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Commission des Thons de l'Océan Indien

# ESTIMATING THE FISHING CAPACITY OF THE TUNA FLEETS IN THE INDIAN OCEAN

Robert Gillett and Miguel Herrera

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# EXECUTIVE SUMMARY

This document gives the results of a study of the capacity of vessels fishing for tuna in the Indian Ocean. This study was requested by the Commission in 2003 and has been possible thanks to extra-budgetary funds from the Government of Australia. The study uses a relatively simple input measure of capacity: the number of vessels fishing for tropical tunas, albacore or swordfish in the important fleets, by year, for 2006-08. The main output of this study is an inventory of tuna fishing vessels in the Indian Ocean, grouped by fleet and vessel length class, and associated with annual catches. The annual catches, although obviously not necessary for making an estimate of the number of vessels, are included as they are important to quantify the relative importance of this component as compared with the catches of other fleets not accounted for in the capacity study.

This study uses various sources of information. The fishing vessel statistics come mainly from: (a) reports from countries on numbers of active vessels and on vessel details in response to IOTC resolutions, (b) information from IOTC-OFCF Project field programmes, and (c) media reports and personal communications.

The number of Indian Ocean tuna vessels is estimated in the following categories: (a) vessels under 24 metres that sometimes fish outside the EEZ of their flag state, (b) vessels 24 metres or greater, (c) vessels from important fleets for which length cannot be determined.

Because of data difficulties, the estimates of fleet sizes, - initially estimated at around 4,000 vessels by year, all fleets combined, - should be considered as preliminary attempts to determine input-type fishing capacity in the various tuna fleets of the Indian Ocean. Much scrutiny and adjustment of vessel numbers on the tables is required to arrive at the point of considering the fleet sizes to be reasonably accurate. The smaller the vessel size, the more inaccurate the data used in this study. Keeping track of the numbers of such vessels is fraught with difficulties for national authorities, plus there is the added problem of determining which of those vessels sometimes fish outside the EEZ of their flag state. This is especially the case with the gillnet fisheries of Pakistan and Sri Lanka and the pole-and-line fishery of Maldives. On the other hand, information on the numbers of the large purse seine vessels is likely to be the most accurate.

The study also attempts to estimate the tuna catches for the fleets for which input capacity was estimated. The annual catches of the concerned vessels represented 68% of the total catches of tropical tunas, albacore and swordfish during 2006-08. Therefore the catches of fleets not included in the capacity study, mostly artisanal fleets from developing states in the IOTC Region, represent a significant proportion of the total catches of these species, and this cannot be ignored.

The data for some fleets need to be considerable improved to be able to determine numbers of vessels and associated catches. The priorities for obtaining better data are those Indian Ocean tuna fleets that have poor data (with respect to number of vessels or catches) and that are (a) made up of a large number of vessels, and (b) make large catches. The following fleets are in this category: Sri Lanka gillnet and longline combination, Pakistan gillnet, Iran gillnet, Maldives pole-and-line, and Indonesia and India longline.

Finally, the study reviews additional issues that may potentially affect estimates of fishing capacity, including the effect of changes in targeting practices and the effect of increases in fishing efficiency of individual vessels. The usefulness of output-based measures of capacity in the context of tuna fisheries is also assessed. More information will need to be collected concerning the above issues, in order to be able to assess the potential effects that they may have on estimates of optimum fishing capacity.

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## ABBREVIATIONS

**Species codes**

| | |
|---|---|
| ALB | Albacore (*Thunnus alalunga*) |
| BET | Bigeye tuna (*Thunnus obesus*) |
| SBT | Southern bluefin tuna (*Thunnus maccoyii*) |
| SKJ | Skipjack tuna (*Katsuwonus pelamis*) |
| SWO | Swordfish (*Xiphias gladius*) |
| YFT | Yellowfin tuna (*Thunnus albacares*) |

**Other**

| | |
|---|---|
| CPUE | Catch per unit of effort |
| DEA | Data envelopment analysis |
| DWFN | Distant-water fishing nation |
| EC | European Community |
| EEZ | Exclusive economic zone |
| FAO | Food and Agriculture Organization of the United Nations |
| GRT | Gross registered tonnage (as per the International Tonnage Convention, Oslo) |
| GT | Gross tonnage (as per the International Tonnage Convention, London) |
| IOTC | Indian Ocean Tuna Commission |
| IOTC CPCs | IOTC Contracting Parties and Cooperating Non-Contracting Parties |
| LOA | Length overall |
| LSTLV | Large-scale tuna longline fishing vessel |
| NA | Not available |
| NEI | Not elsewhere included |

# 1. BACKGROUND

In the management of the world's tuna fisheries the subjects of fishing capacity, over-capacity, and the limitation of capacity is receiving an increasing amount of attention. In most oceans of the world, tuna fleets are larger than needed to take the available harvest. In many areas where tuna stocks are fully exploited, the same amount of fish could be harvested with smaller fleets, resulting in lower costs of production, greater economic returns, and on occasion, lower prices for the consumer. There is almost universal agreement among governments, regional tuna bodies and industry that there is more than enough fishing capacity to harvest the available supplies of tuna, and that limits should be placed on the numbers of vessels allowed to fish (Joseph 2003, 2009).

Partly due to a concern over excess capacity in the world's tuna fisheries, in the mid-2000s the FAO project "Management of tuna fishing capacity" focused significant attention on conceptual issues, methodology, and the measurement of fishing capacity in various tuna fisheries. For the Indian Ocean, during the past ten years there have been five IOTC resolutions dealing with the management of tuna fishing capacity.

A fundamental requirement for the management of fishing capacity is an estimation of current capacity. The difficulties of what may appear a simple task of measuring fishing capacity should not be under-estimated. In a review of global longline fishing capacity, Miyake (2004) states that tuna fishing capacity "very hard to define and furthermore, almost impossible to quantify at present".

In 2003, the Commission requested information concerning the optimum levels of fishing capacity for the fleets fishing for IOTC species within the IOTC Area, requesting the IOTC Scientific Committee to look into this matter and provide results at the next meeting of the Commission, in 2004. In 2004 the Scientific Committee informed the Commission that the estimation of optimum fishing capacity had not been possible to achieve due to the limited time available, noting that additional time and resources would be necessary for such a study to be possible. Following this recommendation, in 2006 the Government of Australia allocated additional extra-budgetary funds for a capacity study to be carried out in the Indian Ocean. Australia, in cooperation with the IOTC Secretariat, prepared the Terms of Reference for the Capacity study (Appendix I), whose results are presented in this report.

The present study is a simple preliminary attempt to estimate tuna fishing capacity in the Indian Ocean. It is intended to assist the Commission in progressing its work on fishing capacity.

# 2. FISHING CAPACITY

## 2.1 Defining Fishing Capacity

The phrase "fishing capacity" is often used rather loosely. The lack of a common understanding of the term is responsible for at least some degree of confusion among the various groups of fishery stakeholders. A publication of a project focussing on tuna fishing capacity states that "the notion of fishing capacity continues to generate substantial differences in opinion regarding its definition and, more generally, its conceptual meaning "(Squires et al. 2007). FAO (2004) helps clarify the situation:

**Defining 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.***

### 2.2 Fishing Capacity as Used in this Study

For the purpose of this study the following definitions of fishing capacity apply:

- 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

Ideally, a survey of fishing capacity in the Indian Ocean tuna fisheries would determine the quantities of fish the existing fleets are capable of capturing. However, it should be realized that the present study is an initial attempt to achieve an ambitious goal: quantifying capacity in the region's tuna fisheries. Consequently, a relatively simple input measure of capacity is used: the number of active vessels in the important fleets.

There is additional justification for using a relatively simple input measure of capacity in this study:

- The wording of IOTC Resolutions dealing with capacity equates capacity to the total tonnage associated with a number of vessels. For example, this is the case of IOTC Resolution 09/02 "On the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating non-Contracting Parties" which calls for IOTC CPC's not to increase their fleet numbers if such increase results in levels of fishing effort which are over those considered acceptable for the stocks under the responsibility of the IOTC.
- A knowledge of numbers of vessels, and their characteristics, and catch information is an important prerequisite for the more complex process of determining how the results of an assessment can be translated into estimates of optimum fishing capacity.

## 3. THE STUDY

The main output of this study is an inventory of tuna fishing vessels in the Indian Ocean, grouped by fleet, and associated with annual catches. The annual catches, although obviously not necessary for making an estimate of the number of vessels, are included as they are important to quantify the relative importance of this component as compared with the catches of other fleets not accounted for in the capacity study. .

### 3.1 Scope of the study

The study's scope is as follows:

- The **vessels** included are those that participate in catching tuna and swordfish and that are either (a) have an LOA of 24 m or greater, or (b) have an LOA less than 24 m that operate beyond the EEZ of its country of registration. This is because IOTC management measures, including capacity limits, apply to these two categories of vessels.. The fleets in these two categories are industrial purse seiners, large and small-scale longliners, pole-and-line vessels, and oceanic

gillnetters. The various types of artisanal vessels that catch tuna are not included because it is unlikely that they fish outside their EEZ. "Participation" by vessels is defined as engaged in fishing for the included species at least one day in an included year.

- The **years** included are 2006, 2007, and 2008 (calendar years). This is because capacity limitations adopted by the IOTC establish baselines at 2006 (vessels targeting tropical tunas) and 2007 (vessels targeting swordfish or albacore).
- The **area** included is the area of the Indian Ocean Tuna Commission (Figure 1).
- The **species** included are (1) tropical tunas (YFT, BET, SKJ), (2) temperate tunas (ALB, SBF), and (3) swordfish (SWO). This is because the IOTC's Resolution 09/02 apply to tropical tunas, albacore and swordfish. SBF is included because vessels catching this species usually catch other tunas or billfish species, including those indicated above.

### 3.2 Data sources

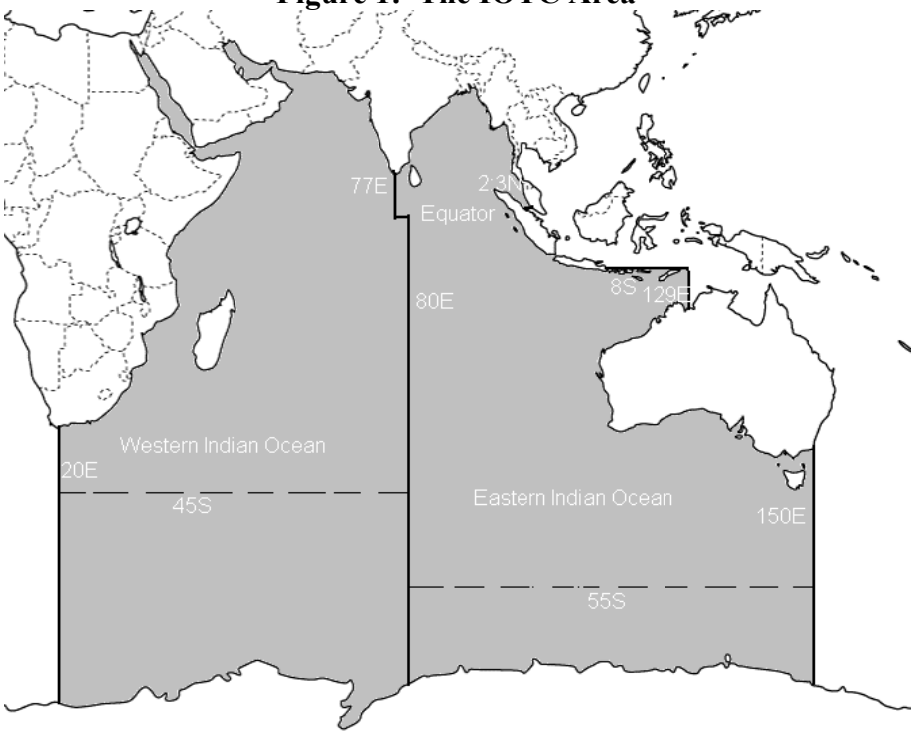
This study uses various sources of information. The fishing vessel statistics come mainly from:

- Reports from countries on numbers of active vessels and on vessel details in response to IOTC resolutions
- Vessel lists publicly available but not submitted to the Secretariat
- Information from IOTC-OFCF Project field programmes

Other less reliable sources for vessel activity used in the study include lists of foreign vessels licensed to operate within the EEZs (from IOTC Resolution 07/04), lists of foreign vessels unloading catches in ports (from IOTC Resolution 05/03), and the IOTC IUU List.

Catch data comes from reports from IOTC CPC's**.** If these data are not reported, the Secretariat estimates a total catch from a range of sources, including: partial catch and effort data; data in the FAO FishStat database; catches estimated from data collected through port sampling; data reports publicly available but not submitted to the Secretariat; and data reported by third parties on the activity of vessels (IOTC Resolution 07/04; IOTC Resolution 05/03) or on imports of bigeye tuna as reported through the Bigeye Statistical Document Programme.

**Figure 1: The IOTC Area**



# 4. BRIEF OVERVIEW OF THE TUNA FLEETS AND CATCHES IN THE INDIAN OCEAN

The combined catches of tropical tunas, albacore and swordfish in the Indian Ocean increased gradually from around 15 thousand t in 1950 to around 200 thousand t in the early 1980s. The catches increased sharply thereafter, with maximum catches recorded in 2005 and 2006, at around 1.2 million t. In recent years the catches have decreased markedly, to values around the 950 thousand t in 2007 and 900 thousand t in 2008.

The purse-seine fishery expanded rapidly between the early 1980s and the mid-1990s and has been relatively stable since. Between 75 and 80 large-scale industrial purse seiners (i.e. having length overall of 24 metres or greater) have been fishing for tropical tunas in the Indian Ocean in recent years. The majority of the purse seiners are registered in countries of the EC (Spain, France, and Italy) and, to a lesser extent, Seychelles, Iran and other countries of the Indian Ocean region. Industrial purse seiners target yellowfin tuna and skipjack tuna. In recent years the catches of industrial purse seiners have accounted for as much as 40% of the total catches of tropical tunas, albacore and swordfish in the Indian Ocean. The majority of this catches have come traditionally from the western Indian Ocean region. Over the last decade, total annual purse seine catches have averaged around 375,000 t. Purse seine catches were considerably higher between 2002 and 2006, the highest catches for this fishery being about 450,000 t in 2003. Purse seine catches dropped markedly in 2007 and 2008, amounting to about 260,000 t and 290,000 t, respectively.

Industrial longline vessels have been operating in the Indian Ocean since 1952. The number of large scale industrial longliners in the Indian Ocean has ranged between 1200 and 1400 in recent years, while the number of small scale longliners (having length overall smaller than 24m) have been around 1200 vessels. At present, longliners from Taiwan,China, Indonesia and Japan account for more than 80% of the total number of longline vessels in the Indian Ocean. India, China, Malaysia and the EC also have important longline fleets in the IOTC Area. Industrial longliners operate over the entire IOTC Area, targeting yellowfin tuna, bigeye tuna, albacore, swordfish or other species, depending on the fishing grounds and gear configurations. In recent years the catches of industrial longliners have accounted for around 25% of the total catches of tropical tunas, albacore and swordfish in the Indian Ocean. Longline catches averaged around 260,000 t per year over the last decade. The highest ever longline catches were recorded in 1993 (329,000 t). Over the last decade longline catches have ranged between the 200,000 t recorded in 2008 and the 300,000 t recorded in 2005. Longline catches have dropped markedly since 2005.

Significant numbers of other types of tuna vessels operate in the Indian Ocean outside the zones of their country of registration. These include pole-and-line vessels from Maldives and Indonesia, gillnet vessels from Iran and Pakistan and vessels from Sri Lanka, that use a combination of gillnets and longlines. At present some of the IOTC CPCs have not supplied complete information about vessel sizes and operating areas, making it difficult to derive the actual numbers of vessels from these countries that are active in the IOTC area. In recent years as many as 9,000 gillnet vessels, 2,800 gillnet/longline vessels and 900 pole-and-line vessels have been operating in the Indian Ocean[1]. Pole-and-line vessels and gillnetters target yellowfin tuna and skipjack tuna, while gillnet/longline vessels target yellowfin tuna, skipjack tuna and swordfish. In recent years the combined catches for these fleets have accounted for as much as 25% of the total catches of tropical tunas, albacore and swordfish in the Indian Ocean. Over the last decade, total annual catches have averaged around 260,000 t per year. Pole-and-line and gillnet catches have dropped markedly since 2005.

[1] Note that the number of gillnet, gillnet/longline and baitboat vessels (and associated catch) refer to the total numbers of vessels operating, including those which operated exclusively within the territory of their flag countries. The Secretariat used these numbers to estimate the number of vessels to be included in the capacity study and their catches (Table 1, page 11).

# 5. RESULTS

## 5.1 Numbers of vessel in the various fleets

Using the various data sources cited in Section 3.2 above, an attempt is made to estimate the numbers of vessels by nationality, size (under/over 24 metres), gear, and year.

5.1.1 Total number of vessels and catches estimated by gear type, vessel length category, and year

The total number of vessels estimated by gear type and year is presented in Table 1. Table 1 also includes the number of vessels estimated by length category and the total catch in 2008, and the average catch by vessel by year for the period of study (2006-08), by fishery.

**Table 1: Estimates of Numbers of vessels and catches, by gear, length category and year**

| Gear | Total no. Vessels | | | By length (2008) | | | Catch (t) in 2008 | Av.catch (t) / vessel / year (2006-08) |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2007 | 2006 | ≥24m | <24m | Unk | | |
| Purse seine | 85 | 92 | 90 | 83 | 2 | | 299,382 | 3,790 |
| Longline | 2,414 | 2,328 | 2,593 | 1,215 | 683 | 516 | 191,529 | 97 |
| Pole-and-line | 87 | 89 | 93 | 87 | | | 25,745 | 341 |
| Oceanic gillnet | 1,029 | 1,029 | 1,027 | 285 | 467 | 277 | 19,776 | 27 |
| Gillnet/Longline | 421 | 369 | 359 | | 421 | | 14,934 | 34 |
| **Total** | **4,036** | **3,907** | **4,162** | **1,670** | **1,573** | **793** | **551,366** | **160** |

The total number of vessels and catch presented in Table 1 is thought to be accurate for purse seine and, to a lesser extent, for longline fisheries. For other fleets, the figures presented are only rough estimates of vessel numbers and catch, conducted at the time of the study, the main reason being the insufficient information available (e.g. lists of vessels and catches by type of vessel and area operated not available).

The purse seine fleet is the only fleet for which complete reports of vessels by length class exist. For longline fleets, vessel length information is not available for as much as 20% of the vessels, the majority under the flag of Indonesia. For other fleets, apart from the oceanic gillnet fishery of Iran, the number of vessels by length category and type of area operated are not available and nor are the catches for those vessels. To estimate this component, which is included in the capacity limits, assumptions were made about the percentage of total vessels by length category (≥24m and <24m) in each fleet and, subsequently, the percentage of vessels <24m possibly fishing on the high-seas (see Appendix II).

For vessels under 24 metres, information reported to IOTC often does not identify the number of vessels that operated on the high-seas, rather including all vessels, regardless of the area operated. This is especially the case with fisheries using oceanic gillnet or a combination of gillnets and longlines. To estimate this component, which is included in the capacity limits, assumptions were made about the percentage of total vessels in each fleet that are possibly fishing on the high-seas (see Appendix II).

In addition, the catches of the pole-and-line, oceanic gillnet and gillnet/longline vessels in Table 1 were estimated using the total catches available for each fleet and the proportion that the number of vessels estimated for the capacity study made out of the total number of vessels recorded under each fleet, and assuming different catch rates for both components, depending on the fishery (see Appendix II).

5.1.2 Number of vessels and associated catches by fleet, gear type, vessel length category, and year

Tables 2 to 4 show total number of vessels and catch and number of vessels by length category by flag, by fishery and year. The sources that were used for vessel numbers and catches are also provided for each fleet:

- Number of vessels:
  - Active vessel list (Active): Number of fishing vessels active as reported by the flag state (IOTC Resolution 07/04); the number of vessels are thought accurate.
  - Internet (Internet): Number of fishing vessels active available in a web page; the number of vessels with length overall 24 m or greater are thought accurate; the number of vessels under 24m length overall are thought less accurate.
  - National report (Nat.Report): Number of fishing vessels active as reported in the National Report presented to the IOTC Scientific Committee. The numbers may not include vessels that operated in the South of the Indian Ocean, between 140°-150° longitude East (area overlapping the WCPFC Area).
  - Record of authorized vessels (Authorized): Number of vessels active not available; the number of vessels in the IOTC Record of Authorized Vessels was used as a proxy for activity, on the assumption that all the vessels authorized were active for the fleet and year concerned. The number of vessels is thought less accurate for this reason.
  - Third Party report (3rdParty): Number of vessels active reported by Third Parties (IOTC Resolutions 07/04 and 05/03); the number of vessels are thought less accurate.
- Catch:
  - Official report: Catches reported by the flag state; catches are thought to be accurate in most cases. The catches of fleets made up of large (≥24m) and small (<24m) vessels are usually combined, making it difficult to assess the catches that fall under each component.
  - Internet: Catches available in a web page; the catches of vessels with length overall 24 m or greater are thought accurate; the catches of vessels under 24m length overall are thought less accurate.
  - Estimated: Catches estimated for the capacity study, due to one of the following reasons:
    - Catches not available at all: No catches were reported for this component; the catches were estimated by using the number of vessels and average catches by vessel from a proxy fleet.
    - Catches aggregated: The catches reported refer to both vessels accounted for in the capacity study and other vessels not accounted for but that operate the same gear. The catches were estimated using the number of vessels available and average catches by vessel for each fleet component, assuming that the vessels accounted for in the capacity study have catch rates that are higher than those from other vessels (ranging from 1.5-3 times higher, depending on the fleet).

The relative sizes of the major fleets are shown in Figure 2.

**Table 2: Estimates of Numbers of Purse seine vessels and associated catches, by year**

**i. Year 2008**

| Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|
| | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Australia | 10 | 10 | | | Nat.Report | 5,323 | Official report |
| EC | 35 | 35 | | | Active | 206,177 | Official report |
| France (OT) | 2 | 2 | | | Authorized | 10,117 | Official report |
| India | 5 | 3 | 2 | | Authorized | 295 | Estimated |
| Indonesia | 3 | 3 | | | Authorized | 3,221 | Estimated |
| Iran | 8 | 8 | | | Authorized | 2,164 | Official report |
| Japan | 5 | 5 | | | Active | 5,368 | Official report |
| Malaysia | 1 | 1 | | | Active | 1,074 | Official report |
| Seychelles | 12 | 12 | | | Active | 56,214 | Official report |
| Thailand | 4 | 4 | | | Active | 9,429 | Official report |
| Total | 85 | 83 | 2 | | | 299,382 | |

**ii. Year 2007**

| Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|
| | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Australia | 11 | 11 | | | Nat.Report | 4,912 | Official report |
| EC | 41 | 41 | | | Active | 187,412 | Official report |
| France (OT) | 2 | 2 | | | Authorized | 9,101 | Official report |
| India | 5 | 3 | 2 | | Authorized | 295 | Estimated |
| Indonesia | 3 | 3 | | | Authorized | 3,787 | Estimated |
| Iran | 9 | 9 | | | Authorized | 2,835 | Official report |
| Japan | 5 | 5 | | | Active | 6,312 | Official report |
| Seychelles | 10 | 10 | | | Active | 49,805 | Official report |
| Thailand | 6 | 6 | | | Active | 11,402 | Official report |
| Total | 92 | 90 | 2 | | | 275,861 | |

**iii. Year 2006**

| Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|
| | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Australia | 14 | 14 | | | Nat.Report | 8,194 | Official report |
| EC | 40 | 40 | | | Active | 307,548 | Official report |
| France (OT) | 2 | 2 | | | Active | 2,962 | Official report |
| India | 5 | 3 | 2 | | Authorized | 295 | Estimated |
| Iran | 9 | 9 | | | Authorized | 12,263 | Official report |
| Japan | 2 | 2 | | | Active | 2,835 | Official report |
| Seychelles | 12 | 12 | | | Active | 79,111 | Official report |
| Thailand | 6 | 6 | | | Active | 23,434 | Official report |
| Total | 90 | 88 | 2 | | | 436,642 | |

**Table 3: Estimates of Numbers of Longline vessels and associated catches, by year**

**i. Year 2008**

| Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|
| | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Australia | 5 | 5 | | | Nat.Report | 180 | Official report |
| Belize | 9 | 9 | | | Active | 582 | Official report |
| China | 69 | 69 | | | Authorized | 6,437 | Official report |
| Taiwan,China | 783 | 344 | 439 | | Internet | 61,011 | Internet |
| EC | 58 | 40 | 18 | | Active | 9,015 | Official report |
| Guinea | 3 | 3 | | | Authorized | 608 | Estimated |
| India | 133 | 76 | 44 | 13 | Authorized | 11,731 | Estimated |
| Indonesia | 907 | 284 | 120 | 503 | Authorized | 39,729 | Official report |
| Japan | 207 | 207 | | | Active | 34,126 | Official report |
| Kenya | 2 | 2 | | | Active | 239 | Estimated |
| Korea Rep. | 24 | 24 | | | Active | 2,317 | Official report |
| Madagascar | 2 | 2 | | | Active | 172 | Estimated |
| Malaysia | 69 | 42 | 27 | | Active | 6,144 | Official report |
| Mauritius | 8 | 2 | 6 | | Active | 525 | Official report |
| Oman | 36 | 24 | 12 | | Authorized | 4,456 | Estimated |
| Philippines | 17 | 17 | | | Active | 3,158 | Official report |
| Senegal | 3 | 3 | | | Authorized | 88 | Estimated |
| Seychelles | 34 | 27 | 7 | | Active | 6,553 | Official report |
| South Africa | 20 | 10 | 10 | | Active | 565 | Official report |
| Sri Lanka | 2 | 2 | | | Pers.Com. | 149 | Estimated |
| Tanzania | 3 | 3 | | | Authorized | 532 | Estimated |
| Thailand | 6 | 6 | | | Active | 269 | Official report |
| NEI | 14 | 14 | | | 3rdParty | 17,334 | Estimated |
| Total | 2,414 | 1,215 | 683 | 516 | | 191,529 | |

**ii. Year 2007**

| Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|
| | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Australia | 3 | 3 | | | Nat.Report | 392 | Official report |
| Belize | 10 | 10 | | | Active | 1,216 | Official report |
| China | 67 | 67 | | | Active | 10,559 | Official report |
| Taiwan,China | 782 | 376 | 406 | | Internet | 85,581 | Internet |
| EC | 66 | 48 | 18 | | Active | 11,678 | Official report |
| Guinea | 3 | 3 | | | Authorized | 823 | Estimated |
| India | 116 | 75 | 38 | 3 | Authorized | 15,219 | Estimated |
| Indonesia | 779 | 238 | 28 | 513 | Authorized | 39,582 | Official report |
| Japan | 245 | 245 | | | Active | 46,985 | Official report |
| Kenya | 2 | 2 | | | Authorized | 239 | Official report |
| Korea Rep. | 31 | 31 | | | Active | 5,555 | Official report |
| Madagascar | 2 | 2 | | | Active | 69 | Estimated |
| Malaysia | 62 | 39 | 23 | | Active | 5,736 | Official report |
| Mauritius | 10 | 4 | 6 | | Active | 352 | Official report |
| Oman | 30 | 18 | 11 | 1 | Active | 4,012 | Official report |
| Philippines | 17 | 17 | | | Active | 3,617 | Official report |
| Senegal | 3 | 3 | | | Authorized | 88 | Estimated |
| Seychelles | 34 | 27 | 7 | | Active | 9,252 | Official report |
| South Africa | 14 | 13 | 1 | | Active | 507 | Official report |
| Sri Lanka | 2 | 2 | | | Active | 149 | Estimated |
| Tanzania | 3 | 3 | | | Active | 631 | Estimated |
| Thailand | 3 | 3 | | | Active | 373 | Official report |
| NEI | 15 | 15 | | | 3rdParty | 19,439 | Estimated |
| Total | 2,328 | 1,273 | 538 | 517 | | 262,054 | |

### iii. Year 2006

| Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|
| | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Australia | 4 | 4 | | | Nat.Report | 418 | Official report |
| Belize | 8 | 8 | | | Active | 1,256 | Official report |
| China | 67 | 67 | | | Active | 13,390 | Official report |
| Taiwan,China | 784 | 376 | 408 | | Internet | 87,942 | Internet |
| EC | 62 | 43 | 19 | | Active | 12,040 | Official report |
| Guinea | 3 | 3 | | | Active | 823 | Estimated |
| India | 85 | 59 | 23 | 3 | Authorized | 9,732 | Estimated |
| Indonesia | 1,190 | 449 | 225 | 516 | Active | 37,457 | Official report |
| Iran | 1 | 1 | | | Authorized | 173 | Estimated |
| Japan | 188 | 188 | | | Active | 48,067 | Official report |
| Kenya | 1 | 1 | | | Authorized | 316 | Official report |
| Korea Rep. | 29 | 29 | | | Active | 7,208 | Official report |
| Madagascar | 2 | 2 | | | Active | 372 | Estimated |
| Malaysia | 28 | 19 | 9 | | Authorized | 2,282 | Official report |
| Mauritius | 8 | 3 | 5 | | Active | 910 | Official report |
| Oman | 24 | 14 | 10 | | Active | 1,660 | Official report |
| Philippines | 18 | 18 | | | Active | 3,792 | Official report |
| Senegal | 3 | 3 | | | Active | 88 | Estimated |
| Seychelles | 38 | 28 | 10 | | Active | 8,094 | Official report |
| South Africa | 13 | 12 | 1 | | Active | 523 | Official report |
| Tanzania | 3 | 3 | | | Authorized | 599 | Estimated |
| Thailand | 3 | 3 | | | Active | 526 | Official report |
| Uruguay | 1 | 1 | | | Active | 142 | Official report |
| NEI | 30 | 30 | | | 3rdParty | 22,754 | Estimated |
| Total | 2,593 | 1,364 | 710 | 519 | | 260,564 | |

## Table 4: Estimates of Numbers of vessels using other Gears and associated catches, by year

### i. Year 2008

| Gear | Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|---|
| | | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Pole-and-line | Maldives | 87 | 87 | | | Estimated | 25,730 | Estimated |
| Oceanic Gillnet | Iran | 752 | 285 | 467 | | Authorized | 17,107 | Estimated |
| | Pakistan | 277 | | | 277 | Estimated | 2,669 | Estimated |
| Gillnet/Longline | Sri Lanka | 421 | | 421 | | Estimated | 14,934 | Estimated |
| | Total | 1,537 | 372 | 888 | 277 | | 60,440 | |

### ii. Year 2007

| Gear | Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|---|
| | | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Pole-and-line | Maldives | 89 | 89 | | | Estimated | 27,547 | Estimated |
| Oceanic Gillnet | Iran | 752 | 285 | 467 | | Authorized | 23,295 | Estimated |
| | Pakistan | 277 | | | 277 | Estimated | 2,669 | Estimated |
| Gillnet/Longline | Sri Lanka | 369 | | 369 | | Estimated | 14,568 | Estimated |
| | Total | 1,487 | 374 | 836 | 277 | | 68,079 | |

### iii. Year 2006

| Gear | Flag | Number of vessels by length category | | | | | Catch | |
|---|---|---|---|---|---|---|---|---|
| | | Total | ≥24m | <24m | na | Source | Catch (t) | Source |
| Pole-and-line | Maldives | 93 | 93 | | | Estimated | 38,538 | Estimated |
| Oceanic Gillnet | Iran | 752 | 285 | 467 | | Active | 36,837 | Estimated |
| | Pakistan | 275 | | | 275 | Estimated | 1,642 | Estimated |
| Gillnet/Longline | Sri Lanka | 359 | | 359 | | Estimated | 9,467 | Estimated |
| | Total | 1,479 | 378 | 826 | 275 | | 86,484 | |

The above tables show that the information available for some fleets is insufficient, in particular vessel length and area of operation. The significance of this is that for some fleets it is impossible to determine which vessels should be included in the capacity study and which excluded.

Some deficiencies in the data need to be acknowledged – most of which relate to the quality of data reported to IOTC. These shortcomings and associated mitigating action are covered in sections 6 and 7 below.

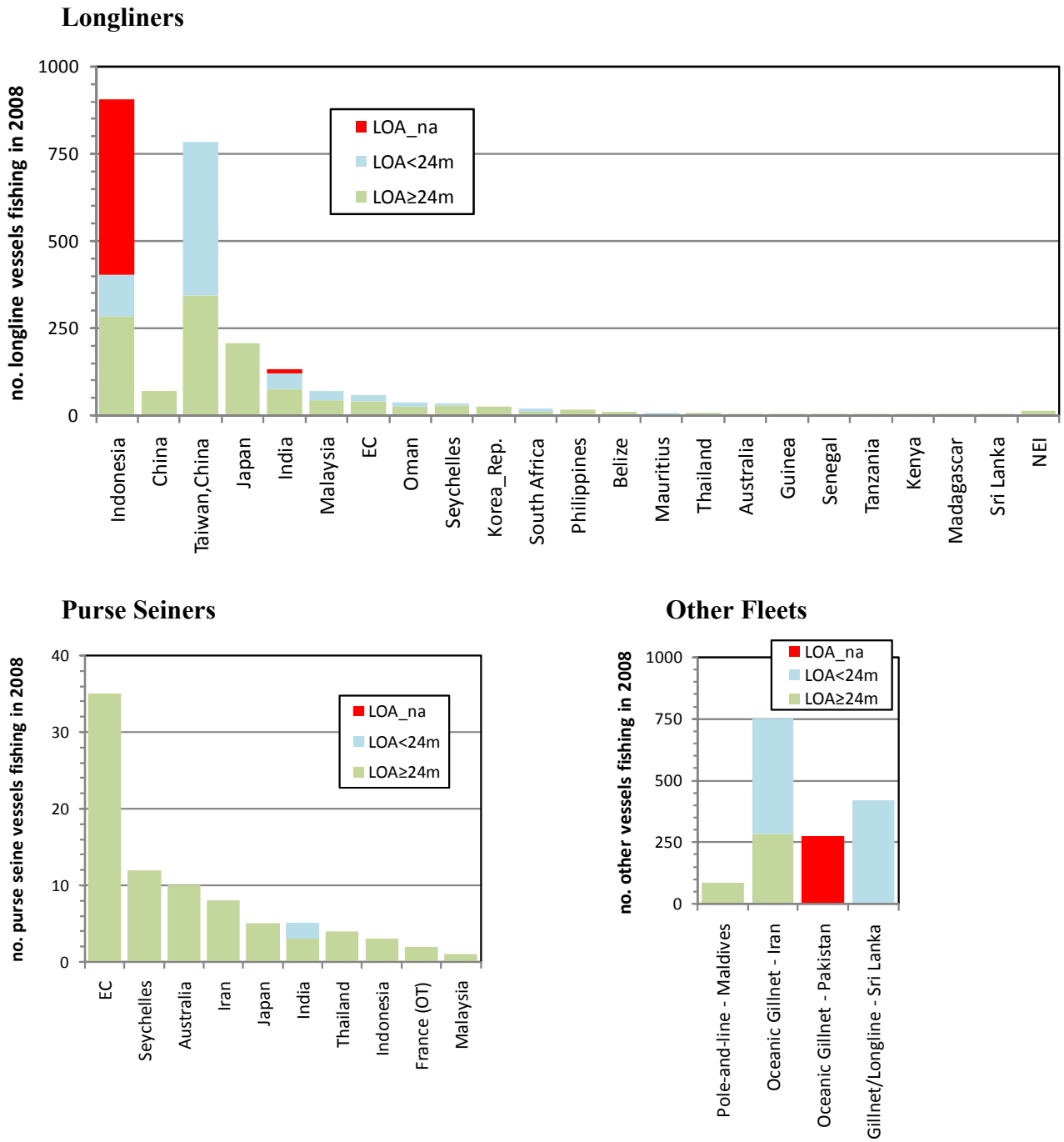
Maldives, Pakistan and Sri Lanka have not reported active vessel lists to the Secretariat. Although the number of vessels (and catch) recorded in these tables represents the best estimate of the number of ships included in the capacity limits at the time of the study, the actual numbers of vessels are unknown.

The errors in estimating vessel numbers that could be introduced by inappropriate assumptions in the Appendix II could be large. In some cases (e.g. for gillnetting) assumptions concerning area of operations could result in errors in vessel numbers which are larger than the size of some of the national fleets in the region.

Because of the above data difficulties, the estimates of fleet sizes in Tables 2 to 4 above should be considered as preliminary attempts to determine input-type fishing capacity in the various tuna fleets of the Indian Ocean. Some scrutiny and adjustment of vessel numbers on the tables is required to arrive at the point of considering the fleet sizes to be reasonably accurate.

The smaller the vessel size, the more inaccurate the data used in this study. Keeping track of the numbers of such vessels is fraught with difficulties for national authorities, plus there is the added problem of determining which of those vessels sometimes fish outside the EEZ of their flag state. This in spite of the fact that many IOTC CPCs have implemented Vessel Monitoring Systems on vessels under their flag in recent years (IOTC Resolution 06/03). On the other hand, information on the numbers of the large purse seine vessels is likely to be the most accurate. These features would have large implications if output-based measures of fishing capacity were to be used for the Indian Ocean (Section 6 below).

**Figure 2: Numbers of vessels in the major fleets in 2008**



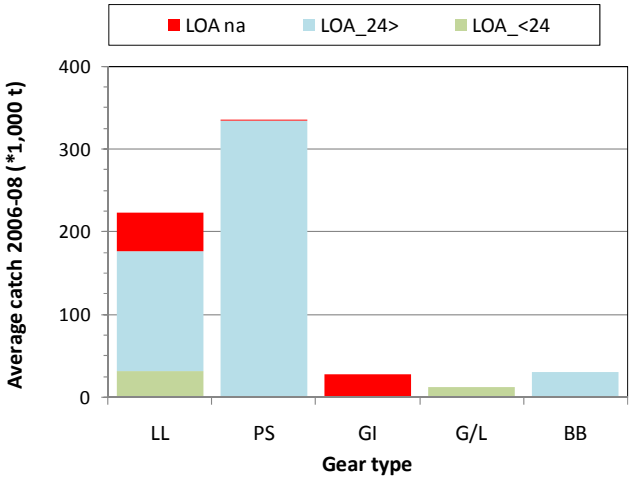

## 5.2 Catches in 2008 by the various fleets

The main outputs of this study are estimates of numbers of vessels that are covered by the IOTC fishing capacity resolutions. The annual catches of the concerned vessels are obviously not necessary for making an estimate of the number of vessels, but deserve some attention as they are important to quantify the relative importance of this component as compared with the catches of other fleets not accounted for in the capacity study.

Using the various data sources given in Section 3.2 above, together with assumptions given in Appendix II, the catches of the various fleets were estimated (Tables 1-4).

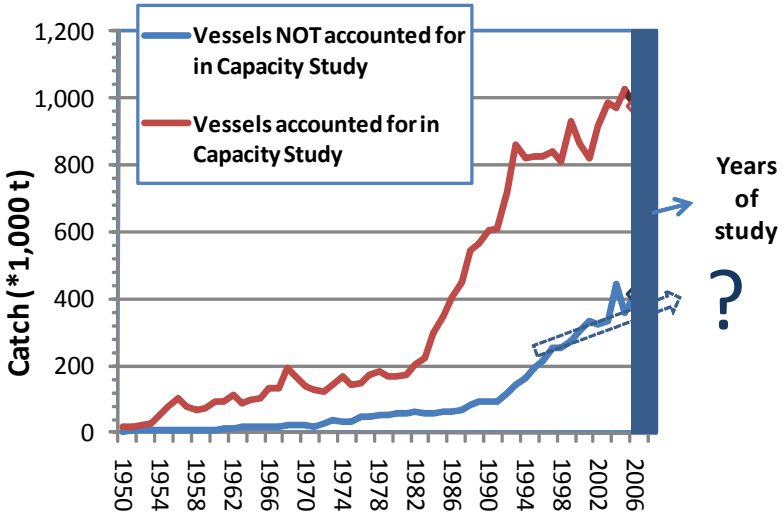
The catches (average 2006-08) estimated for the fleets included in the capacity study are presented in Figure 3, by type of fishery and type of vessel.

**Figure 3: Catches of vessels accounted for in the capacity study (Average catch 2006-08), by type of vessel and fishery**




The catches of fleets not accounted for in the Capacity study were also assessed. Figure 4 shows the catches of vessels included in the capacity study against those of vessels not included. Overall, the catches of tropical tunas, albacore and swordfish estimated for such fleets amounted to as much as **32%** of the total catches of these species in the Indian Ocean. Small and medium-scale fishing vessels using gillnets, hand lines and troll lines are responsible for the majority of these catches.

**Figure 4: Catches of vessels accounted for in the capacity study and catches of other vessels (1950-2008)**




With respect to fishing capacity, the significance of the above figures is that:

- Further work is required to improve the catch data to the point where all catches can be allocated by vessel length category, according to the categories used in the study.
- Should management of Indian Ocean tuna fishing capacity be undertaken in the future, an important issue would be those fleets comprised of small-scale vessels that are not covered by capacity measures at present, as they catch a significant proportion of the catches of tropical tunas, albacore and swordfish.

# 6. DISCUSSION

The main types of problems experienced with using the available data can be placed in several categories. The two difficulties that cause the most problems seem to be:

- In several countries estimates of total vessel numbers are available, however the fleets are composed of vessels of different sizes which operate in different areas – and the numbers of vessels that are 24 m or greater or those less than 24 m which only operate inside the EEZ of the country of registration cannot be estimated precisely. This situation occurs for several fleets, including Pakistan gill netters, Maldives baitboats, and Sri Lanka offshore gillnet/longline vessels. In a worst-case scenario this component could represent as much as 60% of the total number of active vessels estimated for the period of study.
- Some country reports of vessels numbers come from vessel registers, rather than from lists of vessels confirmed to be active in tuna fishing in the Indian Ocean. Vessels on such registers may be out of commission, converted to fish for other species, or fishing outside the region. This problem seems to occur for Indonesia and may be the case for India, Taiwan,China, and Malaysia.

Other gaps and problems with using the available data for estimating vessel numbers are:

- Estimating the numbers of vessels fishing under flags of non-members of IOTC. The Secretariat can estimate the numbers of vessels, based on reports from third parties or information collected unofficially. The accuracy of such estimates is variable and depends on the number of countries that report activities of this type. This type of problem occurs for vessels registered in Equatorial Guinea, Cambodia, Togo, Bolivia, Mongolia, and others. In recent years the number of such vessels has been stable, estimated to be around 15 large-scale fishing vessels (LOA 24m or greater). This number represents a significant drop from the numbers estimated for previous years as many vessels are thought to have changed flag and operate now under flags of IOTC CPC's.
- Problems with multiple registration, leading to double-counting of vessels: Parallel registration (a vessel using a single flag, but registered in two countries) and concurrent registration (a vessel temporarily using the flag of a coastal country while within that country's zone, and subsequently reverting to its own flag when outside the zone).
- Vessel details being inconsistent and/or incomplete. Some countries report no vessel details. Some countries use vessel names or other identifiers inconsistently. Many problems are associated with vessel tonnage. This includes inconsistent use of GRT and GT among countries (GT should always be used) and inconsistent use of GRT and GT within the same country (e.g. Indonesia).
- Some coastal countries may have industrial vessels that go unnoticed if their operations are restricted to areas and ports within their territory, and this information is not reported to the IOTC (e.g. Bangladesh, Myanmar). This is not likely to be a significant issue as the number of such vessels, if any, is thought to be low.

In addition, the following issues were considered:

- Effect of changes in targeting practices: Estimates of fishing capacity directed at a particular species may be greatly affected by changes in targeting practices (longline) and due to the multi-species nature of most tuna fisheries; changes of target species are thought to occur often in longline fisheries.
- Effect of changes in the fishing efficiency of individual vessels: The capacity of individual vessels does not remain static over time. With improvements in technology the efficiency of individual vessels increases over time, meaning that fishing mortality increases for a given fishing effort. Changes in gear configuration or better selection of fishing areas may lead to changes in the efficiency of individual vessels with respect to certain species, especially in the case of multi-species fisheries. Such changes in fishing efficiency are difficult to assess and may affect greatly estimates of optimal fishing capacity.
- Effect that the fleets not included in the estimates of capacity may have over estimates of optimal fishing capacity. The catches estimated for fleets not included in the capacity study represented

32% of the total catches estimated for the species under consideration and, in addition, trends in catches appear to have been increasing over time (Figure 4). The following fleets are included in this component:

- Small scale fleets, usually non-decked vessels having less than 12m LOA, that operate in coastal waters
- Medium scale vessels, usually decked vessels having LOA between 12 and 24m, that operate exclusively within the EEZ of their flag countries

More information will need to be collected concerning the above issues, in order to be able to assess the potential effects that they may have on estimates of optimum fishing capacity. These involve considerations beyond the scope of the present study, but are nevertheless important.

The use of output-based measures of fishing capacity in the context of Indian Ocean tuna fisheries was also assessed. In the current context, considering the limitations existing concerning the data available, the estimation of output capacity will not be possible to carry out for all the fleets included in the capacity study. In addition, the use of output-based measures of fishing capacity for tuna fisheries is thought inappropriate as, at present, measures of output capacity are based on the best conditions experienced by the fishery and this makes it difficult to base management on output capacity. The issue of output capacity is discussed more extensively in Appendix III.

# 7. IMPROVING THE ESTIMATE OF VESSEL NUMBERS

The data for some fleets need to be considerably improved to be able to determine numbers of vessels and associated catches. The priorities for obtaining better data are those fleets that have not reported complete datasets (with respect to number of vessels or catches) and that are (a) made up of a large number of vessels, and (b) make large catches. An examination of the information in Tables 1 to 3 indicates that in 2008, 10 of the fleets have more than 100 vessels. An examination of catch estimates (Tables 1 - 4) shows that in 2008, 9 fleets made catches of tuna greater than 25,000 t. Those fleets in both categories (a) and (b) should be considered as having especially high priority for data improvement. The following fleets are in this category: Sri Lanka gillnet and longline combination, Pakistan gillnet, Maldives pole-and-line, and Indonesia longline.

Action to improve the estimates of numbers of vessels in the various fleets could be taken on several levels. IOTC CPC's need to scrutinize the number of vessels listed in Tables 2 to 4 above to identify any obvious errors in reporting to IOTC and (for vessels under 24 metres), other errors introduced by assumptions made in this study about activities outside the EEZ of the flag state. More rigorous action to improve estimates of vessels would include:

- In the short-term, IOTC could make the necessary arrangements to investigate the situations in those countries that have fleets that are especially problematic. Section 6 above indicates that the following fleets may represent the priorities for those fleets to be analyzed: Pakistan gill netters, Maldives baitboats, Sri Lanka offshore gillnet/longline vessels, and Indonesian longliners.
- A mechanism needs to be identified to strongly encourage those countries that are not providing complete datasets to do so.

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# APPENDIX I: TERMS FOR REFERENCE FOR AN INDEPENDENT REPORT ON FISHING CAPACITY IN THE INDIAN OCEAN

*Objective:*

To investigate and report on the level and type of regulated and unregulated fishing capacity within the IOTC Convention Area, including the activities of Contracting Parties and Cooperating non-Contracting Parties (CPCs) and Non Contracting Parties NCPCs and the catching capacity of their vessels.

The study should include:

1. A background review of the concept of "fishing capacity"

2. A detailed account of the current level of active fishing capacity for each State or fishing entity within the IOTC Convention Area by:
    a. IOTC member status (CPCs, non-CPCs, IUU fishing)
    b. Type of fleet (large-scale, medium-scale, small-scale)
    c. Fishing method (purse seining, longlining, etc);
    d. Analyse the possible transfer between species of fishing capacity through changes in targeting practices.

It is intended that in conducting this work the consultant will utilise the IOTC databases, input from CPCs, NCPCs, International Organisations and non-Government Organisations, working in cooperation with the IOTC Secretariat as necessary.

The conclusions of the study should include:

1. Recommendations for to the IOTC on improving data management with regard to monitoring capacity in the Indian Ocean.
2. An assessment of the areas that should be prioritised for the IOTC to ensure a sustainable level of fishing capacity in the Indian Ocean.

## APPENDIX II: TUNA FLEETS IN THE INDIAN OCEAN

**Assumptions and comments on accuracy of data on vessel numbers and catches**

| Country | Gear | Size | Comment on vessel number | Partitioning the fishing area for vessels <24 m (estimate) | Vessel details | Comment on catches |
|---|---|---|---|---|---|---|
| Australia | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available, but confidential |
| Australia | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available, but confidential |
| Belize | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| China | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Details available (Tonnage, LOA) | • Catches available |
| Taiwan Province of China | Drifting longlines | LOA_24> | • Good estimate of number | | • Details available (Tonnage, LOA) | • Catch for fleet available<br>• Accuracy is fairly reliable |
| Taiwan Province of China | Drifting longlines | LOA_<24 | • Probably unreliable estimate; probably greater number actually exist | 100% sometimes outside | • Details available (Tonnage, LOA) | • Catch for fleet available<br>• Accuracy is uncertain |
| EC-France | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-France | Drifting longlines | LOA_<24 | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-France | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-Italy | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-Portugal | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-Spain | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-Spain | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| EC-United Kingdom | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| France (OT) | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Guinea | Drifting | LOA_24> | • Accurate vessel numbers | | • Some details available | • Estimated by IOTC |

| Country | Gear | Size | Comment on vessel number | Partitioning the fishing area for vessels <24 m (estimate) | Vessel details | Comment on catches |
|---|---|---|---|---|---|---|
| | longlines | | | | | |
| India | Drifting longlines | LOA_24> | • Unknown accuracy<br>• Some problems likely with duplicate flag | | • Details available (Tonnage LOA), but inconsistencies noted | • Not reported, but estimated by IOTC |
| India | Drifting longlines | LOA_<24 | • Unknown accuracy and activity outside zone unknown | 100% sometimes outside | • Details available (Tonnage, LOA), but inconsistencies noted | • Not reported, but estimated by IOTC |
| India | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Aggregate with artisanal catch |
| India | Purse seines | LOA_<24 | • Accurate vessel numbers<br>• Whether operate outside zone is unknown | 100% sometimes outside | • Tonnage and length details available | • Aggregate with artisanal catch |
| Indonesia | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Details available (Tonnage, LOA), some inconsistent tonnage measures | • Catch data for all longline size categories is aggregated but uncertain in accuracy. |
| Indonesia | Drifting longlines | LOA_<24 | • Thought to be inaccurate<br>• Whether operate outside zone is unknown | {combined with those that have no length) 100% sometimes outside | • Details available (Tonnage, LOA), some inconsistent tonnage measures | • Catch data for all longline size categories is aggregated but uncertain in accuracy. |
| Indonesia | Drifting longlines | Na | • This is an Indonesian longline category with no vessel length info<br>• Assume all/most fishing is outside | | • GRT available so could estimate two size categories | • Catch data for all longline size categories is aggregated but uncertain in accuracy. |
| Indonesia | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Aggregate with artisanal catch |
| Iran | Gill nets | LOA_24> | • Accurate vessel numbers | | • Details available (Tonnage, LOA) | • Only catch for entire fleet, including artisanal – not by vessel size category<br>• Catches of vessels >24m and those of <24m that operated outside the EEZ estimated assuming catch rates 3 times higher than for remaining gillnet vessels |
| Iran | Gill nets | LOA_<24 | • Accurate vessel numbers<br>• Partitioning into size categories accurate<br>• This number represent the number operating sometimes outside the zone | This number is good; but no catches associated with this component; | • Tonnage and LOA details available | • Only catch for entire fleet, including artisanal – not by vessel size category<br>• Catches of vessels ≥24m and those of <24m that operated outside the EEZ estimated assuming catch rates 3 times higher than for remaining gillnet vessels |
| Iran | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length | • Uncertain |

| Country | Gear | Size | Comment on vessel number | Partitioning the fishing area for vessels <24 m (estimate) | Vessel details | Comment on catches |
|---|---|---|---|---|---|---|
| | | | | | details available | |
| Japan | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Details available (Tonnage, LOA) | • Catches available |
| Japan | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Kenya | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Korea | Drifting longlines | LOA_24> | • Thought to be accurate<br>• Issue of duplicate flag with India/Oman | | • Tonnage and length details available | • Catches available, but uncertain accuracy |
| Madagascar | Drifting longlines | LOA_24> | • Uncertain | | • Uncertain | • Estimated by IOTC |
| Malaysia | Drifting longlines | LOA_24> | • Thought to be accurate | | • Tonnage and length details available | • Partially available; total catch estimated by IOTC |
| Malaysia | Drifting longlines | LOA_<24 | • Thought to be accurate<br>• Like to be number fishing outside zone | | • Tonnage and length details available | • Partially available; total catch estimated by IOTC |
| Malaysia | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Unavailable |
| Maldives | Pole and lines | Na | • Total fleet number given, but not by size category<br>• All vessels operate within the EEZ of Maldives<br>• 10% of vessels presumed to be ≥24m length | | • Nothing | • Total fleet catches available<br>• No data by size category<br>• Catches of vessels ≥24m estimated assuming catch rates 3 times higher than for remaining pole-and-line vessels |
| Mauritius | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Mauritius | Drifting longlines | LOA_<24 | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Oman | Drifting longlines | LOA_24> | • Unknown accuracy<br>• Some problems likely with duplicate flag | | • Tonnage and length details available | • Catches available, but uncertain accuracy |
| Oman | Drifting longlines | LOA_<24 | • Unknown accuracy<br>• Some problems likely with duplicate flag | 100% sometimes outside | • Tonnage and length details available | • Catches available, but uncertain accuracy |
| Pakistan | Gill nets | Na | • Number likely to be those that are based from Karachi; probably a fraction of total number.<br>• What proportion outside EEZ is | Of those <24 m, 12% sometimes outside; like Iran; | • No vessel details<br>• Cannot partition into two size categories | • Total fleet catch provided but unsure what vessels are included in that amount; likely to be under-estimate<br>• Catches of vessels ≥24m and |

| Country | Gear | Size | Comment on vessel number | Partitioning the fishing area for vessels <24 m (estimate) | Vessel details | Comment on catches |
|---|---|---|---|---|---|---|
| | | | not known, but probably significant | | | those of <24m that operated outside the EEZ estimated assuming catch rates 3 times higher than for remaining gillnet vessels |
| Philippines | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available, but uncertain accuracy |
| Senegal | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Some details available | • Estimated by IOTC |
| Seychelles | Drifting longlines | LOA_24> | • Thought to be accurate | | • Tonnage and length details available | • Good estimate |
| Seychelles | Drifting longlines | LOA_<24 | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Seychelles | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| South Africa | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| South Africa | Drifting longlines | LOA_<24 | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |
| Sri Lanka | Drifting longlines | LOA_<24 | • Accurate vessel numbers<br>• Operate outside EEZ | | • Not available | • Estimated by IOTC |
| Sri Lanka | Gill net/longline | LOA≤24 | • Accurate estimate of numbers<br>• What proportion outside EEZ is not known precisely. | 15% sometimes outside; | • Good LOA category details<br>• No other vessel details<br>• Some info is available to IOTC but not in public domain | • Total catches of whole fleet available<br>• No catches by type of operation (only inside or inside and outside EEZ); catches of vessels <24m that operated outside the EEZ estimated assuming catch rates 1.5 higher than for remaining vessels<br>• Cannot partition catches by LL or GL |
| Tanzania | Drifting longlines | Na | • Accurate vessel numbers | | • Some details available | • Estimated by IOTC |
| Thailand | Drifting longlines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches uncertain |
| Thailand | Purse seines | LOA_24> | • Accurate vessel numbers | | • Tonnage and length details available | • Catches available |

| Country | Gear | Size | Comment on vessel number | Partitioning the fishing area for vessels <24 m (estimate) | Vessel details | Comment on catches |
|---|---|---|---|---|---|---|
| NEI | Drifting longlines | LOA_24> | • Based on third party reports; likely to be under-estimate; some duplicate reporting likely | | • Some details | • Not reported, but estimated by IOTC |
| NEI | Drifting longlines | Na | • Based on third party reports; likely to be under-estimate<br>• Some duplicate reporting likely | | • Some details | • Not reported, but estimated by IOTC |

## APPENDIX III: ADDITIONAL CONSIDERATIONS ABOUT OUTPUT-BASED MEASURES OF FISHING CAPACITY

The present study has used the number of vessels as a simple measure of fishing capacity. As explained in Section 2.2 above, this approached is justified in that the number of participating vessels is a prerequisite for the more complex output measure of capacity and that some of the IOTC Resolutions refer to fishing capacity in terms of the number of participating vessels and their associated tonnage.

Nevertheless, it is important to consider some of the issues in progressing from an input measure of tuna fishing capacity in the Indian Ocean to an output measure of capacity. In this regard, it should be noted that IOTC Resolution 99/01 (on the management of fishing capacity) implies a more analytical measure of capacity. The resolution "asks the Scientific Committee to present, at the Session of IOTC in 2000, recommendations on 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".

Bayliff and Majkowski (2006) express an important limitation of input measures of capacity for management purposes: "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".

The difficulties in making output estimates of fishing capacity should not be underestimated. FAO (2004) elaborates on this subject:

> Except for simple fisheries, quantitative estimation of capacity is relatively difficult. Given the complexity of estimating potential catch, several techniques have been developed to assist in the quantitative measure of excess fishing capacity and overcapacity. These include data envelopment analysis (DEA), stochastic production frontiers, and peak-to-peak analysis. Overcapacity measures that utilize DEA have been developed to measure overcapacity levels in fisheries relative to a biological target level of yield or to an economic target level of yield such as maximum economic yield. Bioeconomic models have also been used to estimate input-based measures of overcapacity or overcapitalization. All of these approaches have both strengths and weaknesses, and the choice of the appropriate method will vary depending on the nature of the fishery, the data available, and the intended use of the capacity measure.

In considering the practicality of output measures of tuna fishing capacity in the Indian Ocean, it may be useful to distinguish between the major gear types in the region's fisheries: purse seine, longline, and gillnet. Discussions with a specialist in the analysis fishing capacity (D.Squires, personal communication, August 2009) point out some features associated with estimating output capacity in these three categories.

First, with respect to the Indian Ocean purse seine fisheries, methods to estimate capacity in terms of maximum output were tested in 2004, including data envelopment analysis[2], as a component of an FAO project on the management of tuna fishing capacity, intended to assess the validity of different methods for the estimation of output fishing capacity in the eastern Pacific Ocean, western and central Pacific, Indian and Atlantic oceans. However, because of the uncertainty about the stock assessments at the time of the study and concerns about some of the assumptions, the meeting agreed that further work was required in order to address these concerns, agreeing to revisit the issue in 2010.

Compared to purse seine, it is more problematic to make estimates of output capacity for the other major gear types in the Indian Ocean. With much less detail in the catch data (i.e. not disaggregated to the boat/trip level), the type of analysis carried out for purse seine gear cannot be undertaken for the longline and gillnet net fleets.

[2] DEA calculates a frontier or maximum landings curve, as determined by the best-practice vessels, given the states of technology, the environment and the resource stocks (fixed inputs), provided that fishing effort (variable input) is fully utilized under normal operating conditions. This frontier represents fishing capacity output. (Bayliff et al., 2005)

For longlining in the Indian Ocean, until more detailed effort data are released, 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 operations of these national fleets. The production frontier is defined by the most productive fleet. The production of other fleets is compared to this frontier to determine capacity utilization.

In Section 5.1 (Table 2, pages 13-15) can be seen that there are eight national longline fleets comprised of vessels greater than 24 metres that catch a substantial amount of tuna (i.e. greater than 2,000 t) and that have catch data available. These fleets (Korea, Philippines, Spain, Seychelles, China, India, Japan, and Taiwan Province of China) would seem to be the likely candidates for a "best practice frontier" capacity analysis.

Due to the fact that only one significant pole-and-line fleet operates in the Indian Ocean, the "best practice frontier" technique would not be appropriate for pole-and-line fishing in the region.

With respect to gillnetting in the Indian Ocean, because there are such major differences between national fleets, it is doubtful that even the "best practice frontier" technique is applicable. Given the current state of data it may be a meaningless exercise to attempt to estimate the output fishing capacity for gillnetting in the Indian Ocean.

In summary, in terms of output fishing capacity of the major tuna fleets in the Indian Ocean, estimates would be possible for purse seining, a crude estimate for longliners could conceivable be made with the available data, and it is currently not possible to make estimates for pole-and-lining or gillnetting.