IOTC-2009-WPTT-11

Preparation of data input files for the assessments of Indian Ocean yellowfin tuna stock using Multifan-CL

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Summary

This document describes the methods used by the IOTC Secretariat to prepare catch, effort and length-frequency tables for the assessments of the Indian Ocean yellowfin tuna stock using Multifan-CL, for the period 1950-2008, using estimates of total catch and the available catch-and effort, size frequency data and other biological data in the IOTC database.

Using information from the IOTC database, the IOTC Secretariat prepared a flat table containing estimates of total catches, and the effort and length-frequency samples available, by fishery, assessment area, year and quarter.

The results are affected by the lack of information for some fleets, areas and years, and, in particular, by the lack of catch, effort and size data from most artisanal fleets and some industrial fleets.

Rationale

The IOTC database contains estimates of total catches by country, gear, year and IOTC Area (**Figure 1**). In addition, the IOTC database contains catch-and-effort data and size frequency data by country, gear, time-area strata and species, which generally represent a sample of the total catches estimated by country, gear, year and species.

The Secretariat used the above data to produce an input file containing estimates of total catches of yellowfin tuna, in number and weight, and the effort and length-frequency samples available by fishery, assessment area, year and quarter. This file was used for the assessments of yellowfin tuna, carried out using Multifan-CL (MF-CL). The results of the assessments are reported in a separate paper[2].

MF-CL Input Table

The Secretariat prepared a table containing the following information for the MF-CL assessments of yellowfin tuna:

a. **Total catches** of yellowfin tuna, in number of specimens and weight, by year, quarter, assessment fishery (**Table 6**), and assessment area (**Table 7** and **Figure 2**).

b. **Effort** data **available** by year, quarter, assessment fishery, and assessment area.

c. Number of yellowfin tuna specimens **sampled** by **length** interval, year, quarter, assessment fishery, and assessment area.

Examples of the input table can be found in **Appendix I**.

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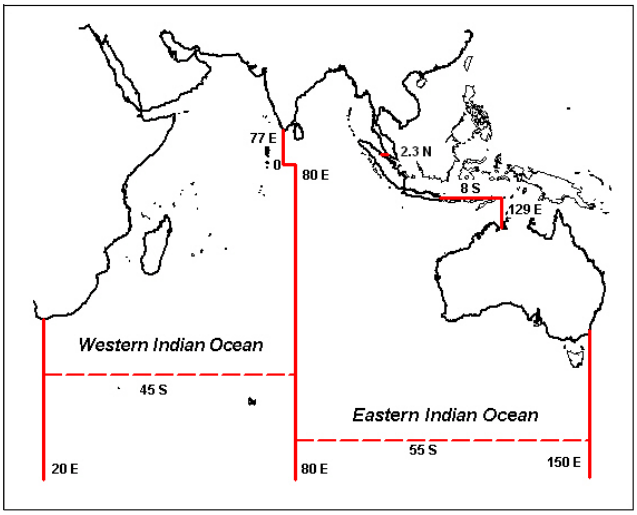
[2] Preliminary stock assessment of yellowfin tuna in the Indian Ocean using MULTIFAN-CL. A.Langley et al. (IOTC-2009-WPTT-10)

Basic Data

Four datasets are used for the preparation of the input file for the assessments of yellowfin tuna with MF-CL:

- *Nominal catches*: Total catch estimates per Species, Fleet, Year, Gear and IOTC Area (**Figure 1**). The data in this dataset issues from two different sources:
  a. Reports from the flag countries or reports from other countries on the catches of foreign vessels operating within its Economic Exclusive Zone or based in ports within its territory.
  b. Estimates carried out by the IOTC Secretariat: this may involve changes in the catches reported by the above or the estimation of catches for non-reporting fleets (e.g. catches recorded under the NEI[3] category).

Figure 1: IOTC areas used for the Nominal Catches



- *Catches and effort by area* (derived from the catch-and-effort table): Catches by species (in tonnes or/and in number of fish) and effort are recorded by Fleet, Year, Gear, Fishing Mode, Time Interval (month or quarter usually) and area (usually 1^0 square areas for industrial purse seine fisheries, 5^0 square areas for industrial longline fisheries and various regular or irregular areas for artisanal fisheries). Catches/effort by area are not available for all Nominal catches strata. When recorded, the catches/effort in these datasets might represent the total catches/effort of the species in the year for the fleet and gear concerned or represent simply a sample of those.
- *Size data*: Size frequency data (standard or processed lengths or standard or processed weights) are recorded by Species, Fleet, Year, Gear, Fishing Mode, Time Interval (month or quarter or year usually) and area (usually 5^0 square areas for purse seine fisheries, 10^0 latitude by 20^0 longitude for longline fisheries and various regular or irregular areas for artisanal fisheries). Size data are not available for all Nominal catches strata. When recorded, the size data might represent the total catches of the species in the strata concerned (Catch-at-Size) or simply a sample of those (non-raised or partially raised samples).
- *Biological data*: includes several types of biological parameters for the yellowfin tuna, in particular:
  a. Conversion from non-standard measurements into fork length: Equations (data) used to convert specimens of yellowfin tuna measured by using non-standard procedures into the standard length measurement used for these species, representing the distance from the tip of the snout to the fork of the tail (fork length).
  b. Conversion from fork length into live weight: Equations (data) used to estimate sample weights from the available lengths (length-weight relationships).

The type of information recorded in each case is summarized in **Table 1** below:

Table 1: Main types of fisheries statistics gathered by the IOTC

Dataset	*Fishery Strata*	*Time Period Strata*	*Area Strata*	*Represents*
Nominal Catches	Fleet-Gear type (or gear aggregate)-Species (or species aggregate)	Year	IOTC Area (Western / Eastern Indian Ocean)	Total catches
Catch-and-Effort	Fleet-Gear (or gear aggregate)-Fishing Mode (purse seine only)-Species	Month (quarter or year)	1^o square area (purse seine) 5^o square area (longline) Other regular or irregular areas	Sample
Size frequency	Species- Fleet-Gear (or gear aggregate)-Fishing Mode (purse seine only)-Type of measurement (length or weight, standard or processed)-Size interval (between size classes)	Month (quarter or year)	5^o square area (purse seine) 10^o Lat.x20^o Lon. area (longline) Other regular or irregular areas	Sample
Biological data	Various, depending on dataset	Various	Various, depending on dataset	Sample

[3] Not elsewhere identified

Data Processing

Summary of the estimation procedures used in the preparation of input files for the assessments of yellowfin tuna with MF-CL

1. Standardizing catch, effort and size frequency tables
    a. Nominal catches (NC): Assigning the catches not reported by species/gear by species/gear (NC➔NCst)
    b. Catch-and-effort (CE): Assigning catches/effort not recorded by quarter by quarter (CE➔CEst)
    c. Size frequency (SF➔LFst):
        i. Converting non-standard measurements into standard measurements
        ii. Breaking the existing lengths into the standard length class intervals used for the species
        iii. Downscaling length frequency distributions to sampled numbers
            1. EC purse seiners: downscaling CAS to the numbers of fish estimated for sampled purse seine sets
            2. Other fleets: downscaling CAS or raised length distributions to the actual numbers of fish sampled, when required
        iv. Assigning length samples by quarter
2. Assigning catches, effort and length samples by year, quarter, fishery and assessment area (NCst/CEst/LFst ➔ NCELfa):
    a. Fleets operating fully within one of the yellowfin tuna assessment areas (artisanal fleets): Assigning total catches (NCst) and available effort (CEst) and length samples (LFst) by fishery, assessment area, year and quarter (NCst/CEst/LFst ➔ $NCELfa_1$)
    b. Fleets operating in two or more assessment areas (industrial fleets):
        i. Breaking CEst by fishery, 5° grid, year and quarter (CEst➔CEds)
        ii. Breaking NCst by fishery, 5° grid, year and quarter using the CEds (NCst➔NCds)
        iii. Assigning LFst by fishery, 5° grid, year and quarter (LFst➔LFds)
        iv. Assigning total catches (NCds) and available effort (CEds) and length samples (LFds) by fishery, assessment area, year and quarter (NCds/CEds/LFds ➔ $NCELfa_2$)
    c. Merging $NCELfa_1$ and $NCELfa_2$ into NCELfa
3. Estimating total catches in number by year, quarter, fishery and assessment area (NCELfa➔NCELra):
    a. Assigning length frequency samples to all NCds strata (Fleet-Gear-Year-Quarter-PS/Other Area) (NCds➔LFcv)
    b. Estimating total catches in number by dividing the catches in weight from NCELfa by the average weights by stratum derived from LFcv (sampled weight in mt/number of fish)
4. **Yellowfin tuna MF-CL input file (**NCELra ➔**$NCEL_{MFCL}$):** re-allocating strata from NCELra into other assessment areas. The catches, effort and length data for some fisheries was reallocated to specific areas when the accumulated catches in the area concerned represented a small proportion of the total catches for the fishery concerned.

Standardizing catch, effort and size frequency tables

i. Estimating total catches of yellowfin tuna by fleet, gear, year and IOTC Area

The catches in the IOTC nominal catches database are not recorded by species and/or by gear in all cases. The Secretariat conducted a review aiming at estimating catches when data were not available by species or gear in the IOTC database. This process was documented in a paper presented to the WPTT in 2004 (IOTC-2004-WPTT-06). The disaggregation of catches does not affect significantly the catches of yellowfin tuna.

ii. Standardizing the available catch-and-effort data

The catches in the catch-and-effort table are recorded under different levels of aggregation. All the catches from this record were assigned by Species-Fleet-Gear-Fishing Mode-Year-Month-5° square grid-Catch in number of fish-(and/or)-Catch in metric tons.

i. Converting from non-standard effort units into standard effort units: The effort units reported vary depending on the fleet and/or fishing period. The units of effort that were selected by fishery are shown in **Table 2** (page 4). In some cases, especially for some artisanal fisheries, the units of effort reported were assumed to be equivalent to the standard units of effort selected for those fisheries.

ii. It is important to note that the effort recorded for industrial purse seine fisheries has not been broken down by fishing mode (LS and FS) as the actual effort exerted on free schools or associated schools is unknown. Thus, **the effort recorded under FS and LS actually represent the effort exerted by industrial purse seiners as a whole, not the effort for the individual fisheries.**

Table 2: Standard length, first length, interval and total number of size classes used for the yellowfin tuna

Fishery	*Standard Effort Units*	*Other effort Units considered to be the same as the standard effort unit*
LS	Number of days fishing (FDAYS)	
FS	Number of days fishing (FDAYS)	
LL	Number of hooks set (HOOKS)	
BB	Number of trips (TRIPS)	Number of fishing days (FDAYS), number of days at sea (DAYS)
GI	Number of trips (TRIPS)	Number of fishing days (FDAYS), number of days at sea (DAYS)
HD	Number of trips (TRIPS)	Number of fishing days (FDAYS), number of days at sea (DAYS)
TR	Number of trips (TRIPS)	Number of fishing days (FDAYS), number of days at sea (DAYS)
OT	Number of trips (TRIPS)	Number of fishing days (FDAYS), number of days at sea (DAYS)

NOTE: Refer to Table 6 for a description of the fisheries referred to above

iii. Area allocation: All the catches/effort not recorded by 5° square areas were assigned to 5° square areas as follows:

a. Allocation of catches/effort recorded under irregular areas to regular grids: The catches/effort recorded under irregular areas (e.g. port of unloading, fishing district, etc.) were assigned to the neighbouring regular grids.

b. Allocation of catches/effort recorded under areas that fell within a single 5° square area: all catches/effort recorded under areas that fell within a 5° square area were assigned to the corresponding 5° square areas.

c. Allocation of catches/effort recorded under areas overlapping two or more 5° square areas: all catches/effort recorded under areas that overlapped two or more 5° square areas were assigned proportionally by 5° square areas (i.e. by using the proportions obtained by dividing the amount of 1 degree square grids that fell within each 5° square area over the total amount of squares from the overlapping area).

iv. Time period allocation: The catches/effort available in the catch-and-effort file were assigned by month as follows:

a. Allocation of catches/effort recorded under time period strata that fall within a single month: all catches/effort recorded under time periods that fell within a month were assigned to the corresponding months.

b. Allocation of catches/effort recorded under time period strata overlapping two or more months: all catches/effort recorded under time periods that overlapped two or more months were assigned proportionally by month (e.g. 1/3 of the catches/effort recorded under the first quarter of a year were assigned to each of the months making up that quarter).

iii. Standardizing the available size frequency data

The following process was used to convert the samples available for the yellowfin tuna into standard form:

i. Converting from non-standard measurement types into standard length (**Table 3**): The regression equations presented in **Table 3** were used to estimate the distance from the tip of the snout to the fork of the tail (fork length) for specimens of yellowfin tuna that were recorded under non-standard lengths or weights in the IOTC database:

a. Conversions from gilled-and-gutted weight into fork length: The conversion from gilled-and-gutted weight into fork length was done by using a distribution matrix for the yellowfin tuna, estimated by using individual weight (GGT)-length (FL) measurements.

b. Other measurements: any other non-standard measurements were converted into fork length by using the equations on **Table 3** (deterministic conversion).

Table 3: Yellowfin tuna: Regression equations used to convert from non-standard measurements into standard lengths

Type Measurement	*Equation*	*Parameters*	*Sample size*	*Size range*	*Variance*	*Covariance ab*	*Mean Residual*	*Gradient*
Weight gilled and gutted[A]	aW^b	a= 44.28699 b= 0.3008591	2,361	Min:14 Max:71	a=0.00752476509 b=2.86244E-07	-4.626246E-05	4.095958	a=3.033852 b=495.6385
Length to the base of the 1st dorsal fin[B]	aL^b	a=2.0759 b=1.1513	7,036	Min: 29 Max: 164				
Length base of first dorsal fin to fork of caudal fin	No equation available							

*A: **Data from IPTP Penang Sampling Programme (1992-93)***
B: Data from the Indian Ocean (Marsac, F. et al in IOTC-2006-WPTT-09)

ii. Breaking the samples by the standard length frequency intervals used for the yellowfin tuna: The length-frequency interval that is used for the yellowfin tuna is shown in **Table 4** (page 5).

a. Allocation of specimens recorded under length classes that fall within a single standard length class:

- Yellowfin tuna specimens recorded under one centimetre length classes were aggregated under the corresponding length classes (e.g. specimens of yellowfin tuna recorded under the classes 16-17cm and 17-18cm were accumulated under fork length 16cm[4]).
- Yellowfin tuna specimens recorded under two centimetre length classes that fell within standard length classes were assigned to the corresponding standard length classes (e.g. specimens recorded under length class 16-18cm were assigned to fork length 16cm)

Table 4: Standard length, first length, interval and total number of size classes used for the yellowfin tuna

Species	*Standard Length**	*First length (cm)*	*Interval between length classes (cm)*	*Total number of size classes*	*Maximum interval allowed (cm)*
Yellowfin tuna	Fork length	10	2	150	4

NOTE: All samples in the IOTC database were assigned according to the specifications above; the samples recorded under length intervals greater than the maximum interval specified above were not used
***Refers to the straight distance measured, to the closest lower centimetre, between the tip of the snout (upper-jaw) and the fork of the tail (FL)**

b. Allocation of specimens recorded under length classes overlapping two or more standard length classes: all the specimens recorded under length classes that overlap the standard classes used for the species (Table 2) were assigned proportionally to the corresponding standard length classes (e.g. 1/3 of the yellowfin tuna specimens recorded under length class 17-20cm were assigned to length 18cm, and 2/3 to length 18cm). All samples containing specimens of yellowfin tuna recorded under length intervals 5cm or higher were discarded.

iii. Weighting length frequency distributions to sample numbers: The length frequency data in the IOTC database do not represent sample numbers in all cases as some countries report length frequency data that has been raised in various ways (e.g. to the catches in the stratum covered through sampling, to the total catches estimated for the country, etc.).

a. EC purse seiners: The EC reports length frequency distributions for EC purse seiners that have been raised to the total catches of each 5° square grid and month; the CAS for each stratum were weighted by the numbers of fish estimated for the sampling units making up the stratum (which is the catches corresponding to all sets within fish compartments where samples were taken).

b. The actual sample numbers were used for all other fleets to weight the reported length frequencies, when required; i.e. the number of specimens recorded under each length class was multiplied by the number obtained by dividing the total number of specimens sampled (all lengths combined) by the total number of specimens in the raised length frequency (all lengths combined).

iv. Time period allocation: The available length frequency samples were assigned by quarter as follows:

a. Allocation of specimens recorded under time-periods that fall within a single quarter: all specimens from samples recorded under time periods that fell within a quarter were assigned to the corresponding quarter.

b. Allocation of specimens recorded under time-periods overlapping two or more quarters: all specimens from samples recorded under time-periods that overlapped two or more quarters were assigned proportionally by quarter (e.g. 2/3 of the specimens recorded under the time period February-April of any year were assigned to the first quarter (Jan-Mar) of that year while the remaining 1/3 specimens were assigned to the second quarter (Apr-Jun)).

v. Estimation of sample weights: Weights by sample were calculated by adding the weights estimated for all the specimens making it. The equations used to estimate weights from the available lengths are shown in **Table 5** (note that deterministic methods were used for the conversion).

Table 5: Yellowfin tuna: Equations used to convert from standard (fork) length into round weight, by species

Species	*Gear Type/s*	*From type measurement – To type measurement*	*Equation*	*Parameters*	*Sample size*	*Length*
Yellowfin tuna	Purse seine Pole and Line Gillnet & other	Fork length – Round Weight(kg)[A]	RND=a*L^b	a= 0.00001886 b= 3.0195	6,752	Min: 29 Max: 164
	Longline Hand line	Fork length(cm) – Gilled and gutted weight(kg)[B] Gilled and gutted weight(kg) - Round Weight(kg)[C]	GGT=a*L^b RND=GGT*1.13	a= 0.0000094007 b= 3.126843987	15,133	Min:72 Max:177

*A: **Data from the Indian Ocean (Marsac, F. et al in IOTC-2006-WPTT-09)***
*B: **Multilateral catch monitoring Benoa (2002-04)***
C: ICCAT Field Manual (Appendix 4: Population parameters for key ICCAT species. Product Conversion Factors)

[4] Note that lengths are recorded to the lowest length interval, i.e. the length range of specimens recorded under length 16cm for a species for which 2cm intervals are used is 16cm(inclusive)-18cm(exclusive); note that medium values are used to estimate weights from the available lengths (17cm in this case).

Assigning catches, effort and length samples by year, quarter, fishery and assessment area

i. Allocation of assessment fishery:

Each Fleet-gear stratum in the length frequency data table was assigned to the corresponding assessment fishery. Details on the fleet-gear length frequency strata making up each fishery are shown in **Appendix III**. **Table 6** shows the fisheries that are used for the assessment of yellowfin tuna. It shows also total catches by fishery accumulated for the entire catch data series (1950-2008) and the contribution that the catches from each fishery made to the total accumulated catches for 1950-2008, and in recent years (2004-08).

Table 6: Fisheries used for the assessments of Indian Ocean yellowfin tuna; the total catches accumulated for the period 1950-2008 (Total Catch 50-08) and the relative importance of each fishery over both the entire catch series (%50-08) and in current years (%04-08) is also shown

Fishery	*Description*	*Total Catch 50-08 (,000 t)*	*% 50-08*	*% 04-08*
FS	Industrial purse seines on free-swimming schools	1,871	20	25
LS	Industrial purse seines on associated schools (FAD)	1,278	14	14
LL	Industrial longlines	3,320	36	25
BB	Pole-and-lines	393	4	4
GI	Gillnets	1,466	16	20
HD	Hand lines	629	7	9
TR	Troll lines	58	1	1
OT	Other artisanal gears	261	3	4

ii. Allocation of assessment area

The total catches, effort and samples existing for the yellowfin tuna were aggregated by assessment area. The areas that were used for the assessments of the yellowfin tuna stock are shown in **Table 7** and **Figure 2**. The catches of yellowfin tuna from areas outside the five areas were assigned to the closest area, as indicated through the arrows on **Figure 2**. **Table 6** shows also total catches by area accumulated for the entire catch data series (1950-2008) and the contribution that the catches from each area made out of the total accumulated catches for 1950-2008, and in recent years (2004-08).

Table 7: Areas used for the assessments of Indian Ocean yellowfin tuna; the total catches (tonnes) accumulated for the period 1950-2008 (Total Catch 50-08), the relative importance of the catches in each area over both the entire catch series (%50-08) and in current years (%04-08), and the accumulated 1950-2008 catches by assessment fishery (Table 6, page 9) in each of the areas concerned are also shown

Area	*Description*	*Catch (,000 t) 50-08*	*% 50-08*	*% 04-08*	*Catches by Fishery 1950-2008 (,000 t)*							
					FS	*LS*	*LL*	*BB*	*GI*	*HD*	*TR*	*OT*
1	Arabian Sea	1,818	20	24	*15*	*34*	**420**	*17*	**727**	**496**	*35*	**35**
2	Western IO	4,437	48	48	**1,709**	**1,094**	**1,116**	**366**	*6*	*27*	**42**	*1*
3	Southwest IO	664	7	6	**99**	**114**	**354**	*2*	*0*	*41*	**76**	*1*
4	Southern IO	235	3	1	*<1*	*0*	**235**	*<1*	*<1*	*0*	*20*	*0*
5	Eastern IO	2,121	23	20	**47**	**36**	**1,196**	*8*	**732**	*65*	**87**	**21**

Note that the catches from areas that were kept for the assessment are shown in bold; the catches from other areas (*italics*) were allocated to one of the areas selected for the assessment, depending on the fishery (refer to Table 8 on page 8 for details)

The following process was used to allocate the existing samples by area:

i. Allocation of catches, effort and length samples available for selected fisheries to specific assessment areas: The catches, effort and samples available for selected fisheries were fully assigned to specific assessment areas on the assumption that the majority of the specimens caught by those fisheries came the areas selected. This is thought to be the case with the majority of artisanal fisheries and with a limited number of industrial fisheries. Details on fleet-gear size frequency strata that make up each area are shown in **Appendix II**.

ii. Allocation of the catches, effort and length samples available for other fisheries:

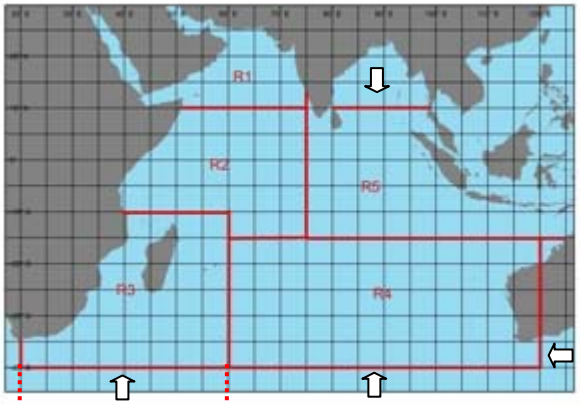
   a. Breaking the nominal catches by time-period and area: the nominal catches for the fisheries concerned were assigned by month and 5° square areas by using the catches by time period and 5° square grids available for the yellowfin tuna (see "*Standardizing the available catch-and-effort data*" on page 3). The following process was used:

      a. Nominal catches strata for which time-area catches exist:

         i. Deleting strata from the CE table: The CE for NEI-(deep)-freezing longliners and NEI-fresh tuna longliners were not used because they refer to very specific areas and time-periods and are not considered to be representative of the activities of these fleets.

         ii. Breaking the nominal catches by time and area: The nominal catches were broken by time and area in years for which spatio-temporal catches were available for the fleet concerned.

Figure 2: Areas used for the assessments of yellowfin tuna using MF-CL



b. Nominal catches strata for which CE data do not exist:

i. Catches per area are available for the same fleet in years before or after the year concerned:

1. Catches for the same species are available: The catches recorded in the five years closest to the year of reference were accumulated and the average values obtained used to break the catches per area in the year concerned. Data extending to up to 25 years above or below the year concerned are used.
2. Catches for other species are available:
   a. The catches recorded in the year of reference were accumulated and the average values obtained used to break the catches per area in the year concerned
   b. The catches recorded in the five years closest to the year of reference were accumulated and the average values obtained used to break the catches per area in the year concerned. Data extending to up to 25 years above or below the year concerned are used.

ii. Catches per area are not available for the same fleet in years before or after the year concerned or they are available but very far in time (more than 25 years before or after the year concerned): The catches available for other fleets (and years) are used to break the nominal catches per month and 5° square area/s.

1. Catches per area for the alternative fleet are available for the same year: This information is used to break the nominal catches per time and area.
2. Catches per area for the alternative fleet are not available for the same year: The same substitution scheme as the one defined in ii.a. above is used.

b. Allocation of catches, effort and length samples recorded under areas that fall within a single assessment area: all catches, effort and length samples recorded under areas that fell within one of the areas used for the assessment (**Figure 2**) were assigned to the corresponding assessment area. It is important to note that all catch and effort data falls under this category (see a. above and "*Standardizing the available catch-and-effort data*" on page 3).

c. Allocation of length samples recorded under areas overlapping two or more assessment areas: all specimens from samples recorded under areas that overlapped two or more assessment areas were assigned proportionally by assessment area (i.e. by using the proportions obtained by dividing the amount of 1° square grids that fell within each assessment area over the total amount of squares making up the overlapping area)

The resulting data were aggregated to obtain total catches (in weight), and effort and length samples available by year, quarter, assessment fishery, and assessment area.

It is important to note that no weighting procedure was used when aggregating the available effort or length samples by assessment fishery and area.

Estimating total catches in number by year, quarter, fishery and assessment area

Catches in number were estimated by dividing the catches in weight estimated by stratum by the average weights estimated for the stratum concerned. The average weights were derived from the Catch-at-Size table estimated for the yellowfin tuna. The process used for the estimation of Catch-at-Size tables for tropical tuna species is explained in a separate document[5].

[5] Estimation of Catch-at-Size, Catch-at-Age and Total Catch per Area, M.Herrera (IOTC-2009-WPTT-12)

Putting together the input file for the assessments of yellowfin tuna with MF-CL

The catches (in number and weight), effort and length frequency samples from some fisheries in some areas were reallocated to other areas, especially in cases where the catches represented a small proportion of the total catches for the fishery concerned and where no tag releases had been recorded for those fisheries and areas. Overall, around 3% of the catches of yellowfin tuna were re-allocated to other areas. The catches in italics in **Table 7** (page 6) represent the catches that were re-allocated to other areas for each fishery. The criteria used for the allocation of catches are shown on **Table 8**.

Table 8: Areas used for the assessments of the Indian Ocean yellowfin tuna stock: criteria used for the re-allocation of catches, effort and length samples from the areas where they were recorded to the areas used for the MF-CL assessment. The proportion of catches from each fishery that were re-allocated to other area/s, over the total catches for that same fishery for the entire time series (1950-2008), is also shown

Fishery	*Areas used (MFCL assessment)*	*Area 1*	*Area 2*	*Area 3*	*Area 4*	*Area 5*	*% of catches re-allocated*
		Catch, effort, length frequency data re-allocated to Area					
FS	2, 3, 5	2	2	3	5	5	1
LS	2, 3, 5	2	2	3	5	5	3
LL	1, 2, 3, 4, 5	1	2	3	4	5	0
BB	2	2	2	2	2	2	7
GI	1, 5	1	1		5	5	<1
HD	1	1	1	1	1	1	21
TR	2, 3, 5	2	2	3	5	5	21
OT	1, 5	1	1	1	5	5	3

After the re-allocation process, the catches (in number), effort and length frequency samples were aggregated by Fishery, Assessment Area, year, and quarter. An example of the Input Table that was built for the assessments of yellowfin tuna with MF-CL can be found in **Appendix I**.

Main issues relating with the preparation of data for the assessments of YFT with MF-CL

i. Estimates of total catches

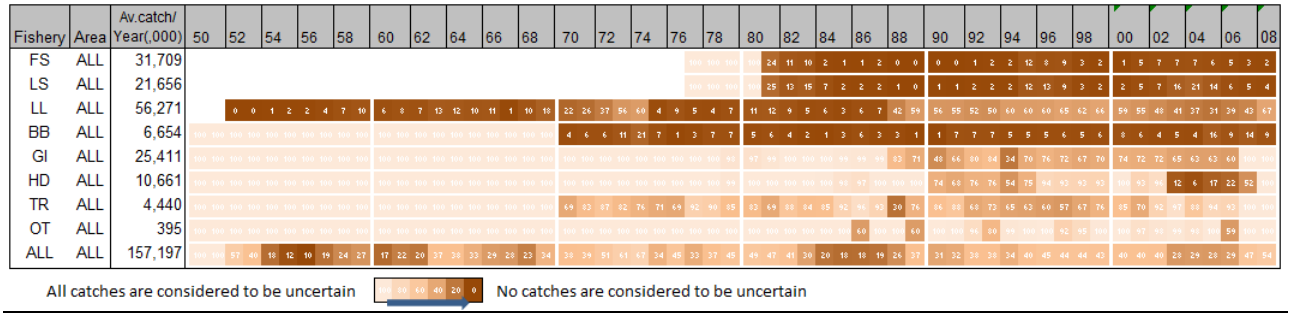
i. Catches in weight: The presumed quality of the time-area catches of yellowfin tuna estimated for the MF-CL assessment is shown in **Figure 3**. The quality of the catches estimated for the yellowfin tuna is thought to be fair to good for industrial fisheries (both purse seine and longline) and, since 1970, for the baitboat fishery. The time-area catches estimated for the remaining artisanal fisheries (gillnet, hand and troll lines and other artisanal fisheries) are thought to be compromised due to:

   a. Uncertain estimates of total catches due to missing or insufficient data collection and/or processing systems in some countries (Yemen, Comoros)

   b. Catches by quarter and/or fishing area not available (Iran, Sri Lanka, Pakistan, India, Indonesia)

   c. Uncertain estimates of catches by fishery: catches by gear not available, affecting especially handline and trolling fisheries

Figure 3: Proportion of time-area catches of yellowfin tuna that are thought to be uncertain, by fishery and year



ii. Catches in number: The numbers of yellowfin tuna caught are derived by using the catches in weight estimated by fishery, quarter and area and average weights estimated from the catch-at-size data for the same strata. Therefore, the estimation of numbers caught is compromised by the lack of samples for some fisheries, areas and periods (**Figure 4**, page 9), especially artisanal fisheries and longline fisheries in recent years.

ii. Quality of effort data

The quality of the effort data by fishery and time-area strata is compromised due to the following reasons:

i. Effort data not available: Effort data are not available from many fisheries, especially artisanal fisheries, and some longline fisheries and periods. In addition, the effort available for industrial purse seiners cannot be broken by fishery; thus, the effort recorded under free-school and associated-school fisheries represent the effort of the purse seine fleets as a whole.

ii. Use of different units of effort for a same fishery: number of fishing trips, number of days-at-sea and number of fishing hours has been indistinctly used as effort units for some artisanal fisheries. In general, it was assumed that, in the case of artisanal fisheries all were equivalent as all days at sea are generally fishing days and trips are usually one day long. However, this assumption needs to be confirmed for some artisanal fleets, for which there is grounds to believe that the fishing grounds exploited and trip durations may have been extended in recent years (gillnet fisheries of Iran, Sri Lanka and Pakistan and Maldivian pole-and-line fishery)

iii. Uneven coverage of effort among the fleets making up a fishery: The effort recorded for a particular fleet may represent the total effort exerted for that fleet or simply a sample of it. In addition, effort coverage levels may be different depending on the fleet, period or area concerned. Thus, the effort recorded for a fishery and time-area strata may be incomplete and effort coverage levels may be uneven throughout the data series. The effort in the MF-CL table represents simply the effort sampled for the fleets for which it is available.

iii. Quality of length frequency samples

Figure 4 shows the proportion that the numbers of yellowfin tuna sampled (or raised to the sampling unit) made out of the total numbers of yellowfin tuna caught, by fishery, year and area. The quality of the length frequency samples by fishery and time-area strata is compromised due to the following reasons:

i. Length frequency samples are not available for some fisheries and periods, including:

   a. Trolling fisheries from area 2 and area 3 and other fisheries from area 1: length samples are not available at all throughout the entire catch series.

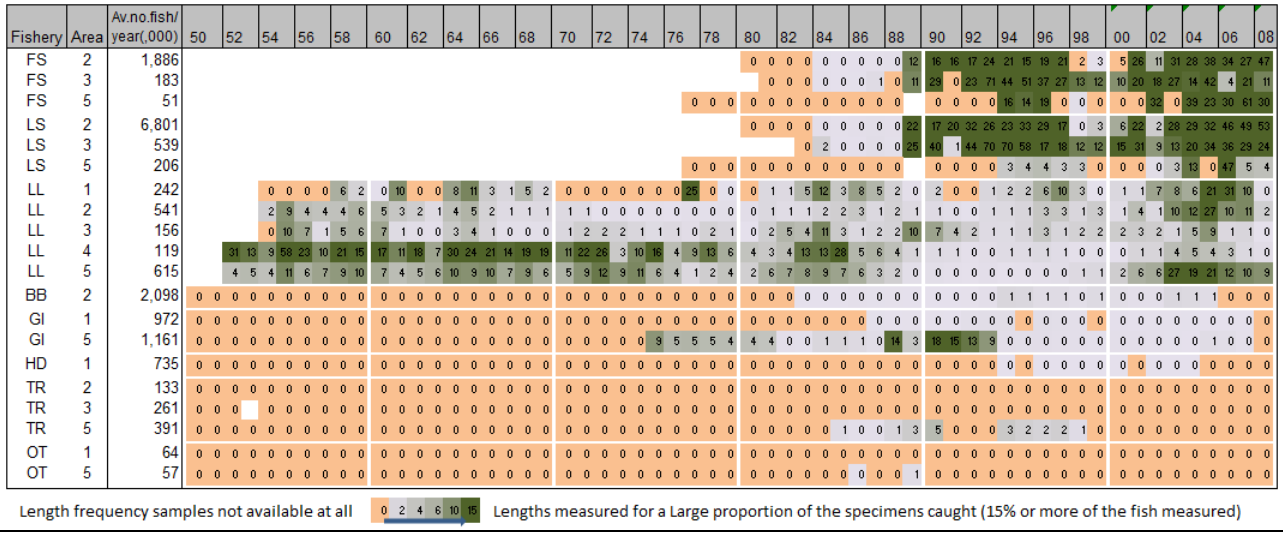
   b. All Handline, Baitboat and Gillnet fisheries and Trolling and Other fisheries from area 5: length samples are only available for some periods, representing a very small proportion of the catches in most cases.

   c. Purse seine and longline fisheries for some areas and periods

ii. Number of fish sampled unknown: The length frequency data available for European, Seychelles and assimilated purse seiners refer to the total number of fish in the sampling units that were sampled, not representing the actual sample numbers, as it is the case with all other fleets. The amount of fish that is actually sampled for purse seiners may range between 4-20% of the number recorded in the length samples, depending on the proportion of specimens of small size or large size within the sampling units. In addition, the length frequency data available for the Sri Lankan fisheries in some periods had been raised to the catches in the stratum, not representing the actual sample numbers. The number of fish sampled was estimated by dividing the number of fish recorded under each length class by the minimum interval obtained between consecutive length classes for the samples concerned.

Figure 4: Yellowfin tuna: availability of length frequency samples, by fishery, area, and year.

- **Industrial purse seine fisheries (FS; LS): Proportion that the total number of yellowfin tuna estimated in sampling units having been sampled made out of the total numbers of yellowfin tuna caught**
- **Other fisheries (LL; BB; GI; HD; TR; OT): Proportion that the total number of yellowfin tuna sampled made out of the total numbers of yellowfin tuna caught**



iii. Uneven coverage of length samples among the fleets making up a fishery: The length samples recorded for a fishery represent simply the lengths from the fleets for which samples are available while the amount of fleets from which samples are available and the sample coverage levels may have changed depending on the fleet or time-area covered. This is believed to be a problem in the following cases:

   a. Longline fisheries: the contribution that the samples from the different fleets has made to the length frequency distributions derived for the longline fishery has changed significantly over the time-series:

      i. 1952 to 1979: Length samples were only available from Japanese longliners, even though longliners from Taiwan,China operated through the majority of this period (since 1954)

      ii. 1980 to mid-1990's: Length samples available from Japan and Taiwan,China; changing numbers of specimens covered through sampling over the total number of specimens caught for this period, depending

on the fleet; Taiwan,China tends to catch yellowfin tuna specimens of smaller size than those caught by Japan.

iii. Mid-1990's to date: Length samples are available from other fleets; the amount of specimens sampled by Japan decreased considerably during this period; large number of yellowfin tuna specimens measured for the fresh-tuna longline fisheries of Indonesia and Taiwan,China (OFCF sampling); Taiwan,China tends to catch yellowfin tuna specimens of smaller size than those caught by Japan.

b. Gillnet, handline and trolling fisheries: Length samples are only available from selected fleets and periods.

In consequence, the length distributions that are derived for the above fisheries and periods are not considered to be representative of those fisheries as a whole.

Changes proposed in the preparation of data for future assessments with MF-CL

The following changes are suggested in the preparation of data for future assessments of yellowfin tuna with MF-CL:

i. Use of catches in weight: The current MF-CL assessments have been conducted using catches in number; considering the uncertainties with regards to the estimation of catches in number (referred to in the previous section), alternative assessments using catches in weight are recommended in the future.

ii. Weighting the existing effort samples by fleet prior to the aggregation of effort under each fishery: The efforts in the MF-CL were built by aggregating the effort samples for the fleets under each fishery, irrespective of the sampling coverage levels for the fleets involved; the estimation of total effort may be improved by weighting the sampled effort by fleet prior to the aggregation of total efforts under each fishery.

iii. Weighting the effort (from above) by the total catches in the stratum concerned: The effort available under each fishery represents simply the effort for the fisheries for which catch-and-effort data are available; the amount of fisheries for which no effort data are available has been uneven over time meaning that the MF-CL effort series for a particular fishery may be misleading; initially, the effort available could be weighted to represent the effort for all the fleets within a fishery.

iv. Weighting all length frequency distributions by the actual sample numbers: The length frequency distributions for purse seiners represent the total number of specimens within the sampling units selected while the length frequency distributions for other fleets represent the actual sample numbers; initially the length frequency distributions for purse seiners could be weighted by the real sample numbers in each stratum.

v. Weighting the existing length samples by fleet prior to the aggregation of samples under each fishery: The length distributions in the MF-CL were built by aggregating the length samples for the fleets under each fishery, irrespective of the sampling coverage levels for the fleets involved; the estimation of length distributions may be improved by weighting the lengths sampled by fleet prior to the aggregation of lengths for the fleets making up a fishery.

APPENDIX I
MF-CL Input Table

Year	The year where the catches were made
Quarter	The quarter where the catches were made (Jan-Mar(1), Apr-Jun(2), Jul-Sep(3), Oct-Dec(4))
FisheryCode	Type of fishery (FS; LS; LL; GI; HD; TR; OT)
AssessmentArea	The areas used for the assessment (1; 2; 3; 4; 5)
Catch	Total catch estimated (in numbers of fish)
Effort	Available fishing effort
C001…C150	Number of yellowfin tuna measured (sampled) by length class, using 10cm as the first class(lower bound) and 2cm intervals
C001	Number of YFT specimens having a fork length between 10cm and 12cm
C002	Number of YFT specimens having a fork length between 12cm and 14cm
	And so forth

APPENDIX II

Fleets whose catches, effort and length samples were fully allocated to specific Assessment Areas

cdeGear	cdeFleet	cdeFishery	MFCLArea	RealArea
BBM	MDV	BB	2	2
BB	AUS	BB	2	4
BBPS	AUS	BB	2	4
BB	EGY	BB	2	1
BB	IDN	BB	2	5
BB	IND	BB	2	99
BB	KOR	BB	2	3
BB	LKA	BB	2	5
BB	MDG	BB	2	3
BB	MDV	BB	2	2
BBN	MDV	BB	2	2
BB	TZA	BB	2	2
BB	ESP	BB	2	2
GILL	SYC	GI	1	2
GILL	TMP	GI	5	5
GILL	THA	GI	5	5
GILL	OAT	GI	1	1
GILL	YEM	GI	1	1
GILL	IDN	GI	5	5
GILL	MYS	GI	5	5
GILL	ARE	GI	1	1
GILL	EGY	GI	1	1
GILL	BHR	GI	1	1
GILL	TZA	GI	1	2
GILL	ERI	GI	1	1
GILL	TWN	GI	5	4
GIHA	OMN	GI	1	1
GILL	BGD	GI	5	5
GILL	OMN	GI	1	1
GILL	PAK	GI	1	1
GILL	KWT	GI	1	1
GILL	IRN	GI	1	1
GILL	ISR	GI	1	1
GILL	IOR	GI	1	1
GILL	KEN	GI	1	2
GILL	SDN	GI	1	1
GILL	SAU	GI	1	1
GILL	IND	GI	99[6]	99
G/L	LKA	GI	5	5
GILL	LKA	GI	5	5
GIOF	LKA	GI	5	5
GILL	AUS	GI	5	4
GILL	DJI	GI	1	1
HAND	MYS	HD	1	5
LLHA	LKA	HD	1	5
LLCO	SAU	HD	1	1
HAND	SAU	HD	1	1
HAND	COM	HD	1	3
HAND	MDV	HD	1	2
HAND	KEN	HD	1	2
HAND	IND	HD	1	99
HAND	LKA	HD	1	5
LL	LKA	HD	1	5
LLF	IDN	HD	1	5
HAND	GBRT	HD	1	2
HAND	IDN	HD	1	5
HAND	OMN	HD	1	1
LLCO	MDV	HD	1	2
HAND	EGY	HD	1	1
LLCO	MYS	HD	1	5
HAND	FRAT	HD	1	3
LL	EGY	HD	1	1
HAND	IRN	HD	1	1
LLCO	IDN	HD	1	5
HAND	ARE	HD	1	1
GIHT	YEM	HD	1	1
HAND	TZA	HD	1	2
HAND	YEM	HD	1	1
HAND	SYC	HD	1	2
HATR	YEM	HD	1	1
HAND	AUS	HD	1	4
HAND	BGD	HD	1	5
HAND	TMP	HD	1	5
HAND	ZAF	HD	1	3
HAND	BHR	HD	1	1
UNCL	ARE	OT	1	1
HATR	BHR	OT	1	1
HOOK	BHR	OT	1	1
UNCL	COM	OT	1	3
HOOK	IND	OT	99	99
TRAW	AUS	OT	5	4
TRAW	BLZ	OT	1	2
PSS	IND	OT	99	99
TRAW	IND	OT	99	99
UNCL	IND	OT	99	99
TRAW	BHR	OT	1	1
HATR	IND	OT	99	99
LIGB	IDN	OT	5	5
LIFT	IND	OT	99	99

cdeGear	cdeFleet	cdeFishery	MFCLArea	RealArea
BS	IDN	OT	5	5
SEN	AUS	OT	5	4
SPOR	AUS	OT	5	4
FN	IDN	OT	5	5
SPOR	GBRT	OT	1	2
HATR	FRAT	OT	1	3
HOOK	AUS	OT	5	4
TRAW	BGR	OT	1	2
TRAW	ERI	OT	1	1
UNCL	BGR	OT	1	2
HATR	AUS	OT	5	4
UNCL	EGY	OT	1	1
TRAW	EGY	OT	1	1
PS	EGY	OT	1	1
PSS	IDN	OT	5	5
TRAP	AUS	OT	5	4
UNCL	IDN	OT	5	5
UNCL	AUS	OT	5	4
DSEI	IDN	OT	5	5
LIFT	IDN	OT	5	5
UNCL	SUN	OT	1	2
UNCL	MYS	OT	5	5
BS	OMN	OT	1	1
CN	OMN	OT	1	1
FN	OMN	OT	1	1
OTHER	IOR	OT	1	1
OTHER	TZA	OT	1	2
TRAP	OMN	OT	1	1
UNCL	OMN	OT	1	1
PSS	SAU	OT	1	1
TRAP	SAU	OT	1	1
TRAW	SAU	OT	1	1
UNCL	SAU	OT	1	1
TRAW	MYS	OT	5	5
PSS	SUN	OT	1	1
PSS	TZA	OT	1	2
UNCL	SYC	OT	1	2
PSS	THA	OT	5	5
TRAW	THA	OT	5	5
UNCL	THA	OT	5	5
HATR	TMP	OT	5	5
UNCL	TMP	OT	5	5
UNCL	TZA	OT	1	2
UNCL	YEM	OT	1	1
HOOK	ZAF	OT	1	3
SPOR	ZAF	OT	1	3
UNCL	ZAF	OT	1	3
UNCL	SDN	OT	1	1
UNCL	JPN	OT	1	2
RIN	LKA	OT	5	5
TRAP	MYS	OT	5	5
PSS	MYS	OT	5	5
UNCL	LKA	OT	5	5
HOOK	MYS	OT	5	5
UNCL	ISR	OT	1	1
UNCL	MDV	OT	1	2
UNCL	IOR	OT	1	1
HATR	LKA	OT	5	5
HARP	LKA	OT	5	5
BS	LKA	OT	5	5
UNCL	KEN	OT	1	2
FN	MDV	OT	1	2
TROL	IOR	TR	2	1
TROL	YEM	TR	2	1
TROL	MUS	TR	3	4
TROL	TZA	TR	2	2
TROL	IND	TR	5	99
TROL	AUS	TR	5	4
TROL	IRN	TR	2	1
TROL	MYS	TR	5	5
TROL	FRAT	TR	3	3
TROL	ARE	TR	2	1
TROL	FRA-	TR	3	4
TROL	ISR	TR	2	1
TROL	BHR	TR	2	1
TROL	TMP	TR	5	5
TROLN	MDV	TR	2	2
TROLM	MDV	TR	2	2
TROL	KEN	TR	2	2
TROL	MDV	TR	2	2
TROL	LKA	TR	5	5
TROL	SYC	TR	2	2
TROL	OMN	TR	2	1
TROL	COM	TR	3	3
TROL	SAU	TR	2	1
TROL	IDN	TR	5	5
TROL	MDG	TR	3	3
TROL	EGY	TR	2	1

[6] Area 99: Catches, effort and length samples in the Western Indian Ocean assigned to Area 1 and those in the Eastern Indian Ocean assigned to Area 5

APPENDIX III

Fleets making up the Fisheries selected for the assessment

Purse seine (PS)

Fishery	Fleet	Gear
PS	AUS	PS
PS	BGR	PS
PS	BLZ	PS
PS	ESP	PS
PS	FRA	PS
PS	FRAT	PS
PS	IRN	PS
PS	JPN	PS
PS	MUS	PS
PS	MYS	PS
PS	NEI-OTH	PS
PS	NEI-SUN	PS
PS	SUN	PS
PS	SYC	PS
PS	THA	PS

Longline (LL)

Fishery	Fleet	Gear
LL	AUS	ELL
LL	BLZ	FLL
LL	BLZ	LL
LL	CHN	FLL
LL	CHN	LL
LL	ESP	ELL
LL	FRA-REU	ELL
LL	FRAT	ELL
LL	GBR	ELL
LL	GIN	ELL
LL	IDN	LL
LL	IDN	FLL
LL	IND	FLL
LL	IND	LL
LL	IND	LLEX
LL	IRN	LL
LL	JPN	LL
LL	KEN	ELL
LL	KOR	LL
LL	LKA	FLL
LL	MDG	ELL
LL	MDG	LL
LL	MDV	FLL
LL	MUS	ELL
LL	MUS	LL
LL	MYS	FLL
LL	NEI-DFRZ	ELL
LL	NEI-DFRZ	LL
LL	NEI-DFRZ	TLL
LL	NEI-ICE	FLL
LL	NEI-IDN	FLL
LL	OMN	FLL
LL	OMN	LL
LL	PAK	LL
LL	PHL	LL
LL	PRT	ELL
LL	PRT	LL
LL	PRT	LLD
LL	PRT	SLL
LL	SEN	ELL
LL	SUN	LL
LL	SYC	ELL
LL	SYC	LL
LL	THA	FLL
LL	THA	LL
LL	TWN	FLL
LL	TWN	LL
LL	TZA	ELL
LL	URY	ELL
LL	ZAF	LL
LL	ZAF	SLL
LL	ZAF	TLL

Pole-and-line (BB)

Fishery	Fleet	Gear
BB	AUS	BB
BB	AUS	BBPS
BB	EGY	BB
BB	ESP	BB
BB	IDN	BB
BB	IND	BB
BB	KOR	BB
BB	LKA	BB
BB	MDG	BB
BB	MDV	BB
BB	MDV	BBM
BB	MDV	BBN
BB	TZA	BB

Gillnet (GI)

Fishery	Fleet	Gear
GI	ARE	GILL
GI	AUS	GILL
GI	BGD	GILL
GI	BHR	GILL
GI	DJI	GILL
GI	EGY	GILL
GI	ERI	GILL
GI	IDN	GILL
GI	IND	GILL
GI	IRN	GILL
GI	ISR	GILL
GI	JOR	GILL
GI	KEN	GILL
GI	KWT	GILL
GI	LKA	G/L
GI	LKA	GILL
GI	LKA	GIOF
GI	MYS	GILL
GI	OMN	GIHA
GI	OMN	GILL
GI	PAK	GILL
GI	QAT	GILL
GI	SAU	GILL
GI	SDN	GILL
GI	SYC	GILL
GI	THA	GILL
GI	TMP	GILL
GI	TWN	GILL
GI	TZA	GILL
GI	YEM	GILL

Handline (HD)

Fishery	Fleet	Gear
HD	ARE	HAND
HD	AUS	HAND
HD	BGD	HAND
HD	BHR	HAND
HD	COM	HAND
HD	EGY	HAND
HD	EGY	LL
HD	FRAT	HAND
HD	GBRT	HAND
HD	IDN	HAND
HD	IDN	LLCO
HD	IDN	LLF
HD	IND	HAND
HD	IRN	HAND
HD	KEN	HAND
HD	LKA	HAND
HD	LKA	LL
HD	LKA	LLHA
HD	MDV	HAND
HD	MDV	LLCO
HD	MYS	HAND
HD	MYS	LLCO
HD	OMN	HAND
HD	SAU	HAND
HD	SAU	LLCO
HD	SYC	HAND
HD	TMP	HAND
HD	TZA	HAND
HD	YEM	GIHT
HD	YEM	HAND
HD	ZAF	HAND

Trolling (TR)

Fishery	Fleet	Gear
TR	ARE	TROL
TR	AUS	TROL
TR	BHR	TROL
TR	COM	TROL
TR	EGY	TROL
TR	FRA-REU	TROL
TR	FRAT	TROL
TR	IDN	TROL
TR	IND	TROL
TR	IRN	TROL
TR	ISR	TROL
TR	JOR	TROL
TR	KEN	TROL
TR	LKA	TROL
TR	MDG	TROL
TR	MDV	TROL
TR	MDV	TROLM
TR	MDV	TROLN
TR	MUS	TROL
TR	MYS	TROL
TR	OMN	TROL
TR	SAU	TROL
TR	SYC	TROL
TR	TMP	TROL
TR	TZA	TROL
TR	YEM	TROL

Other gears (OT)

Fishery	Fleet	Gear
OT	ARE	UNCL
OT	AUS	HATR
OT	AUS	HOOK
OT	AUS	SEN
OT	AUS	SPOR
OT	AUS	TRAP
OT	AUS	TRAW
OT	AUS	UNCL
OT	BGR	TRAW
OT	BGR	UNCL
OT	BHR	HATR
OT	BHR	HOOK
OT	BHR	TRAW
OT	BLZ	TRAW
OT	COM	UNCL
OT	EGY	PS
OT	EGY	TRAW
OT	EGY	UNCL
OT	ERI	TRAW
OT	FRAT	HATR
OT	GBRT	SPOR
OT	IDN	BS
OT	IDN	DSEI
OT	IDN	FN
OT	IDN	LIFT
OT	IDN	LIGB
OT	IDN	PSS
OT	IDN	UNCL
OT	IND	LIFT
OT	IND	HATR
OT	IND	HOOK
OT	IND	PSS
OT	IND	TRAW
OT	IND	UNCL
OT	ISR	UNCL
OT	JOR	OTHER
OT	JOR	UNCL
OT	JPN	UNCL
OT	KEN	UNCL
OT	LKA	BS
OT	LKA	HARP
OT	LKA	HATR
OT	LKA	RIN
OT	LKA	UNCL
OT	MDV	FN
OT	MDV	UNCL
OT	MYS	HOOK
OT	MYS	PSS
OT	MYS	TRAP
OT	MYS	TRAW
OT	MYS	UNCL
OT	OMN	BS
OT	OMN	CN
OT	OMN	FN
OT	OMN	TRAP
OT	OMN	UNCL
OT	SAU	PSS
OT	SAU	TRAP
OT	SAU	TRAW
OT	SAU	UNCL
OT	SDN	UNCL
OT	SUN	PSS
OT	SUN	UNCL
OT	SYC	SUPP
OT	SYC	UNCL
OT	THA	PSS
OT	THA	TRAW
OT	THA	UNCL
OT	TMP	HATR
OT	TMP	UNCL
OT	TZA	OTHER
OT	TZA	PSS
OT	TZA	UNCL
OT	YEM	UNCL
OT	ZAF	HOOK
OT	ZAF	SPOR
OT	ZAF	UNCL