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Managing a multi-species fishery in distant waters: the case of the Spanish-flagged purse seine fishery targeting tropical tuna in the Indian Ocean

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Introduction

According to the latest report on the state of World Food and Agriculture Organization fisheries and aquaculture (SOFIA, 2022), skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) are among the five most caught finfish species of the world, with 2,827 and 1,569 thousand tons in 2020, respectively. The tropical purse seiners deploy large nets around tuna schools in the tropical waters of the world. This method targets three main tuna species, skipjack, yellowfin and bigeye (*Thunnus obesus*) tunas, which are mainly used for canning or frozen markets. This important fishery provides employment opportunities for many people in developing countries. Landings for the European long-distance fishery targeting tuna and tuna-like fishes from Indian Ocean, amounted to 303,638 tons valued at EUR 423.7 million (Prellezo et al., 2022), where the Spanish fleet of purse seiners targeting tropical tuna is the most important. The Spanish tropical purse seine fleet fishing in the Indian Ocean accounts for 26% of the skipjack and yellowfin tunas caught from Indian Ocean, which represent approximately 3% of worldwide catch for both species.

The Indian Ocean Tuna Commission (IOTC) is tasked with managing tuna and tuna-like species in the Indian Ocean region, with the goal of both conserving these species and optimizing their use. This mandate is supported by a scientific process, in which the IOTC's Scientific Committee (SC) provides recommendations on conservation, fisheries management, and research to inform the Commission's decision-making (Meltzer, 2009).

In 2015, the SC assessed the status of the stock of yellowfin tuna in the Indian Ocean, concluding that it was considered overfished and subject to overfishing (Langley, 2015). The SC indicated that "*If the Commission wishes to recover the stock to levels above the interim target reference points with 50% probability by 2024, the Scientific Committee*

recommends that catches be reduced by 20% of current levels.", from the catch levels in 2014 (IOTC–SC18, 2015).

This was the context in which the IOTC, on its 20th annual meeting, adopted the Resolution 16/01 (2016), which stated a rebuilding plan for the yellowfin tuna stock in the Indian Ocean. Different levels of reduction of the catches of yellowfin tuna were established depending on the fishery, from the catches recorded in 2014. Thus, purse seine fisheries, having reported catches of yellowfin tuna greater than 5,000 metric tons in 2014, had to reduce their catches by 15% from those levels, starting in 2017 (Resolution 16/02, 2016). This rebuilding plan was revised each subsequent year (Resolutions 17/01, 18/01, 19/01) and is currently under Resolution 21/01 (2021).

The European Union (EU), as a contracting party of the IOTC, implemented the measures adopted by the IOTC. Thus, the EU decided the yellowfin tuna quota by Member States in Council Regulation (EU) 2017/127 (2017), and subsequently, the Government of Spain have applied them to their flagged fleet.

The main objective of this document is to present the regulations that the Government of Spain has deployed in response to these measures to rebuild the stock of yellowfin tuna in the Indian Ocean. We discuss how such measures represent a unique case within the tuna fisheries; and their usefulness to manage multi-species fisheries.

Measures adopted by EU and Spain to address yellowfin tuna catch limits

In response of the yellowfin tuna catch limits explained above, Spain asked the fleet companies to develop a self-management model to limit their catches that should be applied in 2017 and the fisheries were closed in November 2017. For the fishing years 2018 to 2020, an allocation system was established based on a distribution of catch limits per vessel in proportion to the gross registered tonnage (one limit for large vessels and another for small vessels) (BOE, 2018; BOE, 2019; BOE, 2020). In 2021, through Ministerial Order APA/25/2021 (BOE, 2021), Spain adopted a new allocation scheme, which considered the recent catch history of yellowfin tuna (2012-2016) for each vessel. The total allowable catches were set by using the technical features and the average catches as weights (30% and 70%, respectively).

These implementation measures coincide with subsequent inspections and checks at port by Spanish agents, who performed a monitoring of catch by individual vessel.

Since the beginning of the fishery in the 1980s the need to establish a port-based sampling system to refine the catch estimations reported in the logbooks was evident (Báez et al., 2020). Since the 1990s Spain and France, the major European fleets of tropical purse seiners in the Indian Ocean, have developed a joint sampling design for the correction of catches provided by electronic logbooks filled by captains (Process known as Tropical Tuna Treatment, T3) (Báez et al., 2020). According to Duparc et al. (2022) historically there has been a high correlation in species composition, but since 2018 this trend was broken, especially in the catch under specific floating objects. These changes could be due to changes in the behavior of the Spanish fleet motivated by the different regulations (Báez et al., 2020). Thus, Spanish fishermen use sonar to detect associated schools at depth (where bigeye tuna are abundant), mainly avoiding schools with large yellowfin tuna fishes. However, this break could not explain the differences in deviations between bigeye and yellowfin tuna. According to the IOTC Secretariat, this could be due to changes in data processing methodologies (IOTC Secretariat, 2022). Effectively, these changes were necessitated by the compliance with Spanish national legislative. Previously, the administration relied on a system where fishing catches were reported through a generalized sampling technique known as the T3 (explained above). However, with the establishment of a quota-based allocation system for each individual vessel, the responsibility of reporting the landed catches now rests with the respective ship's captain. To ensure the accuracy and validity of these reported figures, authorized fisheries inspectors have been designated to verify the information provided. Therefore this new estimation method imply official electronic logbook, and routine inspections.In contrast, the previous system, known as the T3 system, employed generalized estimations based on spatial and temporal sampling of large fishing areas. In some instances, this approach led to the attribution of catches to a particular vessel without the vessel being sampled or observed.

The new reporting procedures addressed by the Spanish administration, together with the change in fishermen's behavior could lead to deviations in the annual species composition (in % of catches by species) of the three tropical tunas as reported by Spain administration. In order to avoid this problem, and a shift of fishing effort from yellowfin tuna to the other tropical tuna species, such as skipjack or bigeye, and prevent an overfishing risk on these species, an individual vessel limitation on the total tuna catch (i.e. yellowfin, skipjack and bigeye tunas) volume was implemented since 2020 (BOE, 2020; BOE, 2021). This individual vessel limitation on the total tuna catch volume is calculated as the amount resulting from dividing the yellowfin tuna fishing possibilities available to each vessel by a coefficient of 0.28 (BOE, 2020; BOE, 2021). The coefficient 0.28 relates the catches of yellowfin tuna to the total catches of the three species of tropical tuna, according to the function:

$$\text{Ratio} = \text{YFT catch} / (\text{total tropical tuna catch})$$

This coefficient is based on the average catches equivalent to the average catches of the three years prior to 2020, with a yellowfin tuna catch limit (i.e. the years 2017-2019). The historical series shows a strong fluctuation of this ratio, but it is assumed that it should behave similarly in the years with catch limits.

Figure 1 shows how the change in data processing methodologies in 2018 implied a deviation from T3 estimates. On the other hand, after the joint management of the three tropical tuna species this deviation decreases.

Discussion

The implementation of yellowfin tuna catch limits has led to a decrease in the historical trend of yellowfin tuna catches in the

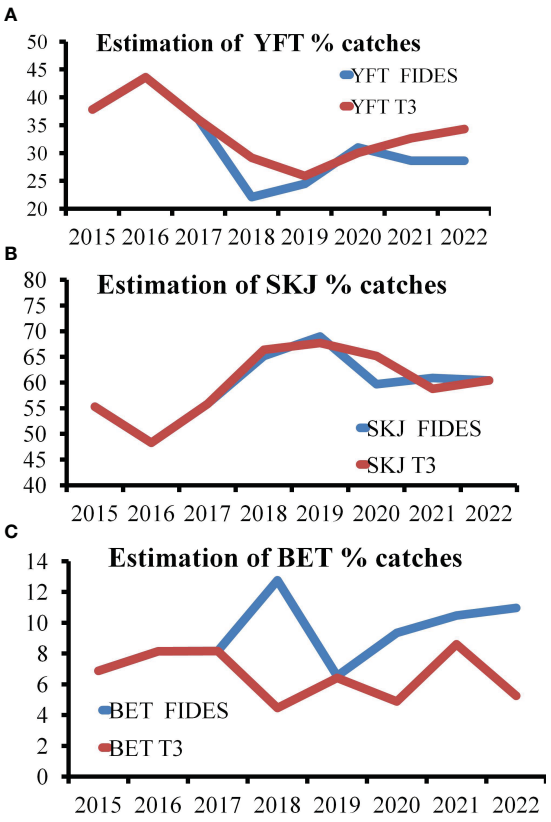

FIGURE 1
The percentage catch of each year for each of the three species of tropical tunas by the Spanish flagged freezer purse seine fleet, and according to the estimates made through the Tropical Tunas Treatment (T3) process, or through the Official Electronic Logbook on Board (FIDES), is shown. **(A)** percentage catch of YFT, yellowfin tuna; **(B)** percentage catch of SKJ, skipjack tuna; **(C)** percentage catch of BET, bigeye tuna.

Spanish flag purse seine fleet, but due to the incorporation of joint management of tuna the mortality of the other species has not increased.

IOTC Resolution 16/02 (2016) (replaced by the Resolution 21/03, 2021) established a harvest control rules for skipjack tuna stock. The objective is to maintain the exploitation of this stock at the MSY. Moreover, recently the IOTC Working Party on Tropical Tunas determined in the last stock assessment of bigeye tuna that, with 79% probability, it was overfished, and recommended a 15% of reduction in catches for the period 2024-2025 (IOTC–WPTT24, 2022). All this, together with the interim rebuilding plan for the Indian Ocean yellowfin tuna stock in the IOTC area of competence (Resolution 16/01, 2016), and the need to establish measures for the reduction of yellowfin tuna catches (Resolution 21/01, 2021), makes it necessary to establish an integral system of catch limitations.

For this reason, limiting the total volume of tuna catches made by the freezer tuna purse seine fleet as a whole, taking into account the interrelation between the catches of all tuna, could help in the joint management of tuna. Moreover, this measure could help to an effective control of fishing in the long-distant fleets, as well as preventing part of the effort targeting yellowfin tuna from being directed towards other stocks.

The application of the catch limit per vessel but taking into account the species composition ratio, also avoids the weaknesses of applying only a total catch control (without taking species composition into account). It has been shown from Chinese fisheries that total catch control regulation does not lead to the recovery of fisheries and the maintenance of community function (Kang et al., 2022). In this study were included different trophic levels, and individual species have different responses to overfishing that highly associated with their biological characteristics (Kang et al., 2022).

There are no other similar cases in tropical tuna management. In fact Atlantic bigeye tuna and yellowfin tuna stocks in the International Commission for the Conservation of Atlantic Tunas (ICCAT) area have catch limits, but in this fishery an individual vessel limitation on the total tuna catch volume was not performed by Spanish Government.

In an international context, the performance of total catch, catch-per-set and catch-per-vessel limits are discussed in detail in other Regional Fisheries Management Organizations such as for example, Inter-American Tropical Tuna Commission (Maunder et al., 2021). However, no explicit mention is made of the application of a species composition ratio system to the total catch per vessel.

Author contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher’s note

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