

A Case for Fishery Closures to Manage Purse Seine Fisheries for Tropical Tunas in the IOTC Area of Competence

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SUMMARY

Total Allowable Catches (TAC's) have been implemented for numerous stocks by tRFMO. However, for IOTC's tropical tuna stocks (yellowfin tuna [Thunnus albacares], skipjack tuna [Katsuwonus pelamis] and bigeye tuna [Thunnus obesus]), catch controls, while intended to ensure that overall fishing mortalities are not exceeded, have failed to maintain catches at the desired level because some IOTC CPCs have consistently exceed targets, and other CPCs were excluded from such controls. This document presents a Case for IOTC to consider moving from a system that involves primarily output-based controls to another that relies on input-based controls for its purse seine fishery. It evaluates how successful the different tRFMO have been in managing their tropical tuna stocks showing that input-based controls, as those used in the Pacific Ocean, are more effective than TACs to manage multi-species fisheries for such stocks. Finally, it shows an example of how the decision support tool presented by Sharma & Herrera (2019c) could be used to set seasonal closures for IOTC purse seine fisheries; and demonstrates that the new scheme proposed can assist the IOTC in achieving more effectively its management objectives for tropical tuna stocks.

KEYWORDS

Catch/effort; Tropical tunas; Season regulations.

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1. Introduction

In recent years, all tuna-Regional Fishery Management Organisations (tRFMO) have adopted various management measures to ensure that tropical tuna stocks are maintained at the target sustainable biomass levels. To ensure those levels are maintained in the long term, tRFMOs have agreed to carry Management Strategy Evaluation (MSE) and move towards the adoption of Control Rules (CR) for their stocks (Hillary *et al.* 2016), which may be input-based (effort), output-based (catch), or a combination of the two.

At present, the Indian Ocean Tuna Commission (IOTC) is the only tRFMO to have formally adopted a Harvest Control Rule (HCR) for a tropical tuna stock, skipjack tuna (SKJ; IOTC 2018; Resolution 16-02; **Figure 1**). Other tRFMO stocks are subject to various interim measures, including TACs, catch limits, vessel day schemes, seasonal closures, FAD closures, limits on active Fish Aggregating Devices (FADs), limits on support vessels, and limits on fishing capacity for partial or complete coverage of a fleet (partial in the case of IOTC). However, not all these measures have been successful at maintaining the target stocks at the recommended levels, e.g. skipjack tuna (SKJ) and yellowfin tuna (YFT) in IOTC, and YFT and bigeye tuna (BET) in ICCAT.

Apart from the SKJ HCR, the IOTC adopted a rebuilding plan for its YFT stock (**Figure 1**), through the adoption of IOTC Resolution 16/01 (*On an Interim Plan for Rebuilding the Indian Ocean Yellowfin Tuna Stock in the IOTC Area of Competence*), with amendments adopted in 2017 (Res. 17/01), 2018 (Res. 18/01), and 2019 (Res. 19/01). While some of the provisions of Resolution 19/01 are currently in force (FAD and support vessel limits; phasing-out of driftnets), the catch limits adopted apply to 2020 and subsequent years. In addition, IOTC adopted Resolution 19/02 (Procedures on a Fish Aggregating Devices (FADs) Management Plan), which limits the total number of active buoys purse seiners can monitor at a maximum of 300 active buoys per vessel. The limits of both numbers of active FADs and support vessels have been reduced since they were first adopted. This has brought substantial reductions in the number of support vessels and, to a lesser extent, active FADs used in the Indian Ocean. In addition, the IOTC adopted measures to prohibit the use of aircraft (Res. 16/08 *On the prohibition of the use of aircrafts and unmanned aerial vehicles as fishing aids*) and artificial light (Res. 16/07 *On the use of artificial lights to attract fish*) to spot and attract tuna schools, respectively. Limits on the number of industrial vessels have also been adopted, although they do not cover all fleets (Res. 03/01 *On the limitation of fishing capacity of Contracting Parties and Cooperating Non-Contracting Parties*). Despite all the measures adopted, the IOTC has been unable to maintain the catches of SKJ and YFT at or below the levels recommended by the Scientific Committee (IOTC 2018b; **Table 3**; **Figure 3**). Also, the stock of BET is not subject to any specific measure.

In the Atlantic Ocean, the ICCAT adopted Total Allowable Catches (TACs) for yellowfin tuna and bigeye tuna (**Figure 1**): since 2001 (ICCAT 2019; Recommendation 00-1) for longline fleets and since 2005 (ICCAT 2019; Recommendation 04-1) for the rest of the fleets in a multiannual management plan (ICCAT 2019; Recommendations 16-1 and 18-1). However, both those TACs have been consistently breached, with recent catches well above the adopted TACs (ICCAT SCRS 2018; **Figure 2**).

On the other hand, the fisheries in the Pacific Ocean are managed primarily using input measures, which include seasonal fishery closures in the Inter-American Tropical Tuna Commission (IATTC; IATTC 2019; Resolution C-17-02; **Figure 1**) and a Vessel Day Scheme in the Western and Central Pacific Fisheries Commission (WCPFC; WCPFC 2019; CMM 2018-01; **Figure 1**). These measures have been more effective in maintaining the stocks of tropical tunas at levels near target reference points in both areas because they are more inclusive in terms of the fleets covered and do not rely on the quality of monitoring and reporting of catches (**Figure 2**).

This document presents a Case for the existing management regimes for tropical tunas at the ICCAT and IOTC, primarily based on catch limits or TACs [and quotas] for some stocks (**Figure 1**), to be replaced by a combination of fishery closures, directed at purse seine fisheries, and TAC and quotas for other fisheries. The document represents a follow-up to other documents presented at ICCAT and IOTC meetings (Sharma & Herrera 2018; Sharma & Herrera 2019; Sharma & Herrera 2019b; Merino *et al.* 2018; Sharma & Herrera 2019c; Herrera 2019). It contains a summary of the management measures in place in each tRFMO; how each tRFMO has addressed the scientific advice for the stocks it manages; an evaluation of how each tRFMO has achieved the catch and effort targets in those measures in recent years; and presents a case for the effort decision support tool presented in document IOTC-2019-WPTT-XXX (Sharma & Herrera 2019c) to be used in building an effective interim effort control rule for the IOTC.

2. Management schemes of tRFMO for tropical tuna stocks

The diagrams presented in **Figure 1** reproduce schematically the management measures that each tRFMO has in place for stocks of tropical tunas, by tRFMO. Although in general those measures have been adopted in response to the management advice (top box) issued by their respective scientific bodies, in most cases the measures adopted fall short of such advice (orange and red colored boxes in the bottom layer of the diagrams). A distinct feature is that, while WCPFC and IATTC manage their tropical tuna stocks primarily through input-based approaches (through a vessel day scheme and seasonal fishery closures, respectively), both ICCAT and the IOTC use output-based approaches (TAC and catch limits, respectively).

The contents of each diagram are briefly explained in the following sections, by tRFMO.

2.1. Inter-American Tropical Tuna Commission

The Inter-American Tropical Tuna Commission (IATTC) has a mandate to manage stocks of tropical tunas and other stocks in the Eastern Pacific Ocean. It manages its stocks of tropical tunas through a combination of input (industrial purse seine) and output (longline) measures. Therefore, measures are gear specific, as follows:

2.1.1. Industrial tuna purse seiners

This component (**Figure 1**, top, Box *PS* more than 182 metric tons carrying capacity) is managed through the implementation of a Control Rule (F_{MULT}) whose output is a total number of days closure (*# Days Closure*: 72 days closure at present). IATTC Resolution C-17-02 establishes that each purse seiner shall select one over two possible seasonal closures (*2 Closure Periods*: 29 July-8 October or 9 November-19 January) during which it will have to remain in port. This prevents the disruption of market supply. The color of the box *2 Closure Periods* is green because the Control rule is fully inclusive as it covers all purse seine vessels that operate in the region and addresses the management advice for the three stocks of tropical tunas. It is further supported by IATTC's limitation on fish carrying capacity and ban on support vessels (*CC Limits*; Resolution C-02-03), and other provisions in Resolution C-17-02 including limits on the number of active FADs (*Active FAD Limits*) that purse seiners can use per day (according to their carrying capacity), and a one-month long *Time-Area Closure* (referred to as the *Corralito*). The color of the latter three boxes is orange because, while these measures may be useful to further reduce the capacity of purse seiners, their actual impact on the resources has not been measured.

2.1.2. Longliners

This component (*LL*) is managed through a Total Allowable Catch (*TAC*). However, such *TAC* is exclusive to the bigeye tuna stock and with *Quotas* allocated to just five fleets (China, Japan, Rep. of Korea, Chinese Taipei, U.S.). This means that longline fleets flagged to other IATTC Member and Cooperating Non-Contracting Parties (CPC) might potentially catch up to 500MT of bigeye tuna unrestrictedly; and that any CPC longline fleet can catch yellowfin tuna unlimitedly. This is the reason why the color of the *Quotas* box in the diagram is orange as there is room for catches to go beyond the *TAC* (BET) or scientific advice (YFT), for both stocks.

2.1.3. Other Fisheries

This component (*OT*) includes all fisheries/fleets not covered above, mainly small-scale. Those fisheries are not covered by any specific measure (*Not Assigned*) and therefore they are unmanaged. This means that catches of tropical tuna stocks may grow unlimitedly for this component and this is why the color of the *Not Assigned* box is set to red.

2.2. Western and Central Pacific Fisheries Commission

The Western and Central Pacific Fisheries Commission (WCPFC) has a mandate to manage stocks of tropical tunas and other stocks in the Western and Central Pacific Ocean. As for IATTC, it manages its stocks of tropical tunas through a combination of input (industrial purse seine) and output (longline) measures (CMM 2018-01). Therefore, measures are gear specific, as follows:

2.2.1. Industrial tuna purse seiners

This component (**Figure 1**, upper middle, *PS*) is managed through the implementation of WCPFC's Vessel Day Scheme, which applies to both the Economic Exclusive Zones of WCPFC coastal and island states and the high seas (*Vessel Day Scheme (EEZ+HS)*). The VDS acts as an input-based Control Rule in which purse seine effort is limited to a total number of effective fishing days each year, including allocation of days by EEZ and high seas. It is further supported by limits on the number of active FADs (*Active FAD Limits*) that purse seiners can use per day (350), and three to five-month long *Time-Area Closures* to fishing on FADs, depending on the case. In addition, WCPFC has adopted other provisions such as limits on fishing capacity (not included in the diagram), although they are not fully inclusive. As for IATTC, the *Vessel Day Scheme* box is green because this tool has the capacity to address the scientific advice (although it is not clear how the total number of active days is estimated or how it relates to a clear management objective). This is not the case of other measures because they are not supported by a clear scientific advice and their impact has not been measured so far (orange).

2.2.2. Longliners

This component (*LL*) is managed through a Total Allowable Catch (*TAC*). However, such *TAC* is exclusive to the bigeye tuna stock and with *Quotas* allocated to just six fleets (China, Indonesia, Japan, Rep. of Korea, Chinese Taipei, U.S.), plus some specific measures adopted for the Philippines. This means that longline fleets flagged to other WCPFC Member and Cooperating Non-Contracting Parties (*CPC*) might potentially catch up to 2000MT of bigeye tuna unrestrictedly; and that any *CPC* longline fleet can catch yellowfin tuna unlimitedly. This is the reason why the color of the *Quotas* box in the diagram is orange as it does not ensure that the management advice is fully addressed. In addition, WCPFC has adopted other provisions such as limits on fishing capacity (not included in the diagram), although they are not fully inclusive.

2.2.3. Other Fisheries

This component (*OT*) includes all fisheries/fleets not covered above, mainly small-scale. Those fisheries are not covered by any specific measure (*Not Assigned (Archipelagic)*) and therefore they are unmanaged. This means that the catches of tropical tuna stocks by those fleets may grow unlimitedly and that is the reason why the color of the *Not Assigned* box is red. Many archipelagic fisheries, with a large contribution to total catches of tropical tunas, are included in this component.

2.3. International Commission for the Conservation of Atlantic Tunas

The International Commission for the Conservation of Atlantic Tunas (*ICCAT*) has a mandate to manage stocks of tropical tunas and other stocks in the Atlantic Ocean (including the Mediterranean Sea). It manages its stocks of tropical tunas through a multi-annual Conservation and Management Program (Recommendation 16-01 plus amendment in Recommendation 18-01), which relies mostly on tropical tuna stock specific output measures (*TAC*), as follows:

2.3.1. Yellowfin tuna

ICCAT manages its stock of Atlantic Yellowfin tuna (*YFT*) through a *TAC* (**Figure 1**). However, such *TAC* has not been allocated by *ICCAT CPC* or fishery (*Not Assigned (58 CPC)*). It means that catches of *YFT* can grow unlimitedly as none of the 58 *ICCAT CPC* is subject to a quota. This is the reason why the color of the *Not Assigned* box is red.

2.3.2. Bigeye tuna

ICCAT manages its stock of Atlantic bigeye tuna (*BET*) through a *TAC*. Such *TAC* is allocated to eligible *CPC*, according to some conditions (*CPC BET > 2100t (1999)*; *CPC* that reported catches of *BET* over 2,100MT in 1999). This means that seven *ICCAT CPC* (China, EU, Japan, Ghana, Rep. of Korea, Philippines, Chinese Taipei) are subject to a *BET* quota (*Quotas (7 CPC)*) while all remaining fifty-one *CPC* (*CPC BET < 2100t (1999)*) are not (*Not Assigned (51 CPC)*). The color of the *Quotas* box is orange because *ICCAT* has identified various issues with the reporting of catch by some of the *CPC* covered by the measure (Ghana and, to a lesser extent, Chinese Taipei and the EU) and catch levels have been well over the *TAC* in recent years (up to around 20,000MT over the *TAC* in 2017). In addition, the color of the *Not Assigned* box is red because the catches of most of those fleets can grow unrestrictedly (up to 3,500MT of *BET* or over for *CPC* that are developing coastal states in the *ICCAT* Area and

up to 1,575MT for other CPC not covered through quotas). In addition, ICCAT has adopted capacity limitation for the seven CPC subject to Quotas (the color is orange because the measure does not cover all fleets).

2.3.3. Skipjack tuna

While the ICCAT Standing Committee on Research and Statistics (SCRS) has recommended that the catches of the two Atlantic Skipjack tuna (*SKJ*) stocks (Eastern and Western) do not exceed specific levels, the Commission has not adopted any measure for those stocks meaning that catches can grow unlimitedly in the future.

2.3.4. Other measures

In addition to the above, ICCAT has adopted other measures to reduce the catches of juvenile YFT and BET by purse seiners, including limits on the number of active FADs (*PS Active FAD Limits*) that purse seiners can use per day (500), and a two-month long *PS Time-Area Closure* to fishing on FADs (January-February). The color of these boxes is orange because, while these measures may be useful to further reduce the capacity of purse seiners, their actual impact on the resources is uncertain (time-area closure) or is yet to be measured (active FAD limits).

2.4. Indian Ocean Tuna Commission

The Indian Ocean Tuna Commission (IOTC) has a mandate to manage stocks of tropical tunas and other stocks in the Indian Ocean. It manages its stocks of tropical tunas through output measures (TAC or catch limits), as follows:

2.4.1. Skipjack tuna

IOTC manages its stock of Indian Skipjack tuna (*SKJ*) through a TAC (**Figure 1**) with the value of the TAC estimated using the Harvest Control Rule (*HCR: TAC*), which IOTC adopted in 2016 for that purpose (Resolution 16-02). However, the TAC resulting from implementation of the HCR has not been allocated by IOTC CPC or fishery (*Not Assigned*), meaning that catches of SKJ can grow unlimitedly as none of the 33 IOTC CPC is subject to a quota. This is the reason why the color of the *Not Assigned* box is red.

2.4.2. Yellowfin tuna

IOTC manages the stock of Indian Yellowfin tuna (*YFT*) through fishery-specific catch limits (Resolution 18/01²), with fisheries eligible to be subject to the catch limit according to the type of fleet (covering only vessels that are large-scale, i.e. having length overall 24m or greater) and where catch levels of YFT in a reference year were higher to the values adopted for each fishery (*Industrial Vessels GI: YFT>2000t (2014) OT: YFT>5000t (2014)*; 2014 for all CPC and fisheries but Seychelles purse seiners for which 2015 applies). Thus, CPC gillnet fisheries that reported catches of YFT over 2,000MT in 2014 have been subject since 2017 to a catch limit set at 90% of the 2014 YFT catch (10% reduction in catch as from catch levels in 2014); purse seine, longline and other gears fisheries that reported catches of YFT over 5,000MT in 2014 (2015 for Seychelles purse seiners) have been subject to catch limits at, respectively, 85% (15% reduction), 90% (10% reduction) and 95% (5% reduction) of those corresponding to the reference year concerned. On the other hand, all fisheries not covered by these provisions are not subject to any specific measure (*Industrial Vessels GI: YFT<2000t (2014) OT: YFT<5000t (2014) Artisanal Vessels*). This refers to some large-scale and all small-scale fisheries which in the Indian Ocean are extremely important. The first group is marked in orange (*Catch Limits PS: 15% (2014) LL/GI: 10% (2014) OT: 5% (2014)*) because IOTC has identified various issues with the reporting of catch by some of the CPC covered by the measure (EU & Seychelles, Chinese Taipei, Indonesia, Sri Lanka, Iran, Pakistan, and many other fleets), catch levels have been well over the catch limits in recent years (Iran, Indonesia and, to a lesser extent, Maldives, Seychelles and the EU), and the measure has had perverse consequences, including changes in the selectivity of YFT and BET (increase in the catches of juveniles) and increased catches of skipjack tuna (see below). As for the second group (*NOT Assigned*), it is colored in red because the catches of those fleets can grow unrestrictedly.

² Now superseded by Resolution 19/01

2.4.3. Bigeye tuna

While the IOTC Scientific Committee (SC) has recommended that the catches of the Bigeye tuna (*BET*) stock do not exceed specific levels, the Commission has not adopted any measure for such stock meaning that catches can grow unlimitedly in the future.

2.4.4. Other measures

In addition to the above, IOTC has adopted other measures to reduce the catches of juvenile YFT and BET by purse seiners, including limits on the number of active FADs (*PS Active FAD Limits*) that purse seiners can use per day (300), limits on the number of vessels that purse seiners can use in support of their operation (a maximum ratio of two support vessels for each five purse seiners, by flag state), and a ban on the use of lights and aircraft in support of fishing (not included in the diagram). The color of these boxes is orange because, while these measures may be useful to further reduce the capacity of purse seiners, their actual impact on the resources is yet to be measured.

3. Evaluating the efficiency of tRFMO measures for tropical tunas

Table 1, **Figure 2** and **Figure 4** present an attempt to evaluate the efficiency of the measures implemented by IATTC, ICCAT, IOTC and WCPFC to address the management advice issued by their respective scientific bodies.

Table 1 and **Figure 4** present an evaluation of the quality of the measures each tRFMO has implemented for its tropical tuna stocks. This is assessed assigning the catches each tRFMO CPC reported for each stock and fishery in recent years (2015-2017), according to the three following categories:

- *Good*: Catches are addressed to this category where the measure implemented addresses the scientific advice in full and compliance by all CPC is very likely to occur (e.g. where there are Vessel Monitoring Schemes, Port Inspection Schemes, or observer programs that have the capacity to ensure compliance with fishery closures and/or VDS limits; or catch monitoring schemes and catch estimates can be independently validated through observer and landing programs);
- *Fair*: Catches are addressed to this category where the measure implemented addresses the scientific advice only partially (e.g. falls short of achieving the catch/effort reduction recommended through the management advice for the stock) and/or full compliance by all the CPC covered is not ensured (e.g. Quotas may be breached as a consequence of poor catch monitoring schemes and/or lack of compliance by CPC);
- *Poor*: Catches are addressed to this category where no measure is directed at the stock or where the target adopted is not allocated by CPC (e.g. unallocated TAC) meaning that implementation of the management advice (i.e. target catch/effort level) is very likely to fail.

On the other hand, **Figure 2** presents a different approach to evaluate the efficiency of the measures in place, which takes into consideration the potential that tRFMO CPC not covered by the measures have to increase their effort and/or catch levels of tropical tunas and therefore undermine the efficiency of the measures tRFMO have adopted to address the scientific advice. This is done presenting where recent catch/effort levels have been for each stock [and fishery] as compared with those levels recommended in the management advice; and how those levels could potentially grow further because the measures tRFMO have taken are not restrictive enough (e.g. they do not cover all CPC or set target levels that are well above those recommended in the management advice).

The results of the evaluation for each tRFMO and stock are summarized in the following sections:

3.1. Inter-American Tropical Tuna Commission

In recent years, industrial tuna purse seiners have reported over 92% of the catches of tropical tunas in the IATTC Area, with the remaining less than 8% reported by other fleets, mainly longliners (7%). Purse seine fisheries are managed using a Control Rule whose output is a total number of days closure. The measure in place is directed at the three stocks of tropical tunas being amended each year to incorporate the number of days closure which is estimated using the Control Rule³. Therefore, the management advice is fully addressed in the measure. Full

³ It is important to note that IATTC did not apply the Control Rule in 2019 due to issues identified with the stock assessments

compliance with the measure is ensured through VMS, port inspection, and the IATTC Observer Program. On the other hand, longline fisheries are managed through TAC and quotas, only applicable to the bigeye tuna stock. However, the quotas only cover some CPC and compliance with those quotas is not ensured, as catch monitoring has been identified as deficient for some longline fisheries (e.g. Chinese Taipei). No measures are in place for other fisheries, although they only represent 1% of the catches of tropical tunas. The situation by stock is reviewed below:

3.1.1. Yellowfin tuna

Over 90% of the catches of yellowfin tuna are taken by purse seiners, for which a Control Rule that addresses the management advice is in place (**Figure 2**, top left), and full compliance is ensured through good MCS (catches assigned to the *Good* category in **Table 1** and **Figure 4**). The remaining catches are taken by longline and other fisheries for which there are no measures in place (catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.1.2. Skipjack tuna

Nearly 100% of the catches of skipjack tuna are taken by purse seiners, for which a Control Rule that addresses the management advice is in place (**Figure 2**, top left), and full compliance is ensured through good MCS (catches assigned to the *Good* category in **Table 1** and **Figure 4**). The remaining catches are taken by fisheries for which there are no measures in place, although catches are very small (catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.1.3. Bigeye tuna

Over 60% of the catches of bigeye tuna are taken by purse seiners, for which a Control Rule that addresses the management advice is in place (**Figure 2**, top left), and full compliance is ensured through good MCS (catches assigned to the *Good* category in **Table 1** and **Figure 4**). While a TAC exists for longline fisheries, which represents over 30% of the catches of BET, quotas have only been allocated to five CPC. Although in recent years BET catch levels for those five CPC have been well below those recommended (**Figure 2**, top right; *catch CPC subject to quota plus catch CPC not subject to quota*), IATTC has identified some issues relating to catch monitoring of the longline component, and MCS is not sufficient for CPC to validate catch reports (very low observer coverage). In addition, there is a potential for the catches of longline fleets that have not been assigned a quota to grow and compromise the efficiency of the measure, leading to catches over the scientific advice (**Figure 2**, top right; *potential catch assuming full compliance*). Therefore, the catches of the five CPC were assigned to the *Fair* category in **Table 1** and **Figure 4**. The remaining catches, while accounting for less than 5% of the total BET catch, are taken by longline and other fisheries for which there are no measures in place or those existing are not restrictive enough (catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.2. Western and Central Pacific Fisheries Commission

In recent years, industrial tuna purse seiners have reported around 79% of the catches of tropical tunas in the WCPFC Area, with the remaining 21% reported by other fleets, including small-scale (15%) and longline fisheries (6%). Purse seine fisheries are managed using PNA/WCPFC Vessel Day Scheme. The measure in place is directed at the three stocks of tropical tunas and the Total Allocated Effort (total number of days that can be fished in the PNA/WCPFC Area) is amended according to the management advice. Therefore, the management advice is addressed in the measure, although it is not clear how the number of days fished is estimated or those days accounted for by each of the Parties of the Nauru Agreement (PNA). Full compliance with the measure is ensured through a regional VMS scheme (Forum Fisheries Agency) and the WCPFC Observer Program. On the other hand, longline fisheries are managed through TAC and quotas, only applicable to the bigeye tuna stock. However, the quotas only cover some CPC and compliance with those quotas is not ensured, as catch monitoring has been identified as deficient for some fisheries (e.g. Indonesia, Philippines, Chinese Taipei). No measures are in place for other fisheries, although they represent as much as 15% of the catches of tropical tunas. The situation by stock is reviewed in the following page:

3.2.1. Yellowfin tuna

Over 65% of the catches of yellowfin tuna are taken by purse seiners, which are subject to a VDS that addresses the management advice and ensures full compliance through good MCS (catches assigned to the *Good* category in **Table 1** and **Figure 4**). The remaining catches are taken by longline and other fisheries for which there are no measures in place (35% of the catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.2.2. Skipjack tuna

Over 85% of the catches of skipjack tuna are taken by purse seiners, which are subject to a VDS that addresses the management advice and ensures full compliance through good MCS (catches assigned to the *Good* category in **Table 1** and **Figure 4**). The remaining catches are taken by fisheries for which there are no measures in place (15% of the catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.2.3. Bigeye tuna

Around 45% of the catches of bigeye tuna are taken by purse seiners, which are subject to a VDS that addresses the management advice and ensures full compliance through good MCS (catches assigned to the *Good* category in **Table 1** and **Figure 3**). While a TAC exists for longline fisheries, which represent around 36% of the catches of BET, quotas have only been allocated to six CPC. Although in recent years BET catch levels for those six CPC have been below those recommended, WCPFC has identified some issues relating to catch monitoring of the longline component (e.g. Indonesia, Philippines, Viet-Nam), and MCS is not sufficient for CPC to validate catch reports (very low observer coverage). In addition, there is a potential for the catches of longline fleets that have not been assigned a quota to grow and compromise the efficiency of the measure, leading to catches over the scientific advice. Therefore, the catches of the six CPC were assigned to the *Fair* category in **Table 1** and **Figure 4**. The remaining catches account for over 20% of the total BET catch and are taken by longline and other fisheries for which there are no measures in place or those existing are not restrictive enough (catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.3. International Commission for the Conservation of Atlantic Tunas

In recent years, industrial tuna purse seiners have reported around 70% of the catches of tropical tunas in the ICCAT Area, with the remaining 30% reported by other fleets, including pole-and-line (13%), longline (11%) and other small-scale fisheries (6%). ICCAT manages its stocks of tropical tunas through TAC [and quotas], with quotas assigned by stock and CPC rather than stock, CPC and Fishery. The multi-annual plan in place contains measures specific to the stocks of bigeye tuna (TAC and quotas) and yellowfin tuna (unallocated TAC), with no specific measures in place for the two stocks of skipjack tuna. Therefore, the management advice is not fully addressed in the measure because it does not cover all stocks or CPC and compliance with the TAC is not ensured, as proven by the fact that TAC levels for the YFT and BET have been exceeded in recent years. The situation by stock is reviewed below:

3.3.1. Yellowfin tuna

The stock of YFT is subject to a TAC, which is unallocated. Because of this, catch levels in recent years have been well above the TAC (**Figure 2**, mid left; *catch CPC not subject to quota*), and the potential for the catches of YFT to grow in the future remains unlimited (**Figure 2**, mid left; *potential catch assuming full compliance*). For this reason, all YFT catches were assigned to the *Poor* category in **Table 1** and **Figure 4**.

3.3.2. Skipjack tuna

While scientific recommendations exist for both Atlantic SKJ stocks, none of the two is subject to specific measures and therefore all SKJ catches were assigned to the *Poor* category in **Table 1** and **Figure 4**.

3.3.3. Bigeye tuna

The stock of BET is subject to a TAC. However, quotas have only been allocated to seven CPC. In addition, in recent years some CPC have exceeded their quotas and increases in BET catches by CPC not covered by the measure have led to catches well above the TAC (**Figure 2**, mid right; *catch CPC subject to quota plus catch CPC not subject to quota*). Furthermore, ICCAT has identified some issues relating to catch monitoring by some CPC

(e.g. Ghana, Senegal, Chinese Taipei, EU), and MCS is not enough for CPC to validate catch reports (very low observer coverage). There is also a potential for the catches of CPC that have not been assigned a quota to grow and compromise the efficiency of the measure, leading to catches over the scientific advice (**Figure 2**, top right; *potential catch assuming full compliance*). Therefore, the catches of the seven CPC, which represent less than 50% of the total) were assigned to the *Fair* category in **Table 1** and **Figure 4**. The remaining catches, accounting for over 50% of the total BET catch, refer to CPC that are not subject to measures or those subject to measures that are not restrictive enough (catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.4. Indian Ocean Tuna Commission

In recent years, industrial tuna purse seiners have reported around 40% of the catches of tropical tunas in the IOTC Area, with the remaining 60% reported by other fleets, including gillnet (17%), longline (13%), and pole-and-line and other small-scale fisheries (28%). Therefore, IOTC is the only tRFMO where the catches of gears other than purse seine are more significant, and the importance of gillnet and small-scale fisheries is paramount. IOTC manages its stocks of tropical tunas through TAC or catch limits, with catch limits assigned by fishery rather than by CPC. Measures are specific to the stocks of skipjack tuna (a TAC issued from a Harvest Control Rule) and yellowfin tuna (catch limits allocated by fishery but only applicable to some CPC and types of vessel), with no specific measures in place for the stock of bigeye tuna. Therefore, the management advice is not fully addressed in the measure because it does not cover all stocks or does it insufficiently. Also, CPC compliance with the measures is not ensured, as proven by the fact that the catches of YFT and SKJ have been over the recommended levels in recent years. The situation by stock is reviewed below:

3.4.1. Yellowfin tuna

The stock of YFT is subject to catch limits, which are only applicable to the fisheries of some CPC. However, the measure does not fully respond to the scientific advice (**Table 2**; **Figure 3**, left). This is because even on the assumption that all CPC covered by the catch limits comply and those not covered maintain their catch levels of YFT as in previous years, the measure still falls short of the target catch reduction recommended by the IOTC (5% instead of the 15% catch reduction recommended). Indeed, in 2017 and 2018 some CPC have exceeded their quotas and increases in YFT catches by CPC not covered by the measure have been well above the TAC (**Figure 2**, bottom left; *catch CPC subject to quota plus catch CPC not subject to quota*; **Figure 3**, right). In addition, IOTC has identified issues relating to catch monitoring by many CPC (e.g. Indonesia, Yemen, Oman, Pakistan, Iran, Sri Lanka, India, Chinese Taipei, EU, etc.), and MCS is not sufficient for CPC to validate catch reports (very low observer coverage both in land and at the landing place). There is also a potential for the catches of CPC that have not been assigned a catch limit to grow and compromise the efficiency of the measure, leading to catches well over the scientific advice (**Figure 2**, top right; *potential catch assuming full compliance*). Therefore, the catches of the CPC Fisheries covered by the catch limits, which represent around 75% of the total, were assigned to the *Fair* category in **Table 1** and **Figure 4**. The remaining catches, accounting for around 25% of the total YFT catch, refer to CPC that are not subject to catch limits (e.g. small-scale fisheries and fisheries with catches below the threshold adopted) or those subject to measures that are not restrictive enough (catches assigned to the *Poor* category in **Table 1** and **Figure 4**).

3.4.2. Skipjack tuna

The stock of SKJ is subject to a TAC, which is the outcome of a Harvest Control Rule. However, the TAC has not been allocated by CPC. Because of this, catch levels in recent years have exceeded the TAC (**Figure 2**, bottom right; *catch CPC not subject to quota*; **Table 3**; **Figure 3**, right), and the potential for the catches of SKJ to grow in the future remains unlimited (**Figure 2**, mid left; *potential catch assuming full compliance*). For this reason, all SKJ catches were assigned to the *Poor* category in **Table 1** and **Figure 4**.

3.4.3. Bigeye tuna

While recent catches of bigeye tuna have been under the recommended levels (**Table 3**; **Figure 3**, right), the stock of BET is not subject to any specific measure. Therefore, all BET catches were assigned to the *Poor* category in **Table 1** and **Figure 4**.

In conclusion, input-based management tends to be more effective for tropical tunas because it covers all CPCs and the three stocks, addressing the management advice for the three stocks combined; is not subject to catch misreporting; is not subject to the perverse impacts TACs may have through changes in effort towards other stocks and/or changes in selectivity towards juveniles; and compliance with input-measures only requires that a Vessel Monitoring System is in place to control the number of days each fishing unit is in operation over the period of reference.

4. A case for IOTC to adopt Seasonal Fishery Closures to manage industrial purse seine fisheries

Table 2 (and **Figure 3**, left) compare management targets in the Resolutions IOTC has adopted for yellowfin tuna (Res. 16/01; 17/01; 18/01; 19/01) with the targets recommended by the Scientific Committee. It shows that Resolution 16/01 and all subsequent amendments adopted by the Commission are unlikely to achieve the scientific targets. While the IOTC Scientific Committee has recommended that catches of yellowfin tuna be reduced by 15% from those recorded for the year 2014, none of the measures adopted by the Commission so far seems to be able to achieve such reduction. As recorded in **Table 2**, the levels of reduction expected go from 3.9% (Res.19/01) to 7.6% (Res. 16/01), unlike the 15% reduction recommended in the scientific advice. Furthermore, the performance of the measure against the scientific advice seems to have worsened through amendments to Res. 16/01, as incorporated in 2017 (Res. 17/01) and 2019 (Res. 19/01), where the Commission agreed to change the reference year and/or level of YFT catch reduction required for CPC that are small island developing states (SIDS). Therefore, **the management target adopted by the Commission in 2019** (Res. 19/01), with catch limits that will enter into force in 2020, **is very likely to fall short of the scientific advice**. It is likely that, in the best-case scenario, **Res. 19/01 could achieve a 3.9% reduction in catch of YFT rather than the 15% recommended**. This is assuming that all fleets subject to catch limits comply fully with such limits, and the YFT catches of other fleets remain at 2014 levels. However, none of the two has occurred, as explained below.

Table 3 (and **Figure 3**, right) presents recent catches (2017-18) performance against limits adopted in IOTC Management Measures (Res. 18/01 for yellowfin tuna and Res. 16/02 for skipjack tuna) and limits recommended as per the Scientific Advice for each stock. As indicated before, the IOTC has adopted catch limits for the YFT and a TAC for the SKJ, the latter resulting from the implementation of a Harvest Control Rule, which was adopted by the Commission in 2016. On the contrary, the stock of Indian Ocean bigeye tuna is not subject to any measure. The performance of the measures for each stock is reviewed below:

- **Yellowfin tuna:** Resolution 18/01 sets YFT catch limits by fishery. It covers only fleets that are large-scale (vessels having length overall 24 meters or greater), setting a threshold catch from which those fleets are subject to the catch limits. Thus: (i) purse seine fleets that caught more than 5,000 tons in 2014 shall reduce their catches of yellowfin tuna by 15%, using 2015 (Seychelles) or 2014 (other purse seine fleets) as reference year; (ii) gillnet fleets that caught more than 2,000 tons in 2014 shall reduce their catches of yellowfin tuna by 10% as from their 2014 levels; (iii) longline fleets that caught more than 5,000 tons in 2014 shall reduce their catches of yellowfin tuna by 10%, as from their 2014 levels; (iv) fleets using other gears that caught more than 5,000 tons in 2014 shall reduce their catches of yellowfin tuna by 5%, as from their 2014 levels. **Table 3** shows that while the reduction in catch expected from implementation of the measure is 4.3% the reality is that catches in 2017 and 2018 were 6% and 11% higher than the target set in the measure, respectively. The difference further increases when comparing the catches in 2017 and 2018 with the scientific advice (2017 catch is 11% higher than the scientific advice, while the catch in 2018 is 26% higher). Furthermore, the catches in both years were higher than the total catches of yellowfin tuna recorded in 2014 confirming that the measure has not been at all effective in reducing the catch of yellowfin tuna.
- **Bigeye tuna:** There is no management target for the bigeye tuna because the Commission has not adopted any specific measure for this stock (**Table 3**). However, the Scientific Committee has recommended that catches of bigeye tuna are maintained at or below the MSY levels estimated from the latest assessment (2015). While the catches of BET in 2017 and 2018 were 13% and 10% below the MSY, respectively, in lack of management measures there is a risk that the status of the stock is undermined in the future.
- **Skipjack tuna:** Resolution 16/02, on a Harvest Control Rule for SKJ, establishes a mechanism to set a TAC for the stock. However, to date the Commission has not adopted an allocation scheme and therefore, the TAC remains unallocated. As presented in **Table 3**, the catches of SKJ in 2017 and 2018 have been in excess of the TAC (8% and 29%, respectively). Should this overharvest continue it could seriously undermine the status of the stock of SKJ.

Therefore, **the measures in place are unlikely to achieve the scientific advice for the stocks of tropical tuna, and the same applies to the new measure adopted by the Commission** (Res. 19/01).

The alternative proposed in this document is to use the decision tool presented in Sharma & Herrera (2019c) to estimate the number of days closure required to achieve a target catch reduction for the purse seine fishery, through the following steps:

1. Use the decision tool to estimate the number of days closure that would be required to achieve the target 15% catch reduction set for purse seine fisheries on YFT, assuming that the catches of bigeye tuna and skipjack tuna will be also reduced through implementation of the closures (e.g. 80 days closure required to achieve the 15% catch reduction);
2. Select two closure windows for the year, both having the same length in terms of the number of days (being at least 30 days apart from each other so as the closures do not compromise supply to the market);
3. Have all purse seine vessel operating in the IOTC tropical tuna fishery to select one of the two closures in which to stop the following year; and CPC communicating which of their vessels will stop in which period for each year;
4. CPC monitoring of implementation of the measure through Vessel Monitoring Systems (flag state), port inspection (port states), observers (flag and/or coastal state), and any other available means;
5. Compliance reporting to the IOTC each year, or as required (e.g. direct reporting of vessel VMS data over the closure period each vessel has selected to adhere to).

In addition to the above proposal, which is exclusive to the purse seine fishery, IOTC should adopt measures for other gear types, especially driftnet, pole-and-line and longline, to cover the three stocks tropical tunas. Those measures should also target reductions in catch for those stocks (e.g. 15% reduction); and cover the majority of IOTC CPC to avoid any unwanted increases in catch.

The above case is presented in **Table 2** (column *Effort Controls (PS)*) and **Figure 3** (left), which shows that the implementation of Fishery Closures for purse seine fisheries plus catch limits for other fisheries, in line with the scientific advice (15% reduction), are likely to achieve a higher reduction in catch: 10.4% reduction rather than the, at best, 3.9% reduction expected from the implementation of Resolution 19/01. While unrealistic, extending the closures to cover all surface fisheries (column *Effort Controls (SURF)*) plus a 15% reduction in the catch of longline fisheries (with YFT catch over 5000 MT in 2014), is likely to achieve a 14.3% reduction in catch.

In addition to the above, effort controls for purse seine, or for all surface fisheries, will have an impact on the catches of bigeye tuna and skipjack tuna, which will be reduced. Regardless of which fisheries Effort Controls are set to cover, TAC should be adopted for each stock for fisheries not covered through effort controls, covering most of the fleets concerned, to avoid unwanted increases in the catch of any of the three stocks.

5. Conclusion

This study shows the potential benefits for IOTC to consider replacing the existing TACs of tropical tunas with fishery closures for, at least, its purse seine component, and prospects for this approach to be extended to other fisheries in the future, where required.

The scheme proposed can be used to assess the time-period and number of fishing days of closure required in order to replace the existing or any future Total Allowable Catches recommended by the IOTC for the industrial tuna purse seine component. Other than the recommended TAC, the following information will be required to estimate the number of closure days for a given year:

1. Number of industrial tuna purse seiners to be in operation, by IOTC CPC, and the expected total number of days that will be fished by those: The number of tuna seiners in operation can be obtained from IOTC's list of active vessels, and the total number of fishing days from past reports of vessel numbers and catch-and-effort data by each CPC as part of IOTC's data requirements;
2. Trend in the total number of active support vessels / FADs used by purse seiners, or any other new piece of technology that could contribute to an increase in effective fishing effort directed at the bigeye tuna stock (i.e. effort creep);

3. Any other management measure IOTC has implemented in complement to the fishery closure that could contribute to a decrease in effective fishing effort directed at tropical tuna stocks.
4. BET Biomass value estimate from the latest stock assessment.

While most of the information covered in 1-4 can be obtained from the IOTC this does not apply to the numbers of active purse seiners and support vessels that will operate in the future in the IOTC Area of Competence as there is no requirement in place for CPC to provide this information in advance to the IOTC. However, IOTC could contemplate to make it a requirement for CPC to provide this information, including fish carrying capacity, if this scheme is implemented in substitution of the TAC.

Therefore, there is a potential for effort controls to be more effective in addressing catch limits for multi-species fisheries, in which catch limits have been adopted for more than one stock (IOTC); or those fisheries that operate over its optimum capacity and target stocks that have been assessed to be fully exploited or above such levels, as it is the case of purse seine fisheries in the ICCAT and IOTC areas.

Given the large uncertainties in achieving TACs and the failure shown in IOTC and ICCAT to do so, effort controls with large industrial multi-species fleets like the purse seine fleet are considered a better alternative. The ability to do so is entirely dependent on the data and management to implement these closures in an effective manner and has already proved effective in the case of the IATTC.

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Table 1. Evaluation of the quality of the management measures for tropical tunas adopted by the tRFMO considering its capacity to address the scientific advice and ensure full compliance by all CPC with the measures. The quality of the measures in place for each tRFMO and stock is assessed assigning the catches reported by each tRFMO CPC-Fishery in recent years (2015-2017) according to the three following categories:

Good: The measure implemented addresses the scientific advice in full and compliance by all CPC is very likely to occur (refers to effort controls);

Fair: The measure implemented addresses the scientific advice only partially (e.g. falls short of achieving the catch/effort reduction recommended through the management advice for the stock) and/or full compliance by all the CPC covered is not ensured (refers to catch controls);

Poor: No measure have been adopted by the tRFMO for the stock or the measure adopted is not addressed by CPC meaning that compliance with the management advice (i.e. target catch/effort level) is very likely to fail (refers to lack of controls).

| Quality of Management | | Good | Fair | Poor | TOTAL |
|-----------------------|-------|---------|--------|---------|---------|
| BET | IATTC | 185818 | 104483 | 8102 | 298403 |
| | ICCAT | | 113789 | 125599 | 239388 |
| | IOTC | | | 273636 | 273636 |
| | WCPFC | 180307 | 149633 | 89832 | 419772 |
| SKJ | IATTC | 992600 | | 3438 | 996038 |
| | ICCAT | | | 755054 | 755054 |
| | IOTC | | | 1403685 | 1403685 |
| | WCPFC | 4498232 | | 726861 | 5225093 |
| YFT | IATTC | 697702 | | 40254 | 737956 |
| | ICCAT | | | 415824 | 415824 |
| | IOTC | | 908623 | 300499 | 1209122 |
| | WCPFC | 1237302 | | 663374 | 1900676 |

Table 2. Evaluation of the performance of IOTC Resolution 16/01 and subsequent amendments to achieve the target reduction in catches of yellowfin tuna recommended by the IOTC Scientific Committee (the scientific advice is that catches of yellowfin tuna should be reduced by 15% from its 2014 levels in 2017 and following years). The last two columns show the performance of the Effort Controls proposed here, implemented only for purse seine fisheries (Effort Controls (PS)) or for all fisheries except longline (Effort Controls (SURF))

| | Res. 16/01 | Res. 17/01 | Res. 18/01 | Res. 19/01 | Effort Controls (PS) | Effort Controls (SURF) |
|-----------------------------|---------------|---------------|---------------|---------------|----------------------------|------------------------------|
| $C_{refY(2014)}$ | 397,205 | 397,205 | 397,205 | 397,205 | 397,205 | 397,205 |
| RSC% | -15.0 | -15.0 | -15.0 | -15.0 | -15.0 | -15.0 |
| $CL_{SciAdvice}$ | 337,624 | 337,624 | 337,624 | 337,624 | 337,624 | 337,624 |
| M_{refC} | 397,205 | 412,814 | 412,814 | 415,104 | 397,205 | 397,205 |
| C_{COV} | 261,693 | 277,303 | 277,303 | 288,679 | 274,527 | 378,742 |
| R_{COV} | 30,181 | 32,522 | 32,522 | 33,375 | 41,179 | 56,811 |
| C_{NOCOV} | 135,512 | 135,512 | 135,512 | 126,425 | 122,678 | 18,463 |
| CEX_{STQUO} | 367,024 | 380,292 | 380,292 | 381,729 | 356,026 | 340,394 |
| $CREX_{ACT}$ | 30,181 | 16,913 | 16,913 | 15,476 | 41,179 | 56,811 |
| REX%_{STQUO} | -7.6 | -4.3 | -4.3 | -3.9 | -10.4 | -14.3 |

Key to Table 2:

$C_{refY(2014)}$ Total catch of yellowfin tuna recorded in 2014, Reference Year identified by the Scientific Advice

RSC% Percentage YFT catch reduction Recommended in the Scientific Advice (from catch in 2014);

$CL_{SciAdvice}$ Maximum catch recommended considering the scientific advice [$C_{refY(2014)} + (C_{refY(2014)} * RSC\%)$];

M_{refC} Reference Catch as adopted in the Resolution (differences with $C_{refY(2014)}$ refer to exceptions granted by the Commission for CPC to use their 2015 rather than 2014 YFT catch (Seychelles and other SIDS CPC);

C_{COV} Reference Catch for the Fleets Covered by the Catch Limits (as per provisions in each measure);

R_{COV} Expected Catch Reduction from the implementation of the Catch limit by the Fleets Covered by the measure [$(PS_{COV} * 15\%) + (GL_{COV} * 10\%) + (LL_{COV} * 10\%) + (OT_{COV} * 5\%)$]; some exceptions apply in Res. 19/01

C_{NOCOV} Reference Catch for the Fleets NOT Covered by the Catch Limits;

CEX_{STQUO} Expected Catch from implementation of measure assuming full compliance with catch limits and freeze in catches by fleets not covered by catch limits;

$CREX_{ACT}$ Actual Reduction Expected from the implementation of the measure assuming the above;

REX%_{STQUO} % Percentage YFT catch reduction expected from implementation of the measure.

Table 3. Recent Catches (2017-18) performance against limits adopted in IOTC Management Measures (*Perform. Limit in Measure*; Res. 18/01 for yellowfin tuna and Res. 16/02 for skipjack tuna) and limits recommended as per the Scientific Advice (*Perform. Scientific Advice Limit*). Data are presented by tropical tuna stock. Currently no specific measure is directed at the stock of bigeye tuna stock.

| Performance | Yellowfin tuna (18/01) | | Bigeye tuna (none) | | Skipjack tuna (16/02) | |
|-----------------------|---------------------------|----------------------------------|---------------------------|----------------------------------|---------------------------|----------------------------------|
| | Perform. Limit in Measure | Perform. Scientific Advice Limit | Perform. Limit in Measure | Perform. Scientific Advice Limit | Perform. Limit in Measure | Perform. Scientific Advice Limit |
| C _{EXP} | 380,292 | 337,624 | | 104,000 | 470,029 | 470,029 |
| C ₂₀₁₇ | 401,382 | 401,382 | | 90,863 | 507,493 | 507,493 |
| CR _{ACT2017} | 6 | 19 | No Measure | -13 | 8 | 8 |
| C ₂₀₁₈ | 423,815 | 423,815 | | 93,515 | 607,701 | 607,701 |
| CR _{ACT2018} | 11 | 26 | | -10 | 29 | 29 |

Key to Table 3:

C_{EXP} Catch expected from implementation of measure (Column *Perform. Limit in Measure*) assuming full compliance with catch limits and no increase in catch for those fleets not covered by the limits; and catch expected as formulated in the Scientific Advice (Column *Perform. Scientific Advice Limit*);

C_{2017/2018} Total catch recorded in 2017/2018 for the stock, as per the IOTC Database;

CR_{ACT2017/2018} Actual catch reduction achieved in 2017/2018 (expressed as a %) considering the management target (*Perform. Limit in Measure*) and scientific advice (*Perform. Scientific Advice Limit*); negative values indicate that 2017/2018 catches were below the management target/scientific advice (i.e. good performance) while positive values indicate that 2017/2018 catches were greater than the management target/scientific advice (poor performance); catches over the management target and/or scientific advice indicate that the measure has failed to maintain the catches at the adopted levels (it falls-short of the scientific advice and/or subject to poor compliance).

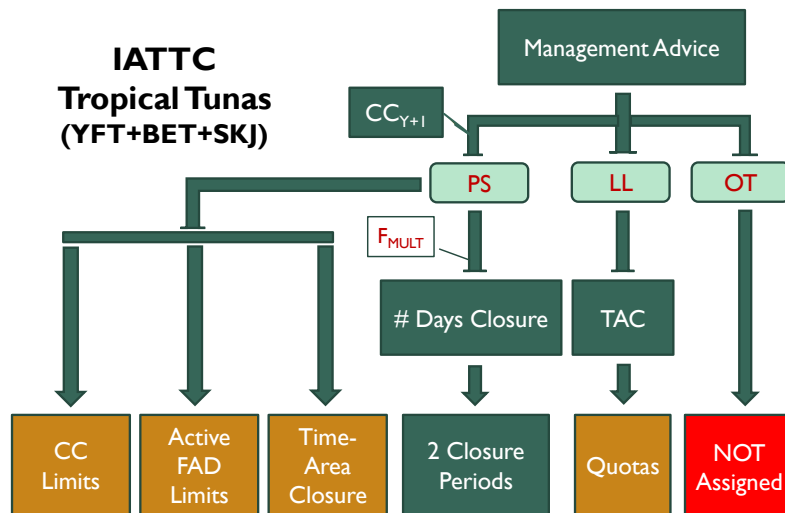


Figure 1. Management schemes used for the stocks of tropical tunas, by tRFMO stock or group of stocks, and fishery or group of fisheries. Details are provided in Section 2 of the main text.

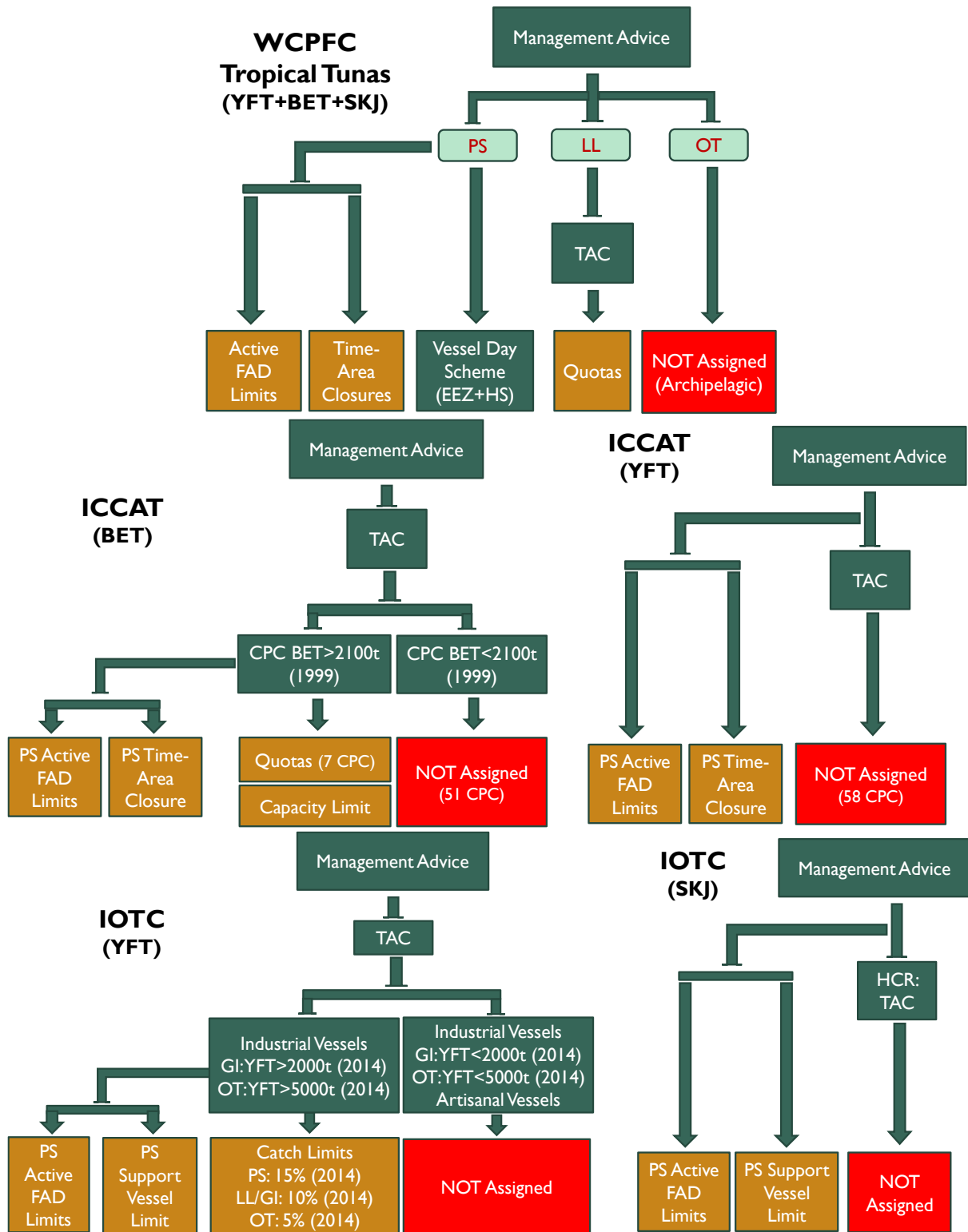


Figure 1 (cont.). Management schemes used for the stocks of tropical tunas, by tRFMO stock or group of stocks, and fishery or group of fisheries. Details are provided in Section 2 of the main text.

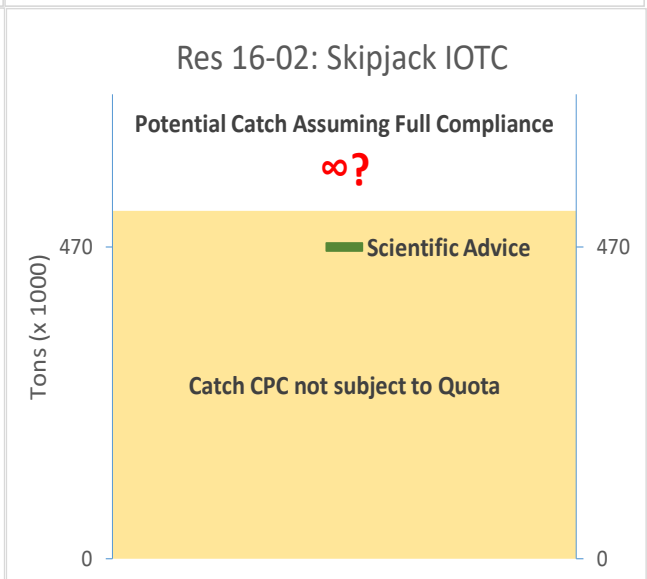
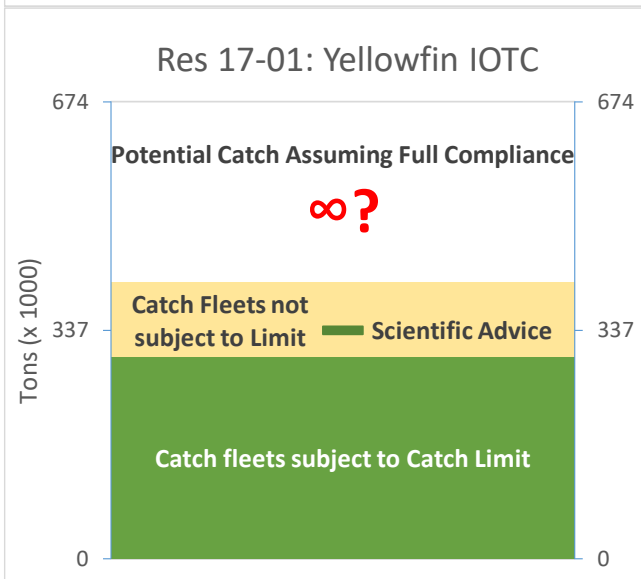
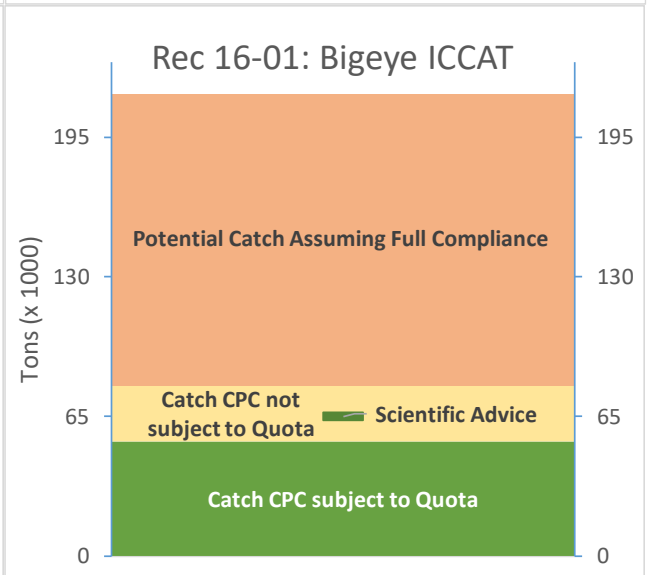
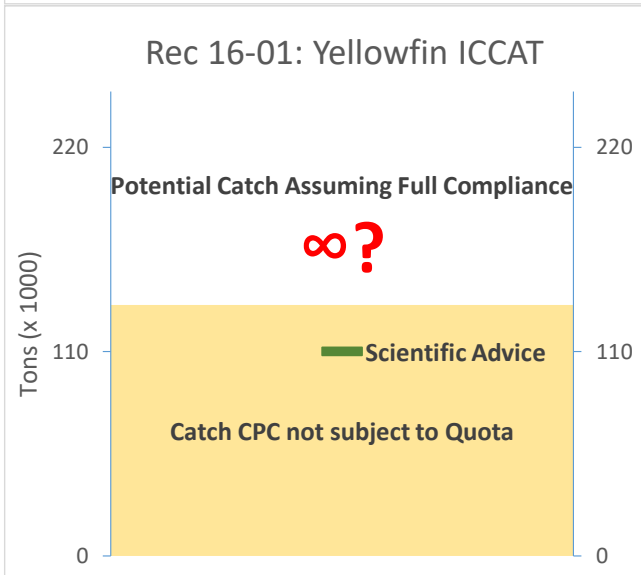
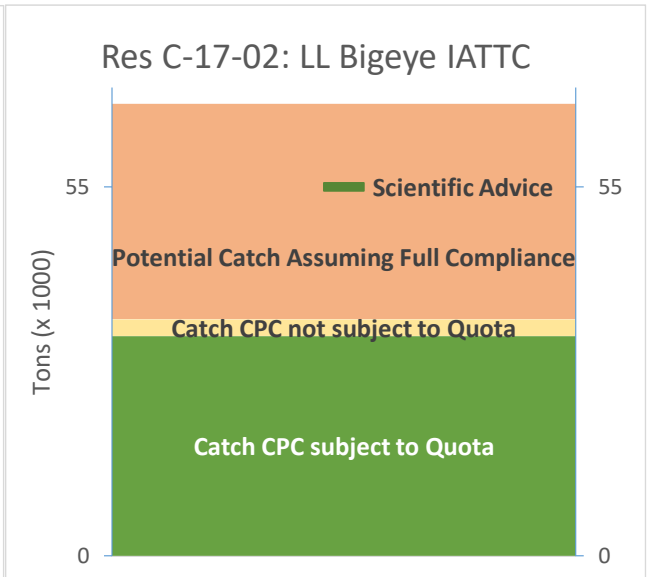
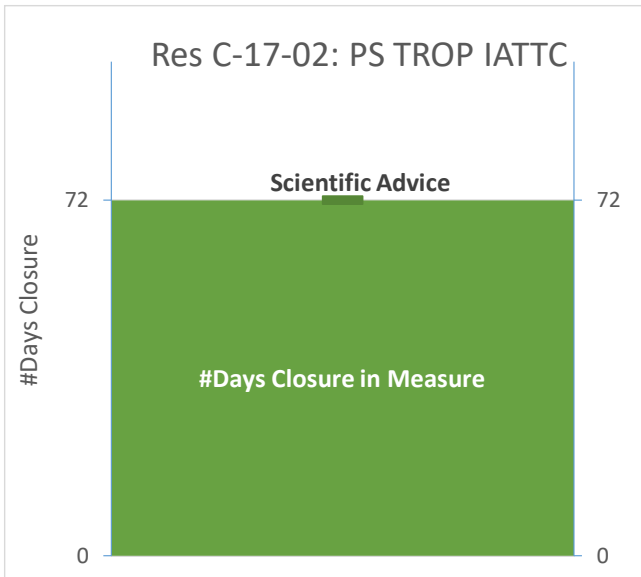


Figure 2 (prev. page). Evaluation of the efficiency of the approaches used by IATTC, ICCAT and IOTC to manage their stocks of tropical tunas. Details are provided in Section 3 of the main text.

Index to Figures:

- Top Left: IATTC Seasonal Fishery Closures intended to maintain the effort of industrial tuna purse seiners according to the scientific advice; it applies to the three stocks of tropical tunas;
- Top Right: IATTC TAC and quotas, intended to maintain the catches of bigeye tuna by industrial longliners at or below the TAC;
- Center Left: ICCAT TAC for the yellowfin tuna (unallocated), intended to maintain the catches of the stock at or below such TAC (covers all CPC and fisheries);
- Center Right: ICCAT TAC and quotas for the bigeye tuna, intended to maintain the catches of the stock at or below such TAC (covers all fisheries from only some CPCs);
- Bottom Left: IOTC Catch Limits for the yellowfin tuna, intended to maintain the catches of the stock at or below such limits (covers only some fisheries);
- Bottom Right: IOTC TAC for the skipjack tuna (unallocated), resulting from the Harvest Control Rule, intended to maintain the catches of the stock at or below such TAC (covers all CPC and fisheries);

Key to Figures:

- #Days Closure in measure (green shaded): number of days closure adopted by the IATTC in measure C-17-02 (72 days) and actual number of days implemented by all purse seiners covered;
- Scientific Advice (green line): number of days closure /TAC/Catch limit recommended by the Scientific Advisory Committee (management advice); potential catch/effort values over the Scientific Advice indicate that the measure adopted is insufficient to ensure compliance with the management advice;
- Catch CPC subject to Quota (green shaded): Catch reported by the IATTC Member and cooperating non-contracting parties (CPC) that have been allocated a quota of bigeye tuna;
- Catch CPC not subject to Quota (yellow shaded): Catch reported by the IATTC Member and cooperating non-contracting parties (CPC) that are not covered by the quota;
- Actual catches (i.e. the sum of the two above) over the Scientific Advice mean that existing catch levels might put at risk the sustainability of the stock
- Potential catch assuming full compliance (orange shaded): Total catch that RFMO CPC could potentially make assuming full compliance with the measure adopted to implement the TAC;
- Potential catch assuming full compliance (white shaded): Total catch that RFMO CPC could potentially make assuming full CPC compliance with the measure adopted to implement the TAC; the potential catch is unlimited because the TAC has not been allocated by CPC;

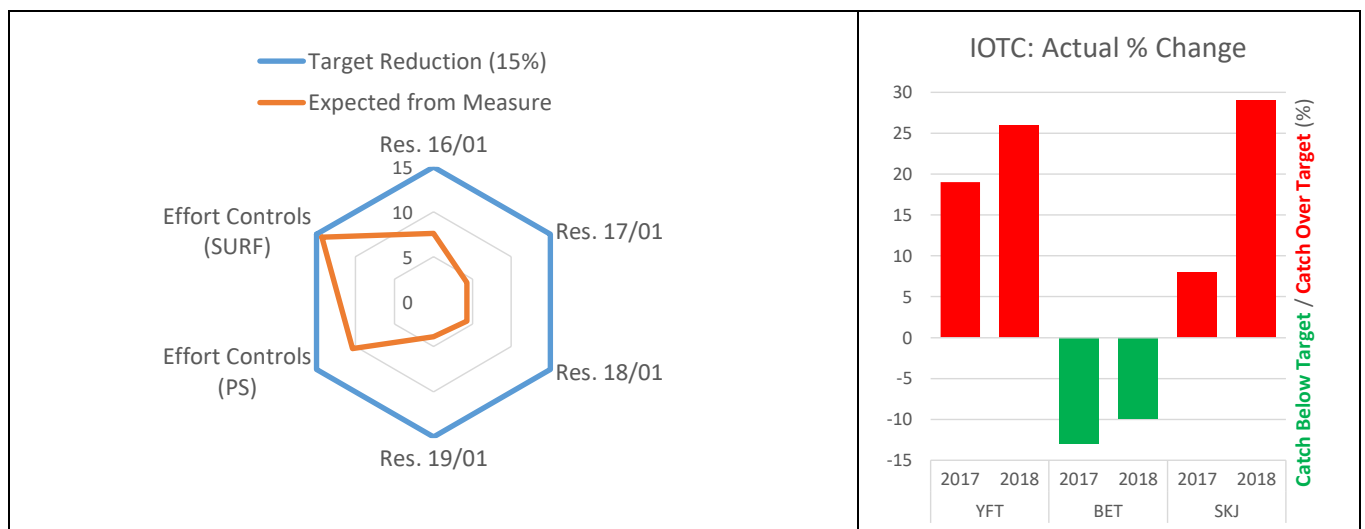


Figure 3. Left: Evaluation of the performance of IOTC Resolution 16/01 (YFT), subsequent amendments, and two types of Effort Controls, as proposed in this document, to achieve the target reduction in catches of yellowfin tuna recommended by the IOTC Scientific Committee (the scientific advice is that catches of yellowfin tuna should be reduced by 15% from its 2014 levels in 2017 and following years). Refer to **Table 2** for further details.

Right: Recent Catches (2017-18) performance against limits recommended as per the Scientific Advice. The zero line represents the scientific target. Red bars over the zero line indicate that catches in that year were over the scientific target (excess is represented as the % that catches were over the target), with green bars indicating that catches were below the scientific target in that year. Refer to **Table 3** for further details.

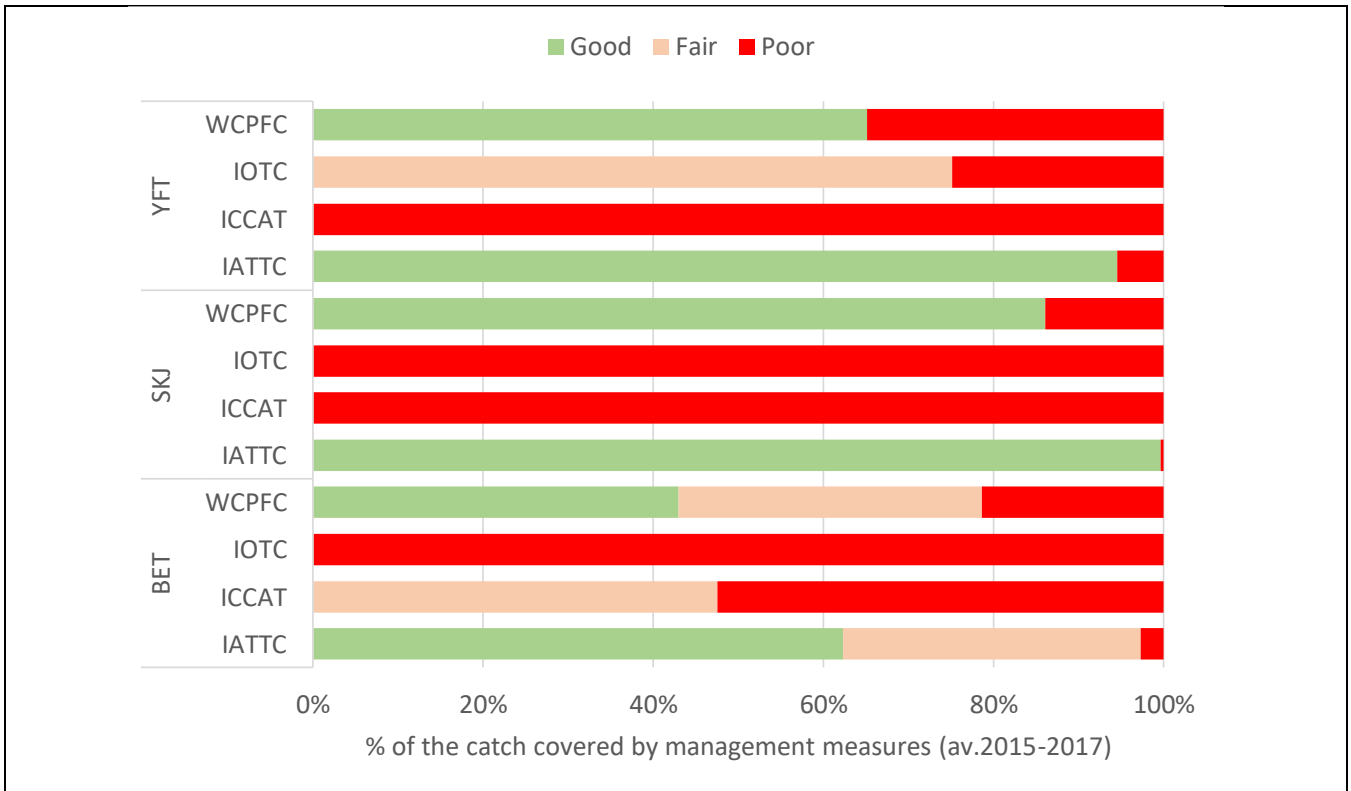


Figure 4: Evaluation of the efficiency of the schemes used by IATTC, ICCAT, IOTC and WCPFC to manage tropical tuna stocks. Data are presented by tRFMO and stock. The quality of the measures in place for each tRFMO and stock is assessed assigning the catches reported in recent years (2015-2017) according to the three following categories:

Good: The measure implemented addresses the scientific advice in full and compliance by all CPC is ensured;

Fair: The measure implemented addresses the scientific advice only partially (e.g. falls short of achieving the catch/effort reduction recommended through the management advice for the stock) and/or full compliance by all the CPC covered is not ensured;

Poor: No measure have been adopted by the tRFMO for the stock or the measure adopted is not addressed by CPC meaning that compliance with the management advice (i.e. target catch/effort level) is very likely to fail.