International Seafood Sustainability Foundation

A review of bycatch in the Indian Ocean gillnet tuna fleet focussing on India and Sri Lanka

Submitted by

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Acronyms

ASFA	Aquatic Sciences and Fisheries Abstracts
CMFRI	Central Marine Fisheries Research Institute, Kochi
CPC	Members and Cooperating, Non-contracting Parties (of IOTC)
CPUE	Catch per Unit Effort
DAHD	Department of Animal Husbandry and Dairying, New Delhi
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organisation
FRP	Fibre Reinforced Plastic
GRT	Gross Registered Tonnage
ICSF	International Collective in Support of Fishworkers
INR	Indian Rupees
IOTC	Indian Ocean Tuna Commission
ISSF	International Seafood Sustainability Foundation
IUU	Illegal, Unreported and Unregulated Fishing
LOA	Length Overall
MoA	Ministry of Agriculture, India
MPEDA	Marine Products Export Development Authority, Kochi
MSC	Marine Stewardship Council
NGO	Non-governmental Organisation
OBM	Outboard motor
RFMO	Regional Fisheries Management Organisation
WPEB	IOTC working party on ecosystems and bycatch
WWF	World Wide Fund for Nature
hp	Horsepower

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Executive Summary

Background and Purpose

The tuna fisheries of the Indian Ocean differ to those in other parts of the world in that artisanal and semi-industrial fisheries are responsible for over 54% of all catches[1], with gillnets responsible for 40% of all catch. The characteristics of the gillnet fisheries of Indian Ocean coastal States are largely unknown, as are levels of bycatch. Bycatch from gillnets is an issue of increasing global concern.

This report provides results of an initial study commissioned by ISSF in order to enable a snapshot characterisation of the bycatch rates of non-target species in key gillnet fisheries for tuna and tuna like species. It provides a brief description of Indian Ocean gillnet fleets and associated bycatch based on data available from the Indian Ocean Tuna Commission (IOTC) nominal catch database. It also collates and assesses available information on bycatch from India and Sri Lanka including compilation of local language grey literature and, where possible, interviews with local fishers. These two countries were highlighted due to relative ease of access to available information whilst noting that there are other major gillnet fisheries in the Indian Ocean. Levels of bycatch in gillnet fleets and areas that may warrant further study are highlighted.

In the report when referring to 'bycatch' we adopt the terminology used by the IOTC, defined by the working party on ecosystems and bycatch (WPEB) as follows:

> "*all species caught in IOTC fisheries other than the 16 species of tuna and tuna-like species that are listed in the IOTC agreement*"

It is also noted that in most developing Indian Ocean countries there is full catch utilisation and there is little discarding of fish.

To remain consistent with data reported to IOTC, all gillnet fishing is considered 'artisanal' but where possible references to fleets are based on information on vessel size and level of mechanisation.

Gillnet Fleet Characteristics

Twenty one Indian Ocean coastal States (countries) fish with gill nets for tuna and tuna like species. Seven were identified as the major contributors to gillnet catch in the Indian Ocean: India, Indonesia, Islamic Republic of Iran, Oman, Pakistan, Sri Lanka, and Yemen. The latter is not a member or cooperating non contracting party to IOTC (often referred to as IOTC CPCs). Gillnet catches from these countries were of an order of magnitude greater than for any other country and were in the range 20,700 (Yemen) - 169,000 t (Iran)per annum.

Data reporting to IOTC by many CPCs with gillnet fleets was found to be poor across all mandatory requirements, including: fleet characteristics, size composition, and catch data (no or inadequate disaggregated species composition data for target and bycatch species).. Only IOTC CPCs have an obligation to report mandatory statistics to IOTC, so data would be expected for all except Yemen amongst the top seven countries. However, reporting of fleet structure and size was found to be

[1] Including both tuna and tuna like species and 'bycatch' species

inconsistent between the different datasets held by IOTC. The Islamic Republic of Iran and Oman reported the largest fleet sizes. Accurate verification however, and quantification of overall fleet composition was not possible from data submitted to IOTC. This was compounded by the fact that gear is not dependent on vessel type, and that frequently any one vessel may fish using multiple gear combinations.

In India, there was a clear distinction between fleet composition and vessel numbers between eastern and western States. Western States were characterised by fewer mechanised vessels, whereas eastern States had a higher number of less mechanised vessels. Segmentation by gear was not possible for the fleets, and in-country interviews indicated that across all vessel types, various gears are used interchangeably depending on factors such as weather, time of year and target species. In general, gillnets were used when fishing closer to shore.

In Sri Lanka gillnets were found to be the main gear employed for both the coastal and offshore fisheries. The highest numbers of mechanised, multi-day vessels were reported for the South West of the country. There was no available breakdown of vessel types by gear, but sources indicated that, as in India, gears were interchangeable across vessel types.

Gillnet Catches, Bycatch and Discards

There is a paucity of information available on bycatch associated with gillnet fisheries throughout the Indian Ocean and it is not possible to accurately quantify the level of bycatch that can be attributed to gillnet vessels that target tuna and tuna like species.

Relative to other gear types employed to catch tuna species in the Indian Ocean, catches of bycatch species from gillnet fishing were found to be high across all species groups, but especially so for sharks. Gillnets account for 40% of tuna and tuna like species reported to IOTC and 64% of shark catches. Due to the quality of submitted data, and the requirement for the IOTC Secretariat to estimate elements of the nominal catch database, data are subject to uncertainty. Nevertheless, bycatch data for non-tuna like bony fish and sharks was available in IOTC data. For turtles, cetaceans and seabirds, very little data were available, although information available in the literature suggests that there is a high risk of turtle mortality within the Indian Ocean from gillnets. Due to the high numbers of gillnet vessels operating in countries to the east of the Indian Ocean (Indonesia, Sri Lanka) this area is considered a high risk area for bycatch of turtles and cetaceans. The greatest bycatch was attributed to the seven countries previously noted as having significant gillnet catches.

The gillnet fisheries of India were found to be highly diverse, and those that targeted tuna and tuna like species were less significant than those that targeted other species. Catch composition was subject to high variability by State. In Southern States, clupeid catches accounted for a large portion of catch. Eastern State catches were dominated by invertebrates and a high number of other, mixed species. Catches in the West were significantly greater than in the East.

Bycatch from targeted tuna gillnet fisheries in India was difficult to quantify. There was conflicting evidence as to levels of shark bycatch. For example, data submitted to IOTC suggest that shark catches by Indian vessels are low. However, in government sources, shark catches were found to be > 80,000 t / year. Elasmobranch catch was split evenly between eastern and western provinces and was not driven by vessel type, suggesting that elasmobranchs are actively targeted across all gears and vessels. Average turtle bycatch was 0.24 per vessel per year for the six fishers interviewed in Tamil Nadu. Only one record of cetacean interaction was reported by one fisher who had caught one dolphin in a gillnet and which had been released alive. Information reported in the literature however suggests that cetaceans are at high risk from gillnet fishing. Responses to questionnaires suggested that fishers are reticent to report incidental catches of turtles and cetaceans due to their protection by legislation. Other literature suggests that high levels of turtle mortalities occur along the East coast of India and that this area is extremely high risk to both turtles and cetaceans, but separating or quantifying the risks from gillnets alone was not possible.

Sri Lanka was the third highest fish producing country within the IOTC area. As with India, the fisheries were found to be highly diverse, with tuna not being dominantly exploited. There was less information available on targeted species than was the case for India, but NGOs concerned with gillnet and bycatch issues suggest that high quantities of elasmobranch and turtle bycatch result from the Sri Lankan gillnet fleets. Turtle bycatch was found to be high, and although about 80% were released alive, levels of bycatch have grown, and this has been attributed to growth in the gillnet fleet.

Details from India and Sri Lanka suggest the majority of tuna based products are exported. The market demand for both sharks and rays is strong and these may often be the target of gillnet fisheries. This implies that suggestions to introduce bycatch mitigation measures for gillnets would be ineffective (i.e. not implemented) in the case of elasmobranchs.

Areas that may warrant further study

This study has highlighted that despite significant gillnet fisheries targeting tuna and tuna like species throughout the countries of the Indian Ocean there is a paucity of information available on bycatch associated with gillnet fisheries, and what data is available is inconsistent. At present it is not possible to accurately quantify the level of bycatch that can be attributed to gillnet vessels targeting tuna and tuna like species.

Of twenty one Indian Ocean coastal countries that fish with gill nets for tuna and tuna like species, seven were identified as the major contributors to gillnet catch and in particular warrant further study and engagement with: India, Indonesia, Islamic Republic of Iran, Oman, Pakistan, Sri Lanka, and Yemen.

The IOTC is the RFMO responsible for managing tuna fisheries in the Indian Ocean and will be a critical body to engage with in relation to its gillnet fisheries. Recognising the poor quality of data reporting, IOTC is taking a number of measures to improve data reporting by 'artisanal' gillnet fleets (e.g. the Commission in 2012 passed a Resolution on minimum reporting requirements for gillnet vessels within the IOTC area of competence (Proposal, L (Rev 3), 2012)), to improve bycatch reporting, and to verify reported catches through a regional observer programme.

Whilst engagement with IOTC and support for its measures is important, there is a need to build capacity within the developing coastal countries of the IOTC in order to improve national reporting against the requirements for mandatory statistics and minimum requirements for gillnets, and to implement observer programmes. There is an IOTC requirement for 5% national observer coverage on all vessels targeting tuna and tuna like species (Resolution 11/04) for all fishing CPCs but the current level of implementation is variable. Some of the highlighted coastal countries either have observer programmes for gillnet fisheries in place (e.g. Pakistan) or plan to implement them in future (e.g. Iran). Others indicate that observer programmes will not be feasible due to the small size of the vessels, and instead plan to develop improved port sampling programmes (e.g. Sri Lanka). Targeted capacity building is thus another major area that would warrant further effort.

In addition to the IOTC regional observer scheme, a coordinated effort to increase observer coverage at the national level throughout the region should be investigated. To maximise effectiveness and resources, coverage should be prioritised by areas identified as high risk on a national level. For example, in India, the eastern coast, especially along Orissa should be a priority, based on the high estimates of turtle mortality. Implementation of such a scheme will require significant capacity building and international support.

Looking beyond IOTC CPCs, Yemen is a significant gillnet fishing country and is not yet a member of IOTC. Participation in IOTC by Yemen should be encouraged in order that they engage in regional fisheries management measures and report information on their catch of tunas and bycatch species to that body.

Gillnet fishing is typically non-selective, but bycatch mitigation research planned by Iran and Pakistan should be supported, and mechanisms for providing incentives to fishers to avoid bycatch should be explored.

Market based information can provide an alternative means of estimating bycatch although it cannot always be attributed directly to gillnet fisheries. For elasmobranchs the relatively good catch and trade data mean that at least part of the landings can be monitored, and their status assessed. Thus in addition to fisheries data collection, management bodies should obtain supplementary trade data to cross check and verify reported catch data.

In addition to engaging with fisheries bodies and fishers in the countries responsible for the greatest gillnet catches, engagement more broadly with non-governmental organisations that have an interest in gillnet fisheries and their associated bycatch is warranted. Possibly building on recent WWF experience, a larger workshop including all interested stakeholders would be warranted, inviting each participant organisation to present the information available to them in order to build a more detailed picture of gillnet fisheries in the Indian Ocean, associated 'bycatch' issues, to discuss the concerns of the different interests, and to seek innovative solutions to conservation issues. In the absence of a forum for collective engagement, it is warranted to seek and engage with relevant individual stakeholders to share information.

1. Introduction

1.1. Background

The International Seafood Sustainability Foundation (ISSF) was founded in 2008 by a group of scientists, industry leaders and environmental advocates with a shared concern as to the future of tuna fisheries. Today, the global coalition has partners and supporters working across the world to achieve its mission of undertaking science based initiatives for the long term conservation and sustainable use of tuna stocks, reducing bycatch, and promoting ecosystem health. A core theme to this mission is bycatch reduction and mitigation. Up to now, ISSF have put a considerable effort into the research and implementation of bycatch mitigation measures in 'industrial' fisheries, especially for purse seine fleets. This report provides an initial characterisation of management concerns associated with what, in the context of fisheries targeting tuna, is termed bycatch from artisanal and semi-industrial gillnet fisheries in the Indian Ocean, initiated due to growing global concern of their environmental impacts, and the large proportion of tuna fisheries employing this type of gear. In the context of this report we use the IOTC definition of 'bycatch', explained more fully in Section 1.2 where we also discuss the use of the term 'artisanal'.

A small number of highly industrialised purse seine vessels produce 65% of global tuna landings [1]. In contrast, 'artisanal' fisheries are responsible for over 54% of all Indian Ocean tuna catches[2]. In the context of the Indian Ocean Tuna Commission, the term 'artisanal' is used loosely and can include vessels greater than or less than 24m in length that fish outside the flag state EEZ. This review focuses on gillnet fisheries and the term artisanal is considered to apply to all categories of gillnet vessels.

Fisheries for tuna and tuna-like species in the Indian Ocean are managed by the Indian Ocean Tuna Commission (IOTC) whose stated objective is to:

"*Promote cooperation amongst its Members with a view to ensuring, through appropriate management, the conservation and optimum utilisation of stocks covered by this Agreement and encouraging sustainable development of fisheries based on such stocks."*

It aims to meet this objective through a combination of mechanisms including: the collection, analysis and dissemination of scientific information, catch and effort statistics and other data relevant to management.

However, a number of coastal States in the Indian Ocean are recognised as developing countries, with serious capacity and infrastructure constraints. This impedes their ability to collect and submit the data necessary to meet their reporting obligations and subsequently the ability of IOTC to meet its stated objective. High participation by developing Indian Ocean coastal States may be a reason for the high proportions of catch attributed to the artisanal sector. Generally, small and medium scale vessels within developing countries may favour use of gillnets as they are low cost and a gear that has low energy consumption for the fuel to fish relationship[3]. Gear is relatively cheap and can be used with a wide range of vessels, from traditional, non-motorised craft, through to larger 24m + vessels. Within the Indian Ocean, gillnets account for a high proportion of catch, however data and statistics remain poor[4].

Gillnet fishing is a passive type of net where fish are 'gilled', entangled or enmeshed in the netting. Several different types of net may be combined in one gear. Gillnets may comprise a single unit of net or, may comprise long lengths of net units joined together. They can be used to fish on the surface, in midwater, or demersally and therefore take a wide variety of fish and therefore defining whether the fishery is targeting tuna can be difficult. Individually, gillnets can be a selective gear, as the species and size of fish caught will be limited by the mesh size. However, a wide array of mesh sizes are available, which may be interchanged or used together on one vessel, and thus become non-selective as a fishing gear *en masse* and in the context of tuna targeted fisheries are associated with high quantities of 'bycatch'. The quality of fish is often low, as the fish can remain in the water for long periods of time and become damaged. However, quantitative catch data is often lacking due to inadequate in-country reporting systems and the large numbers of vessels involved in fisheries employing gillnets. Gillnet bycatch can include bony fish, seabirds, elasmobranchs, turtles, and cetaceans; conservation concern is focussed on the latter three, which may have wider ecosystem and biodiversity implications[5].

1.2. Purpose and Scope

This study provides an initial characterisation and summary of Indian Ocean tuna targeting gillnet fleets. For the purposes of this study, in order to bring all available data together the Indian Ocean is defined as FAO Areas 51 and 57 (Western and Eastern Indian Ocean) (See Figure 1) as used by IOTC.

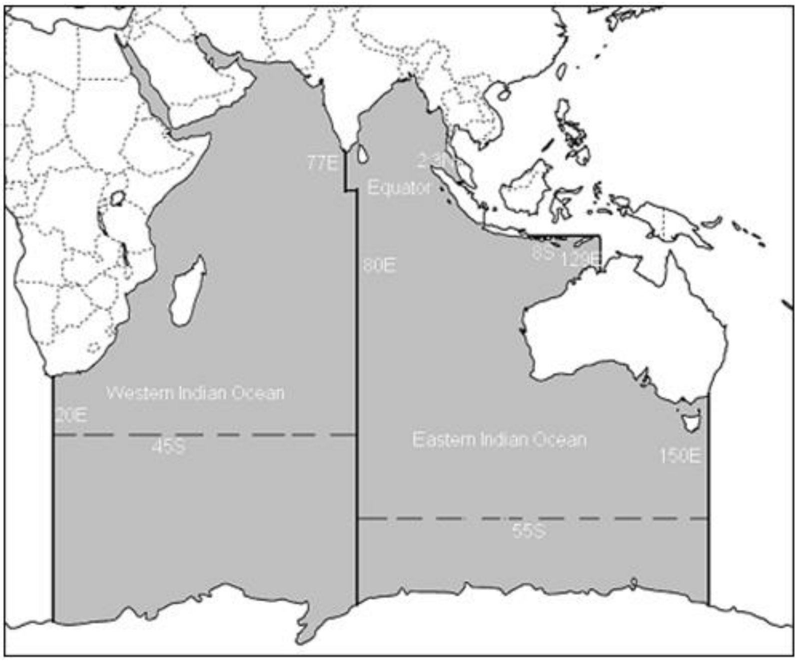


Figure 1 Indian Ocean FAO Areas 51 and 57.

This study does not provide a comprehensive review of the literature on gillnet fisheries. It focuses on using available data from IOTC and from India and Sri Lanka with the aim of providing a snapshot characterisation of the Indian Ocean gillnet fleets and the composition of 'bycatch' in 'artisanal' gillnet fisheries for tuna and tuna like species.

Although gillnet fisheries account for nearly 40% (IOTC nominal catch data: Figure 2) of reported catches in the Indian Ocean, there is limited and often conflicting information for both target and

IOTC bycatch species. Information that is available is often of poor quality and subject to a high degree of uncertainty. In addition, there is frequently a lack of clarity between what constitutes target and non-target catches.

The definition of ‘bycatch’ within the literature and between regional fisheries management organisations (RFMOs) varies. In all cases it refers to catches of all non-target species of a fishery. The discrepancy in its use relates to whether the catch is retained or discarded and thus there is not a consistent separation of information on retained bycatch versus discarded bycatch.

In addition, because the fisheries of the Indian Ocean are highly diverse, target species may overlap with those traditionally treated as bycatch in other regions (e.g. sharks). For the purpose of this report, and to maintain consistency, we adopt the terminology used by the IOTC, defined by the working party on ecosystems and bycatch (WPEB) as follows:

“*all species caught in IOTC fisheries other than the 16 species of tuna and tuna-like species that are listed in the IOTC agreement” (see* Table 2*).*

In using this definition throughout the report, bycatch species can be grouped into five broad categories: non-tuna like bony fish, elasmobranchs, turtles, cetaceans and seabirds.

The confusion over the definition of artisanal fisheries is of particular importance in the Indian Ocean as over 50% of catches are considered to be artisanal. The term however, is used dynamically and interchangeably across the World. In the past, artisanal fisheries have been characterised by coastal fisheries; but recent advances in technology, and access to relatively cheap fuel has meant that this is often not the case. Within the Indian Ocean, it can be difficult to differentiate between fleets operating exclusively within a coastal State’s EEZ, and those operating further offshore. The FAO Glossary of Fisheries for example, presents three different definitions for the term[6]. Generally gillnet fisheries are prevalent across all scales; small scale, artisanal through to more industrial scale, but again there is no objective description for these scales. Within the context of Indian Ocean tuna fisheries the classification between industrial, semi-industrial and artisanal is left to flag States to decide when reporting data to IOTC. Vessels of less than 24m length overall (LOA) are generally reported as artisanal in the IOTC vessel register, but the term artisanal is often used loosely to include larger vessels that originate from developing coastal countries that fish with gillnets and other gears. For the purposes of this report, to remain consistent with data reported to IOTC, all gillnet fishing is considered “artisanal” in that all gillnet catches reported to IOTC would appear to fall within this category, but use of the term is kept to a minimum and references to fleets, where possible, are based on information on vessel size and level of mechanisation.

In this report, in the context of IOTC ‘Coastal State’ refers to Members and Cooperating non-Contracting Parties (CPCs) within the IOTC area of competence. Not all countries in the area are CPCs and thus the term Indian Ocean Countries is also used in a wider context, e.g. to include non CPCs.

Review of publically available and grey literature combined with small scale questionnaire surveys in two key ports (in India) are used to provide a description of Indian Ocean gillnet fleet characteristics, and an estimation of the amount of bycatch landed or discarded. Conclusions are drawn on where information gaps remain and recommendations are proposed for actions to address these information gaps.

1.3. Structure of Report

Table 1 provides a summary of Tasks carried out to complete the review and the section of the report relevant to each.

First, Section 2 details the methods and information sources used to complete the review. Section 3 summarises the fleet characteristics for India and Sri Lanka and other Indian Ocean states. Section 4 summarises the catch and bycatch data available.

Section 5 provides a brief summary of market trends currently driving Indian Ocean export markets. Our conclusions (Section 6) and recommendations for further action are then presented (Section 7).

Table 1 A guide to the structure of this report indicating details of the tasks and section where they are addressed.

Task	Detail	Report Section
Review of IOTC data and literature	Review data submitted to IOTC by Member States and summarise what information is subsequently available (Catch by vessel-gear & flag & location; vessel size; catch rates; target species & bycatch).	Section 3.1 Section 4.1
In country data acquisition	Visit to Sri Lanka and travel within India to gather data, grey literature and where appropriate complete questionnaires through direct interviews.	Section 3.3 Section 3.4 Section 4.3 Section 4.3 & 4.4
Fleet characteristics	Characteristics of gillnet vessels that target tuna for all or part of the year.	Section 3
Catch statistics	Quantification of tuna catch and bycatch and discards by gillnetters within / outside EEZ.	Section 4
Market use	Brief description of use made (markets for) of targeted tunas and bycatch (% to each market type - export, domestic and subsistence).	Section 0
Trade analysis	For coastal states with significant artisanal fisheries for tuna, summary of exports of tuna and determine if certification request been registered.	Section 0
Report Findings	Levels of bycatch in gillnet fleets and areas that may warrant further study	Section 8

2. Methods

2.1. Review of IOTC Data and literature

The majority of data available for catches in the Indian Ocean are collected and submitted to the IOTC by CPCs. Analysing available IOTC data was considered to be the most important source of information for providing an overarching "snapshot" of the Indian Ocean gillnet fleets and fisheries in general. IOTC mandatory reporting requirements extend to the 16 tuna and tuna-like species listed in Annex II of the IOTC Agreement (**Table 2**).

Table 2 A list of tuna and tuna-like species covered by the IOTC Agreement.

	English Name	Scientific Name
1.	Yellowfin tuna	*Thunnus albacares*
2.	Bigeye tuna	*Thunnus obesus*
3.	Skipjack tuna	*Katsuwonus pelamis*
4.	Albacore	*Thunnus alalunga*
5.	Southern bluefin tuna	*Thunnus maccoyii*
6.	Swordfish	*Xiphias gladius*
7.	Black Marlin	*Makaira indica*
8.	Blue Marlin	*Makaira nigricans*
9.	Striped marlin	*Tetrapturus audax*
10.	Indo-Pacific sailfish	*Istiophorus platypterus*
11.	Longtail tuna	*Thunnus tonggol*
12.	Kawakawa	*Euthynnus affinis*
13.	Frigate tuna	*Auxis thazard*
14.	Bullet tuna	*Auxis rochei*
15.	Narrow-barred Spanish mackerel	*Scomberomorus commerson*
16.	Indo-Pacific king mackerel	*Scomberomorus guttatus*

Any other bony fish are considered to be bycatch. There is no obligatory requirement to report on any other bony fish species falling outside of the mandate or cetaceans. However, Resolution 10/02 encourages CPCs to "*record and provide data on species other than sharks and tunas taken as bycatch".* The reporting of interactions with turtles, sharks and seabirds are covered by other mandatory Resolutions.

The publicly available datasets were downloaded from the IOTC website[2]. To be as up to date as possible, the most recent datasets available were used in analyses (shown in brackets below). Not all datasets were used due to a high incidence of null values and a lack of data pertaining to gillnets:

- Nominal catches including aggregated shark catches and other bony fish (all reported catches from 2006 to 2010);
- Shark nominal catches (all catches from 2005 to 2009);

2 www.iotc.org

- CPUE for "Longline", "Purse Seine" and "Other" gears which includes Gillnets (although there was insufficient data for analysis)
- Fishing craft statistics (unless elsewhere stated, figures from 2007, the most recent year were used)
- IOTC Register of Authorised Vessels (figures in this report are the result of a search of the dataset on 2nd February 2012). All vessels over 24m, or those permitted to fish outside a country's EEZ must be on this list.

The proportion of IOTC catches attributed to gillnets was obtained from the nominal catch datasets. The gear and fleet details of countries found to have significant gillnet catches were further described, where possible through a combination of exploring the nominal catches, fishing craft statistics and the IOTC Register of Authorised Vessels. Fishing craft statistics were only available up to 2007 and were found to be incomplete due to inconsistencies with gillnet reported catches in the nominal catch data. A summary of the data available for 2007 are shown in Appendix 3 and information from this data is included where appropriate. The IOTC Register of Authorised Vessels provided limited information on fleet composition, as many of the countries with significant gillnet nominal catches did not report vessels on the Register.

IOTC nominal catch datasets for both IOTC species and sharks were used to summarise catch and bycatch composition for countries with significant gillnet catches. Analysis of gillnet CPUE data was not possible as the data were either incomplete due to a high incidence of null values or are aggregated with "Other" gear data. It was also not possible to investigate discard rates, as the recently compiled IOTC discard database had not, at the time of writing, been published.

In using the IOTC nominal catch databases in this report it should be acknowledged that the data are subject to uncertainty. Although IOTC has put considerable effort into coordinating and standardising data reporting formats, the number of CPCs engaged in fishing in the Indian Ocean which lack institutional capacity means that there is a high degree of data quality fluctuation between them. Data quality in nominal catch datasets for example, are scored from 0-3 depending on the technical and implementation procedures in place for data collection, analysis and reporting.

Other Sources of Information

Country specific fleet information for CPCs with substantial gillnet fisheries was also obtained from national reports submitted to annual IOTC Scientific Committee meetings.

Two additional significant sources of information on country-specific gillnet fishery detail included:

- An FAO study (Gillett, 2011)titled "Bycatch in Small Scale Tuna Fisheries: A Global Review"[7], and;
- A study commissioned by the Convention on Migratory Species using the Sea Around Us Project data (Waugh *et al.*, 2011), which consisted partially of IOTC data from 2006, but also data from local sources and academic studies titled "Assessment of Bycatch in Gillnet Fisheries"[8].

These two papers were useful references in complementing the findings within this study and are referred to throughout the discussions of the general Indian Ocean fleets.

To gauge certification status of fisheries in the Indian Ocean, Marine Stewardship Council (MSC) assessment applications for coastal States in the Indian Ocean were reviewed.

2.2. In-country data acquisition

Country visits were made within India and to Sri Lanka to further explore additional sources of information and to carry out a questionnaire survey of fishers involved in local artisanal gillnet tuna operations.

Library sources included the National Institute of Oceanography, the Goa University and the French Institute in Pondicherry in India, and the National Aquatic Resources Research and Development Agency in Sri Lanka. Special attention was given to grey literature collections, including unpublished local institution and government department reports and regional publications (for a full list see Appendix 1: List of literature obtained from in-country visits to India and Sri Lanka). Several online databases and literature repositories were also utilised, including Aquatic Sciences and Fisheries Abstracts (ASFA) through the National Institute of Oceanography; online databases maintained by the International Collective in Support of Fishworkers (ICSF); CMFRI's eprint library; the online CMFRI dataset[3] and the Sri Lanka Ministry of Fisheries and Aquatic Resources online dataset[4].

For the questionnaire survey two sites were selected to provide an insight into the diversity of tuna fisheries in India, covering the fishing operations, catch, bycatch and markets. One survey was carried out on the east coast (Tamil Nadu) and one along the west coast (Goa) of the mainland. A total of 11 semi-structured questionnaire surveys were completed in Feb 2012; five with artisanal fishers in Tamil Nadu (Injambakkam) and six with fishers of industrial fishing operations in Goa (Betul). Both groups of fishers interviewed used gillnets and targeted tuna along with other species for part of the year.

The questionnaires were conducted in the privacy of the fishers' homes to avoid the influence of others. In Injambakkam these were located in very close vicinity of the beach landing sites (where they land their crafts and catches), while in Betul most homes were some distance away. Boat owners were asked to participate in this survey, as other crew members often change crafts and owners they work with. Participants were asked to provide responses specifically pertaining to gillnets, however extra information on other gear was also recorded if it was used to target tuna.

The participants were asked to describe the details of their fishing operation including information on type and size of vessel, gear, the number of trips per year/season and the duration of the fishing trip. They were also asked to name the target species and bycatch species caught specific to the gillnet operations. Laminated photo identification cards of target and bycatch species were used to aid fishers in confirming catch composition. Participants were asked to estimate their costs and gross incomes (in Indian Rupees INR) per trip. Information on costs per trip were obtained for fuel, crew salaries, storage (ice) and food.

[3] http://www.cmfri.org.in/annual-data.html
[4] http://www.fisheries.gov.lk/statistics.html

3. Fleet Characteristics

3.1. Indian Ocean coastal state overview

The dominance of artisanal fleets in the Indian Ocean means that data available are subject to a high degree of uncertainty, hampering the ability of management bodies including IOTC to provide management advice for the conservation of tuna stocks and biodiversity. Where catch data are reported, catch location is rarely reported. Waugh *et al.*, (2011) highlighted that many developing countries within the Indian Ocean tend to fish within 20 nautical miles of their exclusive economic zone (EEZ), subjecting these regions to highest fishing density and consequently at risk to high levels of 'bycatch'. The majority of artisanal fleets within the Indian Ocean use a combination of fishing gear, but data is particularly lacking for fisheries using gillnets and pole and line[9]. Artisanal fleet data verification and quantification is hindered by a number of factors:

1) The high number of artisanal vessels makes monitoring control and surveillance challenging, yet overall they can catch similar volumes of tuna and tuna like species to a few, highly industrialised vessels that by contrast are easier to monitor and manage;
2) A high proportion of fleets in this category are from developing countries where institutional capacity for fisheries management is low;
3) Artisanal fisheries are scattered in nature and landings take place at multiple locations; data collection is logistically complex;
4) Market chains are diverse;
5) Artisanal fisheries tend to be multi-species, multi-gear fisheries with both subsistence and commercial fishers engaged, and often all species caught will be utilised making the concept of 'bycatch' redundant;
6) Where data are reported, species are often grouped into guilds (e.g. tuna, sharks, etc.) limiting the usefulness of statistics when attempting to adopt a species by species approach to management.

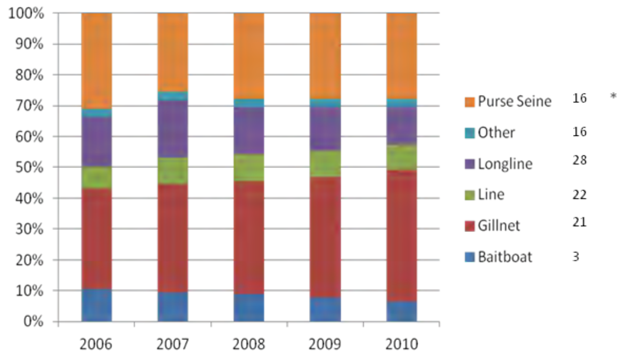
3.2. Gillnet fleets of Indian Ocean Coastal States

Between 2006 and 2010, gillnets contributed between 30-40% of all catches reported to IOTC, with a gradual increase in proportion over the five years. In comparison, for these years, purse seines were responsible for 25-30% of catches, and long lines remained constant at about 15%. This is in contrast to other Oceans where purse seines are generally responsible for the majority of catches. In the Indian Ocean, gillnets were the dominant gear used across all years, with gillnet catches reported for a total of 21 countries in this period (Figure 2). These data are consistent with Waugh *et al.*, (2011) which reported that 48% of catches in the Indian Ocean in 2006 came from gillnets. For six countries, gillnets were responsible for all catches (100 %) of IOTC listed tuna and tuna like species, and they accounted for 50% or more of the 'IOTC' catches for 13 further countries (Table 3). Table 3 excludes those countries that did not report any catches made by gillnets.

The IOTC nominal catch data reporting forms give the option for catches to be reported by broad, overall gear type, and also to sub-divide this into more specific gear categories. Gillnet catches can be sub-classed as the following "Artisanal – Gilllnets", "Semi-industrial - Offshore Gillnets" and "Semi-industrial - Gillnet / longline". Data on such a disaggregated level was rare, with only three entries for all countries between 2006 and 2010 reported by sub-category.

Establishing the number and size of vessels responsible for gillnet attributed tuna catches based on fishing craft statistics and the IOTC List of Authorised Vessels proved difficult. The IOTC vessel statistics dataset was incomplete, especially with regards to gillnet vessels. In some cases, such as with EU countries, gillnet vessels appear on the Register of Authorised Vessels, but no catches were recorded. Conversely, countries such as Bangladesh and Yemen reported 100% of catches deriving from gillnets, but no information on fleet composition was reported. The IOTC List of Authorised Vessels applies to vessels authorised to fish outside a CPC's EEZ. Both Waugh *et al.*, (2011) and Gillett (2011) reported a high proportion of catches attributed to small scale fisheries, which operate within the EEZ, and in many cases within 20 nautical miles of the coast. Comparison of vessels between countries was further hindered by inconsistent units of reporting; which included gross registered tonnage (GRT), and length overall (LOA) reported in feet and metres inconsistently.

Table 3 shows the seven Indian Ocean coastal CPCs with the greatest gillnet catches were India, Indonesia, the Islamic Republic of Iran, Oman, Pakistan, Sri Lanka, and Yemen, and catches from these CPCs were an order of magnitude greater than any other CPC. Whilst this report focuses on India and Sri Lanka where it was possible to collect additional material to that held by IOTC, we also provide available information on the other five major gillnet catch CPCs in the following sections.



* Numbers in legend represent the number of CPCs using this gear type for the periods 2006-2010.

Figure 2 **Total catch (t) by gear type, 2006-2010, as reported in IOTC nominal catch data across all species.**

Table 3 The percentage catch (all species) by gear for countries with gillnet catches represented in the IOTC nominal catch database, and the aggregated catch in t for 2006-2010.

CPC**	GEAR TYPES (% of catch)*						Total Catch
	GILL	BB	LINE	PS	LL	OTHR	
Bangladesh	100	0	0	0	0	0	22,342
Djibouti	100	0	0	0	0	0	801
Eritrea	100	0	0	0	0	0	5,473
Kuwait	100	0	0	0	0	0	685
Pakistan	100	0	0	0	0	0	197,792
Qatar	100	0	0	0	0	0	13,114
Sri Lanka	99	0	0	0	0	1	769,120
Iran, Islamic Republic	96	0	1	0	0	4	882,029
Oman	71	0	13	16	0	0	197,804
Yemen	58	0	42	0	0	0	179,587
United Arab	53	0	9	0	38	0	42,745
Saudi Arabia	51	0	23	0	24	1	47,694
East Timor	50	0	50	0	0	0	30
Kenya	46	0	16	17	21	0	11,401
India	46	12	12	10	14	7	696,278
Indonesia	37	2	11	14	2	35	1,344,404
Bahrain	14	0	66	0	20	0	468
Malaysia	7	0	0	10	13	69	125,575
Thailand	3	0	0	1	15	82	157,106
Total	**47**	**11**	**9**	**12**	**3**	**18**	**4,694,448**

*(**Longline = LL; Gillnet = GILL; Purse Seine = PS; Line = LINE; all other gear = OTHR).**

**** Australia and Maldives were omitted from this table due to catches of < 0.1%.**

Indonesia

IOTC data reported that 37% of Indonesia's tuna catches were from gillnets; Waugh *et al.*, (2011) reported a similar proportion (31%), when data was aggregated for two regions of Indonesia. However, the Indonesian national report submitted to the IOTC Scientific Committee in 2011, recorded only three gillnet vessels in the fleet. Part of Indonesia's EEZ falls within the IOTC Area and therefore reporting may be confounded by interpretation of whether a vessel is considered within the coastal fleet and thus outside reporting obligations to IOTC.

Islamic Republic of Iran

Fleet data for the Islamic Republic of Iran was available in all data sources, and reporting seems to be fairly consistent. The fishing craft statistics from 2007 report 6,363 gillnet vessels ranging from 0 to 100 GRT. The national report from 2011 reports 5,920 gillnet vessels and the fleet is disaggregated into the following (GRT) categories:

< 3 GRT	3 -20 GRT	21-50 GRT	50-100 GRT	>100 GRT
3,444	702	911	580	283

These figures suggest that the highest gillnet fishing pressure occurs within the Islamic Republic of Iran's EEZ and within 20 nautical miles of the coast; the Waugh *et al.* (2011) report estimates a gillnet catch density of 0.36 t km^{-2} within the EEZ.

Oman

Information for Oman was limited, as no national report had been submitted and the fishing craft statistics were null for 2007. However in 2006, 13,706 gillnet vessels between 1-24m LOA were reported. Waugh *et al.*, (2011) classified this fishery as larger than small scale, reporting the a relatively low gillnet catch density within the EEZ of 0.06 t km^{-2}; this may indicate that the majority of fleet fishes outside 20 nautical miles, potentially on the high seas. Within the Omani EEZ the use of large scale drift nets (>2.5km in length) is prohibited but there have been increased incidences of infringements reported. No large scale drift nets are permitted on the high seas[10].

Pakistan

According to the fishing craft statistics, in 2007, Pakistan's fleet comprised 2,308 vessels between 35-50 GRT. No national report was available with which to compare these figures, and at the time of writing, no vessels were on the IOTC Register of Authorised Vessels. All the tuna catch was reported to IOTC as coming from gillnets, which contrast with an estimate of 31% reported by Waugh *et al.*, (2011). Gillett (2011) considered the pelagic gillnetting vessels to be above the small-scale size, and were generally fully decked and inboard powered.

During the 9th IOTC Compliance Committee the delegate from Pakistan provided supplementary information to that contained in their Report of implementation for the year 2011[11]. It was indicated that gillnets were the only method used by that CPC to catch tuna. It was also indicated that 25 national observers have been appointed, and although they would benefit from training, they should be collecting data by July 2012. Locally experiments would be conducted on the hanging ratio of gillnets to mitigate against bycatch.

Yemen

At the time of writing, there were no vessels flagged to Yemen on the IOTC Authorised Vessel List which was likely to be because, few or no vessels operate in the high seas. According to Gillett (2011), vessels are traditional but motorised *Houris* (with outboard engines up to 75 hp) and *Sambuqs* with inboard engines of up to 150 hp. Gillett (2011) estimated that up to 90% of catches are considered small scale. IOTC fishing craft statistics only has data for Yemen up to 2002, when vessel numbers were reported as 9,925 between 5-26m LOA. Waugh *et al.*, (2011) reported much lower gillnet catch densities within the EEZ similar to those for Oman, and therefore it is unclear whether the fishing is concentrated within the EEZ or outside.

3.3. Gillnet fleets of India

IOTC Nominal catch data attributes 47% of India's catches over five years (2006-2010) to gillnets. Figure 3 indicates the catches of IOTC species and the 'IOTC-bycatch' from nominal catch data over this period. Whilst the bycatch volumes appear low relative to the catches of IOTC species, it is apparent that gillnets are responsible for approximately 50% of the bycatch.

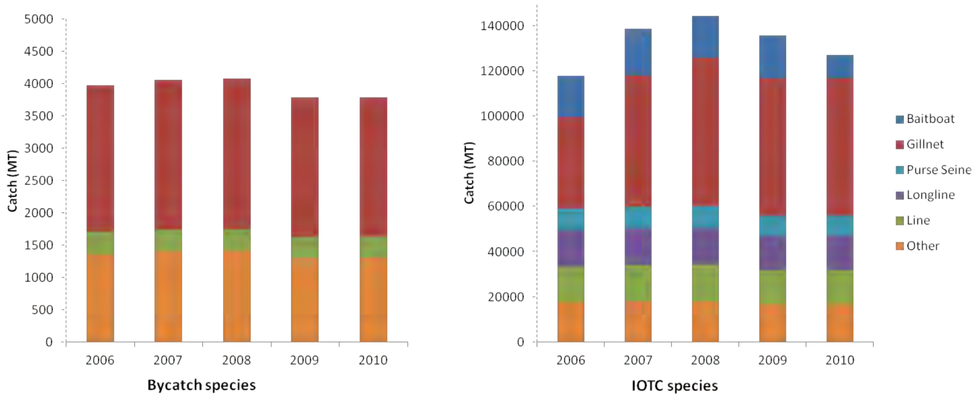


Figure 3 **Reported catches (t) by gear for India from IOTC nominal catch data (2006-2010): IOTC 'bycatch' (bony fish and sharks); and IOTC tuna and tuna-like species.**

The numbers of gillnet vessels and fleet composition operating either within or outside the Indian EEZ was difficult to estimate due to inconsistent reporting. According to the IOTC Register of Authorised Vessels there were seven Indian vessels that were not long lines, and authorised to fish outside of the EEZ. Of these, six were classified as 'line' vessels which could include both trolling and handline gears, ranging between 22-30m LOA. One vessel was classified as 'unknown' and had an LOA of 21.6m. The fishing craft statistic dataset, that includes vessels fishing within the EEZ, was similarly lacking in information and only reported 81 vessels for the year 2007, all of which were longliners. According to India's national report to IOTC however, India's coastal fleet consists predominantly of gillnet vessels, which do not specifically target tuna[12], but an estimate of vessel numbers is not reported. The National report differentiates between its coastal and offshore fisheries. The offshore fleet includes 295 hook and line or longline vessels, but no gillnet vessels, which is in contrast to the high catches attributed to gillnets in the nominal catch data.

Thus fleet composition data reported to IOTC by India appears inconsistent with reported catches in the nominal catch database. To estimate potential numbers of gillnet vessels we can extrapolate from gillnet vessel data reported by Pakistan and Iran (in the fish craft statistics, Appendix 3), which are consistent with catches reported by these two countries (Table 3). Applying an average catch per vessel from 2006-2010 for Pakistan and Iran to Indian gillnet catches, provides an estimate of 2,400-3,700 Indian gillnet vessels.

Internal data from the Ministry of Agriculture (MoA) which was not reported to IOTC gives the total number of vessels operating in India as 243,939; with vessels ranging from traditional, non mechanised vessels that are unable to operate far from the shore through to mechanised vessels. The vessels within this category are not further disaggregated by GRT, LOA or gear types. The MoA data clearly illustrate a distinction between Eastern and Western States, with the majority of mechanised vessels (which include those more likely to fish outside the EEZ) concentrated in the West, but a greater total number of vessels operating in the East (Figure 4). With this division of fleets, near-shore areas in the East could be assumed to be a greater risk area to species vulnerable to bycatch, whereas in the West, offshore environments may be subject to a higher risk. The in-country questionnaire aimed to explore this division further, covering a port from the Eastern (Tamil Nadu) and Western (Goa) coasts.

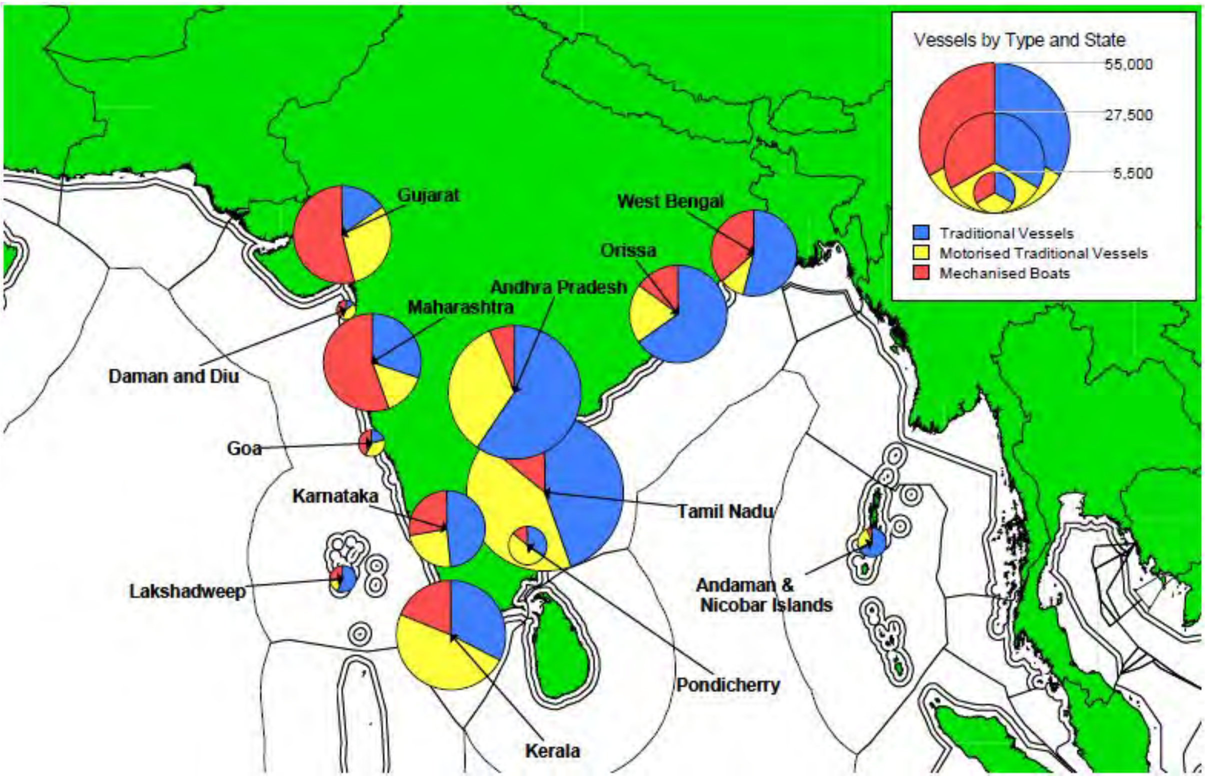


Figure 4 **Distribution of fishing vessels in India. Red indicates the most technologically advanced vessels (highly mechanised); yellow represents less complex mechanised vessels and blue those that are not mechanised. (Source: Ministry of Agriculture, India, 2010).**

In-country questionnaire: fleet results

The results from the questionnaires conducted in Tamil Nadu and Goa correspond with the fishing craft data from the Ministry of Agriculture (

Table 4). In Goa, the vessels were larger, able to fish further from the coast and spend more days at sea. The questionnaires conducted in Tamil Nadu were with fishers using 30 foot FRP vessels, using 10 horsepower engines which were introduced as a result of rehabilitation efforts after the 2004 tsunami. Such rehabilitation efforts have further complicated estimation of fleet numbers and characteristics. It is estimated that 88,035 fishing vessels were damaged or lost in the tsunami and that 1,181 landing centres were damaged[13]. In response to this, rehabilitation efforts resulted newer, more efficient foreign made vessels replacing those damaged. These newer vessels are able to fish further from shore, potentially making it difficult to differentiate between coastal and offshore fisheries. There is no information as to how these new vessels were regulated and controlled with regards to fishing locations. The national report does not describe how the coastal and offshore fleets are partitioned.

Table 4 **Typical vessel characteristics from questionnaire responses at two Indian site visits.**

	Tamil Nadu (East)	Goa (West)
Vessel Size (LOA in feet)	30	60-70
Engine Size	10 horse power outboard motor	Unknown
Average Trip Duration	5.25 (hours day $^{-1}$)	5.5 days
Trips Year^{-1}	252	68
Fuel: Litres Trip^{-1}	Gillnets: 7.5 l Hook and Line: 15	2000
Crew Size	3-4	Unknown

3.4. Gillnet fleets of Sri Lanka

Gillnets are normally operated from the following vessel types: a) motorized traditional canoe, b) 17-22' FRP crafts with an outboard motor, c) 3.5 t inboard (28-32') multipurpose vessels (the industrial sector). According to data from the Ministry of Fisheries and Aquatic Resource, there are a total of 46,138 vessels distributed throughout the country (Figure 5). Of these, 9% are considered able to undertake offshore fishing operations, and are concentrated mainly in the South West of the country, with none registered to any of the northernmost ports. The coastal artisanal fleet is primarily comprised of non motorized traditional craft and fibre reinforced plastic (FRP) boats fitted with outboard motors which make up 47% and 44% of this sector respectively.

Sri Lanka currently has over 3000 vessels on the IOTC authorised vessel list most of which are multipurpose gillnet longline vessels permitted to fish outside the countries EEZ. This is despite the fact that there is currently no provision in the national fisheries legislation for vessels to fish beyond the EEZ. Sri Lanka is currently in the process of revising its fisheries legislation, of introducing logbooks of improving bycatch reporting, introducing a vessel monitoring system[14] and has committed to provide IOTC with a detailed schedule for implementation of these control measures[15].

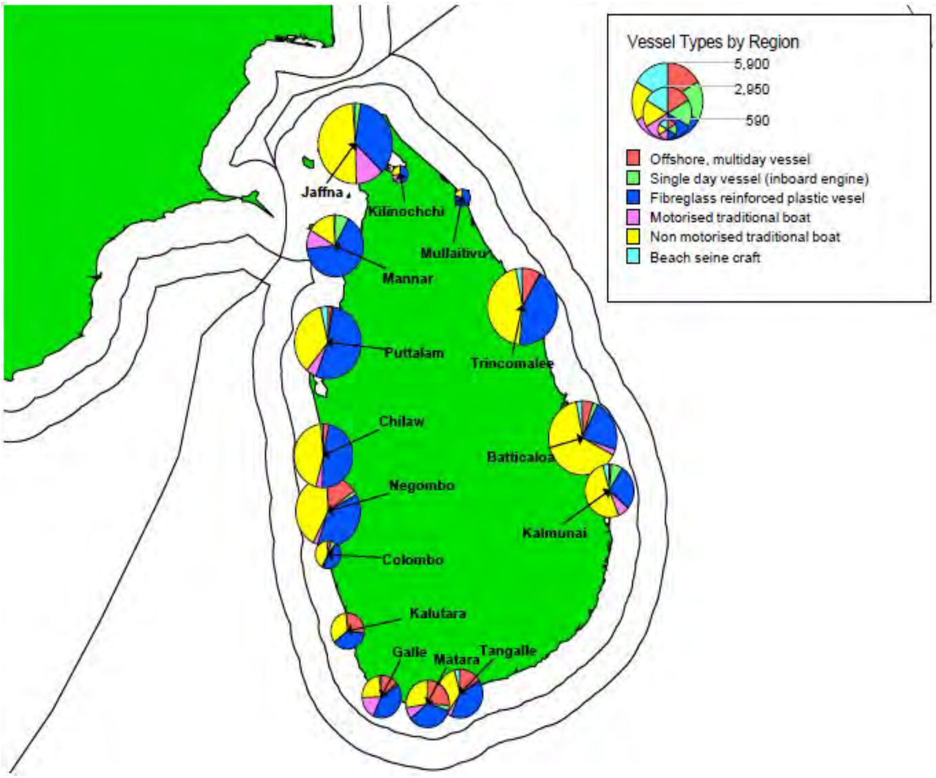


Figure 5 **Distribution of fishing vessels in Sri Lanka. Source: Ministry of Fisheries and Aquatic Resources, 2010.**

With respect to gillnet vessels that catch tuna: all available information sources documented the number of vessels active in Sri Lanka, but the details and specific vessel composition varied between sources (Table 5). At the time of writing, all vessels listed on the IOTC Register of Authorised Vessels (Appendix 3) and reported in the national report submitted by Sri Lanka to the IOTC Scientific Committee[16], were listed as gillnet *cum* longline vessels.

Table 5 **Sri Lanka fishing fleet composition in numbers by source of information.**

Source	Offshore Gillnets	Coastal Gillnets	Total Gillnet	All Offshore	All Coastal	Total
IOTC Register of Authorised Vessels (2012)	n/a	n/a	3,307	n/a	n/a	**n/a**
National Report (2011)	1,993	625	2,618	4000 (offshore)	n/a	**n/a**
IOTC Fishing Craft Statistics (2007)	n/a	n/a	2,618	n/a	n/a	**40,060**
Ministry of Fisheries and Aquatic Resources Data	n/a	n/a	n/a	3,346	42,792	**46,138**

Gillnets are the main gear employed in both coastal and offshore fisheries of Sri Lanka, and are responsible for the capture of nearly 80% of the coastal fish catch and 85-90% of the offshore fish catch[17]. With respect to tuna and tuna like species catches, gillnets account for 99% of the catches reported by Sri Lanka in the IOTC nominal catch database (Table 3) and almost 100% of the bycatch of non-tuna like species and elasmobranchs (Figure 6).

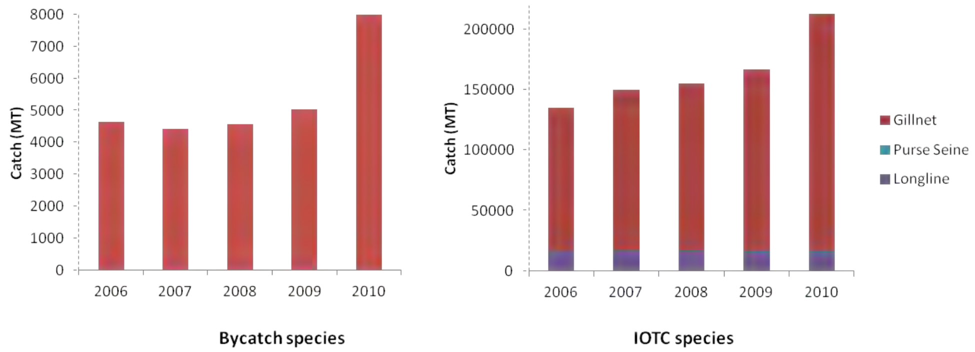


Figure 6 **Reported catch (t) by gear for Sri Lanka from IOTC nominal catch data (2006-2010): IOTC 'bycatch' (bony fish and sharks); IOTC tuna and tuna like species**

4. Catch, bycatch and discard data

4.1. Overview of catches of Indian Ocean coastal States

Review of IOTC catch data showed that the highest catching CPCs and Indian Ocean countries were largely represented by coastal States with gillnets being the main gear in use. Data from these CPCs was of a poorer quality and less robust than that of the more industrial scale CPCs. This is attributed to lack of capacity in developing CPCs, and in many cases, catch data were estimated by IOTC. In depth analysis was not possible due to available catch data being highly aggregated.

IOTC data would suggest that gillnet catches in the Indian Ocean are high, and interpretation of shark catches indicated that for elasmobranchs, gillnets are the main gear responsible for landings. It is unclear from these data alone whether this is due to elasmobranchs resulting as bycatch, or as being actively targeted by these Indian Ocean coastal States. In general, increased demand for shark fins, and more recently manta ray gills in China have been cited as a driver for enhanced elasmobranch catches in the Indian Ocean[18].

No IOTC data were available for cetaceans, turtles and seabirds. Wider literature searches found very few gillnet specific studies on these groups of bycatch. Several non-governmental organisations (NGOs) that have concerns related to bycatch issues were contacted. The Manta Ray Trust[5] indicated they held extensive data on elasmobranch bycatch levels from gillnets in India, Indonesia and Sri Lanka but it was not publically available. Similarly, Sea Turtles of India[6] also hold extensive data relating to turtle bycatch levels, but did not make these data available.

4.2. Indian Ocean Coastal States

Between 2006 and 2010, Indian Ocean coastal States (coastal CPCs) reported total catches to IOTC amounting to just over 8 million t. Ten countries were responsible for 80% of this catch (Figure 7). In 2006, almost 600,000 t of Indian Ocean catches came from gillnets (2006 IOTC data), which represented 3.6% of global gillnet catches (Waugh *et al.*, 2011).

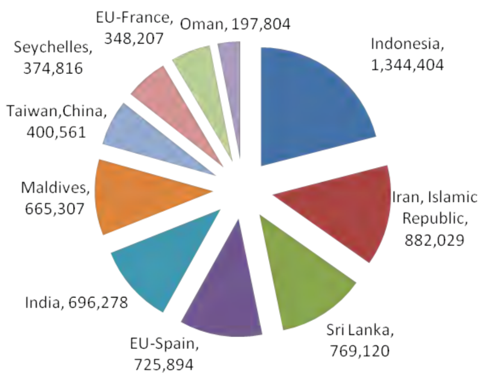


Figure 7 **Total catch (t) as recorded in the IOTC nominal catch dataset by the top ten landing CPCs aggregated from 2006 to 2010.**

[5] www.mantatrust.org
[6] www.seaturtlesofindia.org

As previously identified in Section 3, 7 out of 21 countries with gillnet catches from the Indian Ocean are of particular interest (Table 6) of which Yemen is not a member of IOTC. The same countries also landed the greatest volume of bycatch (**Figure 8**).

Table 6 **Annual gillnet catches by country reported in the IOTC nominal catch database and the average catch between 2006 and 2010 in descending order of total catch. Countries above the thick line had catches at least an order of magnitude greater than the others and were also in the ten countries with the highest IOTC bycatch, regardless of gear.**

Country	2006	2007	2008	2009	2010	Average
Iran, Islamic Republic	205,185	158,557	148,371	163,490	169,408	169,002
Sri Lanka	123,032	137,362	142,414	155,897	204,603	152,662
Indonesia	79,859	88,477	110,307	106,605	106,605	98,371
India	63,400	60,225	67,748	62,982	62,982	63,467
Pakistan	36,657	38,751	39,336	41,524	41,524	39,558
Oman	27,877	29,800	31,092	25,672	25,672	28,023
Yemen	25,707	25,094	17,596	17,596	17,596	20,718
Saudi Arabia	5,117	4,736	4,876	4,876	4,876	4,896
United Arab Emirates	5,904	4,532	3,087	4,659	4,659	4,568
Bangladesh	2,738	2,316	6,326	5,481	5,481	4,468
Qatar	2,253	2,068	2,931	2,931	2,931	2,623
Malaysia	1,748	1,606	1,613	1,564	2,505	1,807
Eritrea	472	1,045	1,200	1,378	1,378	1,095
Kenya	1,048	1,048	1,048	1,048	1,048	1,048
Thailand	438	645	1,036	989	1,099	841
Maldives	1,893	232	111	288	141	533
Djibouti	65	80	292	182	182	160
Kuwait	161	131	131	131	131	137
Bahrain	14	3	24	12	12	13
East Timor	3	3	3	3	3	3
Australia	1	1	5	1	1	2
Total	**583,573**	**556,712**	**579,549**	**597,309**	**652,836**	593,996

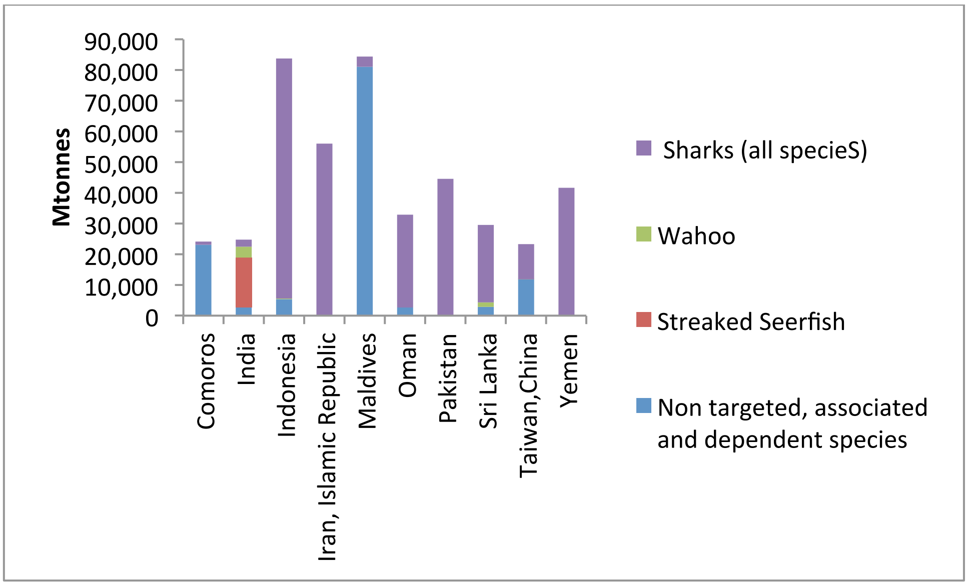


Figure 8 **Countries with the highest aggregate bycatch between 2006 and 2010 by species group (IOTC, nominal catch data).**

Amongst the countries landing the greatest quantities of non tuna species and elasmobranchs indicated in Figure 8, Maldives, Comoros and India differed from the others with respect to species catch composition. For the Maldives and Comoros pole and line and line gear is used respectively, and the species caught may include the baitfish used in the fishery. Indian vessels reported seerfish as the main component of non-tuna and elasmobranch catches, this is discussed in more detail in Section 4.3.

All other countries had significant shark catches. Species level analysis was not possible, due to the high incidence of null values. When assessed by gear type, the greatest proportion of aggregated shark nominal catches was attributed to gillnets (Figure 9).

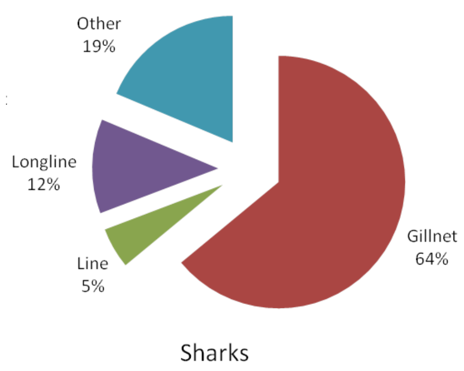


Figure 9 **Proportion of shark catch by gear type for data aggregated over the period 2005-2009 (%) (IOTC shark nominal catch dataset).**

There are no data published by IOTC on catches of turtles, seabirds and cetaceans due primarily to a lack of reporting by CPCs. The IOTC working party on ecosystems and bycatch (WPEB) has not been able to conduct an assessment of turtle bycatch for example, as in 2009 only seven interactions were recorded and submitted[19]. Seabirds are not considered to be as vulnerable to gillnets as they are to longlines, but the evidence to support or negate this is weak due to the lack of directed studies from this region[20]. Cetaceans have not been a priority to date, and in the report of the WPEB, discussion on cetaceans was limited to monitoring depredation in the longline fisheries[21].

A common feature of the analysis of gillnet catch data reported to IOTC was a high proportion of sharks for all countries except India (but note the inconsistency between IOTC and national statistics, see India 4.3). Analysis of the IOTC shark nominal catch data also indicated gillnets accounted for 64% of the catch between 2005 and 2009. It is unclear whether these significant catches of sharks in the Indian Ocean represents targeted fishing or high incidental catches of these species and the answer will likely vary between coastal CPCs. This uncertainty is of concern particularly for Indonesia and India, which are ranked the third and sixth highest capture fishery producing countries in the world[22]. With a high level of shark catch attributed to gillnets, it is essential that robust data for these fleets be obtained to aid management.

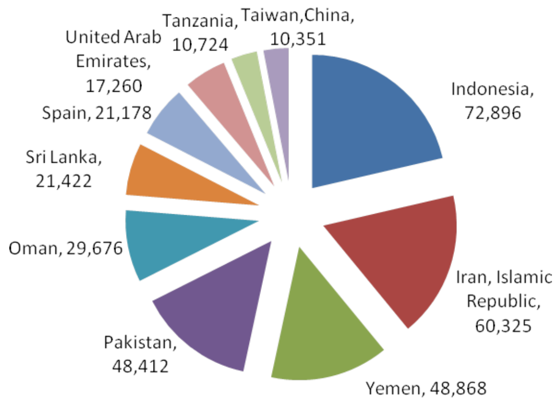


Figure 10 **Shark catches (t) by country for the period 2005-2009 (IOTC shark nominal catch data).**

Waugh *et al.*, (2011) found that the highest density of gillnet fishing occurs (in descending order) within the EEZs of: India, Oman, Islamic Republic of Iran, Tanzania, Pakistan, and Indonesia, which concurs with the focus countries in this report. India was considered the highest risk area globally for turtles being caught by gillnets, with Western Indonesia, Thailand, Bangladesh, the Eastern Indian Ocean (high seas) and Pakistan all ranking within the top thirty in the world. This prevalence of Indian Ocean areas contributing to global turtle bycatch was confirmed by another study (Wallace *et al.*, 2010), where overall reported turtle bycatch from gillnets ranked second in the world, at 5,251 turtles[23]. Although efforts by IOTC and research partners have been made to quantify levels of turtle bycatch, these have been hindered by the lack of reporting of turtle interactions with fishing gear by CPCs.

Table 7 A summary of the Convention on Migratory Species report findings for the Indian Ocean region from Waugh *et al.*, 2011.

Area/EEZ	Gillnet Catch (t)	Percentage of Total Catch (%)	Gillnet Catch Density (t/km^2)
India	1,446,008	41	0.887
Indonesia	711,725	31	0.177
Indian Ocean- Eastern	711,725	69	0.032
Indian Ocean- Western	146,348	27	0.009
Madagascar	79,545	60	0.056
Pakistan	59,522	23	0.269
Iran, Islamic Republic	58,463	29	0.356
Oman	31,791	21	0.590
Yemen	28,370	20	0.052
Maldives	18,353	10	0.020
Tanzania	8,343	35	0.350
Sri Lanka	6,445	27	0.012
Kenya	619	23	0.006

Indonesia

Of all IOTC CPCs, Indonesia landed the most fish across all gears (Figure 7). When gillnet catches were considered separately, it ranked third. Waugh *et al.* (2011) found that gillnet fishing density was very high, second only to India. This high density of gillnet pressure increases the likelihood of elevated bycatch rates.

Islamic Republic of Iran

In the national report submitted to the 2011 IOTC Scientific Committee, the gillnet fishery for tuna and tuna like species is reported as being a major fishery for Iran. Ninety-six percent of catches came from gillnets, but in recent years, the use of purse seines has been increasing. Although over 60,000 t of sharks were reported in catches for the period 2005 – 2009, the national report states that there is no market for sharks within Iran due to "religious legislation" and that landing of all sharks in Iranian ports is banned. This is at odds with the data submitted to IOTC and it is unclear as to the end use of the sharks that were reported. A web based search for Iranian shark exports yielded several companies based in the Islamic Republic of Iran exporting shark products, including Persian shark fins. In 2008, there were 300kg of shark fins exported to Hong Kong which originated from Iran[24]. Waugh *et al.*, (2011) did not present the Islamic Republic of Iran as a country in the 30 highest shark exposure ratings, even though its EEZ was assigned a relatively high gillnet catch density (Table 7).

Analysis of the levels of turtle, cetacean and seabird bycatch attributed to gillnet fisheries in Iran was not possible. It should be noted, however, that Waugh *et al.*, (2011) listed cetaceans as being the most highly exposed to gillnet fisheries of all the animal groups considered for Iran, and Iran fell within the top thirty high risk areas.

Iran has established a pilot logbook scheme for gillnet vessels starting with 50 vessels which will be scaled up to 200 vessels by March 2013 and has undertaken to report shark catches annually. There is not yet an on-board observer programme. Iran is working on a plan of action to reduce shark bycatch[25].

Oman

With all gears considered, Oman was the tenth highest catching CPC reporting to IOTC. When gillnets were considered separately, it was sixth. However, most critically with regards to bycatch, Oman's EEZ was found by Waugh *et al.* (2011) to be the second highest density of gillnet fishing after India of anywhere in the Indian Ocean. Gillet (2011) found that gillnets were typically used to catch the large pelagic fish, with hand and trolling lines used for smaller fish closer to shore.

Pakistan

Although Pakistan's contribution to overall catches ranked 13th, when shark catches were considered separately, it ranked fourth. This high ratio of shark to total catch may indicate active targeting of sharks. Gillett (2011) found that Spanish mackerel and sharks are favoured over tuna as they fetch a better price at market.

Yemen

There was little supplementary information available on the gillnet fisheries of Yemen. Of the countries with highest gillnet attributed catches, Yemen landed the least. It was however, third overall in terms of shark landings (Figure 10). Waugh *et al.* (2011) found that only 20% of catches were from gillnets and that although catches were similar to those of Oman, gillnet fishing density was an order of magnitude lower than in the EEZ of Oman (Table 7). An online search found several shark fin exporters, which would suggest that there is an active, targeted fishery present.

4.3. India

According to IOTC data, between 2006 and 2010, India reported nearly 700,000 t of catch to IOTC, making it the fifth highest catching CPC. Non-tuna like species were predominantly composed of streaked seerfish and wahoo. Shark catches comprised < 10% of reported non tuna like species (2,400 t over five years). The national report submitted to IOTC by India disaggregated coastal and offshore catches. The coastal fishery produced 103,412 t of tuna and allied species during 2010 with offshore catch amounting to 24,203 t. In the IOTC nominal catch records, the entries for India amounted to 130,000 t which is consistent with the national report. Of the coastal catch, 83,944 t consisted of seerfish, which is the main group of non tuna like species reported by India to IOTC. Shark bycatch was cited as contributing 28.3% of production for the coastal fishery, which was not consistent with figures reported to IOTC, which were negligible compared to other catch for the period 2006-2010 (Figure 8).

Figure 11 shows data obtained from the Ministry of Agriculture on catch composition and amount by State for 2007.

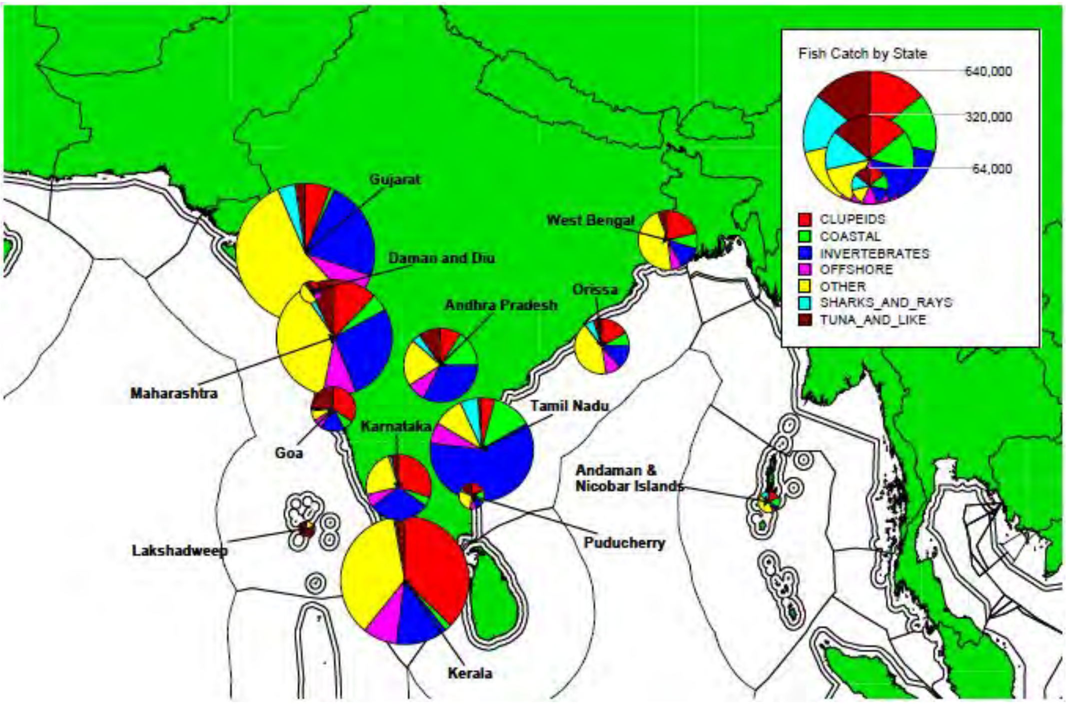


Figure 11 **Fish landings (t) by species group and State. (Ministry of Agriculture, 2007, Govt. of India 2007, Accessed: http://www.indiastat.com/agriculture/2/fisheries/101/stats.aspx)**

Highest catch rates can be seen from Kerala, Maharashtra and Gujarat; these states did not have the largest fleet, but did have the highest proportion of mechanised vessels. Catches are principally taken by the motorised artisanal driftnet/gillnet sector in these states. Tunas currently constitute about 14% of the total catch, with the remaining catch constituted by oil sardines (22%), and low proportions of elasmobranchs, other finfish and prawns[26]. Although catch data from the Ministry of Agriculture were grouped into seven categories for visual representation, the data were reported to species level for 43 species showing a high degree of diversity in fishery catch composition across the country. The Southeast coast (mainly Kerala) is the major tuna producing region in the country contributing to 57 % of the total tuna landings. The Northeast is responsible for <1% of tuna production[27].

The Central Marine Fisheries Research Institute (CMFRI) and the Fishery Survey of India suggest that the Lakshadweep seas are largely underexploited and have suggested ways to increase production[22]. One plan is to convert existing pole and line vessels targeting skipjack tuna to long liners targeting yellowfin tuna. Existing mechanised fishing vessels reported in the region are longline vessels predominantly managed by the State Fisheries Department. Other recent infrastructure developments such the introduction of ice plants on several islands is further evidence of planned development of the fisheries in this region. Although these vessels are primarily set out with the main intention of targeting yellowfin tuna, anecdotal observations reported to the authors suggests that they are currently capturing high quantities of bycatch. The Andaman and Nicobar islands, similarly isolated are also considered by the Indian Authorities to have underexploited fisheries. These areas are currently undergoing a phase of general development, which includes the fisheries sector, with government institutions such as the Marine Products Export Development Authority (MPEDA) and CMFRI promoting the development of tuna fisheries[28,29]. The 2007 data from the

Ministry of Fisheries do not show tuna as a component of the catch, with the predominant catch at the time being relatively diverse and low, consisting of clupeids, other fish and coastal fish (mainly reef associated semi-pelagic such as Carangids).

Elasmobranchs

From analysis of IOTC shark nominal catch data, India reported catches of 2,400 t of sharks between 2005 and 2009. The Ministry of Agriculture reported a total of 85,304 t across the country in 2007. This figure was evenly divided between East and West which suggests that neither the level of mechanisation nor the numbers of vessels were factors affecting catch levels (see Section 3.3). Waugh *et al.* (2011) found that India currently ranks second in the world in terms of total shark landings and the national report submitted to IOTC found that gillnets account for 38% of the total shark landings in the Country[12]. Seerfish was the main non-tuna like fish caught and the 'offshore' species category in **Figure 11** is largely made up of this group. There were no published data available for the level of ray bycatch.

Cetaceans, Turtles and Seabirds

In India, cetaceans and turtles are protected by legislation, making it an illegal act to land either group of animal. Gillnets are the main gear attributed to bycatch of turtles in the country; estimates suggest that they accounted for 76.8% and 60% of turtle bycatch between 1985-95 and 1997-98[30]. The fleets on India's East coast contributed 93% of the turtle bycatch in the country. These estimates exclude the area off the mass nesting beach in Gahirmatha in Orissa, which currently contributes only 1% of fish landings for India. Gahirmatha is the largest nesting rookery of olive ridley turtles (*Lepidochelys olivacea*) in the world and the region has the highest recorded bycatch related mortality of turtles in India. An estimate suggests a mortality count of approximately 100,000 turtles between 1994 -2004[31], however no reports are available on the relative contribution of gear to turtle bycatch at this site. The olive ridley turtle population of the Western and the Northeastern Indian Ocean are identified as among the 11 most threatened turtle populations in the world[32]. A tagging study revealed that although turtles may use mass nesting beaches in Orissa they travel south to feeding grounds along the coast of Sri Lanka and are therefore likely to be at risk of incidental capture in fisheries along the entire Indian east coast[33].

There are several mortality estimates based on numbers of dead turtles washed ashore each year, with the main cause of mortality being attributed to trawler bycatch[31]. However, there are currently a large number of artisanal fishers using gillnets which operate in the vicinity of the area, and although published data is lacking, observations suggest that a large number of turtles are common bycatch in gillnet operations as well. Turtle fishery interactions in this region are a highly contentious issue; because it is illegal to land turtles, fishers are suspected of discarding turtle bycatch rather than reporting interactions. Artisanal fishers are prohibited from fishing within the Gahirmatha marine sanctuary, which is located in a previous fishing ground and thus believe that their rights have been violated. This has further increased tension between fisher livelihood groups such as the National Fishworkers Forum and conservation groups, further complicating implementation of management actions in this region (Bivash Pandav, Wildlife Institute of India, pers. comm., 2012).

Gillnets are also considered to be the main gear responsible for cetacean bycatch in the country. It is estimated that artisanal coastal gillnet fisheries catch approximately 9000-10000 individual cetaceans each year[34]. Bycatch commonly associated with tuna gillnet fleets include small cetaceans, with the highest incidence of dolphin bycatch being recorded during the peak tuna fishing season[35].

There were no data or literature available that addressed the incidence of seabirds as bycatch in gillnets in India. Waugh *et al.*, (2011) did not state India as one of the top thirty regions at risk to birds, but it is unknown if this due to a lack of data.

In-country questionnaire: catch results

During interviews with fishers in Tamil Nadu, all those questioned had caught turtles and dolphins, and if it was not possible to release them alive, they were discarded at sea on account of a fear of sanctions and mistrust of the authorities. The fishers questioned targeted kawakawa, frigate tuna, and to a lesser extent, yellowfin tuna, and average price per kg received is 55 INR. Sharks (primarily milk shark, *Rhizoprionodon acutus*) were caught when fishing with hook and line, and only one respondent had caught a ray (*Mobula sp.*) through gillnetting. All respondents had caught at least one turtle as bycatch over the last five years. This gave a mean catch rate of 0.24 turtles per vessel per year. The number of mechanised vessels in Tamil Nadu, according to the Ministry of Agriculture in 2010 was 7,711. Extrapolating the catch rate would give a total catch of 1850.64 turtles per year. This is a crude estimate and does not take into account the interchangeable use of gear within a vessel; however it is similar to an estimate in Shanker [31].

Table 8 A summary of questionnaire results on bycatch for two Indian States.

	Tamil Nadu (East)	**Goa (West)**
Sample size (N)	5	6
Vessel size	30 foot outboard motor	60-70 foot multiday inboard motor
Target species	Skipjack, frigate and juvenile yellowfin (75%) for export market	Yellowfin and skipjack tuna, seerfish, silver pomfret and catfish
Elasmobranchs	Sharks – occasional bycatch Rays – one devil ray caught by one respondent on one occasion	Sharks - 137 $vessel^{-1}year^{-1}$ Rays – 13.5 $vessel^{-1}year^{-1}$
Turtles	0.24 $vessel^{-1}year^{-1}$	1.83 $vessel^{-1}year^{-1}$
Cetaceans	Caught on one occasion by one respondent, released alive	Porpoises – 0.33 $vessel^{-1}year^{-1}$ Dolphins – caught on one occasion by one vessel

Bycatch rates reported by fishers in Goa were higher than those reported by fishers in Tamil Nadu, and this may be attributable to use of larger vessels with more powerful engines. The fishers in this region targeted different species with pelagic seerfish being an important component of the catch. This species was the most valuable of all the target species, with fishers selling catch for 190INR per kg. The main shark species were blacktip and hammerhead sharks and rays caught were mainly manta rays. The fishers did not state whether these species were actively targeted.

4.4. Sri Lanka

Between 2006 and 2010, Sri Lanka reported nearly 770,000 t of catch to IOTC and was the nation with the third highest production. Gillnets account for the majority of the IOTC species reported in the IOTC nominal catch data, and almost 100% of non-tuna like species and sharks species. Shark was the main bycatch group reported (Figure 5). Sharks were not grouped by species and so it was not possible to differentiate between pelagic and coastal species of shark caught. Catches show an increasing trend, with catches in 2010 24% higher than in the previous year[15]. The national report differentiated between coastal and offshore fisheries which accounted for 60% and 40% of the total marine landings respectively. Tunas form an important constituent of coastal gillnet fisheries and landings are dominated by frigate tuna (78.2 %), followed by skipjack (4.4%) and bullet tuna (1.8%).

Elasmobranchs

The reporting of shark landings as bycatch can be misleading as sharks are among the major target groups in Sri Lanka with certain fleets predominantly dedicated to targeted shark fishing. These include the offshore gillnet and longline fleets, with approximately 2,500 vessels engaged in this fishery. Sharks are also encountered as bycatch in coastal bottom set gillnet and longline fisheries and the artisanal fishery potentially contributes significantly to the landings. However the data on the shark bycatch of the artisanal gillnet sector is largely lacking[36].

A study carried out by the Manta Trust[37] described the bycatch of manta and devil rays in gillnets. They are captured as bycatch in both the mechanised multi-day gillnetters operating from the west coast of the country that target tuna and billfish and the tuna targeting small-scale gillnetters that operate in the South. These rays were previously largely discarded bycatch because their meat was not preferred for local consumption, but have steadily increased in value over the last decade. These species are now increasingly landed for their gillrakers (which are used in Chinese traditional medicine and fetch a high price), and also for their meat. Declines in the catch rates of traditionally targeted species such as tunas, an increased access to new and growing markets (Chinese traditional medicine) and the collapse of ray populations in other previously supplying nations such as Indonesia are cited as some of the main drivers for these increased landings. The main species of manta and devil rays encountered as bycatch based on this market survey study in order of abundance (based on daily encounter rates) were *Mobula japonica*, *Mobula tarapacana*, *Manta birostris* and *Mobula thurstoni*[38].

Turtles, Cetaceans and Seabirds

It is estimated that approximately 13,000 turtles are taken as bycatch in Sri Lankan fisheries each year. The main contributors of turtle bycatch in Sri Lanka are gillnets and longlines primarily targeting tuna and in gillnets targeting flying fish. A study conducted by the Turtle Conservation Programme in Sri Lanka between November and June 2000 recorded 5,241 turtles caught as bycatch, of which 20% were dead or killed and sold by the fishers, while the remaining 80% were released alive. This bycatch was dominated by olive ridleys (*Lepidochelys olivacea,* 37%), loggerheads (*Caretta caretta*, 30%), greens (*Chelonia mydas* 20%) and the remaining 3% were classed as unidentified[39]. Turtle bycatch rates in Sri Lanka have increased from an average of 4,000 in the mid 1970's[40] to 13,000 turtles per year in 2000[41], an increase of 225% over the last 30 years. This has been largely attributed to significant growth in the gillnet fleet in the country.

Gillnets are also the major contributor for cetacean bycatch in the country, with gillnets accounting for an estimate of between 8,042 and 1,182 individuals between 1984 and 1986 [42].

5. Markets for Tuna and Bycatch Products

Tuna from both India and Sri Lanka is mainly for export and in-country consumption is lower than for other species. This is especially the case for larger, pelagic species of tuna. In India, export has increased rapidly over the last few years from 1,230 t in 2002 to 37,302 t in 2008 (Figure 12).

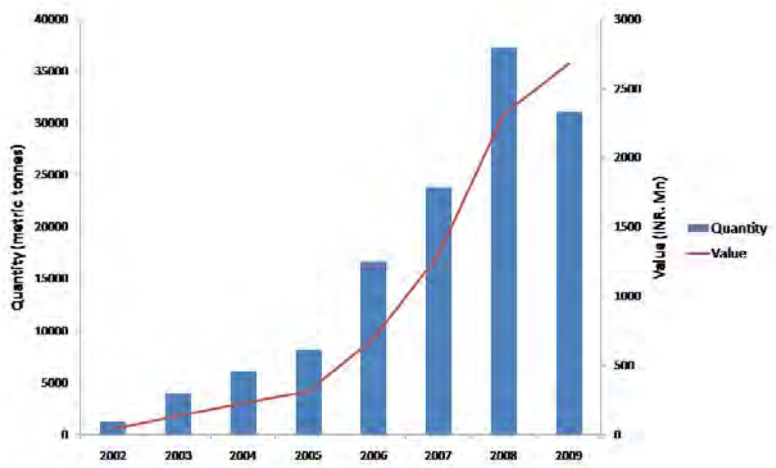


Figure 12 **Trends in export quantities and revenues from tuna and tuna products from India, 2002-2009. Source: John and Pillai, 2009.**

This trend of tuna for export is mirrored in Sri Lanka, where it has become the major exported fish product and has superseded cultured shrimp that dominated the export markets over the last two decades. In Sri Lanka, the main product is exported as frozen, and fresh exports have declined over the last two years. A potential reason may be that lower quality product is acceptable as frozen, as gillnets are unlikely to maintain fish to the high quality standards required by the fresh markets (Figure 13).

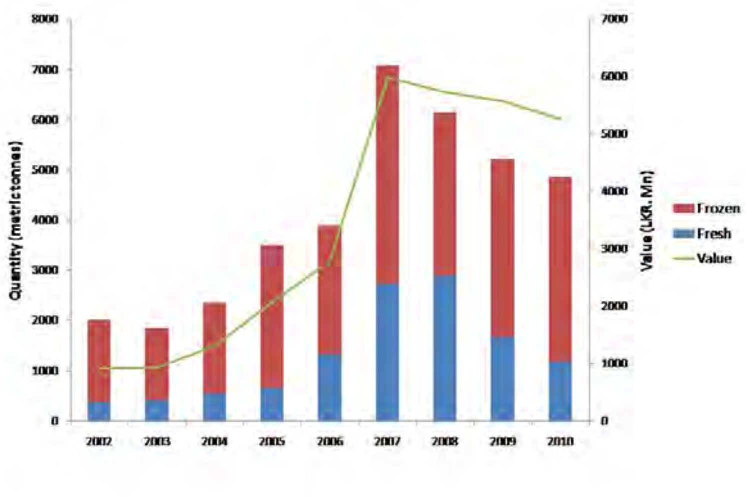


Figure 13 **Trends in export quantities and revenues of tuna and tuna products in Sri Lanka, 2002-2010 (Data source: Custom Returns/ Statistics Unit - Ministry of Fisheries and Aquatic Resources Development, Sri Lanka).**

In India seerfish fetch a higher price than yellowfin tuna and shark prices are also high driven by export markets.

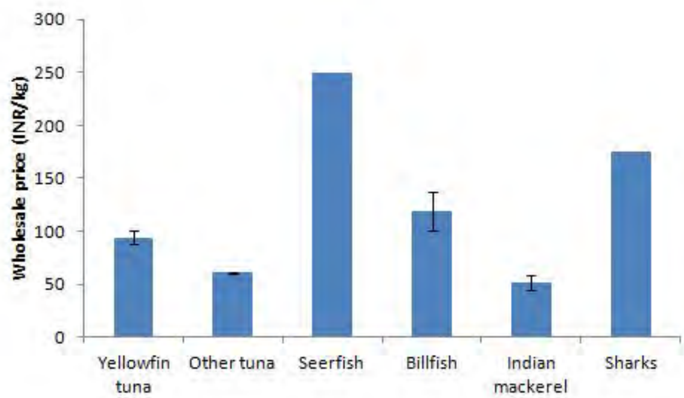


Figure 14 **Mean wholesale price for tuna and associated species from six major landing sites in India as of March 2012 (Cochin, Bhairavpalem, Dummulipeta, Visakhapatnam, Jalaripeta and Lawsons Bay). Other tuna refers to the coastal species. Datasource: http://www.cmfri.org.in/fishwatch.html .**

Data from Sri Lanka show a similar trend with seerfish (Spanish mackeral) commanding higher local prices than tuna species (Figure 15).

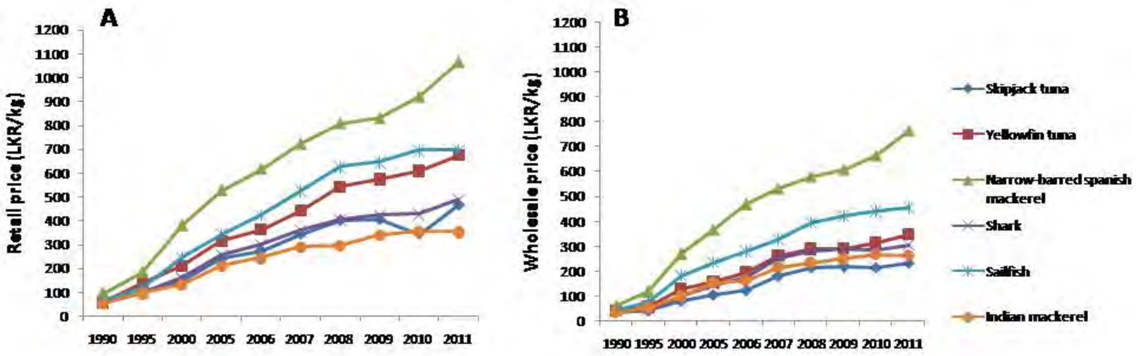


Figure 15 **Trends in retail and wholesale prices of tuna and other associated species in Sri Lanka 1990-2011 (Source :http://www.fisheries.gov.lk/statistics.html).**

Due to the growth in demand for traditional medicinal use coupled with declining populations in other supplying Countries, manta rays are now increasingly landed, fetching a high market price. A price comparison of devil ray gillrakers and meat with other targeted tuna catch suggests that even though the price of devil ray meat is not very high, the price per kg of gillrakers is (324 %) and (836 %) higher than Spanish mackerel/seerfish and yellowfin tuna respectively (Figure 16).

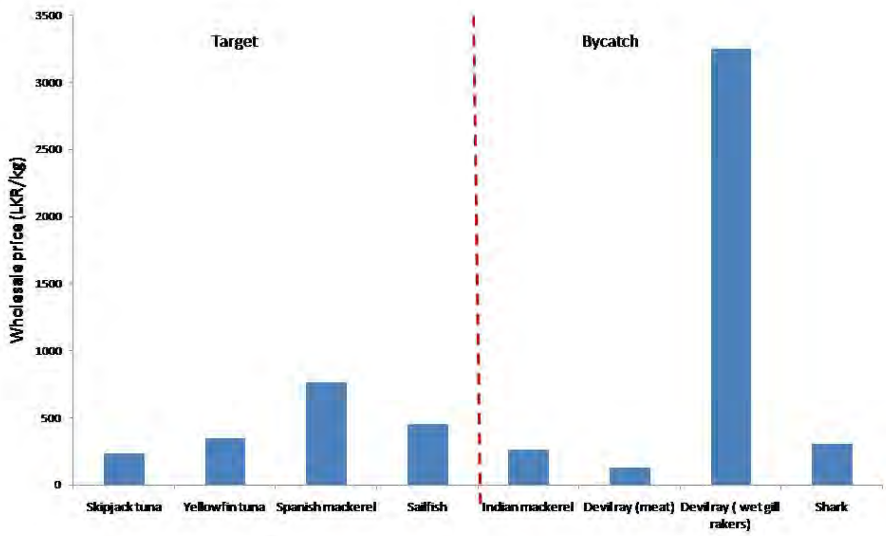


Figure 16 **Wholesale market prices (LKR/kg) of principal target and bycatch species in Sri Lanka (Source :http://www.fisheries.gov.lk/statistics.html, (Fernando and Stevens 2011).**

Online searches generally revealed numerous exporters from Indian Ocean coastal States advertising shark fins. There were fewer exporters found openly trading in manta ray gillrakers, with two based in India openly advertising online.

6. Certification status

There are currently no MSC certified fisheries in the Indian Ocean region and only one fishery is currently undergoing assessment, the Maldives pole and line skipjack tuna fishery (see Appendix 5). It should be noted that there are other eco-labelling certifications which occupy a similar role to the MSC, but these were not explored.

As demonstrated in Section 4, and cited by IOTC, the main catching fisheries of the Indian Ocean are considered to be artisanal. Although eco-labelling trends are on the rise due to increasing public support, it is well documented in the literature that this system may be biased against artisanal fisheries for a number of reasons[43 44]:

Certification schemes are expensive	Small-scale fisheries may find it difficult to afford the process and few have the capital to pay for assessment.
Low institutional capacity for fisheries management	Most fisheries in the Indian Ocean are open access. More heavily industrialised fisheries are subject to more intervention and control, whereas it is difficult to control the larger fleets of less industrialised fisheries.
Lack of data	As shown by the IOTC data source and quality scores in the datasets, many of the data for the Indian Ocean are incomplete. This is especially pertinent for CPUE in a given area, which for the gillnet fleets is almost non-existent.
Mixed Fisheries	Many of the fleets are targeting multiple species and using mixed gears on an *ad hoc* basis dependent on multiple factors. Certification of mixed fisheries complicates the process and requires more data, which is lacking in the first instance.

Notwithstanding the above, plans to certify fisheries in India are underway and two tuna fisheries (both for oceanic species) have been selected as candidates for this process. These include the deep-sea longline fishery that target yellowfin and bigeye tuna and the pole and line skipjack tuna fishery in the Lakshadweep[45] (Vinod Malayilethu, WWF-India, pers.comm).

There remain several concerns about the certification process which primarily pertain to a lack of quantitative data for these fisheries and the extent of exploitation of these species within the Indian EEZ. The high levels of IUU fishing by Indian and foreign fleets, particularly the high number of illegal Sri Lankan tuna longlining vessels has not yet been fully quantified or addressed[46]. Neither is there any reliable information on the levels of bycatch of endangered species in the deep sea longline fishery. While a particular local fishery could follow apparently sustainable practices, it is important to ensure that sustainability is achieved at the level of the population from which these species are harvested before these fisheries are certified.

7. Other work on gillnet fisheries by concerned NGOs

A number of related activities conducted by NGOs concerned with the status of Indian Ocean gillnet fisheries have come to the attention of the authors. Whilst not a comprehensive review of other related work (and outside the terms of reference) this section indicates these details.

Several non-governmental organisations (NGOs) that have concerns related to bycatch issues were contacted. The Manta Ray Trust indicated they held extensive data on elasmobranch bycatch levels from gillnets in India, Indonesia and Sri Lanka but it was not publically available. Similarly, Sea Turtles of India also hold extensive data relating to turtle bycatch levels, but did not make it available to us. Whilst it appears that data on gillnet bycatch levels exists in the NGO sector, but the data are often not publicly available and the quantity and quality has not been verified.

WWF's Global Smart Fishing Initiative (SFI) held a workshop with Northern Indian Ocean stakeholders involved in gill net fishing from Indonesia, Iran, Oman, Pakistan, and Sri Lanka in April 2012 in Sri Lanka. They have also undertaken an *ad hoc* evaluation of gillnet fisheries in Pakistan which suggest that the gillnet fleets of Pakistan and Iran operate together and fish marketing is linked to trade for fuel. These activities are at an early stage of development and there are no workshop outputs immediately available.

A review of stakeholder groups with an interest in Indian Ocean gillnet fisheries is warranted.

8. Areas that may warrant further study

This study has highlighted that despite significant gillnet fisheries targeting tuna and tuna like species throughout the countries of the Indian Ocean there is a paucity of information available on bycatch associated with gillnet fisheries, and what data is available is inconsistent. It is not possible to accurately quantify the level of bycatch that can be attributed to gillnet vessels targeting tuna and tuna like species.

Of twenty one Indian Ocean coastal countries that fish with gill nets for tuna and tuna like species, seven were identified as the major contributors to gillnet catch and in particular warrant further study and engagement with: India, Indonesia, Islamic Republic of Iran, Oman, Pakistan, Sri Lanka, and Yemen.

The IOTC is the RFMO responsible for managing tuna fisheries in the Indian Ocean and will be a critical body to engage with in relation to its gillnet fisheries. Recognising the poor quality of data reporting, IOTC is taking a number of measures to improve data reporting by 'artisanal' gillnet fleets (e.g. the Commission in 2012 passed a Resolution on minimum reporting requirements for gillnet vessels within the IOTC area of competence (Proposal, L (Rev 3), 2012)), to improve bycatch reporting, and to verify reported catches through a regional observer programme.

Whilst engagement with IOTC and support for its measures is important, there is a need to build capacity within the developing coastal countries of the IOTC in order to improve national reporting against the requirements for mandatory statistics and minimum requirements for gillnets, and to implement observer programmes. There is an IOTC requirement for 5% national observer coverage on all vessels targeting tuna and tuna like species (Resolution 11/04) for all fishing CPCs but the current level of implementation is variable. Some of the highlighted coastal countries either have observer programmes for gillnet fisheries in place (e.g. Pakistan) or plan to implement them in future (e.g. Iran). Others indicate that observer programmes will not be feasible due to the small size of the vessels, and instead plan to develop improved port sampling programmes (e.g. Sri Lanka). Targeted capacity building is thus another major area that would warrant further effort.

In addition to the IOTC regional observer scheme, a coordinated effort to increase observer coverage at the national level throughout the region should be investigated. To maximise effectiveness and resources, coverage should be prioritised by areas identified as high risk on a national level. For example, in India, the eastern coast, especially along Orissa should be a priority, based on the high estimates of turtle mortality. Implementation of such a scheme will require significant capacity building and international support.

Looking beyond IOTC CPCs, Yemen is a significant gillnet fishing country and is not yet a member of IOTC. Participation in IOTC by Yemen should be encouraged in order that they engage in regional fisheries management measures and report information on their catch of tunas and bycatch species to that body.

Gillnet fishing is typically non-selective, but bycatch mitigation research planned by Iran and Pakistan should be supported, and mechanisms for providing incentives to fishers to avoid bycatch should be explored.

Market based information can provide an alternative means of estimating bycatch although it cannot always be attributed directly to gillnet fisheries. For elasmobranchs the relatively good catch and trade data mean that at least part of the landings can be monitored, and their status assessed. Thus in addition to fisheries data collection, management bodies should obtain supplementary trade data to cross check and verify reported catch data.

In addition to engaging with fisheries bodies and fishers in the countries responsible for the greatest gillnet catches, engagement more broadly with non-governmental organisations that have an interest in gillnet fisheries and their associated bycatch is warranted. Possibly building on recent WWF experience, a larger workshop including all interested stakeholders would be warranted, inviting each participant organisation to present the information available to them in order to build a more detailed picture of gillnet fisheries in the Indian Ocean, associated 'bycatch' issues, to discuss the concerns of the different interests, and to seek innovative solutions to conservation issues. In the absence of a forum for collective engagement, it is warranted to seek and engage with relevant individual stakeholders to share information.

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Appendix 1: List of literature obtained from in-country visits to India and Sri Lanka

Reference	Description	Type	Language
INDIA			
Ammini, P. L., J. Srinivasan, K. Ramani, M. R. Beena, and M. B. Seynudeen. 2010. Marine fisheries in Kerala - an overview. Marine Fisheries Technical Extension Service **204**:1-10.	An appraisal on fisheries in Kerala which provides details of catch composition of the coastal gillnet fisheries targeting tunas in Kerala, which has the highest tuna landings in the country	Journal article	English
John, M. E., and N. G. K. Pillai. 2009. Current status of tuna and tuna fisheries in India. Indian Ocean Tuna Commission.	Provides an overview of tuna fisheries in India.	Online report	English
Menezes, M. R., S. Kunal, and G. Kumar. 2009. Tuna fisheries in the Exclusive Economic Zone of India: Need of molecular study. Pages 90-92 *in* Z. A. Ansari, editor. Sagar Bodh. National Institute of Oceanography (CSIR), India	A brief overview of tuna fisheries in the Indian EEZ and the role of genetics in answering important questions pertaining to tuna biology in Indian waters	Book Chapter	Hindi
Menezes, M. R., G. Kumar, and K. Swaraj. 2009. Tuna fishery research in India. Pages 7-9 Enviroscan Newsletter.	Discusses the importance of genetic markers in understanding tuna distribution and migration in the Indian ocean	Newsletter	English
Kasim, H. M., and S. Mohan. 2009. Tuna fishery and stock assessment of component species off Chennai Coast. Asian Fisheries Science 22 245-256.	Information on tuna stocks are provided based on the landings at the Chennai fishing harbour between 1985-2006.	Journal article	English
Rohit, P., G. Rao, and K. Rammohan. 2008. Yellowfin tuna fishery by traditional fishermen at Visakhapatnam, Andhra Pradesh. Journal of the Marine Biological Association of India **50**:62-68.	Describes the artisanal tuna operations in the Andhra Pradesh primarily carried out using hook and lines and troll lines.	Journal article	English
CMFRI. 2007. Marine fisheries census 2005 (Part I & II). Central Marine Fisheries Research Institute., Cochin.	Provides statistics of fisheries in India. This census covers the number of landing sites, villages, fisher families, craft, gear etc	Report	English
Pillai, N. G. K., and J. V. Mallia. 2007. Bibliography of tunas. Central Marine Fisheries Research Institute, Kochi.	A consolidation of information on tuna fisheries from	Book	English
Pillai, N. G. K., E. Vivekanandan, and K. P. Said Koya. 2006. Status of fisheries of Lakshadweep. Marine Fisheries Technical Extension Service 187:1-7.	An appraisal of the pole and line skipjack tuna fishery and also includes information on the management of the live bait	Journal article	English

	fishery in the Lakshadweep islands		
Turtles			
Rajagopalan, M., K. Vijayakumaran, and E. Vivekanandan. 2006. Fishery-related mortality of sea turtles in India: An overview. Pages 227-237 in K. Shanker and B. C. Choudhury, editors. Marine turtles of the Indian subcontinent. Universities Press.	A compilation and analysis of turtle bycatch and mortality from the mainland coast of India providing information on the gear responsible and regions with highest bycatch.	Book Chapter	English
Shanker, K., B. Pandav, and B. C. Choudhury. 2004. An assessment of the olive ridley turtle (*Lepidochelys olivacea*) nesting population in Orissa, India. Biological Conservation **115**:149-160.	One of the few quantification of Olive ridley nesting and mortality trends in Orissa.	Journal article	English
Pandav, B., B. C. Choudhury, and K. Shanker. 1998. The Olive Ridley sea turtle (*Lepidochelys olivacea*) in Orissa: An urgent call for an intensive and integrated conservation programme. Current Science 75:1323-1328.	A general overview of the threats faced by sea turtles in Orissa. Special attention is given to bycatch related mortality and strategies for its mitigation.	Journal article	English
Pandav, B., B. C. Choudhury, and C. S. Kar. 1997. Mortality of olive ridley turtles *Lepidochelys olivacea* due to incidental capture in fishing nets along the Orissa coast, India. *Oryx* 31:32-36.	Provides a mortality count of Olive Ridley sea turtles due to bycatch in fishing operations between Dec 1993 and May 1994.	Journal article	English
Frazier, J. G. 1980. Exploitation of marine turtles in the Indian Ocean. Human Ecology **8**:329-370.	Describes the exploitation patterns of sea turtles in the Indian ocean region for subsistence and foreign trade. In addition it also provides estimates of turtle bycatch in the 1970's in this region.	Journal article	English
Cetaceans			
Yousuf, K. S. S. M., A. K. Anoop, B. Anoop, V. V. Afsal, E. Vivekanandan, R. P. Kumarran, M. Rajagopalan, P. K. Krishnakumar, and P. Jayasankar. 2009. Observations on incidental catch of cetaceans in three landing centres along the Indian coast. Marine Biodiversity Records 2:1-5.	Provides an estimate of cetacean numbers captured as bycatch in gillnets in India based on landings and interviews.	Journal article	English
Jayaprakash, A. A., P. Nammalwar, S. Krishna Pillai, and M. N. K. Elayath. 1995. Incidental by-catch of dolphins	Bycatch rates of four species dolphins in drift-gillnets targeting tuna between 1986	Journal article	English

at fisheries harbour, Cochin with a note on their conservation. Journal of the Marine Biological Association of India **37**:126-133.	and 1987.		
Pillai, P., K. Mahadevan, and S. B. Chandrangathan. 1990. On the drift net-entangled dolphins landed at Sakthikulangara. Marine Fisheries Technical Extension Service **104**:16-17.	A short note on single instance of dolphin bycatch in gillnets.	Journal article	English
Silas, E. G., P. P. Pillai, A. A. Jayaprakash, and M. A. Pillai. 1995. Incidental bycatch of dolphins at fisheries harbour, Cochin with a note on their conservation and management in India. Journal of the Marine Biological Association of India **37**:126 - 133	Provides catch statistics of dolphins caught as bycatch in drift gillnets from 1981 to 1987 at the Cochin fisheries harbour in Kerala.	Journal article	English
Lack, M., and G. Sant. 2011. The future of sharks: a review of action and inaction. TRAFFIC International and the Pew Environment Group.	A review of the global shark fisheries and their management with a special focus on Top 20 contributors to shark landings in the world.	Published report	English
Verlecar, X. N., Snigdha, S. R. Desai, and V. K. Dhargalkar. 2007. Shark hunting - An indiscriminate trade endangering to extinction. Current Science 92:1078-1082.	Provides an overview of shark fisheries and their management requirements in India.	Journal article	English
SRILANKA			
Jayathilaka, R. A. M., V. Samaraweera, C. Dissanayake, C. Amarasiri, J. A. D. B. Jayasooriya, S. Fujiwara, K. Itoh, and T. Nishida. 2010. Atlas of tuna fisheries and resources in Sri Lanka. OFCF Tuna Atlas project in the IOTC waters: Tuna Atlas Series – No.4, Sri Lanka.	Detailed information which includes maps of the tuna fisheries in the country primarily based on the monitoring programme by NARA	Book	English
Vindanaje, S., and H. D. Wimalasena. 2000. Socio-economic aspects of ringnet and drift gillnet fishery for small tuna varieties in the southern coast of Sri Lanka. Socio-economic and Market Research Division, National Aquatic Resources Research and Development, Colombo.	Provides a detailed appraisal of drift gillnets and ringnet operations in Sri Lanka.	Report	English
Cetaceans			
Broker, K. C. A., and A. Ilangakoon. 2008. Occurrence and conservation	Provides year round cetaceans abundance estimates in the Bar	Journal article	English

needs of cetaceans in and around the Bar Reef Marine Sanctuary, Sri Lanka. Oryx **42**:286-291.	Reef Marine Sanctuary in Sri Lanka with a note on the threats due to bycatch in this region		
Ilangakoon, A. 1997. Species composition, seasonal variation, sex ratio and body length of small cetaceans caught off the west, south-west and south coasts of Sri Lanka. Journal of the Bombay Natural History Society 94:298–306.	Provides an account of cetaceans caught in fisheries either as target catch or bycatch in Sri Lanka	Journal article	English
Dayaratne, P., and L. Joseph. 1993. A study on dolphin catches in Sri Lanka. Bay of Bengal Programme, Madras, India.	Based on a study conducted between 1991 and 1992 which provides a country wide estimate of dolphin catches (targeted or as bycatch). General information on dolphin capture, trade and consumption are also provided.	Report	English
Turtles			
Kapurusinghe, T. 2006. Status and conservation of marine turtles in Sri Lanka. Pages 173-187 in K. Shanker and B. C. Choudhury, editors. Marine turtles of the Indian sub-continent. Universities Press, Hyderabad, India.	The most recent overview on the status of turtles in Sri Lanka. Provides a review of the species, their distribution and the threats they face which include a detailed overview of threats from incidental capture by fisheries and targeted harvest of turtles for their meat and eggs.	Book chapter	English
Kapurusinghe, T. and M.M. Samana. 2001. Marine turtle by-catch in Sri Lanka. In Proceedings of the 21st Annual Symposium on Sea Turtle Biology and Conservation. Philadelphia, USA.	Provides a country wide estimate of turtle bycatch in Sri Lanka.	Report	English
Fernando, D., and G. Stevens. 2011. A study of Sri Lanka's Manta and Mobula ray fishery. Manta Trust.	Provides a first time account of Sri Lanka’s growing manta and devil ray harvest and trade. This study is provides details on the species harvested as bycatch in gillnets. Information is also provided on the growing markets for their gill rakers and meat.	Report	English
Joseph, L. 1999. Management of shark fisheries in Sri Lanka. Pages 339-366 *in* R. Shotton, editor. Case studies of the management of elasmobranch	An appraisal of shark fisheries in Sri Lanka and includes details on the species caught and the main gear used in their capture.	Report	English

fisheries. Part 1. FAO, Rome			
GENERAL			
Pramod, G. 2010. Illegal, Unreported and Unregulated marine fish catches in the Indian Exclusive Economic Zone, Field Report, Policy and ecosystem restoration in fisheries., Fisheries Centre, University of British Columbia, Vancouver, Canada.	Provides an estimate of IUU fishing in Indian waters which includes information on illegal, unreported landings, discards and use of foreign fishing fleets in Indian waters. Information for this study	Report	English

Appendix 2: Summary of the number of vessels reported in the IOTC vessel registry by flag and vessel type.

Flag State	Bottom and/or midwater trawls	Drifting longline	Drifting longline and purse seine and trap	Fresh Longline	Gillnets	Hand line	Hand line and pole and line	Line	Longline and Gillnets	Longline and line	Longline and Trawl	Longline and Troll line	Pole and Line, Hand Line, Longline	Pole and Line, Hand Line, Longline, Troll line	Pole and Line, Hand Line, Troll line	Pole and lines	Purse seines	Set longline	Supply Vessel Purse Seiners	Troll line	Unknown	Grand Total
Australia		81				34											8				1	124
Belize		2																			4	6
China		65																3			5	73
France (EU)	7	151			2		14			1							44	56		6		281
France (Territories)																	5					5
India		17		21				6													1	45
Indonesia		1005			2												10				195	1212
Iran	2	1			1320												8				2	1333
Japan		284									1	2	1			1	11		1		3	304
Kenya		2																				2
Korea, Republic of		121															13				40	174
Madagascar		2																				2
Malaysia		9																				9

Flag State	Bottom and/or midwater trawls	Drifting longline	Drifting longline and purse seine and trap	Fresh Longline	Gillnets	Hand line	Hand line and pole and line	Line	Longline and Gillnets	Longline and line	Longline and Trawl	Longline and Troll line	Pole and Line, Hand Line, Longline	Pole and Line, Hand Line, Longline, Troll line	Pole and Line, Hand Line, Troll line	Pole and lines	Purse seines	Set longline	Supply Vessel Purse Seiners	Troll line	Unknown	Grand Total
Maldives						4	284						1	3	390	20					1	703
Marshall Islands																					1	1
Mauritius		3																				3
Mozambique		1																				1
Oman		39															2					41
Pakistan																					10	10
Panama																					20	20
Philippines		26															46					72
Portugal (EU)	1	12			5																	18
Senegal		3																				3
Seychelles		26															8		2		1	37
Singapore																					1	1
South Africa		9						3														12
Spain (EU)	1	129														2	33	1	4			170
Sri Lanka									3307													3307
Tanzania		8																				8
Thailand		6	3														4		1			14

Flag State	Bottom and/or midwater trawls	Drifting longline	Drifting longline and purse seine and trap	Fresh Longline	Gillnets	Hand line	Hand line and pole and line	Line	Longline and Gillnets	Longline and line	Longline and Trawl	Longline and Troll line	Pole and Line, Hand Line, Longline	Pole and Line, Hand Line, Longline, Troll line	Pole and Line, Hand Line, Troll line	Pole and lines	Purse seines	Set longline	Supply Vessel Purse Seiners	Troll line	Unknown	Grand Total
United Kingdom (EU)		4																				4
Vanuatu		40																			15	55
Grand Total	**11**	**2046**	**3**	**21**	**1329**	**38**	**298**	**9**	**3307**	**1**	**1**	**2**	**2**	**3**	**390**	**23**	**192**	**60**	**8**	**6**	**300**	**8050**

Appendix 3: Summary of the number of vessels reported to IOTC in the submissions on Fishing Craft Statistics (2007).

country	Baitboat / Pole and Line	Gillnet	Line	Longline	Other	Purse Seine	Grand Total
AUSTRALIA		10	48	3	0	11	72
BAHRAIN		6	22		72		100
BANGLADESH		0					0
BELIZE				10			10
CHINA				67			67
EAST TIMOR					0		0
ERITREA		0			0		0
EUROPEAN COMMUNITY			256	102		41	399
FRANCE-TERRITORIES			0			2	2
GUINEA				3			3
INDIA				81			81
INDONESIA				1075		4	1079
IRAN I R		6363	397	1		9	6770
JAPAN				215		3	218
JORDAN					0		0
KENYA				1	0		1
KOREA REP				31			31
MADAGASCAR				2			2
MALAYSIA		0	0	62	0	0	62
MALDIVES	898		75				973

country	Baitboat / Pole and Line	Gillnet	Line	Longline	Other	Purse Seine	Grand Total
MAURITIUS				9			9
NEI-FRESH				5			5
NEI-FROZEN				11			11
NOT ELSEWHERE INCLUDED							
OMAN		0		29			29
PAKISTAN		2308					2308
PHILIPPINES				17			17
QATAR		0					0
SAUDI ARABIA					0		0
SENEGAL				3			3
SEYCHELLES			370	35		10	415
SOUTH AFRICA			14	24			38
SRI LANKA		2618			40060		42678
TAIWAN,CHINA				782			782
TANZANIA				3			3
THAILAND		80		3	600	259	942
UK-TERRITORIES			47				47
UN ARAB EMIRATES					0		0
URUGUAY							
YEMEN AR RP		0					0
Grand Total	**898**	**11385**	**1229**	**2574**	**40732**	**339**	**57157**

Appendix 4: Fisher questionnaire survey form

Date:

Location: No. boats at the site

Interviewee name: Age/DOB: No.yrs fishing:

What type of gear do you fish with?

gillnet longline hand lines troll lines ring seine/purse seine Other:

What type of craft do you own?

Boat length: _______________ No. fishers/boat: _____________

COSTS

What is the duration of a typical tuna fishing trip?

What are the main fishing costs incurred per trip

Category/Time	
Fuel	
Oil	
Storage (Ice)	
Food	
Labour	

What species of fish do you target (list from most common to least common)?

If primarily targeting tuna, what are the main species of tuna targeted?

Which are the main months of the year that you fish for tuna (for each of the different species)?

Bycatch

Fish bycatch

When you go fishing for tuna what are the other species of fish do you catch?

Sea turtles

Do you ever catch sea turtles while fishing for tuna?

When was the last time you caught a turtle in your net?

How many turtles did you catch during the last five years?

If you catch one, what do you do with it? If sold for how much?

Cetaceans

Do you ever catch dolphins in your net when you go fishing for tuna?

If Yes, when was the last time you incidentally caught a dolphin in your net?

If common, on average how many did you catch in the last five years?

When caught, what do you do with them? If sold for how much?

Additional comments

Information on the market price of fish:

Appendix 5: Fisheries currently undergoing MSC assessment in the Indian Ocean region

Fishery name	Maldives pole and line skipjack tuna
Number of fisheries	1
country	Maldives (the fishery is confined to the EEZ)
Species	Skipjack tuna (*Katsuwonus pelamis*)
Gear	Pole and line
Client	Maldives Seafood Processors and Exporters Association (MSPEA)
Conformity assessment body	Moody Marine Ltd
Type of assessment	Risk Based Framework for Principle 1, PI 2.1.1, and potentially 2.2.1, 2.4.1 and 2.5.1
Fishery management	Regional: IOTC National: Ministry of Fisheries and Agriculture (although the Ministry of Trade is separately responsible for the licensing of foreign vessels in the Maldivian EEZ (75-200 nm).
Landings in 2007	**Pole and line** Skipjack: 95,807 t **Handline** Skipjack: 1,054 t
Commercial market	**Pole & line** **Skipjack: cooked and then put in cans or pouches for export, mainly to Europe.** **handline:** **sold fresh or frozen to domestic and international markets**
Assessment timeline	**scheduled for completion around July 2012**

References

http://www.msc.org/track-a-fishery/in-assessment/Indian-ocean/Maldives-pole-and-line-skipjack-tuna

http://www.msc.org/track-a-fishery/in-assessment/Indian-ocean/Maldives-pole-and-line-skipjack-tuna/assessment-downloads

http://www.msc.org/track-a-fishery/in-assessment/Indian-ocean/Maldives-pole-and-line-and-handline-tuna

http://www.msc.org/track-a-fishery/in-assessment/Indian-ocean/Maldives-pole-and-line-and-handline-tuna/assessment-downloads