Availability: 17 November 2013

Indian Ocean Tuna Commission
Commission des Thons de l'Océan Indien
iotc ctoi

IOTC–2013–SC16–INF04

ESTIMATION OF FISHING CAPACITY BY TUNA FISHING FLEETS IN THE INDIAN OCEAN

Estimation of fishing capacity by tuna fishing fleets in the Indian Ocean

Study commissioned by:

Indian Ocean Tuna Commission
Victoria
Seychelles

Authors of the study:

Guillermo Moreno PhD
Marine Biologist
Consultant

Miguel Herrera
Data Coordinator
Indian Ocean Tuna Commission

Contact details:

Indian Ocean Tuna Commission
Le Chantier Mall
PO Box 1011
Victoria, Mahé, Seychelles
Ph: +248 4225 494
Fax: +248 4224 364
Email: secretariat@iotc.org
Website: http://www.iotc.org

For questions regarding the content of the report, contact the IOTC Secretariat: secretariat@iotc.org

Bibliographic entry: G. Moreno & Herrera, M. (IOTC Secretariat), 2013. Estimation of fishing capacity by tuna fishing fleets in the Indian Ocean. Report presented at the 16th Session of the Scientific Committee of the Indian Ocean Tuna Commission. Busan, Republic of Korea, 2–6 December 2013. IOTC–2013–SC16–INF04.

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Acknowledgements

The following countries shared data on the capacity of their fleets and their input is appreciated: Australia, Comoros, Indonesia, Kenya, Mauritius, and Mozambique. Dr. E. Vivekanandan provided a document on the capacity of India's fleets that was very helpful.

Various people at the IOTC office in Seychelles provided logistical support and their help is acknowledged. Mr. Alejandro Anganuzzi (Seychelles Fishing Authority) made useful comments on the report.

Executive Summary

The aim of this study is to produce a new estimate of the fishing capacity of industrial and artisanal fleets that target tuna and tuna-like species in the Indian Ocean. The result of this study, then, is an estimate of active input fishing capacity expressed as the number of tuna fishing vessels in the Indian Ocean, categorised by fleet (gear), vessel length class, and includes associated catches and areas of operation. Associated catches, in conjunction with number of vessels, allows for a comparison of total catches produced by the fleets, a useful validation exercise due to the uncertainty associated to some of the data reported by countries fishing in the region. Furthermore, the relative importance of each fleet on the overall catches of tuna in the Indian Ocean and where future efforts need to be placed to improve reporting systems are also assessed.

The report was based on information extracted from Indian Ocean Tuna Commission (IOTC) databases, input from Contracting Parties and Cooperating Non-Contracting Parties (CPCs), Non-contracting Parties (NCPCs), international organisations, and non-governmental organisations (NGOs), as well as information available online.

The specific objectives of this study were to estimate levels of input fishing capacity[1] for IOTC species and major species of sharks within the IOTC Area, to cover the activities and catches of vessels from all IOTC CPCs, and those of NCPCs fishing in the Area. Information was insufficient to produce estimates of fishing effort therefore we focussed on obtaining estimates of fleet size. In particular we aimed to review and update the estimates for the 2006-08, including number of active vessels, gross tonnage or fish carrying capacity if available, and estimates of average levels of catch for each fleet and vessel category. Also, we strived to calculate levels of fishing capacity for the period 2009-12. The most difficult part of this study was the estimation of fishing capacity for fleets not covered in the previous study, in particular fleets of small-scale, decked, motorized inboard fishing vessels that operate within the Exclusive Economic Zone (EEZ) of their flag states; fleets of vessels powered with outboard engines; and all non-motorized fisheries. In addition to vessel numbers, this study also attempts to estimate total tuna[2] and shark[3] catches per fleet[4] to determine the output capacity of each fleet.

Industrial, semi-industrial, and artisanal-subsistence fleets[5] are presented separately. Although better documented, there is a paucity of data for the industrial fleet, as it is

[1] Input fishing capacity is defined as the amount of fishing units/fishing effort devoted to catch a given resource over a period of time (*e.g.* a year or a fishing season) (Gillett and Herrera 2009)

[2] In the context of this study the word tuna refers to the IOTC species, including 16 species of tuna and tuna-like species, as defined by the Commission (https://www.iotc.org/Common/dataforms/Guidelines%20Data%20Reporting%20IOTC[E].pdf)

[3] In the context of this study the word sharks refer to all species of Elasmobranches caught by fisheries directed at IOTC species, in particular species of pelagic sharks, as identified by the Commission

[4] We loosely define fleet as a group of fishing crafts of the same type that use the same fishing gear, target similar species and are flagged in an IOTC CPC or other Party.

[5] For explanation on these fleets please see section **2.** Characterisation of tuna fishing fleets.

not known whether all registered vessels are active. Furthermore, not all CPCs have made their lists of active vessels available to the IOTC. In this case, we used numbers from the authorised list as a proxy. Nonetheless, these estimates are thought to be more accurate than for the other two fleets. A confusing aspect of the definition of industrial *vs.* artisanal stems from the fact that vessels of the same characteristics (vessels below 24 m) may fit in one category or the other depending on whether they fish outside (industrial) or inside (artisanal) their EEZ.

Estimation of fishing capacity is certainly applicable to industrial fleets that have structured operations and fixed gears, and partially so to semi-industrial fleets. However, there is considerable uncertainty behind the estimation of output capacity from the size of artisanal fleets, and its use should be treated with extreme caution. The use of the size of an artisanal fleet to estimate catches or to estimate output fishing capacity in the absence of reported captures by flag states is highly questionable. First, there are many uncertainties about the numbers of artisanal boats in many countries in the Indian Ocean area due to a lack of reliable information from the countries concerned. Second, even if the numbers were accurate, semi-industrial and artisanal fleets suffer from a series of maladies that industrial fleets do not experience: **a.** they are highly affected by small economic fluctuations (*e. g.* changes in prices of fish), **b.** are more influenced by weather conditions due to the smaller sizes of the vessels, **c.** they are more susceptible to changes in the ranges of certain fish species as a result of global warming, and **d.** because they are opportunistic this translates in a high degree of uncertainty on the species they target and gears they use. Previous trips by the authors to ports and landing sites in the Indian Ocean, have shown large fleets in port for long periods of time due to any of the above issues, conditions that make it hard to forecast catches year to year and country to country. Flexibility, opportunism and vulnerability to a range of factors make it problematic to confidently estimate size, activity levels, and catches of artisanal fleets even when gear composition is known, a factor that in most cases is rarely understood.

Sources for details on industrial and artisanal fleets (as per IOTC definition) are different as the latter are not requested by the IOTC and, although available in some cases, many gaps in information exist. The revised numbers show substantial changes in the reported capacity. An average increase of 70% was observed between this and the previous capacity study (Gillett and Herrera 2009). The average fleet capacity for purse seine, longline, pole and line, oceanic gillnet and gillnet/longline was 7,078 vessels from 2009-2012. These results are presented in detail for each fleet component in the Results section.

The semi-industrial fleet here proposed, part of the artisanal component in the IOTC context, has shown a tremendous increase in the last few years, and it is the constituent of the total fleet that deserves the most attention. Better information is required for this part of the total fleet as it is made of many vessels that catch considerable quantities of IOTC species and that exhibit more defined targeting, compared to truly artisanal fleets that are mostly opportunistic. Fleets that merit increased monitoring are the fresh-tuna longline from Indonesia and Taiwan Province of China, gillnet from India, Indonesia, Iran, Oman and Pakistan, pole and line from Maldives, coastal purse seines from Indonesia, Malaysia and Thailand, and gillnet/longline from Sri Lanka. Furthermore, semi-industrial fleets have the potential to leave the EEZs of their flag countries and there is a need to better monitor their activities. Thus the Commission has a need to establish standards for the collection of individual vessel data for this fleet. If limitations of input capacity are to be effective in the future, the IOTC will need to monitor numbers of active semi-industrial vessels fishing in the Indian Ocean.

Artisanal fleet numbers are much harder to estimate and their gears, and catches by species can only be speculated for most of the countries, as there is little information available on this subject for the Indian Ocean. To further complicate the issue, artisanal fleets are opportunistic and will change gears and target species very rapidly according to local conditions, making any forecasting difficult, and in some cases impossible. Nonetheless there is the need to at least compile total numbers of active craft for the artisanal component as it catches considerable amounts of the species of concern to the IOTC.

Countries fishing in the region put forth fleet development plans (FDPs) as proposed in IOTC Resolution 12/11 *On the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating non-Contracting Parties*. If said plans are completed in the proposed timeline, and countries already fishing in the area keep their current levels of capacity, the fleets fishing for tuna and tuna-like species in the Indian Ocean by the year 2020 will be more than 250% over the capacity baselines from 2006-07, obviously an untenable position for stocks of tuna and tuna-like species in the area.

Abbreviations

Species codes

ALB	Albacore (*Thunnus alalunga*)
BET	Bigeye tuna (*Thunnus obesus*)
BLM	Black marlin (*Makaira indica*)
BSH	Blue shark (*Prionace glauca*)
BTH	Bigeye thresher shark (*Alopias superciliosus*)
BUM	Blue marlin (*Makaira nigricans*)
COM	Narrow-barred Spanish mackerel (*Scomberomorus commerson*)
DUS	Dusky shark (*Carcharhinus obscurus*)
FAL	Silky shark (*Carcharhinus falciformis*)
FRI	Frigate tuna (*Auxis thazard*)
KAW	Kawakawa (*Euthynnus affinis*)
LOT	Longtail tuna (*Thunnus tonggol*)
MAK	Mako sharks (*Isurus* spp.)
OCS	Oceanic whitetip shark (*Carcharhinus longimanus*)
POR	Porbeagle (*Lamna nasus*)
PTH	Pelagic thresher shark (*Alopias pelagicus*)
RSK	Requiem shark nei (Carcharinidae)
SBT	Southern bluefin tuna (*Thunnus maccoyii*)
SFA	Indo-Pacific sailfish (*Istiophorus platypterus*)
SKH	Sharks various nei
SKJ	Skipjack tuna (*Katsuwonus pelamis*)
SMA	Shortfin mako (*Isurus oxyrinchus*)
SPL	Scalloped hammerhead (*Sphyrna lewini*)
SPY	Bonnethead, hammerhead sharks (Sphyrnidae)
SRX	Rays, stingrays, mantas nei
SWO	Swordfish (*Xiphias gladius*)
YFT	Yellowfin tuna (*Thunnus albacares*)

Others

AMSY	Average maximum sustainable yield
CPCs	Contracting Parties and Cooperating Non-Contracting Parties
CPUE	Catch per unit of effort
DEA	Data envelopment analysis
DWF	Distant water fleet
EEZ	Exclusive economic zone
EIO	Eastern Indian Ocean
EU	European Union
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FDP	Fleet development plan
F_{msy}	Maximum rate of fishing mortality
FSI	Fishery Survey of India
GRT	Gross registered tonnage (International Tonnage Convention, Oslo)

GT	Gross tonnage (International Tonnage Convention, London)
hp	Horsepower
IO	Indian Ocean
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, unreported and unregulated
LOA	Length overall
m	metre
MSY	Maximum sustainable yield
MT	Metric tonne
NA	Not available
NCPCs	Non-contracting Parties
NEI	Not elsewhere included
NGO	Non-governmental organisation
nm	Nautical mile
RAV	Record of authorised vessels
OT	Overseas territories
ULT	Ultra-low temperature
USSR	Union of Soviet Socialist Republics
WCPFC	Western & Central Pacific Fisheries Commission
WIO	Western Indian Ocean
WWF	World Wide Fund for Nature

1. Background

Early in its history, Members of the Indian Ocean Tuna Commission moved towards implementing a control of input fishing capacity. In 1999, the Commission requested the IOTC Scientific Committee to present at its next session "the best estimate, on the basis of existing data and analyses, of the optimum fishing capacity of the fishing fleet which will permit the sustainable exploitation of tropical tunas." The Scientific Committee was not able to produce such estimates because as the Working Party on Tropical Tuna in 2001 stated, there were a number of issues that made this difficult. Said estimates of overall fishing capacity needed to determine the relative effects of different types of vessels and gears on the stock (*e. g.* estimate relative fishing power or what the fishing mortality rate for a specific combination of vessel types and number would be). The information required to generate reliable estimates of vessel-specific fishing power was not available at that time. In 2003, the IOTC CPCs took the first step to control fishing capacity by freezing the number for fleets that were larger than 50 vessels. This approach was expanded when fishing capacity (in tonnage) was frozen to the levels found on 2006 (for vessels targeting tropical tunas) and to 2007 (for vessels targeting swordfish and albacore). Finally, recommendations from the IOTC Performance Review Panel (Anonymous 2009) resulted in IOTC Resolution 09/01 where "IOTC should establish a stronger policy on fishing capacity to prevent or eliminate excess fishing capacity" and that "loopholes in the current systems of fishing capacity limitation, such as the establishment of fleet development plans and exemptions for vessels less than 24 meters, should be closed"[6]. This series of actions to limit input fishing capacity, measured as either number of vessels or total tonnage, reinforced the need to have estimates of capacity as accurate as possible, to better appreciate the evolution of the fleets and their pressure on the resources.

Despite improvements in the quantity and quality of the information available over the years, the IOTC Scientific Committee was unable to revisit the issue until 2009. At that time, thanks to the assistance provided by the government of Australia, the IOTC Secretariat comprehensively revised existing estimates of fishing capacity for the region[7]. While the report contained improved estimates of input fishing capacity in the Indian Ocean, including all vessels, regardless of size, fishing for tunas in the high-seas, or vessels larger than 24 m fishing in their EEZs, it only covered large-scale fishing vessels or vessels smaller than 24 m fishing outside their EEZ that captured IOTC species. The report acknowledged that the input capacity estimated for some of the fleets was unlikely to be accurate, due to the paucity of data on those fleets. The main purpose of this study, then, is to update the figures published in 2009, to present data

[6] IOTC (2013a) Report of the Seventeenth Session of the Indian Ocean Tuna Commission. Mauritius, 6–10 May 2013. IOTC–2013–S17–R[E]: 129 pp. Appendix XV - Update on Progress Regarding Resolution 09/01 – On the Performance Review Follow–up.

[7] Gillett R, Herrera M (2009). Estimating the Fishing Capacity of the tuna fleets in the Indian Ocean (IOTC-2009-SC-INF13) Report presented at the Twelfth Session of the IOTC Scientific Committee, Victoria, Seychelles, 30 November-4 December 2009. 29 pp.

from 2009-2012 and, where possible, include estimates of fishing capacity for fleets not covered previously, in specific fleets of semi-industrial and other artisanal vessels[8].

Objectives of this study:

To estimate levels of input fishing capacity[9] for IOTC species and major species of sharks within the IOTC Area, to cover the activities and catches of vessels from all Parties operating in the IOTC Area.

The study includes a detailed account of current levels of active input fishing capacity within the IOTC Area for Party, by year period, type of fleet, vessel size category, fishing method, and target species; in particular:

1. Review and update of previous estimates of input fishing capacity, including:
    a. Review of estimates for the period 2006-08, including number of active vessels, gross tonnage or fish carrying capacity, and estimates of average levels of catch and fishing effort for each fleet and vessel category;
    b. New estimates of levels of fishing capacity for the period 2009-12, for the same fleets and according to the same standards as in a. above.

2. Estimates of fishing capacity for fleets not covered in the previous study, in particular:
    a. Fleets of small-scale[10] decked, motorized inboard fishing vessels that operate within the EEZ of their flag states.
    b. Fleets of vessels powered with outboard engines.
    c. All non-motorized fisheries.

    The standards in 1a. above also apply for 2a.-2c.

The report includes:

1. Estimates of input fishing capacity in the Indian Ocean for the period 2006-12, including the fisheries and as per the standards defined previously.
2. An evaluation of potential levels of input fishing capacity in the future using the information reported by IOTC CPCs in their Fleet Development Plans, as well as information on the actual implementation of such plans, where available.

The report was based on information extracted from IOTC databases, input from CPCs, NCPCs, international organisations, and non-governmental organisations (NGOs), working in cooperation with the IOTC Secretariat, as well as information available online.

[8] For explanation on these fleets please see section **2.** Characterisation of tuna fishing fleets.
[9] Input fishing capacity is defined as the amount of fishing units/fishing effort devoted to catch a given resource over a period of time (*e. g.* a year or a fishing season) (Gillett and Herrera 2009).
[10] Refers to vessels having less than 24 meters length overall (LOA)

This report gives a brief review of fishing capacity and issues, the tuna fishery in the Indian Ocean, and methodology used. Results are presented by fishing gear (*e. g.* purse seine, longline, etc.) and further subdivided by fleets according to similarities in techniques, vessel characteristics, and target species (*e. g.* fresh-tuna longline, swordfish longline). Results are given by industrial and semi-industrial fleets in the same section and by artisanal fleets separately.

2. Characterisation of tuna fishing fleets in this study

The IOTC classifies as industrial all vessels with LOA above 24 m regardless of where they fish, and vessels below 24 m fishing outside the EEZ of their flag states. Artisanal fisheries are defined as those undertaken by vessels (or any other types of fishing crafts) with LOA less than 24 m and operated full time within the EEZ of their flag states. Therefore, vessels of equal characteristics that are less than 24 m and fish inside their EEZs are classified as artisanal while those fishing outside their EEZs are classified as industrial, a confusing point that needs to be addressed.

As it stands, this definition of artisanal vessel in the IOTC encompasses a wide array of boats with vastly different characteristics. They range from the pirogue that fishes close to shore for subsistence with no motor, no deck and no holding facilities, to a longliner, gillnetter or purse seiner of less than 24 m with an inboard motor, deck, communications, fish holding facilities, and in some cases chilling or freezing capabilities. This latter vessel could potentially conduct fishing operations offshore, including outside its EEZ. Obviously, these boats at the extremes do not share evident characteristics that warrant their inclusion into a single category. Size as definition of the artisanal fleet in the IOTC is, in itself, is a poor descriptor of capacity for this fleet and we propose to the Commission to further divide the fleet to allow for higher resolution and to decrease the inclusion of vastly different vessels in the same category. However, for this study, and due to existing definitions and limitations of available data, we propose a semi-industrial component that will include vessels between 15-24 m that fish exclusively inside their EEZ and an artisanal component that includes all vessels having overall lengths up to 15 m (Table 1).

Table 1: Proposed classification scheme for vessels in the Indian Ocean depending on type, size and area of operation[11].

Type of boat	Boat size	Area of Operation	Fleet
Non-motorised	All	EEZ	Artisanal
Motorised outboard	All	EEZ	Artisanal
Motorised inboard	<15 m	EEZ	Artisanal
Motorised inboard	15-24 m	EEZ	Semi-industrial
Motorised inboard	<15 m	High seas	Semi-industrial
Motorised inboard	15-24 m	High seas	Industrial
Motorised inboard	≥ 24 m	Anywhere	Industrial

[11] In some cases, non-motorized vessels or vessels powered with outboard engines that are based in areas where EEZs are not extensive (*e. g.* Mozambique Channel) may operate beyond their EEZs, mostly in the EEZs of neighbouring countries.

The IOTC requires CPCs to report a list of active vessels above 24 m fishing for tuna and tuna-like species (regardless of where they operate), and any vessel below 24 m that fishes outside its EEZ every year. At this time the Commission does not have a requirement for CPCs to report vessels below 24 m fishing in the EEZ of their flag countries although the information about the number and size of vessels in this component is routinely requested.

3. Fishing Capacity

The term fishing capacity has been used in a variety of contexts, leading to confusion on its meaning. Squires *et al.* (2007) stated "the notion of fishing capacity continues to generate substantial differences in opinion regarding its definition and, more generally, its conceptual meaning."

In this study, as in that of Gillett and Herrera (2009), the following definitions were used.

- **Input fishing capacity:** the amount of fishing units/fishing effort devoted to catch a given resource over a period of time (*e. g.* a year or a fishing season)
- **Output fishing capacity:** the maximum amount of fish that can be produced over a period of time (*e. g.* a year or a fishing season) by a vessel or a fleet if fully utilized and for a given resource condition

Fishing Capacity:

Different groups of people generally have a different understanding of capacity. Fishing technologists often consider fishing capacity as the technological and practical feasibility of a vessel achieving a certain level of activity – be it days fishing, catch or processed products. Fisheries scientists often think of fishing capacity in terms of fishing effort, and the resultant rate of fishing mortality (the proportion of the fish stock killed through fishing). Fisheries managers generally have a similar view of fishing capacity, but often link the concept directly with the number of vessels operating in the fishery. Many managers express fishing capacity in measures such as gross tonnage or as total effort (e.g. standard fishing days available). Most of these ideas reflect an understanding of capacity primarily in terms of inputs (an input perspective). In contrast, economists tend to consider capacity as the potential catch that could be produced if the boat were to be operating at maximum profit or benefit (an output perspective). To reflect these different views of fishing capacity, an FAO technical consultation developed a definition of fishing capacity that is both input (e.g. effort, boat numbers, etc.) and output (catch) based:

Fishing capacity is the amount of fish (or fishing effort) that can be produced over a period of time (e. g. a year or a fishing season) by a vessel or a fleet if fully utilized and for a given resource condition. (FAO 2004)

Worldwide, more than 60% of the total catch of the main market tuna species is caught with purse seine, 14% by longline, and 11% by pole and line (Joseph 2009). These percentages are considerably different for the Indian Ocean due to the importance of semi-industrial and artisanal fleets which use a wide array of gears including longlines, gillnets, seine nets, handlines, troll and others including multiple combinations of the ones previously mentioned. In the Indian Ocean these two fleets may contribute up to 43% of the catch of the main tuna species and up to 61% of the total catch of all tuna and tuna-like species (Gillett and Herrera 2009, Herrera *et al.* in press), making it unique among the other oceans where industrial fleets capture a much larger proportion of the catch.

4. Overview of tuna fishing fleets and their catches in the Indian Ocean

Tuna fishing in the Indian Ocean has a long history, extending back almost a thousand years for traditional fisheries such as those in the Maldives. Since the advent of mechanized fishing, catches of main market species of tunas in the region have increased dramatically. In 1950, approximately 15,000 MT of tropical tunas (skipjack tuna *Katsuwonus pelamis*; bigeye tuna *Thunnus obesus*; yellowfin tuna *T. albacares)*, albacore (*T. alalunga*) and swordfish (*Xiphias gladius*) were caught, number that rose to around 200,000 MT in the early 1980s. Catches climbed in the mid 1980s upon the arrival of the purse seine fleet. Sharp increases were again observed in 2005 and 2006 when approximately 1.2 million MT were fished. Soon thereafter, 2007 to 2008, catches stabilized just below the 1,000,000 MT mark. Security issues due to piracy from Somalia on the high seas affected the tuna fishery in 2009-2011 when catches dropped to just below 900,000 MT. In those years, some fleets left the West Indian Ocean region, and effort was reduced or displaced altogether to other areas of the Indian Ocean or other oceans. Catches in 2012 remained around the 860,000 MT mark.

Since its arrival to the Indian Ocean, the purse seine fleet has been dominant in captures of tropical tunas. Purse seine has been mostly conducted by countries from the EU (Spain, France and Italy to a lesser extent), with a few vessels from Seychelles, Islamic Republic of Iran and other countries from the region. The catch with this gear accounts for approximately 35% of the total catch of tropical tunas, albacore and swordfish in the Indian Ocean. The fleet had 80 vessels in 2006 but this number dropped to 57 in 2011 in due big part to security problems associated with piracy from Somalia starting in 2008.

This fleet employs two very different methods to catch tuna: free schools and associated schools (mainly with the use of drifting FADs). In fact, the two could be considered separate fisheries, as their impact on the resources is different. Natural drifting FADs such as palm fronds, drifting logs (Taquet *et al.* 2007, Castro *et al.* 2002), whale sharks, large dead whales, marine debris, and others have been used to catch tuna for a long time. In the early 1980s, around 50% of the catch was associated with these structures (Fonteneau 2003). Soon after, with the introduction of radio buoys (Moron *et al.* 2001) and other technologies like GPS in the late 1990s the fishery switched to the use of human-made FADs and the catch associated to them increased. FADs are arguably one of the most pervasive and powerful introductions to the industrial purse seine fishery. Fish aggregate under FADs and fishers exploit this behaviour to capture about 50% of the world's tuna (Pianet *et al.* 2005, 2004,). The use of FADs by the purse seine fleet in the western Indian Ocean is of particular relevance, as this fishery landed an average of 225,000 tonnes of tuna per year from 1999-2003 (Moreno *et al.* 2007, Pianet *et al.* 2005). This represents 50-70% of the total catch by the purse seine fleet in the region and the highest FAD-associated percentage worldwide (Fonteneau 2003).

FADs in the western Indian Ocean have modified the behaviour of the fleet and concerns exist about their impact. It has been suggested that they act as ecological traps, increase the catch of undersized tropical tuna (Marsac *et al.* 2000) and bycatch species like turtles and sharks but empirical data on some of these issues are few and inconclusive according to Dagorn *et al.* (2012).

Longline follows in importance (22%) in catches of tropical tunas, albacore and swordfish in the Indian Ocean. Vessels from Taiwan Province of China, Indonesia, and Japan dominate the longline fleet accounting for up to 80% of the fleet with India, China, Malaysia, Seychelles, EU and others accounting for the rest. This fleet targets yellowfin tuna, bigeye tuna, albacore, and swordfish. The swordfish longline fleet also catches substantial numbers of sharks. Furthermore, longline fleets may target sharks depending on the area and period of the year. In recent years some longline vessels have targeted other species including oilfish (*Ruvettus pretiosus*) and tunas have become a bycatch.

Gillnet, in particular drift gillnet, is the third most important gear with catches around 18% of the total catches of tropical tuna, albacore and swordfish. The last major gear that is important for this group of species is pole and line with around 11% of the total catch.

These rankings change considerably if we look at the catches of all IOTC species. Gillnet becomes the main gear in the Indian Ocean with 31% of the catch, due to its increasing importance in the fishery for neritic tunas and tuna-like species, followed by purse seine (27%), longline (15%) and pole and line (7%).

In addition to purse seiners and longliners, there are large numbers of tuna fishing vessels of 24 m or larger operating outside and/or inside the EEZ of their flag country. These include baitboats using pole-and-line from Maldives; gillnet vessels from Indonesia, Iran and Pakistan; purse seine vessels from Indonesia; and vessels from Sri Lanka that use a combination of gillnets and longlines. Pole and line vessels target skipjack tuna and yellowfin tuna, and gillnet/longline vessels go after skipjack tuna, yellowfin tuna and sharks. Maldivian baitboats take a substantial part of the catch, and they target free-swimming schools of skipjack tuna, or schools of tropical tunas associated to anchored fish aggregating devices (FADs) or dolphins (Adam *et al.* 2003).

The vessels larger than 24 m mentioned immediately above, along with vessels between 15 m to 24 m that are not truly artisanal, fall into a yet undefined, medium-scale, semi-industrial category (Gillett 2005; Berkes *et al.* 2001). For practical purposes, and because the component 24 m or larger is already covered by various IOTC resolutions, the semi-industrial fleet defined here will only include vessels from 15 to 24 m fishing inside their EEZs. Although technically artisanal according to the IOTC definition, this component catches an estimated 500,000 tonnes of tuna and tuna-like species in the Indian Ocean. Iran, Oman, Pakistan, and Sri Lanka have important drift gillnet fisheries that target yellowfin tuna, skipjack tuna, longtail tuna (*T. tonggol*) and other species. Because of the characteristics of the gear, this fishery is non selective and it has been the subject of various studies and much concern regarding bycatch species in particular birds, turtles and marine mammals. India and Indonesia have multi-gear fisheries that use a plethora of gears including longlines, other lines (*e. g.* troll), gillnets, pole and line, purse seine, lift nets, ring nets, trawls and other gears to catch oceanic and neritic tuna species. In the case of Indonesia, these fisheries are associated in great part to anchored FADs and they catch large numbers of juvenile yellowfin and bigeye tunas. This semi-industrial category is the least understood, possibly the fastest growing, and may be the fishing sector with the most impact in the Indian Ocean. The fact that some IOTC Resolutions do not cover all vessels in this group (*e. g.* Vessel Monitoring System[12], Limitation on fishing capacity[13]), or do not cover them to the same extent as industrial fleets, makes it very difficult to know the spatial distribution or composition of these fleets. Vessels in these fleets may be fishing outside the EEZs of their countries possibly in considerable numbers and they seem to be the fastest growing segment of the fishing fleet in the Indian Ocean. As such, we separate this component and start calculating the numbers for the semi-industrial fleet to understand its impact.

Finally, artisanal and subsistence are by far the most numerous and most opportunistic of all fleets. In most cases, however, the catch of IOTC species per boat is small due to limitations on their capacity to go offshore and use large gears, as well as to the fact that these are multi-species fisheries that do not target any type of fish in particular but search opportunistically for species that are available. Nonetheless, because of the large numbers in this fleet, the total catch for this component is substantial for the Indian Ocean.

Data for artisanal fisheries are lacking and, depending on how gears are classified, it is estimated that they catch close to 600,000 tonnes of tuna and tuna-like species annually in the Indian Ocean. This fishery contributes around 40% of all tuna and tuna-like fishes caught in the Indian Ocean. There are at least 16 countries in the region that catch more than 5,000 tonnes per year in these fisheries: Comoros, India, Indonesia (Indian Ocean sector), Iran, Madagascar, Malaysia, Maldives, Mozambique, Myanmar, Oman, Pakistan, Saudi Arabia, Sri Lanka, Thailand, United Arab Emirates and Yemen (Herrera *et al.* in press). Gillnets account for 45% of the tuna and tuna-like species caught by artisanal gears while various types of lines (excluding longline) account for 23%, purse seine 15%, other gears 9% (trawl, Danish seine, beach seines, traps, etc.) and longline 6%.

It must be noted that for each category, particularly for semi-industrial and artisanal gears, there are many configurations depending on target species and country where they are used. This makes any comparisons and aggregation of said gears difficult, as

[12] IOTC Resolution 06/03 On establishing a vessel monitoring system programme

[13] IOTC Resolution 12/11 On the implementation of a limitation of fishing capacity of contracting Parties and cooperating non-contracting parties

the effort, techniques, configurations and species caught are different. This diversity and its implications should not be ignored as the collection of similar gears under a generic grouping, longline for example, will result in misleading interpretations due to the factors previously mentioned. Some semi-industrial and artisanal fisheries target particular species but opportunism is the norm, while industrial fisheries tend to be very specialized because changes in gear or operations are logistically difficult and economically unsound.

5. Methodology

Most of the information presented here for industrial and semi-industrial fleets was collected from the Record of Active vessels and fishing craft statistics available at the IOTC. The Record of Active Vessels is part of the data requirements since 1998, following adoption of a Resolution[14] calling IOTC CPCs having large-scale vessels fishing for IOTC species in the IOTC Area to report individual details for said vessels annually. This Resolution was subsequently superseded in 2005, 2007, and 2010[15], the main purpose being to update and extend the existing requirements to incorporate other vessel details (*e. g.* IMO number, GT as measure of vessel tonnage instead of GRT, *etc.*) and details on the species targeted; move forward data reporting deadlines; and include all vessels operated on the high seas, irrespective of their size. Fishing craft statistics have been compiled since the early 1980s by the Indio-Pacific Tuna Development and Management Programme, the precursor to IOTC, for all fishing parties known to operate in the IOTC Area. However, this information is not formally requested by the Commission and, for that reason, is only available for some fleets. Data available includes the numbers of vessels fishing per flag, vessel size category, gear type, and year, and, although it is often complete for industrial vessels, it is mostly lacking for other fleets. Country reports and other documents were used to validate the data above or to complement it when information was missing.

Various sources were consulted to arrive at the final figures here presented: country reports, scientific committee reports, IOTC databases, responses to IOTC Circular 79 (Appendix 1) requesting information for this study, relevant publications, personal communications as well as information available online. Due to contradictory reports from some countries about their fleets, other sources were consulted to ascertain the validity of the information.

Data for all fleets are in many cases estimated by the IOTC Secretariat as the numbers reported by the CPCs are in many cases contradictory or inconsistent, deemed too low or high when compared to similar fleets, or are not reported at all. In any of these cases the Secretariat uses catches per vessel estimated from years in which the information was available for the same fleet or from other fleets thought to operate in a similar manner. Ratios of total effort *vs.* number of vessels fishing are used to

[14] Resolution 98/04 *Concerning registration and exchange of information on vessels, including flag of convenience vessels, fishing for tropical tunas in the IOTC area of competence*

[15] Resolutions 05/04, 07/04, and 10/08 *Concerning a record of active vessels fishing for tunas and swordfish in the IOTC area*

estimate numbers of vessels back in time (*e. g.* used to estimate the historical numbers of deep-freeze longline tuna vessels from Japan particularly from the 1950-1990). In some cases it was necessary to assign vessels to a single flag when the same vessel was recorded under two or more flags due to changes of flag within the year of reference, due to parallel registration, or due to concurrent registration. For this latter case, for example, charter arrangements between India and Taiwan Province of China allowed through the Letter of Permit, for vessels to be flagged in India and monitored by Indian authorities while fishing inside its EEZ but were monitored by the original flag country while outside the EEZ of India.

For semi-industrial and artisanal fleets, numbers are presented for countries that had the information available. Special emphasis was placed in getting numbers for the more important tuna fishing countries, and countries whose small and medium-scale fisheries have grown substantially in recent years (India, Indonesia, Iran, Maldives, Oman, Pakistan, and Sri Lanka). In addition, data are presented for countries that responded to the request of the Commission to submit information on their artisanal fleets through IOTC Circular 79 (Appendix 1). These countries include Australia, Comoros, Indonesia, Kenya, Mauritius, and Mozambique.

In this study we reviewed the information available and calculated estimates of numbers of vessels above 24 m regardless of where they fish, and of all vessels fishing outside their EEZ regardless of their size by nationality, size category (under and over 24 m), gear type, and year. Data were inspected for duplicates (*e. g.* double flagging), missing data (*e. g.* information missing from reports but data taken from third party reports), conflicting reports (*e. g.* active and authorised vessel lists presenting different values for vessel dimensions), and incomplete reports (*e. g.* missing vessel details). These numbers were then compared with those from the previous capacity study (Gillett and Herrera 2009) for 2006-2008 and additional data from 2009-2012 were added. Numbers of vessels for the EU purse seine fleet were taken from the EU database FIBATO to identify changes in flag and duplicate records.

Because of large operational differences within each the purse seine and longline fleets from different countries (*e. g.* EU v*s*. Japan), and those that target different species (*e. g.* albacore *vs.* tropical tuna) or markets (*e. g.* fresh *vs.* frozen tuna markets), we chose to split them into "functional" components. These groupings were done to reduce the variability within a fleet and it was done based on fishing methods and average catches per boat and year that were considered consistent. These grouping then refer to fleets from countries that share similarities in the way they operate, gear configurations used, area of operation, and species targeted. The purse seine fleet was divided into purse seine directed at tropical tunas or temperate tunas (Australia only). The tropical component was further subdivided into: **1.** EU and similar fleets; **2.** Indonesia; **3.** Iran; **4.** Japan and Korea; and **5.** Russia and Thailand.

Similarly, the longline fleet was divided into swordfish longline, deep-freeze tuna longline, and fresh-tuna longline. Furthermore, the swordfish longline was subdivided into **1.** EU and similar fleets, and **2.** African semi-industrial fleets (Mauritius, Reunion and Seychelles). The tuna longline component was subdivided into **1.** Japan and similar fleets, and **2.** Taiwan Province of China and similar fleets. The fresh-tuna fleet was divided into **1.** Taiwan Province of China, and similar fleets, and **2.** Indonesia. The pole and line fleet was kept as one. The oceanic gillnet fleet was divided into **1.** Western Tropical Indian Ocean and **2.** Arabian Sea. Finally, the gillnet/longline from Sri Lanka was kept as one fleet.

Data for sharks are presented for industrial and semi-industrial fleets that report them, namely the various type of longline, gillnet from Oman, and gillnet/longline from Sri Lanka. Gillnet from Iran/Pakistan did not report catches of sharks, an issue that needs to be addressed. Data for shark catches in the industrial purse seine fleet are scant and even though some studies have tried to characterise the catches for this fleet (Amandè *et al.* 2012) the consensus is that available data quality is poor and that species resolution is not yet achievable. Where reported, shark catches are likely to represent a gross underestimate, as they usually do not include all retained catches and seldom include the amounts of sharks discarded.

Capacity in itself does not refer only to number of fishing vessels but also includes technology and its improvements through time. If there are improvements that increase efficiency, capacity will increase even if the number of vessels stays constant. Among the many technical advances that have resulted in increases in fishing efficiency are larger vessel sizes, bird radars, sonars, echo sounders, FADs, support vessels, sea surface temperature from satellites, and others (Moron 2007). Furthermore, FADs (anchored or drifting) may be monitored through radio and satellite buoys and in many cases are fitted with echo sounders that gather information on the quantity and size of fish under them.

The numbers of FADs, manner of use, and frequency of deployment have an impact on the fishing capacity of a fleet and their impact warrants investigation. Supply vessels that deploy FADs also form part of the capacity of this fishery. These vessels are used to deploy and maintain FADs, as well as to report to purse seiners the amount of fish under the FADs, as well as search for free-schools in areas other than those covered by the purse seiners they support, thus increasing fishing efficiency substantially. The Spanish purse seine fleet is the main user of supply vessels and they started operating in the Indian Ocean at the end of the 1990s (Ramos *et al.* 2010). In this report we explore the issue and report the use of FADs and supply vessels by the industrial purse seine fleet in the Indian Ocean as best as the limited amount of data allowed us. Unlike vessels, no attempt was made in this study to estimate the total numbers of FADs used across all fisheries and time periods due to the paucity of the data available and high variability in their use across purse seine fleets.

6. Results

Although a significant portion of the fleet fishing on the high seas is industrial, there is a large component that belongs to the semi-industrial category. For clarity's sake, we have divided the fleets into industrial, semi-industrial and artisanal keeping in mind that there is no clear break between categories and as such no single fleet characteristic describes them completely.

ESTIMATION OF NUMBER OF VESSELS IN THE INDUSTRIAL AND SEMI-INDUSTRIAL FLEETS FISHING FOR TUNA AND TUNA-LIKE SPECIES IN THE INDIAN OCEAN

The combined number of vessels of industrial purse seine and the various types of longline was at its lowest point in 2010 since 1998, and values in 2012 were just above the number of vessels for the same year. The main component in terms of number of industrial vessels comes from the 15-24 m tuna longline fleet (Figure 1) specifically fresh-tuna longline.

The two main industrial fishing gears in the Indian Ocean, purse seine and longline, showed reduced levels of capacity compared to 2006, the year in which the IOTC established the baseline to freeze input fishing capacity for industrial fleets directed at tropical tunas (2007 for those directed at swordfish and/or albacore) (Table 2). The same may be said of two important semi-industrial arts, pole and line from Maldives and gillnet/longline from Sri Lanka. The one gear that showed a modest increase was oceanic gillnet from Iran and Pakistan. This reduction, in good part, is due to security concerns because of piracy from Somalia. Another aspect, however, is the shift in fleet composition to vessels lower than 24 m. Although any vessel of any size fishing outside its EEZ must be registered in the IOTC's Authorised Vessel List, it is known that some vessels fish on the high seas and offload in their flag countries and therefore are not counted as part of the high-seas fishing fleet. Vessel Monitoring System (VMS) is only required for vessels in the Authorized Record. Reports of vessels not on this list come from vessel owners or skippers rather than factual information about the whereabouts of the vessel. We strongly suggest that for VMS to be effective it should cover all vessels that could *potentially* operate outside the EEZ of the flag country. Decked vessels over 12 m are a reasonable minimum limit as they have been found in international waters or in the EEZ of countries other than their flag country (Greenpeace 2013).

Figure 1: Historical series of numbers of industrial vessels between 15-24 m LOA fishing outside their EEZs or larger than 24 m fishing anywhere in the Indian Ocean. Categories presented by length overall (m).

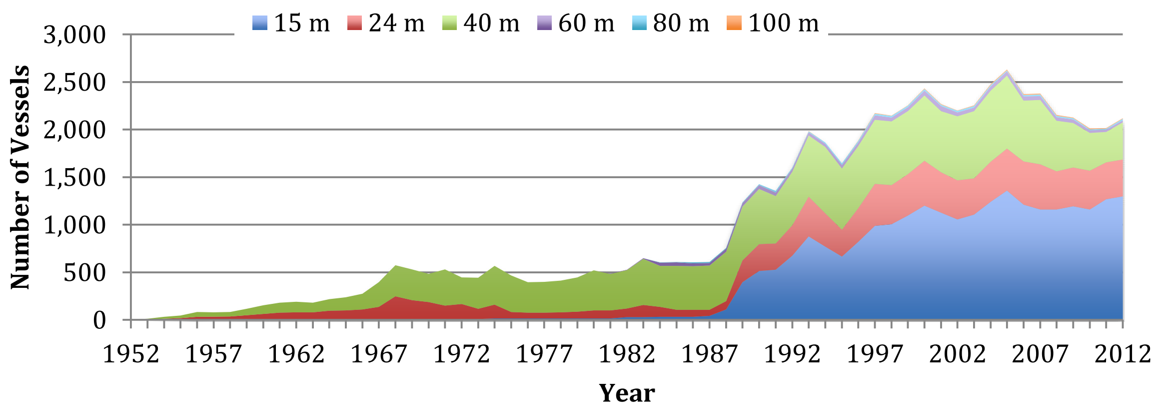


Table 2: Estimates of numbers of vessels by gear, length category, and year for all vessels fishing outside the EEZ of their flag country in the Indian Ocean or inside their EEZ but larger than 24 m from **a.** 2006-2008 and **b.** 2009-2012. Numbers in parentheses show estimates from previous capacity study (Gillett and Herrera 2009).

a.

Gear	Total Number of Vessels			By vessel length (2008)		
	2006	2007	2008	< 24 m	≥ 24 m	Unknown
Purse Seine	83 (90)	82 (92)	76 (85)	(2)	76 (83)	
Longline	2,272 (2,593)	2,279 (2,328)	2,062 (2,414)	1,158 (683)	904 (1,215)	(516)
Pole and Line	925 (93)	894 (89)	867 (87)		(87)	867* (0)
Oceanic Gillnet	1,007 (1,027)	1,099 (1,029)	1,195 (1,029)	808 (467)	387 (285)	(277)
Gillnet/Longline	2,394 (359)	2,460 (369)	2,809 (421)	2,809 (421)		
Total	**6,681 (4,162)**	**6,814 (3,907)**	**7,009 (4,036)**	**4,775 (1,573)**	**1,367 (1,670)**	**867 (793)**

*Maldives did not report these numbers by size category. It is uncertain when the fishery with boats larger than 24 m started.

b.

Gear	Total Number of Vessels				By vessel length (2012)		
	2009	2010	2011	2012	< 24 m	≥ 24 m	Unknown
Purse Seine	81	71	57	68	3	65	
Longline	2,028	1,928	1,948	2,041	1,293	748	
Pole and Line	920	708	608	698	424	274	
Oceanic Gillnet	1,296	1,270	1,261	1,243	812	431	
Gillnet/Longline	2,934	3,346	3,319	2,482	2,481	1	
Total	**7,259**	**7,323**	**7,193**	**6,532**	**5,013**	**1,519**	

i. Purse seine fleets

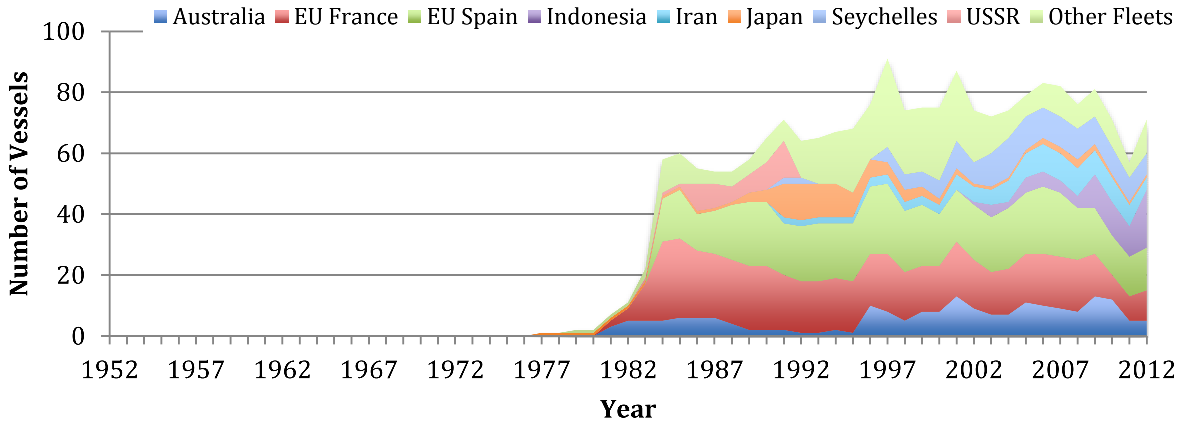
The industrial purse seine fleet was divided into two groups based on the target species, tropical and temperate tuna. The tropical component was further subdivided into: **1.** EU and similar fleets; **2.** Indonesia; **3.** Iran; **4.** Japan and Korea; and **5.** Russia and Thailand. The total number of industrial purse seiners shows a decrease in number compared to Gillett and Herrera (2009) (Table 2a). This is likely to result from the duplication of records of vessels fishing in the area and this issue has been rectified in the present study. Furthermore, reporting of numbers of vessels has improved for some of the fleets, purse seine included. Fleet size before 2008 was more or less stable but it dropped considerably following the onset of piracy off the coast of Somalia increasing in 2012, probably as a consequence of improved security in the area. The fleet in 2006 was of 83 vessels and in 2012 this number was down to 68 vessels. Numbers for this fleet are considered reliable.

a. Industrial purse seine fleet targeting tropical tuna

This fleet targets skipjack tuna and yellowfin tuna, although it also catches bigeye tuna, albacore and various neritic tuna and other species as bycatch. Industrial purse seining first appeared in the Indian Ocean in 1977 when Japan sent one ship. Numbers increased rapidly and in 1984 there were 58 vessels from nine countries. Historically, the two dominant countries of the purse seine fleet in the Indian Ocean have been EU-France and EU-Spain. A fleet of vessels using flags of convenience, the majority under

European ownership, appeared in the mid 1980s. The fleet reached its zenith in 1997 when 91 vessels from 12 nations fished in the Indian Ocean. Purse seine fleet capacity dropped in 2010 and then again sharply in 2011 due to piracy and although it has rebounded, current levels have not been this low since 1995 (Figure 2).

Figure 2: Historical series of numbers of industrial purse seine vessels between 15-24 m LOA fishing outside their EEZs or larger than 24 m fishing anywhere in the Indian Ocean by flag.



<u>EU and similar fleets</u>

Historically, this cluster groups all relevant EU countries (France, Italy, and Spain) and other flags that have operated in a similar manner, either in the past (Belize, Ivory Coast, Malta, Netherland Antilles, Panama, Reunion, Saint Vincent and the Grenadines), or currently (Seychelles). At this time only the EU and Seychelles operate under this category. This is the largest component of the purse seine fleet in the Indian Ocean. This fleet uses FADs extensively and fishes mainly on the Western Indian Ocean, offloading fish mainly in Seychelles, Madagascar and Kenya to a lesser degree. Fish are not dry-frozen but stored in brine at a very low temperature. Approximately half of the catch is skipjack tuna, followed by yellowfin tuna and a smaller percentage of bigeye tuna (Table 3). Large yellowfin tuna are mainly caught from free-schools while the smaller fish of this species and of bigeye tuna come from fishing associated to FADs. This fleet shows the highest catch rate of any other fleet fishing in the Indian Ocean with 6,511 MT per vessel per year.

Table 3: Characteristics of the purse seine fleet from the EU and similar fleets. Species and regions are presented as percentage of the total catch of this fleet per year. Note that there is a very small catch in the Eastern Indian Ocean every year but the percentages are too low to register in most years. Total catch and average catch per vessel are in MT. %LS shows the percentage of the total that was caught on schools associated to logs/FADs.

Year	Region %		Species %				Total Catch (% LS)	Number of vessels	Average catch per vessel
	WIO	EIO	SKJ	YFT	BET	ALB			
2006	99.9	0.1	57	38	5	0	381,417 (69%)	51	7,479
2007	100	0.0	54	37	9	0	241,421 (67%)	51	4,734
2008	100	0.0	49	41	10	1	265,390 (64%)	47	5,647
2009	99.8	0.2	57	33	10	0	249,795 (81%)	42	5,948
2010	99.2	0.8	55	37	8	0	271,756 (85%)	35	7,764
2011	100	0.0	49	43	8	0	263,062 (82%)	34	7,737
2012	99.9	0.1	35	57	7	1	225,699 (70%)	36	6,269

The EU reported shark discards from its purse seine fleet from 2003-2007, numbers that were derived from data from the Regional Observer Scheme. A recent study suggests, however, that these figures are not precise enough to allow detailed description by species (Amandè *et al.* 2012). For this reason, these data have yet to be incorporated into the IOTC database. This fleet is known to catch oceanic shark species (Greenpeace 2013, Chavance *et al.* 2011) where approximately 33% of the shark catch is kept on board and the rest discarded. Amandè *et al.* (2008) estimated that around 35.5 MT of bycatch were produced for every 1,000 MT of tuna landed by purse seiners from the EU and similar fleets. Of this 35.5 MT, they further calculated that sharks accounted for 10.1% (3.6 MT/1,000 MT of tuna landed) where the main species were silky sharks (79%) and oceanic whitetip (11%) although these percentages are now known not to be accurate (Amandè *et al.* 2012).

Indonesia

Indonesia started operations in the Indian Ocean in 2002 with one vessel slowly increasing to 10 vessels in 2011. This fleet is based in Indonesia and fishes on the Eastern Indian Ocean. Skipjack tuna and kawakawa make about 70% of the catch with bigeye tuna, frigate tuna and yellowfin tuna the rest (Table 4). There are obvious problems with the data reported by Indonesia. First, it is unknown whether the industrial fleet is actually working at this time. Second, the captures reported are for small purse seine, a fleet composed of semi-industrial vessels that tend to fish close to anchored FADs. The average catch per vessel of 8,733 MT per year is obviously too large and it is suspected not to be the catch of the industrial fleet but that of the semi-industrial, where many more vessels exist and where the catch per vessel would be much lower than the one here calculated. The numbers were included here for two reasons: to highlight the importance of the Indonesian semi-industrial fleet; and to give an example of the inconsistency of the data encountered through this study where the artisanal fleet (as per IOTC definition) was concerned. Indonesia's report of active vessels is partially driven by foreign markets where purse seiners that export fish are reported as active irrespective of their size and whether they operate fully within the EEZ (two conditions that would exclude them from said list). This is done because buyers would not import the fish unless the vessels are registered in the IOTC Record of Authorized Vessels. The increase in the numbers of vessels reported over the years may be, for this reason, misleading.

There is no information on shark captures for this fleet. This fleet commonly fishes associated to anchored FADs but information on this type of fishing by this fleet is not available. If we take ratios estimated for drifting FADs, like those used by industrial purse seiners from the EU and similar countries, it could be assumed that 3.6 MT of sharks are caught for every 1,000 MT of tuna landed. Because anchored FADs are much closer to shore than drifting FADs, we cannot speculate on the composition of sharks caught.

Table 4: Characteristics of the purse seine fleet from Indonesia. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %[16]					Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SKJ	KAW	BET	FRI	YFT			
2006	0	100	43	25	8	8	7	43,766	5	8,753
2007	0	100	43	25	8	8	7	51,190	4	12,798
2008	0	100	43	25	8	8	7	66,416	4	16,604
2009	0	100	43	25	8	8	7	68,270	11	6,206
2010	0	100	43	25	8	8	7	71,217	11	6,474
2011	0	100	43	25	8	8	7	74,932	10	7,493
2012	0	100	43	25	8	8	7	53,298	19	2,805

Iran

Iran had two vessels fishing in 1991 increasing to nine vessels from 2006 to 2008, but soon after these numbers dropped. It is likely that this fleet fishes in the Western Indian Ocean although there is a lack of time-area data to corroborate this. This fleet is mostly based in the port of Bandar-Abbas. It catches yellowfin tuna, skipjack tuna and longtail tuna with a small percentage of bigeye tuna (Table 5). The average catch per vessels is low compared to the EU fleet due to operational difficulties and the fact that they operate part of the year only.

This fleet does not report catches of sharks. These vessels target free schools where catches of sharks tend to be lower (0.3 MT/1,000 MT of tuna landed for purse seiners flagged in countries of the EU) than for the above fleets that target free schools plus schools associated to logs and FADs. This same estimate may be used for some of the purse seine fleets presented below, as they fish in a similar manner.

Table 5: Characteristics of the purse seine fleet from Iran. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	YFT	SKJ	LOT	BET			
2006	100	0	57	27	16	0	14,566	9	1,618
2007	100	0	45	9	45	1	5,156	9	573
2008	100	0	44	31	25	0	4,858	9	540
2009	100	0	44	30	26	0	3,846	8	481
2010	100	0	75	19	7	0	3,377	8	422
2011	100	0	19	29	49	2	4,621	7	660
2012	100	0	22	32	41	3	5,120	4	1,280

Japan and Korea

Japan was the pioneer of industrial purse seining in the Indian Ocean starting in 1977 with one vessel increasing suddenly to 11 vessels in 1991. Numbers dropped steadily until there was only one vessel left in 2011. Korea is a newcomer to purse seining in the Indian Ocean fishing only in 2012 with three vessels. In recent years Japan's purse seine fleet has been based in Phuket (Thailand), with fishing grounds in the Eastern

[16] Species percentages are repeated through time and this is a consequence of the fact that fixed species ratios were used for the time period presented. Issues with data reporting in Indonesia resulted in a study on partition of catches by species and gears for this country (Moreno *et al.* 2012).

Indian Ocean. In 2009 and 2010 the whole catch was taken in the Eastern Indian Ocean due to piracy in the Western Indian Ocean. This fleet captures skipjack tuna followed by bigeye tuna and yellowfin tuna (Table 6). The average catch per vessel per year was 2,234 MT per year. This fleet does not report catches of sharks and, considering that the majority of the catches are taken using FADs, EU shark catch rates on FADs could be applied here as well.

Table 6: Characteristics of the purse seine fleet from Japan and Korea. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %			Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SKJ	BET	YFT			
2006	10	90	70	19	11	2,835	2	1,418
2007	8	92	69	16	15	6,312	2	3,156
2008	4	96	59	18	23	5,417	3	1,806
2009	0	100	62	28	10	5,562	2	2,781
2010	0	100	54	29	17	2,055	1	2,055
2011	28	72	53	36	11	3,157	1	3,157
2012	48	52	53	16	30	5,062	4	1,266

Russia and Thailand

This group includes vessels originally flagged in the Soviet Union, which after the dissolution of the USSR operated under various flags, the last of which was Thailand. Russia started fishing in the Indian Ocean in 1983 with one vessel until 1991 where 12 vessels operated in the area. This fleet is mainly based in Singapore and Thailand although also present in Seychelles seasonally, and fishes part of the time on the Eastern Indian Ocean although the majority of its catches come from the Western Indian Ocean. It catches a much higher percentage of skipjack tuna and bigeye tuna compared to the fleet from the EU and similar countries (Table 7). The Thai fleet did not operate purse seine vessels in the Indian Ocean in 2012. It moved to the Atlantic Ocean following the kidnapping of one of its vessels by Somali pirates and currently operates in Ghana. The average catch per boat per year, excluding 2010, is 2,758 MT. This fleet does not report catches of sharks.

Table 7: Characteristics of the purse seine fleet from Russia and Thailand. Species and regions are presented as percentage of the catch of this fleet per year. The fleet moved to the Atlantic Ocean in 2011. Total catch and average catch per vessel are in MT.

Year	Region %		Species %					Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SKJ	BET	YFT	KAW	ALB			
2006	98	2	72	17	11	0	1	23,492	6	3,915
2007	85	15	72	15	11	2	0	11,656	6	1,943
2008	99	1	64	24	10	2	0	9,609	4	2,402
2009	88	12	68	21	10	1	0	11,084	4	2,771
2010	72	28	65	21	14	0	0	3,629	4*	907

Note: This fleet only operated part of 2010 because pirates hijacked one of the vessels and the rest of the fleet left the Western Indian Ocean. The drop in effort is reflected on the average catch per vessel for 2010.

b. Industrial purse seine fleet targeting southern bluefin tuna

Australia operated five vessels in the Indian Ocean in 2012 targeting southern bluefin tuna (*T. maccoyii*) for farm cage grow-out. Vessels vary in length from 20 to 45 m

(Hobsbawn *et al.* 2012). The Commission for the Conservation of the Southern Bluefin Tuna monitors the activities of this fleet. This fleet may seasonally fish for skipjack tuna in the Gulf of Carpentaria.

c. Fish aggregating devices (FADs) in the industrial purse seine fleet

Approximately 74% of the industrial purse seine tuna catch in the Indian Ocean comes from schools associated with natural and artificial FADs (Figure 3). Actual numbers of FADs used, however, were only available for 2010-2011 for fleets flagged in EU countries (France and Spain). The Spanish fleet uses trees and other flotsam, and manmade drift FADs with and without nets. Approximately 62% of all sets done with FADs are done with FADs with nets, while 30% is done on trees and other flotsam; 4% is done on both FADs without nets and an unspecified *Other* category. Use of FADs with nets and trees peaked on the third quarter of both 2010 and 2011, time the fleet fishes off the coast of Somalia in the Western Indian Ocean, and is a reflection of increased effort (Figure 4). The nets used in FADs contribute substantially to ghost fishing, through entanglement of sharks, marine turtles, and other species. Filmalter *et al.* (2013) estimated that between 480 and 960 thousand silky sharks die each year, caught in the nets of drifting FADs.

Figure 3: Percentage of the total catch by the industrial purse seine fleet made on tuna schools associated to natural or human-made FADs.

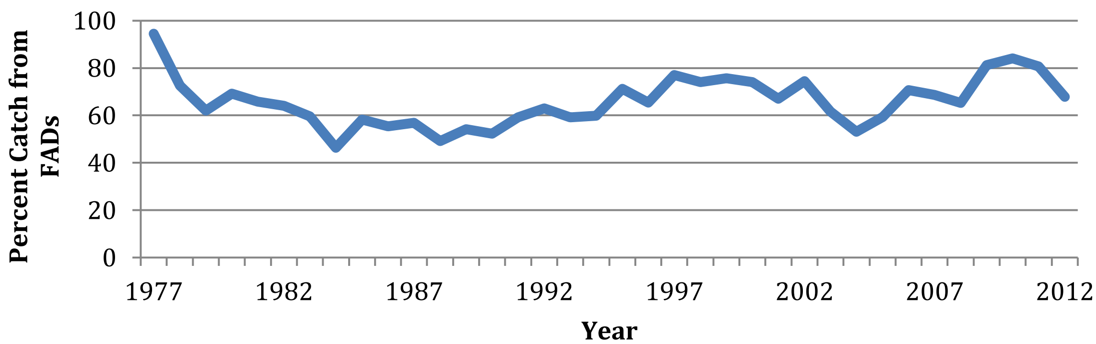
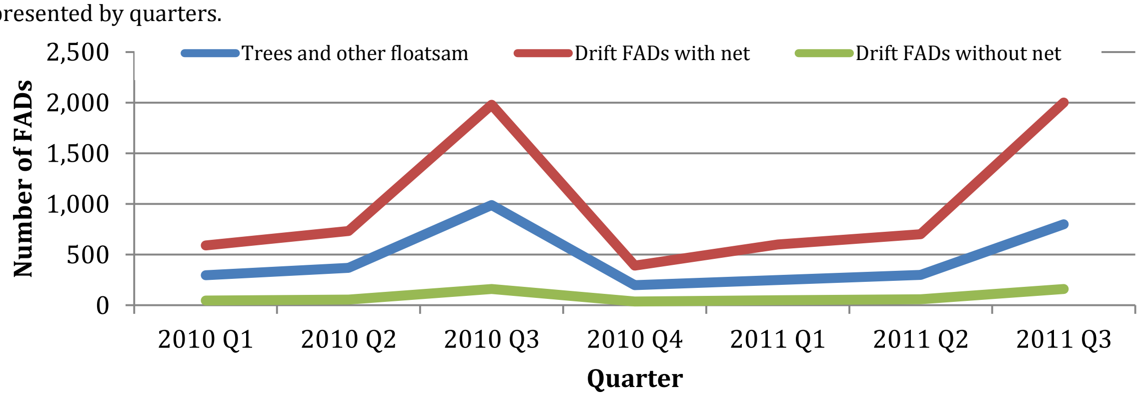


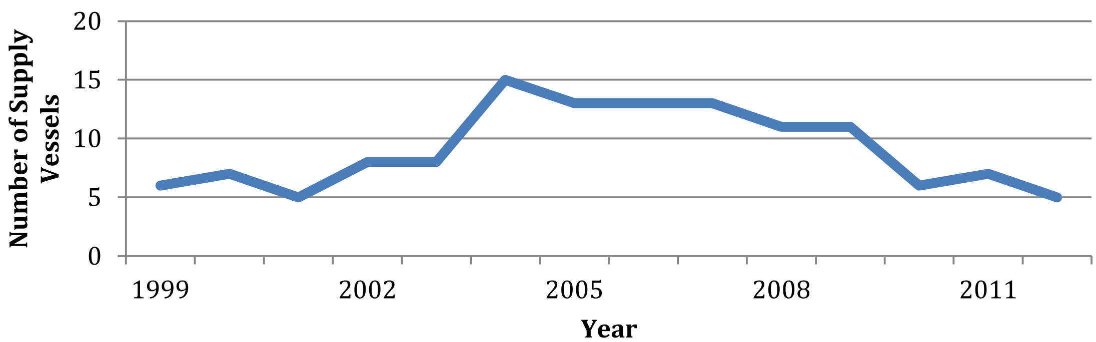
Figure 4: Number of the different types of FADs used by the industrial Spanish purse seine fleet in 2010 and 2011 presented by quarters.



d. Supply vessels in the industrial purse seine fleet

Supply vessels work closely with purse seiners by helping with the deployment and repair of FADs, search for free-schools of tuna and therefore they contribute to the fishing effort. For this category, like the FADs section immediately above, numbers are few and their quality unknown. The Spanish purse seine fleet started using supply vessels in 1999 and current levels of usage are similar to those 14 years ago. This fleet reached its peak in 2004 with 15 vessels (Figure 5). In the past Thailand used one supply vessel although it no longer operates in the Indian Ocean. The supply vessel fleet also moved out of the area due to piracy and this may have had an impact on the catch rates of purse seiners, in particular as there were two supply vessels anchored in seamounts acting as FADs themselves, where the average catches were between 3,000-8,000 MT per boat per year.

Figure 5: Historical series of numbers of supply vessels working with the Spanish purse seine fleet in the Indian Ocean.

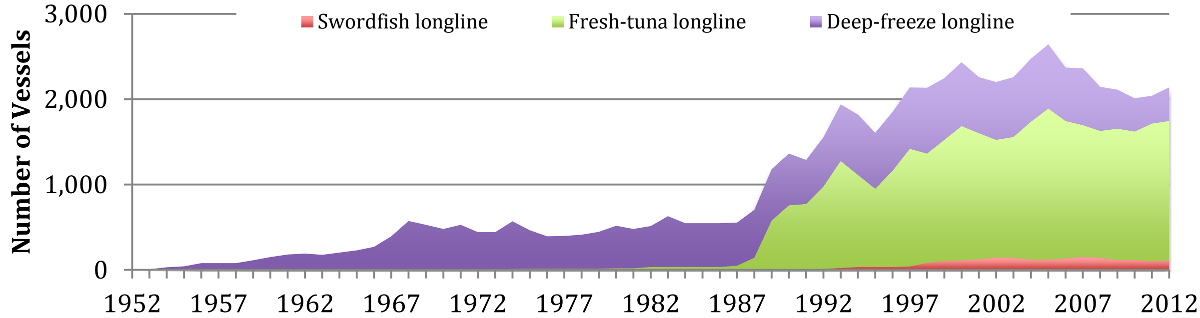


ii. Longline fleets

The longline fleet in this study was divided into swordfish, deep-freeze tuna and fresh-tuna fleets. These fleets target different species or work differently thus the separation. The swordfish fleet was further subdivided into **1.** EU and similar fleets, and **2.** African semi-industrial fleets. The deep-freeze tuna longline fleet was subdivided into **1.** Taiwan Province of China, and similar fleets, and **2.** Japan and similar fleets. Finally, the fresh-tuna longline fleet was divided into **1.** Taiwan Province of China, and similar fleets, and **2.** Indonesia.

Longline fleets worldwide have experienced drastic reductions due to high fuel costs and the stagnation of prices for sashimi-grade tuna. The swordfish longline fleet, a modest fleet of vessels that reached its peak in 2007 with 154 boats, was at its lowest point in 2011 since 1998. The main component of the longline fleet is made of fresh-tuna longline vessels, the majority below 24 m, from Indonesia and Taiwan Province of China (Figure 6). The deep-freeze fleet was at its lowest capacity levels in 2011 since 1966. This fleet has decreased in size due to an increase in fuel and labour costs as well as a buyback programme from the Japanese government (Barclay and Koh 2005, Wildman 1993). This decrease has occurred in spite of this fleet receiving substantial subsidies from the Japanese government.

Figure 6: Historical series of numbers of longline vessels between 15-24 m LOA fishing outside their EEZs or larger than 24 m fishing in the Indian Ocean.

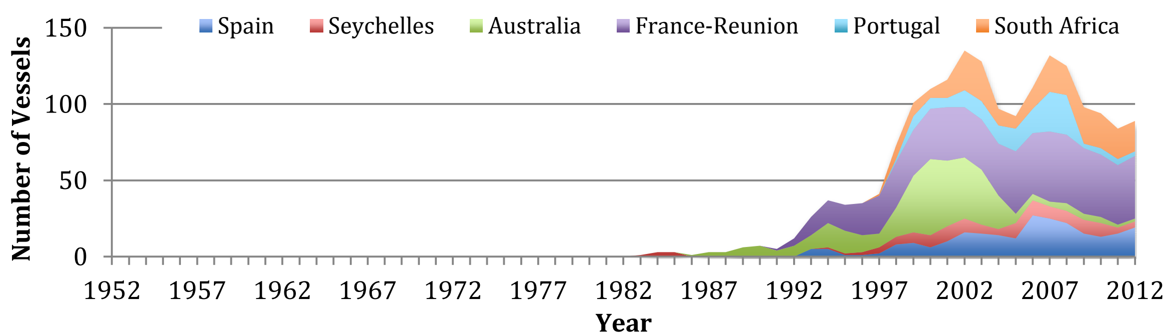


a. Swordfish fishing fleet

Unlike other longline fleets, swordfish vessels set their longlines at or near the surface and fish at dusk or night. This fleet targets swordfish but also catches large numbers of blue shark (*Prionace glauca*), other shark species, and to a lesser extent tropical and temperate tunas, billfish and others (Ramos-Cartelle *et al.* 2008, García-Cortés and Mejuto 2001).

Starting in 1993 the fleet began to increase rapidly with the start of the swordfish fishery off western Australia and the seasonal operations of vessels from Spain also fishing in the Atlantic Ocean. The fleet reached its peak in 2003 with 103 vessels from nine countries. From 2007 to 2009 there was a 30% drop in vessel numbers, probably due to piracy issues in the area (Figure 7), although in theory this fleet fishes away from the most affected areas, compared to tuna fishing fleets that operate closer to the coast of East Africa (IOTC 2012).

Figure 7: Historical series of numbers of swordfish longline vessels between 15-24 m LOA fishing outside their EEZs or larger than 24 m fishing in the Indian Ocean for the main flags.



EU and similar fleets

Vessels from the EU or vessels that operate in similar manner make up 63% of the swordfish fleet in 2012 with 33 vessels from countries like EU-Spain (19), Tanzania (8), EU-Great Britain (3) and EU-Portugal (3). Another important component of the current fleet comes from South Africa, which had a peak number of 26 vessels in 2002-2003, down to 20 in 2012. Australian vessels came into the fishery in 1986 with one vessel, expanding to a maximum of 50 vessels in the year 2000. In 2012 there were only two Australian flagged vessels fishing for swordfish in the Indian Ocean. Current fleet size is 55 vessels (54% from its peak in 2002) from seven countries.

The EU component of this fleet may switch from the Atlantic Ocean to the Indian Ocean depending on catch rates. Sharks may dominate the catches of some fleets during some times of the year and this is likely due to a change of targeting from swordfish. Main ports of call are in Mauritius and South Africa. While this fleet fishes mainly on the Western Indian Ocean and its main catch is swordfish, some of the catch is made of albacore, bigeye tuna and yellowfin tuna (Table 8). The average catch per boat per year is of 154 MT.

Table 8: Characteristics of the swordfish fleet from the EU and similar fleets. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SWO	ALB	BET	YFT			
2006	84	16	83	6	5	3	15,021	80	188
2007	81	19	83	8	3	3	12,882	92	140
2008	85	15	81	5	5	4	9,295	82	113
2009	87	13	80	8	4	5	9,039	61	148
2010	84	16	79	9	4	5	10,552	60	176
2011	86	14	82	2	8	5	7,756	52	149
2012	91	9	79	2	9	6	9,174	55	167

The swordfish fleet from the EU and similar fleets catches a substantial amount of sharks. By far, the species caught most often was the blue shark (*Prionace glauca*) accounting for an average 84% of the total, followed by shortfin mako (11%, *Isurus oxyrinchus*). The average total catch of all shark species for the fleet was estimated around 6,234 MT per year from 2006-2012.

African semi-industrial fleets

There is a semi-industrial component to this fishery formed by the coastal countries of Madagascar, Mauritius, Reunion, and Seychelles. Vessels generally operate in coastal waters although some may go beyond their EEZs. Seychelles started its fishing operations in 1983 and Reunion in 1991 with one vessel each. The fleet reached a peak of 62 vessels in 2007 and 2012. In 2012 Reunion had 41, Madagascar eight, Mauritius five and Seychelles four vessels. Piracy had a strong effect from 2008 to 2011 particularly on Seychellois boats. In addition, high levels of mercury and other heavy metals in the fish resulted in a ban of imports from the main market, the EU, for this fishery. This may have led to a change in target species, specifically sharks, during some periods.

This fleet is more opportunistic, fishes exclusively on the Western Indian Ocean and shows a catch composition that is very different to the EU and similar fleets directly above. It shows a lower percentage catch of swordfish and an increased catch of albacore, bigeye tuna and yellowfin tuna (Table 9). The average catch per vessel per year is of 53 MT.

Table 9: Characteristics of the semi-industrial swordfish fleet from African coastal countries. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

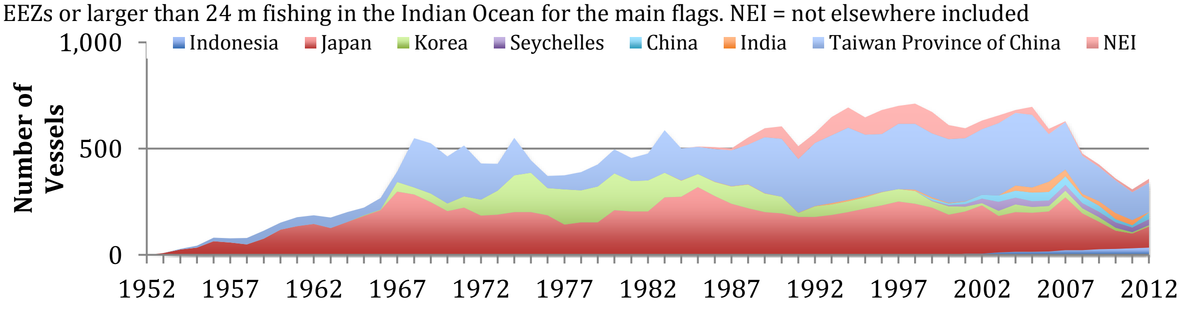
Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SWO	ALB	BET	YFT			
2006	100	0	35	17	20	24	3,250	57	57
2007	100	0	33	22	21	19	3,829	62	62
2008	100	0	39	21	21	15	2,769	61	45
2009	100	0	39	23	17	16	2,538	55	46
2010	100	0	47	18	15	15	2,869	58	49
2011	100	0	47	14	17	17	2,919	50	58
2012	100	0	47	13	17	17	2,879	58	50

This fleet did not report sharks by species until 2010 when part of the catch was identified. The catch per vessel, as derived from the catches reported, is low, around 1 MT per vessel per year, and approximately 52% is made of the oceanic whitetip shark (*Carcharhinus longimanus*). However, the catch rate by boat derived from the data available is thought to be too low considering that swordfish is the target species and fishing for this species occurs at dusk or night, when catches of sharks are at their maximum.

b. Deep-freeze tuna longline fleet

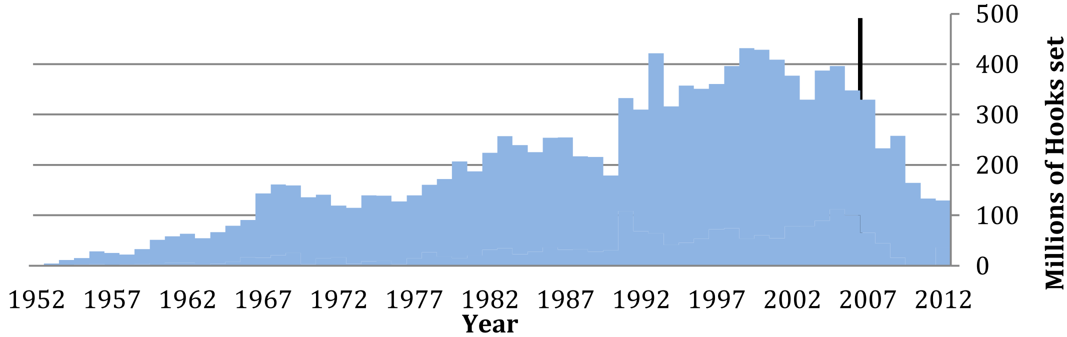
The fleet was first documented in 1952 with two vessels from Japan. Taiwan Province of China followed soon after in 1954 with three vessels and later in 1961 the USSR joined the fishery as well. The fleet peaked in 1998 with a total of 769 vessels from the aforementioned nations plus Korea (Republic of) who started in 1965 (Figure 8). In 2012 the fishery had a total of 392 vessels from 11 countries. The number of boats in this fishery for the last three years has been the lowest since 1960. The Japanese fleet initially targeted yellowfin tuna and albacore for the canning industry in the USA but it later switched to bigeye tuna. This fleet underwent a massive transformation in the 1980s due to substantial rises in fuel prices; increased labour costs resulting from increased standard of living in Japan; reduced demand in the United States of America for large tuna for canning due to concerns over high levels of mercury; the declaration of the 200 nautical mile EEZ by many countries; and the development of super-cold freezing equipment among others (Ward 1996).

Figure 8: Historical series of numbers of deep-freeze longline vessels between 15-24 m LOA fishing outside their EEZs or larger than 24 m fishing in the Indian Ocean for the main flags. NEI = not elsewhere included



Vessels in this fleet are larger than 24 m LOA, steel-hulled and have ultra-low temperature (ULT) freezer capabilities (-55 to -60°C) and most have trip lengths of 18 months to 2 years. Transhipment, refuelling and re-supply typically occur at sea (Hamilton *et al.* 2011). This fleet may set drift longlines at depths down to 300 m as well as surface lines targeting yellowfin tuna, the fish are processed on board, and deep-frozen. Around 40% of the catch is transhipped on the high seas, the rest in ports in the region or in the flag countries. The main ports are Port Louis (Mauritius), Singapore, Durban and Cape Town (South Africa). The deep-freeze longline fishery is the oldest of the industrial tuna fisheries in the Indian Ocean. Following the onset of piracy in the tropical western Indian Ocean, this fleet changed its area of operation, with vessels moving to other areas from 2008-2011, including the eastern and southern Indian Ocean, and the Pacific and Atlantic Oceans (Figure 9).

Figure 9: Total number of hooks set by deep-freezing longliners in the Indian Ocean over the period 1952-2012 (the black line shows the year of onset of Somali piracy)



Taiwan Province of China, China, and similar fleets

These longliners are steel-hulled, greater than 24 m and 100 GT and the great majority are between 40-60 m LOA. They target and freeze sashimi-grade tuna (main species is bigeye) although they may also catch albacore, yellowfin tuna, swordfish, and southern bluefin tuna (Hamilton *et al.* 2011). China is a relative newcomer to this fishery in the Indian Ocean starting in 1999 with eight vessels. The Chinese fleet is composed of large vessels (up to 70 m). Seychelles has a large fleet with 28 vessels currently operating in the Indian Ocean, the majority targeting bigeye tuna.

This fleet is highly opportunistic and will switch target species and even freezing and holding temperatures to maximize the value of its catches (Hamilton *et al.* 2011). In addition, it may change area of operation between the Indian and Pacific Oceans. Targeting will depend on the vessel, area and time of the year. Bigeye appears as the main catch followed by yellowfin, swordfish and albacore. The fleet fishes mainly on the Western Indian Ocean but captures about 30% of its catch from the Eastern Indian Ocean. The average catch per vessel per year is 253 MT (Table 10).

Table 10: Characteristics of the deep-freeze longline fleet from Taiwan Province of China, China and other fleets. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	BET	YFT	SWO	ALB			
2006	78	22	45	36	8	4	119,237	406	294
2007	76	24	54	29	8	3	97,478	381	256
2008	76	24	55	21	10	7	65,964	314	210
2009	61	39	56	18	10	9	72,523	303	239
2010	56	44	42	22	9	19	62,394	287	217
2011	56	44	50	25	7	10	59,470	248	240
2012	82	18	62	16	8	3	90,461	285	317

Levels of reporting of shark catches by this fleet have improved in recent years. As seen for other fleets, species details are lacking for a sizable part of the catch. Average catch per vessel for 2012 was of 22 MT and the main species caught was blue shark.

Fleets from Japan, Korea and Thailand

The oldest industrial fleet documented in the Indian Ocean is the Japanese but it has experienced large drops in numbers of vessels in large part due to high fuel prices as well as the ageing of experienced officers (Hamilton *et al.* 2011). Most of the Korean fleet is made of ULT vessels from 350-500 GRT although it was not present on the Indian Ocean in 2012. The longline tuna fleet from Thailand has been modest with an average number of three vessels per year from 2006-2010 and two vessels from 2011-2012.

This fleet fishes mainly on the Western Indian Ocean but because of recent security problems, starting in 2009 around 40% of the catch came from the Eastern Indian Ocean. The average catch is of 193 MT per vessel per year. This fleet catches approximately 32% yellowfin tuna, 34% bigeye tuna, 16% albacore and 10% southern bluefin tuna (Table 11).

Table 11: Characteristics of the deep-freeze longline fleet from Japan, Korea and Thailand. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	YFT	BET	ALB	SBT			
2006	86	14	45	30	12	7	57,420	217	265
2007	83	17	41	36	10	6	54,891	283	194
2008	73	27	32	39	14	7	36,580	199	184
2009	56	44	25	40	16	11	24,429	153	160
2010	54	46	25	28	26	13	16,940	100	169
2011	63	37	32	27	18	14	15,421	77	200
2012	57	43	26	36	18	12	19,273	107	180

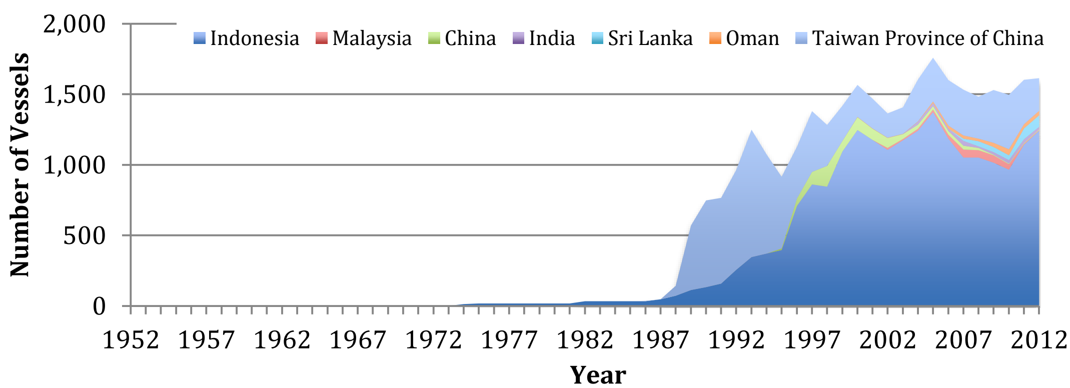
As seen above, levels of reporting of shark catches by this fleet have improved in recent years. The main species are blue shark (79%) and shortfin mako (16%). This fleet shows much-improved species identification compared to fleets presented before.

c. Fresh-tuna longline fleet

The first records of fresh-tuna longline fishery in the Indian Ocean date back to 1973 for three Indonesian vessels. This number increased rapidly in 1988 to 138 with the fleet split evenly between Indonesia and Taiwan Province of China. Other flags joined the fleet China in 1995, Belize and Oman in 2000, Malaysia in 2002 and India in 2004. In 2012 Indonesia dominated the fleet (1,179; 79%), followed by Taiwan Province of China (232; 16%) and the rest split among Oman, India, Belize, Malaysia, China, Tanzania, Maldives and Vanuatu in order of decreasing importance. The fleet reached a high of 1,699 vessels in 2005, dropping substantially in 2007-2008 (Figure 10). In 2012 there were 1,570 fresh-tuna longline vessels fishing in the Indian Ocean.

Fresh-tuna longline vessels catch, cut and chill fish to very specific guidelines for the sashimi market (Blanc *et al.* 2005). The fish are chilled with ice slurry, refrigerated or chilled seawater (Haputhantri 2012) to reduce their temperature as they are endotherms and the flesh will "cook" to some degree if not cooled. This fleet consists mainly of small boats less than 24 m (79%) that make short fishing trips (up to 30 days) to return the fish for delivery before the quality of the flesh deteriorates. Some fleets have collector boats or tranship their catch to other fishing vessels to allow them to remain on the fishing grounds. This practice saves fuel and time for the fishing vessels and improves the quality of the fish caught, as they are transferred shortly after capture and delivered to port faster (Nootmorn 2012). The main target species are yellowfin tuna and bigeye tuna with bycatch of albacore and a variety of billfish (up to 30% of the total catch for vessels from Sri Lanka) and shark species (Haputhantri 2012).

Figure 10: Historical series of numbers of fresh-tuna longline vessels between 15-24 m LOA fishing outside their EEZs or larger than 24 m fishing anywhere in the Indian Ocean for the main flags.



<u>Taiwan Province of China and similar fleets</u>

Taiwan Province of China and similar fleets catch an average of 97 MT per year, of which 39% is yellowfin tuna, 31% albacore and 18% bigeye tuna. Most of the fishing takes place on the Eastern Indian Ocean although operations shifted partially to the Western Indian Ocean since 2009 (Table 12), especially the south where albacore was caught in greater proportions since 2010.

Table 12: Characteristics of the fresh-tuna longline fleet excluding Indonesia. The main country in this fleet is Taiwan Province of China. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	YFT	BET	ALB	BUM			
2006	19	81	48	23	16	5	45,991	420	110
2007	27	73	40	19	32	3	55,971	490	114
2008	24	76	41	19	28	4	52,655	433	122
2009	43	57	37	20	27	6	44,338	521	85
2010	37	63	37	15	34	6	41,111	539	76
2011	42	58	35	15	35	5	35,308	471	75
2012	46	54	33	12	41	5	37,315	391	95

While fresh-tuna longliners have improved the levels of reporting of shark catches in recent years, the amounts reported are thought to only account for the shark carcasses retained on board and not include discards. In 2012 this fleet reported 2,160 MT of sharks, which represents 6 MT of sharks per vessel. This fleet shows little or no identification of shark species.

<u>Indonesia</u>

The fleet from Indonesia is presented separately due to the large differences it shows compared to the rest of the fleet. In particular, its catches were much lower (29 MT per vessel per year) and it fishes almost exclusively on the Eastern Indian Ocean (Table 13). However, reports from third parties, in particular catches reported by Mauritius from vessels flagged in Indonesia, indicate that some activity and catches may occur in the western Indian Ocean, although these cannot be estimated (and are excluded from Table 13). This fleet also catches yellowfin tuna, bigeye tuna, and albacore but it also shows a much higher percentage of swordfish in its catches. The number of vessels in this fleet may be inflated as it comes from the vessel registry and not from the number of active vessels, thus the lower catch rates shown by vessel may be an artefact.

Table 13: Characteristics of the fresh-tuna longline fleet from Indonesia. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	YFT	BET	ALB	SWO			
2006	0	100	36	30	18	6	26,554	1,125	24
2007	0	100	33	35	17	4	34,046	999	34
2008	0	100	36	37	13	4	36,023	999	36
2009	0	100	26	27	36	3	26,232	964	27
2010	0	100	28	28	32	3	23,413	916	26
2011	0	100	32	33	22	4	28,365	1,083	26
2012	0	100	33	34	21	4	33,560	1,179	28

As above, the amounts of sharks reported are thought to only account for shark carcasses retained on board and not include discards. Therefore, it is very unlikely that the levels of catch per vessel per year reported are accurate. Catches by species are only partially available for 2007, in which the blue shark accounts for 90% of the catches of sharks.

iii. Gillnet fleets

Captures with gillnet account for approximately 31% of the total catch of IOTC species yet there is little information on gear characteristics, species caught, bycatch and other details of the fleet. We chose to split the fleet between vessels fishing on the Western Tropical Indian Ocean and those fishing on the Arabian Sea.

a. Western Tropical Indian Ocean

Iran has a large industrial gillnet fleet fishing outside its EEZ in the Western Indian Ocean. Fleet capacity increased since 2006 although it seems to have levelled off and has started to drop slightly. The fleet reached its highest number in 2009 with 1,296 vessels but in 2012 it was down to 1,253 (Table 14). This may be due to, in part, to piracy where the fleet either moved to its EEZ, to the Arabian Sea or stopped fishing altogether.

Pakistan only reported ten gillnet vessels operating beyond its EEZ for 2011 and 2012. Catches for coastal gillnet, however, are quite high and it is questioned here whether its EEZ can support reported levels of fishing effort.

Table 14: Characteristics of the gillnet fleet from Iran and Pakistan fishing on the Western Indian Ocean. Data for the 10 vessels reported by Pakistan for 2011 and 2012 are estimated using data from Iran. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

	Region %		Species %				Total	Number	Average catch
Year	**WIO**	**EIO**	**SKJ**	**YFT**	**BUM**	**FRI**	**Catch**	**of vessels**	**per vessel**
2006	100	0	73	18	3	1	135,376	1,007	134
2007	100	0	79	11	3	4	85,734	1,099	78
2008	100	0	71	15	3	7	59,631	1,195	50
2009	100	0	73	15	3	4	61,275	1,296	47
2010	100	0	66	20	4	5	32,788	1,270	26
2011	100	0	69	18	3	4	23,599	1,271	19
2012	100	0	71	15	3	4	35,897	1,253	29

Note precipitous drop in average catch per vessel. This is due to the fact that a large part of the fleet is fishing inshore or in port and not fishing because of piracy. This is an example of fleet numbers not being an appropriate proxy for effort.

This offshore fleet targets skipjack tuna but also catches around 20% yellowfin tuna, and small quantities of blue marlin and frigate tuna (Table 14). The average catch per vessel per year has dropped considerably from 2006 (134 MT) to 2012 (29 MT) probably due to the fact that a substantial part of the fleet is fishing inshore, or not fishing and in port but the number of vessels in the fleet shows an increase. The reverse trend is observed in the Arabian Sea component presented below, where the average catch per vessel has gone up from 10 MT to 35 MT. It is here speculated that this is due to the offshore fleet having moved into the EEZ or the Arabian Sea but the vessels are still registered as fishing offshore and their catch is registered as coastal. According to the FAO FishStat database, catches of sharks in Pakistan have been decreasing over the years, to levels that in recent years are well below those recorded in the past[17]. However, catches of sharks are not recorded by area and therefore

[17] The ratio of sharks to IOTC species changed from 0.73 (average 1997-2001) to 0.11 (average 2007-2011).

catches in the western tropical area are unknown. To date, Iran has not reported catches of sharks for its gillnet fisheries.

b. Arabian Sea

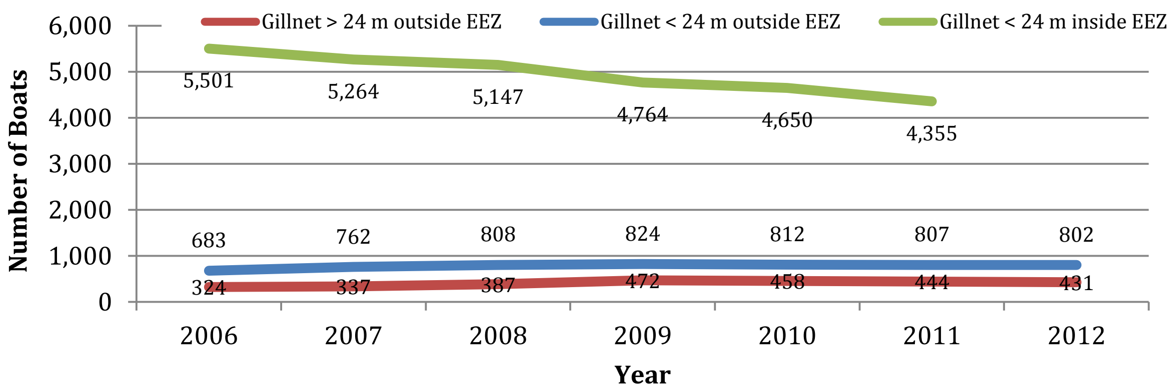
Iran has a substantial fleet of gillnet vessels fishing in the Arabian Sea, a traditional fishing ground for this fleet. In 2006 it had 5,501 vessels that by 2011 had dropped to 4,355 (Figure 11). This fleet targets a variety of neritic and tropical tunas as well as two species of seerfishes. This fleet catches mainly longtail tuna, followed by kawakawa, narrow-barred Spanish mackerel and yellowfin tuna (Table 15).

Table 15: Characteristics of the gillnet fleet from Iran fishing on the Arabian Sea. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	LOT	KAW	COM	YFT			
2006	100	0	41	22	15	11	56,293	5,501	10
2007	100	0	42	26	15	6	61,002	5,264	12
2008	100	0	40	26	13	9	78,289	5,147	15
2009	100	0	51	19	8	11	92,093	4,764	19
2010	100	0	50	13	8	17	126,498	4,650	27
2011	100	0	51	14	9	15	153,543	4,355	35

Note increase in average catch per vessel through time. This is due to a large component of the high-seas fleet moving inshore or into the Arabian Sea due to issues with piracy but it is not counted as part of this fleet.

Figure 11: Numbers of gillnet vessels smaller and larger than 24 m LOA fishing in the EEZ of Iran and on the high seas as reported by the country from 2006-2012.



Oman has a fleet of dhows (10-24 m) that use gillnets exclusively, the latter ranging in size from 2-8 nm (F. Giroux pers. comm.). This fleet catches an average of 4,951 MT per year. From 2006 to 2008 this fleet used to catch 12 MT per vessel but this almost halved to 7 MT from 2009-2012 (Table 16). In addition, starting in 2011 a new coastal fleet of vessels from 14-30 m fished in Omani waters (C. Kilgour pers. comm.). The gears used by this fleet, and where it fishes, are not known. There were 22 and 56 vessels in this fleet in 2011 and 2012 respectively.

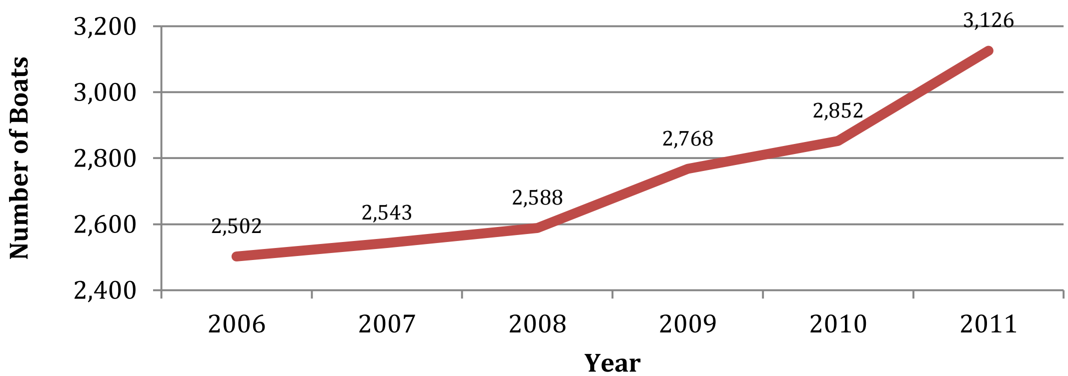
The Omani fleet has reported catches of sharks although they are not classified by species. The average catch per boat per year is of 3 MT and, unlike Pakistan, rates seem to have been stable over the years.

Table 16: Characteristics of the gillnet fleet from Oman fishing on the Arabian Sea. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	YFT	LOT	COM	SFA			
2006	100	0	60	32	4	1	4,851	440	11
2007	100	0	63	30	4	1	5,338	458	12
2008	100	0	67	26	3	2	5,986	460	13
2009	100	0	38	43	6	7	5,005	612	8
2010	100	0	18	55	8	12	4,972	728	7
2011	100	0	12	65	7	6	4,252	704	6
2012	100	0	12	65	7	6	4,252	698	6

A sizable number of boats make up the coastal component of the tuna fishery in Pakistan. Gillnet is the only gear used to harvest tropical and neritic tunas in deep waters. The fleet has increased steadily, by 25%, from 2006 to 2011 when Pakistan reported 2,502 to 3,126 vessels of 35 to 50 GRT fishing in its waters (Figure 12). This fleet targets yellowfin tuna, skipjack tuna, kawakawa (*Euthynnus affinis*), longtail tuna and frigate tuna (*Auxis thazard*). All boats are assumed to be between 10-15 m LOA.

Figure 12: Numbers of gillnet vessels between 35-50 GRT fishing in the EEZ of Pakistan as reported by the country from 2006-2011.



iv. Pole and line fleet

The main semi-industrial pole and line fleet operating in the Indian Ocean is in Maldives and works wholly within its EEZ. Numbers of vessels for this fleet are not clear as reporting by Maldives presents fluctuations from report to report. Breakdown by size category is not available from 2006-2009. This fleet started to use handlines as an alternate fishing method, but the precise time and effort are not known. Handline is reported as far back as 2007 for this fishery (http://www.msc.org) but its start cannot be determined with the information found. For 2012, numbers of vessels were taken from the MSC website (http://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/).

The fleet has been reduced considerably since 2006 when the total number of boats was 925. It is not clear if the whole fleet was operating at that time (Table 17) as the Maldivian government used to pay fuel subsidies and some boats operated only one day per month to access this help. Now that this subsidy has been stopped, the numbers of active vessels reported may be more accurate. In addition, there is a shift to larger boats that can do multiday fishing compared to the older fleet that made single-day trips.

The baitboat fleet catches an average of 120 MT per boat per year and it fishes exclusively on the Western Indian Ocean. Skipjack tuna makes up around 80% of the catch, yellowfin tuna 13% and the rest is split between frigate tuna, kawaka and other species (Table 17).

Table 17: Characteristics of the baitboat fleet from Maldives. Species and regions are presented as percentage of the catch of this fleet per year. Numbers in parentheses show the number of boats smaller than 24 m. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SKJ	YFT	FRI	KAW			
2006	100	0	86	10	2	1	158,146	925	171
2007	100	0	83	11	3	2	115,338	894^	129
2008	100	0	79	15	5	2	107,859	867	124
2009	100	0	75	16	5	2	87,136	920	95
2010	100	0	81	12	3	3	88,925	(437) 708	126
2011	100	0	80	14	2	3	65,299	(374) 608	107
2012	100	0	80	16	1	2	63,522	(424) 698*	91

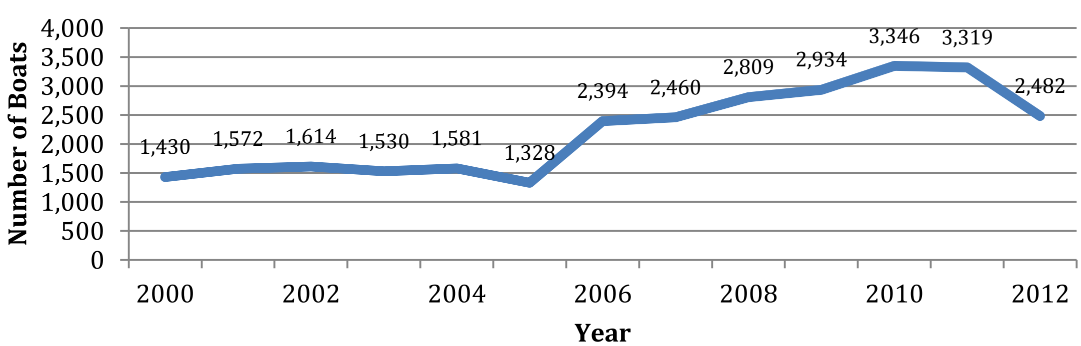
^ Tentative start of the handline fishery in conjunction with pole and line
* Data extracted from msc.org

Indonesia has a large fleet of pole and line vessels but most vessels operate in the Banda Sea-Pacific Ocean. An unknown number of vessels operates off Kupang (Nusa Tenggara Timur) and catch skipjack tuna (approximately 79%) and yellowfin tuna (15-20%) although the catches are small (1,000-3,000 MT per year). Additional records of pole and line catches exist for Labuhan Lombok (Nusa Tenggara Barat) but the catches here are insignificant, not reaching 500 MT per year. In 2006 Indonesia reported three vessels of 30-50 GT, and nine of 50-150 GT. In 2007 it reported one and nine vessels respectively.

v. *Gillnet/longline fleet from Sri Lanka*

This fleet uses multiday boats of 9-18 m LOA and is here considered semi-industrial.

Figure 13: Numbers of boats using gillnet-longline combination in Sri Lanka from 2000-2012. Note sharp increase from 2005-2006.



The number of boats has shown an increase of 40% from 2006-2010. The fleet was quite stable until 2005 when some boats were damaged by the tsunami at the end of 2004, and in 2006 there was a steep increase possibly due, in part, to relief efforts (Figure 13).

This fleet catches an average of 22 MT per boat per year and fishes almost exclusively in the Eastern Indian Ocean (Table 18). Although all the catch is currently allocated to the Eastern Indian Ocean, some effort takes place in the Western Indian Ocean and this discrepancy needs to be resolved (NARA 2011). An average of 74% of the catch is skipjack tuna, followed by yellowfin tuna (11%), Indo-Pacific sailfish (*Istiophorus platypterus*, 5%), and black marlin (*Makaira indica*, 3%).

Table 18: Characteristics of the gillnet/longline fleet from Sri Lanka. Species and regions are presented as percentage of the catch of this fleet per year. Total catch and average catch per vessel are in MT.

Year	Region %		Species %				Total Catch	Number of vessels	Average catch per vessel
	WIO	EIO	SKJ	YFT	SFA	BLM			
2006	0	100	68	16	6	4	47,692	2,394	20
2007	0	100	76	10	5	3	60,353	2,460	25
2008	0	100	78	9	5	3	62,289	2,809	22
2009	0	100	76	11	5	3	64,755	2,934	22
2010	0	100	75	12	4	3	68,126	3,346	20
2011	0	100	74	9	5	4	65,427	3,319	20
2012	0	100	71	13	4	2	64,268	2,482	26

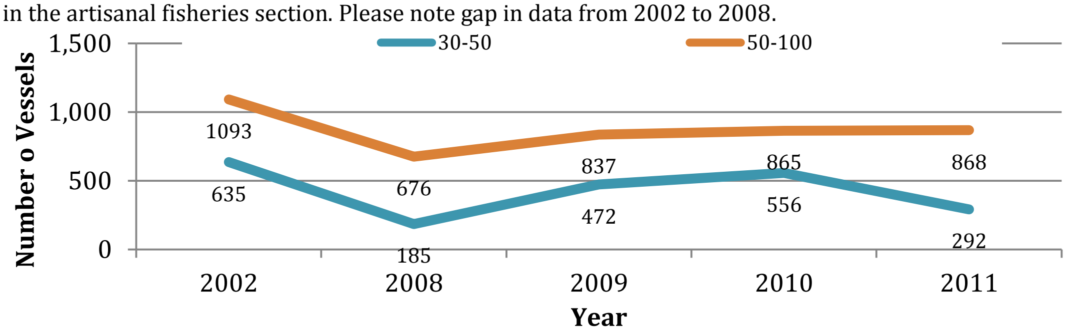
This fleet currently reports modest catches of sharks per boat per year with an average of 0.6 MT. In the past this fleet targeted sharks but marked drops in catches led to changes in gear configuration and/or fishing areas, as well as a shift on targeting towards other species. The main species caught is the silky shark although its catches dropped considerably in 2012 and was partially replaced by two species of thresher shark (bigeye thresher, *Alopias superciliosus* and pelagic thresher shark *A. pelagicus*), species that were not reported in previous years.

vi. Other fleets

Occasional records of other fleets were encountered in the literature and are presented here. A ring net fishery exists in India that is typically artisanal but a record of vessels larger than 24 m was found. van de Heijden (2007) reported a fleet of 80 ring net vessels of 25 m in the village of Alappad Panchayat north of Trivandrum, Kerala on the west Indian coast. Although this fleet targets oil sardines, it is likely that it may also catch neritic tuna and seerfish species.

Indonesia has a significant semi-industrial fleet that uses longlines, gillnets and purse seines among other gears. Numbers of vessels by gear, however, were not available. Nonetheless this is the most important component of the largest tuna-fishing coastal country in the Indian Ocean. As such, numbers of vessels by art must be calculated to provide a realistic view of the fleet in Indonesia. If we consider inboard-motorised crafts from 30-100 GT as semi-industrial, we can see that the fleet dropped in size since 2002 (Figure 14). It must be kept in mind that these numbers include vessels fishing all marine species including shrimp, demersal fishes, small pelagic species, etc. Furthermore, the numbers presented below may also include the various fleets working outside the EEZ of Indonesia like the fresh-tuna fleet that must be subtracted from here to arrive to a total number.

Figure 14: Numbers of the various sizes (GT) of inboard fishing vessels in Indonesia for 2002 and 2008-2011. Only vessels of 30-100 GT are considered semi-industrial in this study. Smaller inboard vessels are reported in the artisanal fisheries section. Please note gap in data from 2002 to 2008.



ESTIMATION OF NUMBER OF ARTISANAL VESSELS FISHING FOR TUNA AND TUNA-LIKE SPECIES FROM COASTAL COUNTRIES IN THE INDIAN OCEAN

Due to the enormity of the scale of the task, we chose to concentrate on those countries that have significant fleets of boats that capture species of interest to the IOTC (India, Indonesia, Iran, Oman, Pakistan, Sri Lanka, and Yemen) and also included countries that responded to the request from the Commission to provide the necessary data (Australia, Comoros, Indonesia, Kenya, Mauritius, and Mozambique). Together, in 2012 they accounted for around 63% of the catch of species of interest to the IOTC in the Indian Ocean. This component of the study proved to be the most difficult to compile due to the lack of basic data from countries in the region. Because fleets were not discriminated by gear in most cases, we had to present the information by country and not gear types as above. It must be emphasized that this is not a complete list as most numbers of vessel/gear combinations are unknown or the information is not publicly available.

It is difficult to characterise some gears as they are used in most fleets occasionally. This is the case of handline and troll, which are probably the most ubiquitous gears in all artisanal fleets. They are used opportunistically while waiting for nets or longlines to soak or during transit to and from fishing grounds. There are a few dedicated boats that use these gears and where specific information was found it is presented under each country. The exclusive use of this gear is increasing as fishers aim to add value to their catches through exports for the sashimi market. Some vessels from Indonesia, Maldives, and Sri Lanka, among others, use handline alone or in conjunction with other gears to catch large yellowfin tuna for export (Irianto *et al.* 2013).

Due to lack of data it was not possible to present definitive numbers but hopefully this attempt is a start to calculate quantities of artisanal vessels fishing for tuna and tuna-like species in the Indian Ocean. Appendix 2 shows the numbers of artisanal boasts for all countries in the Indian Ocean by gear where possible. In many cases it was not possible to present numbers of boats fishing for tuna and tuna-like species thus the whole fleet was presented.

i. Comoros

Comoros is one of the few countries that replied to the request from the Commission to report the boat/gear combinations from 2006-2012. The fishing fleet in Comoros is quintessentially artisanal. Although the fleet has increased in size and in motorisation, the basic fleet composition has not really changed in the last 20 years. In 1994 there were 3,946 vessels and 5,323 in 2011 (Table 19) a 26% increase but only around 60% of the fleet is active. The most dramatic change is on the motorisation of the fleet increasing from 14% to 32% for those years (Toihir 2011). There are six types of vessels in the fishery, five motorised and one non-motorized. The vessels range in size from 2-10.5 m and are made of wood or fibreglass. Similarly, the gears used have remained simple with trolling and short handline being the two most important gears for the capture of tuna and tuna-like species. Comoros catches about 6,000 MT of species of interest to the IOTC per year. Comoros does not have a fisheries development plan although it has stated that it may present one at a later date. In 2011, the Arab Committee for Development and Investment in the Comoros signed a Memorandum of Understanding to create the Comorian Fishing Company. A Sri Lankan company will construct, manufacture, manage and market products for the Comorian Fishing Company. There is a plan to build around 300 fishing vessels of 6 m, 36 of 9 m and 10 of 18 m. In addition, a new processing plant is being built along with a small fishing port and other port infrastructure to facilitate landings.

Table 19: Gear and fishing craft numbers for Comoros.

Gear	2011	2012
Handline	407	69
Troll	1,444	1,146
Total number of gears	**1,851**	**1,215**

Fishing craft		
Motorised outboard	1,101	834
Non-motorised	2,131	2,224
Total number of boats	**3,232**	**3,058**

Note that the total number of gears is smaller than the total number of boats

ii. India

India's fleet is divided into mechanised (inboard motors), motorised (outboard motors) and non-motorised boats. The country has a total of 25 vessel-gear combinations and this obviously complicates the characterisation of any fishery.

India has one of the largest fleets of coastal gillnet vessels in the Indian Ocean. Vivekanandan (2010) reported a total of 14,183 mechanised gillnet boats of 10-15 m. These numbers coincide closely with independent estimates made by the authors from separate records. In addition, there were 75,591 boats with outboard motors that use a variety of gears including gillnets, seines, lines and other gears that catch neritic tunas and seerfishes (Table 20). Also, he reported 104,270 non-motorised boats that using similar gears also catch neritic tunas. The motorised component cannot be ignored, as there are reports of over 20,000 boats of this type using gillnets in the state of Tamil Nadu alone. Unfortunately, data for other states in India were not available.

There are 1,190 liners 10-15 m LOA that catch neritic tunas and 983 purse seiners of the same size operating on both coasts targeting kawakawa, longtail tuna and frigate tuna. The catches for any of these fleets are unknown either by species or quantity.

Table 20: Fishing craft numbers for India from the 2005 census conducted by CMFRI (2006) numbers taken from Pramod (2012). Results from the census in 2010 taken from the CMFRI Annual report 2011-2012

Source	Non motorised	Motorised	Mechanised				
			Gillnet	Liners	Purse seiners	Mechan. Total	Total All
India Census 2005	104,383	70,049				61,864	236,296
India Census 2010	52,982	73,410				72,749	199,141
Vivekanandan 2010	104,270	75,591	14,183	1,190	983	NA	196,217

In addition India has an artisanal fleet of approximately 1,500 sailboats (Vivekanandan 2010) that targets tuna species on the east coast off Andhra Pradesh with longlines and troll (Rohit *et al.* 2008). The boats are wooden catamarans (4-6 m LOA) and fibreglass canoes (6.5-7.5 m) propelled by sails but a few also have outboard engines (10 hp). Species targeted include kawakawa, frigate tuna, bullet tuna and skipjack when fishing within the 100 m depth contour and yellowfin tuna when operating beyond 200 m depth. In India, 397 trawlers of 13-24 m LOA were converted into longliners targeting yellowfin tuna (Vivekanandan 2010) although catches have been poor due to lack of experience with this gear.

India also has a fleet of baitboat vessels in the Lakshadweep islands that contributes a significant portion to this country's catch of skipjack tuna. The country reported 365 vessels in 2009 (Vijayakumaran and Varghese 2010) and 103 in 2011 (FSI 2012a).

Trawl, a gear not usually associated with species of interest to the IOTC, may be used to catch seerfishes and various neritic tuna species in India. Trawlers are the most common mechanised vessels in this country.

Ring seine is another gear used in India to fish for tuna and seerfish.

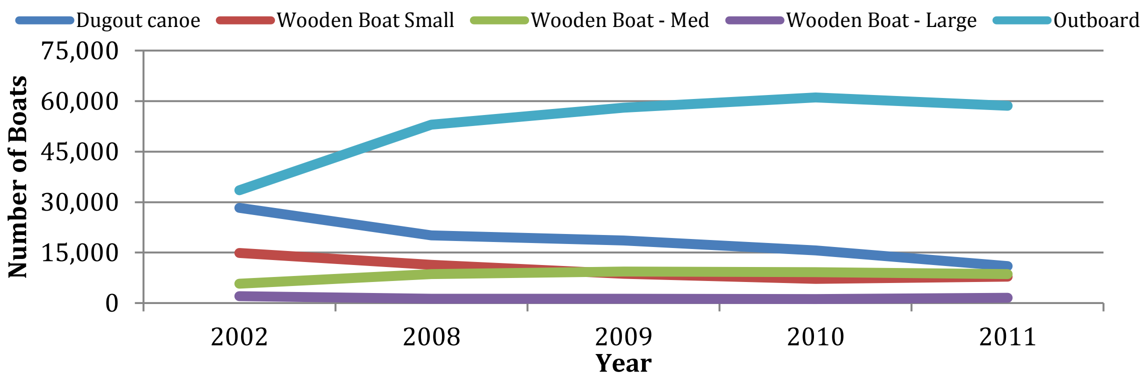
The numbers presented for India may possibly be underestimated. Various authors have pointed at the presence of large numbers of unregulated or unlicensed fishing boats in India (Pramod 2010, Malhotra and Sinha 2007).

iii. Indonesia

For the purposes of this study we considered any vessel 30-100 GT to be semi-industrial and any vessel below 30 GT artisanal although exceptions exist (see gillnet/longline for Sri Lanka). In Indonesia vessels below 10 GT are licensed by the district while those between 10-30 GT by the provincial governments. Vessels above 30 GT are considered semi-industrial and their licensing is handled at the national government level. Indonesia reports the number of vessels by GT but not by GT/gear combination thus only the classification for the former is presented. The number of canoes, wooden boats of various sizes, and boats with outboard motors for 2011 was 87,753. The number of boats with inboard motors from < 5GT to 30 GT was 29,108 for the same year. The number of wooden boats has gone down in number since 2008 while the number for inboard motor boats gone up in the same time period mainly from the component of the fleet less than 5 GT (Figures 15 a and b). In theory, all vessels above 30 GT must use a VMS and licenses should not be issued unless they do so.

Figure 15: Numbers of the various categories of artisanal **a.** wooden and outboard boats and **b.** inboard boats less than 30 GT in Indonesia for 2002 and 2008-2011. Please note gap in data from 2002 to 2008.

a.



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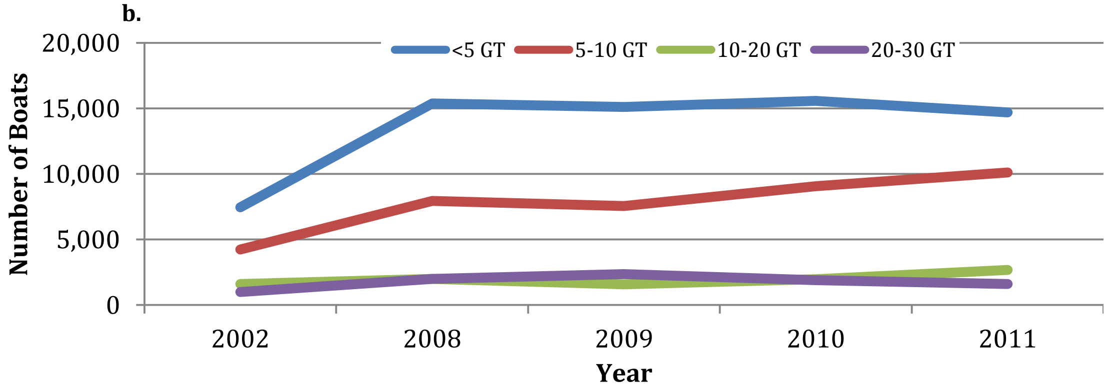


Indonesia has a large fleet of artisanal purse seiners catching neritic tuna species as well as tropical tunas. They often fish close to anchored FADs and the catch in this case is made of a large proportion of juvenile bigeye tuna and yellowfin tuna.

Indonesia's artisanal fleet uses a variety of longlines that target different species of fish. These include drift longline, set longline, and demersal longline among others. The number of vessels that use them is not known and the number of gears registered in the country may not be used as a proxy due to problems with this methodology (*e. g.* Ingles *et al.* 2008).

iv. Iran

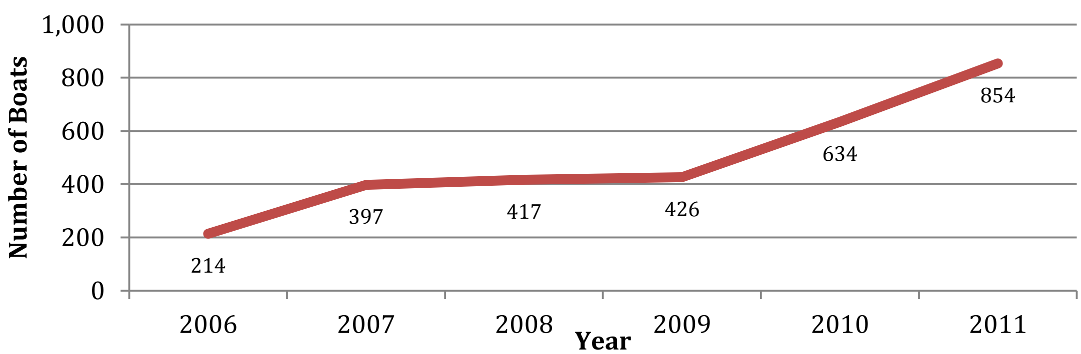
In addition to the large Western Indian Ocean and Arabian Sea fleets, there is also a large artisanal component that uses gillnet. This fleet catches neritic tuna species including longtail tuna, kawakawa, frigate tuna along with tropical tuna species, and seerfish. The fishing grounds are in the Persian Gulf, hence the large capture of neritic species, although vessels may also fish in the Arabian Sea. The number of boats fishing inside the EEZ in 2006 was 4,858 but the fleet shrunk to 3,926 in 2011 (Table 21).

Table 21: Numbers of artisanal gillnet boats fishing inside Iran's EEZ by GT from 2006-2011.

Tonnage	2006	2007	2008	2009	2010	2011
3-20 GT	733	731	761	753	702	586
0-2.9 GT	4,125	3,966	3,974	3,828	3,444	3,340
Total	**4,858**	**4,697**	**4,735**	**4,581**	**4,146**	**3,926**

Iran reports a non-mechanised trolling fleet although the size of the vessels is unknown. The number of boats in this fleet has increased by 400% since 2006 to 2011 and shows no signs of levelling off (Figure 16). The fishery targets longtail tuna, yellowfin tuna, narrow-barred Spanish mackerel (*Scomberomorus commerson*), and Indo-Pacific king mackerel (*S. guttatus*).

Figure 16: Numbers of non-mechanised trolling boats fishing in Iran 2006-2011.



v. Kenya

Kenya is one of the few countries that replied to the request from the Commission to report the boat/gear combinations from 2006-2012. The fleet in Kenya is artisanal and the catches of tuna and tuna-like species are modest not exceeding 617 tonnes in 2011. The fleet is mainly non-motorized (around 75%). The main gears used are handline, gillnet and troll (Table 22). This fleet catches a variety of tunas and seerfish although the species are not identified.

Table 22: Numbers of artisanal fishing craft by gear that target tuna and tuna-like species in Kenya from 2006-2012.

Gear	2006	2007	2008	2009	2010	2011	2012
Handline	18	18					37
Other hook-and line			4	4	4	4	1
Ring nets	5	5	4	4	4	4	8
Trolling	33	33	12	12	12	12	53
Gillnet	3	3	1	1	1	1	18
Total motorised outboard	**59**	**59**	**21**	**21**	**21**	**21**	**117**
Handline	98	98	48	48	48	48	88
Other gears			44	44	44	44	3
Other hook-and line			12	12	12	12	4
Trolling	14	14	1	1	1	1	24
Gillnet	85	85	22	22	22	22	57
Seines	3	3	1	1	1	1	
Total non-motorised	**200**	**200**	**128**	**128**	**128**	**128**	**176**

Kenya reports one inboard vessel trolling for tuna from 2008-2011 although its GT and LOA are unknown. It is here assumed to be below 30 GT therefore artisanal.

vi. Mauritius

Mauritius also reported details of its fleet as requested by the Commission. Mauritius has a small fleet of boats targeting tuna and tuna-like species. Specifically there are inboard boats that use surface longlines to fish for swordfish. The numbers are quite low and the fleet has been reduced even further in recent years (Table 23). The other fleet is more substantial and it fishes associated to the 24 anchored FADs around the island. The fishing fleet consists of 180 inboard vessels and they use vertical longlines, handlines and trolls to mainly catch albacore tuna.

Table 23: Numbers of artisanal fishing craft by gear for Mauritius from 2006-2012. Numbers in parentheses indicate vessels 15-24 m LOA out of the total outside the parentheses.

Gear	2006	2007	2008	2009	2010	2011	2012
Surface longline for swordfish	5 (2)	6 (6)	6 (6)	0 (0)	2 (1)	4 (2)	4 (2)
Vertical longline, handline, troll	180	180	180	180	180	180	180

vii. Mozambique

As with many fleets in the Indian Ocean, Mozambique's boats are archetypal artisanal. The fleet is considerable in size and has grown 23% in the last six years mainly on the non-motorised component, although the outboard fleet has also shown an important increase (32%) in the same period (Table 24). As with most artisanal fleets, it is opportunistic and as such does not have specific targets. It is expected that even though the fleet is large, because of the small size of the vessels the catch of tuna species is not important with the possible exception of seerfish species.

Table 24: Numbers of artisanal fishing craft and gears for Mozambique for 2006 and 2012.

Craft	2006	2012
Non-motorised	29,229 (5,401 with sails)	38,105 (6,877 with sails)
Outboards	548	806
Inboards <15 m	126	79
Inboards 15-24 m	39	38
Total	**29,942**	**39,028**

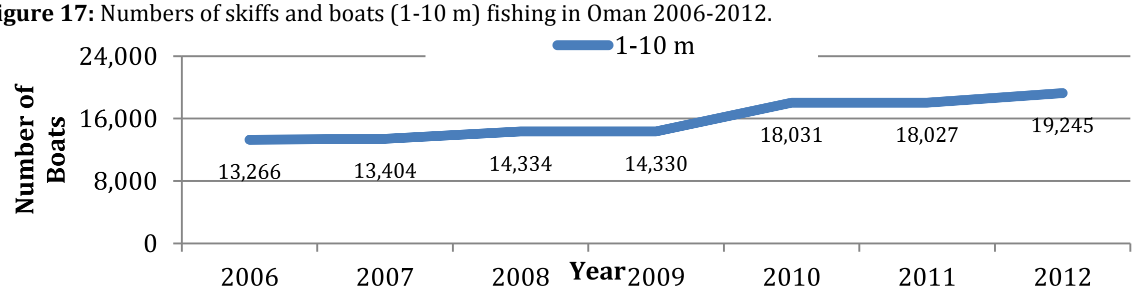
Gears		
Costal purse seine or ring nets	372	380
Other seine nets	6,273	9,042
Gillnets	10,541	14,817
Handlines	9,275	12,683
Longlines	555	678
Other	5,482	5,976
Total	**32,498**	**43,576**

Mozambique also responded to the request from the Commission for data on its artisanal fleet.

viii. Oman

Boats in Oman are undecked and there is no refrigeration system. The skiff/boat component from 1-10 m LOA uses a combination of gillnets and handlines and they target large yellowfin. These vessels are by far the most numerous, reaching up to 19,245 boats in 2012 (Figure 17).

Figure 17: Numbers of skiffs and boats (1-10 m) fishing in Oman 2006-2012.



ix. Sri Lanka

Sri Lanka presents data in a similar manner to Indonesia, thus there is no characterisation of vessel numbers by gear used (Table 25). The outboard fleet, in particular de OFRP component, shows a 63% increase from 2005-2010, in big part due to the international relief effort after the tsunami in late 2004 that destroyed a significant portion of the fishing fleet in Sri Lanka.

Table 25: Numbers of the various categories of artisanal fishing crafts in Sri Lanka from 2000-2010. Modified from Fisheries Statistics, Ministry of Fisheries and Aquatic Resources, Sri Lanka. Excel File submitted to IOTC in 2010.

	Inboard Engines	Outboard Engines		Non-motorised	Total
Year	1DAY	OFRP	MTRB	NTRB	
2000	1,170	8,690	1,205	15,100	26,165
2001	993	8,744	640	15,200	25,577
2002	1,112	9,033	776	15,600	26,521
2003	1,486	11,020	618	15,040	28,164
2004	1,493	11,559	674	15,260	28,986
2005	1,164	11,010	1,660	14,739	28,573
2006	907	13,860	1,842	16,347	32,956
2007	1,060	15,200	1,680	16,640	34,580
2008	1,940	14,747	3,179	17,042	36,908
2009	958	17,193	2,126	18,243	38,520
2010	1,177	18,770	2,680	20,165	42,792

1DAY: Inboard engine boats conducting fishing trips of less than 24 hours
OFRP: 6-7 m flat-bottomed fibre reinforced plastic boats powered by outboard engines (8-25 hp)
MTRB: Traditional craft powered by outboard motor of 6-9 hp
NTRB: Traditional fishing craft without motor engine

x. Yemen

The artisanal fleet in Yemen catches a considerable quantity of yellowfin tuna (mean catch from 2003-2005 was 41,000 MT) accounting for 52.8% of the whole marine production of the country (Shaher 2007). In addition, this fleet catches longtail tuna, kawakawa and skipjack tuna in substantial numbers. Two main types of boats are present **1.** sambuqs and **2.** hubris. The former is made of wood or fiberglass, 12-18 m LOA, typically mechanised, and operates 15-25 miles from shore. This fleet is made of 1,500 vessels that catch yellowfin tuna in large quantities with the use of handlines and troll lines. This fleet may also use small seines or surface gillnets. Hubris boats are 3-11 m LOA, motorised and fish closer to shore. They use longline for shark and tunas, troll for billfish and use other gears. In 2005 there were 15,390 vessels of 0-12 m LOA.

7. Discussion

The Indian Ocean suffers from pressures not seen on other oceans of the world. It is surrounded by a large number of countries, most of them developing, and it is possible to go from one end to the other in small vessels, along the same latitudes, as there are many ports along the way. This presents the unique opportunity for semi-industrial vessels as small as 12 m to make it far from their ports of origin thus making their surveillance and control difficult. Furthermore, because there are so many developing countries around the Indian Ocean, most have significant semi-industrial and artisanal fleets and their catches contribute appreciably to the total catch of tuna in the region. Unfortunately, many of the countries in the area have poor monitoring of said fleets thus introducing high uncertainty in the total catches by species, areas and gears.

Although the ultimate aim of a survey of fishing capacity is to determine the quantities of fish that could be theoretically caught by existing fleets, its limitations must be understood. These limitations stem from the lack of reliable information, particularly for the semi-industrial and artisanal fleets. Furthermore, and specifically for the latter fleet, the calculations of annual catches are nothing more than anecdotal due to the vagaries that afflict it. The final output of this study, then, is a count of active vessels for the important fleets according to size, gear and target species.

There are glaring gaps in the data available for semi-industrial and artisanal fleets fishing for tuna and tuna-like species in the Indian Ocean. This lack of information is not new and was highlighted in a previous capacity report (Gillett and Herrera 2009) and other studies, although data for the industrial fleet have improved in quality (Appendix 3). An important issue, however, is the lack of reporting requirements for other fleets here presented: semi-industrial and artisanal (Appendices 4 and 5). Moreno (2011) suggested a revision of the definition of artisanal vessels for the IOTC, as the current one of artisanal vessels as those below 24 m operated within the EEZ of their flag states does not reflect the reality of fisheries in countries in the Indian Ocean area. There is a need to assign new categories to vessels currently fishing in the region. Because size is a poor indicator of capacity, we propose the use of a matrix of characteristics from which a vessel will have to fulfil a determined number to fit into a chosen category. Gillett (2005) proposed the following criteria: (i) characteristics of the vessel (type of vessel, level of mechanization, vessel tonnage, vessel length, fish carrying capacity, type of fish preservation); (ii) fishing method used (gear type and mechanization); (iii) distance to fishing grounds; (iv) duration of the fishing trip; (v) destination of the catches; (vi) labour intensity; or a combination of the above. Considering the characteristics of tuna fisheries in the Indian Ocean and the substantial influence of what is classified here as semi-industrial fleet, we propose that the Commission identifies its data needs in respect to this group and requests said information from the CPCs. Ideally then, the data requirements of the Commission should be elevated to a quantity and quality sufficient to correct the gaps in knowledge that currently exist, and to change the status of the data requested at this time from the qualitative levels of yellow or red to green (Table 26).

The use of gear capacity in artisanal fleets is fraught with problems as seen in the WWF study *Getting off the Hook* (Ingles *et al.* 2008). This report shows a highly inflated catch for Indonesia in the Indian Ocean region, a result of taking numbers of gears and using a factor to raise them to total catch. As indicated before, artisanal fleets are highly unpredictable and they are very susceptible to a suite of environmental, social and economic influences. These factors, along with the fact that they are extremely opportunistic, make any forecasting of catches an exercise in unpredictability.

Table 26: IOTC Measures that apply to Flag Countries. This table shows the current status of data requested and whether they fulfil the needs for capacity studies. Boat size in LOA m

Type of boat	Boat size	Area of Operation	Vessel Data	Vessel Dimensions	Target Species	Catch & Effort	IOTC Resolutions
Non-motorised	All	EEZ			NA		11/04 (Regional Observer Scheme; Artisanal); 10/02 (Data Requirements; Coastal)
Motorised outboard	All	EEZ			NA		
Motorised inboard	<15 m	EEZ					
Motorised inboard	15-24 m	EEZ					
Motorised inboard	<15	High seas					11/04 (Regional Observer Scheme; Industrial); 10/02 (Data Requirements; Surface and Longline); 10/08 (Active Vessel List)
Motorised inboard	15-24m	High seas					
Motorised inboard	>=24m	Anywhere					

Vessel Data: Individual vessel details requested (Green); total numbers of active fishing craft per size class requested (Yellow); no information requested (Red)

Vessel dimensions: Maximum fish carrying capacity for individual vessels requested (Green); GT, LOA, or other vessel dimensions requested for individual vessels (Yellow); other (Red)

Target Species: Information on target species requested for individual vessels and catch and effort data (Green); information on target species requested for individual vessels not for catch and effort (Yellow); Information on target species not requested (Red); information on target species not relevant (Blank)

Catch & Effort data: Catches unloaded/effort per vessel per fishing trip requested (Green); combined catches/effort per vessel class size requested (Yellow); combined catches/effort per gear type requested (Red)

Other studies looking at the commercial fleet, may encounter similar biases. "Data envelopment analysis (DEA) derives a deterministic production frontier describing the most technically efficient combination of outputs, given the state of fishing technology, the fish stock and unrestricted variable inputs" (Reid and Squires 2007). Simply put, this analysis uses the highest catch of the most productive vessel as an indicator of the *potential* of that size class/gear combination to fish. As explained above for the artisanal fleet, these generalizations may inflate estimates of catches to numbers that are not real to the situation in the region. In addition, comparing purse seiners from the EU and similar fleets (*e. g.* Seychelles) to vessels from other countries, where catches in the former are five to six times larger due to use of more technologically advanced FADs, supply vessels, number of trips per year, and other factors, increases the expected output and gives a distorted view of the *true* catch of a fleet for a specific country, and therefore that of its capacity. Capacity, furthermore, is influenced by characteristics such as skill of the captains and differences in technology that may not be quantifiable (Kirkley *et al.* 1998, Squires and Kirkley 1999, Pascoe and Coglan 2002). Fishing capacity, if measured as number of vessels, is not a static quantity and therefore fishing power may increase markedly over time. In addition, different combinations of numbers and types of vessels can have comparable effects on the stock. Consequently, when a variety of vessel types and sizes exist in a fishery, there is no unique combination of vessels that would yield "optimal" performance in terms of normal stock assessment performance criteria (*e. g.* MSY, F_{MSY}, risk statistics). Finally, vessels of the same capacity may not act at their full potential for technical, economic, political, environmental or social reasons. This perspective may be useful from a macro economic point of view but it is hard to reconcile those results to the reality and limitations of the fleets in each country. A company or country looking to streamline its operations would find DEA a very useful exercise to reduce costs and improve earnings. Diverging interests from countries as far apart and with different aims as are found in the Indian Ocean, as well as fleets as large as the ones found in the Indian

Ocean would have limited use or application for this type of analysis. Nonetheless, if such a study is desired, the characteristics of each fleet should be taken into account and production frontiers established for each fleet separately.

While one of the initial objectives was to determine the input capacity of artisanal fleets in the Indian Ocean by vessel type and gear combination, the lack of data made this task impossible for most of the countries in the region. This is due to a variety of reasons. One is that the information is not available for most countries. It was lucky if we could find numbers on fleet and size category but information on the combination of size category and gear is rare in the Indian Ocean. The second is that those countries that have it are not always willing to share it. IOTC Circular 79 (Appendix 1) was sent to the coastal countries to collaborate with the research but there was limited response. Further actions must take place to ensure that CPCs comply with the requirements of the Commission as well as support authorised studies in relevant topics. Finally, there are no explicit requirements from the Commission concerning artisanal fleets thus there is no obligation from the CPCs to comply with any requests on this fleet. If data on the artisanal component (here presented as semi-industrial and artisanal) are of importance to the IOTC, something that would hardly be put in doubt considering the nature of tuna fisheries in the Indian Ocean, then it is urgent to determine the needs of the Commission and the obligations of the countries concerned.

It is essential that vessel capacities be reported consistently to allow for valid comparisons. Although size seems to be the most common measure, there are various ways in which it may be presented: gross registered tonnage (GRT), gross tonnage (GT), and length overall (LOA) for example. We propose that the Commission presents a resolution to reduce these discrepancies to a minimum by requiring the CPCs to report the capacity of their vessels by a more descriptive attribute of capacity such as fish carrying capacity in metric tons or total hold volume in cubic meters. In addition, a standard form should be designed and presented to the relevant countries for them to report their fleet and their characteristics annually, particularly for those fleets not covered in the Active List Resolution. Although this Resolution does not cover semi-industrial vessels smaller than 24 m fishing within their EEZs, and considering the increasing importance in fishing capacity of said fleet, an amendment could resolve this oversight by establishing the same standards as for industrial vessels. Finally, and because of their importance due to the extensive size of the fleet, artisanal vessels as defined in this study should also be included.

As it stands, the Commission is a long way from reliably determining optimal capacity for the various fleets currently fishing in the Indian Ocean. Current requirements are not sufficient to gather data in the detail desired to conduct said studies. There is a need to increase data resolution and this applies in particular to details on vessel dimensions, target species and catch and effort (Table 26).

The types of information required to measure fishing capacity and data available at the IOTC Secretariat at present are presented in Table 27:

Table 27: Types of information required to measure fishing capacity versus the type of data that the Commission request from IOTC CPCs at present

Optimal data required	Minimal data required	Data available at IOTC
<u>Fixed inputs</u>: Individual vessel data, including: • Fleet component, in particular details about the gear used (and fishing mode) • unique vessel ID* • dimensions, as GT and/or well capacity • power, engine horsepower • fish preservation and freezing capacity per day, where applicable	<u>Fixed inputs</u>: For each fleet component data aggregated by vessel size category, including the number of vessels and totals or average values for vessel dimensions, power, and preservation and freezing capacity	<u>Fixed inputs</u>: • Individual vessel data are available for vessels flagged in IOTC CPCs in the IOTC Record of Authorized Vessels, however, not all vessel details are available for all fleets (*e. g.* GRT instead of GT) • Data aggregated by vessel size category are available for some of the vessels not included above, in particular the semi-industrial component • Data are not available for the majority of artisanal fleets
<u>Associated outputs:</u> Catch data for each unique vessel ID	<u>Associated outputs</u>: Total catches for each fleet component and aggregate by vessel size category	<u>Associated outputs</u>: Catch data are not available for each individual boat and are rarely available for each aggregate of vessel size category; in most cases catch data are available aggregated across all vessel size categories
<u>Variable inputs</u>: for each unique vessel ID: • Effort data, as fishing or searching days, number of sets, number of hooks set, number of lines set (e.g. number of poles for baitboats), depending on the type of fishery • Fuel consumption	<u>Variable inputs</u>: Effort data and fuel consumption for each fleet component and aggregate of vessel size category	<u>Variable inputs</u>: • Effort data are not available for each individual boat and are rarely available for each aggregate of vessel size category; where available, effort data are aggregated across all vessel size categories. No effort data are available for some industrial fleets and the majority of semi-industrial and artisanal fleets. • Fuel consumption data are not available

*Note that identification of individual vessels by name is not required; while vessel IDs are necessary to identify each vessel, these can be randomly generated numbers as tracing back of vessel name and details from IDs is not necessary. Based on Reid and Squires (2007) plus modifications by the authors.

The main types of problems experienced with the data for the industrial fleet may be summarized as follows:

1. The IOTC has measures to limit capacity according to target species (*e. g.* albacore-swordfish) yet information on the species targeted by each fishing vessel is not available in most cases or reports refer to aggregates of target species (*e. g.* tropical tuna plus albacore). Furthermore, vessels may opportunistically change their target species and this will lead to changes in gears, gear configuration, effort, depth, bait, etc.
2. Capacity in industrial vessels will improve with advances in technology thus changing the fishing mortality for a vessel or fleet. These changes may be

subtle but will become significant in the long term as fishing efficiencies improve without noticeable changes in infrastructure or numbers of vessels. These changes are evident when we compare the purse seine industry fishing with and without FADs and the accompanying technology, support vessels, and their effects on catch rates.

3. Although there are requirements from the Commission about reporting of vessels by size categories and where they operate, monitoring activities for a significant component of the fleet are still poor. This situation applies to Indonesian longliners, Maldivian pole and liners, Pakistani gillnetters, and Sri Lankan gillnet/longline vessels. This component of the fleet may account for up to 60% of the total number of active vessels, thus a very important part of the whole fleet. IOTC Resolution 06/03 *On Establishing a Vessel Monitoring System Programme*, states that vessels with LOA greater than 15 m that are authorised to fish outside their EEZs must have a VMS system on board. However, this Resolution does not cover vessels between 15-24 m LOA that are not in the IOTC record of Authorised Vessels that could potentially operate outside of the EEZ of their flag countries, thus reducing the ability of the countries to monitor their activities. Extending VMS requirements to cover all vessels that could *potentially* operate outside the EEZs of their flag states would help IOTC CPCs and the Commission to improve monitoring of the fishing fleets as a whole, and assess the amount of effort exerted within and outside EEZs more accurately. This request is supported by recent findings of Sri Lankan vessels of around 12 m fishing illegally in Chagos Islands, British Indian Territory (Greenpeace 2013).
4. Vessel numbers may come from vessel registries rather than from lists of vessels actively fishing in the Indian Ocean. Said vessels may be fishing for other species, decommissioned, or fishing outside the region.
5. There is poor monitoring of vessel activities and gears used. It is common for countries to report the gear for which a vessel has a permit to fish but in reality said vessels may use many more or has changed gears altogether.
6. There are a number of non-members of the IOTC fishing in the Indian Ocean and these estimates come from unofficial reports from third parties and their accuracy is questionable. Approximately 15 large vessels (over 24 m LOA) from Bolivia, Cambodia, Equatorial Guinea, Mongolia, Togo, and other non-member countries, or unidentified flags, are in this category. The number of vessels from non-member nations has decreased considerably since the implementation of management measures from the Commission to reduce IUU activities in the area.
7. It is not uncommon for vessels to be registered multiple times and this leads to double counting and at least two situations arise: **a.** parallel registration when a vessel uses a single flag but is registered in two countries; and more commonly **b.** concurrent registration when a vessel temporarily uses the flag of a coastal country while fishing in that country's EEZ but subsequently reverts to its own flag when outside the EEZ. Examples of double flagging were an issue in India where longliners from Taiwan Province of China flew

the Indian flag while inside the Indian EEZ and that of Taiwan Province of China when they were in international waters (Pramod 2010).

8. Vessel details (name, GT, GRT, LOA) are inconsistent or incomplete for some countries and fleets. It must be emphasised that GT should be reported. For example, Indonesia may use two measures interchangeably in its reports (*e. g.* GT and GRT).
9. Some coastal countries like Bangladesh and Myanmar that are not CPCs, have industrial vessels (over 24 m) that operate within their EEZs and are not included in the active list. This is unlikely to be a significant issue if the number of vessels is low which appears to be the case for both of these countries.
10. There is an urgent need to get more detailed information on shark species composition in catches in the Indian Ocean. Although the situation has improved somewhat, fleets are far from having detailed species information. Only 48% of shark catches in 2012 were identified to species, and the rest were grouped under a "Shark" category. This does not provide enough detail for stock assessment or population analyses of individual species.

Status of estimates of number of vessels

The data presented here may be considered an improvement over previously presented numbers. Nonetheless, as time progresses and information gets lost or manipulated, the rationale of reviewing numbers that were never certain to begin with is questioned. It is easy to fall in the trap of wanting to present numbers that "make sense" but this bias does not necessarily improve the quality of the data and further obfuscates what is an already confused situation.

This and the previous capacity study for the Indian Ocean (Gillett and Herrera 2009) use the simplest measure of fishing capacity: number of vessels. Bayliff and Majkowski (2007) eloquently highlighted the limitation of input measures of capacity for management purposes by stating that the "use of nominal capacity measures such as GRT, number of vessels, or other similar metrics, alone, appears to be a rather blunt instrument for managing fishing capacity". This approach obviously is the stepping-stone for further, more complex and detailed analyses but they will require significantly more detailed, complete and consistent data, numbers that at this time, and in the foreseeable future, are not be available for the Indian Ocean.

Considering the peculiarities of the fleets fishing in the Indian Ocean, that is the large number of fleets using the same gear with very different outputs, maybe the use of "technically efficient output" would be a more appropriate approach. "The difference between capacity output and technically efficient output is that variable inputs are fully utilized in the former and are utilized at the observed levels (which could be fully utilized) in the latter" (Reid and Squires 2007).

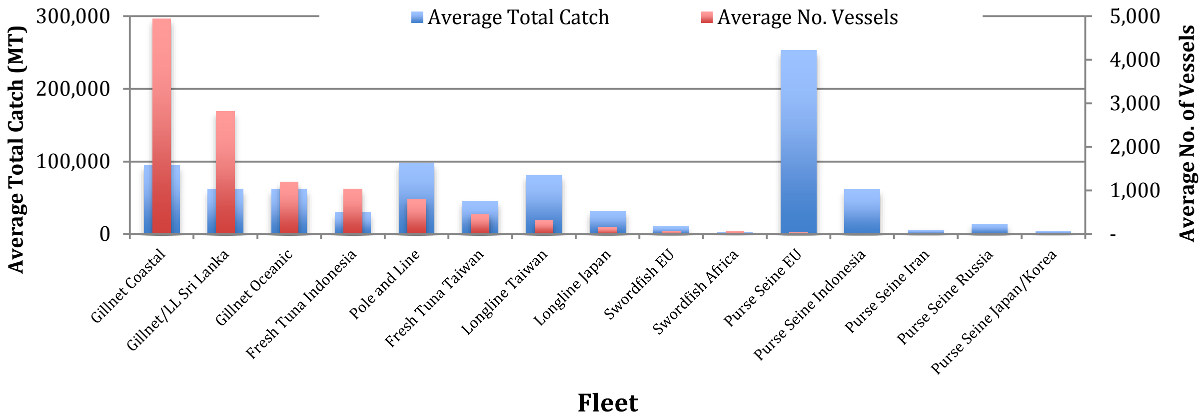
At this time there are enough data to conduct output studies in one of the fleets in the Indian Ocean, the purse seine fleet. Other fleets present significant differences (*e.g.*

gillnet) to exclude them from said approach. In the case of longlining, Gillett and Herrera (2009) suggested that the "most appropriate method for estimating output capacity is probably the "best practice frontier" technique (D. Squires, personal communication, August 2009). Longliners in the region are broken into national fleets and the assumption is made that there are not great differences in the mode of operation of these national fleets." The most productive fleet then defines the production frontier and other fleets are compared to this frontier to determine capacity utilization. In this study we chose to divide purse seine, longline and gillnet fleets into "functional" components. This was done to reduce variability within fleets and to present a more accurate picture of where and what said fleets fish, as well as the production per fleet per year. This proved to be a useful exercise as details were lost when fleets of different types, countries and targeting different species were grouped together.

Unfortunately, availability of data has not improved much since Reid and Squires (2007) stated "at this stage it appears that there is not sufficient data to under[take] any meaningful DEA of longline or pole and line fishing capacity in the Indian Ocean". Of course number of vessels is a necessary requirement but at the heart of the problem is relating input data (number of vessels) with variable input (effort) and variable output (catch) (Reid and Squires 2007).

A reduction in capacity of the artisanal fleet in the Indian Ocean is highly unlikely to take place as a result of management measures. The commercial purse seine fleet is another story. Joseph *et al.* (2007) estimated that capacity for this fleet could be reduced by 23% without a concurrent reduction in captures. This reduction may have already taken place temporarily, albeit unintentionally, through the effects of piracy on the western Indian Ocean. Restrictions will have to be set for all industrial and semi-industrial fleets if capacity is to be limited effectively. Although there are large numbers of semi-industrial and artisanal vessels, the bulk of the catch is captured by a few boats from the industrial purse seine fleet (Figure 18). The purse seine fleet from the EU and similar fleets has less than an average 1% of the fleet yet it captures an average 40% of the total catch of IOTC species in the Indian Ocean.

Figure 18: Average total catch and average number of industrial and semi-industrial vessels by fleet operating in the Indian Ocean from 2006-2012.



By far, the most numerous industrial and semi-industrial fleets are those using gillnets. They include an average 75% of all industrial and semi-industrial vessels operating in the Indian Ocean for the last six years yet they only capture an average 25% of the total catch of the species of interest to the IOTC (sharks not included), nonetheless a considerable quantity of fish (Figure 18).

Numbers presented for artisanal fleets in the region are but pieces of a very complicated and incomplete puzzle. For example, a recent study (MRAG 2012) attempted to estimate the gillnet fleet in India. The suggested number in that report of 2,400-3,700 gillnet vessels is 17-26% of the number presented here which in itself is an underestimate of the fleet of vessels using gillnet if we consider that data in this report do not include the tens of thousands of motorised and non-motorised vessels using said gear. The state of Tamil Nadu alone reported 22,478 vessels with outboard motors that use gillnet (CMFRI 2011). Unfortunately, data for the rest of India's states were incomplete and a total number could not be calculated.

For the artisanal fleet it was not possible to break down the number of vessels by gear although it can be said that one of the most important gears in this category is gillnet. The overall estimate of the artisanal fishing fleet, as per IOTC definition, is of 584,068 boats keeping in mind that this does not include recent values for all the countries in the Indian Ocean. Furthermore, many of the numbers presented here refer to the *whole* artisanal fleet of a country, including those vessels that catch other species as there were no detailed data on the fleets that catch tuna and tuna-like species. This fleet captures an estimated 915,112 MT per year excluding sharks of interest to the IOTC.

A limited amount of data on FADs has been presented here and this is due to the secrecy that surrounds their deployment. There are no complete numbers of artificial FADs deployed in the Indian Ocean although it is suggested that numbers range in the thousands. Because FADs alter the ability to catch tuna species and therefore their fishing mortality, understanding the effects of FADs on fish populations and their fisheries is a must for fishery biologists. Knowing the numbers and distribution of

FADs in time and space is an initial and essential step to achieving this goal.

A final, but important, point needs to be made about the presence of vessels that do not report (and are presumably IUU) their activities in the Indian Ocean. In past years, vessels from non-reporting flags, the majority from countries not participating in IOTC, have been listed under a category called "Not Elsewhere Included" or NEI. This category has shown a marked decrease in recent years. In many cases, the situation of the vessels has been regularized and the vessels are now listed in the Record of Authorized Vessels. In other cases, vessels may have been re-flagged, scrapped, or moved to other oceans.

On the other hand, recent reports point to vessels flagged in coastal countries that are operating outside their EEZ and that are not included in the Record of Authorized Vessels (Greenpeace 2013, IOTC 2013c).

Although it is possible that the extent of IUU fishing is declining relative to historical levels, there is no accurate estimate of the number of IUU vessels or vessels that are engaged in IUU activities and, therefore, this number is not included in full here.

Fleet development plan for CPCs in the Indian Ocean and outlook to likely levels of input fishing capacity in the future

Countries fishing in the Indian Ocean have presented fleet development plans (FDPs) that foresee an increase in capacity as part of their strategic fisheries production. This increase is particularly relevant to coastal countries that plan to increase the number of vessels into the year 2020 (*e. g.* India, Indonesia, Iran, Maldives, Mauritius, Mozambique, Oman, Pakistan, Seychelles, Sri Lanka and Tanzania) although other non-coastal countries have also presented plans for extension of their capacities (*e. g.* Belize, China, EU, Vanuatu).

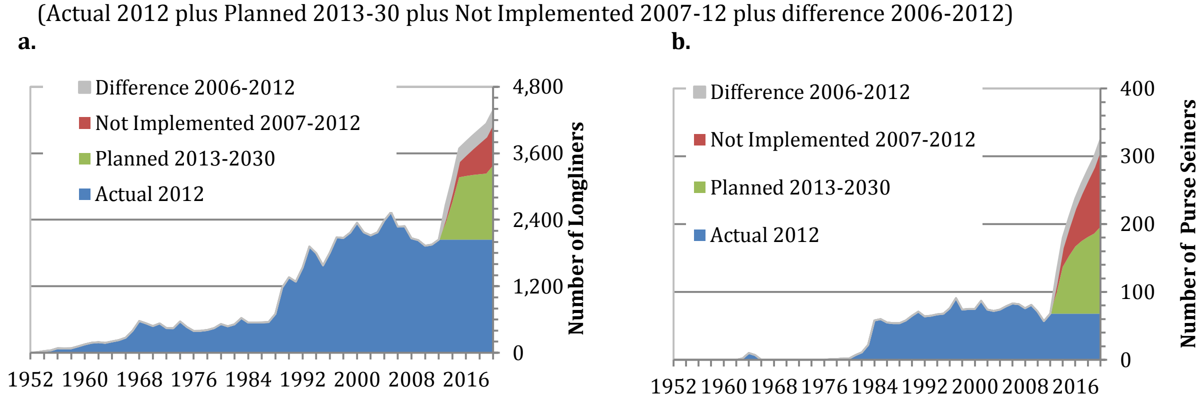
IOTC Resolution 12/11 *On the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating non-Contracting Parties* (which supersedes Resolutions 09/02, 07/05 and 06/05) paragraph 6 states that "other CPCs which had the objective of developing their fleets following the provisions of IOTC Resolution 03/01, through the introduction to the IOTC of a fleet development plan, shall confirm, by 31 December 2009, *inter alia*, the type, size, gear and origin of the vessels included in the Fleet Development Plans and the programming (precise calendar for the forthcoming 10 years) of their introduction into the fisheries. All future fishing efforts shall be in accordance with such development Plans of the concerned CPCs."

The FDPs use a reference point in terms of vessel tonnage (GT, although some parties are still using GRT) and number of vessels based in the capacity present for tropical tuna in 2006 and swordfish and albacore in 2007 (Figure 20). For most countries, the fleet capacity in 2012 is well under the projected values due to a lack of implementation of the FDPs. The active capacity in 2012 in terms of vessel tonnage is 86% of the reference point in 2006-07 (Figure 20c. All Fleets, light Green). The reference capacity, that is the reference point plus the planned FDPs for the same period, is 163% over the reference period meaning that the active capacity for 2012 is just over half or 56% of what was projected (Figure 20c. All Fleets, dark Green). In terms of vessel numbers, however, the conclusion is the opposite (Figure 20a.). The active capacity in number of vessels for tropical tuna and swordfish and albacore for 2012 is 122% over the reference point in 2006-07. The large number of vessels of low tonnage that were introduced in Sri Lanka may explain this discrepancy. It may also show a trend of regional usage where more, smaller vessels are used to fish in the Indian Ocean to increase efficiency and reduce costs. If countries in the region fulfil the projections in their FDPs and other countries without FDPs maintain current levels of capacity, overall fleet capacity in the Indian Ocean in 2020 will be over 250% that of the 2006-07 reference point (Figure 19).

An attempt was made here to project the number of active purse seiners and longliners into the future considering various scenarios of implementation of the fleet development plans presented by IOTC CPCs (Figure 19). FDPs are applicable since 2006 (tropical tunas) and 2007 (albacore and swordfish) when the Commission established baselines for the limitation of fishing capacity for fleets flagged in IOTC CPCs.

Figure 19: Total numbers of active purse seiners (right) and longliners (left) estimated over the period 1952-2012 (Actual) and numbers of vessels estimated for 2013 and following years assuming that all IOTC CPCs will execute their fleet development plans as planned; the following scenarios were considered:

1. CPCs will execute their plans fully for 2013 and following years and all new vessels will add to the number of active vessels estimated for 2012 (Actual 2012 plus Planned 2013-30)
2. CPCs will execute their plans fully for 2013 and following years as in **a**. above, and, in addition, the CPCs that did not realize their FDPs for 2007-12 will execute their plans gradually in 2013 and following years (Actual 2012 plus Planned 2013-30 plus Not Implemented 2007-12)
3. CPCs will execute their plans for 2007 and following years fully, starting in 2013 and all new vessels will add to the number of active vessels estimated for 2006, which was the year in which the IOTC established the baseline (Actual 2012 plus Planned 2013-30 plus Not Implemented 2007-12 plus difference 2006-2012)



As expressed in the previous paragraph, if the implementation of FDPs is realized, be it partially (Figure 19 scenarios 1 and 2), or in full (Figure 19 scenario 3), and levels of capacity for other fleets remain at values near the baseline, it is very unlikely that the numbers of active purse seiners and longliners in the Indian Ocean can be sustainable in the very short-term. In particular, IOTC CPCs have presented plans that, if fully realized, will lead to a two-fold increase in the number of longliners operating in the

Indian Ocean. (Figure 19a). For industrial purse seiners, an almost five-fold increase is expected under the same circumstances (Figure 19b).

In addition, it is noted that other IOTC CPCs have presented plans to expand their semi-industrial fleets. Sri Lanka, in particular, presented a plan to increase its number of semi-industrial gillnet and longline boats by 616 boats during 2011-15, and has already implemented part of said plan (280 boats added between 2011 and 2012).

It must be remembered that these numbers refer to plans that may not necessarily translate into actual capacity in the near future (Figure 20). If governments do not subsidize these fleet plans, and economics drive the process it is unlikely that most of them will come to fruition. However, if the plans were to be implemented by the CPCs concerned, they will lead to sharp increases in the numbers of active fishing vessels, and it is questioned here whether the Indian Ocean will be able to support such levels of effort. This increase will happen unless the Commission takes the necessary steps to ensure that levels of fishing effort are in line with the recommendations from the IOTC Scientific Committee and the IOTC Performance Review Panel, to ensure that "loopholes in the current systems of fishing capacity limitation, such as the establishment of fleet development plans and exemptions for vessels less than 24 meters, should be closed" (Anonymous 2009).

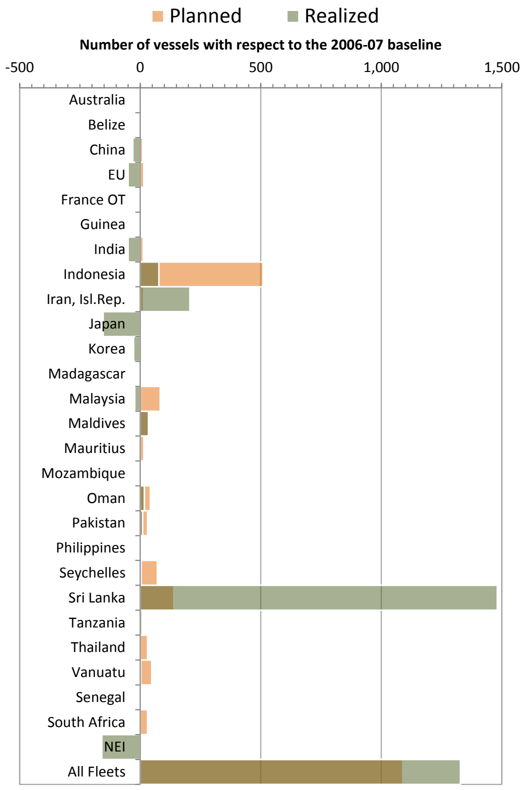
Fig.20: Performance of IOTC CPCs in implementing their FDPs, where existing, and levels of input fishing capacity for CPCs that had not presented FDPs and other fleets operating in the IOTC Area (NEI):

a. Number of active fishing vessels:

- CPCs that have presented FDPs: performance in terms of the number of active fishing vessels recorded in 2012 over the number of vessels existing at the time the baselines were established (2006-07) and the number of vessels that each CPC planned to add during 2007-12, as recorded in its FDP;
- CPCs that have not presented FDPs and other parties fishing in the Indian Ocean: number of fishing vessels recorded in 2012 *versus* the numbers existing at the time the baselines were established (2006-07).

The green bars show the difference between the number of vessels operated in 2012 and the 2006-07 baselines for each fleet, i.e. the actual number of fishing vessels that was added/removed (**Realized**) by each Party over the period 2007-12

The orange bars show the number of fishing vessels that IOTC CPCs having presented FDPs **Planned** to add to their fleets over the years 2007-2012

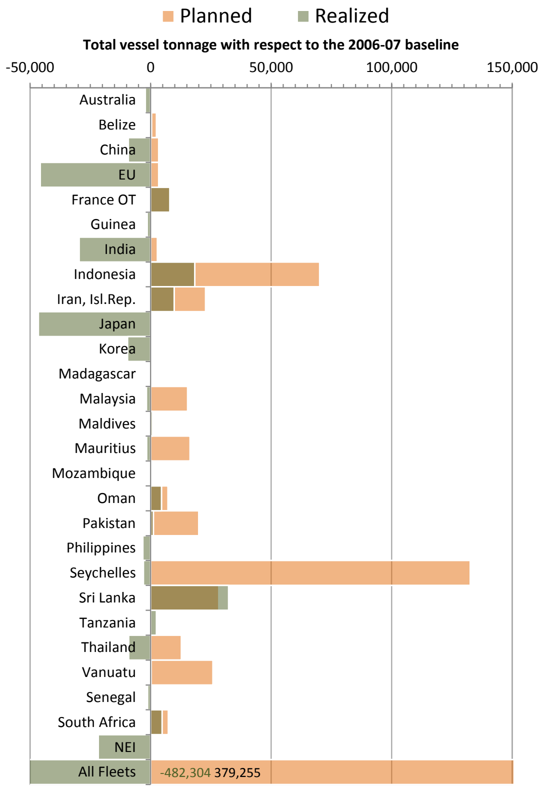


b. Overall vessel tonnage for all active fishing vessels combined:

- CPCs that have presented FDPs: performance in terms of the overall GRT/GT of the active fishing vessels recorded in 2012 over the GRT/GT existing at the time the baselines were established (2006-07) and the GRT/GT that each CPC planned to add during 2007-12, as recorded in its FDP;
- CPCs that have not presented FDPs and other parties fishing in the Indian Ocean: overall GRT/GT of the active fishing vessels recorded in 2012 *versus* the GRT/GT existing at the time the baselines were established (2006-07).

The green bars show the difference between the GRT/GT of vessels operated in 2012 and the 2006-07 baselines for each fleet, i.e. the actual number of fishing vessels that was added/removed (**Realized**) by each Party over the period 2007-12

The orange bars show the overall GRT/GT of fishing vessels that IOTC CPCs having presented FDPs **Planned** to add to their fleets over the years 2007-2012



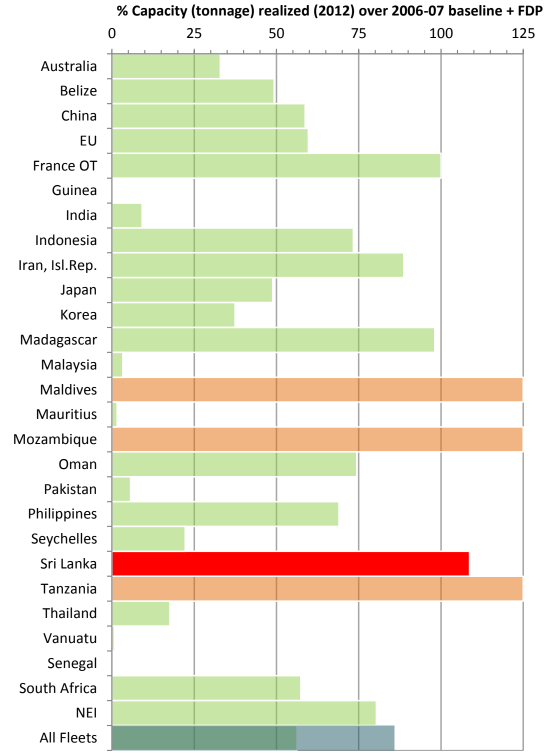
c. Vessel tonnage realized over the period:

- CPCs that have presented FDPs: performance (%) in terms of the amount of vessel tonnage (GRT/GT) that the GRT/GT in 2012 represents over the GRT/GT existing at the time the baselines were established (2006-07) plus the GRT/GT that each CPC planned to add during 2007-12, as per its FDP.
- CPCs that have not presented FDPs and other parties fishing in the Indian Ocean: performance (%) in terms of the amount of vessel tonnage (GRT/GT) that the GRT/GT in 2012 represents over the GRT/GT existing at the time the baselines were established (2006-07)

Green bars are used for CPCs that did realize their FDPs or did not realize them fully; or those CPCs for which the total vessel tonnage in 2012 was the same or below the baseline (≤100%).

Orange bars are used for CPCs that did not have baselines and/or FDPs and reported active vessels in 2012

Red bars are used for CPCs that exceeded the vessel tonnage that they had planned to add through their FDPs (>100%)



Note that Comoros, Eritrea, Kenya, Sierra Leone, Sudan, United Kingdom (Overseas Territories), and Yemen did not reprot lists of active fishing vessels for 2006, 2007 (baselines), or 2012 and, to date, have not presented fleet development plans to the Commission.

8. References Cited

Adam MS, Anderson RC, Hafiz A (2003). The Maldivian tuna fishery. WPTT-03-23. IOTC Proceedings no. 6, pp. 202-220.

Amandè JM, Chassot E, Chavance P, Murua H, Delgado de Molina A, Bez N (2012). Precision in bycatch estimates: the case of tuna purse-seine fisheries in the Indian Ocean. ICES Journal of Marine Science. 69(8): 1501–1510.

Amandè JM, Ariz J, Chassot E, Chavance P, Delgado de Molina A, Gaertner D, Murua H, Pianet R, Ruiz J (2008). By-catch and discards of the European purse seine tuna fishery in the Indian Ocean. Estimation and characteristics for the 2003-2007 period. IOTC-2008-WPEB-12.

Anonymous (2009). Report of the IOTC Performance Review Panel: January 2009. Indian Ocean Tuna Commission. 56 pp.

Barclay K, Koh S-H (2005). Neoliberalism in Japan's Tuna Fisheries? Government intervention and reform in the distant water longline industry. Asia Pacific School of Economics and Government, The Australian National University. 30 pp.

Bayliff WH, Majkowski J (2007). Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, United States of America, 8–12 May 2006. FAO Fisheries Proceedings. No. 8. Rome, FAO. 218pp.

Berkes F, Mahon R, McConney P, Pollnac R, Pomeroy R (2001). Managing small-scale fisheries: Alternative directions and methods. International Development Research Centre. 309 pp.

Blanc M, Desurmont A, Beverly S (2005). Onboard handling of sashimi-grade tuna. A practical guide for crewmembers. Noumea, New Caledonia, Secretariat of the Pacific Community. 24 pp.

Castro JJ, Santiago JA, Santana-Ortega AT (2002). A general theory on fish aggregation to floating objects: an alternative to the meeting point hypothesis. Reviews in Fish Biology and Fisheries 11:255–277.

Chavance P, Amande JM, Pianet R, Chassot E, Damiano A (2011). Bycatch and discards of the French tuna purse seine fishery during the 2003-2010 period estimated from observer data. IOTC-2011-WPEB07-23.

CMFRI (2012a). Marine Fisheries Census 2010. Central Marine Fisheries Research Institute, Government of India, Ministry of Agriculture, Department of animal Husbandry, Dairying and Fisheries. New Delhi.

CMFRI (2012b). Annual Report 2011-12. Central Marine Fisheries Research Institute, Cochin, 141 pp.

CMFRI (2011). Annual Report 2010-11. Central Marine Fisheries Research Institute, Cochin, 163 pp.

CMFRI (2006). Marine Fisheries Census 2005. Central Marine Fisheries Research Institute, Government of India, Ministry of Agriculture, Department of animal Husbandry, Dairying and Fisheries. New Delhi.

Dagorn L, Holland KN, Restrepo V, Moreno G (2012). Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? Fish and Fisheries 14(3):391-415.

Demena BA (2011). Determinants of fishing catch levels in artisanal fishing in Eritrea. Masters of Arts Thesis in Development Studies. International Institute of Social Studies, The Hague, The Netherlands. 63pp

FAO (2004). The State of World Fisheries and Aquaculture 2004. Food and Agriculture Organization of the United Nations. Rome.

Filmalter JD, Capello M, Deneubourg J-L, Denfer Cowley P, Dagorn L (2013). Looking behind the curtain: quantifying massive shark mortality in fish aggregating devices. Front. Ecol. Environ. 11(6): 291–296, doi:10.1890/130045.

FSI (2012a). Marine Fisheries Census 2010. Union territories of Andaman & Nicobar and Lakshadweep islands. Department of Animal Husbandry, Dairying & Fisheries. 164 pp.

FSI (2012b). Handbook on fishery statistics. Ministry of Agriculture. Department of Animal Husbandry, Dairying & Fisheries. 147 pp.

Fonteneau A (2003). Prospects for the management of FAD fisheries in the Indian Ocean. Report of the Fifth Session of the IOTC Working Party on Tropical Tunas, Victoria, Seychelles, 3– 12 June 2003. IOTC WPTT-03-04.

García-Cortés B, Mejuto J (2001). Preliminary scientific estimations of by-catches landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Indian Ocean: years 1993-2000. IOTC Proceedings no.4 (2001):19-23, WPDCS01-02.

Gillett R (2005). Global study of non-industrial tuna fisheries. In: Bayliff WH, de Leiva Moreno JI, Majkowski J (eds). Proceedings of the Second Meeting of the Technical Advisory Committee of the FAO Project “Management of tuna fishing capacity: conservation and socio-economics” Madrid, 15-18 March. Fisheries Proceedings No. 2, FAO, Rome. Pages 177-232.

Gillett R, Herrera M (2009). Estimating the fishing capacity of the tuna fleets in the Indian Ocean. IOTC-2009-SC-INF13.

Greenpeace (2013). Esperanza Indian Ocean Expedition 2013. Summary of findings.

Hamilton A, Lewis A, McCoy MA, Havice E, Campling L (2011). Market and industry dynamics in the global tuna supply chain. FFA. 395 pp.

Haputhantri SSK (2012). Analysis of billfish landings made by small fresh tuna longline vessels operated from Sri Lanka during 2005-2009. IOTC-2012-WPB10-09.

Herrera M, Gillett B, Pepperell J (in press). Tunas and their fisheries: safeguarding sustainability in the 21st century. Chapter 6: Small-scale fisheries (artisanal, local subsistence and recreational fishing). Wiley-Blackwell.

Hobsbawn PI, Patterson HM, Larcombe J (2012). Australian national report to the Scientific

Committee of the Indian Ocean Tuna Commission for 2012. IOTC-2012-SC15-NR01.

Ingles J, Flores J, Musthofa I, Mous P (2008). Getting off the hook: reforming the tuna fisheries in Indonesia. WWF-Coral Triangle Initiative.

IOTC (2013a). Report of the Seventeenth Session of the Indian Ocean Tuna Commission. Mauritius, 6–10 May 2013. IOTC–2013–S17–R[E]: 129 pp. Appendix XV - Update on Progress Regarding Resolution 09/01 – On the Performance Review Follow–up.

IOTC (2013b). Report on the implementation of a limitation of fishing capacity of contracting and cooperating non-contracting parties. IOTC-2013-CoC10-05[E]

IOTC (2013c). Report on the Tenth Session of the Compliance Committee. IOTC-2013-CoC10-R.

IOTC (2012). Examination of the effect of piracy on fleet operations and subsequent catch and effort trends. IOTC-2012-SC15-07[E].

IOTC (2007). Mission to Yemen. Powerpoint presentation

Irianto HE, Wudianto,Satria F, Nugraha B (2013). Tropical tuna fisheries in the Indian ocean of Indonesia. IOTC–2013–WPTT15–20.

Islam MS (2003). Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh Ocean & Coastal Management 46 (2003) 763–796

Joseph J (2009). Addressing the Issues of Fishing Capacity in the World Tuna Fleets. Second Joint Tuna RFMOs Meeting, San Sebastian, 2009.

Joseph J, Squires D, Bayliff W, Groves T (2007). Requirements and alternatives for the limitation of fishing capacity in tuna purse-seine fleets. In: Bayliff W, Majkowski J. (eds). Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, United States of America. FAO Fisheries Proceedings. No. 8. Rome, FAO. Pages 153-191.

Kirkley J, Squires D, Strand I (1998). Characterizing managerial skill and technical efficiency in a fishery. Jour. Prod. Anal. 9:145-160.

Malhotra SP, Sinha VRP (2007). Marine Fisheries in India. Part 1, Chapter 6, pages 179-205. In: Indian Fisheries and Aquaculture in a Globalizing Economy. Delhi, Narendra Publishing House, 746 pp.

Marsac F, Fonteneau A, Menard F (2000). Drifting FADs used in tuna fisheries: An ecological trap? In: Biology and behaviour of pelagic fish aggregations. p: 537-552.

Moreno Gala, Dagorn L, Sancho G, Itano D (2007). Fish behaviour from fishers' knowledge: the case study of tropical tuna around drifting fish aggregating devices (DFADs). Can. J. Fish. Aq. Sci. 64:15-17-1528.

Moreno G, Herrera M, Pierre L (2012). Pilot project to improve data collection for tuna, sharks and billfish from artisanal fisheries in the Indian Ocean. Part II: Revision of catch statistics for India, Indonesia and Sri Lanka (1950-2011). Assignment of species and gears to the total catch and issues on data quality. Paper presented at the 15th Session of the

Scientific Committee of the Indian Ocean Tuna Commission, Seychelles, 10–15 December 2012.

Moreno G (2011). Pilot project to improve data collection for tuna, sharks, and billfish from artisanal fisheries in the Indian Ocean. Paper presented at the 14th Session of the Scientific Committee of the Indian Ocean Tuna Commission, Seychelles, 12–17 December 2011.

Moron J (2007). Tuna fishing capacity: perspective of the purse-seine fishing industry on factors affecting it and its management. In: Bayliff WH, Majkowski J (eds). Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, United States of America. FAO Fisheries Proceedings. No. 8. Rome, FAO. Pages 117-127.

Moron J, Areso JJ, Pallares, P (2001). Statistics and technical information about the Spanish purse seine fleet in the Pacific. 14th Meeting of the Standing Committee on Tuna and Billfish, Noumea, New Caledonia, 9–16 August. Standing Committee on Tuna and Billfish Working Paper No. SCTB14.

MRAG (2012). A review of bycatch in the Indian Ocean gillnet tuna fleet focussing on India and Sri Lanka. ISSF Technical Report 2012-05. International Seafood Sustainability Foundation, Washington D.C., USA. 53 pp.

NARA (2011). Implementation of conservation and management. National Report of Sri Lanka. IOTC-2011-S15-CoC59.

Needham S, Alonso E, Wilson C, Rodrigues P, Pereira M, Griffiths D (2013). Community-based data gathering and co-management of marine resources in Timor-Leste. Regional Fisheries Livelihoods Programme for South and Southeast Asia (GCP/RAS/237/SPA). Field Project Document 2013/1.

Nootmorn P, Rodpradit S, Chaiyen T, Panjarat S (2012). Tropical tunas from foreign tuna fleets unloading in Phuket, Thailand during 1995-2011. IOTC–2012–WPTT14–16.

Pascoe S, Coglan L (2002). Contribution of unmeasurable factors to the efficiency of fishing vessels. Amer. Jour. Agri. Econ. 84(3): 45-57.

Pianet R, Pallares P, Delgado de Molina, A, Nordstrom V, Dewals P, Lukas V (2005). Statistics of the main purse seine fleets fishing in the Indian Ocean (1981–2004). IOTC-2005-WPTT-23.

Pianet R, Pallares P, Norström V, Hervé A, Delgado de Molina, A, Ariz, J (2004). Statistiques de la pêcherie thonière europeenne et assimilée 65urant la période 1991–2002. ICCAT Collect. Vol. Sci. Pap. 56(2):737–759.

Pramod G (2012). Illegal and unreported fishing: global analysis of incentives and a case study estimating illegal and unreported catches from India. PhD in the Faculty of Graduate Studies. The University of British Columbia, Vancouver, Canada. 343 pp.

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, 30 pp.

Ramos ML, Delgado de Molina A, Ariz J (2010). Analysis of activity data obtained from supply vessels' logbooks implemented by the Spanish fleet and associated in Indian Ocean.

IOTC-2010-WPTT-22.

Ramos-Cartelle A, García-Cortés B, Mejuto J (2008). Scientific estimates of bycatch landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Indian Ocean with special reference to the 2004–2006 period. IOTC-008-WPEB-03.

Reid C, Squires D (2007). Measuring Fishing Capacity in Tuna Fisheries: Data Envelopment Analysis, Industry Surveys and Data Collection. In: Bayliff WH, Majkowski J (eds). Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. FAO Fisheries Proceedings. No. 8. Rome, FAO. Pages 87-97.

Rohit P, Rao GS, Rammohan K (2008). Yellowfin tuna fishery by traditional fishermen at Visakhapatnam, Andhra Pradesh. J. Mar. Biol. Ass. India, 50(1):62–68.

SEAFDEC (2012). Fishery statistical bulleting of southeast Asia 2010. SEC/ST/42.

SFA (2012). Seychelles Fishing Authority Annual Report 2011. Victoria, Seychelles.

Shaher S (2007). Biology and status of shark fishery in Yemen. IOTC-2008-WPEB-05

Squires D, Kirkley J (1999). Skipper skill and panel data in fishing industries. Canadian Journal Fish. Aquatic Sci. 56(11): 2011-2018.

Taquet M, Sancho G, Dagorn L *et al.* (2007). Characterizing fish communities associated with drifting fish aggregating devices (FADs) in the Western Indian Ocean using underwater visual surveys. Aqua. Liv. Resour. 30:331–341.

Toihir IM (2011). Census of the artisanal fishing fleet in the Union of Comoros. IOTC-2011-WPTT13-13.

Van der Heijden PGM (2007). Training on fisheries management for staff of South Indian Federation of Fishermen Societies (SIFFS). Trivandrum, Kerala, India. Capacity development and institutional change programme, Wageninden International, the Netherlands.

Vijayakumaran K, Varghese SP (2010). Update on the status of tuna fisheries in India. IOTC-2010-SC-Inf12.

Vivekanandan E (2010). Prospects of estimating fishing capacity for India. IOTC-WPTC-2010-53

Ward PJ (1996). Japanese longlining in eastern Australian waters 1962-1990. Bureau of Resource Sciences, Canberra. 249 pp.

Wildman MR (1993). World fishing fleets: An analysis of distant-water fleet operations. Past-present-future. Volume III Asia. NOAA Tech. Memo. NMFS-F/SPO-11. 144 pp.

9. Appendices

Appendix 1: IOTC Circular 2013-79

12 September 2013 / 12 septembre 2013

IOTC CIRCULAR 2013–79 / CIRCULAIRE CTOI 2013–79

Dear Sir/Madam,

SUBJECT: NUMBERS OF ARTISANAL ACTIVE FISHING CRAFT FISHING FOR IOTC SPECIES IN THE IOTC AREA FOR 2006-2012

As you probably know, since 2003 the Indian Ocean Tuna Commission has adopted several measures with the objective of addressing the issue of fishing capacity (Resolution 03/01, 06/05, 07/05, 09/02[1] and 12/11[2]). In addition, IOTC Resolution 09/01 *On the Performance Review follow-up* notes that the IOTC "*should establish a stronger policy on fishing capacity to prevent or eliminate excess fishing capacity*", and noted that "*to date these resolutions have not resulted in a strong control on fishing capacity, and the concern remains that overcapacity might result from this lack of control*" stressing the need for "*Loopholes in the current systems of fishing capacity limitation, such as the establishment of fleet development plans and exemptions for vessels less than 24 meters*" be closed.

Following a request from the Commission and assistance provided by the Government of Australia in 2009, the IOTC Secretariat hired the services of a Consultant to work with the IOTC Secretariat towards deriving estimates of the total number of industrial vessels[3] that fished for IOTC species in the IOTC Area of Competence during 2006-08. The results of the study were presented to the IOTC Working Party on Fishing Capacity in 2009 and the Report presented to the twelfth Meeting of the IOTC Scientific Committee, later that same year[4].

We are pleased to inform that, in order to assist the Commission in the implementation of Resolution 09/01, in particular provisions relating to artisanal fisheries[5] and Fleet Development Plans, the IOTC Secretariat has hired the services of a Consultant, Dr Guillermo Moreno, to work with the IOTC Secretariat in updating previous estimates of fishing capacity for industrial fleets and attempt to derive estimates for artisanal fleets. The Terms of Reference that will guide the work of the Consultant are attached, for your information.

In order to facilitate this work and assist the Commission in fulfilling its objectives, I would be grateful if you could facilitate fishing craft statistics for your country, in particular the types of artisanal fishing crafts operated in the country that catch IOTC species[6], by year, including the following data for the period 2006-12:

Year fished: the year of activity (2006-12)
Type of fishing craft, according to the following categories: Non-motorized, motorized outboard, motorized inboard having length overall less than 15 meters, motorized inboard having length overall 15 meters or greater and less than 24 meters.

1 IOTC Resolution 09/02 superseded IOTC Resolutions 06/05 and 07/05

2 IOTC Resolution 12/11 superseded IOTC Resolution 09/02

3 For the purpose of the study industrial vessels are defined as all those fishing for tunas in the IOTC Area that have a length overall 24 meters or greater, and those with length overall less than 24 meters that operate outside of the Economic Exclusive Zone of their country of registration (i.e. those in the IOTC Record of Authorized vessels that fished for tunas in the IOTC area during the referred year).

4 R. Gillett & Herrera, M. (2009) Estimating the Fishing Capacity of the Tuna Fleets in the Indian Ocean. Report presented at the 12th Session of the Scientific Committee of the IOTC. Victoria, Seychelles, 30 November-4 December 2009. (IOTC-2009-SC-INF13)

5 Artisanal fisheries are defined as all those not included in 3 above.

6 The list of IOTC species is presented in annex to this message, for your information.

Distribution / Destinataires:

IOTC Members / Membres de la CTOI: Australia, Belize, China, Comoros, Eritrea, European Union (For Reunion), France (Territories), Guinea, India, Indonesia, Iran (Islamic Rep of), Japan, Kenya, Rep. of Korea, Madagascar, Malaysia, Maldives, Mauritius, Mozambique, Oman, Pakistan, Philippines, Seychelles, Sierra Leone, Sri Lanka, Sudan, United Rep. of Tanzania, Thailand, United Kingdom (OT), Vanuatu, Yemen. **Cooperating non-Contracting Parties / Parties coopérantes non-contractantes:** Senegal, South Africa. **Chairperson IOTC / Président de la CTOI**
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- **Type of gear(s)** used, according to the following categories: coastal purse seines or ring nets; other seine nets; drifting gillnet for large tunas; drifting gillnet for small tunas or seerfish; other types of gillnet; pole-and-line; handline; trolling; other hook-and-line gear; other gears not elsewhere identified.
- **Type of catch**: Indicate if IOTC species were the target of the fishery at any time during the year, or not; where possible, indicate the species or species group the fishery is directed at.
- **Total number of fishing craft operated**

If your country has difficulties to provide data as per the above resolution we would appreciate if you could provide any fishing craft statistics available for the period specified at your earliest convenience, preferably within the next three weeks to allow us to complete this assessment. .

Thank you very much in advance for your cooperation with this study.

ANNEX 1

Species under the IOTC Mandate

	IOTC Code	Species English name	Species French Name	Species Scientific name
1.	YFT	Yellowfin tuna	Albacore	*Thunnus albacares*
2.	BET	Bigeye tuna	Patudo; Thon obèse	*Thunnus obesus*
3.	SKJ	Skipjack tuna	Listao	*Katsuwonus pelamis*
4.	ALB	Albacore	Germon	*Thunnus alalunga*
5.	SBF	Southern bluefin tuna	Thon rouge du Sud	*Thunnus maccoyii*
6.	SWO	Swordfish	Espadon	*Xiphias gladius*
7.	BLM	Black Marlin	Makaire noir	*Makaira indica*
8.	BUM	Blue Marlin	Makaire bleu	*Makaira nigricans*
9.	MLS	Striped marlin	Marlin rayé	*Tetrapturus audax*
10.	SFA	Indo-Pacific sailfish	Voilier indo-pacifique	*Istiophorus platypterus*
11.	LOT	Longtail tuna	Thon mignon	*Thunnus tonggol*
12.	KAW	Kawakawa	Thonine orientale	*Euthynnus affinis*
13.	FRI	Frigate tuna	Auxide	*Auxis thazard*
14.	BLT	Bullet tuna	Bonitou	*Auxis rochei*
15.	COM	Narrow-barred Spanish mackerel	Thazard rayé indo-pacifique	*Scomberomorus commerson*
16.	GUT	Indo-Pacific king mackerel	Thazard ponctué indo-pacifique	*Scomberomorus guttatus*

Appendix 2: Estimates of numbers of artisanal vessels as per IOTC definition and their catches

Gear	**Gillnet**		**Line**		**Longline**		**Pole and Line**		**Purse Seine**		**Other Gears**		**Total**	
Country	**Boats**	**Catch**	**Boats**	**Catch**	**Boats**	**Catch**	**Boats**	**Catch**	**Boats**	**Catch**	**Boats**	**Catch**	**Boats**	**Catch**
Australia (2012)			3	303									**3**	**303**
Bahrain (2008)	6	6	20	31							37		**63**	**37**
Bangladesh (2003)		2,350											**17,331[i]**	**2,350**
Comoros (2012)		81	3,058	5,010									**3,058**	**5,091**
Djibouti (2004)		182											**90[b]**	**182**
East Timor (2012)		3		3									**3,113[k]**	**6**
Egypt (2009)		621											**4,708[m]**	**621**
Eritrea (2009)		837											**493[h]**	**837**
EU France-Reunion (2011)			167	149									**167**	**149**
France OT (2006)			350	799									**350**	**799**
India (2010)	14,183[a]	69,029	1,190	36,284			103[f]	11,214	983	15,077	182,785[e]	18,545	**199,244**	**150,149**
Indonesia (2011)		75,181		69,743		49,357				81,589	116,861	46,275	**116,861**	**322,145**
Iran (2011)	4,355	153,543	854	1,522									**5,209**	**155,065**
Jordan (2006)		88		12									**49**	**100**
Kenya (2012)	75	445	207	172					8		3		**293**	**617**
Iraq													**NA**	**NA**
Kuwait		131											**N/A**	**131**
Madagascar (2006)				8,400									**62,000[b]**	**8,400**
Malaysia (2001)	4,699	2,114	219	54					245	20,558	3,015	3,783	**8,178**	**26,509**
Maldives (2009)			64	32,061		4							**64**	**32,065**
Mauritius (2012)			184	547									**184**	**547**
Mozambique (2012)	13,271		11,359		607				340		13,451		**39,028**	**6,212[n]**
Myanmar (2010)	577	2,650		17					6,316	1,659	11,584	8,551	**18,477[l]**	**12,877**
Oman (2012)	19,943	12,228	19,245	4,892								1	**19,943[g]**	**17,121**
Pakistan (2011)	3,126[d]	58,060											**3,126**	**58,060**
Qatar (2004)	330	2,442											**330**	**2,442**
Saudi Arabia (2004)		4,220		2,304		6				166			**12,046**	**6,696**
Seychelles (2011)			432	76									**432[j]**	**76**
Somalia													**N/A**	**N/A**
South Africa (2010)			18	51									**18**	**51**
Sri Lanka (2010)		17,956		6,514		8,017				1,883	42,792	1,731	**42,792**	**36,101**
Sudan (2005)		34											**460[b]**	**34**
Tanzania (2008)		3,714		572						1			**3,044**	**4,287**
Thailand (2011)	42	868							312	12,610	571	1,586	**925**	**15,064**
United Arab Emirates (2004)		9,185		1,468									**5,052**	**10,653**
UK Territories (2011)			47	22									**47**	**22**
Yemen (2005)			16,890[c]	39,313									**16,890[c]**	**39,313**
Total	**60,607**	**415,968**	**54,307**	**210,319**	**607**	**57,384**	**103**	**11,214**	**8,204**	**133,543**	**371,099**	**80,472**	**584,068**	**915,112**

Number of artisanal vessels presents the most recent record encountered per country (date of record in parentheses). All catch estimates of IOTC species are from 2011 and extracted from the IOTC database.

[a] This number is only for mechanised boats and does not include motorised or non-motorised boats using this gear.

[b] Data taken from www.fao.org Country profiles.

[c] Data from IOTC (2007).

[d] Number of vessels 35-50 GRT. No data for 2012 were available therefore the value for 2011 was used.

[e] This number was calculated by subtracting known gillnet, liners and purse seiners from the total mechanised and adding it to the motorised and non-motorised components. Note that there is a large discrepancy between the numbers presented by Vivekanandan (2010) and the CMFRI 2010 Census (2012). The latter's numbers were used in this table.

[f] Data from 2011.

[g] Numbers in the gear columns do not add up to the total as the majority of boats use a combination of line (handline and troll) and gillnet and are thus repeated in these two categories.

[h] Number of boats for Eritrea taken from Demena (2011).

[i] Data from Islam (2003). 14,014 non-mechanized and 3,317 mechanized boats although gears are not specified.

[j] Data taken from SFA (2012)

[k] Data taken from Needham *et al.* (2013).

[l] Data taken from SEAFDEC (2012).

[m] Data taken from www.fao.org Country profiles. Data include vessels in the Red Sea and the Mediterranean Sea. Only motorised vessels.

[n] Data from 2010.

Line: handline, troll, and other hook and line including sport fisheries.

NA: Not applicable. Iraq has a fishing fleet but there is no record that it catches species of interest to the IOTC.

N/A: Not available.

Other: lift nets, beach seines, traps, and others.

Purse seine: includes ring nets as well as artisanal purse seines.

Numbers in red indicate boats that may or may not fish for tuna and tuna-like species. This number is given when there is no gear/species breakdown and it usually includes the whole artisanal fleet for that country.

Mozambique reported its number of vessels and gears separately. Numbers of vessels per gear were calculated according to the percentage of each gear over the total number of gears and these percentages were applied to the total number of vessels reported. Obviously these estimates need verification.

Appendix 3: Tuna fishing fleets in the Indian Ocean - Industrial

Quality of data reported by flag in the industrial fleet in 2011/2012. Quality of statistical data was determined for 2011 as there may be delays on data submission by countries for 2012. Countries organised in descending order of importance in terms of catches per year.

Flag	(2011) Scientifically Estimated Catches	Vessel Data (2012)			Statistical Data (2011)				
		Vessel Details	Gear Details	Target Species	Quality of Estimated Catches	Effort	Discards	Length Frequencies	Area of Operation
EU	180,878						Not available for all fleets	Not available for all species and fleets	
Sri Lanka	103,441				Combines gears & vessels in the EEZ and high seas	Combines gears & vessels in the EEZ & high seas	Reported zero discards	Less than 1 fish per MT and not by area	
Seychelles	70,376								
Maldives	65,299		Gears not reported		Combined catches for artisanal and industrial fleets	Not by IOTC grid		Less than 1 fish per MT and not by area	Not by IOTC grid
Pakistan	58,060	Authorised vessels only			Combines vessels in the EEZ and high seas			Less than 1 fish per MT and not by area	
China	2,088							2011 no data 2012 reported FTLL less than 1 fish per MT	
Taiwan,China	53,801	Missing GT							
Indonesia	36,404	Missing GT		Aggregated target	No monitoring of DWF				
Iran, Islamic Republic	28,034				Combines vessels in the EEZ and high seas	Effort not by IOTC standards	Partial discard reported at WPEB08	Less than 1 fish per MT and not by area	CE not available
France Territories	26,610			Aggregated target					
Japan	16,678							Less than 1 per MT and not by area	
Oman	9,401			Aggregated target	Catch estimated				
India	7,155	Missing GT			Catch reports not validated	Incomplete catch and effort (only 3 months)			Incomplete catch and effort
Korea, Republic of	1,532							Data available 2010 & 2012	
Tanzania	1,267				Catch estimated				
South Africa	875						Reported in National report SC15		
Thailand	368			Aggregated target			Research vessels only at SC-15		
Vanuatu*	331			Aggregated target					
Mozambique	298	Missing GT		Aggregated target	Catch estimated				
Madagascar	291					Not by IOTC grid			Not by IOTC grid
Australia	260	Missing GT						Less than 1 fish per MT	
Philippines	210					Effort not by IOTC standards		Data not by IOTC standard	
Belize	200		Most vessels no gear details	Aggregated target			Reported zero discards	Highly aggregated size categories	
Mauritius	117							Less than 1 fish per MT and not by area	
Malaysia	113	Missing GT			No monitoring of DWF	Not by IOTC grid		Not to IOTC standards	Not by IOTC grid

Scoring: 0-41% red
41-81% yellow
81-100% green

Scoring was taken from the Summary report on the level of compliance IOTC-2013-CoC10-03 and from the IOTC database

Vessel details: IMO, Vessel type, LOA, GRT, GT

Gear details: description of gear *e. g.* length and mesh size of gillnet (green), general description *e. g.* gillnet (yellow), no description (red)

Target species: Tropical tunas, swordfish/albacore, southern bluefin tuna (green), aggregated (target not specified, yellow), unknown (red)

Estimated catches: estimated by the IOTC Secretariat. As per IOTC requirements (green), partial (yellow), no catches (red)

Effort: as per IOTC requirements (green), other type of effort (yellow), no effort (red). This information will include FADs and supply vessels for the purse seine fleet

Discards: by species and quantities

Length frequencies: as per IOTC requirements (green), partial (yellow), no length frequencies (red).

Area of operation: as per IOTC requirements (green), partial (yellow), no area specifications (red)

***** Vanuatu had no vessels on 2011 thus data for 2012 are presented

DWF: Distant water fleet

EEZ: Exclusive economic zone

FTLL: Fresh-tuna longline

HS: High seas

The following CPCs did not have an industrial fleet operating in the Indian Ocean in 2011: Comoros, Eritrea, Guinea, Kenya, Senegal, Sierra Leone, UK Territories, and Yemen. There was no information for Sudan.

Appendix 4: Tuna fishing fleets in the Indian Ocean – Semi-industrial

Quality of data reported by flag in the semi-industrial fleet fishing for tuna and tuna-like species the Indian Ocean in 2011. Please note that CPCs and NCPCs are NOT required to report data for semi-industrial fleets in the detail here presented unless they fish outside their EEZs.

Flag	Fishing craft	Size Categories	Gear Details	Reported Catches	Effort	Discards	Length Frequencies	Area of Operation	Response Capacity Circular
Australia									
Eritrea	Published information data aggregated	Published information data aggregated							
India	Published information data aggregated	Not as per capacity circular		Published information data aggregated					
Indonesia	Published information data aggregated	Not as per capacity circular	Published information data aggregated	Published information data aggregated					Data sent not as requested
Iran, Islamic Republic		Not as per capacity circular		Published information data aggregated	Published information data aggregated		Less than 1 fish per MT and not by area		
Madagascar				Published information data aggregated	Not to IOTC standards			Not to IOTC standards	
Malaysia				Published information data aggregated				Not to IOTC standards	
Maldives			Published information data aggregated	Published information data aggregated	Published information data aggregated		Less than 1 fish per MT and not by area		
Mozambique				Partial reporting in 2011					
Oman	Published information data aggregated			Published information data aggregated	Not to IOTC standards				
Pakistan	Published information data aggregated	Published information data aggregated		Published information data aggregated			Less than 1 fish per MT and not by area		
Seychelles		Published information data aggregated					Less than 1 fish per MT		
Sri Lanka	Published information data aggregated	Not as per capacity circular	Published information data aggregated	Published information data aggregated			Less than 1 fish per MT and not by area		
Thailand				Published information data aggregated					

Scoring: 0-40% red
41-80% yellow
81-100% green

Scoring was taken from the Summary report on the level of compliance IOTC-2013-CoC10-03 and from the IOTC database

Vessel details: IMO, Vessel type, LOA, GT

Gear details: description of gear *e. g.* length and mesh size of gillnet (green), general description *e. g.* gillnet (yellow), no description (red)

Target species: Tropical tunas, swordfish/albacore, southern bluefin tuna (green), aggregated (target not specified, yellow), unknown (red)

Reported catches: as per IOTC requirements (green), partial (yellow), no catches (red)

Effort: as per IOTC requirements (green), other type of effort (yellow), no effort (red).

Discards: by species and quantities

Length frequencies: as per IOTC requirements (green), partial (yellow), no length frequencies (red).

Area of operation: as per IOTC requirements (green), partial (yellow), no area specifications (red).

Published information refers to data found from other than official sources (theses, etc.). Flag countries should provide this information as per IOTC requirements.

The following CPCs did not have a semi-industrial fleet operating in the Indian Ocean in 2011: Comoros, France OT, Kenya, Mauritius, South Africa, Tanzania, UK Territories, and Yemen. There was no information for Sudan.

Appendix 5: Tuna fishing fleets in the Indian Ocean - Artisanal

Quality of data reported by flag in the artisanal fleet fishing for tuna and tuna-like species in the Indian Ocean in 2011. Please note that CPCs and NCPCs are NOT required to report data for artisanal fleets in the detail here presented.

Flag	Number of Boats	Vessel Details	Gear Details	Reported Catches	Effort	Length Frequencies	Response Capacity Circular
Comoros							
Eritrea	Published information data aggregated	Published information data aggregated	Published information data aggregated				
France Territories							
India	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated			
Indonesia	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated			Data sent not as requested
Iran, Islamic Republic				Published information data aggregated			
Kenya				Reported for 2011 only	Reported for 2011 only		
Madagascar							
Malaysia				Published information data aggregated			
Maldives	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated	
Mauritius							
Mozambique				Partial reporting in 2011			
Oman	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated		
Pakistan	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated		Less than 1 fish per MT and not by area	
Seychelles	Published information data aggregated	Published information data aggregated	Published information data aggregated				
South Africa							
Sri Lanka	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated		Less than 1 fish per MT and not by area	
Sudan							
Tanzania				Estimated by IOTC			
Thailand	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated	Published information data aggregated		
UK Territories							

Scoring: 0-40% orange
41-80% yellow
81-100% green

Vessel details: Vessel type, LOA, GT.

Gear details: description of gear *e. g.* length and mesh size of gillnet (green), general description *e. g.* gillnet (yellow), no description (red).

Reported catches: as per IOTC requirements (green), partial (yellow), no catches (red).

Effort: as per IOTC requirements (green), other type of effort (yellow), no effort (red).

Length frequencies: as per IOTC requirements (green), other (yellow), no length frequencies (red).

Response capacity circular: details as requested (green), partial details (yellow), no response or no information (red).

Fleet assumed to be opportunistic thus not targeting species.

Discards are assumed to be non-important for the artisanal fleet.