# Reconstruction of total marine catches for the Maldives: 1950 – 2010[1]

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## Abstract

The republic of the Maldives has always relied on its marine resources for food and employment security, and for trade revenue. Traditionally, Maldivian fisheries focused on tuna, shark and live-bait. During the 1970s, rapid development, expansion and diversification (including reef fisheries) of marine fisheries and the tourist industry began. Catch statistics have been recorded by the Ministry of Fisheries, Agriculture and Marine Resources (MoFAMR) since 1959. A total enumeration system has evolved over time, initially focusing on catches by the pole-and-line tuna fishery, it has since been expanded to incorporate other gears types and species. A lack of financial and human resources has led to concerns over the accuracy of the catch data reported to the FAO. A catch reconstruction approach, using quantitative and qualitative sources, was used to reconstruct total marine fisheries catches for the 1950-2010 time period. Total reconstructed marine catches were estimated, which were 23% more than the tonnage reported by the Maldives to the FAO. Total catches increased from around 22,000 t·year$^{-1}$ in the 1950s to a peak of 223,000 t in 2006, before declining to about 143,000 t·year$^{-1}$ in the late 2000s. When tuna and non-tuna catches were examined separately, large skipjack tuna catches were found to be masking the under-reporting of other species such as grouper, sea cucumber, and sharks, all of which are known to be susceptible to over-fishing. The Maldives fishing and tourism industries, as well as food and employment security are dependent on healthy marine ecosystems, it is therefore imperative that reported catch statistics more accurately reflect total extractions from the marine environment.

## Introduction

Marine fisheries are crucial for small island countries, providing food and employment security as well as foreign trade and investment (Zeller *et al.* 2007). To better understand the interactions between marine fisheries and marine ecosystems, it is important to have as complete a record of total marine extractions as possible, both past and present. Unfortunately, officially reported landings data are often incomplete (Zeller *et al.* 2006; Zeller *et al.* 2007; Le Manach *et al.* 2012).

The Food and Agriculture Organization (FAO) publishes marine capture landings data, as reported to them by most nations of the world. The data received, however, are generally missing discarded, subsistence and recreational catches, and even commercial catches are often under-reported or missing (Zeller *et al.* 2007). As catch statistics are often used to develop marine policy and management plans, and set catch quotas, under-reported total catches are a serious concern. A reconstruction methodology has been developed by Zeller *et al.* (2007), and is being used here to reconstruct total marine catches since 1950 for the Maldives.

### *The Maldives*

The Republic of the Maldives is an atoll archipelago, 700 km south-west of Sri Lanka in the Indian Ocean (Figure 1). The country is comprised of 26 atolls and approximately 1190 islands, about 200 of which are permanently inhabited and a further 80 have been developed into tourist resorts (Anderson *et al.* 2003). The Maldives stretch for 840 km along the 73°E longitude, from 8°N to 1°S and have a total land area of only around 300 km², but an Exclusive Economic Zone (EEZ) of over 900,000 km² (www.seaaroundus.org). Fishing within the EEZ by other countries is

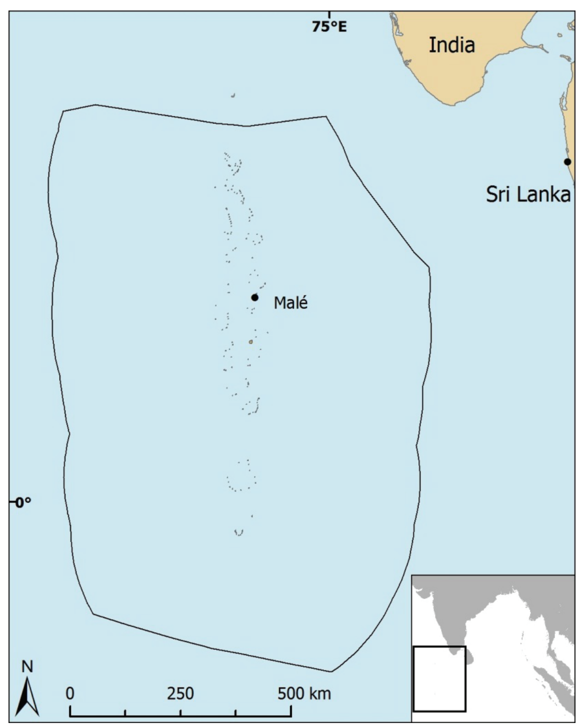


**Figure 1.** Map of Maldives and its Exclusive Economic Zone (solid line).

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permitted by license, however, a 75 mile exclusion zone exists around all atolls (the Coastal Fishery Zone), solely for Maldivian fishers. Coral reefs are the dominant ecosystem, covering an area of 4513 km$^2$. The country's atoll geomorphology, minimal terrestrial area, poor quality soil and lack of fresh water limit agricultural potential. The human population is therefore highly dependent on the marine resources for food, trade, employment and income (Weir no date).

Tourism began in 1972 (Firaag 1997; Bhat *et al.* 2010) and the industry expanded quickly. By 1985, tourism had surpassed fisheries as the largest revenue earner for the government and it provided a desirable, alternative form of employment. However, the large number of visitors has increased food demand, which is met by local fishers (Anderson *et al.* 2003). Additional fishing pressure comes from recreational fishing trips, targeting both reef and pelagic species.

## *Traditions, changes and developments in Maldivian Fisheries*

Maldivian fisheries depend heavily on hook-and-line fishing techniques (Anderson 1986; Rochepeau and Hafiz 1990; Adam *et al.* 2003; Adam 2004, 2007), as pelagic net-based fishing gears are banned (Adam *et al.* 2003). The traditional Maldivian fishing fleet consists of three main vessel types, varying in size, range and utilisation: *Masdhnoi* (8-12 m; 8-14 fishers), *Vadhu Dhoni* (5-8 m; 3-5 fishers), and *Bokkora* (3-5 m; 2-3 fishers). Fishing activity has intensified from subsistence to artisanal levels, to supply the increasing demand. Local fishing pressure has been compounded by the increase in distant water fleets operating in the region (Pandya 2009), raising questions about the stock resilience of some species (Laipson 2009).

Traditional fishing activity includes subsistence fishing, as artisanal fishers were traditionally paid with fish from the daily catch (Cole 2001). The traditionally preferred fishing method was live-bait pole-and-line fishing for skipjack tuna (*Katsuwonus pelamis*) and surface swimming juvenile yellowfin tuna (*Thunnus albacares*) (Anderson 1988; Anderson and Hafiz 1988; Adam and Anderson 1996; Adam and Jauharee 2009). Incidental catches included bigeye (*Thunnus obesus*), frigate tunas (*Auxis thazard thazard*) and kawakawa (*Euthynnus affinis*). This fishery may have existed for over 1000 years (Anderson and Hafiz, 1997). A second approach utilized trolling gear to target tuna-like species, kawakawa, frigate and bullet tuna (*Auxis rochei rochei*) along the outer atoll reefs, although vessel numbers have declined significantly in recent years (Adam *et al.* 2003).

A traditional shark fishery existed to provide shark oil, used to waterproof the wooden hulls of boats. The main target species were tiger shark *Galeocerdo cuvier*, whale shark *Rhincodon typus* and six gilled shark *Hexanchus griseus* (Anderson and Ahmed 1993; Anderson and Hafiz 1997). In the 1960s, artisanal night-time long-lining for pelagic shark species began, and driven by the high prices for the Asian shark fin market, fishing pressure and catches increased (Anderson and Waheed 1999). A deep-water benthic shark fishery began in 1979-1980 to produce high value squalene-rich oil for Japanese markets (Anderson and Ahmed 1993).

Some hand-lining for reef and tuna-like species has also always been conducted, but mostly on a part-time basis (Shakeel 1995; Shakeel and Ahmed 1997; Sattar 2008), when tuna fishing conditions were poor (Anderson 1999). The dominance of and preference for tuna meant reef species and sharks were generally considered less important, which is reflected in the poorer quality and resolution of the landings data (Anderson and Hafiz 1988; Sattar 2008).

The 1970s saw rapid mechanization of fisheries and a major shift in the economic focus of the country (Anderson *et al.* 2003; Adam 2004; Ali 2004; Adam 2007). Modern technology further resulted in effort creep (Cole 2001; Adam *et al.* 2003; Ali 2004; Pauly and Palomares 2010). Throughout the 1980s and 1990s, vessels increased, and larger holds were incorporated in their design (Rochepeau and Hafiz 1990; Adam 2007).

The resulting catch increase prompted the development of post-harvest processing facilities. Frozen tuna were first exported in 1972 and canned in 1975 (Ali 2004). Revision of fisheries and export regulations in the 1990s attracted further investment (Adam 2007), encouraging the diversification of the fisheries and their export products, including a yellowfin hand-line fishery supplying the sashimi markets of Japan and Europe (Adam 2004; Adam and Jauharee 2009).

## *Statistics and data collection*

The Ministry of Fisheries, Agriculture and Marine Resource (MoFAMR) began collecting tuna landings statistics using an enumeration system in 1959 (Anderson 1986; Nishida 1988). Initially focused on the *Masdhoni* fleet, both catch (numbers of fish caught) and fishing effort (numbers of days fished) were recorded (Rochepeau and Hafiz 1990; Anderson *et al.* 2003). Conversion factors were used to convert the fish count into weight estimates. The system proved to be adaptable and was expanded to include catch and effort data for other tuna and non-tuna species during the 1960s

**Table 1.** Taxa reported and categories used by the different organisations.

| Basic fisheries statistics | MoFAMR | FAO |
|---|---|---|
| Skipjack tuna | Large skipjack tuna | Skipjack tuna |
| | Small skipjack tuna | |
| Yellowfin tuna | Large yellowfin | Yellowfin tuna |
| | Small yellowfin | |
| Tuna-like species | Tuna-like species | Tuna-like species |
| | Frigate | Frigate/Bullet |
| | Kawakawa | Kawakawa |
| | Dogtooth | Dogtooth |
| | | Big Eye |
| Other marine species | Reef species | Misc. marine fishes |
| | Group 1 (e.g., Wahoo, Jacks) | Misc. marine fishes |
| | Group 2 (e.g., Rainbow Runner, Snapper) | Misc. marine fishes |
| | Group 3 (e.g., scads) | Misc. marine fishes |
| | Sharks | Sharks |
| | - | Bêche-de-mer |
| | - | Marine molluscs |
| | - | Lobster |

and 1970s (Anderson 1986; Anderson and Hafiz 1996). These statistics are published by MoFAMR, however, some of the catches are aggregated into more general categories (Table 1). Of particular concern is the 'Other marine species' category which includes everything from sea cucumber to large sharks. The lack of catch data for tourist resorts and live-bait fisheries, the statistical errors in tuna records and the under reporting of subsistence catches raise questions about the accuracy of these catch data.

## Methods

The national fisheries statistics published by the Ministry of Fisheries, Agriculture and Marine Resource (MoFAMR), consisting of four categories; skipjack, yellowfin, tuna-like and 'Other Marine Species' (Table 1) from 1971 to 2003 compared well with the data reported by FAO. Thus, data transfer between MoFAMR and FAO is well established.

However, literature review and data analysis suggested several sectors and taxa where the reported catch statistics do not properly reflect total catches. These included: tuna, live-bait, tourist consumption, lobster, shark, grouper, bêche-de-mer and local consumption of both tuna and non-tuna species. Independent, reconstructed estimates of catches for these components were made and combined with FAO statistics to give the total reconstructed catch for the Maldives from 1950-2010.

### *Tuna fishery*

Historically, there were two main gear types being used, pole-and-line and trolling. More recently, a hand-line fishery for the sashimi export market has also developed. Pole-and-line fishing is highly selective, resulting in very little by-catch (Gillett 2010), we assumed the same for the troll fishery. However, low post-harvest processing capacity during the early years may have led to discarding of spoiled catches or smaller individuals. As 'per vessel purchasing quotas' were imposed at processing facilities (Anon. 1991; Van de Knaap *et al.* 1991), the available data may not fully represent total catches. Therefore, reconstructed tuna catches are assumed to be conservative.

Subsistence tuna catches prior to 1970 are thought to be poorly represented in the official data due to the low resolution of the enumeration system employed. Exports were low at this time and unreported catches would most likely have been consumed locally. Between 1970 and 1986, reported catches of tuna are known to have been under- as well as over-reported. After 1990 however, statistical error associated with conversion factors and catch categorisation suggested that skipjack and yellowfin tuna catches had to be increased by 5% and 15%, respectively (Parry and Rasheed 1995). However, to be conservative in our reconstructions, we reduced the suggested percentage by 60% and hence applied a 3% and 9% increase to skipjack and tuna catches, respectively.

Large yellowfin tuna catches have been reported separately in the national statistics since 1992 and an estimated 50% of the catches made by hand-liners were estimated to be unreported in 2008 (Adam and Jauharee 2009). To quantify the level of under reporting in other years, export statistics and product conversion factors were used. The primary export markets are for fresh, chilled whole fish (head on and gutted) or as fresh, chilled fillets and loins. Conversion factors of 1.15 and 2, respectively, were used to convert product weights published by the Ministry of Planning and National Development (1991-2003) and the Maldives Customs Services (2006-2008) into wet weights. When compared to the reported large yellowfin tuna catches, any differences were considered to be the unreported catch for this sector (Adam and Jauharee 2009).

**Table 2.** Summary of live-bait utilisation studies (Anderson *et al.* 2003).

| Period | CPUB (kg/kg) | Tuna catch ($t \cdot year^{-1}$) | Live bait used ($t \cdot year^{-1}$) | Uncertainty (%) |
|---|---|---|---|---|
| 1978-1981 | 8.0 | 26,267[a] | 3,283.4 | 26.6[a] |
| 1985-1987 | 10.6 | 54,158[a] | 5,109.3 | 25.0[a] |
| 1993 | 7.3 | 78,500 | 10,753.4 | 24.7 |
| 1994 | 8.3 | 89,599 | 10,795.1 | 25.5 |
| 2003 | 9.6 | 135,968 | 14,163.3 | - |

[a] Time period average

### *Tuna live-bait fishery*

The increasing fishing effort and catches of the pole-and-line fleet have increased the demand for live-bait. Live-bait are caught and utilised directly by the fleet and consequently the annual catch is not included in the national landings statistics reported to the FAO (Adam 2004). Estimates of Catch per Unit Bait (CPUB) from several studies (Anderson 1994; Anderson and Hafiz 1996; Anderson 1997; Anderson *et al.* 2003), are displayed in Table 2. However to be conservative in our estimates, reduced live bait values were applied in our reconstructions, ranging from 1,973 $t \cdot year^{-1}$ from 1978-1981 to 8,509 $t \cdot year^{-1}$ in 2003. The resulting CPUB values ranges from 9.56 kg tuna per kg bait to 15.35 kg tuna per kg bait. Combining the derived bait catch rates with reconstructed pole-and-line tuna catches allowed us to derive a time series of live-bait catches from 1950-2008. The ratio between the 2008 live-bait amount and the 2008 reported tuna landings were extended for 2009 and 2010.

**Table 3.** Taxonomic breakdown of live-bait catch was derived from the average of 1994 and 1996 data. Names were updated to current valid names using FishBase. Source - Anderson (1994, 1997).

| English name | Dhivehi name | Scientific name | % |
|---|---|---|---|
| Fusiliers | Muguraan | *Caesionid* spp. | 37.25 |
| Silver-stripe round herring | Rehi | *Spratelloides gracilis* | 33.75 |
| Cardinal fish | Boadhi & Fatha | *Apogonid* spp. | 11.00 |
| Anchovy | Miyaren | *Encrasicholina heteroloba* | 8.75 |
| Delicate round herring | Hondeli | *Spratelloides delicatulus* | 5.75 |
| Silver sides | Thaavalha & Boduboa | *Odonthestes* spp. | 1.50 |
| Damsel fish | Bureki & Nilamehi | Pomacentridae | 1.25 |
| Other | | Misc. reef fishes | 0.75 |

Live-bait catches were dominated by fusiliers (Caesionidae) and silver-stripe round herring (*Spratelloides gracilis*), which contributed over 70% of the catch (Table 3). Reconstructed live-bait catches were assigned to taxa based on available data (Table 3).

### *Tourist consumption*

Seafood consumption by tourists, particularly reef species, have increased substantially since 1972. As these catches are sold directly to tourist resorts, it was assumed that these catches were unaccounted for in official statistics. Tourist consumption surveys have only been conducted twice in the Maldives. Van de Knaap *et al.* (1991) reported 1.67 kg·tourist$^{-1}$·night$^{-1}$, based on fish purchases in 1988, while Sattar (2008) estimated the 2006 consumption per tourist night (CPTN) as 1.29 kg·tourist$^{-1}$·night$^{-1}$. Here, we assumed the CPTN rate of 1.67 kg·tourist$^{-1}$·night$^{-1}$ was constant between 1972 and 1988, linear interpolation of CPTN was used between 1988-2006, and the CPTN of 1.29 kg·tourist$^{-1}$·night$^{-1}$ was held constant from 2006 onwards.

**Table 4.** Catch composition for local and tourist consumption of reef species. Source - Sattar (2008).

| Scientific name | English name | % | Scientific name | English name | % |
|---|---|---|---|---|---|
| Carangidae | Jacks | 51.0 | Lutjanidae | Snapper | 27 |
| *Alectis ciliaris* | African pompano | 6.0 | *Aprion virescens* | Green jobfish | 9 |
| *Carangoides caeruleopinnatus* | Coastal trevally | 4.5 | *Aphareus rutilans* | Rusty jobfish | 3 |
| *Carangoides ferdau* | Blue trevally | 4.5 | *Lutjanus gibbus* | Humpback red snapper | 3 |
| *Carangoides orthogrammus* | Island trevally | 4.5 | *Lutjanus bohar* | Two spotted red snapper | 3 |
| *Caranx ignobilis* | Giant trevally | 4.5 | *Macolor niger* | Black and white snapper | 3 |
| *Caranx lugubris* | Black trevally | 4.5 | *Macolor macularis* | Midnight Snapper | 3 |
| *Caranx melampygus* | Bluefin trevally | 4.5 | Lethrinidae | Emperor | 8 |
| *Caranx sexfasciatus* | Bigeye trevally | 4.5 | *Lethrinus harak* | Thumbprint emperor | 3 |
| *Gnathanodon speciosus* | Golden trevally | 4.5 | *Lethrinus microdon* | Smalltooth emperor | 1 |
| *Scomberoides lysan* | Doublespotted queenfish | 4.5 | *Lethrinus olivaceus* | Longface emperor | 1 |
| *Seriola rivoliana* | Longfin yellowtail | 4.5 | *Lethrinus rubrioperculatus* | Spotcheek emperor | 1 |
| Sphyraenidae | Barracuda | 10.0 | *Lethrinus xanthochilus* | Yellowlip emperor | 1 |
| Miscellaneous marine fishes | - | 4.0 | - | - | - |

**Table 5.** Catch composition for the artisanal shark fisheries of the Maldives.

| Scientific name | English name | % | Scientific name | English name | % |
|---|---|---|---|---|---|
| Oceanic sharks | | | Reef sharks | | |
| *Carcharhinus falciformis* | Silky shark | 75 | *Carcharhinus albimarginatus* | Silver tip shark | 25.0 |
| *Carcharhinus longimanus* | Oceanic white tip shark | 3 | *Carcharhinus amblyrhynchos* | Blacktail reef shark | 25.0 |
| *Carcharhinus altimus* | Bignose shark | 3 | *Carcharhinus melanopterus* | Black tip reef shark | 25.0 |
| *Galeocerdo cuvier* | Tiger shark | 3 | *Triaenodon obesus* | White tip reef shark | 25.0 |
| *Prionace glauca* | Blue shark | 3 | | | |
| *Carcharhinus albimarginatus* | Silver tip shark | 3 | Benthic sharks | | |
| *Isurus oxyrinchus* | Shortfin mako | 3 | *Centrophorus* spp. | Gulper shark | 90.0 |
| Alopiidae | Thresher sharks | 3 | *Hexanchus griseus* | Bluntnose sixgill | 3.3 |
| Sphyrnidae | Hammerhead sharks | 3 | *Odontaspis ferox* | Smalltooth sand tiger | 3.3 |
| *Rhincodon typus* | Whale shark | 3 | *Pseudotriakis microdon* | False catshark | 3.3 |

Occupancy rates and tourist capacity were published by the Ministry of Planning and National Development (MoPND; 1972-1998) (www.planning.gov.mv) and by the Ministry of Tourism, Arts and Culture (MoTAC; 1998-2008) (www.tourism.gov.mv). Using these sources, we calculated total annual tourist-nights, which combined with the derived time series of CPTN allowed us to estimate total tourist consumption.

Available literature (Anderson *et al.* 2003; Sattar 2008) suggested tourist preference is for reef-associated species, although some tuna consumption was assumed. Of the reconstructed total catches, 15% was assumed to be skipjack and yellowfin tuna at a 2:1 ratio. The taxonomic composition of the remaining tourist consumption (Table 4) was based on data from Sattar (2008).

Lobster catches are only reported in the data supplied to the FAO for 2000, 2001 and 2006, although it is known that tourist consumption is considerable. MoFAMR lobster data, as numbers caught (Anderson *et al.* 2003), were available from 1988-2002 (Table 5). It was assumed the reported landings were included in the 'Other Marine Species' category by MoFAMR. After 2002, it was assumed landings were included in the tourist consumption calculation as part of 'miscellaneous marine fishes' category (Table 4).

## *Shark fishery*

Expanding global shark fin markets in Asia have caused dramatic changes to the fishery since 1950. The unfortunate pooling of sharks and reef species landings in the national statistics required catches to be reconstructed using alternative data sources (Anderson and Ahmed 1993; Anderson and Waheed 1999) and export estimates.

The FAO only started reporting shark landings in 1970. Traditional shark catches made prior to this were therefore unaccounted for. For 1950 to 1962, an estimate of 322 t·year$^{-1}$ (Anderson and Ahmed 1993) was used. For 1963-1969, an export based average of 356 t·year$^{-1}$ (Anderson and Waheed 1999) was applied.

The development of the artisanal shark fishery during the late 1960s and the low level of shark consumption locally (except for oil use) meant catches could be reconstructed based on fin and oil exports (Anderson and Ahmed 1993; Anderson and Waheed 1999). For 1970 to 1991, FAO landings and export based reconstructed values were comparable, therefore, no adjustment were made (Figure 2). Between 1992 and 2003, FAO shark landings increased substantially from 1,773 t in 1991 to a high of 13,523 t in 2000, followed by a decrease to 880 t in 2005 (Figure 2). However, catch estimates based on export statistics do not show this dramatic increase (Figure 2). The sum of FAO reported shark and 'miscellaneous marine fishes' catches were comparable to the 'other marine species' category reported by MoFAMR during this period (Figure 3). Therefore, it was assumed that the FAO shark catches were incorrectly allocated and were assigned back to the 'miscellaneous marine fish' category. Export based reconstructed values were used from 1992 to 2003.

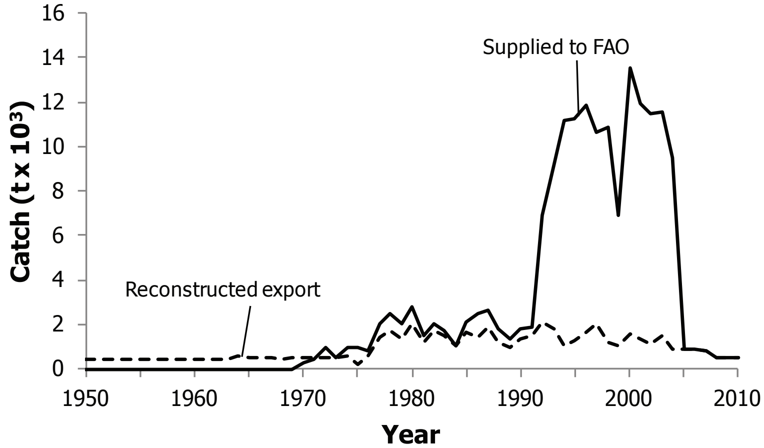


**Figure 2.** FAO landings vs. reconstructed exports for shark catch in Maldives, 1950-2010.

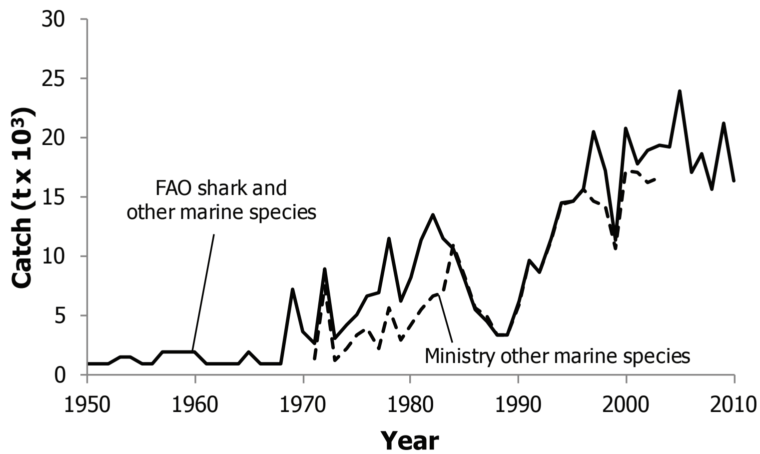


**Figure 3.** Reported FAO shark and other marine species landings vs. reported Ministry other marine species landings for Maldives.

Catch estimates for the traditional shark-oil fishery were approximately 460 t·year$^{-1}$ prior to 1970 (Anderson and Ahmed 1993; Anderson and Waheed 1999). As alternative vessel-hull treatments were introduced after 1970, it was assumed catches from this sector declined to 55 t in 1993. Traditional catches were allocated equally to the three target species: tiger shark (*Galeocerdo cuvier*), whale shark (*Rhincodon typus*) and six gilled shark (*Hexanchus griseus*).

The taxonomic composition for the commercial (export-oriented) shark fisheries required the reconstructed catches to be considered by their three ecosystem components; deep water benthic, oceanic and reef sector. For 1963, it was assumed that oceanic sharks accounted for 10%, while reef sharks accounted for 90% of catches. By 1992, this ratio had changed to 50% each (Anderson and Ahmed 1993). By 1998, a 60% oceanic, 40% reef shark breakdown was assumed (Anderson and Waheed 1999). Deep water benthic catch estimates (1963-1996) (Anderson and Waheed 1999) and estimates made from oil export figures provided the benthic fishery contribution. The taxonomic composition for each component was based on all available information (Table 5).

## *Grouper fishery*

A small artisanal grouper fishery developed in 1994, mainly to supply the Asian live reef-fish market. A comparison between catches reported by fishers and those estimated using export figures (Sattar and Adam 2005) showed as much as 90% of catch, by numbers, went unreported between 1994 and 2004 (Table 6). To assess the validity of the reported catches, they were compared to the export-based estimates.

**Table 6.** Taxonomic composition of grouper catches.

| Grouper Species | % |
|---|---|
| *Aethaloperca* spp. | 10 |
| *Cephalopholis* spp. | 10 |
| *Epinephelus* spp. | 40 |
| *Plectropomus* spp. | 25 |
| *Variola* spp. | 10 |
| Serranidae | 5 |

The reconstruction of total catches used conversion factors to calculate wet weights, as exploitation has reduced the size of individuals caught (Sattar and Adam 2005). Conversation factors declined from 0.9 kg·fish$^{-1}$ in 1991 (Anderson *et al.* 1992) to 0.73 kg·fish$^{-1}$ in 2008 (Table 6). After 2002, grouper catches were assumed to be included in 'Other Marine Species' category (MoFAMR). The ratio between the grouper amount and the reported 'marine fishes nei' landings for 2008 were extended for the rest of the period.

The taxonomic composition of the reconstructed grouper catches was generated using the assumption that higher valued species (e.g., *Plectropomus* and *Epinephelus* spp., Table 7) made up the largest proportions of the catch (Sluka 2000; Adam 2004).

## *Bêche-de-mer fishery*

The Ministry of Planning and National Development (MoPND) reports dried bêche-de-mer for 1991–2008. A conversion factor of 3 was used to convert the dried weight to wet weight of catch, based on the FAO conversion factor for the nearest reporting country (Tanzania). This is a highly conservative estimate, as other studies have suggested a conversion factor of 10 (Conand 1991; Dalzell *et al.* 1996). These tonnages matched the tonnage reported by FAO as sea cucumber landings, thus suggesting that data were transformed into wet weight equivalents. Stock collapses of some species (Joseph 1992) suggest that catch composition is best considered as total catches per species for 1986-1990 (Table 8).

## *Local consumption*

Local *per capita* consumption of fish has always been high in the Maldives. However, studies of local seafood consumption are rare and show variations from 74 kg·person$^{-1}$·year$^{-1}$ (Maizan 1986) to 205 kg·person$^{-1}$·year$^{-1}$ (Anon. 2003). Domestic seafood supply (MoFAMR; 1971-2003) figures were used in conjunction with population figures to calculate *per capita* supply, which ranged from 45 kg·person$^{-1}$ in 1970 to 203 kg·person$^{-1}$ in 2006. To determine a realistic consumption rate, the available datasets (Table 9) and the following assumptions were used:

Domestic supply = Landings + Imports – Exports;

Consumption rate = Domestic supply / Population;

Domestic demand = Consumption rate * Population;

Unreported catches = Domestic demand – Domestic Supply.

Population of the Maldives

Human population data were obtained from Populstat (www.populstat.info) for 1950–2001, and the World Bank (data.worldbank.org) for 1960-2008. The two sources matched closely for the period of overlap, thus the average was taken for these years and completed using data from each of the sources (Figure 4).

Import data

Import data were published by the Ministry of Trade for the Maldives (1988-2003). Figures were only reported as the total import cost per year, and are known to be mainly for tourist consumption. It was therefore assumed marine product imports had little impact on domestic consumption.

Export data

Records of total marine exports are published by MoFAMR from 1971-2008, while more detailed species and product data were published by the Department of National Planning (DoNP) for 1991-2003 and the Maldives Customs Service (MCS) for 2006-2008. Data for interim years

**Table 7.** Reported grouper exports, landings and conversion factors (CF).

| Year | Export (Nos.) | Catch (Nos.) | CF |
|---|---|---|---|
| 1994 | 198,131 | - | 0.87 |
| 1995 | 846,722 | 4,072 | 0.86 |
| 1996 | 808,825 | 7,783 | 0.85 |
| 1997 | 1,004,404 | 90,298 | 0.84 |
| 1998 | 457,609 | 401 | 0.83 |
| 1999 | 637,695 | 12,577 | 0.82 |
| 2000 | 568,138 | 3,160 | 0.81 |
| 2001 | 595,901 | 45,998 | 0.80 |
| 2002 | 460,193 | 665,371 | 0.79 |
| 2003 | 460,218 | - | 0.78 |
| 2004 | 287,579 | - | 0.77 |
| 2005 | 338,336 | - | 0.76 |
| 2006 | 389,093 | - | 0.75 |
| 2007 | 428,081 | - | 0.74 |
| 2008 | 546,984 | - | 0.73 |

**Table 8.** Total wet weight of bêche-de-mer caught by species (1986-1990).

| Scientific name | English name | t |
|---|---|---|
| *Actinopyga* spp. | Blackfish | 327 |
| *Halodeima atra* | Lollyfish | 296 |
| *Actinopyga mauritiana* | Surf redfish | 247 |
| *Microthele nobilis* | White teat fish | 232 |
| *Stichopus chloronotus* | Greenfish | 219 |
| *Bohadschia marmorata* | Amberfish | 192 |
| *Thelenota ananas* | Prickly redfish | 112 |
| *Microthele axiologa* | Elephant trunkfish | 68 |
| *Thelenota anax* | Turtleshell | 45 |

**Table 9.** Data available for local consumption calculation.

| Source | Dates | Type |
|---|---|---|
| MoFAMR | 1971-2008 | Total domestic supply |
| | 1971-2008 | Total marine exports |
| | 1971-2008 | Basic fisheries statistics, aggregated (Table 2). |
| DoNPD | 1991-2003 | Detailed export data, by species and product weight. |
| MCS | 2006-2008 | Detailed export data, by species and product weight. |
| FAO | 1950-2008 | Tuna |
| | 1950-2008 | Other marine species |
| Sri Lanka | 1950-1974 | Import data |

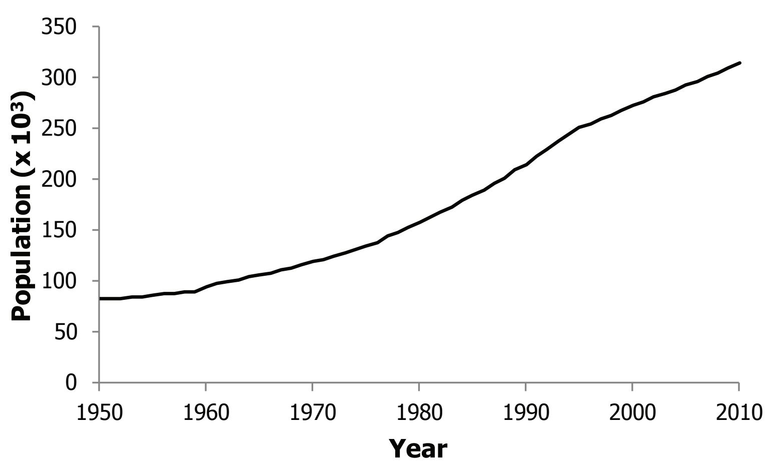


**Figure 4.** Local population of the Maldives from 1950-2008.

were estimated using linear interpolation. Wet weights were calculated using product conversion factors (Table 10). Datasets permitted separation of exports into tuna and non-tuna exports. It was assumed that product exports increased linearly from zero in the year they were first recorded, to estimate wet weights for years prior to 1991.

**Table 10.** Export product type conversion factors for the Maldives. Sources - MoFAMR, DoNP, MCS.

| Product | Conversion Factor |
|---|---|
| Frozen fish | 1.00 |
| Dried fish | 5.00 |
| Salt-dried fish | 3.00 |
| Canned fish | 3.00 |
| Maldives Fish | 5.00 |
| Steamed/cooked fish | 4.00 |
| Shark fin | 0.01 |
| Shark oil | 0.23 |

*Exports of tuna (1950 – 1990):* Skipjack tuna is the sole tuna species being exported in the form of 'Maldives Fish', either canned or frozen. Early exports of 'Maldives Fish' were predominantly to Sri Lanka (thus labelled 'Maldive Fish'), whose import records were available for 1951-1975 (Pathirana 1972). Interpolations were used for years with no data.

*Exports of non-tuna (1970 – 1980):* Here, we assume that no marine product exports (other than tuna) existed prior to 1970. We assume linear increases in exports from 1970 to first reported data in 1980. Up to 1998, exports of salt-dried shark meat were included in the 'salt-dried reef species' category. As shark meat is rarely consumed locally, we disaggregated exports of shark from reef species, using salted-dried shark meat estimates for 1991-1996 from Anderson and Waheed (1999), and salt-dried reef species exports between 1980 and 1991 from Anderson and Ahmed (1993).

Domestic supply

The domestic supply based on reported data between 1950 and 2008 was estimated using FAO landings data adjusted for exports as outlined above. The *per capita* rate calculated for 2008 was extended for the rest of the period. Data were separated into total domestic supply and domestic supply of tuna (Figure 5). On average, total and tuna *per capita* consumption rates were of 109 kg·person$^{-1}$·year$^{-1}$ and 94 kg·person$^{-1}$·year$^{-1}$, respectively, suggesting a non-tuna local consumption rate of 15 kg·person$^{-1}$·year$^{-1}$. The estimated total average consumption rate of 109 kg·person$^{-1}$·year$^{-1}$, although high, does not seem excessive for an atoll country such as the Maldives, given other atoll-based island countries, such as Kiribati, have been found to have a *per capita* consumption rate of 200 kg·person$^{-1}$·year$^{-1}$ (Gillett 2002). The difference between domestic supply and demand enabled us to estimate a minimum quantity of unreported catch. Unreported tuna catches were allocated to taxa in proportion to the breakdown of reported FAO landings. Non-tuna species were allocated using the same taxonomic composition as used for tourist consumption (see Table 4).

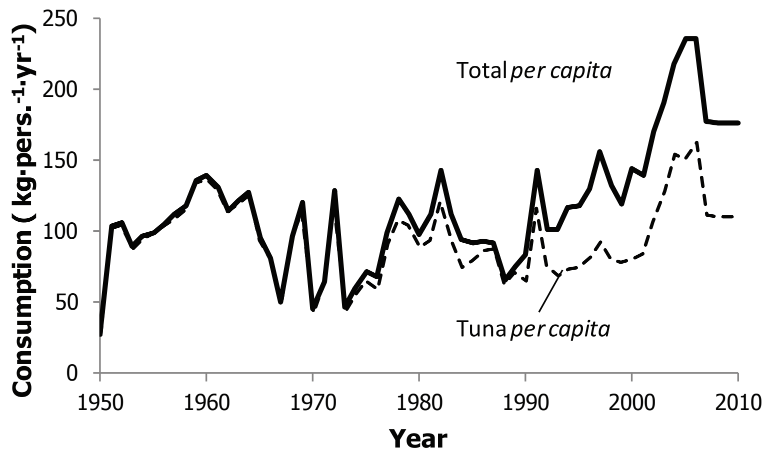


**Figure 5.** Total and tuna *per capita* local consumption rate for Maldives, 1950-2010.

## Results

### *Reconstructed total catch*

The reconstructed total catch was 23% higher than the reported landings for 1950-2010 (Figure 6a). The reconstructed total catch averaged 26,600 t·year$^{-1}$ from 1950-1970 and subsequently increased to 66,400 t·year$^{-1}$ in the 1980s. Catches reached a peak of 223,000 t in 2006, and declined to 150,000 t·year$^{-1}$ for the rest of the period. The industrial sector comprises the majority of the total reconstructed catch of Maldives at 66%, while subsistence and artisanal compose 24% and 10%, respectively (Figure 6a).

### *Taxonomic composition*

The majority of the reconstructed total catch consists of tuna (79%), followed by Carangidae (7%), Lutjanidae (4%) and Fusilier (2%). The remaining 18 taxa compose 1% of the total reconstructed catch (Figure 6b).

### *Tuna fishery*

The reconstructed total catch of tuna from 1950-2010 was estimated to be approximately 3.7 million t, compared to the 3.3 million t reported to the FAO. During the early 1960s (just after records began in 1959), under reporting was at its highest. By the 2000s, reporting accuracy had improved, with an approximately 90% reporting accuracy, but 15,000 t·year$^{-1}$ in missing tuna catches (Figure 7a).

Tuna catches are dominated by skipjack tuna, which in recent years contributed just under 80% of the total tuna landings (Figure 7b), the majority of which are caught by pole-and-line gear. The catches of yellowfin tuna have increased from 15,000 t (1998) to almost 30,000 t (2008), the majority of which were for export.

## *Non-tuna fisheries*

Reconstructed total non-tuna catches for the time period 1950-2010 were estimated at 961,000 t, with 509,000 t being reported to the FAO (Figure 8a). Thus, on average, approximately 7,000 t·year$^{-1}$ were missing from the reported statistics. In 1950, reported landings of non-tuna species were 1,000 t, whereas 2,550 t were estimated as unreported, or 72% of the catch. In recent years (2000s), the average reported catch has increased to 19,000 t·year$^{-1}$, while the total reconstructed catch averaged 33,000 t·year$^{-1}$, suggesting 57% of catches were reported. The reconstruction of non-tuna species consists of various taxas such as Carangidae (35%), Lutjanidae (18%) and Clupeidae (10%) (Figure 8b). It also encompasses catches for local consumption; tourist consumption; live-bait; sharks, grouper, sea cucumber and lobster.

## *Tuna live-bait fishery*

The annual live-bait catch increased as tuna catches increased, and reconstructed total catches of live-bait was estimated to be 222,000 t over the full time period considered here, none of which were reported. Live-bait catches averaged 1,000 t·year$^{-1}$ from 1950 to 1970 and increased in the 1990s to an average of 6,390 t·year$^{-1}$. Catches peaked in 2006 with 10,500 t and declined towards the late 2000s with 6,000 t·year$^{-1}$. Although at least seven species are utilized, fusiliers (*Caesionid* spp.) and silver striped round herring (*Sprattelloides gracillis*) are the two main bait species, contributing 37% and 34%, respectively.

## *Tourist consumption*

Tourist consumption was estimated back to the start of tourism in 1972. Catches increased steadily, from 190 t in 1973 to 6,900 t in 2004, followed by a decline in 2005 after the tsunami of 2004, and increased to 8,280 t by 2010. Overall, around 83% of tourist consumption was reef species, including jacks (Carangidae), snappers (Lutjanidae), emperors (Lethrinidae) and lobster (*Panulirus* spp.), with the remainder being primarily skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*).

## *Shark fishery*

Traditional shark catches for oil used on fishing vessels between 1950 and 1970 were not reported

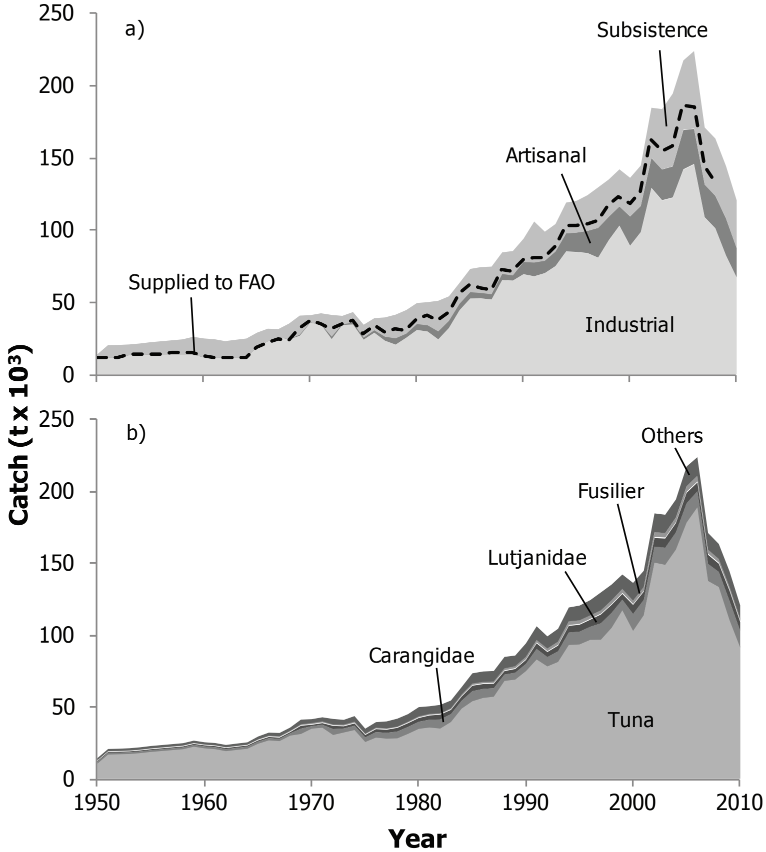


**Figure 6.** Reconstructed total catch for the Maldives, 1950-2010 a) by sector with data reported by the FAO overlaid as a line graph; and b) by major taxonomic groups. 'Others' represent an additional 18 taxonomic groups.

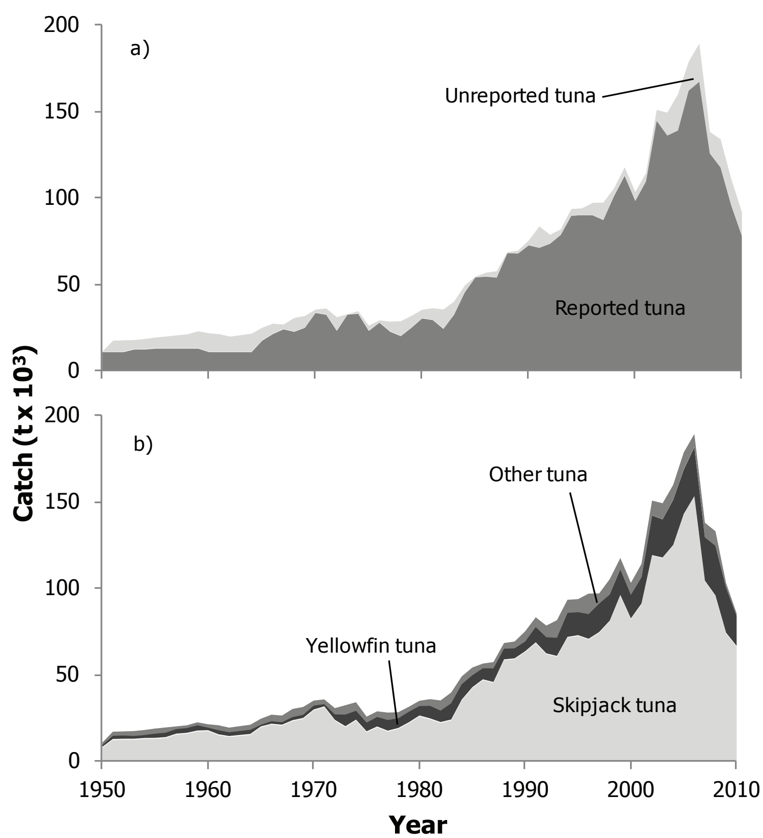


**Figure 7.** Reconstructed total tuna catch for the Maldives, from 1950-2008, by a) reported vs unreported status; and b) major tuna taxa.

to the FAO, and were estimated at 279 t·year⁻¹ for the period. Between 1971 and 1991, reconstructed catches totalled 25,200 t with an annual average of 1,146 t·year⁻¹.

The sudden increase in FAO shark landings between 1992 to 2005 were considered to be a result of incorrect taxonomic allocation of the 'other marine species' catches reported by MoFAMR. Export based catch estimates for this period averaged 1,410 t·year⁻¹, compared to the 10,500 t·year⁻¹ reported by the FAO. The over-estimated catch was re-assigned to 'miscellaneous marine fishes'.

### *Grouper fishery*

The export-oriented grouper (Serranidae) fishery started in 1994, with an estimated total catch of 4,500 t. Catches peaked in 1997 at nearly 600 t, and have declining since to 276 t by 2010. As national statistics were available for some years, however, in 1999 reconstructed catches for this fishery were estimated at 360 t, whereas only 10 t were officially reported.

### *Bêche-de-mer fishery*

Reported sea cucumber catches began in 1981 with 0.25 t, peaked in 1990 at 2,240 t and have declined to 629 t in 2010. Originally, fishers targeted the high valued prickily redfish (*Thelenota ananas*) and white teatfish (*Microthele nobilis*), but more recently over nine species are targeted.

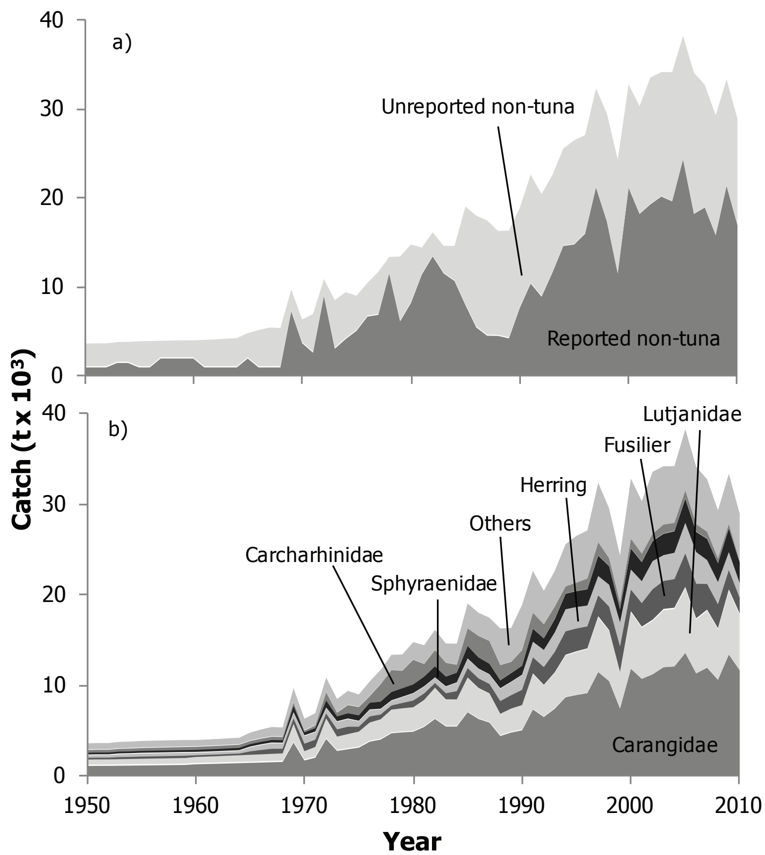


**Figure 8.** Reconstructed total non-tuna catch by a) reported vs unreported values and b) major groups. 'Others' contains an additional 65 taxas.

### *Local consumption*

The total under-reported catch for local consumption was about 387,000 t for 1950-2008. Local consumption has increased from 1,260 t in 1950 to over 7,500 t in 2010, as the human population has increased.

## Discussion

The catch reconstruction for the Maldives suggests that around 81% of actual total catches were reported. Under reporting was higher in the earlier periods, with more than 50% of the total catch being unaccounted for in some years. As total annual catches increased, particularly following the mechanisation of the fishing fleet and investment in the post-harvest facilities, reporting accuracy increased. The commercially and domestically important tuna species appear to be well reported, although some sources suggest up to 30% being not reported (Parry and Rasheed 1995). Significantly, it has been suggested that reporting accuracy has been deteriorating since the mid-1990s (Parry and Rasheed 1995; Anderson and Hafiz 1996). This deterioration of comprehensive accounting of the most crucial marine resource in the Maldives (i.e., tuna) requires addressing. Conversely, catches of non-tuna species were even more poorly accounted for, with poor taxonomic resolution and a significantly decreasing reporting accuracy.

Stocks of skipjack tuna have sustained the Maldivian population for more than a thousand years, and local fishers consider the ocean to be bountiful and its fish stocks inexhaustible (Anderson and Ahmed 1993). However, regional assessments point to increasing threats facing the Indian Ocean tuna stocks (IOTC 2010). It has become abundantly clear, however, that some of the other target species (grouper, sea cucumber etc.) are exhibiting signs of over-exploitation and in some cases stock collapse (Joseph 1992; Sattar 2008). There are also reports that bait-fish abundance may be declining in areas with high fishing intensities (Anderson 2006; Adam and Jauharee 2009). This can affect both the pole-and-line and hand-line tuna fisheries, possibly leading to less sustainable fishing methods being employed.

The Maldivian fishers local-scale view of tuna stocks is concerning, as it does not account for regionally increasing fishing pressure in the Indian Ocean (Gillett 2010) and the migratory nature of the target species. Tuna stocks may be responding negatively to the increase in fishing effort and unreported or illegal catches make it difficult to determine their real rate of regional and stock-wide exploitation. Although the stocks of tuna, in particular skipjack, in the Indian Ocean are believed to be high, concerns over declining yellowfin stocks in Maldivian waters are mounting

(Adam and Jauharee 2009). Interestingly, FAO skipjack landings for the Maldives do show a decrease of 51,000 t between 2006 and 2008, with a further decline of 29,000 t by 2010. It remains to be seen if this will be a continuing trend.

Tourist consumption estimates made in this study are considered conservative. They do not account for the growing recreational fishing sector targeting both reef and large pelagic species, with associated catches potentially large. Recreational fishers are not required to report catches or fishing effort, therefore, fishing pressure and its impacts are hard to determine.

The current catch reporting system once served the Maldives very well, but the nature of the fisheries has changed considerably since the 1950s and 1960s. The present system is fortunately now recognised by MoFAMR as being inadequate and in need of revision (Anderson *et al.* 2003; Adam 2007). Alternative systems, such as log book based accounting systems have been trialled. However, a main concern about such an approach at a country-wide level is the support system required for data entry and analysis. A potentially more suitable approach is that of regular, albeit non-annual (e.g., every 3-5 years) country-wide and all sector encompassing survey and estimation approaches, with intervening years being filled through interpolation (Zeller *et al.* 2007). Such a system of surveys, combined with country-wide expansion and interpolation can also be used for obtaining other administrative and governmental service related information, e.g., as obtained through household surveys and national census surveys. Utilizing such an approach for deriving comprehensive estimates of total fisheries catches (all sectors) as well as effort and catch composition data would go a long way towards addressing national and global data needs, without necessarily requiring extensive domestic resources (Zeller *et al.* 2007). Such an approach should also be supported through resource expertise by regional (e.g., Bay of Bengal Large Marine Ecosystem Project, www.boblme.org) and international agencies and institutions (e.g., UNEP and FAO).

A major challenge in the collection of accurate fisheries statistics is the lack of financial and human resources (Anderson *et al.* 2003; Adam 2004, 2007). It is concerning that a country so dependent on its marine resources is increasingly finding it difficult to finance the management and monitoring programs required to ensure sustainable exploitation and use of marine ecosystems. It has been suggested that even a small levy placed on each tourist night could cover 85% of current operating costs (Bhat *et al.* 2010). The recent ban on shark product export, driven by tourist perceptions and concerns, shows the weight tourist opinion carries in the eyes of the Maldivian policy makers. Educating tourists about Maldives marine resource and ecosystems and what is required to protect them may help drive policies and funding, ensuring the Maldives can prosper and develop without sacrificing their main natural resource.

## Acknowledgements

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**Appendix Table A1.** FAO landings vs. reconstructed total catch (in tonnes), and catch by sector for Maldives, 1950-2010.

| Year | FAO landings | Reconstructed total catch | Industrial | Artisanal | Subsistence |
|---|---|---|---|---|---|
| 1950 | 12,000 | 14,600 | 11,800 | 560 | 2,160 |
| 1951 | 12,000 | 20,900 | 11,800 | 560 | 8,510 |
| 1952 | 12,000 | 21,100 | 11,800 | 560 | 8,690 |
| 1953 | 14,000 | 21,400 | 13,400 | 610 | 7,360 |
| 1954 | 14,000 | 22,100 | 13,400 | 610 | 8,010 |
| 1955 | 14,000 | 23,000 | 14,000 | 560 | 8,420 |
| 1956 | 14,000 | 23,600 | 14,000 | 560 | 9,070 |
| 1957 | 15,000 | 24,300 | 14,000 | 660 | 9,630 |
| 1958 | 15,000 | 24,900 | 14,000 | 660 | 10,280 |
| 1959 | 15,000 | 26,700 | 14,000 | 660 | 12,040 |
| 1960 | 13,000 | 25,500 | 11,800 | 660 | 13,060 |
| 1961 | 12,000 | 25,000 | 11,800 | 560 | 12,620 |
| 1962 | 12,000 | 23,700 | 11,800 | 560 | 11,310 |
| 1963 | 12,000 | 24,600 | 11,800 | 570 | 12,230 |
| 1964 | 12,000 | 25,500 | 11,800 | 570 | 13,100 |
| 1965 | 19,600 | 29,600 | 18,900 | 670 | 9,960 |
| 1966 | 22,400 | 32,200 | 23,000 | 570 | 8,670 |
| 1967 | 25,100 | 32,000 | 25,900 | 570 | 5,520 |
| 1968 | 23,700 | 35,800 | 24,400 | 570 | 10,810 |
| 1969 | 32,300 | 41,300 | 26,900 | 1,200 | 13,190 |
| 1970 | 37,273 | 41,600 | 35,900 | 642 | 5,040 |
| 1971 | 35,176 | 42,900 | 34,600 | 667 | 7,570 |
| 1972 | 32,268 | 41,700 | 24,600 | 2,111 | 14,990 |
| 1973 | 35,706 | 41,100 | 34,400 | 941 | 5,770 |
| 1974 | 37,258 | 43,700 | 34,700 | 1,597 | 7,400 |
| 1975 | 28,325 | 35,000 | 24,200 | 1,835 | 8,920 |
| 1976 | 34,634 | 39,500 | 29,000 | 2,089 | 8,380 |
| 1977 | 29,636 | 40,000 | 23,500 | 3,174 | 13,340 |
| 1978 | 31,769 | 41,900 | 20,800 | 4,804 | 16,330 |
| 1979 | 31,175 | 45,100 | 25,600 | 3,193 | 16,320 |
| 1980 | 38,624 | 49,900 | 30,900 | 4,474 | 14,510 |
| 1981 | 40,916 | 50,500 | 29,900 | 4,687 | 15,970 |
| 1982 | 37,838 | 51,500 | 24,400 | 5,908 | 21,150 |
| 1983 | 44,110 | 54,500 | 32,300 | 5,268 | 16,960 |
| 1984 | 56,081 | 63,800 | 44,600 | 4,781 | 14,440 |
| 1985 | 62,076 | 73,400 | 52,700 | 4,676 | 16,040 |
| 1986 | 59,964 | 74,700 | 52,800 | 4,015 | 17,840 |
| 1987 | 58,502 | 75,000 | 52,000 | 3,935 | 19,040 |
| 1988 | 72,589 | 84,800 | 65,500 | 4,436 | 14,890 |
| 1989 | 72,065 | 85,700 | 65,100 | 3,802 | 16,820 |
| 1990 | 80,225 | 94,200 | 69,500 | 8,606 | 16,050 |
| 1991 | 81,523 | 106,000 | 68,100 | 9,676 | 28,280 |
| 1992 | 80,750 | 99,000 | 70,300 | 8,676 | 20,060 |
| 1993 | 88,740 | 104,300 | 75,100 | 10,190 | 19,000 |
| 1994 | 103,422 | 119,100 | 85,300 | 12,566 | 21,230 |
| 1995 | 103,813 | 120,400 | 84,900 | 13,430 | 22,020 |
| 1996 | 104,639 | 124,200 | 84,200 | 15,343 | 24,650 |
| 1997 | 106,821 | 129,600 | 81,000 | 20,610 | 27,970 |
| 1998 | 117,411 | 135,000 | 93,100 | 16,212 | 25,720 |
| 1999 | 123,461 | 142,000 | 103,200 | 13,271 | 25,550 |
| 2000 | 118,290 | 136,100 | 89,200 | 20,241 | 26,670 |
| 2001 | 126,687 | 144,600 | 98,600 | 18,076 | 27,870 |
| 2002 | 162,967 | 184,400 | 129,300 | 20,609 | 34,480 |
| 2003 | 155,090 | 183,400 | 120,800 | 21,250 | 41,450 |
| 2004 | 158,528 | 194,100 | 122,600 | 21,416 | 50,020 |
| 2005 | 186,274 | 217,000 | 142,200 | 27,150 | 47,650 |
| 2006 | 185,299 | 223,400 | 145,800 | 24,233 | 53,330 |
| 2007 | 144,508 | 170,800 | 108,900 | 22,614 | 39,250 |
| 2008 | 133,338 | 163,200 | 101,300 | 22,460 | 39,410 |
| 2009 | 11,7061 | 144,212 | 82,495 | 25,563 | 36,154 |
| 2010 | 94,953 | 120,602 | 67,234 | 20,330 | 33,037 |

**Appendix Table A2.** Reconstructed total catch (in tonnes), by major taxonomic group for Maldives, 1950-2010. 'Others' contain 18 additional taxonomic categories.

| Year | Tuna | Carangidae | Lutjanidae | Fusilier | Others |
|---|---|---|---|---|---|
| 1950 | 11,000 | 1,150 | 611 | 305 | 1,480 |
| 1951 | 17,300 | 1,170 | 619 | 305 | 1,490 |
| 1952 | 17,500 | 1,170 | 619 | 305 | 1,490 |
| 1953 | 17,700 | 1,180 | 626 | 347 | 1,560 |
| 1954 | 18,300 | 1,200 | 634 | 347 | 1,570 |
| 1955 | 19,100 | 1,210 | 641 | 361 | 1,600 |
| 1956 | 19,800 | 1,230 | 649 | 361 | 1,600 |
| 1957 | 20,400 | 1,240 | 656 | 361 | 1,610 |
| 1958 | 21,000 | 1,250 | 664 | 361 | 1,620 |
| 1959 | 22,800 | 1,270 | 671 | 361 | 1,620 |
| 1960 | 21,600 | 1,340 | 710 | 305 | 1,560 |
| 1961 | 21,000 | 1,370 | 725 | 305 | 1,570 |
| 1962 | 19,700 | 1,400 | 740 | 305 | 1,580 |
| 1963 | 20,500 | 1,430 | 759 | 305 | 1,610 |
| 1964 | 21,300 | 1,460 | 774 | 305 | 1,620 |
| 1965 | 24,800 | 1,500 | 793 | 488 | 1,950 |
| 1966 | 27,200 | 1,530 | 810 | 594 | 2,140 |
| 1967 | 26,600 | 1,570 | 830 | 669 | 2,290 |
| 1968 | 30,500 | 1,600 | 846 | 630 | 2,230 |
| 1969 | 31,600 | 3,720 | 1,971 | 694 | 3,260 |
| 1970 | 35,300 | 1,760 | 931 | 931 | 2,650 |
| 1971 | 36,000 | 2,060 | 1,093 | 902 | 2,830 |
| 1972 | 30,900 | 4,120 | 2,180 | 645 | 3,880 |
| 1973 | 32,600 | 2,810 | 1,486 | 905 | 3,260 |
| 1974 | 34,400 | 2,990 | 1,583 | 918 | 3,860 |
| 1975 | 26,000 | 3,170 | 1,676 | 644 | 3,470 |
| 1976 | 29,100 | 3,820 | 2,023 | 775 | 3,780 |
| 1977 | 28,400 | 4,050 | 2,144 | 631 | 4,830 |
| 1978 | 28,600 | 4,750 | 2,514 | 561 | 5,510 |
| 1979 | 31,700 | 4,840 | 2,563 | 694 | 5,280 |
| 1980 | 35,200 | 4,920 | 2,604 | 843 | 6,370 |
| 1981 | 36,100 | 5,440 | 2,881 | 818 | 5,260 |
| 1982 | 35,400 | 6,320 | 3,346 | 625 | 5,820 |
| 1983 | 40,000 | 5,490 | 2,905 | 777 | 5,420 |
| 1984 | 49,300 | 5,480 | 2,901 | 1,012 | 5,180 |
| 1985 | 54,400 | 7,060 | 3,736 | 1,132 | 7,090 |
| 1986 | 56,700 | 6,310 | 3,341 | 1,141 | 7,190 |
| 1987 | 57,600 | 5,920 | 3,135 | 1,130 | 7,260 |
| 1988 | 68,500 | 4,450 | 2,355 | 1,498 | 7,960 |
| 1989 | 69,400 | 4,820 | 2,554 | 1,573 | 7,360 |
| 1990 | 75,300 | 5,070 | 2,685 | 1,779 | 9,330 |
| 1991 | 83,400 | 7,360 | 3,895 | 1,850 | 9,520 |
| 1992 | 78,600 | 6,540 | 3,461 | 2,034 | 8,390 |
| 1993 | 81,700 | 7,430 | 3,936 | 2,324 | 8,900 |
| 1994 | 93,500 | 8,710 | 4,609 | 2,652 | 9,610 |
| 1995 | 93,900 | 8,950 | 4,740 | 2,582 | 10,220 |
| 1996 | 97,100 | 9,160 | 4,849 | 2,504 | 10,580 |
| 1997 | 97,200 | 11,470 | 6,074 | 2,358 | 12,450 |
| 1998 | 105,500 | 10,470 | 5,544 | 2,656 | 10,860 |
| 1999 | 117,600 | 7,460 | 3,951 | 2,886 | 10,020 |
| 2000 | 103,300 | 11,830 | 6,263 | 2,450 | 12,280 |
| 2001 | 114,300 | 10,730 | 5,678 | 2,659 | 11,280 |
| 2002 | 150,800 | 11,220 | 5,942 | 3,424 | 12,990 |
| 2003 | 149,300 | 12,000 | 6,353 | 3,144 | 12,690 |
| 2004 | 159,900 | 12,090 | 6,399 | 3,212 | 12,500 |
| 2005 | 178,700 | 13,590 | 7,192 | 3,744 | 13,770 |
| 2006 | 189,300 | 11,320 | 5,995 | 3,863 | 12,940 |
| 2007 | 138,000 | 11,950 | 6,325 | 2,903 | 11,580 |
| 2008 | 133,800 | 10,610 | 5,618 | 2,700 | 10,390 |
| 2009 | 110,850 | 13,404 | 7,096 | 2,199 | 10,663 |
| 2010 | 91,667 | 11,665 | 6,176 | 1,792 | 9,302 |