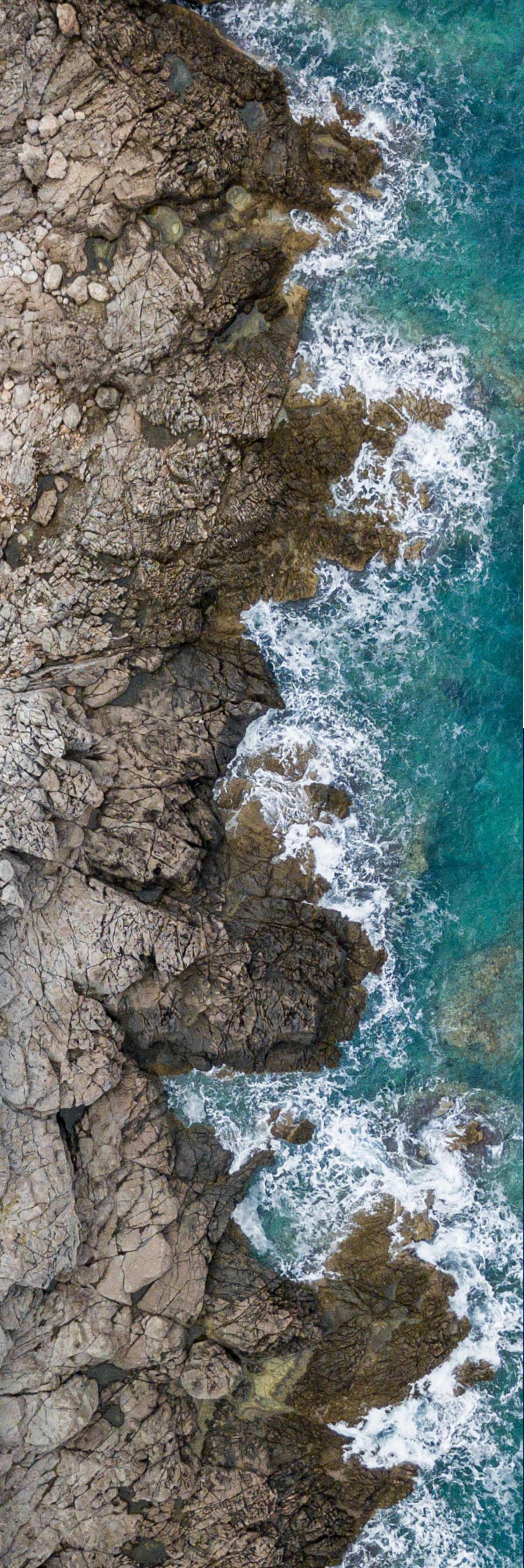

GLOBAL TUNA ALLIANCE

NAUNET Fisheries consultants

THIS REPORT HAS BEEN PREPARED BY NAUNET FISHERIES CONSULTANTS FOR THE GLOBAL TUNA ALLIANCE (GTA)

Developing management advice to rebuild the Indian Ocean yellowfin tuna (Thunnus albacares) stock in two generations

June 2020

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List of acronyms and abbreviations

B	Stock biomass (total)
Blim	Minimum biomass limit
BMSY	Biomass which produces MSY
CFP	Common Fisheries Policy
CI	Confidence interval
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting Parties and Cooperating Non-Contracting Parties
CPUE	Catch per Unit Effort
EEZ	Exclusive Economic Zone
EU	European Union
F	Fishing mortality
FAD	Fish Aggregation device
FAO	Food and Agriculture Organization of the United Nations
FL	Fork Length
Flim	Fishing mortality rate associated with the LRP (limit reference point)
FMSY	Fishing Mortality at MSY
FS	Free swimming (tuna) school
GLM	Generalised Linear Model
GTA	Global Tuna Alliance
HCR	Harvest Control Rule
HS	Harvest Strategy
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IO	Indian Ocean
IO	RTTP Indian Ocean Regional Tuna Tagging Programme
IOTC	Indian Ocean Tuna Commission
IOTC-SC	Indian Ocean Tuna Commission Scientific Committee
IOYFT	Indian Ocean Yellowfin Tuna
IPNLF	International Pole and Line Foundation
ISSF	International Seafood Sustainability Foundation
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unregulated and Unreported Fishing
K2SM	Kobe II Strategy Matrix
LDC(s)	Least Developed Countries
LOA	Length overall (of a vessel)
LRP	Limit Reference Point
LL	Longline
M	Natural Mortality

MEY	Maximum Economic Yield
MP	Management Procedure
MPA	Marine Protected Area
MSE	Management Strategy Evaluation
MSE	Management Strategy Evaluation
MVLN	Multivariate lognormal
MSY	Maximum Sustainable Yield
NGO	Non-Governmental Organization
OM	Operating Model
OT	Overseas Territory
PI	Performance Indicator
PRI	The (biomass) point where recruitment would be impaired (point of recruitment impairment)
PRP	Precautionary reference point
PS	Purse seine
PSA	Productivity Susceptibility Analysis
q	Catchability
RBC	Recommended Biological Catch
RFMO	Regional Fisheries management organisation
SB	Spawning Biomass
SSB	Spawning Stock Biomass
SSBMSY	Spawning Stock Biomass which produces MSY
SC	Scientific Committee
SE	Standard Error
SIDS	Small Island Developing States
SS3	Stock Synthesis III
SVE(s)	Small Vulnerable Economies
TAC	Total Allowable Catch
TAE	Total Allowable Effort
TCAC	Technical Committee on Allocation Criteria
TCMP	Technical Committee on Management Procedures
ToR	Terms of Reference
TRP	Target Reference Point
VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Commission
WP	Working Party of the IOTC
WPDCS	Working Party on Data Collection and Statistics of the IOTC
WPM	Working Party on Methods of the IOTC
WPTmT	Working Party on Temperate Tuna
WPTT	Working Party on Tropical Tunas of the IOTC
YFT	Yellowfin Tuna

Glossary of terms *(page 1)*

TERM	DEFINITION
CPUE	Catch per unit of fishing effort. Used as an index of stock abundance, where some relationship is assumed between that index and the stock size.
Fishing effort	Fishing effort is the amount of fishing gear of a specific type used on the fishing grounds over a given unit of time e.g. hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day.
FMSY	The fishing mortality rate that produces MSY.
Generation time	Generation time is defined by MSC as the average age of a reproductive individual in an unexploited stock.
Harvest Control Rule	A pre-agreed and well-defined rule or action(s) that describes how management should adjust management measures in response to the state of specified indicator(s) of stock status. This is described by a mathematical formula.
Kobe II Strategy Matrix	Scientific stock assessment advice given by the IOTC Scientific Committee is presented in the form of the Kobe II Strategy Matrix (K2SM). Traditionally the K2SM shows the probabilities by year for different catches of achieving the management objective of ensuring that the stock biomass is greater than BMSY and fishing mortality less than FMSY.
Kobe plot	A plot that shows the current stock status, or a trajectory over time for a fished population, with abundance on the horizontal axis and fishing mortality on the vertical axis. These are often shown relative to BMSY and FMSY, respectively. A Kobe plot is often divided into four quadrants by a vertical line at B=BMSY and a horizontal line at F=FMSY.
Management Objectives (Objectives)	The social, economic, biological, ecosystem, and political (or other) goals for a given management unit (i.e. stock). These typically conflict, and include concepts such as maximising catches over time, minimising the chance of unintended stock depletion, and enhancing industry stability through low inter-annual variability in catches. For the purposes of Management Strategy Evaluation (MSE) these objective need to be quantified in the form of performance statistics (see below).
Management Procedure	A management procedure has the same components as a harvest strategy. The distinction is that each component of a management procedure is formally specified, and the combination of monitoring data, analysis method, harvest Control Rule and management measure has been simulation tested to demonstrate adequately robust performance in the face of plausible uncertainties about stock and fishery dynamics.
Management Strategy Evaluation	A process whereby the performances of alternative harvest strategies are tested and compared using stochastic simulations of stock and fishery dynamics against a set of performance statistics developed to quantify the attainment of management objectives.
Maximum Sustainable Yield	The largest (typically annual) yield that can be taken continuously from a stock sustainably (i.e. without reducing its size). In real, and consequently stochastic situations, this is usually estimated as the largest average long-term yield that can be obtained by applying a constant fishing mortality F, where that F is denoted as FMSY. The highest theoretical equilibrium yield that can be continuously taken on average from a stock under existing environmental conditions without affecting significantly the reproduction process.
Management Strategy/Harvest Strategy	Some combination of monitoring, assessment, Harvest Control Rule and management action designed to meet the stated objectives of a fishery. Sometimes referred to as a 'Management Strategy'. A fully specified harvest strategy that has been simulation tested for performance and adequate robustness to uncertainties is often referred to as a 'Management Procedure'.

Glossary of terms *(page 2)*

Nominal catches	Total annual retained catches (in live weight and number), estimated per fleet, IOTC area, gear and year for a large area.
Operating model (s)	A mathematical–statistical model (usually models) used to describe the fishery dynamics in simulation trials, including the specifications for generating simulated resource monitoring data when projecting forward in time. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery. This usually refers to the combination of the generic projection software and suite of model specifications used to simulation test the performance of candidate MPs.
q	Catchability. It is defined as the relationship between the catch rate (CPUE) and the true population size (B).
Subsistence fishery	A subsistence fishery is a fishery where the fish caught are consumed directly by the families of the fishers rather than being bought by middle-(wo)men and sold at the next larger market (FAO).
SSBMSY	The equilibrium spawning biomass that results from fishing at FMSY. In the presence of recruitment variability. Fishing a stock at FMSY will result in a biomass that fluctuates above and below SSBMSY.
Total Allowable Catch	The catch quota set by an MP (it could be fishery-specific or the aggregate across fisheries, depending on context).
Total Allowable Effort	A fishery effort constraint set by an MP. In this context it is manifested as an effort multiplier applied to recent estimates of fishery-specific fishing mortality from an assessment model. For the simulation testing, there is an assumption that effort regulations will translate directly into fishing mortality regulations. In practice, it may be very difficult to define effort is such a way that this can be achieved.
Tuning	The process of adjusting values of control parameters of the Harvest Control Rule in a Management Procedure to achieve a single, precisely-defined performance statistic in a specified simulation test. This reduces confounding effects to allow the performance of different candidate MPs to be compared more readily with respect to other management objectives. For example, in the case of evaluating rebuilding plans, all candidate MPs might be tuned to meet the rebuilding objective for a specified simulation trial; then the focus of comparisons among MPs is performance and behaviour with respect to catch and CPUE dimensions.
Tuning objectives	The single highest priority performance objective that managers want to achieve (e.g. probability of rebuilding spawning biomass by year X) in the MSE process.

I. Executive Summary

The Global Tuna Alliance (GTA) is an independent group of retailers and supply-chain companies, working to ensure that tuna ultimately meets the highest standards of environmental performance and social responsibility.

The Indian Ocean Tuna Commission (IOTC), established in 1996 under Article XIV of the FAO Constitution, takes advice from the Scientific Committee (IOTC-SC) and its working parties for managing 16 species of tuna and tuna-like species in the Indian Ocean. One of such working groups is the Working Party on Tropical Tunas (WPTT), in charge of reviewing and analysing issues relevant to the fisheries and status of the three tropical tuna species (skipjack, bigeye and yellowfin tuna) under the IOTC mandate. The IOTC-WPTT carries out the stock assessment; the IOTC-SC reviews the stock assessment process and provides management advice to the Commission. Then it is up to the IOTC Commission to agree on the management measures to be taken based on the advice provided. The IOTC Secretariat facilitates the process.

Some GTA members source tuna from the Indian Ocean (IO). To comply with their sustainability commitments in 2020, the IO tuna stocks must be sustainably managed and rebuilding back to sustainable levels through recovery strategies based on sound scientific advice and the application of precautionary management. Should an agreement between member states, in line with advice from the scientific committee, prove impossible in 2020, then individual supply-chain members will be forced to re-evaluate their purchasing decisions.

However, the most recent stock assessment of the Indian Ocean yellowfin tuna (Thunnus albacares) stock (IO YFT henceforth) concluded that based on the available data, the stock was overfished and subject to overfishing. Although the IOTC-SC did not provide explicit scientific catch advice at that time due to several issues with assessment model used, it was agreed that a reduction in total catches was necessary to avoid overfishing the stock and to allow it to recover to sustainable levels. However, several resolutions recently adopted by the Commission to reduce the YFT catch and thus allow its rebuilding have not been adequately implemented and have fallen short in their objectives. This failure has resulted in increased catches in recent years, putting the stock at risk of collapse and preventing the implementation of the objectives set in the Tuna 2020 Traceability Declaration[1].

Naunet Fisheries Consultants was commissioned by the GTA to develop management advice for the Indian Ocean yellowfin tuna that would rebuild the stock in two generations. In order to meet the assignment, a desk-based study was undertaken. Relevant reports have been consulted and a series of interviews with stock assessment experts, fisheries managers, NGO representatives and other stakeholders have been held. Major concerns for the stock assessment are the uncertainties in data inputs (reported nominal catch data, CPUE indices, size-frequency data, tagging data, etc.) and stock assessment model assumptions (stock distribution, growth, natural mortality, maturity at size/age, steepness of the stock-recruitment relationship) which jeopardise the stock assessment results.

Based on the findings, a series of recommendations are given:

- Firstly, a harvest management strategy, or in this case, a rebuilding plan that will rebuild the YFT stock to SSBMSY in two generations is proposed. The information provided by several IOTC scientific groups suggests that major catch reductions of between 20% and 35% relative to 2017 would be necessary to recover the stock. This notion is shared by the majority of the experts interviewed.
- Furthermore, urgent measures to reduce current fishing mortality are necessary as, if no measures are taken, scientific data presented in the IOTC in 2018 indicates that the YFT stock could collapse as early as 2024. Specific catch reductions by fishery/fleet segment are then suggested to meet this overall objective and ensure the effectiveness and equitability of these catch reductions.
- Finally, a range of complementary management measures which would help to achieve the objective of recovering the stock to sustainable levels are discussed.

[1] The Tuna 2020 Traceability Declaration is a non-legally binding declaration born under the UN Sustainable Development Goal (SDG) 14, whose main goal is to prevent unsustainable managed and/or illegally fished tuna from entering the market.

In short, to achieve the objective of rebuilding the IO YFT stock to MSY levels within two generation times, our main conclusions are as follows:

1) Adoption of one of the three proposals for catch reduction presented in Section VIII for implementation by the IOTC. Based on the stock synthesis assessment Kobe II Strategy Matrix (K2SM) provided for yellowfin tuna in the 21st session of the IOTC Scientific Committee, we consider that a catch reduction of 25% relative to the catch in the year 2017 is necessary for recovering the stock. This measure should be agreed at the 24th session of the IOTC Commission scheduled for November 2020 and implemented no later than January 2021.

2) The adoption of the catch reduction proposal must be accompanied by the end of the explicit exemption for fleets below 24m LOA fishing within EEZs. The exemption should only apply to vessels ≤12 m LOA; i.e. only subsistence fisheries would be exempt from this measure. All fishing fleets composed of vessels larger than 12 m LOA must abide with the catch reduction scheme regardless of their fishing grounds. The sole criteria for identifying whether a fleet is subject to the reduction scheme should be whether its catch reaches the threshold suggested in the chosen catch reduction scheme.

3) The implementation of seasonal and spatial closures. Given that output controls have not been effective so far, and as a complementary measure for reducing the catch of YFT, we recommend the establishment of one (or several) fishery closures, which might include one or more spatial closures in specific areas where the catch of immature tuna is concentrated. Several options are given in Section X.

4) Monitoring and enforcement must be effective. IOTC's responsibility is to ensure that each CPC fulfils its obligations. An effective system of sanctions for repeated non-compliance by CPCs should be established.

5) Improving data collection and inputs into the stock modelling. Currently the stock assessment presents several weaknesses associated with the quality of the data collected and fed into the stock model. Data collection and inputs to the model need to be improved in several areas, such as tagging programmes, excessive reliance on longline data, etc.

It is important to highlight that this project requires management measures aiming to recover the stock to be implemented no later than 2021, which makes very difficult the implementation of new measures not previously tested for the yellowfin tuna stock in the IOTC area. We consider the implementation of an overall catch reduction, as an emergency measure which needs to be approved as soon as possible in order to recover the stock in the expected framework. The approval of other complementary management measures (such as area closures, TACs, etc.) would follow afterwards and as indicated, they are supplementary measures which will help to recover the stock, but they are not intended to substitute the catch reduction scheme

II. Preface: project goals

The aim of this project as described in the Terms of Reference (ToR) by the GTA is: "to develop management advice for Indian Ocean yellowfin tuna (Thunnus albacares) that would rebuild the stock in two generations". This objective refers to the wording used by the Marine Stewardship Council (MSC) standard v.2.1 in PI 1.1.2 (Stock rebuilding). Therefore, first of all, it is necessary to clarify what is meant in the MSC standard by "rebuilding" and "two generations", so that the objectives of this consultancy are clear in terms of rebuilding level and timeframe.

In Principle 1 of the MSC standard v2.1, when assessing the "Stock status" (Performance Indicator (PI) 1.1.1, see Table 1 below), the scoring issue (a) SG60 indicates: "It is likely that the stock is above the point where recruitment would be impaired (PRI)". The guidance (SA 2.2.1) further indicates: "In P1 the terms "likely", "highly likely" and "high degree of certainty" are used to allow for either qualitative or quantitative evaluation. In a probabilistic context and in relation to scoring issue: (a) Likely means greater than or equal to the 70th percentile of a distribution (i.e., there shall be at least a 70% probability that the true status of the stock is higher than the point at which there is an appreciable risk of recruitment being impaired)".

In PI 1.1.1 the scoring issue (b) SG80 indicates: "The stock is at or fluctuating around a level consistent with MSY".

Table 1: PI 1.1.1 Stock status PISGs (Table SA1 of the MSC standards v2.0)

Component	PI	Scoring issues	SG60	SG80	SG100
Outcome	Stock status 1.1.1 The stock is at a level which maintains high productivity and has a low probability of recruitment overfishing.	**(a)** Stock status relative to recruitment impairment	It is **likely** that the stock is above the point where recruitment would be impaired (PRI)	It is **highly likely** that the stock is above the PRI	There is a **high degree of certainty** that the stcok is above the PRI
		(b) Stock status in relation to achievement of Maximum Sustainable Yield (MSY)		The stock is at or fluctuating around a level consistent with MSY	There is a **high degree of certainty** that the stock has been fluctuating around a level consistent with MSY or has been above this level over recent years

In the case of IO YFT, based on the stock projections shown in the 2018 SC report (IOTC–2018–SC21–R[E]), it is likely that the stock in 2020 is over the PRI (defined in this case as Blim) as P(SSB < SSBlimit(0.4SSBMSY)) = 0.23, which corresponds to a 77% probability of being above SSBlimit (thus higher than the 70% value indicated by the MSC). Therefore, the stock would reach the 80 score for the scoring issue 1.1.1a. However, it cannot be considered that the stock is at or fluctuating around a level consistent with MSY, as the stock is in the Kobe quadrant's red zone (see the stock status section, Section IV, for more information) and it does not meet the 80 score for scoring issue 1.1.1b. Therefore, as the MSC guidance indicates, when PI 1.1.1 does not achieve an 80 score at both scoring issues, PI 1.2.2 (stock rebuilding) must be scored.

In PI 1.2.2 (Stock rebuilding, see Table 2 below), scoring issue (a) "Rebuilding timeframes" indicates: "A rebuilding timeframe is specified for the stock that is the shorter of 20 years or two times its generation time [...]". MSC further provides guidance as to how to estimate generation time in Box GSA4. The MSC defines a generation time as the average age of a reproductive individual in an unexploited stock, consistent with the definition in (Goodyear 1995)".

1)

$$G=\frac{\sum_{a}^{A}-1\ aEaNa}{\sum_{a}^{A}-1\ EaNa}$$

where a is age, A is the oldest age in an unfished state, Ea is the maturity at age a, and Na is the number per recruit alive at age a in the absence of fishing, i.e.,

2) $$Na=N_0e^{-Ma}$$

where M is natural mortality and No =1 (per recruit).

A reasonable approximation for GT, when 0.1 ≤ M ≤ 2 is

3) $$1/M+A_{m50}$$

where Am50 is the age at 50% maturity.

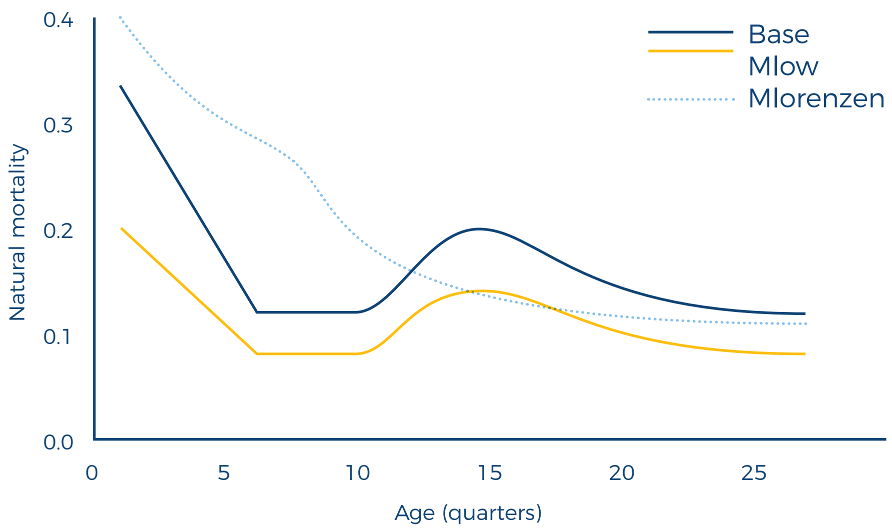
Natural mortality is variable with age. In the case of the Indian Ocean yellowfin tuna IO YFT, the values of M used in the 2018 stock assessment of the yellowfin tuna are shown in Figure 1 below (Fu et al. 2018b, IOTC–2018–WPTT20–33). They varied between 0.1 and 0.3 depending on the age of the fish. However, this value is much lower than the natural mortality used by the ICCAT for the same species, which assumes it to be 0.8 for ages 0 and 1, and 0.6 for ages 2+ (ICCAT 2015).

Other studies using tagging data (Bousquet 2012, Urtizberea et al. 2019) calculate a natural mortality for yellowfin tuna in the Indian Ocean between 0.4 and 0.67, in line with the value of M used by the ICCAT for this species.

Table 2 PI 1.1.2 Stock rebuilding PISGs (Table SA3 of the MSC standards v2.0)

Component	PI	Scoring issues	SG60	SG80	SG100
Outcome	Stock rebuilding **1.1.2** Where the stock is reduced, there is evidence of stock rebuilding within a specified timeframe	**(a)** Rebuilding timeframes	A rebuilding timeframe is specified for the stock that is the **shorter of 20 years or 2 times its generation time.** For cases where 2 generations is less than 5 years, the rebuilding timeframe is up to 5 years		The shortest practicable rebuilding timeframe is specified which does not exceed **one generation time** for the stock
		(b) Rebuilding evaluation	Monitoring is in place to determine whether the rebuilding strategies are effective in the rebuilding the stock within the specified timeframe	There is **evidence** that the rebuilding strategies are rebuilding stocks, or **it is likely** based on simulation modelling exploitation rates or previous performance that they will be able to rebuild the stock within **the specified timeframe**	There is **strong evidence** that the rebuilding strategies are rebuilding stocks or it is **highly likely** based on simulation modelling exploitation rates or previous performance that they will be able to rebuild the stock within the **specified timeframe**

Figure 1 The age-specific natural mortality schedule assumed for the assessment model (Base) and other age-specific M schedules from various model options in the IOTC YFT tuna assessment (Fu et al., 2019 IOTC–2018–WPTT20–33).



In both cases, the approximation provided by the MSC guidance can be used to calculate generation time. The age at 50% maturity Am50 is assumed to be around 3-5 years for females and males (IOTC 2017, ICCAT 2015).

Therefore, using a range of M values between 0.4 and 0.6 and a 50% maturity (Am50) between 3 and 5, **the generation time from the IO YFT would range between 4.7 and 7.5 years and two generation times would thus correspond to a value between 9.4 and 15 years,** which is in line with the available literature (Brown 1995, ICCAT 2019) . As a precautionary approach we will use the value in the lower boundary. Therefore, **we consider that this initiative aims to have the stock of IO YFT rebuilt to MSY levels before 2029/2030 (9 years from 2020/2021).**

Finally, it is important to note that the MSC standard not only aims at rebuilding the stocks, but as is also indicated in PI 1.2.1 (Harvest Strategy), it is expected that the Harvest Strategy in place will achieve the management objectives reflected in PI 1.1.1 SG80, which refer to keeping the stock *"fluctuating around a level consistent with MSY"* (the MSC guidance further explains (GS2.2.2) that the level of fluctuation cannot go below the 90% BMSY value). Therefore, the aim of this project is to provide management advice not just to rebuild the stock of YFT at MSY levels before 2029/2030, but also **keeping the stock at around that level afterwards.**

III. Analysis of available stock assessments of Indian Ocean YFT: *current stock status and trends*

The IOTC was established in 1996 under Article XIV of the FAO Constitution. It manages 16 tuna and tuna-like species in the Indian Ocean based on the scientific advice provided by the Scientific Committee (SC). The IOTC's primary objective is the conservation and optimum utilisation of the stocks for long-term sustainability (ISSF 2018).

Since 2013 (Resolution 13/01 superseded by Resolution 15/01), the IOTC has adopted interim target and limit reference points (TRPs and LRPs, respectively) for the three tropical tuna species, albacore and swordfish based on MSY-related reference points, and requires stock status to be reported against these species-specific reference points. The reference points currently in place for the YFT are shown in Table 3 below.

Table 3 Target and limit reference points for tropical tuna and swordfish in the Indian Ocean (Resolution 16/09).

Stock	Target ref. point	Limit ref. point
Albacore Yellowfin tuna Swordfish	BTARGET=BMSY FTARGET=FMSY	BLIM=0.40 BMSY FLIM=1.40 FMSY
Bigeye tuna	BTARGET=BMSY FTARGET=FMSY	BLIM=0.50 BMSY FLIM=1.30 FMSY
Skipjack tuna	BTARGET=BMSY FTARGET=FMSY	BLIM=0.40 BMSY FLIM=1.50 FMSY

Stock assessments are usually conducted every three years (although it depends on status of the stock and uncertainty of the assessment) by the Contracting Party and Cooperating Non-Contracting Party (CPCs) national scientists, the results agreed in the species' pertinent working parties and endorsed in the meetings of the Scientific Committee. The stocks are considered to be overfished if the biomass falls below the target (BMSY), and "subjected to overfishing" if the fishing mortality is above the target (FMSY).

As shown in Fig. 2, prior to 1990 exploitation rates of yellowfin tuna in the Indian Ocean were low and adult biomass remained well above SSBMSY. In the early 1990s F/FMSY increased and biomass levels declined before stabilising during the mid-1990s/early 2000s. Overall fishing mortality rates increased sharply in 2005 in line with the large increase in catches during 2004/2005, which peaked at over 500,000 t. Adult biomass declined considerably in the following years due to a period of very low recruitment between 2004 and 2006 and declined below the SSBMSY level in 2008. The stock recovered during the period 2009-2012 before declining below the SSBMSY level again in 2015-2017 (Fu et al., 2018a, OTC–2018–WPTT20–33).

[2] Collette et al. 2011, indicate lower generation times for yellowfin tuna of around 2.2 and 3.5, although it is unclear where this data is coming from, as the original report does not include any reference to this species. [3] A robust and precautionary harvest strategy in place would be an essential requirement for this stock to have any possibility of being certified under the MSC standard.

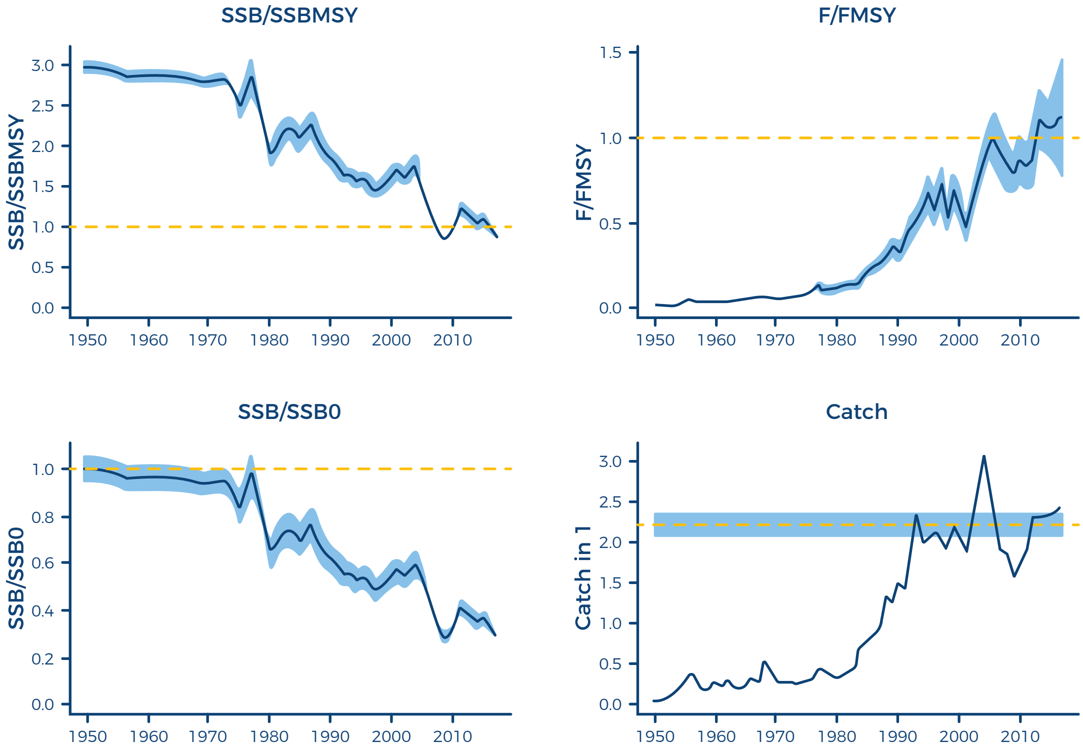


Figure 2: Stock status summary for the Indian Ocean yellowfin for the base case model (2018 stock assessment). Thick black lines shaded areas represent 5th and 95th percentiles. In the catch plot, dotted lines represent estimate of MSY, the shaded area represents 5th and 95th percentiles (Fu et al., 2018, IOTC–2018–WPTT20–33).

Thus in 2015, a stock assessment for YFT was carried out using Stock Synthesis III (SS3), a statistical, length-based, age structured model. As a consequence of the large and unsustainable catches of yellowfin tuna taken over the previous three years, and also due to the relatively low recruitment levels estimated by the stock assessment model, the YFT stock was considered overfished and subject to overfishing (Langley 2015). As a result, in 2016, the IOTC in its 20th Annual Meeting (or Commission Meeting) adopted an Interim Plan for Rebuilding the Indian Ocean Yellowfin Tuna Stock in the IOTC area of competence (Resolution 16/01, superseded by Res. 17/01, Res. 18/01 and Res. 19/01), which was revised each subsequent year.

In 2016 the YFT assessment was updated using new CPUE indices (see Section IV for more information about model inputs), which resulted in a somewhat more optimistic estimate of stock status, although the YFT stock was determined to remain overfished and subject to overfishing (Langley 2016).

In the last full stock assessment carried out in 2018, spawning stock biomass was estimated to be at 83% of the SSBMSY level (SSB2017/SSBMSY = 0.83) and fishing mortality was estimated to be above FMSY (F2017/FMSY = 1.20(1.00-1.71). Spawning stock biomass was estimated to be close to the historically low level, at 30% (0.27-0.33) of the unfished levels. The stock was therefore considered once more to be overfished and subject to overfishing (see Fig. 3).

However, the extent of the stock depletion varied considerably amongst the different model options explored (SSB/SSBMSY = 0.74-0.97), which means that the state of the stock could vary between these two values (IOTC–2018–SC21–R[E]).

The possible drivers of the decline in stock status to below MSY level were not well explained due to the lack of understanding of stock dynamics due to various data and model uncertainties in the assessment (see the section below). The SC noted that the retrospective and hindcasting analyses suggested that the 2018 stock assessment model had poor predictive capacity and although a K2SM was provided, no explicit recommendations on catch limits were given (IOTC-2018-SC21-R, IOTC–2019–SC22–R[E]). As a precautionary measure, SC recommended that the Commission should ensure that catches are reduced to end overfishing and allow the SSB to recover to SSBMSY levels. A workplan was developed by the Commission to address the issues identified, aimed at providing more specific and robust advice by 2019.

Catches in 2018 were 437,422 t, around 10% higher than the estimated Maximum Sustainable Yield (403,000 t (339,000-436,000 t)).

The average catch in recent years (2014-2018) is estimated at around 407,377 t, slightly above the MSY.

In 2019, the WPTT presented an alternative stock assessment model (see Section VI), but it was considered that further research was necessary before new advice was provided relative to the status of the stock of yellowfin tuna, and before the projections were carried out to build advice on catch limits. Therefore, specific recommendations on catch limits were not provided due to "the complexity of the tasks, lack of agreement on key model aspects and time constraints during the WPTT" (IOTC-2019-SC22-INF01).

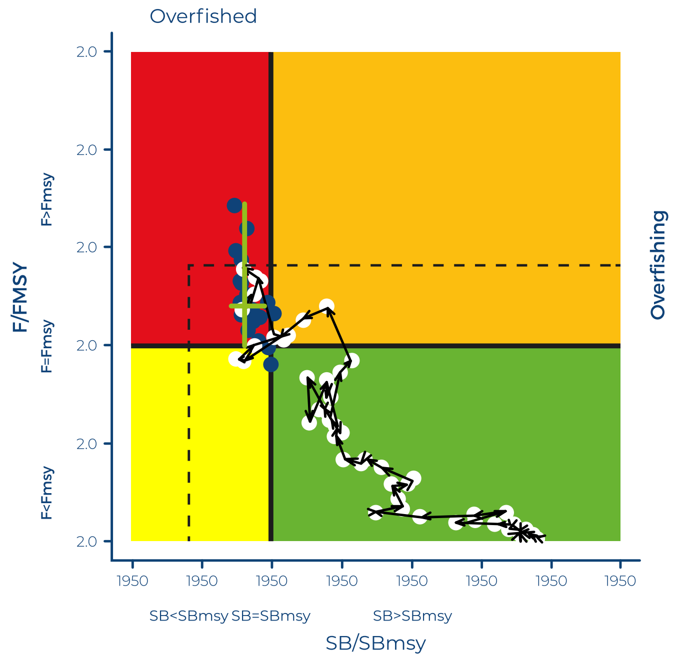


Figure 3: Yellowfin tuna: Stock synthesis Kobe plot (2018). Blue dots indicate the trajectory of the point estimates for the SB/SBMSY ratio and F/FMSY ratio for each year 1950–2017. The grey line represents the 80% confidence interval associated with the 2017 stock status. Dotted black lines are the interim limit reference points adopted by the Commission via Resolution 15/10. The white circles represent 2017 stock status for each of the 24 grid run (Fu et al., 2018a, IOTC–2018–WPTT20–33).

Table 4: Summary of the 2019 stock assessment for the Indian Ocean yellowfin tuna (IOTC 2019a).

Area[1]	Indicators		2018 stock status[3] determination
Indian Ocean	Catch 2018[2]: Average catch 2014-2018:	423,815t (437,422t)[4] 404,655 t (407,377t)[4]	94%
	MSY (1000t)(80% CI)[3]: F_{MSY} (80% CI): SB_{MSY} (1000t)(80% CI): F_{2017}/F_{MSY} (80% CI): SB_{2017}/SB_{MSY} (80% CI): SB_{2017}/SB_0 (80% CI):	403 (339-436) 0.15 (0.13-0.17) 1069 (789-1397) 1.20 (1.00-1.71) 0.83 (0.74-0.97) 0.30 (0.27-0.33)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat for catches in 2018: 11%
[3] Median and quantiles calculated from the uncertainty grid taking into account of weighting on models
[4] Considering the alternative purse seine log-associated catches for the EU fleet in 2018 as per IOTC-2019-WPTT21-R.

Colour Key	Stock overfished ($SB_{year}/SB_{MSY}<1$)	Stock not overfished ($SB_{year}/SB_{MSY}\geq1$)
Stock subject to overfishing ($F_{year}/F_{MSY}>1$)	94%	2%
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq1$)	4%	0%
Not assessed/Uncertain		

IV. Uncertainties in the stock assessment models used for assessing the Indian Ocean yellowfin tuna

Prior to 2008, the IOTC used assessment methods such as Virtual Population Analysis (VPA) and production models to assess the stock of yellowfin tuna (Nishida & Shono 2005, 2007). In 2008, a preliminary stock assessment was conducted using MULTIFAN-CL, a length-based, age, and spatially structured model, enabling the integration of the tag release/recovery data collected from the large-scale tagging programme conducted in the Indian Ocean in the preceding years, which was revised and updated in the following years (Langley et al. 2008, 2009, 2010, 2011, 2012a and 2012b).

In 2015, a new fully integrated model, the Stock Synthesis III (SS3), was introduced to assess the YFT stock (Langley 2015). This is a statistical, length-based, age-structured model that integrates fishery data including total catch, CPUEs, and length-frequency data, from all Indian Ocean fleets catching tuna. This model is now used to assess the three tropical tuna stocks (bigeye, yellowfin and skipjack) under the IOTC management area.

In 2018, the results of 24 model runs (scenarios) were used to advise the IOTC Commission on yellowfin stock status, which as indicated in the previous section was considered overfished and subject to overfishing (Fu et al. 2018b, IOTC–2018–WPTT20–33). However, the IOTC-SC identified several issues that may hamper its capacity to provide sound advice for yellowfin tuna. The SC noted that the retrospective and hindcasting analyses suggested that the 2018 stock assessment model had poor predictive capacity, which led the SC not to provide explicit catch limits advice, although a K2SM was provided. The assessment results were only based on a low number of model runs, which was recognised as insufficient to explore the spectrum of uncertainties and scenarios, noting the large uncertainty associated with data quality (e.g., spatial representativeness of CPUE coverage, estimation of catch and inconsistency in length-frequency) and lack of considering model statistical uncertainty. It was noted that the quantified uncertainty in stock status most likely underestimated the underlying uncertainty of the assessment (Kell & Sharma 2019).
Also in 2018, the IOTC-SC adopted a workplan to address the uncertainties of the yellowfin tuna stock assessment. This workplan contains two main components: Uncertainty in Data and Model Uncertainty, each one with several tasks with specific activities, responsibilities and timelines (Merino et al. 2019a). A summary of the main uncertainties and current development status of the workplan is given below:

Data uncertainties

The four sources of data used in the yellowfin stock assessment are: catch data, CPUE indices, size-frequency data and tagging data. The uncertainties associated with each of these elements are explained below (see also Fig. 4 below):

- **Catch data**

  Catch data is submitted by IOTC's CPCs to the IOTC Secretariat. When catch data is not adequately reported, total catch is estimated using a range of sources: partial catch-and-effort data, data in the FAO FishStat database, data collected through port sampling of landings, trade data, national websites, etc. This nominal catch data is then used as input for the stock assessment model and it is generally used as if they were perfectly reported and known. This means that the potential uncertainties in these data are not explored and therefore, the impact of potential misreporting is largely ignored (Sharma 2018).

  Overall, the IOTC Secretariat considers that nominal catches are generally well known for the major industrial fisheries (major Purse Seine (PS) and Longline (LL) fleets), with the proportion of catches estimated, or adjusted, by the IOTC Secretariat relatively low. There are however poor estimates for other fleets: many coastal fisheries, notably those from Indonesia, Sri Lanka, Yemen, and Madagascar; the gillnet fishery of Pakistan; non-reporting industrial purse seiners and longliners (NEI), and longliners of India. Improving data collection through field sampling and observer coverage for coastal fisheries, in particular gillnet fisheries, has been recommended (Resolution 19/01).

- **CPUE indices**

  When fitting stock assessment models, it is assumed that standardised CPUE time series are indices of relative abundance of the stock. If indices conflict, however, then model estimates may be uncertain or biased (Kell & Sharma 2019, IOTC-2019-WPTT21-48). Two main CPUE series are being used or have been explored by the IOTC in the assessment of yellowfin tuna: the LL fisheries CPUEs and the PS FS fisheries CPUEs.

Japanese longline CPUEs were initially used, but since 2016 a new joint longline CPUE index derived from the main longline fleets (Japanese, Korean, Taiwanese and later Maldives LL fisheries) has been used (IOTC–WPTT18 2016). Several issues have been identified for these CPUEs, including: the low spatial coverage of some fleets in the Western Indian Ocean in recent years that may be underestimating yellowfin abundance and the potential impact of unreported discards of small fish in longline fleets due to the very low, or nil, fisheries observer coverage in these fleets (Merino et al., 2019a).

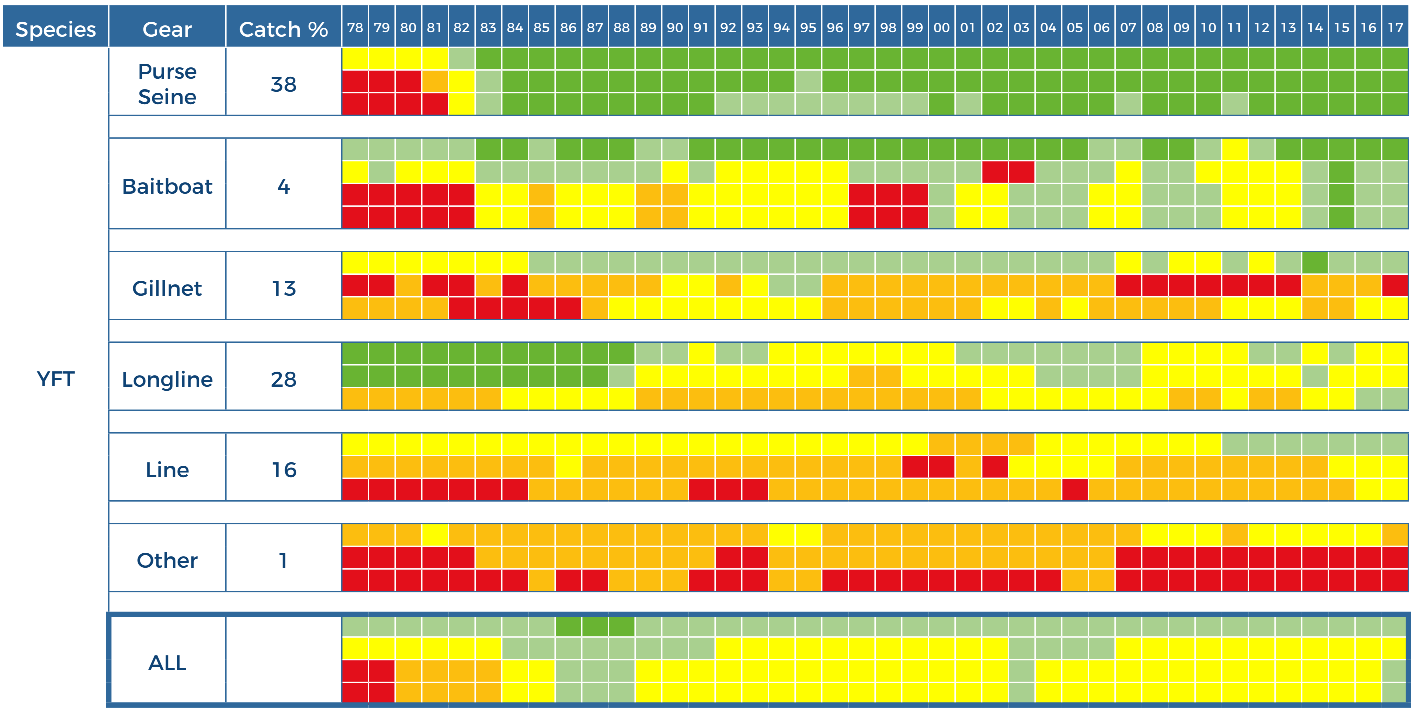
The use of PS CPUE indices was first considered for the yellowfin assessment in 2016 (Langley 2016). The problem with PS CPUE indices is that changes in catchability are not fully accounted for in the standardisation process, and their relationship with stock abundance is unlikely to be proportional (Fu et al., 2018). In 2019 two additional abundance indices were developed for Indian Ocean yellowfin tuna: the EU-PS free school (FS) CPUE (Guéry et al., 2019) and the fishery-independent Buoy Abundance Index which measures abundance in real time of fish aggregations underneath the buoys (Santiago et al., 2019b). These two indices are derived from the area in the Western Indian Ocean and reflect the catch rates of the PS fleets, which have been less affected by piracy in Somalian waters than the longline fleets (Merino et al., 2019a).

The use of alternative CPUEs series from the Maldives bait-boat (pole-and-line, BB) and hand-line (HL) fisheries have also been preliminarily explored. Future assessments should continue to evaluate the utility of these as new indices of stock abundance.

- **Size-frequency data**

Several issues have been identified by the IOTC Secretariat regarding the size-frequency data which is used as input to the stock assessment. The main issues include inconsistencies between the length-frequency data and catch-and-effort of longline fleets reported by Taiwan, China and Japan; and the lack of reporting of size-frequency data by several CPCs for their longline, gillnet, and other (artisanal) fleets (hand lines, trolling lines) (IOTC, 2018c). The potential misreporting of small size fish by industrial longlines at least since 2004, due to high-grading (Sharma 2018, Urtizberea et al., 2019, IOTC-2019-WPTT21-50), may also have a large effect on the joint longline CPUE used in the yellowfin stock assessment (Merino et al., 2019a).

Figure 4: Quality of the catch data for the YFT stock by gear and year. Top panel: nominal catch, medium panel: catch-and-effort, low panel: size-frequency data (IOTC 2018_WPTT20).



- **Tagging data**

  Data from tag-recapture programmes is used to obtain information on fish population dynamics and to provide input data (spatial movements, growth, natural mortality, etc.) for stock assessment models (Merino et al., 2019a). However, the data from the Indian Ocean Tuna Tagging Programme (IO-RTTP) currently included in the yellowfin stock assessment has not been adequately analysed. During the 2019 WPTT meeting it was considered that the biggest challenge for the group was probably the treatment of tagging data and to model the movements of the stock (Merino et al., 2019a). These issues have implications on the spatial configuration of the model, which in turn has a significant impact on estimates of stock productivity and status (Langley 2012, Hoyle 2015, Sharma 2018, Merino et al., 2019a). Analysis undertaken by Urtizberea et al. (2019, IOTC-2019-WPTT21-50) suggested that tagging data currently in use do not contain enough information to estimate the movement between the areas defined within the model used (see the spatial structure subsection below). Therefore, it was proposed to reduce or remove the influence of tagging data from the stock assessment model.

Model uncertainties

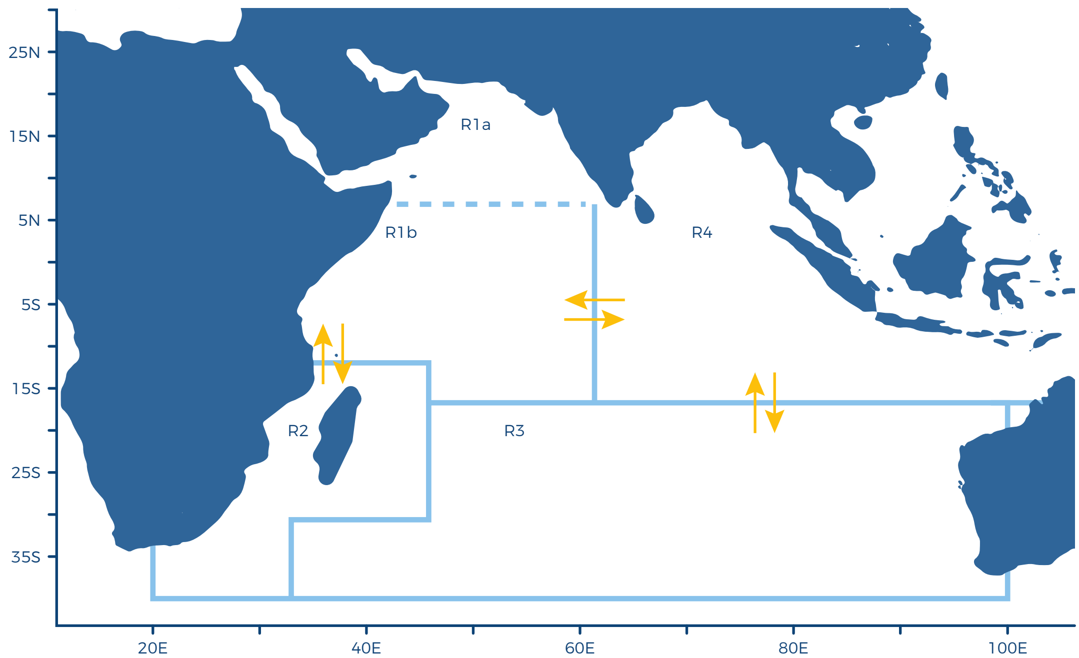
As indicated above there are also various issues related to the configuration of the models and interpretation of model results. Main model uncertainties are summarised below:

- **Spatial structure**

  The geographic area considered in the assessment is the Indian Ocean defined by the coordinates 40˚S 25˚N, 20˚S 25˚N, 20˚E 150˚E. Early YFT stock assessments adopted a five region spatial structure, but analyses conducted during the 2015 assessment indicated several issues and it was replaced by a four region model structure (Langley 2015), which has been used in the case base model until 2018 (see Fig. 5 below) (Merino et al., 2019a). However, Urtizberea et al. (2019) indicated that tagging data did not contain enough information to estimate the movement between these four areas, and the use of a simpler spatial structure of two regions was suggested.

  In a recent peer-reviewed publication Varghese et al. (2019) reviewed several studies (Barth et al., 2017, Kunal et al., 2013) which indicate the existence of discrete YFT subpopulations in Indian waters (Northern Arabian Sea, Lakshadweep Islands and rest of Indian Seas), and the possibility of a distinct population in the Arabian Sea in addition to Atlantic and Indo-Pacific populations. Furthermore, Mullins et al. (2018) suggested that yellowfin tuna caught in South Africa's Atlantic coast, which was thought to stem from the Atlantic stock, could belong to the Indian Ocean stock. These mismatches between biological and management units could have an important effect on stock assessment and management, and the most appropriate structure for the stock assessment is still to be decided.

Figure 5: Spatial stratification of the Indian Ocean for the four region assessment model. The black arrows represent the configuration of the movement parameterisation of the base assessment model (Fu et al., 2018) (IOTC–2018–WPTT20–33)



- **Issues with other key inputs**

  Uncertainties in other parameters, such as growth function, natural mortality and steepness of the stock-recruitment relationship have important implications for stock assessment. Scenarios with alternative values of steepness, growth, natural mortality (and also sources of data) have been used by the WPTT to characterise structural uncertainty (Merino et al., 2019a). There is also some model sensitivity to the choice of method used for weighting different data series and the time period in which recruitment deviates are active. The impact of statistical uncertainty on the model has not been adequately explored either. However, the use of a multivariate lognormal approach to estimate statistical uncertainty about stock status and future projections (Winker and Walter, 2019) was recommended by the WPM and adopted by the WPTT (Merino et al., 2019a). Finally, the 2019 WPTT agreed on several diagnostics to be applied to the stock assessment models that include likelihood profiles, jitter analysis, hindcasting, retrospectives and methods to evaluate the robustness of the models (Merino et al., 2019a). When combined, all these added uncertainties further increase the overall uncertainty of the stock assessment.

V. Critique of the current interim plan for rebuilding the YFT stock *(Resolution 19/01)*

As indicated above, in 2015, as a direct result of the large and unsustainable catches of yellowfin tuna taken over the previous three years, and the relatively low recruitment levels estimated by the stock assessment model, the stock of yellowfin tuna was considered overfished and subject to overfishing (Langley 2015). As a result, the SC recommended that the catches of yellowfin tuna had to be reduced by 20% of the 2014 levels to recover the stocks to levels above the interim target reference points with 50% probability by 2024 (IOTC–2015–SC18).

In 2016, the IOTC adopted an interim rebuilding plan (Resolution 16/01), to address overfishing of the stock of yellowfin tuna. This Resolution attempts to implement a gear-wise reduction relative to 2014 base year (Table 6) and other additional measures aimed at reducing the capacity of industrial purse seine fisheries, such as the control of the number of Fish Aggregating Devices (FADs) or the number of supply vessels. The IOTC Commission agreed to maintain stocks "in perpetuity and with high probability, at levels not less than those capable of producing their maximum sustainable yield" (Resolution 16/01).

Based on the information on catch provided by the CPCs under Resolution 15/02, the IOTC set out catch reductions for the fisheries which surpassed specified catch thresholds in 2014 (Circular 2016-077) (see Table 5). CPCs agreed to observe these catch limits for yellowfin tuna starting in January 2017.

The catch limits applied in all rebuilding measures apply to all fishing vessels targeting tuna and tuna-like species in the Indian Ocean of 24 metres overall length and over, and those under 24 metres if they fish outside the EEZ of their flag state, within the IOTC Area of Competence.

Fisheries affected, catch reductions and catch limits were established as indicated below, with a summary shown in Tables 5 and 6.

- Purse seine: CPCs whose purse seine catches of yellowfin reported for 2014 were above 5,000 MT to reduce their purse seine catches of yellowfin by 15% from the 2014 levels.

- Gillnet: CPCs whose gillnet catches of yellowfin reported for 2014 were above 2,000 MT to reduce their gillnet catches of yellowfin by 10% from the 2014 levels.

- Longline: CPCs whose Longline catches of yellowfin reported for 2014 were above 5,000 MT to reduce their Longline catches of yellowfin by 10% from the 2014 levels.

- CPCs's other gears: CPCs whose catches of yellowfin from other gears reported for 2014 were above 5,000 MT to reduce their other gear catches of yellowfin by 5% from the 2014 levels.

Gear	If 2014 applicable catches are above...	Reduction
Purse seine	5000 mt	15%
Longline	5000 mt	10%
Gillnet	2000 mt	10%
Other gears	5000 mt	5%

Table 5.: Percentages and catch limits by gear. Source IOTC (Circular 2016-77)

Reported data				Resolution 16/01		
Flag YFT catches	Gear	YFT catches 2014 (MT)		"Threshold (MT)"	Reduction (%)	New limit (2017+)
		Report	Confirmed			
Maldives	BB	18,481		5,000	5	15,709
India	GILL	5,153		2,000	10	4,638
Iran, Islamic Rep.	GILL	41,326		2,000	10	37,193
Pakistan	GILL	7,533		2,000	10	Not applicable
Sri Lanka	GILL	2,867		2,000	10	2,580
Tanzania	GILL	3,210		2,000	10	Not applicable
Maldives	HL	30,246		5,000	5	28,734
Indonesia	LL	16,714		5,000	10	15,043
Sri Lanka	LL	16,985		5,000	10	15,287
Taiwan, Province of China	LL	12,285		5,000	10	11,057
European Union	PS	91,409	91,409	5,000	15	77,698
Indonesia	PS	5,452		5,000	15	4,634
Korea, Republic of	PS	8,847		5,000	15	7,520
Mauritius	PS	5,186	4,844	5,000	15	Not applicable
Seychelles	PS	23,449	23,463	5,000	15	19,944

Table 6: Limits for CPCs in accordance to the information available from IOTC, based on the submission of total catch data made by CPCs under Resolution 15/02 (previously Resolution 10/02. Gears: BB (Pole-and-Line); GILL (Gillnet); HL (Handline); LL (Longline); PS (Purse seine). Note: YFT Catch in 2014 column are nominal catches reported by CPC without excluding of the vessel <24m operating inside the EEZ. Source IOTC (Circular 2016-085/b/c)) including amendments of the IOTC circular 2017-057 released on May 16th 2017.

The measures introduced in Resolution 16/01 were revised in the following years 2017, 2018 and 2019 (Resolutions 17/01, Resolution 18/01 and Resolution 19/01).

Until resolution 19/01 the only modification made since 16/01 was to include an exception for the catch reduction of Small Island Developing States (SIDS), Least Developed Countries (LDCs) and Small Vulnerable Economies (SVEs) that can choose to use 2014 or 2015 as their catch reference year.

The interim rebuilding plan for the rebuilding of YFT stock was first evaluated in 2018, using 2017 catch data available and the Resolution 18/01 in force. According to the report of the WPTT 20th session of WPTT (IOTC–2018–WPTT20), it noted that many of the fisheries subject to catch reductions had achieved either a partial or full decrease in catches in 2017 in accordance with the levels of reductions specified in the Resolution, such as Republic of Korea (PS) had decreased by 29%; Taiwan, China (LL) had decreased by 26% and Sri Lanka had decreased by 26%. However, the total catch of YFT in 2017 had increased by around 3% from 2014/2015 levels, as the decrease in catches by those fisheries subject to Resolution 18/01 were offset by increases in the catches from gillnet and other coastal fisheries exempt from limitations. For instance, all of these fleets had increased substantially their YFT catch from the 2014 level: Pakistan (gillnetters) had increased by 76%, Mauritius (purse seiners) had increased by 59%, Oman (gillnetters and handline) had increased by 325 % and 97% respectively, and I.R. Iran (coastal longliners) had increased by 15252%.

In 2019, using 2018 catch data available and the Resolution 18/01 in force, according to the report of the 21st session of WPTT (IOTC–2019–WPTT21), YFT catches from all fleets subject to Resolution 18/01 had decreased by 15% from 2014/2015 levels, but in fact the IO-wide overall YFT catch increased by 10% in the same period (reaching the same level as reported in 2007), as the decrease in catches reported by such fisheries was offset by increases in the catches from some fisheries exempt from limitations on their catches of yellowfin tuna (Table 17 C, D, E, F G).

The table below (table 7) has calculated the annual differential from 2015 to 2019 of the nominal and disaggregated data of the total catches of YFT with respect to 2014, confirming that the reduction obtained is rather distant from the recommendation of 20% reduction.

Table 7: Estimates of reductions in total catches since the IO yellowfin tuna rebuilding plan was implemented. Under "raw" nominal catches, data are shown exactly as reported by all IOTC CPCs, whilst "disaggregated" nominal catches is "raw" nominal catches but with catches by gear aggregates and species aggregates broken down to their individual components Source: IOTC data (IOTC-2019-WPTT21-DATA03-NC and IOTC-2019-DATASETS-NCDB_061219) and own calculations based on IOTC data.

Year		2014	2015	2016	2017	2018
Sum of "raw" nominal Catch/ Capture(mt)		403,554	400,257	424,988	418,929	432,401
Difference with baseline	**Absolute**		-3,297	21,434	15,375	28,847
	%		-0.82%	5.31%	3.81%	7.15%
Sum of "disaggregated" nominal Catch/ Capture(mt) Estimated by WPTT21		397,205	391,538	409,336	401,382	423,815
Difference with baseline	**Absolute**		-5,667	12,131	4,177	26,610
	%		-1.43%	3.05%	1.05%	6.70%

In this study we re-created the tables presented in the report of WPTT21 (OTC–2019–WPTT21). Tables are presented in Annex I (see Table 17 A, B, C, D, E, F and G). Some discrepancies in the calculations made in the original tables that have been reported to the IOTC were detected. The following errors have been confirmed by IOTC (Fabio Fiorellato, Data Coordinator IOTC, pers. comm.):

✓ **Error 1:** The subtotal for the absolute difference with the baseline should consider both reported captures for BB and HL for MDV (Maldives) for "other fleets". Therefore, that value should read as -21,274 MT instead of +8,972. (see Table 17G, "All other fleets").

✓ **Error 2:** The correct absolute difference with the baseline for "all other fleets" should be 13,985 MT instead of 44,231 MT, which gives a difference with the baseline (in percentage) of +10% instead of +31%. It is calculated by dividing the absolute difference with the baseline (+13,985 MT) by the "Other fleets" baseline total for 2014 (144,029 MT). (see Table 17G, "All other fleets").

✓ **Error 3:** The calculation of the % of difference with baseline for "all purse seine fleets" was not made considering 2015 as the baseline year for SYC (Seychelles). The correct value should be -9% (when looking at the official YFT catch data reported by SYC for 2018) as results by dividing the absolute difference of -13,677 MT by a baseline total of 157,761 MT (correctly including SYC catches for 2015). (see Table 17C, "Purse Seine").

After processing the corrections pertinent to the tables published in the WTTP21 report (See Annex 1, Table 17 C, D, E, F and G) and tables published in the WTTP20 report (IOTC–2018–WPTT20, Table 1), the following points were noted regarding the level of total reported catch for all fleets:

- All purse seine fleets. In 2017 the total catch by all PS fleets decreased by 1%, and in 2018 it decreased by 9% compared to the 2014 level, as shown in the Table of “officially reported data” (Annex 1, Table 17 C. However, Table 17 D, which includes the 2018 data revisions for purse seine, is not used officially. If these data are verified, all purse seine fleets combined would not have made any reductions in 2018 with regards the 2014 level.

  During the 21st session of the Working Party on Tropical Tuna (WPTT21) it was noted that, 2018 catches of bigeye tuna reported by the EU purse seine fleet alone exceeded the catches recorded by all purse seine fleets in 2017; furthermore, that, in 2018, bigeye tuna was reported by the EU purse seine fleet as the dominant species (in terms of recorded catches) in several grids where the fishery has been operating in conjunction with other PS fleets.

  It was acknowledged that this data inconsistency seems to arise from the Spanish component of the EU purse seine fleet, the WPTT noted that this could be due to changes introduced in the type of statistical methodologies adopted for the production of final catch statistics by EU-Spain in 2018, or changes in fishing patterns reported by the fleet during the same year or a combination of both.

  For this reason, the WPTT agreed that a methodology to revise the bigeye tuna catches reported by EU-Spain in 2018 (limited to their log-associated school component) should be identified and discussed.

  The WPTT reviewed an approach to revising the bigeye tuna catch, which applied the species composition recorded for the log-associated component of EU-Spain purse seine catches in 2017 to the total catches (log-associated) reported in 2018 by the same fleet.

  The WPTT noted that this approach causes marked reductions in catches of bigeye tuna reported by the EU purse seine fleet component in 2018 by 12,102 t, increasing yellowfin tuna catches by 13,606 t when compared to the official estimates, while leaving skipjack tuna catches basically unaltered (1,504 t less compared to official estimates).

- All gillnet fleets increased their catches by 18%, both in 2017 and 2018 from 2014 level (Annex 1, Table 17E).

- For all longline fleets it is noted that they achieved a reduction of 18% and 4% from 2014 level, in 2017 and 2018 respectively (Annexe 1 Table 17F).

- All the “other gears” fleets: In 2017 they achieved a reduction of -4% compared to 2014, but in 2018 they increased their catches by 10% from 2014 level (Annex 1, Table 17G).

If we analyse the joint fleet catch data (see Table 8 below), it can be seen that the total YFT catch by all IO fleets increased by 4% in 2017 and by 7% in 2018 compared to the 2014 baseline.

Therefore, not only was the target catch reduction not achieved, but there was in fact a net increase in total catch.

<table>
<tr><th colspan="2">All fleets</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th></tr>
<tr><td colspan="2">All purse seine fleets</td><td>142152</td><td>151459</td><td>155991</td><td>156046</td><td>144085</td></tr>
<tr><td colspan="2">All gillnet fleets fleets</td><td>78203</td><td>80342</td><td>80490</td><td>92044</td><td>92391</td></tr>
<tr><td colspan="2">All longline fleets</td><td>39371</td><td>39838</td><td>36048</td><td>32368</td><td>37801</td></tr>
<tr><td colspan="2">All other fleets</td><td>144029</td><td>128874</td><td>152002</td><td>138100</td><td>158014</td></tr>
<tr><td colspan="2">Sum</td><td>403755</td><td>400513</td><td>424531</td><td>418558</td><td>432291</td></tr>
<tr><td>Absolute</td><td rowspan="2">Difference with baseline</td><td></td><td>-3242</td><td>-3242</td><td>20776</td><td>14803</td></tr>
<tr><td>%</td><td></td><td>-1%</td><td>5%</td><td>4%</td><td>7%</td></tr>
</table>

Table 8: Net catch “reduction” for all fleets. Source: WPTT21 report and own calculations based on IOTC data.

Despite the fact that in 2019 the interim plan for rebuilding the Indian Ocean Yellowfin tuna stock had only two years (2017 and 2018 catches), from its entry into force on 1 January 2017 to verify its compliance. During this period two key facts have been confirmed: one, is that the reduction achieved on total catches of yellowfin tuna is far from the 20% reduction recommended by the Scientific Committee (see table 7 and 8); and the second is that any positive effect accrued by the partial but insufficient reductions would have been completely cancelled out by the catch increase of the by fleets not subject to exempt from catch reductions and the by Gillnet fleet subject to catch limits.

Indeed, in 2018, there has been an increase in catch by the Iran gillnet fleet (which is subject to reduction), whose catch increased by 46% regarding the 2014 baseline catch level (table 17E). In the case of fleets not subject to reductions this increase is especially relevant, in the PS fleets, whose catch increased remarkably by 53% regarding the 2014 baseline catch level (tables 17C, D) and in the "other gears" fleets not subject to resolution, whose catch increased by 37% regarding the 2014 baseline catch level (table 17G). The fact that despite the agreement on the need to reduce current catch levels, the overall net catch has increased, not decreased, with regards the 2014 catch baseline, raises doubts about the effectiveness of the catch reduction scheme established by IOTC.

Worryingly, Resolution 19/01 retains some criteria that were severely criticized by some CPCs during the 23rd Session of the Indian Ocean Tuna Commission: for instance, it still uses the fleet segmentation based on the LOA limit between vessels under or above 24 m, and keeps allowing those fleets under the 24m LOA limit to remain exempt from the obligation to reduce its catch. It also keeps allowing some CPCs to choose between 2014 and 2015 as their baseline catch level, etc. (IOTC-2019-S23-PropB_Rev1, IOTC-2019-S23-PropK, IOTC-2019-S23-PropP, IOTC-2019-S23-PropS).

Unlike the previous Resolutions, Resolution 19/01 introduces new exceptions and, importantly, a "sanction mechanism" for those CPCs that exceed the annual catch limit. Although the "sanction mechanism" might be seen as a positive step towards increasing the enforcement likeliness of the catch reduction scheme, it still presents several important weaknesses (see Table 9).

The actual effectiveness of the new sanction mechanism introduced by Resolution 19/01 cannot be assessed until 2019 catch data become available.

Using the new measures introduced by Resolution 19/01 we have carried out an analysis of the weaknesses detected regarding the current catch limits and their effect on the overall catch (see Table 9).

Table 9: Overview of Resolution 19/01 and weaknesses detected. Note: only includes measures taken with regard to catch limits. Source IOTC.

	Resolution 19/01	Weakness
Application	Paragraph 1. This resolution shall apply to all fishing vessels targeting tuna and tuna like species in the Indian Ocean of 24 meters overall length and over, and those under 24 meters if they fish outside the EEZ of their flag State, within the IOTC Area of Competence. Paragraph 2. The measures contained within this Resolution shall be considered as interim measure and will be reviewed by the Commission no later than at its annual Session in 2020. Paragraph 3. Notwithstanding paragraph 2, this Resolution shall be reviewed when a formal Management Procedure for the management of the yellowfin tuna stock is adopted by the Commission and in effect. Paragraph 4. Nothing in this resolution shall pre-empt or prejudice future allocation of fishing opportunities.	Since the beginning of the yellowfin tuna rebuilding plan, this criterion of application has been maintained. However, we believe that this is one of the main weaknesses of the plan, since it allows those countries that exceed the catch limits established by the plan, to be exempted from the application of the reductions if they have fishing vessels <24m LOA operating within its EEZ. In those cases, the reduction will not be applied.

Paragraph 5. Purse seine: CPCs whose purse seine catches of yellowfin reported for 2014 were above 5000 MT to reduce their purse seine catches of yellowfin by 15 % from the 2014 levels.

Paragraph 6. Gillnet: CPCs whose Gillnet catches of yellowfin reported for 2014 were above 2000 MT to reduce their Gillnet catches of yellowfin by 10 % from the 2014 levels.

Paragraph 7. Longline: CPCs whose Longline catches of yellowfin reported for 2014 were above 5000 MT to reduce their Longline catches of yellowfin by 10 % from the 2014 levels.

Paragraph 8. CPCs' other gears: CPCs whose catches of yellowfin from other gears reported for 2014 were above 5000 MT to reduce their other gear catches of yellowfin by 5 % from the 2014 levels.

Paragraph 9. In applying the catch reductions by gears in provisions in paragraph 5, 6, 7 and 8, Small Island Developing States and Least Developed Countries can either choose between catches of yellowfin tuna reported for either 2014 or 2015. For such CPCs Paragraph 13(a) is applicable over the accumulated catch in 2018 and 2019.

Paragraph 10. Exceptionally for 2019 and 2020, Small Island Developing States CPCs that contributed less than 4% of the total yellowfin catch of the Indian Ocean in 2017, shall reduce their purse seine catch by 7.5% of 2018 levels.

Paragraph 11. Any CPC to whom para 5-10 do not apply and whose catches exceeded the threshold limits in any subsequent year (from 2017), shall reduce their catches to the levels prescribed for that particular gear as mentioned in paragraphs 5, 6, 7 and 8.

Paragraph 12. Flag States will determine appropriate methods for achieving these catch reductions, which could include capacity reductions, effort limits, etc., and will report to the IOTC Secretariat in their Implementation Report every year.

Resolution 18/01 remains binding on India.

Paragraph 5-8: it keeps 2014 as the reference year, without evaluating the possible alternative options for setting a different year as the baseline catch.

Paragraph 9: The original purpose of this exception was to allow those Small Island Developing States (SIDS) and Least Developed Countries (LDC) to develop their fishing industry. However, at present it is used by some countries (such as Mauritius that chose 2014 catch levels), so that the reduction is not applied to them when they exceed the catches threshold limits for the following subsequent years. In the case of Mauritius, since 2015 it has been continuously exceeding the catch threshold above it would have become subject to catch restrictions –but, being a SIDS, it is exempt from it. The case of Seychelles is similar, except that in this case it chose 2015 as the baseline year.

Paragraph 10: less than 4% of the total Yellowfin tuna catch in 2017 (less than 16,055 MT) (data source: "disaggregated" nominal catch/capture). Only applicable to Mauritius.

Paragraph 11: If the criterion of exemption depending on the size of the fishing vessels (i.e. all vessels <24 m LOA operating within the respective EEZ) prevails over this paragraph, it would not apply to any CPCs whose catches exceeded the threshold limits in any subsequent year (from 2017 onwards), provided these catches were taken by fleets that declare to be composed by fishing vessels <24 m LOA and within the respective EEZ. Thus, all of the following fleets would remain exempt from complying with any catch reduction:

- Purse seine: any PS fleet fishing within EEZ with vessels <24 m LOA
- Longlines: any LL fleet fishing within EEZ with vessels <24 m LOA
- Gillnets: any GN fleet fishing within EEZ with vessels <24 m LOA
- Other gears: any fleet categorized under "other gears" fishing within EEZ with vessels <24 m LOA

Detailed data about vessel size and fleet compositions could not be found for many CPCs. However, it is likely that a large share of GN and Other gears fleets will be under the 24m LOA vessel size limit, and thus, under current resolution 19/01, they will become automatically exempted from complying with any catch reduction, provided they keep within their EEZs. Since GN and Other gears represent a large share of total YFT catch, and they are increasing their catch steadily, this exemption undermines totally the aim of reducing the catch of YFT back to sustainable levels.

Table 9: Continued

Over catch of annual limit	Paragraph 13. If over-catch of an annual limit for a given fleet of a CPC listed in paragraph 5 to 10 occurs, catch limits for that fleet shall be reduced as follows: a. If the accumulated catch in 2017, 2018 and 2019 exceeds the sum of the catch limit for 2017, 2018 and 2019 the excess (over-catch) shall be deducted from the 2021 catch limit. b. For 2020 and following years, 100% of that over-catch shall be deducted from the following two years limit; unless c. Over-catch for that fleet has occurred in two or more consecutive years, in which case 125% of the over-catch shall be deducted from the following two years limit. Paragraph 14. CPCs shall inform the Commission via the IOTC Compliance Committee, any reductions in the following year because of over catch in paragraph 13 in their implementation Report. Paragraph 15. The revised limits will apply in the following year and CPCs compliance shall be assessed against the revised limits reported to the IOTC Compliance Committee.	The sanction mechanism used by IOTC in cases of over catch above the annual limit is focused on post-infraction sanctions. The IOTC does not include prior control mechanisms to avoid over catch during the fishing year in progress. This is due to the fact that under the current control framework, CPCs inform to the Executive Secretary only when the fleet has already reached, or is about to reach imminently its total catch limit and the CPCs themselves are responsible for taking measures not to exceed 100% of the total catch limit. But there is no control by the IOTC Secretariat to ensure that this is enforced.

Hence, based on the catch data available up to 2018, we have simulated how the catch limits will be from 2019 onwards and which countries will be subject to Resolution 19/01. It is noted that Resolution 19/01 brings about some new amendments regarding the CPCs that are subject to it. As stated in Table 9, one of the main weaknesses of the current catch reduction scheme is the criteria for application according to the fleet segments defined by the LOA of the vessels. When the official record of vessels allowed to fish in the Indian Ocean (IOTC vessel record) is cross-checked with the list of CPCs subject to resolution, some discordances are found. For instance, some CPCs (e.g. India) declare fleet segments below and above the 24m LOA limit. Thus, their smaller (<24m) fleet segments would be exempted from applying any reductions (if they keep within the EEZ), but their larger (≥24m) fleet segment may be subject to reductions if they reach the threshold. In the case of India, this is what happens in at least two fleet segments ≥24m LOA: PS and Other gears. However, all Indian fleet segments are exempted from applying catch reductions.

Although the IOTC requested CPCs to submit the breakdown of their YFT catches already separated between fleet segments subject to, and exempted from, catch reduction dictated by Resolution 17/01 (and superseding ones), in several cases this request has not been complied with and in some cases, it is still too difficult to determine which CPCs are subject to the resolution.

VI. Stock projections.

As indicated above in 2018 the YFT stock was considered overfished and subject to overfishing (IOTC–2018–SC21–R[E]). As was also mentioned, due to the numerous uncertainties in the stock assessment, no explicit catch advice has been given by the SC since 2016. However, between 2018 and 2019 several studies have conducted stock projections to evaluate the impact of alternative catch levels on the stock. Their results are summarized below:

- During the 2018 stock assessment, stock projections were conducted for a 10-year period (2018–2027) to evaluate the impact of five alternative catch levels, ranging from 60% to 100% in reference to the 2015 catch level (391,587 t) (see table 10)(Fu et al., 2018a, IOTC–2018–WPTT20–33). For each stock scenario, the probability of the biomass being below the SSBMSY level was determined after 3 years (2020), 5 years (2022) and 10 years (2027). The base case model[4] indicated that a 20% catch reduction would be necessary to recover the stock to MSY level with levels of probability higher than 60% by 2026. Higher catch reductions of around 30% were required for the reference model (Fu et al., 2018a, IOTC–2018–WPTT20–33). The base model indicated that the maximum annual catches should be set at between 280,000 – 325,000 t, whereas the reference case indicated a further reduction to 250,000 – 280,000 t for recovering the stock. Furthermore, the base case model indicated that with the 2015 catch levels the stock would crash (catches exceeded the stock biomass) between 2024 and 2025, whereas for the reference model the crash is predicted to happen even earlier, in 2021, if catches are higher than 370,000 t. This last model indicated that even with catches as low as 325,000 t, which represent a 20% catch reduction in reference to the 2015 level, the stock would still crash by 2026 (Fu et al., 2018, IOTC–2018–WPTT20–33).

Table 10: Projected stock status: spawning biomass relative to SBMSY and the probability of being below SBMSY, in 3-, 5- and 10 years for five alternative levels of catch (relative to 2015) for the base model. A value of zero for SB/SBMSY indicates that catches exceeded the stock biomass (the stock crashed), or the estimated variance was implausibly high (Fu et al., 2018, IOTC–2018–WPTT20–33)

Model option	Catch	3 years (2020)		5 years (2022)		10 years (2027)	
		SB/SB_{MSY}	$P_r(SB<SB_{MSY}$	SB/SB_{MSY}	$P_r(SB<SB_{MSY}$	SB/SB_{MSY}	$P_r(SB<SB_{MSY}$
Base	100%	0.714	0.908	0.666	0.849	0.508	0.524
	90%	0.817	0.822	0.873	0.645	0.947	0.547
	80%	0.918	0.642	1.061	0.421	1.326	0.215
	70%	1.019	0.479	1.237	0.238	1.596	0.055
	60%	0.287	0.278	1.404	0.129	1.825	0.016
		SB/SB_{MSY}	$P_r(SB<SB_{MSY}$	SB/SB_{MSY}	$P_r(SB<SB_{MSY}$	SB/SB_{MSY}	$P_r(SB<SB_{MSY}$
Reference	100%	0.52	0.98	0.00	1.00	0.00	1.00
	90%	0.63	0.93	0.58	1.00	0.00	1.00
	80%	0.74	0.87	0.83	0.70	0.86	0.56
	70%	0.85	0.73	1.05	0.47	1.38	0.16
	60%	0.95	0.61	1.24	0.24	1.67	0.03

[4] The base case model used in the 2018 stock assessment has the same configuration that the models used to assess the stock of yellowfin tuna in previous years (Langley 2016). The reference model has the same configuration but excluded the size data 2015 – 2017. The estimated stock biomass was appreciably lower than the base model, particularly for recent years.

- New projections were again published by the WPTT in 2018 (Fu et al., 2018b, IOTC–2018–SC21–16) for the 2018–2027 period, this time in reference to the 2017 catch level (409,567 t). Eleven alternatives of catch levels were modelled ranging from 60% to 120% from 2017 catch (see Fig. 6). The projections indicated that 2017 catch levels (or above) were not sustainable – the stock has a high probability of falling below both the target and limit reference points in the short term. Moreover, with catch reductions of around 15% or 20%, the mean SSB increased in the first five years, possibly driven by the recent above-average recruitment, but declined afterwards, under average recruitment conditions. With 20% catch reduction or more, there is an over 50% probability for the SSB to recover to be above BMSY at the end of the projection period 2027. Maximum annual catches of 307,000 t corresponding to a catch reduction of 25% in reference to the 2017 catch level were necessary to reach the SSBMSY level and to keep the stock fluctuating at that level afterwards. If catch levels were equal or higher than in 2017, the stock would crash by 2025 (Fu et al., 2018b, IOTC–2018–SC21–16).

- Based on the previous projections, the scientific committed in the 2018 meeting presented advice in the form of the Kobe II Strategy Matrix (K2SM) based on the projections presented above (see Table 11). Traditionally the K2SM shows the probabilities by year for different catches of achieving the management objective of ensuring that the stock biomass is greater than BMSY and fishing mortality less than FMSY. The K2SM provided in 2018 (not updated in 2019) is shown in table 10 below (IOTC–2018–SC21–R[E]). As can be seen, for recovering the stock to MSY levels in 2027 with a likelihood higher than 70% (B2027 < BMSY ≤ 0.30), which is in line with the objectives of this study (see section IX for more information), a 25% catch cut would be necessary, which would correspond to a TAC of 307,175 t). These recommendations were not updated in 2019. Therefore, they still apply (IOTC–2019–SC22–R[E]).

- Winker et al., 2019 used a multivariate lognormal (MVLN) Monte-Carlo approach to conduct projections based on the 2018 reference grid of the Stock Synthesis model used to assess the YFT stock (see table 12). In this case, fixed catch scenarios ranging from 60-120% of the 2017 catch level were projected. These projections predict that a 20% reduction of current catches is required to achieve MSY-based targets by 2027 and a reduction by at least 15% is required to prevent a stock crash by 2024.

Figure 6: Trajectory of the mean SSB over SSBMSY across the model grid (weighted) with a 10-year projection (2018-2027) assuming a constant level of catch at 60% –120% of the 2017 catch level (i.e. 409,567t). The grey area represents the projection period (Fu et al., 2018b, IOTC–2018–SC21–16, Unpublished figure).

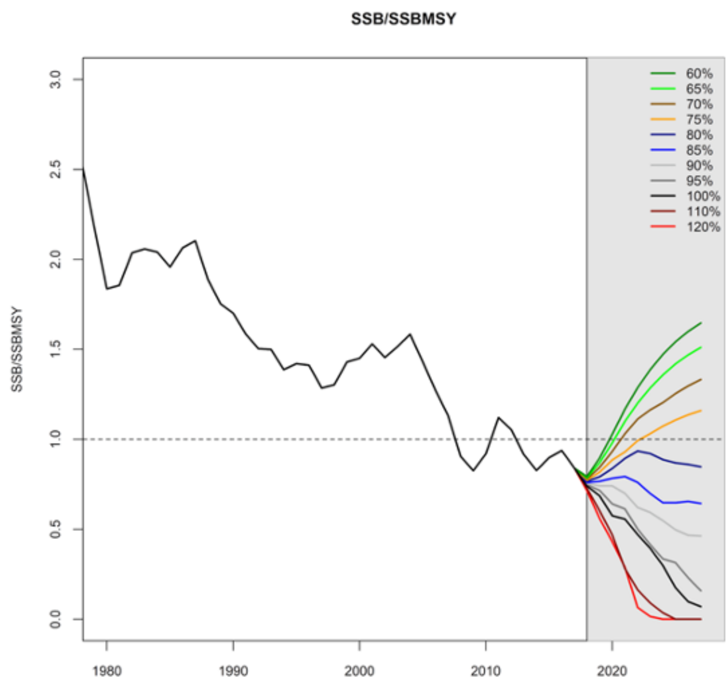


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Table 11 Yellowfin tuna: Stock synthesis assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to the catch level from 2017 (409,567t), -35%, -30%, -25%, -20%, -15%, ± 10%, -5%) projected for 3 and 10 years (IOTC–2019–SC22–R[E]).

Reference point and projection timeframe	Alternative catch projections (relative to the catch level from 2017) and probability (%) of violating MSY - based target reference points *($B_{targ}=B_{MSY}$; $F_{targ}=F_{MSY}$)*								
	65% (266,218t)	70% (286,697t)	75% (307,175t)	80% (327,654t)	85% (348,132t)	90% (368,610t)	95% (389,089t)	100% (409,567t)	110% (450,523t)
$B_{2020}<B_{MSY}$	0.48	0.48	0.73	0.85	0.85	0.96	0.98	0.98	1.00
$F_{2020}>F_{MSY}$	0.08	0.23	0.25	0.48	0.56	0.79	0.96	0.98	1.00
$B_{2027}<B_{MSY}$	0.08	0.08	0.25	0.42	0.56	0.79	0.98	1.00	1.00*
$F_{2027}>F_{MSY}$	0.06	0.08	0.23	0.42	0.63	0.85	1.00	1.00	1.00*
Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2017) and probability (%) of violating MSY - based target reference points** *($B_{LIM}=0.4\ B_{MSY}$; $F_{LIM}=1.4\ F_{MSY}$)*								
	65% (266,218t)	70% (286,697t)	75% (307,175t)	80% (327,654t)	85% (348,132t)	90% (368,610t)	95% (389,089t)	100% (409,567t)	110% (450,523t)
$B_{2020}<B_{LIM}$	0.00	0.00	0.00	0.00	0.00	0.06	0.15	0.23	0.42
$F_{2020}>F_{LIM}$	0.00	0.06	0.08	0.21	0.23	0.42	0.56	0.63	0.92
$B_{2027}<B_{LIM}$	0.00	0.06	0.08	0.27	0.42	0.50	0.83	0.90	1.00*
$F_{2027}>F_{LIM}$	0.00	0.08	0.23	0.42	0.50	0.65	0.94	0.94	1.00*

Table 12: Comparison of Kobe II Strategy Matrices derived from the 2018 yellowfin tuna reference grid of 24 Stock Synthesis models, based on MVLN posteriors from Monte-Carlo simulations (top) and probabilities directly calculated from the 24 model point estimates (bottom), after Fu et al. (2018b). Probability of violating the MSY-based target reference points, SSB < SSBMSY and F > FMSY, for constant catch projections are presented for 2020 (3 years) and 2027 (years). Constant catches represent percentages (65%-110%) of the 2017 catch (409,567t). The colour coding classifies the stock status according the Kobe quadrant based the highest probabilities (Winker et al., 2019)

Reference point and projection timeframe	Alternative catch projections (relative to the catch level from 2017) and probability (%) of violating MSY - based target reference points *($B_{targ}=SSB_{MSY}$; $F_{targ}=F_{MSY}$)* based on the MVLN posterior for reference grid								
	65% (266,218t)	70% (286,697t)	75% (307,175t)	80% (327,654t)	85% (348,132t)	90% (368,610t)	95% (389,089t)	100% (409,567t)	110% (450,523t)
$SSB_{2020}<SSB_{MSY}$	0.41	0.48	0.57	0.67	0.77	0.85	0.92	0.96	1.00
$F_{2020}>F_{MSY}$	0.04	0.12	0.27	0.43	0.58	0.72	0.85	0.95	1.00
$SSB_{2027}<SSB_{MSY}$	0.01	0.03	0.06	0.23	0.83	1.00	1.00	1.00	1.00
$F_{2027}>F_{MSY}$	0.01	0.07	0.17	0.41	0.99	1.00	1.00	1.00	1.00
Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2017) and probability (%) of violating MSY - based target reference points** *($B_{targ}=SSB_{MSY}$; $F_{targ}=F_{MSY}$)* **based on binary probabilities of point estimates from the reference grid**								
	65% (266,218t)	70% (286,697t)	75% (307,175t)	80% (327,654t)	85% (348,132t)	90% (368,610t)	95% (389,089t)	100% (409,567t)	110% (450,523t)
$SSB_{2020}<SSB_{MSY}$	0.48	0.48	0.73	0.85	0.85	0.96	0.98	0.98	1.00
$F_{2020}>F_{MSY}$	0.04	0.12	0.25	0.48	0.56	0.79	0.96	0.98	1.00
$SSB_{2027}<SSB_{MSY}$	0.08	0.08	0.25	0.42	0.56	0.79	0.98	1.00	1.00
$F_{2027}>F_{MSY}$	0.06	0.08	0.23	0.42	0.63	0.85	1.00	1.00	1.00

Finally, since 2012 the IOTC has been involved in the development of a Management Strategy Evaluation (MSE) in order to find and agree Management Procedures (MP) to support a Harvest Control Rules (HCR) for the YFT stock. This is a collaborative, interactive process (i.e. to ensure that the IOTC scientific and management communities have ample opportunity to contribute and have their concerns addressed) and key decisions are made in the technical working party reports of the IOTC (WPTT, WPM, TCMP, informally known as MSE Task Force). In the most recent working papers, presented by the CSIRO to the WPTT/WPM/TCMP in 2019 (Kolody & Jumppanen 2019a and b), several tuning objectives (defined by probabilities of reaching the target level in a specific year) were tested (as requested by the TCMP (2019)):

1. p(B(2024)>BMSY) = 0.5 (average SB in 2024 exceeds SBMSY in exactly 50% of the simulations);
2. p(B(2029)>BMSY) = 0.5;
3. p(B(2034)>BMSY) = 0.5 and 0.6.

The earliest possibly recovery dates (i.e. based on continuous quota drops) for the YFT stock for a range of Total Allowable Catch (TAC) constrains (with quotas effective starting 2021) were also determined in 2019 (see Fig. 7). The results indicated that TAC reductions between 35% and 15% were necessary to recover the stock in 2029 and 2034 respectively (see Figure 7). For a shorter recovery period a fishing moratorium for YFT was necessary (Kolody & Jumppanen 2019a and b). However, this work may not have been be endorsed the TCMP and the underlying Operating Model (used in simulation) is based on the assessment (base case) model and its allied scenarios.

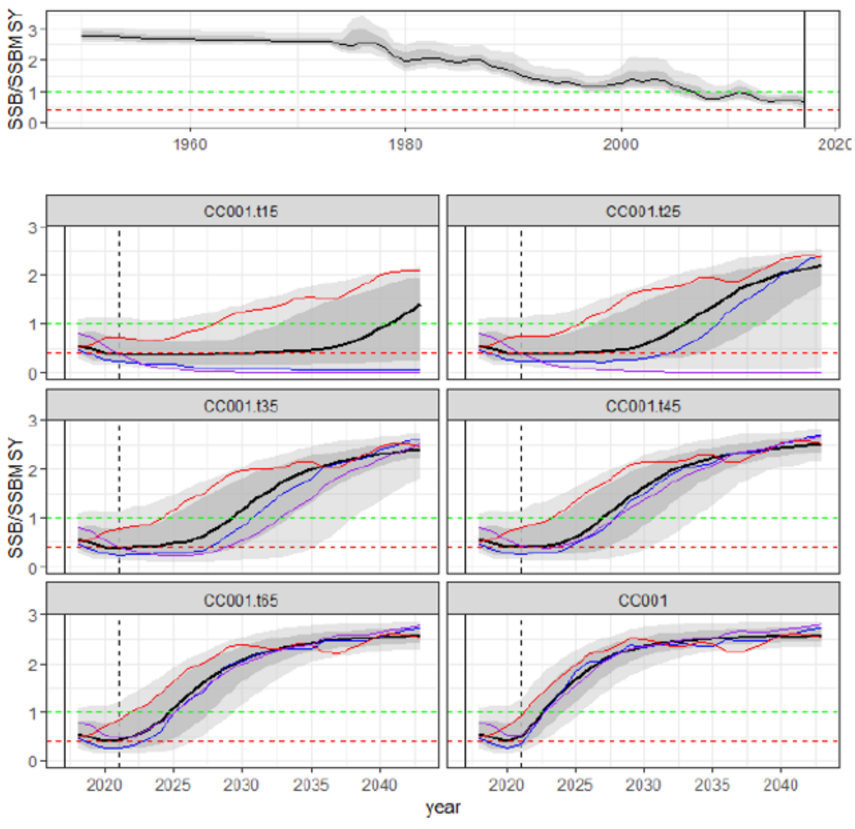

Figure 7: Minimum spawning biomass recovery trajectories associated with TAC change constraints of 15, 25, 35, 45, 65 and 100% per triennial TAC application. The earliest recovery rates are: 2042 with a 15% change constraint; 2031 with a 25% change constraint; 2029 with a 35% change constraint and 2022 with a fishing moratorium (Kolodi & Jumppanen 2019, IOTC–2019–WPM10–11).

Several aspects of the projections shown above make them more suited for short-term advice (three to five years) rather than very long- term projections (Walter et al., 2019):

1. The projections use deterministic (constant) rather than stochastic (random) recruitment. Constant recruitment deviations are unlikely to be the case in the future and are prone to more optimistic projection outcomes

than stochastic autocorrelated recruitment deviations;

2. Second, the projections assume a constant fleet allocation pattern and constant selectivity in reference to the reference levels, which may change in the future as a result of management regulations or changes in fishing practices which would affect the reliability of long-term projection results;

3. Third, the projections are for a 10-year time period which encompasses two YFT generation times and hence represent a relatively long time period in relation to the biology of the species.

As also indicated in section IV of this report, there are substantial concerns about the most recent YFT assessment, and therefore the corresponding operating models upon which the MP evaluations are undertaken.

However, despite the identified shortcomings, based on the information provided by the different IOTC scientific groups, major catch reductions between 20 and 35% would be necessary to recover the YFT stock to MSY levels in two generation times. However, some of these results come from working papers and have not been proved by the scientific committed due to low predictive capability and major uncertainties of the model which do not seem to recreate the population dynamic of the stock correctly in the future. Therefore, we take as reference the K2SM presented and approved by the SC in 2018, which indicates that a catch reduction of 25% is necessary for recovering the stock to sustainable levels (MSY) with a likelihood greater than 70% (see section IX). Furthermore, measures are urgently required to curb the YFT catch because, if no measures are taken, the range of information presented indicates that the stock could crash as early as 2024 (based on the case model presented in the 2018 stock assessment).

VII. Management advice for recovering the stock to SSBMSY levels in two generations.

Resolution 15/01 “On target and limit reference points and a decision framework” sets interim target and limit reference points for the major tuna stocks in the Indian Ocean, including YFT. This resolution indicated that the IOTC SC shall recommend options for Harvest Control Rules (HCRs) to the Commission taking the following into account: that the biomass is maintained at or above levels required to produce MSY or its proxy; the fishing mortality rate F is kept at or below FMSY or its proxy; and that the biomass stays above BLIM and the fishing mortality rate below FLIM.

Furthermore, the resolution specifies that for a stock where the assessed status falls within the upper left Kobe quadrant (i.e. the red area, such as in the case of YFT), the aim is to end overfishing with a high probability and to rebuild the stock biomass in as short a period as possible.

The YFT stock is assessed as overfished and subject to overfishing (IOTC–2018–SC21–R[E], IOTC–2019–SC22–R[E]). The agreement on a recovery strategy for the stock is an important first step to rebuild the stock and ensure long term sustainability of the resource. The definition of an adequate recovery strategy would include: the target reference points to be achieved, the period in which that level needs to be reached, the likelihood of reaching it, the likelihood of not falling below that level afterwards and finally, the likelihood of not falling below the limit levels.

As explained in the introduction section, based on the objectives of this project, the target reference point is the MSY level, and the recovery year would be 2029. As also indicated, through resolution 15/01 the Commission endorsed ending overfishing with a high probability and to rebuild the biomass of the overfished stock in as short a period as possible. However, “high probability” is not defined anywhere in the IOTC documents. In the 3rd IOTC Technical Committee on Management Procedures meeting (IOTC–2019–TCMP03–R[E]), a questionnaire was distributed to group members asking about their interpretation of "high probability" in reference to Resolution 15/10. It also asked whether this interpretation should be the same when related to achieving the target objectives or avoiding falling below the limits, among other questions, all of the relevance for this study. However, the results of that questionnaire were not published because some TCMP participants argued that the survey results would not be appropriately representative of the Commission composition.

During the MSE process for YFT a range of tuning objectives were tested. It included several recovery periods (timeframes) but only two probabilities, 0.5 and 0.6 (average SB exceeds SBMSY in exactly 50% or 60% of the simulations) (Kolody & Jumppanen 2019b). However, neither of these probabilities would seem to correspond to a "high probability" as defined by the MSC standard as best international practices.

Therefore, following best international practices and based on the objectives of this project, we recommend that the Commission should adopt a management procedure (recovery strategy, to become later a harvest strategy) which:

1. Allows the YFT tuna spawning stock to achieve the target reference point (BMSY) with at least a 70% probability (value based on the MSC standard definition of "likely"[5]; in the case that the "high probability" indication as included in Resolution 15/10 is followed, the probability should increase to 80%) by 2029 (two generation times);

2. Maintains the stock of YFT fluctuating around the target reference point with at least 60-70% probability afterwards (no specific likelihood is set by the MSC standard, but it indicates that the stock cannot fail below 90% of the MSY level);

3. Maintains the stock of YFT tuna over the PRI (interim limit reference point set by resolution 15/10) with a 80% probability (value based on the MSC standard definition of "highly likely", necessary for achieving the 80 score in P.1.1.1. It is understood that the probability of not falling below the PRI should be higher than the probability of not falling below MSY level as the former is a limit reference point).

   The management procedure should be adopted by the Commission in 2021 and used to set a global TAC which ensures that the objectives set in the previous point are achieved. Any TAC increase after the target reference point is reached should be limited to a specific percentage of the total TAC (5-10%). Given that under normal circumstances the assessment of tropical tunas stocks in the Indian Ocean is carried out every three years, it is understood that the TAC should be set for three-year periods, and the new TAC implemented the year immediately after the scientific advice is published.

Crucially, an adequate monitoring and enforcement system should be in place to ensure that the rebuilding objectives of the plan are achieved within the specified timeframe (a minimum requirement for any specific rebuilding strategy). It would be the role of the IOTC Compliance Committee to ensure that CPCs do comply with the recovery strategy. A number of management measures may be used by the Commission, based on the scientific advice, to ensure than the target reference point is reached in the specified timeframe and kept afterwards. These management measures are discussed in more detail in the following sections.

VIII. Proposals for catch reduction: *total and by fishery*

As stated above, the stock projections conducted by WPTT, CSIRO and independent researchers (see section VII), indicated that 2017 catch levels were not sustainable and suggested a range of catch reductions between 20% and 35% to recover the stock to the SSBMSY levels. As explained in the section VII, based on the information provided by the IOTC scientific committee in 2018 and 2019, a 25% catch reduction in reference to the 2017 catch levels is considered by the authors the most adequate level of reduction to bring the stock back to sustainable levels.

According to the recommendation of catch reduction, we tested **three different** catch limit strategies, **Proposal 1, 2 and 3** (Table 13). For

[5] Scoring issue 1.1.2 (b) rebuilding evaluation of the MSC standard indicates: "There is evidence that the rebuilding strategies are rebuilding stocks, or it is likely based on simulation modelling, exploitation rates or previous performance that they will be able to rebuild the stock within the specified timeframe". It was confirmed by the MSC standards' team, that in this case, such as in 1.1.1, the term "likely" need to be interpreted as a 70% probability.

each proposal we have considered two different scenarios, using 2017 or 2018 catch data as the reference year, which has resulted in slightly different results. Although stock projections made by the IOTC scientists were based on 2017 catch data, it has also been considered relevant to use the latest catch data of 2018 for the proposals, taking into consideration when using these scenarios that these data have not yet been validated.

Furthermore, It has been included the scenario called "Base Case" (Annex 1 Table 19) in order to show the total reduction achieved by Resolution 19/01 whether it would preserve the catch limits established, but applying to all active fishing vessels in the Indian Ocean regardless of their length and which exceed the YFT catch thresholds set for each of the fleet / fishing gear, and taking as reference catch the years 2017 and 2018. The total reduction achieved would be 11% and 10% taking as reference year 2017 or 2018, respectively (Annex 1 Table 20).

For all the proposals, (table 13 A) PS, B) PS (including revisions to 2018 PS LS), C) GN, D) LL and E) Other fleets) the following **Common application criteria** are established:

- The catch limits shall apply to all active fishing vessels targeting tuna and tuna like species in the Indian Ocean regardless of their length and area of operation and which exceed the YFT catch thresholds set for each of the fleet / fishing gear, with the exception of those fishing vessels of an overall length (LOA) of less than 12 m (small-scale fisheries CFP definition) if they fish within the IOTC Area of Competence

- It is important to note that for any of the 6 scenarios shown, the IOTC must prevent those fleets not subject to catch limits from increasing their catches beyond the catch level they declared in 2017 or 2018.

- The suggested catch limits would enter into force not later than January 2021 for all CPCs. The work plan would be subject to review every 3 years or when a new full stock re-assessment is available, whichever period is shorter.

Proposal 1
This proposal shows how the YFT catch limits would look like if a 25% reduction was applied equally to all fleets which exceed the thresholds set for each of the fleet / fishing gear and the threshold for longline catch was lowered to 3,000 MT. **The total reduction achieved** by this proposal would be **25% or 24%**, taking 2017 or 2018 as catch reference year (Table 14).

Catch limits under Proposal 1:

✓ Purse seine (PS): CPCs whose reported PS YFT catch for 2017 or 2018 was equal or above 5,000 MT shall reduce their PS YFT catch by 25 % from 2017 or 2018 levels.

✓ Gillnet (GN): CPCs whose reported GN YFT catch for 2017 or 2018 was equal or above 2,000 MT shall reduce their GN YFT catch by 25 % from 2017 or 2018 levels.

✓ Longline (LL): CPCs whose reported LL YFT catch for 2017 or 2018 was equal or above 3,000 MT shall reduce their LL YFT catch by 25 % from 2017 or 2018 levels.

✓ Other gears: CPCs whose reported YFT catch from other gears for 2017 were equal or above 5,000 MT shall reduce their other gear YFT catch by 25 % from 2017 or 2018 levels.

Proposal 2
This proposal maintains the relative weight of catch restrictions assigned per fleet by the IOTC resolutions (18/01, superseded by 19/01), but increases the percentage of reductions required for each fleet, and lowers the thresholds for longlines and other gears (from 5,000 MT to 3,000 MT for both fleets), with the aim of increasing the number of fleets subject to resolution.

The total reduction achieved by this proposal would be **25% or 24%**, taken as reference year 2017 or 2018, respectively (Table 14).

Catch limits under Proposal 2:

✓ **Purse seine:** CPCs whose reported PS YFT catch for 2017 or 2018 was equal or above 5,000 MT shall reduce their PS YFT catch by 35 % from 2017 or 2018 levels.

✓ **Gillnet:** CPCs whose reported GN YFT catch for 2017 or 2018 was equal or above 2,000 MT shall reduce their Gillnet catches of YFT by 25 % from 2017 or 2018 levels.

✓ **Longline:** CPCs whose reported LL YFT catch for 2017 or 2018 was equal or above 3,000 MT shall reduce their LL YFT catch by 25 % from 2017 or 2018 levels.

✓ **Other gears:** CPCs whose catches of YFT from other gears reported for 2017 were equal or above 3,000 MT shall reduce their other gear YFT catch by 15 % from 2017 or 2018 levels.

Regarding those CPCs that in 2017 and 2018 achieved a reduction equal to, or above the YFT catch limits established by IOTC resolutions using 2014 catch as baseline, the following will apply: The percentage differential from the proposed reduction, as long as no irregularities are detected in their reported catch and no increase in catch occurs. This exceptional status has been recognised for the Korean purse seine fleet and the Taiwanese longline fleet. Therefore, instead of applying the reduction corresponding to them (35% and 25%). It would be applied the difference between the percentage reduction requested by Resolution 19/01 (15 % and 10% respectively) and the current one requested, so It would have to apply only a 20% and 15% reduction respectively.

The Korean purse seine fleet reduced its catch by 28% in 2017 and by 39% in 2018 regarding the 2014 baseline (thus, well above the -15% that was requested by previous resolutions), and the Taiwanese longline fleet reduced its catch by 26% in 2017 and 12% in 2018 regarding the 2014 baseline (also above the -10% that was requested by previous resolutions).

Proposal 3

The target of this proposal is to achieve the 25% catch reduction necessary to reach the SSBMSY level taking into account the contribution by each fleet (by weight) to the total catch and the percentage of reduction or increase in their catches achieved in 2017 and 2018 regarding the baseline year 2014. A balance has been sought so that those fleets that made a minor reduction effort or even incurred in a catch increase will contribute a proportionally higher share to the reduction. Furthermore, in this proposal the threshold for longlines has been lowered from 5,000 MT to 4,000 MT.

The total reduction achieved would be **25% or 24%**, taken as reference year 2017 or 2018, respectively (Table 14).

In recent years (2013–2017), purse seine has been the dominant fishing method harvesting 33% of the total IO YFT catch (by weight), with the longline, handline, gillnet fisheries, comprising 14%, 19% and 14% of the catch, respectively. A smaller component of the catch was taken by the regionally important baitboat (5%) and troll (5%) fisheries. The recent increase in the total catch has been attributable to an increase in catch from all the major fisheries (IOTC–2018–WPTT20–33).

Thus, the five main fleets by percentage of total YFT catches (2014–18) were: EU-Spain (purse seine): 13%; Maldives (handline, pole-and-line): 13%; I.R. Iran (gillnet): 13%; Seychelles (purse seine): 9%; Sri Lanka (gillnet, coastal longliners): 9% (IOTC-2019-WPTT21-08_Rev1).
Catch limits under Proposal 3:

✓ **Purse seine fleets:** CPCs whose reported PS YFT catch for 2017 or 2018 was equal or above 5,000 MT shall reduce their PS YFT catch by 27 % from the 2017 or 2018 levels. Regarding the baseline 2014 level, based on officially endorsed data by IOTC, total catches of the combined PS fleet decreased by 1% in 2017 and by 9% in 2018. However, revised 2018 catch data including the revisions for purse seines (PS LS) catch became afterwards available from IOTC and as such it is included in the annex 1 (Table 17, D), it has not been verified yet by the IOTC and thus it is not officially endorsed.

If that revised catch data for purse seine catch in 2018 was verified, the purse seine fleet would not have made any reduction in catches with regard to the year 2014. The reduction effort required by the IOTC resolutions (18/01 and 19/01) was a decrease in catches of 15% from the catch level reported in 2014. Under this proposal, a full reduction of 25% is required to achieve the objectives.

✓ **Gillnet fleets:** CPCs whose Gillnet catches of YFT reported for 2017 or 2018 were equal or above 2,000 MT shall reduce their Gillnet catch of YFT by 35 % from the 2017 or 2018 levels.

In 2017, all gillnet fleets have increased their catches by 18 % regarding the year 2014. In 2018, the same trend is repeated for the gillnet fleet, as there is almost no increase in catches between 2017 and 2018. The reduction effort required by the IOTC resolutions was a decrease in catches of 10% from the catches reported in 2014. Under the above data, the full reduction of 25% is requested, plus the 10% that was previously required.

✓ **Longline fleets:** CPCs whose Longline catches of YFT reported for 2017 or 2018 were equal or above 4,000 MT shall reduce their Longline catches of YFT by 15 % from the 2017 or 2018 levels.

In 2017 is noted that the reduction in catches of all longline fleets from the 2014 baseline was 18 %. However, in 2018 was only 4%. The reduction effort required by the IOTC resolutions was a decrease in catches of 10% from the catches reported in 2014. Under this proposal, a reduction of 15% is requested, taking into account both its previous reduction and the weight of its catches in the total.

✓ **Other gears:** CPCs whose catches of YFT from other gears reported for 2017 or 2018 were equal or above 5,000 MT shall reduce their other gear catches of YFT by 20 % from the 2017 or 2018 levels.

In 2017, all other fleets decreased their catches by 4% regarding the year 2014. However, in 2018, achieved an increase of 10 % with regarding the year 2014.

This is one of the fleets where more uncertainties have been detected in their recorded catch data. The reduction effort required by the IOTC resolutions was a decrease in catches from the 5% declared in 2014. This minimal reduction would compensate for the increase that may occur as LDC and SIDC CPCS develop their fleets. However, an analysis of the data shows that most of the countries that have recorded an increase in their catches do not belong to this LDC and SIDC group. According to the data of increases in catches recorded of all other gears fleet and the weight of their catches in the total, a reduction of 20% is requested. In addition, although previous efforts have been made to advance in the separate registration of the fleets, it is recommended to continue working with the CPCs in order to improve their data and provide data by individual fleet, to the extent possible.

Those CPCs that in 2017 and 2018 achieved a reduction equal to, or above the YFT catch limits established by IOTC resolutions using 2014 catch as baseline, the following will apply: The percentage differential from the proposed reduction, as long as no irregularities are detected in their reported catch and no increase in catch occurs. This exceptional status has been recognised for the Korean purse seine fleet and the Taiwanese longline fleet. Therefore, instead of applying the reduction corresponding to them (27% and 15%). It would be applied the difference between the percentage reduction requested by resolution 19/01 (15% and 10% respectively) and the current one, so It would have to apply only a 12% and 5 % reduction respectively.

The Korean purse seine fleet reduced their catch by 28% in 2017 and 39% in 2018 regarding the year 2014 (requested of previous resolutions -15%), and Taiwanese longline fleet reduced their catch by 26% in 2017 and 12% in 2018 regarding the year 2014 (requested of previous resolutions -10%).

In recognition of the special requirements of Developing States Parties, in particular Small Island Developing States, in relation to conservation and management of YFT in Indian Ocean, they are allowed to choose 2017 or 2018 as their catch reference year. This exception does not apply if any of the catch of any of these years is under the threshold.

*Table 13: Proposals of catch limits strategies. Subject to Reduction (pink), No Subject to Reduction (clear blue) CPC differential reduction applied (clear green) * Least developed countries **Small Island developing countries. Catches for 2018 are preliminary. Source data: IOTC-2019-WPTT21-DATA03-NC).*

Subject to Reduction	No Subject to Reduction	Subject to Reduction, but differential reduction applied

Subject to Reduction (purple) No Subject to Reduction (clear blue) CPC differential reduction applied (blue) * Least developed countries **Small Island developing countries

A) Purse seine fleets (officially reported)

Purse seine fleets	2014	2017	2018	Proposal 1				Proposal 2				Proposal 3			
				(5000 MT baseline 2017)		(5000 MT baseline 2018)		(5000 MT baseline 2017)		(5000 MT baseline 2018)		(5000 MT baseline 2017)		(5000 MT baseline 2018)	
EU	91,405	86,893	75,375	25	65,170	25	56,531	35	56,480	35	48,994	27	63,432	27	55,024
KOR	8,852	6,392	5,415	25	4,794	25	4,061	20	5,114	20	4,332	12	5,625	12	4,765
SYC**	23,463	41,694	35,023	25	31,271	25	26,267	35	27,101	30	22,765	27	30,437	27	25,567
EGY				N/A		N/A		N/A		N/A		N/A		N/A	
IDN	5,598	5,214	9,564	25	3,911	25	7,173	35	3,389	35	6,217	27	3,806	27	6,982
IND	98	63	120		63		120		63		120		63		120
IRN	4,832	1,746	3,898		1,746		3,898		1,746		3,898		1,746		3,898
JOR				N/A				N/A				N/A			
JPN	433	712	404		712	N/A	404		712	N/A	404		712	N/A	404
KEN		73	73		73		73		73		73		73		73
LKA	2,627	5,505	2,891	25	4,129		2,891	35	3,578		2,891	27	4,019		2,891
MOZ*															
MUS**	4,844	7,681	11,322	25	5,761	25	8,492	35	4,993	35	7,359	27	5,607	27	8,378
PHIL		73		N/A	73	N/A		N/A	73	N/A		N/A	73	N/A	
	142,152	156,046	144,085		117,701		109,910		103,322		97,053		115,592		108,102

B) Purse seine fleets (including revisions to 2018 PS LS)

Purse seine fleets	2014	2017	2018	Proposal 1				Proposal 2				Proposal 3			
				(5000 MT baseline 2017)		(5000 MT baseline 2018)		(5000 MT baseline 2017)		(5000 MT baseline 2018)		(5000 MT baseline 2017)		(5000 MT baseline 2018)	
EU	91,405	86,893	88,981	25	65,170	25	66,736	35	56,480	35	57,838	27	63,432	27	64,956
KOR	8,852	6,392	5,415	25	4,794	25	4,061	20	5,114	20	4,332	12	5,625	12	4,765
SYC**	23,463	41,694	35,023	25	31,271	25	26,267	35	27,101	35	22,765	27	30,437	27	25,567
EGY															
IDN	5,598	5,214	9,564	25	3,911	25	7,173	35	3,389	35	6,217	27	3,806	27	6,982
IND	98	63	120		63		120		63		120		63		120
IRN	4,832	1,746	3,898		1,746		3,898		1,746		3,898		1,746		3,898
JOR				N/A				N/A				N/A			
JPN	433	712	404		712	N/A	404		712	N/A	404		712	N/A	404
KEN		73	73		73		73		73		73		73		73
LKA	2,627	5,505	2,891	25	4,129		2,891	35	3,578		2,891	27	4,019		2,891
MOZ*															
MUS**	4,844	7,681	11,322	25	5,761	25	8,492	35	4,993	25	7,359	27	5,607	27	8,265
PHIL		73		N/A	73	N/A		N/A	73	N/A		N/A	73	N/A	
	142,152	156,046	157,691		117,701		120,115		103,322		105,897		115,592		117,921

C) Gillnet fleets

Gillnet fleets	2014	2017	2018	Proposal 1 (2000 MT baseline 2017)		Proposal 1 (2000 MT baseline 2018)		Proposal 2 (2000 MT baseline 2017)		Proposal 2 (2000 MT baseline 2018)		Proposal 3 (2000 MT baseline 2017)		Proposal 3 (2000 MT baseline 2018)	
IRN	24,401	37,193	35,534	25	27,895	25	26,651	25	27,895	25	26,651	35	24,175	35	23,097
AUS	0	1	1		1		1		1		1		1		1
BHR	1	0	0		0		0		0		0		0		0
COM**	16	547	135	N/A	547	N/A	135	N/A	547	N/A	135	N/A	547	N/A	135
DJI*	38	95	15		95		15		95		15		95		15
EGY															
IDN	341	317	252		317		252		317		252		317		252
IND	5,153	3,297	13,717	25	2,473	25	10,288	25	2,473	25	10,288	35	2,143	35	8,916
IRN	16,925	8,358	6,537		6,269		4,903		6,269		4,903		5,433		4,249
JOR	0	5	7	N/A	5		7	N/A	5		7	N/A	5		7
KEN	54	157	157		157	N/A	157		157	N/A	157		157	N/A	157
LKA	11,246	3,142	1,479		2,357		1,479		2,357		1,479		2,042		1,479
OMN	2,268	9,646	14,184	25	7,235	25	10,638	25	7,235	25	10,638	35	6,270	35	9,220
PAK	14,452	25,472	16,541		19,104		12,406		19,104		12,406		16,557		10,752
QAT	93			N/A		N/A		N/A		N/A		N/A		N/A	
TMP**	0	0	0		0		0		0		0		0		0
TZA*	3,210	3,814	3,814	25	2,861	25	2,861	25	2,861	25	2,861	35	2,479	35	2,479
YEM*	5		18			N/A	18			N/A	18			N/A	18
	78,203	92,044	92,391		66,453		66,931		66,453		66,931		57,742		58,279

D) Longline fleets

Longline fleets	2014	2017	2018	Proposal 1				Proposal 2				Proposal 3			
				(3000 MT baseline 2017)		(3000 MT baseline 2018)		(3000 MT baseline 2017)		3000 MT baseline 2018)		(4000 MT baseline 2017)		(4000 MT baseline 2018)	
TWN	12,285	9,115	10,845	25	6,836	25	8,134	15	7,748	15	9,218	5	8,659	5	10,303
LKA	8,625	6,448	8,554		4,836		6,416	25	4,836	25	6,416	15	5,481	15	7,271
AUS	19	65	38		65	N/A	38	N/A	65	N/A	38		65	N/A	38
BLZ	46														
CHN	1,078	2,962	4,641		2,962	25	3,481		2,962	25	3,481		2,962	15	3,945
EU	894	369	331		369		331		369		331		369		331
IDN	4,009	2,353	1,606		2,353		1,606		2,353		1,606		2,353		1,606
IND	327	6	7		6		7		6		7		6		7
JPN	3,639	3,291	2,999		2,468		2,999	25	2,468		2,999		3,291		2,999
KEN			116				116				116				116
KOR	1,557	1,802	1,575	N/A	1,802		1,575		1,802		1,575	N/A	1,802		1,575
MDG*	59	28	29		28		29		28		29		28		29
MDV**	120	220	106		220	N/A	106		220	N/A	106		220	N/A	106
MOZ*	1	89	63		89		63		89		63		89		63
MUS**	15	266	259		266		259		266		259		266		259
MYS	77	384	446		384		446		384		446		384		446
NEICE	4065														
NEIFR	417														
OMN	28	110	177		110		177		110		177		110		177
PHL	69														
SYC**	1616	4613	5678	25	3,460	25	4,259	25	3,460	25	4,259	15	3,921	15	4,826
THA	187														
TZA*	155					N/A				N/A				N/A	
ZAF	83	247	331		247		331		247		331		247		331
	39,371	32,368	37,801		26,501		30,372		27,413		31,456		30,253		34,428

E) All other fleets

All other fleets	2014	2017	2018	Proposal 1 (5000 MT baseline 2017)		Proposal 1 (5000 MT baseline 2018)		Proposal 2 (3000 MT baseline 2017)		Proposal 2 (3000 MT baseline 2018)		Proposal 3 (5000 MT baseline 2017)		Proposal 3 (5000 MT baseline 2018)	
MDV BB**	18,481	17,500	10,749	25	13,125	25	8,062	15	14,875	15	9,137	20	14,000	20	8,599
MDV HL**	30,246	30,563	16,704		22,922		12,528		25,979		14,198		24,450		13,363
AUS	0	1	0		1	N/A	0	N/A	1	N/A	0		1		0
COM**	1,383	4,259	3,059		4,259		3,059	15	3,620	17	2,600		4,259		3,059
EGY				N/A								N/A		N/A	
EU	291	445	407		445		407	N/A	445	N/A	407		445		407
GBRT	2	3	4		3		4		3		4		3		4
IDN	15,327	14,278	11,319	25	10,709	25	8,489	15	12,136	15	9,621	20	11,422	20	9,055
IND	27,849	10,566	23,644		7,925		17,733		8,981		20,097		8,453		18,915
IRN	57	8,806	12,682		6,605		9,512		7,485		10,780		7,045		10,146
JOR	30	20	17	N/A	20	N/A	17	N/A	20	N/A	17	N/A	20	N/A	17
KEN	17	174	174		174		174		174		174		174		174
LKA	15,280	22,883	26,892	25	17,162	25	20,169	15	19,451	15	22,858	20	18,306	20	21,514
MDG*	675	675	675	N/A	675	N/A	675	N/A	675	N/A	675	N/A	675	N/A	675
MDV BB**			6,870			25	5,153			15	5,840			20	5,496
MDV HL**			12,256				9,192				10,418				9,805
MOZ*	4	80	93		80	N/A	93		80	N/A	93		80	N/A	93
MUS*	50	69	75		69		75		69		75		69		75
OMN	4,912	9,693	14,281	25	7,270	25	10,711	15	8,239	15	12,139	20	7,754	20	11,425
SYC**	0	57	43	N/A	57	N/A	43	N/A	57	N/A	43	N/A	57	N/A	43
TMP**	3	3	3		3		3		3		3		3		3
TZA*	76	90	90		90		90		90		90		90		90
YEM*	29,346	17,935	17,977	25	13,451	25	13,483	15	15,245	15	15,280	20	14,348	20	14,382
ZAF	0			N/A		N/A		N/A		N/A		N/A		N/A	
	144,029	138,100	158,014		105,044		119,671		117,628		134,549		111,655		127,339

Table 14: Total catch reduction of Proposals of catch limits strategies. Source data: IOTC-2019-WPTT21-DATA03-NC.

A) Overall (offcially reported catches)

All fleets		2014	2017	2018	Proposal 1		Proposal 2		Proposal 3	
					baseline 2017	baseline 2018	baseline 2017	baseline 2018	baseline 2017	baseline 2018
All purse seine fleets		142152	156046	144085	117701	109910	103322	97053	115592	108102
All gillnet fleets fleets		78203	92044	92391	66453	66931	66453	66931	57742	58279
All longline fleets		39371	32368	37801	26501	30372	27413	31456	30253	34428
All other fleets		144029	138100	158014	105044	119671	117628	134549	111655	127339
Sum		403755	418558	432291	315700	326883	314815	329988	315243	328148
Absolute	Difference with baseline				-102859	-105408	-103743	-102303	-103315	-104143
%					-25%	-24%	-25%	-24%	-25%	-24%

B) Overall (including revisions to 2018 PS LS)

All fleets		2014	2017	2018	Proposal 1		Proposal 2		Proposal 3	
					baseline 2017	baseline 2018	baseline 2017	baseline 2018	baseline 2017	baseline 2018
All purse seine fleets (including revisions to 2018 PS LS)		142152	156046	157691	117701	120115	103322	105897	115592	117921
All gillnet fleets fleets		78203	92044	92391	66453	66931	66453	66931	57742	58279
All longline fleets		39371	32368	37801	26501	30372	27413	31456	30253	34428
All other fleets		144029	138100	158014	105044	119671	117628	134549	111655	127339
Sum		403755	418558	445897	315700	337088	314815	338832	315243	337967
Absolute	Difference with baseline				-102859	-108810	-103743	-107065	-103315	-107930
%					-25%	-24%	-25%	-24%	-25%	-24%

It is important to highlight two circumstances. Firstly, our proposals are a snapshot of the current situation in the Indian Ocean and no future increases in the catches of yellowfin tuna of other fleets (not subject to reductions) are considered. If increases in fishing mortality are permitted for smaller fleets or countries, stronger reductions should be necessary for the main fleets to achieve the reduction goal. Secondly, our proposals consider that these cuts are implemented on all the vessels of the fleets affected, regardless the size of the vessel (except for subsistence fisheries), and that there is a 100% level of compliance with the regulation. A range of alternative scenarios (implementation on a certain size of vessels, different percentages of non-compliance, etc) could be tested but it would make our conclusions too complicated. In this regard, it is recommended that the IOTC should establish catch control measures with the objective that the catch limits of the CPCs can be controlled in the current year and not at one year away in the future as it is done up to now. In that case, the proposed mechanism is that the CPCs shall notify the IOTC when the YFT catch reaches 80% of the total catch limit for the current year. At 90% of the total catch limit, the IOTC shall notify CPCs of an estimated closure date for each fleet, and at 100% the IOTC will announce the immediate closure of the fishery.

As seen in the summary table shown above (Table 12), the overall catch reduction of YFT for the entire fleet for proposals 1-3 would reach the 25% catch reduction , enough for avoiding stock crashes, and in line with the values of reduction indicated by the SC and the WPTT for recovering the stock to MSY levels (Fu et al., 2018a and b), but still far from the 30% or even 35% cuts suggested by other sources consulted (Winker et al., 2019, Kolody & Jumppanen 2019a and b). Furthermore, an important consideration when developing catch limits strategies is how to account for mixed fishery interactions. A better understanding of the interactions that occur between the bigeye, yellowfin and skipjack fisheries is crucial to the successful recovery of the tuna fishery in the Indian Ocean. Therefore, it is important to take into account that these catch limit strategies should be combined with other measures (effort control, closures, etc.) (Pons et a l2016), to achieve a more effective YFT rebuilding plan and increase the chances of reaching the SSBMSY level (see Conclusions). These complementary measures are explained in the following section.

IX. Complementary measures

The level of compliance with the catch reduction scheme currently in place has been very poor, with total recent YFT catch not only failing to reach the required reduction level of 15% but actually increasing by 10% in 2018, reaching the same levels reported in 2007 (IOTC WPTT21 2019). Thus, judging by recent experience this pattern is likely to be repeated with Resolution 19/01. Hence it becomes necessary to assume that the catch reduction strategy alone is unlikely to work unless an unprecedented improvement in compliance by all CPCs is achieved in the very short term. Given this situation, alternatives should be explored to be used complementarily to the main measure, i.e. catch reductions, as discussed in the previous sections:

Effort reduction strategies (time/area closures)
One of the main complementary alternatives to tackle the issue of YFT overfishing is that of applying effort reduction strategies, as proposed by Sharma & Herrera (2019) and also assessed by Merino et al. (2018).

- One of the main arguments for effort reduction measures is that they can be more easily implemented (i.e. the fleet or fleets subject to the measures would be moored during the closure period) and the level of compliance is easier to assess than with catch reduction strategies (Merino et al. 2018, Sharma & Herrera 2019).

  A second argument for effort reduction is that it seems better geared to the reality of tuna fisheries which, for most gears, are multi-specific in nature. In this sense a seasonal closure might have a positive impact on the stock status of all tuna stocks being fished (including also non-target species, such as those species vulnerable to bycatch). This is so, because besides yellowfin tuna there are another two tropical tuna species (skipjack Katsuwonus pelamis (SKJ) and bigeye Thunnus obesus (BET)) caught by the same gears as YFT.

  IO Skipjack tuna

  In 2019 the status of the IO skipjack stock was officially deemed not overfished (SSBcurrent/ SSBTarget = 1.00, range: 0.88-1.17); but note that the range does encompass a possible overfished status, and also officially deemed not subject to overfishing (Fcurrent/ FTarget=0.93, range: 0.70-1.13; here too the range does not exclude the possibility of overfishing (IOTC-2019-SC22-ES03).

  Furthermore, the uncertainty of the skipjack stock status in the IO is illustrated by the fact that in the last available update (2019) the estimated probability that the stock is in the quadrant of the Kobe plot corresponding to the combination of not overfished and also not overfishing was estimated at 47%; but probability of it being in the Kobe quadrant corresponding to the combination of overfished and also subject to overfishing was estimated at 38%, hence not dismissible (IOTC-2019-SC22-ES03). Tellingly, the skipjack catch has been increasing in the past years up to the point that 2018 catch was 604,500t (ISSF 2020), which is much in excess of the 2018 -2020 TAC (470,029t) (IOTC-2019-SC22-ES03).

  IO Bigeye tuna

  According to the last bigeye tuna stock assessment (IOTC–SC22 2019), bigeye in the IO is officially deemed not overfished but experiencing overfishing, as indicated by the median values of the respective points of reference: SSB2018/SSBmsy = 1.22 (range 0.82–1.81) and F2018/Fmsy = 1.2 (0.70-2.05). The vast confidence intervals associated to each estimate are a clear sign of the high uncertainty associated to the stock assessment. In fact, the probability that the stock is in the quadrant of the Kobe plot corresponding to the combination of "not overfished but subject to overfishing" was estimated at 38.2%, which is only marginally above than the probability that it is in the "overfished and subject to overfishing" quadrant at 34.6%.

Currently, no quotas are defined and no other measures are active to reduce the fishing pressure on bigeye tuna in the Indian Ocean. However, according to IOTC's 2019 management advice (IOTC–SC22 2019), BET catches should be reduced by at least 10% regarding 2018 catch level in order to have a 50% probability that the stock will not fall below MSY level by 2021 and 2028: "The SS3 projections from the 2019 assessment show that there is a risk of breaching MSY-based reference points by 2021, and 2028 if catches are maintained at 2018 levels at the current selectivity and therefore size distribution of catch (Table 2). Should the management objective of maintaining biomass at levels higher than SBMSY with more than 50% probability in 2028 be pursued, the overall catch should be reduced 10% from current levels (73,272 t)."

Sharma and Herrera (2019) explored the application of full seasonal closures to the multi-species tuna purse seine fishery in the IO in order to achieve the levels of catch reduction defined by the IOTC (15% reduction from 2014 YFT catch level, and in the case of Seychelles, the 2015 YFT catch level). Furthermore, a reduction of 10% in the BET from 2018 levels catch was also recommended by the IOTC-SC in 2019, as seen above, although no resolution has yet been put in place to implement this recommendation.

Sharma and Herrera (2019) aimed to define a Control Rule which yielded a range of possible closure periods highlighting the effect that each of these periods would have in terms of reduced catch of immature or mature YFT, BET and SKJ. Thus the authors developed and run a model which used data from the EU-PS and Seychelles fleets for the period 2002-2017. In the authors' words, these were the only purse seine fleets selected because "the EU-PS (...) and Seychelles fleets have reported the highest catches in recent years and are the only fleets for which catch, effort, and size data are fully available".

Sharma and Herrera produced the following tables:

Table 15: Number of fishing hours (FHOUR) and levels of expected reduction (expressed as a %) in the catches of yellowfin tuna (YFT), bigeye tuna (BET) and skipjack tuna (SKJ) for each fishing day in each month estimated using the model. The two columns to the right of each %-stock show the contribution of one fishing day in each month to the reduction of catches of Mature (M) and Immature (I) fish for that stock. (From: Sharma and Herrera 2019)

Month	FHOUR	%YFT	%YFTM	%YFTI	%BET	%BETM	%BETI	%SKJ	%SKJM	%SKJI
JAN	435	0.51	0.67	0.15	0.36	0.60	0.23	0.15	0.15	0.07
FEB	422	0.49	0.60	0.24	0.38	0.58	0.28	0.24	0.24	0.08
*FEB**	*408*	*.048*	*0.58*	*0.23*	*0.37*	*0.56*	*0.27*	*0.23*	*0.23*	*0.08*
MAR	358	0.23	0.19	0.34	0.31	0.18	0.38	0.35	0.35	0.21
APR	323	0.20	0.20	0.21	0.20	.017	0.22	0.27	0.27	0.21
MAY	315	0.14	0.14	0.14	0.12	0.11	0.13	0.25	0.25	0.08
JUN	259	0.26	0.33	0.11	0.29	0.64	0.10	0.09	0.09	0.11
JUL	301	0.23	0.26	0.16	0.24	0.33	0.19	0.17	0.17	0.18
AUG	364	0.18	0.08	0.41	0.30	0.06	0.42	0.42	0.42	0.46
SEP	343	0.24	0.12	0.51	0.34	0.08	0.47	0.45	0.45	0.69
OCT	309	0.24	0.13	0.50	0.29	0.10	0.39	0.48	0.48	0.81
NOV	338	0.26	0.24	0.32	0.26	0.18	0.30	0.30	0.30	0.28
DEC	342	0.33	0.39	0.19	0.21	0.32	0.15	0.12	0.12	0.08

**Applies to leap years (e.g 2020)*

Table 15 above shows how each fishing day in the months of September and October represented the maximum reduction in the catch of immature YFT and SKJ. In the case of BET, maximum daily catch reductions in the catch of immature BET were achieved in September, with August and October rallying were close to each other for the 2nd and 3rd maximum reduction level.

Table 16 (below) presents the same results as Table 15 raised to full months:

Table 16: Number of fishing hours (FHOUR) and levels of expected reduction (expressed as a %) in the catches of yellowfin tuna (YFT), bigeye tuna (BET) and skipjack tuna (SKJ) corresponding to full month closures, as estimated using the model. The two columns to the right of each %-stock show the contribution of full month closures to the reduction of catches of Mature (M) and Immature (I) fish for that stock. (From: Sharma and Herrera 2019)

Month	FHOUR	%YFT	%YFTM	%YFTI	%BET	%BETM	%BETI	%SKJ	%SKJM	%SKJI
JAN	13490	15.8	20.7	4.6	11.1	18.5	7.2	4.7	4.7	2.1
FEB	11827	13.8	16.9	6.7	10.8	16.3	7.8	6.7	6.7	2.2
MAR	11106	7.3	5.8	10.6	9.7	5.6	11.9	10.8	10.9	6.6
APR	9699	6.0	6.0	6.2	6.1	5.0	6.7	8.0	8.0	6.4
MAY	9753	4.3	4.3	4.5	3.7	3.3	3.9	7.7	7.7	2.6
JUN	7759	7.8	9.8	3.2	8.7	19.1	3.1	2.6	2.6	3.3
JUL	9332	7.2	8.2	5.1	7.4	10.2	5.8	5.2	5.2	5.4
AUG	11281	5.5	2.4	12.6	9.2	1.9	13.2	13.0	12.9	14.1
SEP	10301	7.1	3.5	15.2	10.2	2.5	14.2	13.6	13.6	20.6
OCT	9592	7.5	4.0	15.5	8.9	3.0	12.1	14.9	14.8	25.2
NOV	10133	7.8	7.1	9.6	7.7	5.5	8.9	8.9	8.9	8.5
DEC	10603	10.3	12.1	6.0	6.5	9.8	4.7	3.9	3.9	2.4
TOTAL	124875	100	101	100	100	101	100	100	100	100

**Applies to leap years (e.g 2020)*

September and October appear thus as the core months where maximum reductions in the catch of immature YFT and SKJ can be attained. In the case of immature BET, September is again the crucial month, with August following slightly behind. For SKJ, the period Aug-Oct is also best for achieving a maximum reduction in the catch of mature specimens –thus making it the best period for an overall reduction in SKJ catch.

However, in the case of YFT and BET catches the problem is that the Aug-Oct period during which the maximum reduction in immatures catch is reached, is not mirrored by a parallel reduction in the catch of mature YFT and BET. In both stocks the best period to achieve a maximum reduction for mature tuna catch is January-February. The strong reductions in catch of mature tuna achieved in these two months determine that Jan-Febr is also the period with a higher overall reduction of YFT and BET catch.

These contradictory results regarding the best choice for reduction of overall YFT (and BET) catch, as opposed to the best choice for reduction of immature YFT (and BET) are not necessarily unsurmountable. There are at least two options for reconciling them:

a. Setting two periods of annual closures: one closure aimed to decrease the overall catch of YFT, i.e. in January-February, and the second aiming to decrease the catch of immature YFT, thus in September-October. The total duration of both periods would have to be determined through further analysis based on the model and results presented by Sharma and Herrera (2019).

b. A choice of either just one seasonal closure aimed to reduce the overall catch of YFT, or two closures as in a), could be combined with the implementation of a further spatial and time closure focused in the area off the Somali coast where most immature catches are concentrated. A suggestion -merely for illustrative purposes- of the possible delimitation of the spatial closure is presented in Fig. 8 (below). In this way, for instance, a full IO-wide closure could be implemented during January-February each year, followed by a second, more limited, spatial closure in a period to be defined between August and October. As in a), the possible combinations for achieving maximum reduction in both overall catch and immature catch would be explored and identified with a model based in the work by Sharma and Herrera. The model would also incorporate the spatial closure of the mentioned area off Somalia's coast. This would apply to the duration of both closures and also to the spatial extension of the closure off Somalia.

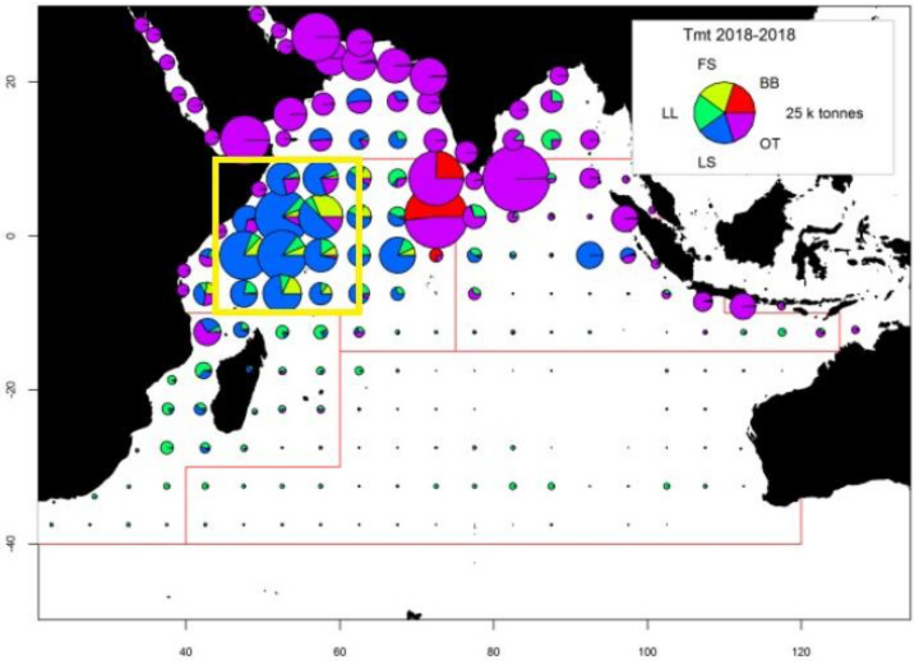

Figure 8: Suggestion of spatial closure (wide yellow line). Source: Adapted from Figure 21 in: IOTC–2019–WPTT21–08_Rev1

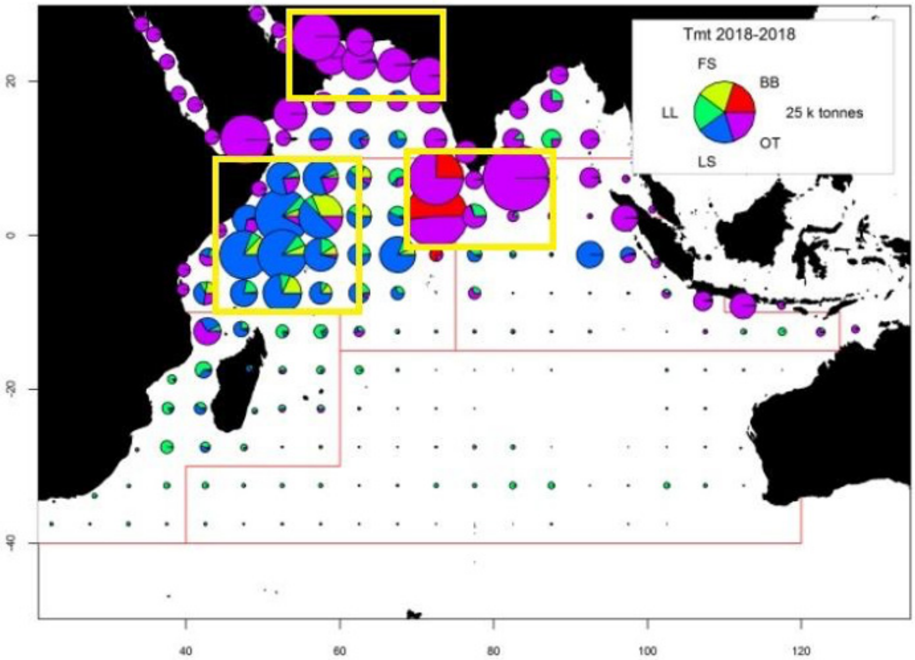

Figure 9: Suggestion of spatial closure (wide yellow line). Source: Adapted from Figure 21 in: IOTC–2019–WPTT21–08_Rev1

c. A third, more complex alternative would imply combining a) the IO-wide closure in January-February; b): the already suggested spatial closure off Somalia and c) one or more further spatial closures aimed to reduce the catch of immature YFT by the "Other gears" fleet segment of the IOTC, which is responsible for practically half the total catch of YFT within the IO. Again, a visual suggestion of possible further spatial closures for the "Other gears" fleet is presented in Fig. 9.

The a, b and c alternatives have the precedent of similar arrangements already implemented by the IATTC and the WCPFC (see Annex 5). Mirroring the measures adopted by both RFMOs, the requirement of full observer coverage onboard all industrial fleets (purse seine, longline, gillnet and baitboat), and the compliance with full retention of all tuna caught (as mandated by IOTC Res. 19/05) should also be a top priority for the IOTC.

Thus, the catch reduction scheme suggested in previous sections of the report could be complemented (but by no means replaced) with a combination of the above presented measures: namely, the establishment of one (or several) fishery closures, which might include one or more spatial closures in those areas where catch of immature tuna is concentrated.

These alternative strategies do not need to be exclusive of the catch reduction scheme. Rather, effort reduction can be implemented in parallel to the catch reduction scheme, as a warrant against failure from IOTC to comply with the required reduction. After a given trial period (for instance, 3 years) results could be assessed to determine whether it would be best to:

- **Keeping the combined catch limit + fishing closures strategy, strengthening monitoring so that catch reductions can realistically be monitored and fulfilled;**
- **Introduce further reductions in the number of FADs used per vessel in the purse seine fishery.**

- **Further reductions in the number of FADs used per vessel**

  A further issue concerning catches of all three tropical tunas (YFT, BET and SKJ) in the IO is the increasing share of the catch accrued to purse seine sets on Floating Aggregating Devices (FADs) (in 2017, 35% of the YFT PS catch was done on free schools versus only 11% in 2018) (IOTC 2019a).

Networks of thousands of artificial drifting and anchored FADs possibly act as 'ecological traps' of pelagic species by altering their natural spatial and temporal distributions, habitat associations, migration patterns, and residence times (Marsac et al. 2000, Bromhead et al. 2003, Hallier & Gartner 2008, Dagorn et al. 2013). FADs may transport tunas away from their traditional forage areas to areas of low productivity, thus resulting in reduced growth and condition, lower fitness, and increased natural mortality. Indeed, the rate of empty stomachs is very high for the tunas caught under drifting FADs (74% vs. 13% for unassociated schools for skipjack tuna, and 49% vs. 7% for YFT) (Hallier & Gaertner 2008).

However, the Ecological trap hypothesis is seen controversial among scientists (for a review, see Dagorn et al 2013). Although this subject has received considerable research attention, it is difficult to evaluate the impacts of FADs on the ecology of tunas, largely due to uncertainty in how tunas interact with floating objects (e.g. length of association, reasons for joining/leaving an object). Consequently, the ecological trap hypothesis remains open to discussion (Leroy et al. 2013, Davies et al. 2014).

In contrast, the feature of FADs-associated purse seine being a source of fishing mortality for juvenile tunas is strongly supported by the literature. Thus, the size distribution of tuna caught in the IO's FAD sets peaks at around 50 cm for YFT (the same size as for pole and line caught YFT (Adam 2018)), at 45 cm for SKJ and it is even smaller, 35 cm, for BET (Baez 2018). Hence, effort reduction measures are needed to curb the currently existing (YFT, BET) or potential (SKJ) overfishing of the stocks, putting a focus on the reduction of juvenile mortality.

The control in the number of FADs deployed by the purse seine fleet in the Indian Ocean has been one of the main objectives of the IOTC in recent years. Although it has decreased in recent years, catches of yellowfin tuna on FADs have increased, and stronger reductions in the number of FADs have been requested by several CPCs and NGOs (from 300 FADs per purse seine to 100/50 per vessel). The aim of the proposed reduction is to move from a passive use of the FADs (where they are deployed by the vessels and left practically unmanaged until they spent their time-life) to an active management, in which each vessel would have a proper control of the FADs used. Several benefits would result from this management system, such as the reduction in the catch of juvenile yellowfin and bigeye tuna, already commented, reinstating the original movements of tropical tunas along the Indian Ocean, reducing the number of FADs lost and drifted ashore (thus reducing marine pollution, the risk of ghost fishing, etc). More work is necessary in order to evaluate the impact of this measure on the YFT and other tuna stocks.

- **Use a joint/combined TACs for all three tropical tunas**

  Due to the multi-species nature of tropical tuna surface fisheries, several experts interviewed suggested the introduction of a joint TAC for all tropical tunas (skipjack, yellowfin and bigeye), might have a positive impact on the stock status of all the stocks. A joint TAC would prevent the problem of exhausting a TAC for a specific species too early in the year. In this case, the joint TAC should be set taking into consideration the expected reduction in catches and the percentage of each species in the sets (in the case of purse seine fisheries, the TT3 methodology, which is used to provide accurate catch estimates per species for the European purse seine fleet, or improved methodologies, should be used). However, this measure is not further explored here as it would suppose a dramatic shift in the way these species are currently managed by the IOTC and more research is necessary on the fisheries which could be managed by this system.

X. Conclusions and recommendations

The stock of YFT in the Indian Ocean is overfished and subject to overfishing since 2016. Despite the indications that the stock could collapse as early as 2024, and although scientific advice (in the form of Kobe II 2 Strategy Matrix) were provided by the scientific committee in 2018, the management measures implemented by the Commission in Resolution 16/01 and its amendments have not been effective in reducing fishing mortality on the stock. A number of uncertainties on the data and the models used to assess the stock have been identified. However, regardless of the uncertainties, stock projections carried out by the IOTC scientists indicate that between a 20% and 35% catch reduction would be necessary to recover the stock to sustainable levels. Based on the K2SM shown in the 2018 scientific meeting report, it is considered that for recovering the stock in two generation times with a probability higher than 70%, a 25% catch reduction in reference to the 2017 catch levels will be necessary. Based on these findings, three proposals on catch reductions are suggested in our report:

- The first proposal recommends a 25% catch cut to all the fisheries which surpassed a set threshold in 2017 or 2018;

- Our second proposal keeps the current balance of Resolution 16/01 and its amendments (higher reductions for purse seines, medium reductions for gillnets and longlines and smaller reductions for other gears) but it increases the level of these reductions and decreases the catch thresholds, for which the catch cuts apply, to include more fisheries;

- Finally, our last proposal, a number of catch cuts are recommended for the different fleets taking into account the contribution by each fleet (by weight) to the total catch and the percentage of reduction or increase in their catches achieved in 2017 and 2018 regarding the baseline year 2014.

In all proposals, a 24-25% catch reduction is achieved. These reductions in fishing mortality could be reached either reducing the fishing effort by fleet or implemented a cap in the number of vessels for the large fleets.

The implementation of resolution 16/01 and its amendments, has had undesirable results, such as the increase in the number of juveniles of yellowfin and bigeye tuna caught by the purse seine fleet, the increase of the effort on skipjack, and an increasing risk on protected species, as the purse seine fishery has shifted its effort towards FAD sets, in order to avoid exhausting their TAC of yellowfin tuna too early in the year. Therefore, it is important to take into account that the suggested catch limit strategies should be combined with complementary measures such as seasonal and/or spatial closures, FAD reduction or joint TACs presented in the previous section. We consider that the implementation of a single management measure such as a catch reduction will not be enough to recover the stock, as it has been demonstrated in recent years, and the use of an available range of measures is necessary.

Finally, we would like to stress that the recovery of the stock of yellowfin tuna is an objective that only can be achieved with the joint effort of all the fleets and countries. Not much time is left for the yellowfin tuna, and if no effective measures are implemented in the next couple of years, it seems that the stock could crash in less than one generation time, which would be catastrophic for the livelihoods of many fishers and coastal communities in the Indian Ocean.

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XII. IOTC Documents

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Circular 2016-077 Determination of catch limits for yellowfin tuna under resolution 16/01.

Circular 2017-057 Confirmation of catch limits for Yellowfin tuna under Resolution 16/01.

Resolution 10/02 Mandatory Statistical Reporting Requirements for IOTC Contracting Parties and Cooperating Non-contracting Parties (CPCs).

Resolution 15/02 Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's).

Resolution 16/01 on an interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence.

Resolution 17/01 on an interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence.

Resolution 18/01 on an interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence.

Resolution 19/01 on an interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence.

IOTC–2016–S20 Report of the 20th session of the IOTC Committee. La Reunion, France, 23–27 May 2016.

IOTC–2017–S21 Report of the 21st session of the IOTC Committee. Yogyakarta, Indonesia, 22–26 May 2017.

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IOTC–2019–WPDCS15 Report of the 15th Session of the IOTC Working Party on Data Collection and Statistics. Karachi, Pakistan, 27-30 November 2019.

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IOTC-2019-DATASETS-NCDB Last updated: 19 December 2019

IOTC-2019-WPTT21-DATA03-NC

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IOTC-2019-S23-PropB_Rev1 on an interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence. Submitted by: Rep. of Korea.

IOTC-2019-S23-PropK on an interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence. Submitted by: European Union.

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IOTC-2019-S23-INF03 ISSF_position_statement.

IOTC-2019-S23-INF04 International_Game_Fish_ Association_position_statement.

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IOTC-2019-S23-INF07 IPNLF_Policy_ Statement_2019.

IOTC-2019-S23-INF12 FPAOI_Statment_2019.

IOTC-2019-S23-INF15 Sustainable_Indian_ Ocean_Tuna_Initiative.

IOTC-2019-S23-INF16 IOTC_UK_Market_ Statement.

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IOTC–2018–WPTT20–33 Preliminary Indian Ocean Yellowfin tuna stock assessment 1950-2017 (stock synthesis). Dan Fu et al, 2017.

IOTC–2018–SC21–16 Indian Ocean Yellowfin tuna SS3 model projections. Dan Fu et al, 2018.

IOTC–2019–TCMP03–R[E]. TCMP 2019. Report of the 3rd IOTC Technical Committee on Management Procedures.

XIII. Annex 1

Supporting figures and tables (sections V, VIII and conclusions)

Table 17: status of YFT catches by gear category in relation to the requirements of Resolution 18/01 (including corrections) and simulation of Resolution 19/01. Note: Seychelles fleet uses year 2015 as baseline according to paragraph 13 of Resolution 18/01 and paragraph 9 of Resolution 19/01. Source IOTC-2019-WPTT21-DATA03-NC own calculations based on IOTC data.

A) Overall (officially reported catches)

All other fleets		Reduction	2014	2015	2016	2017	2018	Difference with baseline	
								Absolute	%
EU	PS	15%	91405	86149	87075	86893	75375	-16030	-18%
KOR	PS		8852	7509	10347	6362	5415	-3437	-39%
SYC	PS		23463	39072	40014	41694	35023	-4049	-10%
TWN	LL	10%	12285	13921	16958	9115	10845	-1440	-12%
LKA	LL		8625	5933	3939	6448	8554	-71	-1%
IRN	GN	10%	24401	26780	31079	37193	35534	11133	46%
MDV**	BB	5%	18481	15796	8550	17500	10749	-7732	-42%
MDV**	HL		30246	36300	44385	30563	16704	-13542	-45%
Total			**217758**	**231460**	**242347**	**235768**	**198199**	**-35168**	**-15%**

B) Overall (including revisions to 2018 PS LS)

All other fleets		Reduction	2014	2015	2016	2017	2018	Difference with baseline	
								Absolute	%
EU	PS	15%	91405	86149	87075	86893	88981	-2424	-3%
KOR	PS		8852	7509	10347	6362	5415	-3437	-39%
SYC	PS		23463	39072	40014	41694	35023	-4049	-10%
TWN	LL	10%	12285	13921	16958	9115	10845	-1440	-12%
LKA	LL		8625	5933	3939	6448	8554	-71	-1%
IRN	GN	10%	24401	26780	31079	37193	35534	11133	46%
MDV**	BB	5%	18481	15796	8550	17500	10749	-7732	-42%
MDV**	HL		30246	36300	44385	30563	16704	-13542	-45%
Total			**217758**	**231460**	**242347**	**235768**	**211805**	**-21562**	**-9%**

C) Purse seine fleets (officially reported)

Purse seine fleets		Resolution 18/01 (above 5,000 MT)	2014	2015	2016	2017	2018	Difference with baseline		Resolution 19/01 (above 5,000 MT)	New limit (2019+)
								Absolute	%		
Subject to Res. 18/01	EU	15	91,405	86,149	87,075	86,893	75,375	-16,030	-18%	15	77,694
	KOR		8,852	7,509	10,347	6,392	5,415	-3,437	-39%		7,524
	SYC**		23,463	39,072	40,014	41,694	35,023	-4,049	-10%		33,211
	Sub-total		123,720	132,730	137,436	134,979	115,813	-23,516	-17%		
Not Subject to Res. 18/01	EGY	N/A									
	IDN		5,598	5,493	5,214	5,214	9,564	3,966	71%	Should reduce 15%. Resolution 18/01 remains binding	4,758
	IND		98	76	84	63	120	22	22%	N/A	
	IRN		4,832	3,842	3,465	1,746	3,898	-934	-19%		
	JOR										
	JPN		433	338	422	712	404	-29	-7%		
	KEN					73	73	73			
	LKA		2,627	3,532	1,966	5,505	2,891	264	10%		
	MOZ*										
	MUS**		4,844	5,448	7,404	7,681	11,322	6,478	134%	Should reduce 7.5 %. Apply par.9, and par. 10.	10,473
	PHIL					73		0			
	Sub-total		18,432	18,729	18,555	21,067	28,272	9,840	53%		
All purse seine fleets			142,152	151,459	155,991	156,046	144,085	-13,676	-9%		

D) Purse seine fleets (including revisions to 2018 PS LS)

Purse seine fleets		Resolution 18/01 (above 5,000 MT)	2014	2015	2016	2017	2018	Difference with baseline		Resolution 19/01 (above 5,000 MT)	New limit (2019+)
								Absolute	%		
Subject to Res. 18/01	EU	15	91,405	86,149	87,075	86,893	88,981	-2,424	-3%	15	77,694
	KOR		8,852	7,509	10,347	6,392	5,415	-3,437	-39%		7,524
	SYC**		23,463	39,072	40,014	41,694	35,023	-4,049	-10%		33,211
	Sub-total		123,720	132,730	137,436	134,979	129,419	-9,910	-7%		
Not Subject to Res. 18/01	EGY	N/A									
	IDN		5,598	5,493	5,214	5,214	9,564	3,966	71%	Should reduce 15%. Resolution 18/01 remains binding	4,758
	IND		98	76	84	63	120	22	22%	N/A	
	IRN		4,832	3,842	3,465	1,746	3,898	-934	-19%		
	JOR										
	JPN		433	338	422	712	404	-29	-7%		
	KEN					73	73	73			
	LKA		2,627	3,532	1,966	5,505	2,891	264	10%		
	MOZ*										
	MUS**		4,844	5,448	7,404	7,681	11,322	6,478	134%	Should reduce 7.5 %. Apply par.9, and par. 10.	10,473
	PHIL					73					
	Sub-total		18,432	18,729	18,555	21,067	28,272	9,840	53%		
All purse seine fleets			142,152	151,459	155,991	156,046	157,691	-70	0%		

E) Gillnet fleets

Gillnet fleets		Resolution 18/01 (above 2,000 MT)	2014	2015	2016	2017	2018	Difference with baseline		Resolution 19/01 (above 2,000 MT)	New limit (2019+)
								Absolute	%		
Subject to Res. 18/01	IRN	10	24,401	26,780	31,079	37,193	35,534	11,133	46%	10	21,961
	Sub-total		24,401	26,780	31,079	37,193	35,534	11,133	46%		
Not Subject to Res. 18/01	AUS	N/A	0	0	1	1	1	1	335%		
	BHR		1	1	1	0	0	-1	-67%		
	COM**		16	117	905	547	135	119	744%	N/A	
	DJI*		38	27	34	95	15	-23	-61%		
	EGY										
	IDN		341	334	317	317	252	-89	-26%		
	IND		5,153	3,974	4,392	3,297	13,717	8,564	166%	According to the vessel database, it is not possible to determine whether it is subject to resolution.	
	IRN		16,925	11,632	4,031	8,358	6,537	-10,388	-61%		
	JOR		0	0	1	5	7	7	1542%	N/A	
	KEN		54	82	82	157	157	103	191%		
	LKA		11,246	8,559	5,469	3,142	1,479	-9,767	-87%		
	OMN		2,268	8,145	6,914	9,646	14,184	11,916	525%	According to the vessel database, it is not possible to determine whether it is subject to resolution.	
	PAK		14,452	16,791	23,392	25,472	16,541	2,089	14%		
	QAT		93	85	57			-93	-100%	N/A	
	TMP**		0	1	1	0	0	0	-66%		
	TZA*		3,210	3,814	3,814	3,814	3,814	604	19%	According to the vessel database, it is not possible to determine whether it is subject to resolution.	
	YEM*		5				18	13	260%	N/A	
	Sub-tot		53,802	53,562	49,411	54,851	56,857	3,055	6%		
All gillnet fleets			78,203	80,342	80,490	92,044	92,391	14,188	18%		

F) Longline fleets

Longline fleets fleets		Resolution 18/01 (above 5,000 MT)	2014	2015	2016	2017	2018	Difference with baseline		Resolution 19/01 (above 5,000 MT)	New limit (2019+)
								Absolute	%		
Subject to Res. 18/01	TWN	10	12,285	13,921	16,958	9,115	10,845	-1,440	-12%	10	11,057
	LKA		8,625	5,933	3,939	6,448	8,554	-71	-1%		7,763
	Sub-tot		20,910	19,854	20,897	15,563	19,399	-1,511	-7%		
Not Subject to Res. 18/01	AUS	N/A	19	73	66	65	38	19	100%	N/A	
	BLZ		46								
	CHN		1,078	1,793	1,812	2,962	4,641	3,563	331%		
	EU		894	732	651	369	331	-563	-63%		
	IDN		4,009	5,077	2,826	2,353	1,606	-2,403	-60%		
	IND		327	669	106	6	7	-320	-98%		
	JPN		3,639	3,140	2,967	3,291	2,999	-640	-18%		
	KEN						116	116			
	KOR		1,557	1,674	1,374	1,802	1,575	18	1%		
	MDG*		59	72	61	28	29	-30	-51%		
	MDV**		120	63	286	220	106	-14	-12%		
	MOZ*		1	56	21	89	63	62	4408%		
	MUS**		15	32	94	266	259	244	1627%		
	MYS		77	144	156	384	446	369	479%		
	NEICE		4065	3009	418						
	NEIFR		417	451	639						
	OMN		28	205	135	110	177	149	532%		
	PHL		69								
	SYC**		1616	2395	3247	4613	5678	4,062	251%		
	THA		187	109							
	TZA*		155	108	109						
	ZAF		83	182	183	247	331	248	299%		
	Sub-total		18,461	19,984	15,151	16,805	18,402	-59	0%		
All longline fleets			39,371	39,838	36,048	32,368	37,801	-1,570	-4%		

G) All other fleets

All other fleets		Resolution 18/01 (above 5,000 MT)	2014	2015	2016	2017	2018	Difference with baseline		Resolution 19/01 (above 5,000 MT)	New limit (2019+)
								Absolute	%		
Subject to Res. 19/01	MDV BB**	5	18,481	15,796	8,550	17,500	10,749	-7,732	-42%	5	16,633
	MDV HL**		30,246	36,300	44,385	30,563	16,704	-13,542	-45%		27,221
	Sub-total		**48,727**	**52,096**	**52,935**	**48,063**	**27,453**	**-21,274**	**-44%**		
Not Subject to Res. 19/01	AUS	N/A	0	0	0	1	0	0	-32%	N/A	
	COM**		1,383	1,630	4,678	4,259	3,059	1,676	121%		
	EGY			16	15			0			
	EU		291	361	564	445	407	116	40%		
	GBRT		2	2	2	3	4	2	158%		
	IDN		15,327	15,041	14,278	14,278	11,319	-4,008	-26%	According to the vessel database, it is not possible to determine whether it is subject to resolution.	
	IND		27,849	12,440	14,662	10,566	23,644	-4,205	-15%	N/A	
	IRN		57	345	6,535	8,806	12,682	12,625	22010%		
	JOR		30	29	28	20	17	-13	-43%		
	KEN		17	27	27	174	174	157	897%		
	LKA		15,280	14,647	22,361	22,883	26,892	11,612	76%		
	MDG*		675	675	675	675	675	0	0%		
	MDV BB**						6,870				
	MDV HL**						12,256				
	MOZ*		4	13	27	80	93	89	2219%		
	MUS*		50	50	87	69	75	25	50%		
	OMN		4,912	6,833	13,935	9,693	14,281	9,369	191%	According to the vessel database, it is not possible to determine whether it is subject to resolution.	
	SYC**		0	0	0	57	43	43	10887%	N/A	
	TMP**		3	3	3	3	3	0	0%		
	TZA*		76	90	90	90	90	14	18%		
	YEM*		29,346	24,576	21,100	17,935	17,977	-11,369	-39%	According to the vessel database, it is not possible to determine whether it is subject to resolution.	
	ZAF		0						0%		
	Sub-total		**95,302**	**76,778**	**99,067**	**90,037**	**130,561**	**35,259**	**37%**		
All other fleets			**144,029**	**128,874**	**152,002**	**138,100**	**158,014**	**13,985**	**10%**		

Table 18 Vessels registered in the IOTC by country and gear (IOTC data)

CPC	Total	>=24	<24	Purse seine	Line	Longline	Gillnet	Trawl	Multi-purpose	Pole & lines	Supply vessel	Research vessel
AUS	65	14	51	10	11	43	-	-	-	1	-	-
China	116	116	0	-	-	116	-	-	-	-	-	-
EU	277	236	41	54	1	194	1	4	-	7	16	-
IDN	4	4	0	-	-	4	-	-	-	-	-	-
IND	341	207	134	77	-	264	-	-	-	-	-	-
Iran	1,310	495	815	8	-	5	1,295	2				-
Japan	203	203	0	10	-	190	-	-	-	-	1	2
Kenya	3	3	0	-	-	3	-	-	-	-	-	-
Korea, Rep	99	99	0	11		87	-	-	-	-	1	-
Madagascar	8	0	8	-	-	8	-	-	-	-	-	-
Malaysia	17	16	1	-	-	17	-	-	-	-	-	-
Maldives	874	364	510	-	-	30	-	-	-	844	-	-
Mauritius	15	4	11	3	-	11	-	-	-	-	1	-
Mozambique	12	1	11	-	-	12	-	-	-	-	-	-
Oman	7	1	6	-	-	7	-	-	-	-	-	-
Pakistan	10	0	10	-	-	-	10	-	-	-	-	-
Philippines	55	55	0	48	-	7	-	-	-	-	-	-
Seychelles	96	73	23	13	-	78	-	-	-	-	5	-
South Africa	35	13	22	-	-	17	-	-	17	1	-	-
Sri Lanka	1766	20	1746	-	-	30	-	-	1736	-	-	-
Tanzania	1	1	0	-	-	1	-	-	-	-	-	-
Thailand	3	3	0	-	-	0	-	-	-	-	-	3
Total	5317	1928	3389	234	12	1124	1306	6	1753	853	24	5

Table 19. Case Base. Source data: IOTC-2019-WPTT21-DATA03-NC.

Subject to Reduction	No Subject to Reduction

Subject to reduction (purple) No subject to reduction (clear blue) * Least developed countries **Small Island developing countries

A) Purse seine fleets (officially reported)

Purse seine fleets	2014	2017	2018	Base case			
				(5000 MT baseline 2017)		(5000 MT baseline 2018)	
EU	91,405	86,893	75,375		73,859		64,069
KOR	8852	6392	5415	15	5,433	15	5,433
SYC**	23,463	41,694	35,023		35,440		29,770
EGY				N/A		N/A	
IDN	5,598	5,214	9,564	15	4,432	15	8,129
IND	98	63	120		63		120
IRN	4,832	1,746	3,898		1,746		3,898
JOR				N/A			0
JPN	433	712	404		712	N/A	404
KEN		73	73		73		73
LKA	2,627	5,505	2,891	15	4,679		2,891
MOZ*				N/A			
MUS**	4,844	7,681	11,322	15	6,529	15	9,624
PHIL		73		N/A	73	N/A	
	142,152	156,046	144,085		133,039		124,411

B) Purse seine fleets (including revisions to 2018 PS LS)

Purse seine fleets	2014	2017	2018	Base case			
				(5000 MT baseline 2017)		(5000 MT baseline 2018)	
EU	91,405	86,893	88,981	15	73,859	15	75,634
KOR	8852	6392	5415		5,433		5,433
SYC**	23463	41694	35023		35,440		29,770
EGY				N/A		N/A	
IDN	5,598	5,214	9,564	15	4,432	15	8,129
IND	98	63	120		63		120
IRN	4,832	1,746	3,898		1,746		3,898
JOR				N/A			0
JPN	433	712	404		712	N/A	404
KEN		73	73		73		73
LKA	2,627	5,505	2,891	15	4,679		2,891
MOZ*				N/A			
MUS**	4,844	7,681	11,322	15	6,529	15	9,624
PHIL		73		N/A	73	N/A	
	142,152	156,046	157,691		133,039		135,976

C) Gillnet fleets

Gillnet fleets	2014	2017	2018	Base case			
				(2000 MT baseline 2017)		(2000 MT baseline 2018)	
IRN	24,401	37,193	35,534	10	33,474	10	31,981
AUS	0	1	1	N/A	1	N/A	1
BHR	1	0	0		0		0
COM**	16	547	135		547		135
DJI*	38	95	15		95		15
EGY							
IDN	341	317	252		317		252
IND	5,153	3,297	13,717	10	2,967	10	12,345
IRN	16,925	8,358	6,537		7,522		5,883
JOR	0	5	7	N/A	5	N/A	7
KEN	54	157	157		157		157
LKA	11,246	3,142	1,479	10	2,828	10	1,331
OMN	2,268	9,646	14,184		8,681		12,766
PAK	14,452	25,472	16,541		22,925		14,887
QAT	93			N/A		N/A	
TMP**	0	0	0		0		0
TZA*	3,210	3,814	3,814	10	3,433	10	3,433
YEM*	5		18			N/A	18
	78,203	92,044	92,391		79,519		79,760

D) Longline fleets

Longline fleets fleets	2014	2017	2018	Base case (5000 MT baseline 2017)		Base case (5000 MT baseline 2018)	
TWN	12285	9115	10845	10	8,204	10	9,761
LKA	8625	6448	8554		5,803		7,699
AUS	19	65	38		65		38
BLZ	46						
CHN	1,078	2,962	4,641		2,962		4,641
EU	894	369	331		369		331
IDN	4,009	2,353	1,606		2,353		1,606
IND	327	6	7		6		7
JPN	3,639	3,291	2,999		3,291		2,999
KEN			116				116
KOR	1,557	1,802	1,575		1,802	N/A	1,575
MDG*	59	28	29		28		29
MDV**	120	220	106		220		106
MOZ*	1	89	63	N/A	89		63
MUS**	15	266	259		266		259
MYS	77	384	446		384		446
NEICE	4065						
NEIFR	417						
OMN	28	110	177		110		177
PHL	69						
SYC**	1616	4613	5678		4613	10	5,110
THA	187						
TZA*	155					N/A	
ZAF	83	247	331		247		331
	39,371	32,368	37,801		30,812		35,293

E) All other fleets

All other fleets	2014	2017	2018	Base case (5000 MT baseline 2017)		Base case (5000 MT baseline 2018)	
MDV BB**	18,481	17,500	10,749	5	16,625	5	10,212
MDV HL**	30,246	30,563	16,704		29,035		15,869
AUS	0	1	0	N/A	1	N/A	0
COM**	1,383	4,259	3,059		4,259		3,059
EGY							
EU	291	445	407		445		407
GBRT	2	3	4		3		4
IDN	15,327	14,278	11,319	5	13,564	5	10,753
IND	27,849	10,566	23,644		10,038		22,462
IRN	57	8,806	12,682		8,366		12,048
JOR	30	20	17	N/A	20	N/A	17
KEN	17	174	174		174		174
LKA	15,280	22,883	26,892	5	21,739	5	25,547
MDG*	675	675	675	N/A	675	N/A	675
MDV BB**			6,870			5	6,527
MDV HL**			12,256				11,643
MOZ*	4	80	93		80	N/A	93
MUS*	50	69	75		69		75
OMN	4,912	9,693	14,281	5	9,208	5	13,567
SYC**	0	57	43	N/A	57	N/A	43
TMP**	3	3	3		3		3
TZA*	76	90	90		90		90
YEM*	29,346	17,935	17,977	5	17,038	5	17,078
ZAF	0			N/A		N/A	331
	144,029	138,100	158,014		131,489		150,676

Table 20. Total catch reduction of Case Base. Source data: IOTC-2019-WPTT21-DATA03-NC.

All fleets		2014	2017	2018	Base Case baseline 2017	Base Case baseline 2018
All purse seine fleets		142152	156046	144085	133039	124411
All gillnet fleets fleets		78203	92044	92391	79519	79760
All longline fleets		39371	32368	37801	30812	35293
All other fleets		144029	138100	158014	131489	150676
Sum		403755	418558	432291	374859	390140
Absolute	Difference with baseline				-43699	-42151
%					-10%	-10%

IX.

Annex 2 Management measures to control fishing effort implemented by other RFMOs.

The IATTC (Inter-American-Tropical-Tuna-Commission)

The main conservation measure established by the IATTC for YFT are Resolutions C-17-01 and C-17-02, which include an annual fishing closure for purse seine vessels greater than 182 tonnes carrying capacity (IATTCC C-17-01). This measure calls for:

- A 72-day closure for purse seiners greater than 182 tonnes capacity through 2020;
- A seasonal closure of the purse seine fishery in an area known as "El Corralito", west of the Galapagos Islands, where catch rates of small bigeye are high;
- A full retention requirement for all purse seine vessels regarding bigeye, skipjack and yellowfin tunas.
- Limits on the number of active FADs that each purse seiner can have, ranging from 70 FADs/vessel for the smallest ones to 450 FADs/vessel for Class 6 vessels (1,200 m3 capacity). Class 6 vessels are also required to recover, within 15 days prior to the start of the closure period, a number of FADs equal to the number of FADs set upon during that same period.

The WCPFC (Western & Central Pacific Fisheries Commission) (adapted from MCS-UK 2019)

A bridging measure has been devised to manage the combined catch of YFT, BET and SKJ. This measure contains the following points which are binding to any fleet operating within the tropical region defined by the Commission (between 20 degrees North and 20 degrees South):

- Prohibition of use and deployment of FADs for five months (three months for Kiribati and Philippines)
- Effort (vessel days) limits to be applied to high seas purse seining (SIDS are excluded)
- Full retention requirement for all tuna caught
- Full (100%) observer coverage onboard for any purse seiner operating within the 20 ˚N – 20 ˚S area (regardless of whether they are on the high seas or within any EEZ)
- The number and capacity of large (over 24m) purse seiners and longliners (with freezing capacity and ice-chilled) operating in this area is frozen to 2016 levels (excluding SIDs and Indonesia).


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