Senses Laamu as part of the nation-wide study launched by the Maldives government	*X*
		Reef Health	Seagrass Conserva-tion	Yearly seagrass surveys using methods from the Maldives National Seagrass Monitoring Network Protocol, including quadrat data that include depth, seagrass cover, seagrass species composition, canopy height, algae cover, epiphyte prevalence, sediment type, and photo data	*X*
		Reef Health / Fish Surveys	Mangrove Forests	Characterization of the mangrove forests on Laamu Atoll, including the mangrove species and local fish communities	*X*
ReefCheck Maldives	Marine volunteering expeditions across the Maldives. Data housed in Global Reef Tracker	Ecological Indicators	Fish Surveys	Survey data for 373 fish surveys between 1997-2019, accounting for Haemulidae, Groupers, *Cheilinus undulatus*, Lutjanidae, Scaridae, Chaetodontidae, Palinuridae, Gorgonacea, hard/ soft corals, urchans, whale sharks (not species specific)	✓

Appendix Table A2. A non-exhaustive list of relevant fishery dependent data sources found for Maldives fisheries. Information about the organization, dataset, and public availability (***X*** not publicly available; ✓ publicly available; **~** some data are publicly available to view or download) of datasets found in the Maldives using a web search.

Organization	Description	Dataset Type	Dataset Name	Data Description	Public Download
Darwin Reef Fish Project	Funded by the UK Darwin Initiative and organized by the Marine Conservation Society to establish a long-term monitoring and evaluation program for the development of a management plan for Maldives coral reef fisheries in 2009-2013	Catch and Effort Statistics	Vessel Information and Effort	Field officers collected data on fishing vessels and crew, the time spent for each activity (bait collection, fishing), the locations of bait hauling and fishing, the gear and bait used, the sale of catch, the catch composition and site-specific size composition of catch to the family level across 12 islands and 10 atolls	***X***
		Purchase and Consumption Statistics	Resort-Reported Purchase Data	Resort-reported collection of fish and lobster purchases (numbers and weights of key species), collection of size sampling data for reef fish or lobster (1 consignment per week for reef fish for catering and all consignments for lobsters) in 2013	***X***
		Catch and Effort Statistics	Recreational Fishing Catch	Catch and size composition for night fishing trips at 7 resorts	***X***
		Purchase and Consumption Statistics	Household Reef Consumption Surveys	Surveys sent to secondary schools in Atoll Education Centers and Malé to understand the impact that household consumption has on fisheries resources	***X***
		Fisher Consultations	Fisher Consultations	Consultations with reef fishermen from 16 islands in 10 atolls	***X***
		Catch and Effort Statistics	Online Logbook System	Electronic logbooks were trialed by the end of the project that should require fishers to record catch by species and location to the Fisheries Management Agency; fishers were also required to submit a validation request to the Fisheries Management Agency to check exports against recorded check	***X***
Maldives Custom Services	Provides customs statistics in the Maldives	Export Data	Export Data	Country-specific export data for all fisheries available from the mid-1990s onward, including the export for pelagic species by export type (prepared/preserved, canned, dried, salted, frozen, fresh/chilled)	✓

Appendix Table A2 continued.

Organization	Description	Dataset Type	Dataset Name	Data Description	Public Download
Maldives Government		Fisher Information	Licensed Fishing Vessel List	Lists of fishing vessels that have been registered (English)	✓
		Fisher Information	FAD's Position List	List of locations of FADs (Dhivehi)	✓
		Fisher Information	Weekly Fisheries Price Information	Infographic with prices of fish for that week (Dhivehi)	✓
		Fisher Information	Fishermen's Forum Report	Report that includes presentation notes and notes from working sessions with fishers, but is not always in English	✓
		Catch and Effort Statistics	Fishery logbook data	The logbooks and the subsequent revisions expanded on the information collected in the previous data collection system; from vessel specific monthly data of catch and effort and the resulting catch of target and non-target species, to trip level catch and effort information relating to bait, target catch, bycatch and discards. Catch data available upon written request to the Ministry, some data available on the Ministry's website or on the Statistical Yearbook of the Maldives	~
		Catch and Effort Statistics	Fishery observer data	Anhusan et al. 2019 indicates that the observer program/ coverage might be fairly limited in Maldives at present. Would be good to follow up with Maldivian Govt. to ascertain potential value of this dataset	***X***
		Catch and Effort Statistics	Purchase Reports	Licensed collectors and holding facilities for Marine Aquarium species are required to submit purchase reports to the Ministry of Fisheries monthly.	***X***

Appendix Table A2 continued.

Organization	Description	Dataset Type	Dataset Name	Data Description	Public Download
Maldives Marine Research Institute	Research division of the Ministry of Fisheries and Agriculture	Mapping	Grouper Fisheries Management	MMRI, in collaboration with the Blue Marine Foundation, surveyed 100 fishers to identify areas for grouper protection	X
		Ecological Indicators	Grouper Measurements	MMRI, in collaboration with the Blue Marine Foundation, measured camouflage grouper (*Epinephelus polyphekadion*) and squaretail coral grouper (*Plectropomus areolatus*) to validate size at maturity	X
		Ecological Indicators	Grouper Maturity	Through the Sustainable Fisheries Resource Development project, maturity studies for four grouper species are complete and six are underway	~
Maldives Marine Science Symposium	Presentations of emerging science in the Maldives	Unknown	Unknown	Although the topics presented in the Symposium are unknown, the data that are presented are available to participants at the Symposium or are publicly accessible when the data are published in marine or fisheries journals	~
Maldives Underwater Initiative	Marine conservation team at the Six Senses Laamu in collaboration with the Blue Marine Foundation	Catch and Effort Statistics	Fisheries Management	Records of catch from 9 fishers who have signed up for a fisher code of conduct; must fish with only handlines and target mature semi-pelagic and pelagic species	X
Various - Scientific Publication	Chang, S. (2020). Exploring the Spatial Relationships between Resorts and Reef Fish in the Maldives (p. 28) [Final Capstone Report]. Scripps Institution of Oceanography, University of California, San Diego. https://escholarship.org/uc/item/78k2r4s4	Catch and Effort Statistics	Landing Site Surveys	Reef fish that were brought to landing sites were recorded (does not include catch sold directly to resorts)	X
Various - Scientific Publication	Sattar, S. A., Amir, H., & Adam, M. S. (2012). Reef Fish Tagging Programme-Baa Atoll Pilot Project. Atoll Research Bulletin.	Ecological Indicators	Reef Fish Tagging Program	Baa Atoll pilot project in 2008-2009 that used tag-recapture methods for fish caught during commercial fishing trips	X

B. Tuna species

Appendix Table B2. Species fished in the Maldives tuna fishery as indicated by the Maldives Tuna Fishery Management Plan. IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
Auxis thazard	frigate tuna	LC (2010)	27.83	Medium
Euthynnus affinis	kawakawa	LC (2009)	37.34	Medium
Katsuwonus pelamis	skipjack tuna	LC (2010)	38.12	Medium
Thunnus albacares	yellowfin tuna	NT (2011)	50.67	Medium
Thunnus obesus	bigeye tuna	VU (2011)	55.53	Medium

C. Billfish species

Appendix Table C3. Species found in the Maldives billfish fishery as indicated by the Maldives Billfish Fishery Management Plan. IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
Istiophorus platypterus	Indo-Pacific sailfish	LC (2010)	67.65	Low
Xiphias gladius	swordfish	EN (1996)	71.96	Medium
Makaira indica	black marlin	DD (2009)	78.22	Medium
Makaira mazara	Indo-Pacific blue marlin	N.E.	70.43	Low
Tetrapturus audax	striped marlin	NT (2011)	43.35	Low

D. Livebait species

Appendix Table D4. Species commonly fished in the Maldives livebait fishery as indicated by the Maldives Livebait Fisheries Management Plan and/or personal communication from the Ministry of Fisheries, Marine Resources, and Agriculture. Species provided by MoFMRA but not explicitly listed in the Fisheries Management Plan are indicated with an asterisk. IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
*Chromis viridis**	blue-green damselfish	N.E.	20.93	High
*Decapterus macarellus**	mackerel scad	LC (2012)	19.87	High
Encrasicholina heteroloba	shorthead anchovy	LC (2017)	10	High
*Lepidozygus tapeinosoma**	fusilier damselfish	N.E.	21.88	High
*Odonus niger**	red-toothed triggerfish	N.E.	37.89	Medium
*Selar crumenophthalmus**	bigeye scad	LC (2013)	39.44	High
Spratelloides delicatulus	blue sprat	LC (2017)	10	High
Spratelloides gracilis	silver sprat	LC (2017)	10	High
*Atherinidae**	silversides			
Apogonidae	cardinalfishes			
Caesionidae	fusiliers			

E. Grouper species

Appendix Table E5. Grouper species recorded in the Maldives as indicated by the Maldives Grouper Fishery Management Plan. IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible. Fresh/chilled and live export rates from 2010 were reported by Sattar et al. (2011).

Species Scientific Name	Species Common Name	IUCN Listing (Year Assessed)	Vulnerability	Resilience	Minimum Size Limits (cm)	Fresh/Chilled Export Rate (MVR per individual)	Live Export Rate (MVR per individual)
Aethaloperca rogaa	redmouth grouper	LC (2016)	48.76	Medium	20	28.5	
Anyperodon leucogrammicus	slender grouper	LC (2016)	52.18	Low	25	24.2	
Cephalopholis argus	peacock hind	LC (2017)	48.76	Medium	20	40.7	
Cephalopholis aurantia	golden hind	LC (2016)	48.76	Medium	20		
Cephalopholis boenak	chocolate hind	LC (2016)	31.04	Medium			
Cephalopholis leopardus	leopard hind	LC (2017)	28.08	High	20		
Cephalopholis miniata	coral hind	LC (2017)	65.12	Low	20	24.6	
Cephalopholis nigripinnis	blackfin grouper	LC (2018)	30.82	Medium			
Cephalopholis polleni	harlequin hind	LC (2018)	37.06	Medium			
Cephalopholis sexmaculata	sixblotch hind	LC (2017)	33.23	Medium	20		
Cephalopholis sonnerati	tomato hind	LC (2017)	46.24	Medium	20		
Cephalopholis spiloparaea	strawberry hind	LC (2017)	29.46	Medium	20		
Cephalopholis urodeta	darkfin hind	LC (2016)	13.87	High	20		
Epinephelus areolatus	areolate grouper	LC (2016)	35.95	Low		23.9	
Epinephelus chlorostigma	brownspotted grouper	LC (2016)	37.9	Low			
Epinephelus coeruleopunctatus	whitespotted grouper	LC (2016)	55.67	Low	25		
Epinephelus fasciatus	blacktip grouper	LC (2016)	53.43	Low	25	81	

Appendix Table E5 continued.

Species Scientific Name	Species Common Name	IUCN Listing (Year Assessed)	Vulnerability	Resilience	Minimum Size Limits (cm)	Fresh/Chilled Export Rate (MVR per individual)	Live Export Rate (MVR per individual)
Epinephelus flavocaeruleus	blue-and-yellow grouper	LC (2016)	58.18	Low	30	48.5	
Epinephelus fuscoguttatus	brown-marbled grouper	VU (2016)	57.09	Medium	25-45, 60	25.7	94.5
Epinephelus lanceolatus	giant grouper	DD (2016)	85.41	Very low		747.9	
Epinephelus longispinis	longspine grouper	LC (2016)	44.06	Medium			
Epinephelus macrospilos	snubnose grouper	LC (2016)	42.43	Medium	25	31.9	77.1
Epinephelus melanostigma	one-blotch grouper	LC (2018)	34.24	Medium			
Epinephelus merra	honeycomb grouper	LC (2017)	28.85	High		9.7	
Epinephelus ongus	white-streaked grouper	LC (2016)	33.34	Medium	20		
Epinephelus miliaris	netfin grouper	LC (2018)	25.05	Medium			
Epinephelus morrhua	comet grouper	LC (2016)	42.81	Medium			
Epinephelus multinotatus	white-blotched grouper	LC (2016)	39.07	Medium			
Epinephelus poecilonotus	dot-dash grouper	LC (2016)	52.18	Low			
Epinephelus polyphekadion	camouflage grouper	VU (2016)	52.06	Medium	40	8.3	
Epinephelus retouti	red-tipped grouper	LC (2017)	40.85	Medium			
Epinephelus spilotoceps	foursaddle grouper	LC (2017)	34.24	Medium	20	36.4	31.4
Epinephelus tauvina	greasy grouper	DD (2016)	59.27	Low			
Epinephelus undulosus	wavy-lined grouper	LC (2016)	69.14	Very Low			
Gracila albomarginata	masked grouper	LC (2016)	35.96	Medium			
Hyporthodus octofasciatus	eightbar grouper	LC (2016)	68.09	Very Low			
Plectropomus areolatus	squaretail coralgrouper	VU (2016)	30.28	Medium	38	56.8	

Appendix Table E5 continued.

Species Scientific Name	Species Common Name	IUCN Listing (Year Assessed)	Vulnerability	Resilience	Minimum Size Limits (cm)	Fresh/Chilled Export Rate (MVR per individual)	Live Export Rate (MVR per individual)
Plectropomus laevis	blacksaddled coralgrouper	LC (2016)	56.09	Medium	25	54.7	80.1
Plectropomus pessuliferus	roving coralgrouper	LC (2016)	61.24	Low	49	45	66.2
Variola albimarginata	white-edged lyretail	LC (2017)	28.91	Low	22	27.5	
Variola louti	yellow-edged lyretail	LC (2016)	48.64	Medium	22	39.8	

F. General reef fish species

Appendix Table F6. Reef fish species commonly found in the Maldives as indicated by the Maldives Reef Fishery Management Plan. Tuna species are removed from this list, as they are listed under Appendix B. IUCN listing, vulnerability, and resilience values were gathered from FishBase, where possible. Species names with asterisks (*) represent species that are currently banned from harvests or exports as indicated in the Maldives Reef Fishery Management Plan.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
Paracaesio sordida	dirty ordure snapper	LC (2015)	35.05	Medium
Paracaesio xanthura	yellowtail blue snapper	LC (2015)	35.55	Medium
Alectis ciliaris	african pompano	LC (2009)	71.04	Low
Carangoides chrysophrys	longnose trevally	LC (2015)	40.62	Medium
Carangoides coeruleopinnatus	coastal trevally	LC (2015)	29.2	High
Carangoides ferdau	blue trevally	LC (2015)	43.95	Medium
Carangoides fulvoguttatus	yellowspotted trevally	LC (2015)	66.28	Low
Carangoides gymnostethus	bludger	LC (2015)	47.39	Medium
Carangoides orthogrammus	island trevally	LC (2015)	39.91	Medium
Carangoides plagiotaenia	barcheek trevally	LC (2015)	32.71	Medium

Appendix Table F6 continued.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
Caranx ignobilis	giant trevally	LC (2015)	82.12	Medium
Caranx lugubris	black jack	LC (2012)	60.08	Low
Caranx melampygus	bluefin trevally	LC (2015)	55.89	Medium
Caranx sexfasciatus	bigeye trevally	LC (2009)	45.19	Medium
Gnathanodon speciosus	golden trevally	LC (2015)	37.51	Medium
*Cheilinus undulatus**	humphead wrasse	EN (2004)	86.18	Low
Aphareus furca	small toothed jobfish	LC (2015)	35.93	Medium
Aphareus rutilans	rusty jobfish	LC (2015)	58.21	Medium
Aprion virescens	green jobfish	LC (2015)	61.35	Medium
Lethrinus conchyliatus	redaxil emperor	LC (2009)	53.23	Low
Lethrinus erythracanthus	orange-spotted emperor	LC (2015)	46.28	Medium
Lethrinus harak	thumbprint emperor	LC (2015)	27.35	Medium
Lethrinus lentjan	pink ear emperor	LC (2015)	24.93	Medium
Lethrinus mahsena	sky emperor	N.E.	64.89	Medium
Lethrinus microdon	smalltooth emperor	LC (2015)	45.71	Medium
Lethrinus nebulosus	spangled emperor	LC (2015)	45.8	Low
Lethrinus obsoletus	orange-striped emperor	LC (2015)	33.45	Low
Lethrinus olivaceus	longface emperor	LC (2015)	39.66	Low
Lethrinus ornatus	ornate grouper	LC (2015)	27.43	High
Lethrinus rubrioperculatus	spotcheek emperor	LC (2015)	31.11	Medium
Lethrinus xanthochilus	yellowlip emperor	LC (2015)	57.48	Low
Lutjanus argentimaculatus	mangrove red snapper	LC (2015)	59.54	Medium
Lutjanus bengalensis	bengal snapper	N.E.	26.59	High
Lutjanus biguttatus	two-spot banded snapper	LC (2015)	24.1	High

Appendix Table F6 continued.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
Lutjanus bohar	two-spot red snapper	LC (2015)	68.83	Medium
Lutjanus decussatus	checkered snapper	LC (2009)	29.47	Medium
Lutjanus ehrenbergii	blackspot snapper	LC (2016)	18.81	High
Lutjanus fulvus	blacktail snapper	LC (2015)	29.2	Medium
Lutjanus gibbus	humpback red snapper	LC (2015)	35.26	Medium
Lutjanus kasmira	common bluestripe snapper	LC (2015)	40.21	Medium
Lutjanus madras	indian snapper	N.E.	26.59	High
Lutjanus monostigma	one-spot snapper	LC (2015)	39.61	Medium
Lutjanus rufolineatus	yellow-lined snapper	LC (2015)	26.59	High
Lutjanus sebae	emperor red snapper	LC (2015)	58.91	Medium
Macolor macularis	midnight snapper	LC (2015)	38.55	Medium
Macolor niger	black and white snapper	LC (2015)	45.54	Medium
Pinjalo lewisi	slender pinjalo	LC (2015)	47.33	Medium
Gnathodentex aureolineatus	striped large-eye bream	LC (2015)	30.1	Medium
Gymnocranius elongatus	forktail large-eye bream	N.E.	32.61	Medium
Gymnocranius grandoculis	blue-lined large-eye bream	LC (2015)	41.78	Medium
Gymnocranius griseus	grey large-eye bream	LC (2015)	37.53	Medium
Monotaxis grandoculis	humpnose big-eye bream	LC (2015)	43.83	Medium
Elagatis bipinnulata	rainbow runner	LC (2012)	50.69	Medium
Seriola rivoliana	longfin yellowtail	LC (2012)	75.78	Very low
Diagramma pictum	painted sweetlips	N.E.	44.59	Medium
Plectorhinchus albovittatus	two-striped sweetlips	N.E.	67.31	Very low

Appendix Table F6 continued.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability	Resilience
Plectorhinchus chaetodonoides	harlequin sweetlips	N.E.	54.35	Low
Plectorhinchus gibbosus	harry hotlips	LC (2011)	45.03	Medium
Plectorhinchus vittatus	indian ocean oriental sweetlips	N.E.	61.28	Low
Scomberoides lysan	doublespotted queenfish	LC (2015)	39.51	Medium
Trachinotus baillonii	small spotted dart	LC (2015)	35.68	Medium
Trachinotus blochii	snubnose pompano	LC (2015)	62.64	Medium
All species belonging to families Sphyraenidae and Belonidae	big eye barracuda, great barracuda and all species of Needlefish			
All species belonging to the family Scaridae*	all species of parrotfish			

G. Marine aquarium fish species

Appendix Table G7. Marine aquarium species commonly exported in the Maldives in 2017 as indicated by the Maldives Marine Aquarium Fishery Management Plan. Please refer to the Marine Aquarium Fishery Management Plan for an extensive list of species and their Total Allowable Export Limits. Habitat and depth estimates were provided by the Maldives Marine Aquarium Fishery Management Plan. IUCN listing, vulnerability, and resilience values were gathered from FishBase and SeaLifeBase, where possible.

Species Scientific Name	Species Common Name	Habitat	Depth (m)	IUCN Listing (Year Assessed)	Vulnerability	Resilience
Acanthurus leucosternon	powderblue surgeonfish	Shallow, clear coastal and island coral reefs, along reef flats and upper seaward slopes	> 25	LC (2010)	37.16	Medium
Zebrasoma velifer	sailfin tang	Lagoons/seaward reefs; juveniles in shallow/sheltered rocks/coral	1-45	LC (2010)	36.94	Medium
Nemanthias carberryi	threadfin anthias	Schooling off outer reef slopes	4-30	LC (2017)	18.38	High
Pseudanthias bimaculatus	two-spot basslet	Deep coastal drop-offs	20-100	LC (2017)	19.81	High
Pseudanthias evansi	yellowback anthias	Schools along outer reef slopes	4-40	LC (2017)	21.31	High
Pseudanthias parvirostris	sunset anthias	Small schools close to the substrate	17-70	LC (2015)	12.93	High
Pseudanthias squamipinnis	sea goldie	Coral outcrops/patch reefs of clear lagoons, channels, out reef slopes	1-40	LC (2015)	22.97	High
Cirrhilabrus exquisitus	exquisite wrasse	Rubble/low patch reefs with current, reef edges around bomboras with rubble zones	2-32	DD (2009)	25.41	High
Cirrhilabrus rubrisquamis	red velvet fairy wrasse	Deep reefs over coral, rubble, sandy substrate	40-50	DD (2009)	15.01	High
Pseudocheilinus hexataenia	sixline wrasse	Seaward reefs over coral branches, dense coral habitats on shallow reef crest or slopes	2-35	LC (2009)	17.67	High

Appendix Table G7 continued.

Species Scientific Name	Species Common Name	Habitat	Depth (m)	IUCN Listing (Year Assessed)	Vulnerability	Resilience
Halichoeres leucoxanthus	canarytop wrasse	Reef edge, sand/ rubble	7-60	LC (2009)	21.39	High
Macropharyn-godon bipartitus	rare wrasse	Lagoons, sand/rubble patches on seaward coral reefs	1-30	LC (2009)	22.77	High
Valenciennea sexguttata	sixspot goby	Sandy areas of lagoons and bays	3-25	N.E.	23.86	High
Naso lituratus	orangespine unicornfish	Benthopelagic above coral/rock/rubble in lagoon/seaward reefs	> 90	LC (2010)	34.14	Medium
Nemateleotris decora	elegant firefish	Sandy burrows over hard, open bottoms at reef base, sand/rubble patches, deep coastal drop-offs with strong currents	25-75	LC (2015)	10	
Nemateleotris magnifica	fire goby	Burrows on the upper outer reef slopes	6-61	LC (2009)	10	
Blenniella chrysospilos	red-spotted blenny	Reef-associated in clear coastal reef flats, surge-swept seaward reefs	> 6	LC (2009)	27.68	High
Ecsenius midas	persian blenny	2-3 m above coral reefs with moderate currents	2-40	LC (2009)	23.67	High
Echinaster sepositus	red starfish	Sheltered/moderately exposed rocky substrate	> 250	N.E.		
Labroides dimidiatus	bluestreak cleaner wrasse	Coral-rich areas of inner lagoons, sub-tidal reef flats to seaward reefs	1-40	LC (2008)	23.67	Medium

H. Sea cucumber species

Appendix Table H8. Species commonly fished in the Maldives sea cucumber fishery as indicated by the Maldives Sea Cucumber Fisheries Management Plan. IUCN listing and vulnerability values were gathered from FishBase and SeaLifeBase, where possible. Resilience values were unable to be collected.

Species Scientific Name	Species Common Name	IUCN Listing	Vulnerability
Actinopyga caerulea	blue sea cucumber	DD (2010)	30
Actinopyga echinites	deep-water redfish	VU (2010)	25
Actinopyga lecanora	white-bottomed sea cucumber	DD (2010)	
Actinopyga mauritiana	surf redfish	VU (2010)	25
Actinopyga miliaris	hairy blackfish	VU (2010)	25
Bohadschia argus	leopard fish	LC (2010)	44
Bohadschia atra	tigerfish	DD (2010)	
Bohadschia marmorata	chalky cucumber	DD (2010)	30
Bohadschia vitiensis	brown sandfish	DD (2011)	30
Holothuria atra	lollyfish	LC (2010)	44
Holothuria cinerascens	tufted sea cucumber	LC (2010)	
Holothuria edulis	pinkfish	LC (2010)	25
Holothuria fuscogilva	white teeth	VU (2010)	42.8
Holothuria fuscopunctata	elephant trunkfish	LC (2010)	48
Holothuria hilla	tiger tail	LC (2010)	15
Holothuria leucospilota	white threads fish	LC (2010)	42
Holothuria nobilis	black teatfish	EN (2010)	44
Holothuria sp.			
Pearsonothuria graeffei	blackspotted sea cucumber	LC (2010)	35
Stichopus chloronotus	greenfish	LC (2010)	25
Stichopus herrmanni	curryfish herrmanni	VU (2010)	
Stichopus horrens	selenka's sea cucumber	DD (2010)	40
Synapta maculata	maculated synaptid		90
Synaptula sp.			
Thelenota ananas	prickly redfish	EN (2010)	52
Thelenota anax	amber fish	DD (2010)	60

I. Lobster species

Appendix Table I9. Lobster species recorded in the Maldives as indicated by the Maldives Lobster Fishery Management Plan. Depth information was collected from the Maldives Reef Fisheries Management Plan. IUCN listing and vulnerability values were gathered from FishBase and SeaLifeBase, where possible. Resilience values were unable to be collected.

Species Scientific Name	Species Common Name	Depth (m)	IUCN Listing (Year Assessed)	Vulnerability
Eduarctus martensii	striated locust lobster	>1399	LC (2009)	10
Enoplometopus voigtmanni	voigtmann's reef lobster	6-35	DD (2009)	
Panulirus femoristriga	stripe-leg spiny lobster	15-35	LC (2009)	
Panulirus japonicus	japanese spiny lobster	1-15	DD (2009)	20
Panulirus longipes	longlegged spiny lobster	1-122	LC (2009)	20
Panulirus ornatus	ornate spiny lobster	1-50	LC (2009)	40
Panulirus penicillatus	pronghorn spiny lobster	> 200	LC (2009)	30
Panulirus polyphagus	mud spiny lobster	3-90	LC (2009)	30
Panulirus versicolor	painted spiny lobster	> 900	LC (2009)	30
Parribacus antarcticus	sculptured mitten lobster	> 20	LC (2009)	10
Scyllarides squammosus	blunt slipper lobster	20-80	LC (2009)	30