REVIEW OF DATA ON DRIFTING FISH AGGREGATING DEVICES

Prepared by IOTC Secretariat[1]

Introduction

IOTC Resolution 15/09 was adopted in 2015 to create a scientific forum aiming at assessing the consequences of the increasing number and technological developments of fish aggregating devices (FADs) in tuna fisheries and their ecosystems, in order to inform and advise on future FAD-related management options. The first session of the IOTC *ad hoc* Working Group on FADs (WGFAD01) was held in Madrid, Spain on 18 April 2017 (IOTC 2017).

The overarching objective of this paper is to provide participants to the 3rd Working Group on FADs (WGFAD03) with a review of the data and information on FADs and FAD-related fisheries as available in the IOTC databases as of September 2022. The document summarises data on fishing capacity, fishing effort, and catches for the species caught with purse seine in association with drifting floating objects (FOBs) for the period 1950-2021, as well as data sets providing information on FAD-related activities (e.g., deployments, retrievals, etc.) and spatio-temporal distribution of FOBs across the Indian Ocean.

Materials

Several data sets shall be reported to the IOTC Secretariat by the Contracting Parties and Cooperating Non-Contracting Parties (CPCs) as per all relevant IOTC Conservation and Management Measures (CMMs) and following the standards and formats listed in the IOTC Reporting guidelines. Although not mandatory, the use of the IOTC forms is recommended to report the data to the Secretariat as they facilitate data curation and management.

Nominal catch data

Nominal catches correspond to the total retained catches (in live weight) estimated per year, Indian Ocean major area, fleet, and gear (IOTC Res. 15/02) and can be reported through IOTC form 1RC.

Changes in the IOTC consolidated data sets of nominal catches (i.e., raw and best scientific estimates) may be required as a result of:

i. Updates, received by December 30th each year, of the preliminary data for longline fleets submitted by June 30th of the same year (IOTC Res. 15.02);

ii. Revisions of historical data by CPCs following corrections of errors, addition of missing data, changes in data processing, etc.

iii. Changes in the estimation process performed by the Secretariat based on evidence of improved methods and/or assumptions (e.g., selection of proxy fleets, updated morphometric relationships) and upon endorsement by the Scientific Committee.

Geo-referenced catch and effort data

Catch and effort data refer to fine-scale data, usually from logbooks, reported in aggregated format and stratified by year, month, grid, fleet, gear, type of school, and species (IOTC Res. 15/02). The IOTC forms designed for reporting geo-referenced catch and effort data vary according to the nature of the fishing gear (e.g., surface, longline, and coastal

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gears). In addition, information on the use of FADs and effort exerted by support vessels that assist industrial purse seiners shall also be collected and reported to the Secretariat through IOTC forms 3FA and 3SU.

Discard data

The IOTC follows the definition of "discards" adopted by FAO in previous reports, and considers all non-retained catch as discarded catch, including individuals released alive or discarded dead (Alverson et al. 1994; Kelleher 2005). Estimates of total annual discard levels in live weight (or number) by Indian Ocean major area, species and type of fishery shall be reported to the Secretariat as per IOTC Res. 15/02. The IOTC form 1DI has been designed for the reporting of discards and the data contained shall be extrapolated at the source to represent the total level of discards for the year, gear, fleet, Indian Ocean major area, and species concerned, including turtles, cetaceans, and seabirds.

Nevertheless, discard data reported to the Secretariat with IOTC Form 1DI are generally scarce, not raised, and not complying with all IOTC reporting standards. For these reasons, the most accurate information available on discards comes from the IOTC Regional Observer Scheme (IOTC Res. 11/04) that aims to collect detailed information (e.g., higher spatio-temporal resolution, fate) on discards of IOTC and bycatch species for industrial fisheries (see below).

Size frequency data

The size composition of catches may be derived from the data set of individual body lengths or weights collected at sea and during the unloading of fishing vessels. The IOTC Form 4SF provides all fields requested for reporting size frequency data to the Secretariat following a stratification by fleet, year, gear, type of school, month, grid and species as required by IOTC Res. 15/02. While the great majority of size data reported with IOTC Form 4SF are for retained catches, some size data on fish discarded at sea may be collected through onboard observer programs and reported to the Secretariat as part of the ROS.

FOB-related data

The entry in force of IOTC Res. 15/08 (September 15th 2015), combined with the new requirements expressed by IOTC Res. 15/02, called all CPCs with vessels fishing on FOBs to report to the Secretariat (in agreement with the annual statistical data submission cycle of IOTC) all data elements specific to activities on drifting and anchored FOBs, possibly with the support of the recommended IOTC form 3FA.

In particular, drifting FOBs shall be categorized according to the IOTC classification that combines the nature of the FOB, the type of tracking system, and the presence of net webbing hanging underneath (**Fig. 1 & Table 21**). The activities to be recorded shall always refer to the corresponding number of FOBs affected by the activity itself, and include events such as: deploying or encountering a FOB at sea, retrieving a FOB from the water, and recording a FOB as no longer remotely monitored when the GPS signal is lost (**Table 22**). Furthermore, the numbers of sets made on schools associated with drifting FOBs must also be reported for each time-area stratum, along with the corresponding species-specific catches.

At-sea deployments (IOTC form 3FD and 3FA)

In 2020 the IOTC Secretariat developed IOTC form 3FD to support the temporary data reporting requirements introduced by IOTC Res. 19/01, which require CPCs to provide collated geo-referenced data on the total number of FADs deployed in 2018 and 2019 by their purse seine and associated supply vessels by 1°x1° grid (see Para. 19). Beside serving the original purposes of IOTC Res. 19/01, the information received through this additional form can also be used to cross-verify the data on deployments of FOBs submitted through IOTC Form 3FA for the years 2018-2019, and identify potential inconsistencies with the latter.

In fact, information on the deployments of FOBs was submitted by CPCs to the Secretariat using both IOTC form 3FA and IOTC form 3FD. Data from IOTC forms 3FA are stratified by fleet, year, month, vessel type (purse seiners or supply vessels) and 1°x1° grid, and cover to various degrees the years between 2013 and 2021, while data from IOTC forms 3FD are stratified by fleet, year, vessel type (purse seiners or supply vessels) and 1°x1° grid, and cover only the years 2018 and 2019.

While IOTC form 3FD is specifically dedicated to the reporting of FOB deployments, in IOTC form 3FA this same information is available only through the records associated to the FOB activity type '*DD*' ('*Deployment of drifting FAD*', see **Table 22**), and the number of FOBs deployed should be inferred from the *NUM_FOBS* column in the collated dataset (or from the *EFFORT* column in the original IOTC form 3FA submissions).

Sets on FOBs (IOTC form 3CE and 3FA)

Information on the number and location of sets on FOBs was submitted by CPCs to the Secretariat using both IOTC form 3FA and IOTC form 3CE. Data from IOTC forms 3FA and data from IOTC forms 3CE are both stratified by fleet, year, month, and 1°x1° grid. While the former (available through the column *NUM_SETS_ON_FOB* within the corresponding data set) is expressed in number of sets by default, the latter (available through the column *EFFORT* within the corresponding source data set) might appear with different unit of measures, and for this reason only records where the effort unit is indicated as *SETS* (and the school type as *LS* - *Log-associated schools*) are considered here. This is a limiting factor when selecting the strata for which the information from both sources can be compared, due to the use of non-standard effort units from many purse seine fleets and for several years in the catch and effort data for purse seine fisheries.

Catches on FOBs (IOTC form 3CE and 3FA)

Information on the location and magnitude of catches on FOBs was submitted by CPCs to the Secretariat using both IOTC form 3FA and IOTC form 3CE. Catch data from IOTC forms 3FA and catch data from IOTC forms 3CE are both stratified by fleet, year, month, 1°x1° grid, and species. The former is available through the columns *ALB*, *BET*, *SKJ* and *YFT* within the corresponding data set (and is expressed in metric tons by default), while the latter is available through the columns *ALB-LS*, *BET-LS*, *SKJ-LS* and *YFT-LS* within the corresponding data set, and might potentially appear with different catch units according to the reference unit stored under the *CatchUnit* column.

For the purpose of this analysis, only catches of tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) will be considered from both data sets.

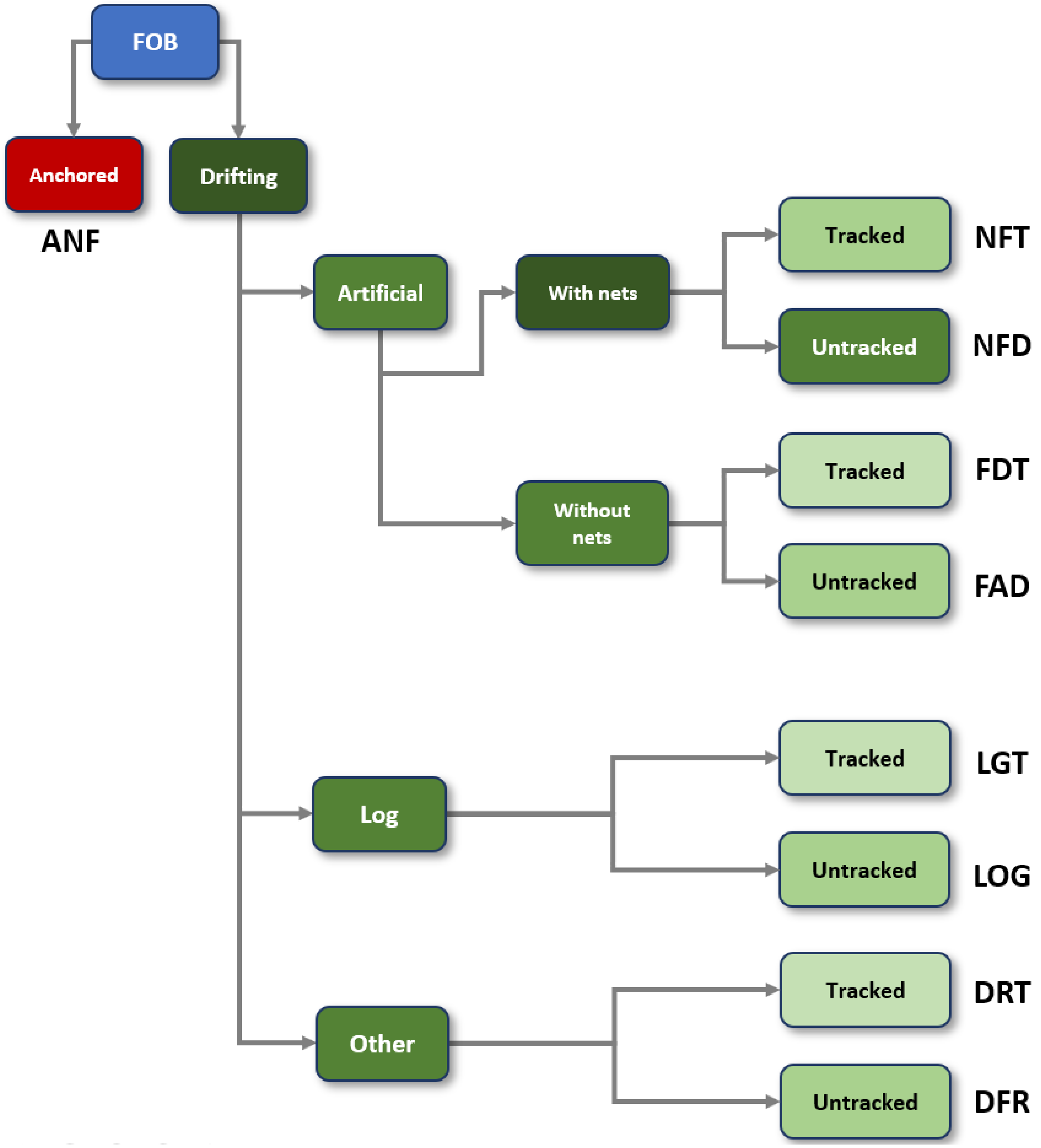

Figure 1: Classification of types of floating objects in use at the IOTC Secretariat. See Appendix I for description of each code

FOB-tracking data

As a consequence of the entry in force of IOTC Res. 19/02, IOTC CPCs with fishing vessels using drifting FOBs have now the obligation to report daily information (since January 1st 2020) on all active FOBs monitored at sea with satellite-tracked buoys. The information to report to the Secretariat shall follow the structure and formats of IOTC form 3BU and contain the date, instrumented buoy ID, assigned vessel and daily position of each monitored buoy, which shall be compiled at monthly intervals, and reported to the IOTC Secretariat with a time delay of at least 60, but no longer than 90 days.

According to paragraph 24 of IOTC Res. 19/02, the information thus collected shall be used "*to support the monitoring of compliance with the limitation established in Paragraph 4, while protecting business confidential data* (…)". A preliminary attempt at using those data for scientific purposes, after aggregating all sensitive details in order to not disclose activities of any single vessel, was made for the first time during this scientific forum, and after receiving explicit acknowledgement from all concerned CPCs.

This global data set covers the period from January 2020 to May 2022, and does not include data for the buoys monitored by the Republic of Korea, which have been submitted to the Secretariat in incomplete and non-standard form, preventing their inclusion within the IOTC database. Also, no information is available from the active purse seiners of I.R. Iran, due to the country being subject to an embargo restricting access to standard satellite communication, while additional information is required from Kenya to clarify if their recently developed purse seine fishery (comprising six vessels of around 50 m LOA and 493 GT) has been actively fishing on FOBs between 2020 and 2022 and is therefore subject to this requirement.

Regional Observer Scheme

Fisheries observer data collected as part of the Regional Observer Scheme (ROS; Resolution 11/04) include information on: (i) fishing activities and vessel positions, (ii) catch estimates with a view to identifying catch composition and monitoring discards, bycatch and size frequency, (iii) gear type, mesh size and attachments employed by the master, and (iv) information to enable the cross-checking of entries made to the logbooks (i.e., species composition and quantities, live and processed weight and location). Furthermore, observers deployed on large-scale purse seiners of the EU, Mauritius, and Seychelles collect a large range of information on FAD-related activities (e.g., deployments, retrievals), design and components of the FADs, and handling practices for the safe release of sensitive bycatch species such as sharks, rays, and turtles (Goujon et al. 2017; Grande et al. 2019; Wain et al. 2022).

However, due to changes in data reporting formats for some fleets, fisheries, and years, and the temporary use of a non-comprehensive format of exchange of the ROS data with the Secretariat, data collected on FADs by observers at sea on industrial purse seiners are not yet available for scientific analysis and therefore are not included in the present report, nor in any of its accompanying public data sets.

Methods

The release of the curated public-domain data sets is done following some checking and processing data steps which are briefly summarized below. First, standard controls and checks are performed to all data sets received at the Secretariat to ensure that the metadata and data are consistent and include all mandatory fields (e.g., dimensions of the strata, etc.). The controls depend on each data set and may require the submission of revised data from CPCs if the original one is found to be incomplete.

Nominal catch data

For the nominal catch data, a series of processing steps is applied to derive the best scientific estimates for the 16 IOTC species (see **Appendix V** of IOTC (2014)), by implementing the following rules:

a. When nominal catches are not reported by a CPC, catch data from the previous year may be repeated or catches may be derived from a range of sources, e.g., partial catch and effort data, the FAO FishStat database, data on imports of tropical tunas from processing factories collaborating with the International Seafood Sustainability Foundation, etc.;

b. For some specific fisheries characterized by well-known, outstanding issues in terms of data quality, a process of re-estimation of species and/or gear composition may be performed based on data available from other years or areas, or by using proxy fleets, i.e., fleets occurring in the same strata which are assumed to have a very similar catch composition (e.g., Moreno et al. (2012) and IOTC (2018));

c. Finally, a disaggregation process is performed to break down the catches by species and gear when they are reported as aggregates (IOTC 2016). Briefly, the process estimates the catch proportion of each IOTC species of an aggregate in a given stratum from past reports of catches where the species and gears were reported separately, following a substitution scheme.

Geo-referenced catch data

For albacore, bigeye tuna, skipjack tuna, yellowfin tuna, and swordfish, geo-referenced catches were raised to the best scientific estimates of nominal catches using available information and by either leveraging data from proxy fleets or adopting substitution schemes when the spatio-temporal information is not available for a given stratum. For this reason, the raised data sets represent the best scientific estimates of the geo-referenced catches given the information available to the Secretariat and the well-known issues with data availability and data quality affecting several fisheries.

The resulting data set is comprised of catches in weight and number and stratified by year, month, fleet, gear, school type (when available), and 5°x5° grid and covers the entire time series for which nominal catches of each species are available. The species-specific average weight in the catch can be computed directly from the raised weights and numbers for each fishery, with the accuracy of the results being directly proportional to the availability and quality of geo-referenced catch and size-frequency data for the stratum. From the raised geo-referenced catch data sets, information on the type of school association becomes available for the nominal catches of the three tropical tuna species caught with purse seine.

Geo-referenced effort data

Fishing vessels

Until recently, effort information for vessels fishing on FOBs was not strictly standardized, and therefore data were provided by CPCs to the IOTC Secretariat using a variety of different effort units, that included fishing hours, fishing days, days at sea as well as number of sets. For this reason, the Scientific Committee of IOTC, at its 22nd session in 2019 recommended that "*(…) all purse seine fleets reporting effort as fishing hours or fishing days begin to submit this information as 'number of sets' instead, in particular when fulfilling the reporting requirements of Resolution 15/02 (…)*" (IOTC 2019).

Several concerned CPCs are currently transitioning towards the implementation of this requirement, and actively liaising with the IOTC Secretariat to ensure that the provision of revised historical effort information (expressed as number of sets) can be progressively incorporated within the IOTC databases.

In the ad-interim period, until this transition is fully completed, no conversion is applied by the IOTC Secretariat to effort data provided by purse seine fleets using non-standard units (e.g., fishing days or fishing hours), and this limits the comparative analysis that could be performed in combination with more specific information available through the dedicated data reporting forms for FOB-related activities.

Supply vessels

Effort data for supply vessels have been exclusively reported to the Secretariat as the total number of days spent at sea, stratified by flag, year, month, and 1°x1° grid within the IOTC area of competence. CPCs were requested to report this information following the entry in force of IOTC Res. 15/02 in 2015, and since then the level of implementation of this requirement has been extremely variable, with full reporting (from all concerned CPCs) available only in 2018 and 2019, with some CPCs also providing historical data covering statistical years prior to 2015 (albeit partially).

In agreement with the data confidentiality requirements expressed by IOTC Res. 12/02, and in light of the fact that for several years only a single supply vessel was known to be active for some CPCs, the information is currently disseminated in aggregated format, i.e. without indication of the vessel flag. Furthermore, and in order to support the analysis of total yearly effort for all combined fleets, this dataset includes records that either completely lack spatial / temporal information (and are therefore aggregated annually) or refer to grid codes that fall outside of Indian Ocean waters (when not on the mainland).

Size data

Filtering and conversions are applied to the size data of all 16 IOTC species plus the most common shark species in order to harmonize their format and structure and remove data which are non-compliant with IOTC standards, such as those provided with size bins exceeding the maximum width considered meaningful for the species (IOTC 2020). The standard length measurements considered vary with the species and size samples collected using other types of measurements are converted into the standard measurements using the IOTC conversion equations, considering different size ranges and intervals according to the species. If no IOTC-endorsed equations exist to convert from a given length measurement for a species to the standard size measurements, the original size data are not disseminated but kept within the IOTC databases for future reference.

FOB-related activity data

Notwithstanding the fact that - although with varying levels of accuracy - CPCs have been submitting data on FOB-related activities to the IOTC Secretariat since the statistical year 2015 (following the entry in force of IOTC Res. 15/08) this information was not publicly disseminated until WGFAD02 in 2021, due to well-known issues with the corresponding data collection and reporting requirements, concerning in particular the interpretation of the FOB activity types, their underlying business logic as well as the expected mechanism to report the number of interacted FOBs as well as the positive sets on FOBs and their associated catches by species.

This lack of clarity, together with the difficulties found by some CPCs in mapping IOTC FOB types and FOB activity types to the standard classifications adopted at national level (e.g., Gaertner et al. (2016)) resulted in a combined dataset that is not fully accurate and representative of the information it is supposed to describe.

In particular, and as already indicated earlier in the case of effort data reported for supply vessels, several records were identified that refer to grid codes that are either plain wrong or fall outside of Indian Ocean waters (when not on the mainland), while in other cases evidences were found in the original records of positive sets (i.e., sets with non-NIL catches) reported for FOB activities that are not supposed to be followed by setting / hauling (e.g., deployment or loss of FOBs) (Fiorellato et al. 2017).

In order to provide a minimum level of support to future analysis requested by this scientific forum, and with the aim of fostering further discussions on the current limitations of these sources of information, the IOTC Secretariat has collated and made available the data provided so far by all concerned CPCs through IOTC form 3FA, although for the reasons indicated above this specific data set is provided *as is*, i.e., with only a minimum level of standardization applied to the original data and the reference codes within it.

The level of availability of explicit FOB deployment data (IOTC form 3FD), as well as of geo-referenced catch and effort data for sets on log-associated schools (IOTC form 3CE), are adequate enough to support basic cross-verification tasks with the data collated from IOTC form 3FA, and to identify potential issues with over / under reporting of efforts and catches, as well as seasonal patterns emerging from the information contained within.

Although historical FOB activity data are also available for some CPCs for years preceding the entry in force of IOTC Res. 15/08 (2013 and 2014, in particular), the information here presented will mostly focus on the years 2017-2021.

FOB tracking data

Data sets recording positions and ancillary data of instrumented operational buoys were received by the IOTC Secretariat on a regular basis and mostly in compliance with the requirements and structure of the IOTC Form 3BU.

First, duplicates were removed from the original data sets and vessels and flags were formatted to comply with IOTC reference code lists. As part of the fishing strategy of the purse seine companies, some buoys may be monitored by several vessels at the same time but this information on buoys shared among purse seiners is not available for all fleets. Following the methodology defined to deal with the reporting of buoys shared between purse seiners in some fleets (Maufroy and Goujon 2019), an individual weight of 1/(number of sharing purse seiners) was assigned to each daily buoy position.

While the individual daily buoy position data sets are devoted to compliance purpose, all CPCs with active purse seiners fishing on FOBs have agreed to release in the public domain the buoy position data sets in aggregated format, i.e. stratified by CPC, year, month, and 1°x1° grid. For each CPC and all CPCs combined, the summary statistics (minimum, first quartile, median, mean, third quartile and maximum) of the daily total number of active buoys were computed for each 1°x1° grid and month covering the period from January 2020 to May 2022.

Results

Historical catch trends

World oceans

Global purse seine catches of the main tropical tunas have steadily increased over the last seven decades and are largely dominated by catches from the Western-Central Pacific Ocean which have been driving the increasing trend since the early 1980s (**Fig. 2**). In 2019, the global purse seine catch reached a maximum close to 4 million metric tons of tropical tuna, with the Indian Ocean contributing to about 12% of the total catches through its industrial purse seine component.

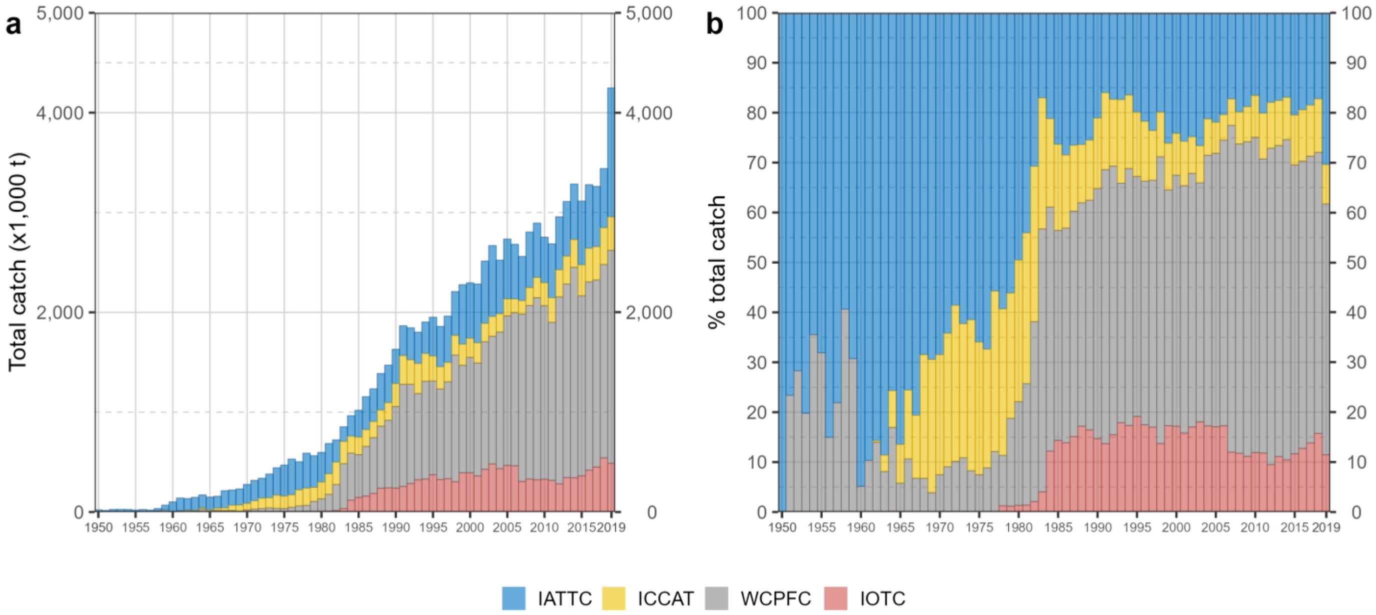

Figure 2: Annual time series of cumulative nominal absolute (a) and relative (b) global purse seine catches (metric tons; t) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) by tuna RFMO for the period 1950-2019. IATTC = Inter-American Tropical Tuna Commission; ICCAT = International Commission for the Conservation of Atlantic Tunas; WCPFC = Western-Central Pacific Fisheries Commission; IOTC = Indian Ocean Tuna Commission. Source: FIRMS Global Tuna Atlas

At global scale, the volume of tropical tuna caught in association with drifting FOBs has steadily increased since the mid-1970s and has exceeded 2 million metric tons since 2016 (**Fig. 3a**). The contribution of this school type to the total purse seine catches of tropical tuna increased from about 30% in the early 1980s to about 50% in the 1990s, and about 55% in the 2000s-2010s (**Fig. 3b**). The relative stability of the proportion of catches of tuna associated with drifting FOBs over the last two decades is explained by the concurrent increase of catches of free-swimming schools while catches in dolphin-associated schools have remained fairly constant over time.

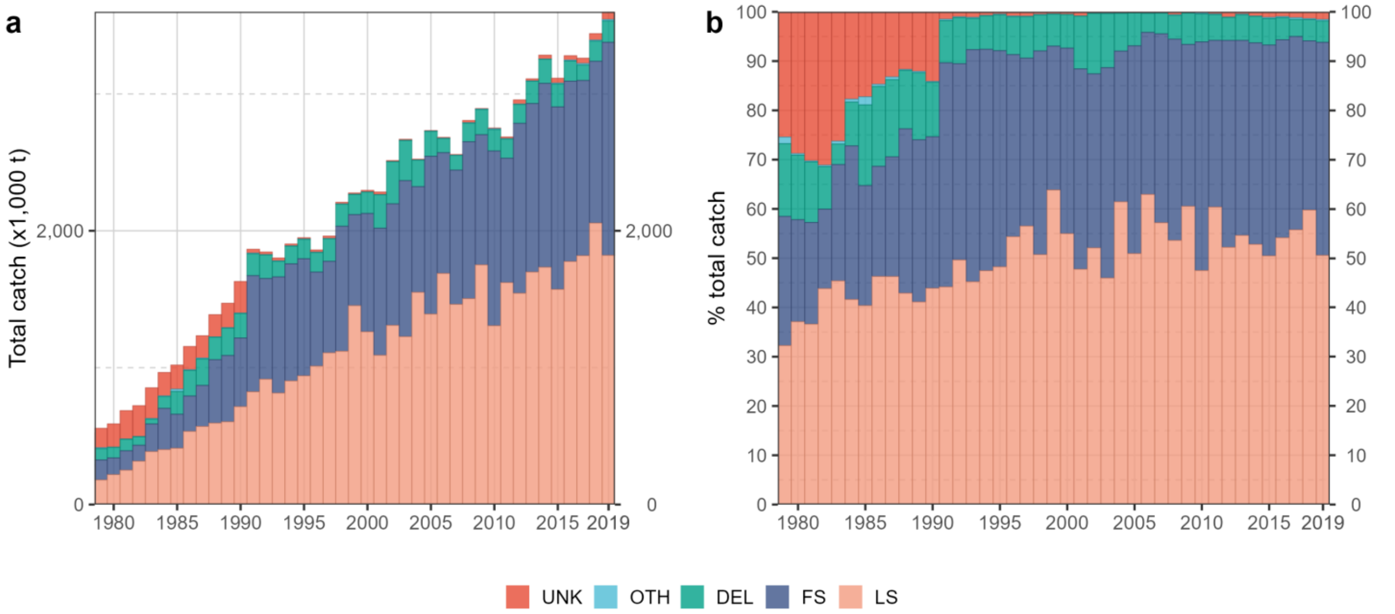

Figure 3: Annual time series of cumulative nominal absolute (a) and relative (b) global purse seine catches (metric tons; t) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) by type of school association for the period 1979-2019. LS = floating object-associated school; FS = free-swimming school; DEL = dolphin-associated school; OTH = other; UNK = unknown. Source: FIRMS Global Tuna Atlas

Purse seine catches on drifting FOBs in each ocean basin show a general increasing trend over time, although with some variability between RFMOs (**Fig. 4a**). Following the development of the purse seine fisheries in the early 1980s, the contribution of the Indian Ocean to the global purse seine catches taken on schools associated with FOBs has varied between 11% and 24% over the last 35 years. The contribution decreased from an average of about 20% during 1985-2003 to about 15% during 2004-2017 but showed an increasing trend since 2012 and reached more than 20% in 2018-2019 (**Fig. 4b**).

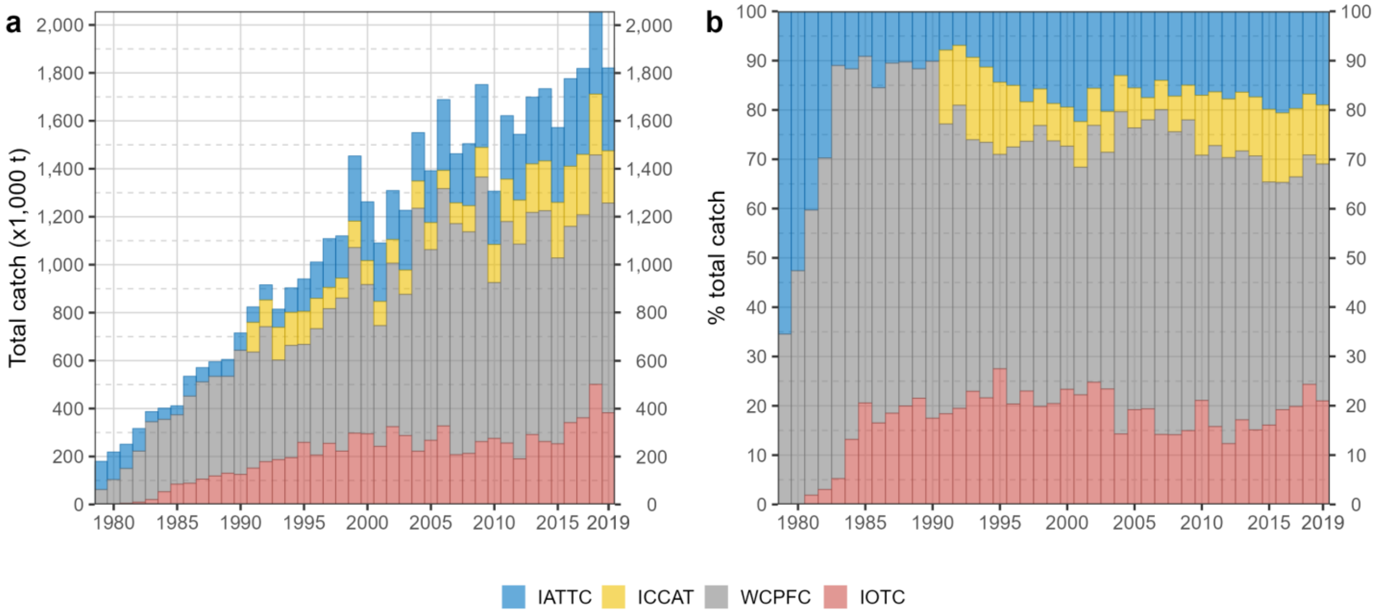

Figure 4: Annual time series of cumulative nominal absolute (a) and relative (b) global purse seine catches (metric tons; t) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) caught on schools associated with drifting floating objects for the period 1979-2019. Source: FIRMS Global Tuna Atlas

Indian Ocean

Catches of tuna schools associated with drifting FOBs have always dominated the total catches of the purse seine fishery of the Indian Ocean (**Fig. 5**). As early as in the 1980s, a large part of the purse seine catches was taken on tuna schools that were mainly composed of natural objects at that time (Hallier et al. 1992). Catches on both school types showed an increase during the period from the fishery development to its expansion until the mid-1990s. Therafter, catches on free swimming schools showed an overall decrease over the years, with the notable exception of the “golden years” 2003-2005, to reach a minimum of less than 30,000 t in 2018 and about 62,000 t in 2021 (**Fig. 5a**). In the meantime, the FAD fishery developed substantially, showing a sharp increase from 2015 and reaching a maximum of about 466,000 t in 2018. In 2021, the total reported catches for the Indian Ocean purse seine fishery on associated schools was about 406,000 t, representing 86.6% of the total purse seine catch (**Fig. 5b**).

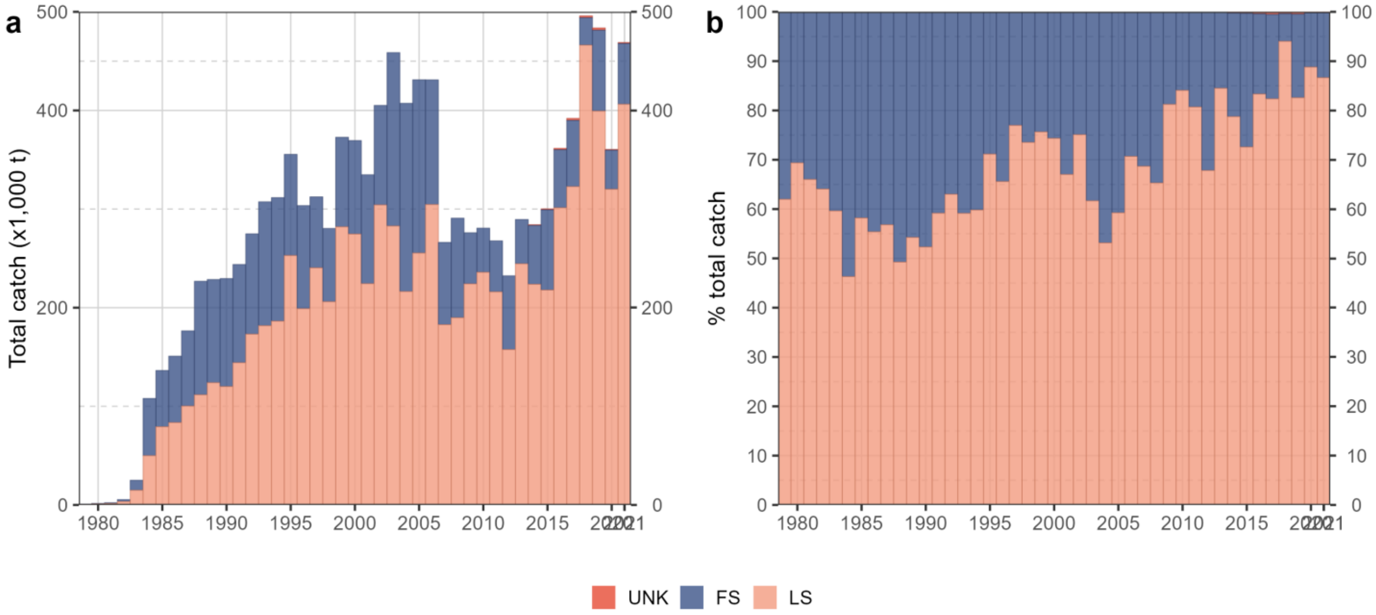

Figure 5: Annual time series of cumulative nominal absolute (a) and relative (b) purse seine catches (metric tons; t) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) by school type in the Indian Ocean for the period 1979-2021. LS = floating object-associated school; FS = free-swimming school; UNK = unknown. Source: raised IOTC geo-referenced catches

All purse seine fleets of the Indian Ocean show an overall increasing trend in the proportion of catch taken on FOB-associated schools over the last four decades, although with some inter-annual variability (**Fig. 6**). While the three main purse seine fleets show similar patterns over time, the fleet of EU,France has been characterized by a significantly lower proportion of catches in weight on associated schools than the other main fleets over time, varying between 1% and 24% less than EU,Spain over the period 2000-2021. In 2021, about 87% of the total purse seine catch was taken on associated schools, with Seychelles, EU,Spain, and EU,France contributing to 24.4%, 27.4%, and 13.6% of the total purse seine catches on tropical tuna associated with drifting FOBs (**Fig. 6**).

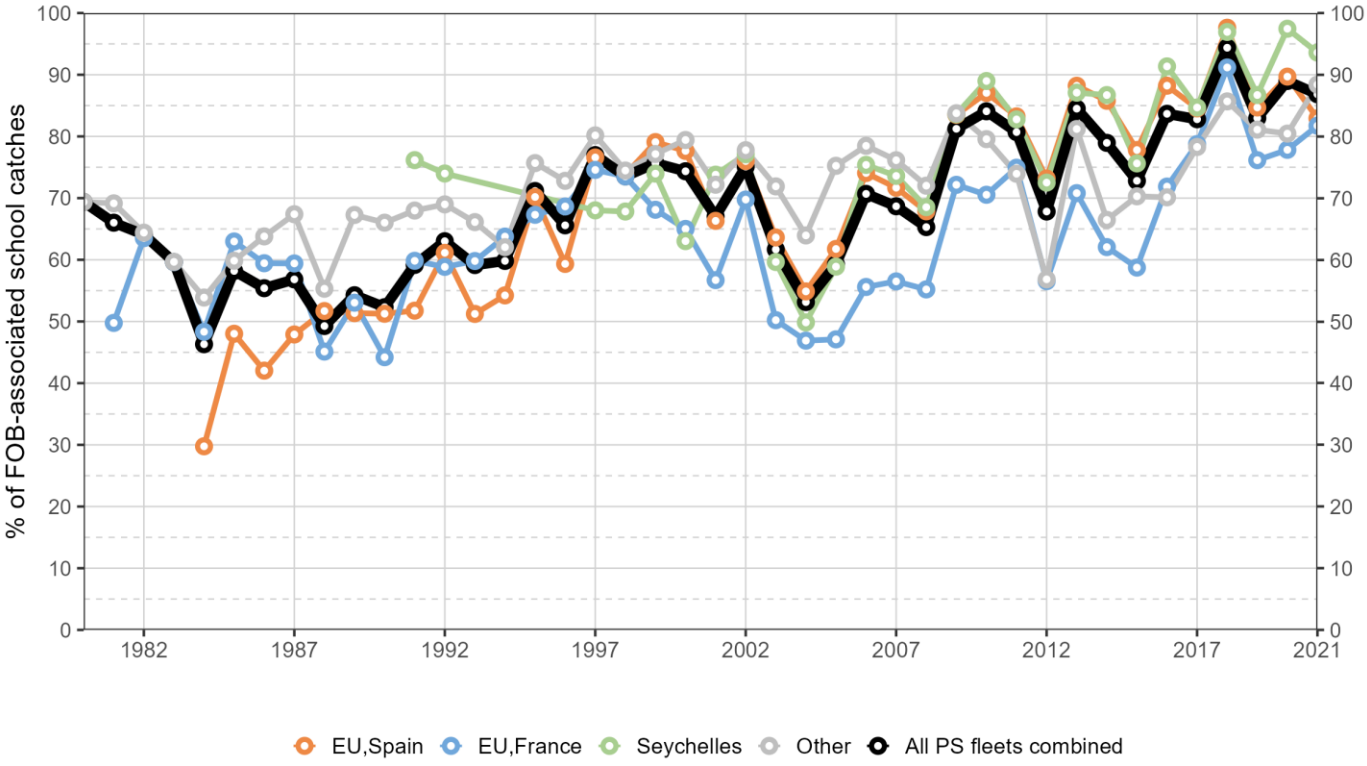

Figure 6: Annual time series of percentage of purse seine catches of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) caught on floating object-associated schools in the Indian Ocean by fleet for the period 1980-2021. Source: raised IOTC geo-referenced catches

Spatial distribution

Decadal view, 1980-2019

Decadal maps of the distribution of purse seine catches in the Indian Ocean since the inception of the fishery in the early 1980s show that purse seine fishing grounds are essentially located in the western Indian Ocean (**Fig. 7**). Except for the Mozambique Channel, almost no purse seine catches have been reported south of 10°S (i.e., within the Indian Ocean gyre located south of the South Equatorial Current (Schott et al. 2009)). The fishery expanded rapidly between the 1980s and the 1990s further south of the Mozambique Channel and in areas beyond national jurisdiction located in the north-western Indian Ocean (**Fig. 7a-b**). Catch levels increased in the 2000s and some important catches on free-swimming schools were reported between 10°S and the equator during the decade 2000-2009 (**Fig. 7c**). In the last decade, catches on schools associated with drifting FOBs have dominated in all grid areas of the whole purse seine fishing grounds, with an increasing gradient from 10°S to the north of the equator (**Fig. 7d**).

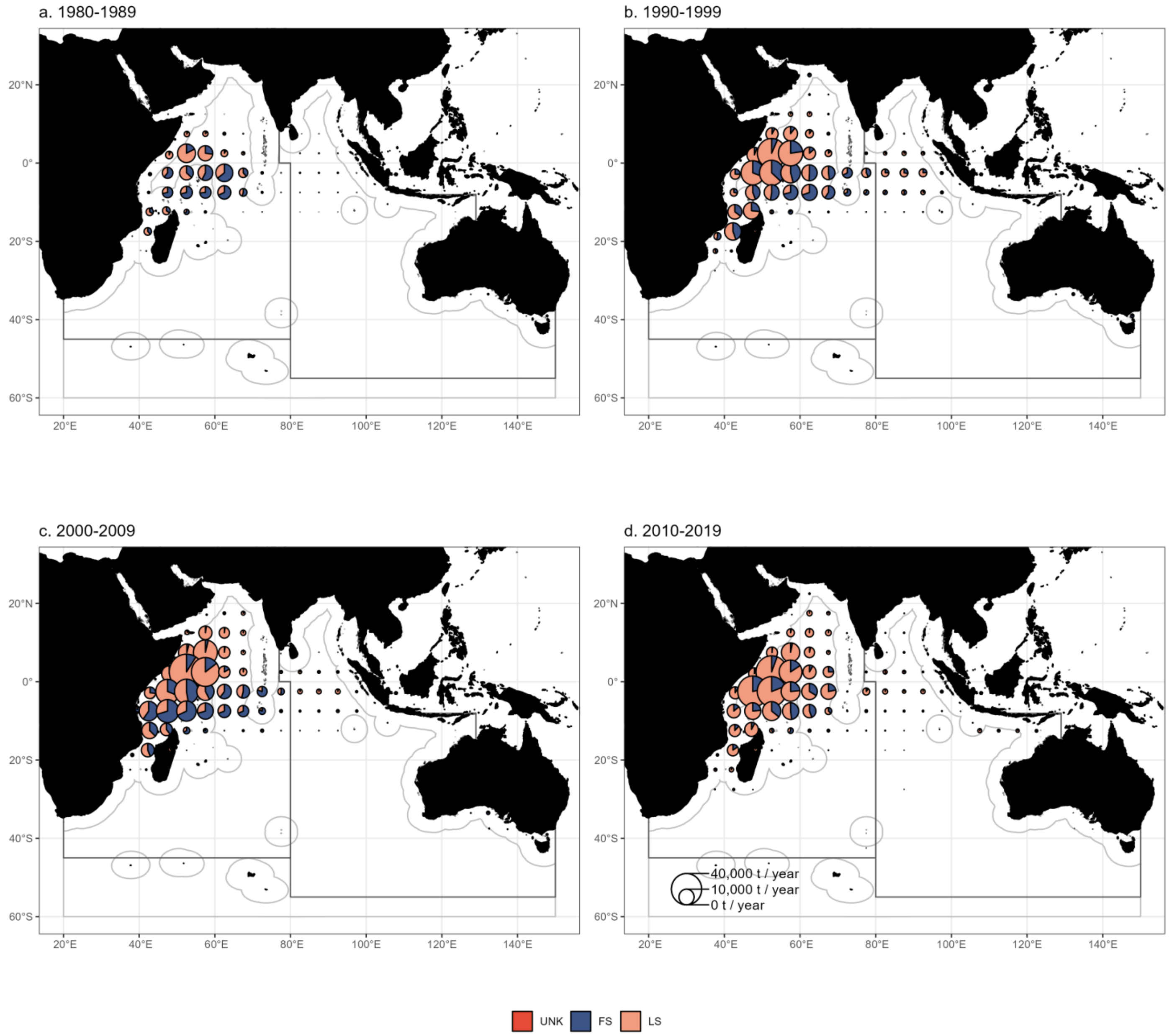

Figure 7: Mean annual time-area purse seine catches (metric tons; t) of tropical tunas for the period 1980-2019 by decade and type of school association. LS = floating object-associated school; FS = free-swimming school; UNK = unknown. Source: raised IOTC geo-referenced catches

Seasonal patterns, 2017-2021

The spatial distribution of the purse seine catches does not show a marked seasonal variability over recent years, with the mean annual distribution of the catches per quarter between 2017 and 2021 indicating a major concentration of the purse seine fishing grounds around the Seychelles archipelago all year long (**Fig. 8**). During January-March catches appear on average to be more stretched along the equator, with some fishing also occurring in the Mozambique Channel down to 25°S (**Fig. 8a**). During April-June, the fishery extends towards the north of the western Indian Ocean up to 20°N (**Fig. 8b**). In July-September catches are more concentrated in the core fishing grounds around the equator, before the purse seine fleet moves north of the equator, outside Somalia EEZ, to almost exclusively fish on FADs between October and December (**Fig. 8c-d**).

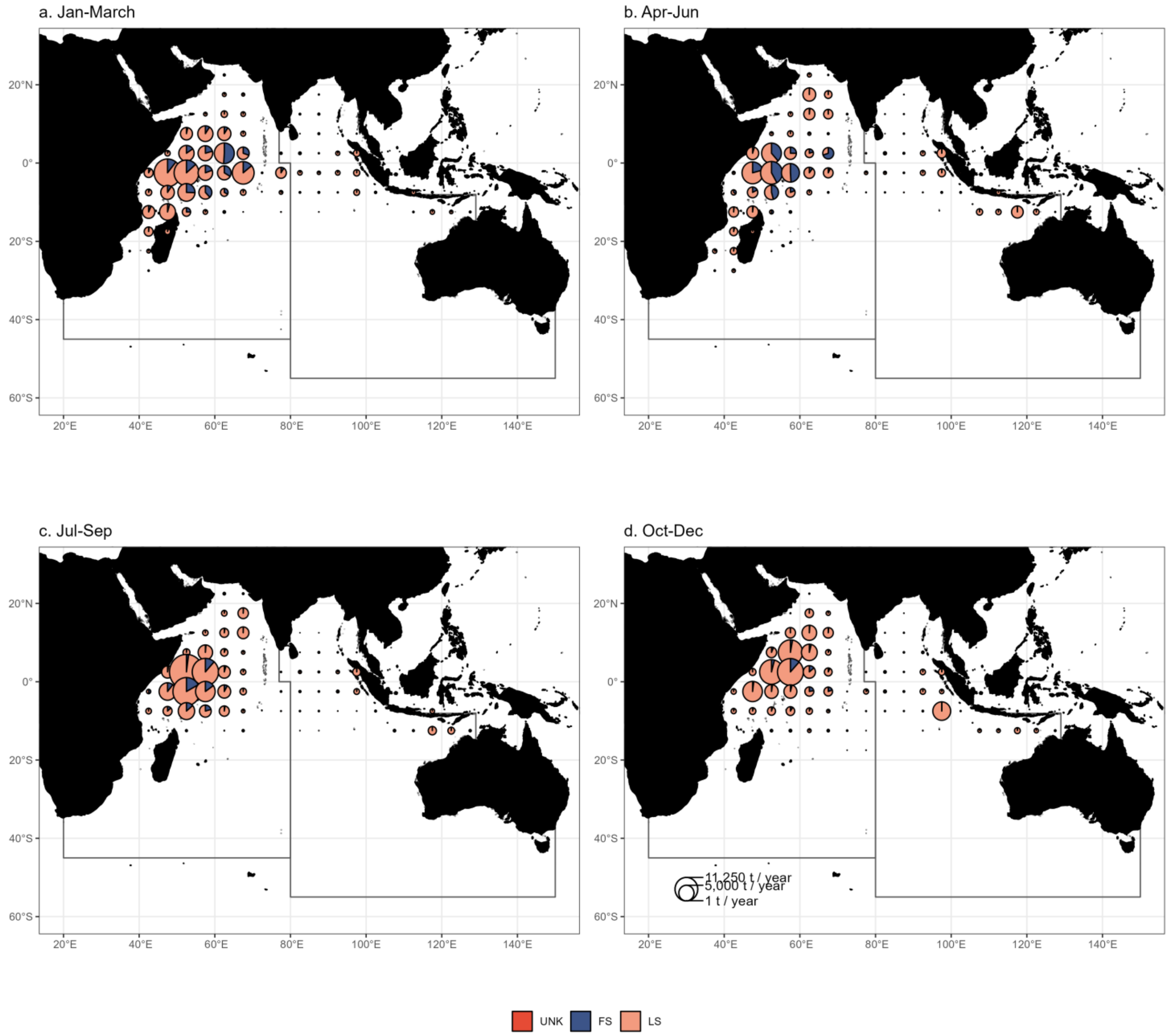

Figure 8: Mean annual time-area purse seine catches (metric tons; t) of tropical tunas for the period 2017-2021 by quarter and type of school association. LS = floating object-associated school; FS = free-swimming school; UNK = unknown. Source: raised IOTC geo-referenced catches

Composition of the catch

Species composition

Purse seine catches on schools associated with drifting FOBs are dominated by skipjack tuna, followed by yellowfin tuna and with bigeye tuna representing a small component of the catch, as the species is not specifically targeted by the large-scale purse seine fishery. After an initial period of increase, catches of skipjack on FOB-associated schools reached annual catch levels of around 175,000 t during 1999-2006, before showing a decrease to around 124,000 t between 2007 and 2015 (**Fig. 9a**). From 2016 onward, catches of skipjack showed a sharp increase, reaching a maximum of 301,000 t in 2018 and an average annual catch of 269,000 t during the period 2018-2021. Purse seine catches of yellowfin tuna on associated schools also showed an increase between the late 1970s and the mid-1990s, reaching a level of around 70,000 t between 1996 and 2006. Since 2008, catches have shown an increasing trend from 42,000 t to around 93,000 t in 2021 (**Fig. 9a**). Catches of bigeye tuna remained fairly constant over the last two decades at around 20,000 t, except for an abnormal high value in 2018 which was due to the reporting of around 25,000 t of bigeye tuna by EU,Spain in that year, before being re-estimated to a much lower 11,000 t by the IOTC Secretariat in agreement with (IOTC 2019).

The contribution of skipjack tuna to total catches of tropical tuna also shows large inter-annual fluctuations over the last decades. Following an initial period of exploration and fishery development until 1984, the percentage of skipjack tuna in the total purse seine FOB-school catches has varied between a minimum of 49% in 2013 and a maximum of 73% in 1991 (**Fig. 9b**). In recent years (2017-2021), skipjack tuna contributed to around 67% of the total purse seine catches on associated schools. Since 2000, the proportion of yellowfin tuna in the FOB-associated catches has varied between a minimum of 20% to a maximum of 42% in 2012-2013, with a mean value of 26.9% in recent years (**Fig. 9b**).

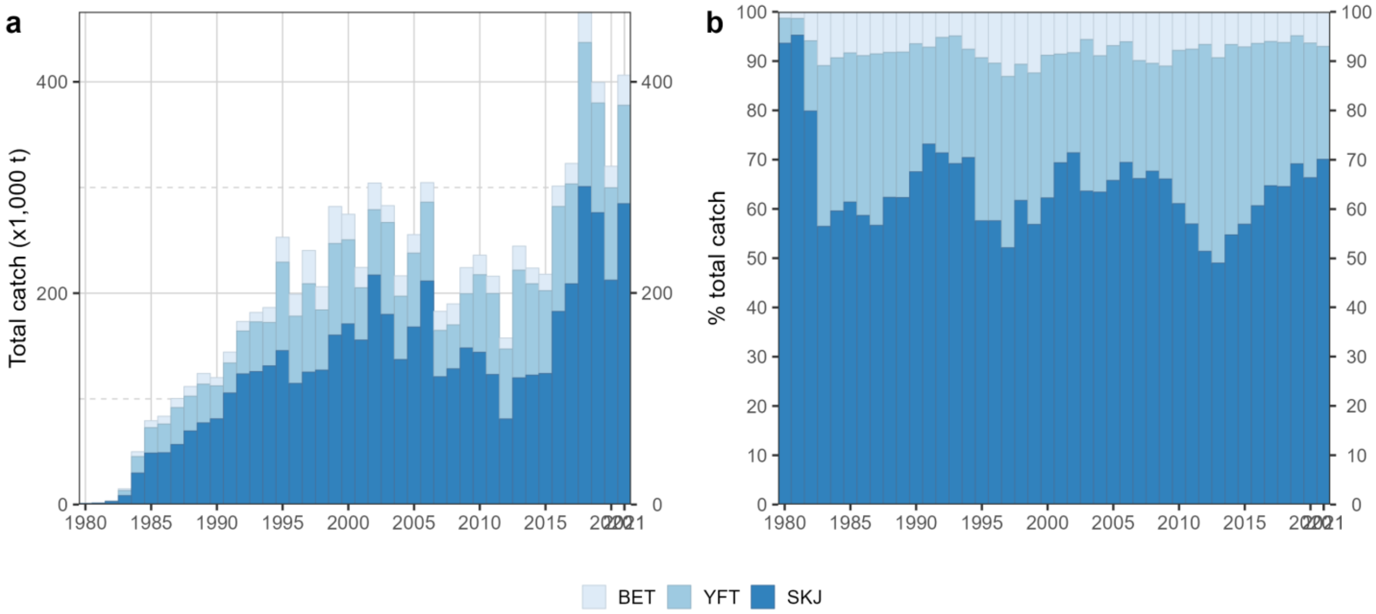

Figure 9: Annual time series of cumulative nominal absolute (a) and relative (b) purse seine catches (metric tons; t) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) caught in schools associated with drifting floating objects in the Indian Ocean for the period 1980-2021. Source: raised IOTC geo-referenced catches

Size structure

The very large majority of the tropical tunas caught in association with drifting FOBs are fish smaller than 60 cm fork length (FL), i.e., juveniles in the case of yellowfin and bigeye tuna (**Fig. 10**). While some yellowfin tuna larger than 90 cm in FL are reported in the catches, adult bigeye tunas almost never occur in association with FOBs at the surface of the Indian ocean. When considering only individuals of less than 90 cm FL, the three species show a very similar size range with most fish caught between 45 and 55 cm, and skipjack showing a median fork length (44.5 cm) smaller than bigeye tuna (49 cm) and yellowfin tuna (51 cm). The distributions of fork length measurements for the three species over the last two decades show some inter-annual variability in the catch composition with no clear trend in the time series of the fork length median values (**Fig. 10**).

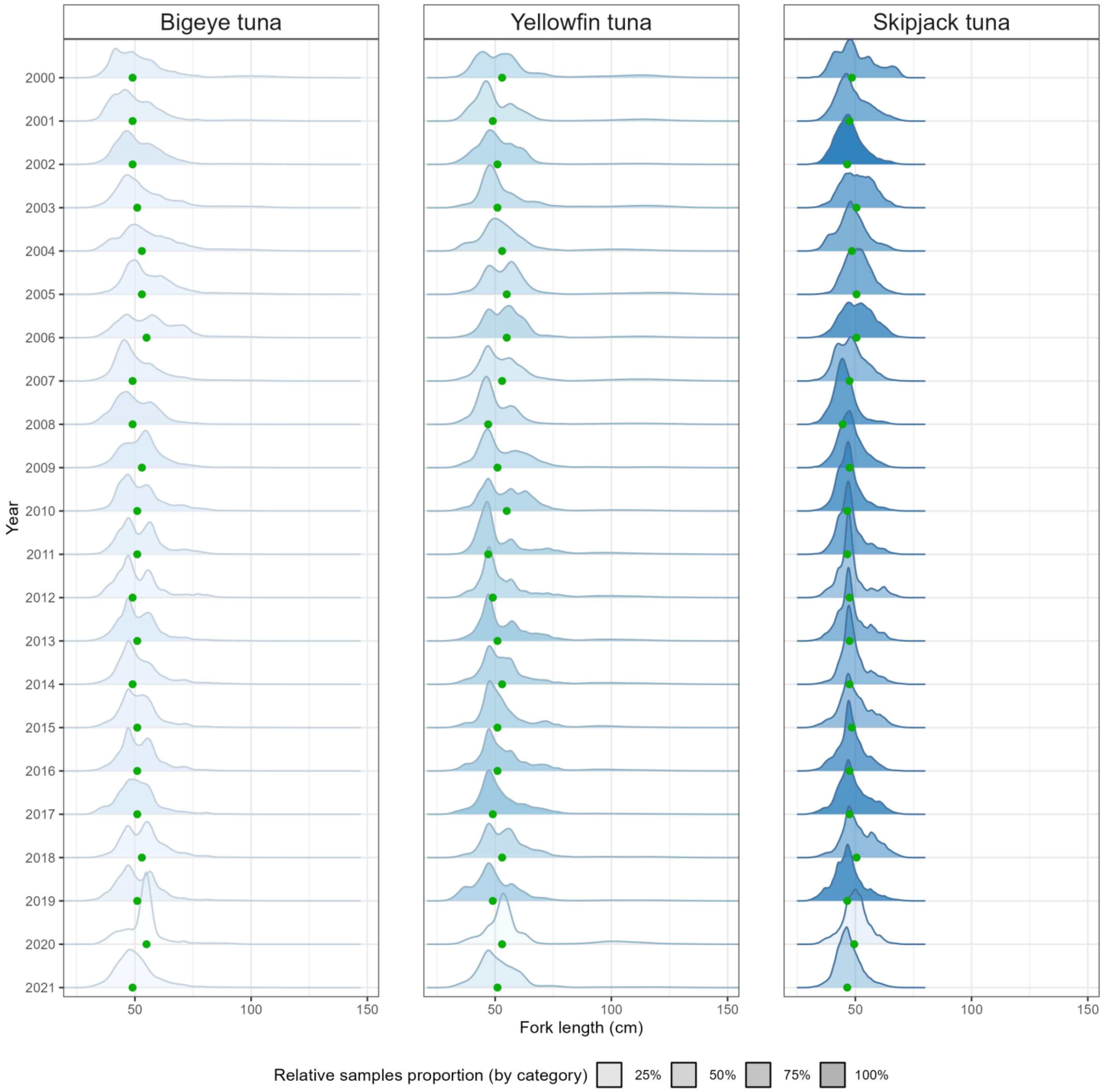

Figure 10: Annual size (fork length; cm) frequency distributions of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) caught in schools associated with drifting floating objects in the Indian Ocean for the period 2000-2021. Green dots indicate the median value. Source: raised IOTC geo-referenced catches

The average weight of the three tropical tunas caught in association with drifting FOBs has decreased over the last four decades. Information on size data in the purse seine fishery was sparse and incomplete prior to the 1990s, so the values of average weights estimated during the 1980s should be considered with care (Pianet 1999). Despite some major inter-annual variability, the estimated weights of both yellowfin and bigeye tuna show a decreasing trend between the 1990s and the late 2010s with a significant correlation between the two time series (**Fig. 11**). Bigeye tuna caught on associated schools in the early 1990s were described by an average weight of around 4.94 kg while their average weight was estimated to be around 3.77 kg in recent years (2017-2021). Yellowfin tuna shows the most marked decline with an average weight having decreased from about 8.21 kg during the period 1984-1995 to around 5.56 kg between 1996 and 2007, and 4.79 kg since 2008. In 2021, the average weight of yellowfin tuna in purse seine catches on drifting FOBs was estimated to be 4.75 kg (**Fig. 11**).

The estimated average weight of skipjack tuna in the purse seine catches on FOBs shows a more complex pattern, with an initial decrease from around 3.33 kg in the late 1980s-early 1990s to about 3.02 kg in the 2000s before reaching very small values between 2008 and 2011 (2.21-2.61 kg). Since then, the estimated average weight of skipjack has increased to a mean value of 2.86 kg between 2017 and 2021 (**Fig. 11**).

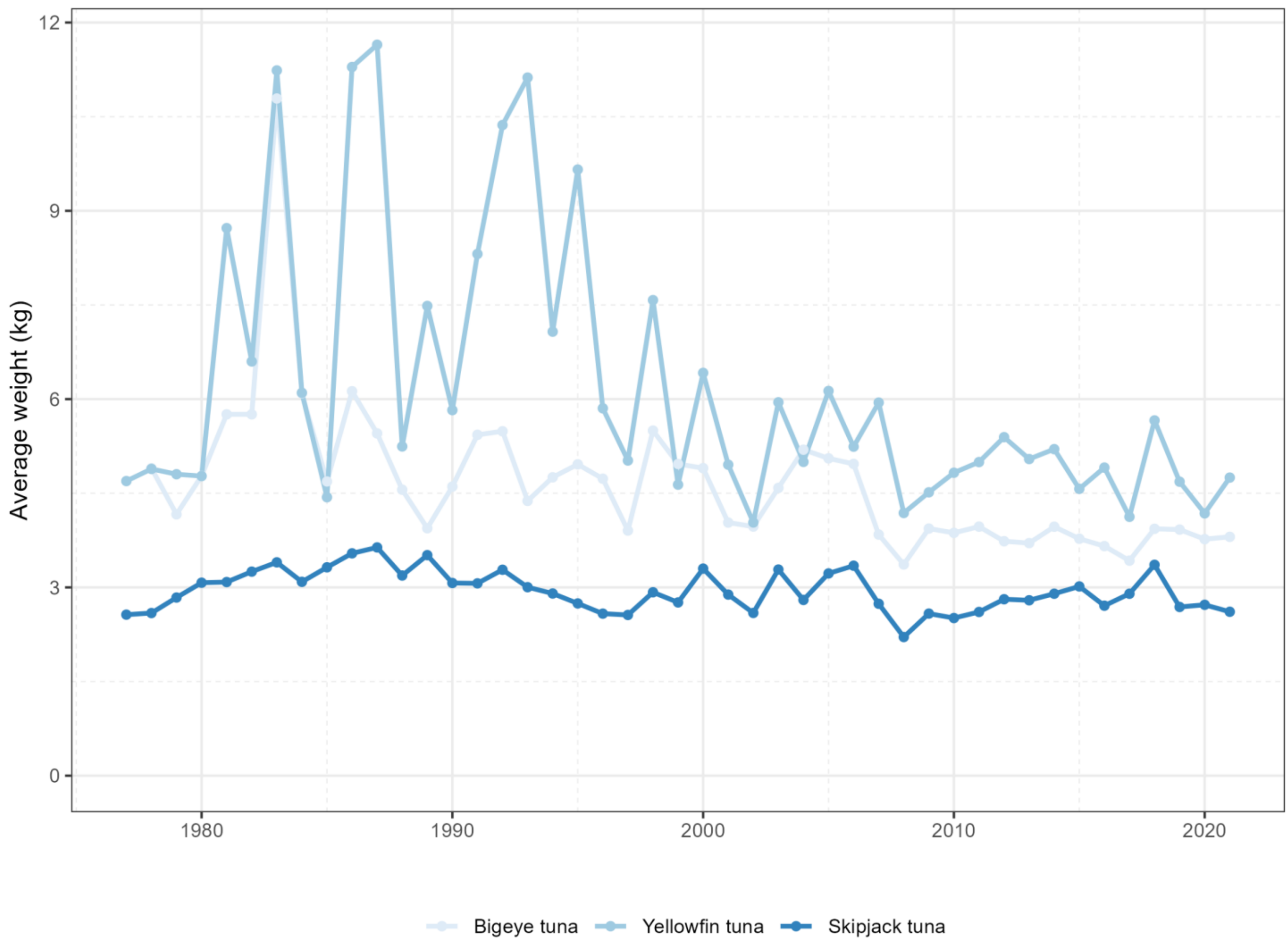

Figure 11: Annual time series of the mean annual weight (kg) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) in the catch of purse seine on schools associated with drifting floating objects in the Indian Ocean for the period 1977-2021. Source: raised IOTC geo-referenced catches

The recent distribution of average weights in the FOB-associated tuna catches from the purse seine fishery shows strong spatial patterns across the Indian Ocean. Overall, tropical tunas caught in coastal waters at the periphery of the distribution areas and in the eastern part of the Indian Ocean between 2017 and 2021 appeared to be generally smaller than their counterparts taken in deeper waters of the western Indian Ocean (**Fig. 12**). Bigeye tuna and skipjack tuna showed overall similar spatial patterns between 2017 and 2021. In fact, the grids described by the highest average weights were found in the regions located at the southeast and east of the Seychelles archipelago and around the Chagos archipelago for both species (**Fig. 12a-b**). The highest weights (>4 kg) of yellowfin tuna in the recent FOB-associated catches were located in the western Indian Ocean, while average weights of less than 2-3 kg were estimated along the coasts of Indonesia, off the coasts of Sri Lanka, and in the Arabian Sea. It is to note that few size data have been reported by the industrial purse seine fisheries of Indonesia, Sri Lanka, and I.R. Iran, resulting in some large uncertainties on the tuna weights estimated in their fishing grounds.

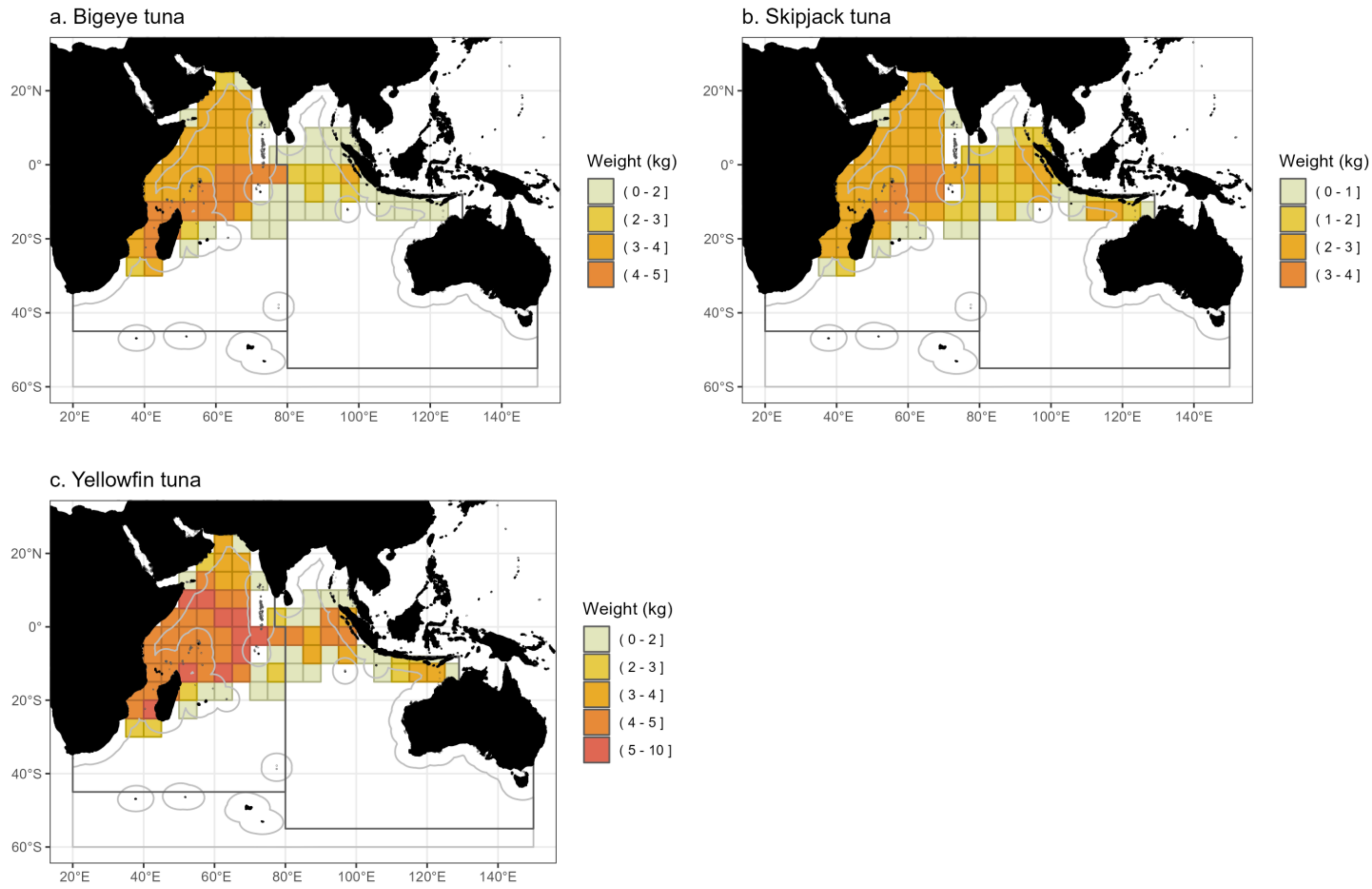

Figure 12: Estimates of average weight per fish (kg) of the three principal market tropical tunas (bigeye tuna, skipjack tuna, and yellowfin tuna) in the catch of purse seine on schools associated with drifting floating objects in the Indian Ocean for the period 2017-2021.

Analysis of FOB-related data

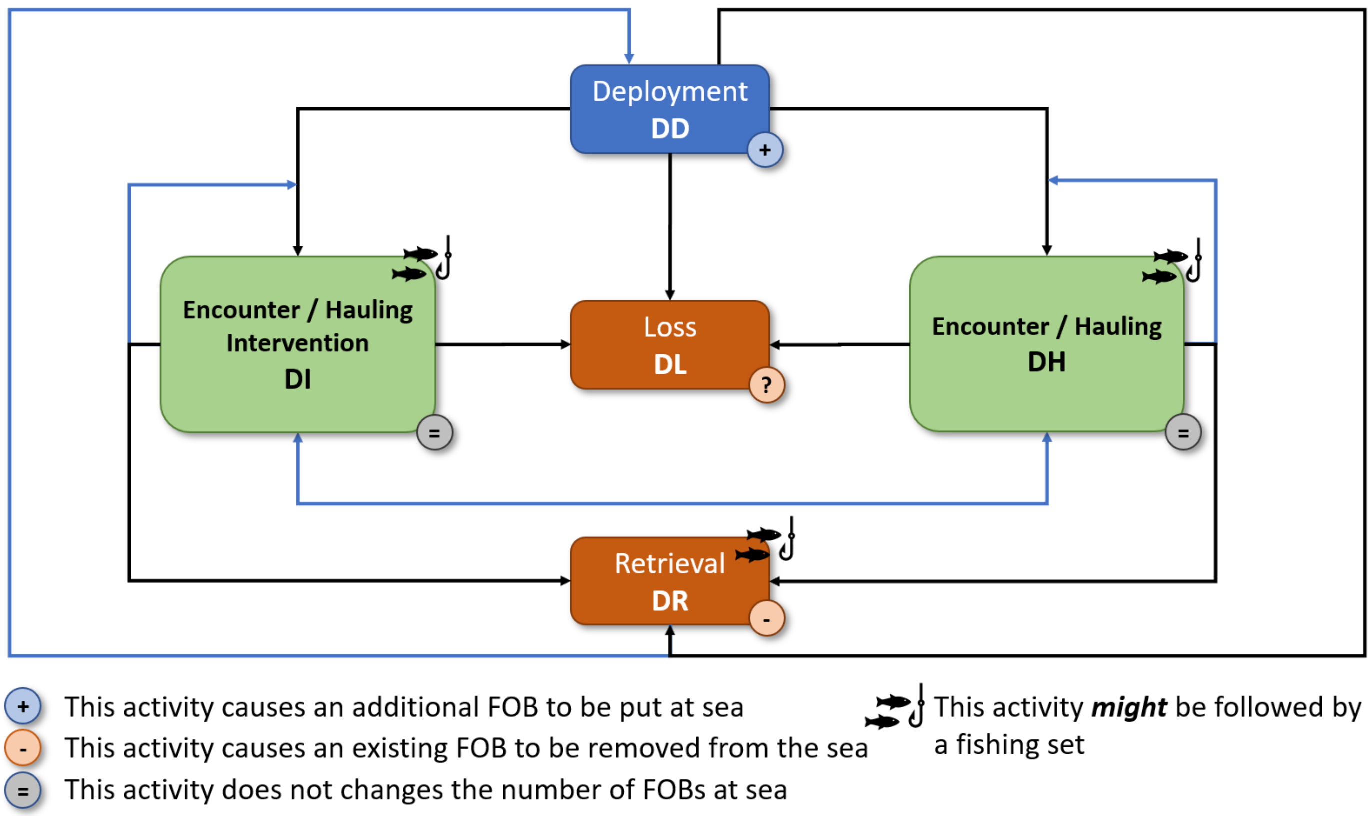

Figure 13: Classification of types of FOB activities in use at the IOTC Secretariat and their state-transition diagram. See Appendix II for description of each code

At-sea deployments

Tables 1-6 summarize the information available for all concerned CPCs across the years for which data were submitted to the IOTC Secretariat via IOTC form 3FA and IOTC form 3FD.

The meaning of each column in these tables is as follows:

- **FLAG**: the flag of the fleet that reported the information;
- **YEAR**: the statistical year;
- **FD**: the number of FOBs (of whatever nature) deployed in the year by the reporting fleet, regardless of the type of vessel, derived from IOTC form 3FD (available only for 2018 and 2019, as per IOTC Res. 19/01);
- **FA**: the number of FOBs (of whatever nature) deployed in the year by the reporting fleet, regardless of the type of vessel, derived from IOTC form 3FA (records with activity type set to *DD*);
- **DIFF**: the arithmetic difference between **FD** and **FA**;
- **FD_PS**: the number of FOBs (of whatever nature) deployed in the year by purse seine vessels from the reporting fleet, derived from IOTC form 3FD (available only for 2018 and 2019, as per IOTC Res. 19/01);
- **FA_PS**: the number of FOBs (of whatever nature) deployed in the year by purse seine vessels from the reporting fleet, derived from IOTC form 3FA (records with activity type set to *DD*);
- **DIFF_PS**: the arithmetic difference between **FD_PS** and **FA_PS**;
- **FD_SU**: the number of FOBs (of whatever nature) deployed in the year by supply vessels from the reporting fleet, derived from IOTC form 3FD (available only for 2018 and 2019, as per IOTC Res. 19/01);

- **FA_SU**: the number of FOBs (of whatever nature) deployed in the year by supply vessels from the reporting fleet, derived from IOTC form 3FA (records with activity type set to *DD*);
- **DIFF_SU**: the arithmetic difference between **FD_SU** and **FA_SU**.

FD cells for years other than 2018 and 2019 should always be blank, as there was no requirement to report this data outside those two years. Grayed-out cells correspond to strata for which there is no information available.

For each stratum, the following identities are always valid:

- **FD** = **FD_PS** + **FD_SU**
- **FA** = **FA_PS** + **FA_SU**

Summary by fleet

EU,Spain

Table 1: Summary of total number of FOBs deployed by the Spanish component of the European Union purse seine fleet, as reported through IOTC form 3FD and IOTC form 3FA for the period 2015-2021

FLAG	YEAR	FD	FA	DIFF	FD_PS	FA_PS	DIFF_PS	FD_SU	FA_SU	DIFF_SU
EU,ESP	2015		17,176			17,176				
EU,ESP	2016		19,058			19,058				
EU,ESP	2017		10,749			10,749				
EU,ESP	2018	10,181	10,167	14	5,979	10,167	-4,188	4,202		
EU,ESP	2019	8,176	8,365	-189	4,845	8,365	-3,520	3,331		
EU,ESP	2020		7,902			7,902				
EU,ESP	2021		8,910			3,503			5,407	

Data on deployments by Spanish-flagged vessels of the European Union fleet are in relatively good agreement overall between IOTC form 3FD and IOTC form 3FA (see the *DIFF* column in **Table 1**). When considering the breakdown of all deployments by vessel type, though, it is evident how the deployment data reported through IOTC form 3FA are erroneously accounted for exclusively by purse seine vessels (see the *FA_PS* column in **Table 1**), while the data from IOTC form 3FD indicates an almost even split between FOBs deployed by purse seines and supply vessels in 2018 and 2019 (see the *FD_PS* and *FD_SU* columns in **Table 1**). Regardless of the vessel type, the deployments of FOBs show a negative trend from 2016 onward, after reaching a peak of about 19,000 FOBs deployed by the Spanish fleet during that year. Data extracted from form 3FA for 2021 indicate that most FOBs deployed by EU,Spain during the year were managed by their supply vessels.

EU,France

Table 2: Summary of total number of FOBs deployed by the French component of the European Union purse seine fleet, as reported through IOTC form 3FD and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	FD	FA	DIFF	FD_PS	FA_PS	DIFF_PS	FD_SU	FA_SU	DIFF_SU
EU,FRA	2013		827			827				
EU,FRA	2014		914			914				
EU,FRA	2015		1,531			1,531				
EU,FRA	2016		2,260			2,260				
EU,FRA	2017		3,627			3,627				
EU,FRA	2018	4,464	4,202	262	3,296	4,202	-906	1,168		
EU,FRA	2019	3,404	3,352	52	2,433	3,352	-919	971		
EU,FRA	2020		3,946			3,946				
EU,FRA	2021		4,281			4,281				

Data on deployments by French-flagged vessels from the European Union fleet are in reasonable agreement between IOTC forms 3FD and 3FA, and in particular for the year 2019. Unfortunately, deployments reported through form 3FA were only associated to purse seine vessels, with no information provided on deployments from supply vessels which were instead available through form 3FD. The annual number of deployed FOBs according to IOTC form 3FA increased from 827 in 2013 to 4,281 in 2021.

Japan

Table 3: Summary of total number of FOBs deployed by the Japanese purse seine fleet, as reported through IOTC form 3FD and IOTC form 3FA for the period 2013-2020. Japan did not report purse seine fisheries activities in Indian Ocean in 2021 to the IOTC Secretariat

FLAG	YEAR	FD	FA	DIFF	FD_PS	FA_PS	DIFF_PS	FD_SU	FA_SU	DIFF_SU
JPN	2013		93			93				
JPN	2014		183			183				
JPN	2015		227			227				
JPN	2016		224			224				
JPN	2017		251			251				
JPN	2018	331	299	32	301	299	2	30		
JPN	2019	119	69	50	69	69	0	50		
JPN	2020		33			33				

Deployment data for the Japanese fleet are available from both IOTC forms 3FA and 3FD, and show an almost perfect agreement when considering deployments from purse seine vessels only (see the *DIFF_PS* column in **Table 3**). The trends in deployed FOBs derived from either IOTC form 3FD or IOTC form 3FA are in agreement with the evolution of the Japanese purse seine fleet which has been dramatically reducing operations in the Indian Ocean in recent years and not been active in 2021.

Republic of Korea

Table 4: Summary of total number of FOBs deployed by the Korean purse seine fleet, as reported through IOTC form 3FD and IOTC form 3FA for the period 2014-2021

FLAG	YEAR	FD	FA	DIFF	FD_PS	FA_PS	DIFF_PS	FD_SU	FA_SU	DIFF_SU
KOR	2014		1,618			1,618				
KOR	2015		1,940			1,940				
KOR	2016		1,749			1,749				
KOR	2017		1,445			1,445				
KOR	2018		489			489				
KOR	2019		412			412				
KOR	2020		399			399				
KOR	2021		1,861			1,861				

FOBs deployment data for the Korean fleet are exclusively available through IOTC form 3FA and therefore it is not possible to substantiate their accuracy with the help of data from IOTC form 3FD. In any case, the total annual number of FOBs deployed shows a trend similar to what already observed for EU,Spain, decreasing systematically from a peak level of 1,940 FOBs in 2015 to a minimum of 399 FOBs in 2020 (**Table 4**). In 2021, the number of FOBs deployed increased to reach the levels observed during the period 2014-2016, with a total of 1,861 FOBs deployed during that year.

Mauritius

Table 5: Summary of total number of FOBs deployed by the Mauritian purse seine fleet, as reported through IOTC form 3FD and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	FD	FA	DIFF	FD_PS	FA_PS	DIFF_PS	FD_SU	FA_SU	DIFF_SU
MUS	2013									
MUS	2015		106			106				
MUS	2016		1			1				
MUS	2017		929			346			583	
MUS	2018	600	718	-118	141	141	0	459	577	-118
MUS	2019	893	848	45	252	199	53	641	649	-8
MUS	2020		408			273			135	
MUS	2021		824			7			817	

The annual numbers of deployments appear to be under-estimated in some years for the Mauritian purse seiners that were in operation between 2013 and 2021, suggesting that the information has not been consistently reported in the logbooks and/or not well managed and reported to the Secretariat. Since 2017, Mauritius has submitted FOB deployments broken down between purse seiners and their supply vessels. The information on FOBs deployed by

Mauritius as provided through IOTC form 3FA shows a generally decreasing trend from a peak of 929 FOBs deployed in 2017 to 408 deployed in 2020, but rose again to 824 in 2021. Whilst deployment from purse seine fishing vessels decreased, deployment by supply vessels increased, whereby over 90% of the FOBs deployed in 2021 was from supply vessels. The comparison of data from IOTC forms 3FA and 3FD for the years 2018 and 2019 shows a perfect agreement in deployments reported by purse seine vessels in 2018, with a mild under-reporting in 2019 (evidence of 53 more FOBs deployed by Mauritian purse seiners in IOTC form 3FD, see the *DIFF_PS* column in **Table 5**). The situation is inverted when considering deployments from supply vessels, in which case, there is a slight over-reporting for 2019 and a more marked over-reporting for 2018 (see the *DIFF_SU* column in **Table 5**).

Additionally, Mauritius reported a single record corresponding to a FOB deployment event through IOTC form 3FA in 2013, but this record actually indicated zero FOBs being deployed (therefore explaining the blank row for 2013 in **Table 5**), and furthermore was followed by a non-NIL value of the number of sets on FOBs: this suggests a potential issue with the provision (through IOTC form 3FA) of both the number of FOBs and the number of sets on FOB for the year and flag concerned.

Seychelles

Table 6: Summary of total number of FOBs deployed by the Seychellois purse seine fleet, as reported through IOTC form 3FD and IOTC form 3FA for the period 2013-2019

FLAG	YEAR	FD	FA	DIFF	FD_PS	FA_PS	DIFF_PS	FD_SU	FA_SU	DIFF_SU
SYC	2013		1,354						1,354	
SYC	2014		4,103						4,103	
SYC	2015									
SYC	2016									
SYC	2017									
SYC	2018									
SYC	2019	1,465						1,465		

Information on FOB deployments for Seychelles is sparse and often inaccurate (**Table 6**). Data from IOTC form 3FA are available for the years between 2013 and 2021, but for 2015, 2016, 2017, 2019, 2020 and 2021 all the records related to FOB deployment activities (*DD*) explicitly indicate zero deployed FOBs. Similarly to what detected for Mauritius, this situation might indicate a potential issue with the provision (through IOTC form 3FA) of the number of FOBs and the number of sets on FOB for the years and flag concerned.

Furthermore, data from IOTC form 3FD for Seychelles are only available for 2019, and indicate all FOBs as exclusively being deployed by Seychellois supply vessels, with no explicit deployment attributed to purse seiners.

Forms 3FA for the years 2020 and 2021, while available, only include 'DH' activities and therefore cannot provide any information on deployments of FOBs by Seychelles-flagged purse seiners or supply vessels for the years concerned.

Geo-referenced annual FOB deployments

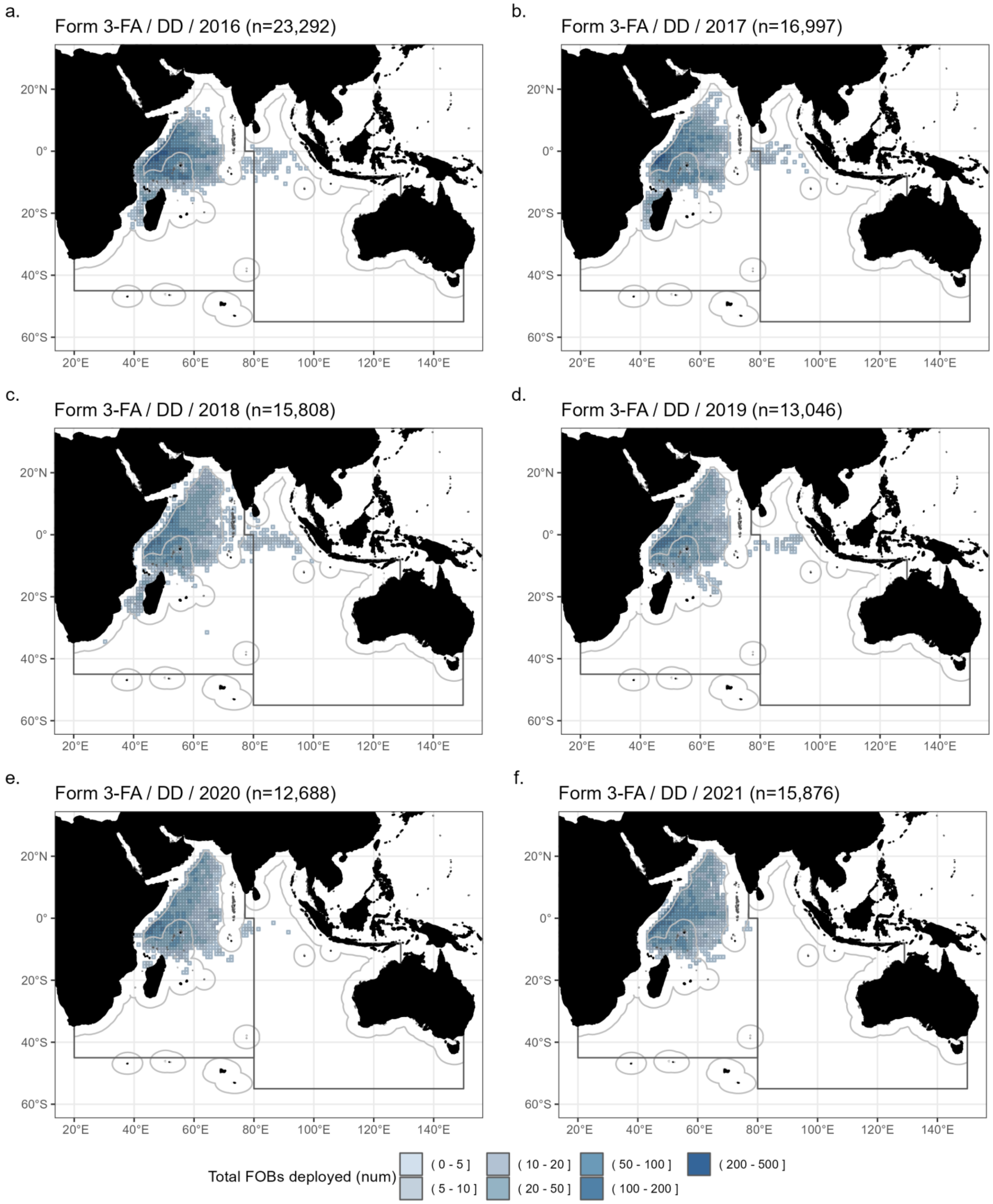

Figure 14: Total number of FOBs deployed by year and grid, as reported through IOTC form 3FA (activity type = DD) for all fleets and FOB types, for the period 2016-2021. Source: [IOTC collated FOB activity data]

Geo-referenced quarterly FOB deployments

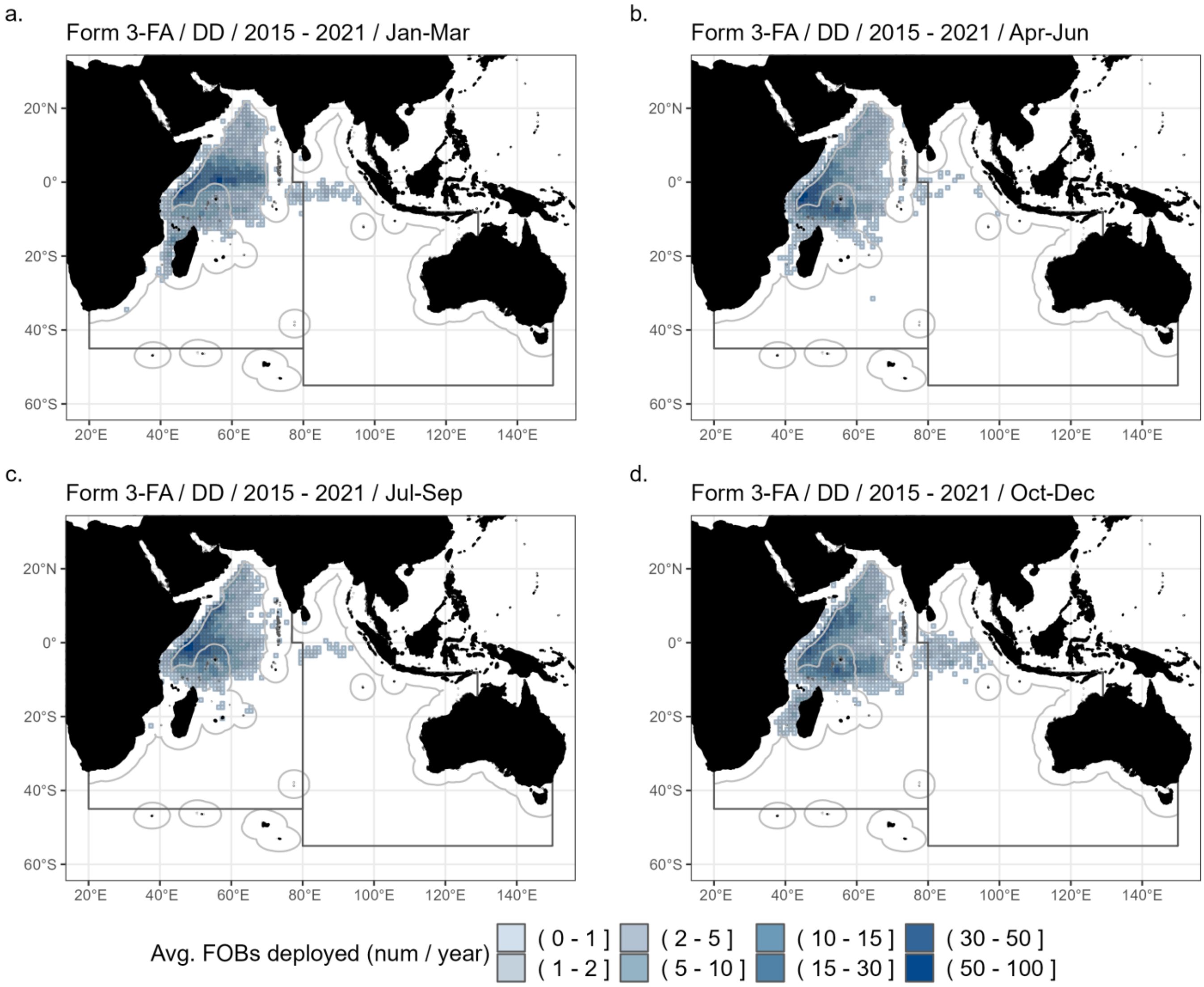

Figure 15: Average annual number of FOBs deployed by quarter, as reported through IOTC form 3FA (activity type = DD) for all fleets and FOB types, for the period 2015-2021. Source: IOTC collated FOB activity data

Aggregated quarterly FOB deployments data from IOTC form 3FA (2015-2021) show how deployments in the Southwest Indian Ocean / Mozambique Channel are apparently more frequent during the first and fourth quarters of the year (**Fig. 15.a** and **15.d**), with less deployments reported on average in the area during the second quarter (**Fig. 15.b**) and close to zero during the third quarter (**Fig. 15.c**).

Geo-referenced annual FOB deployments for 2018 and 2019

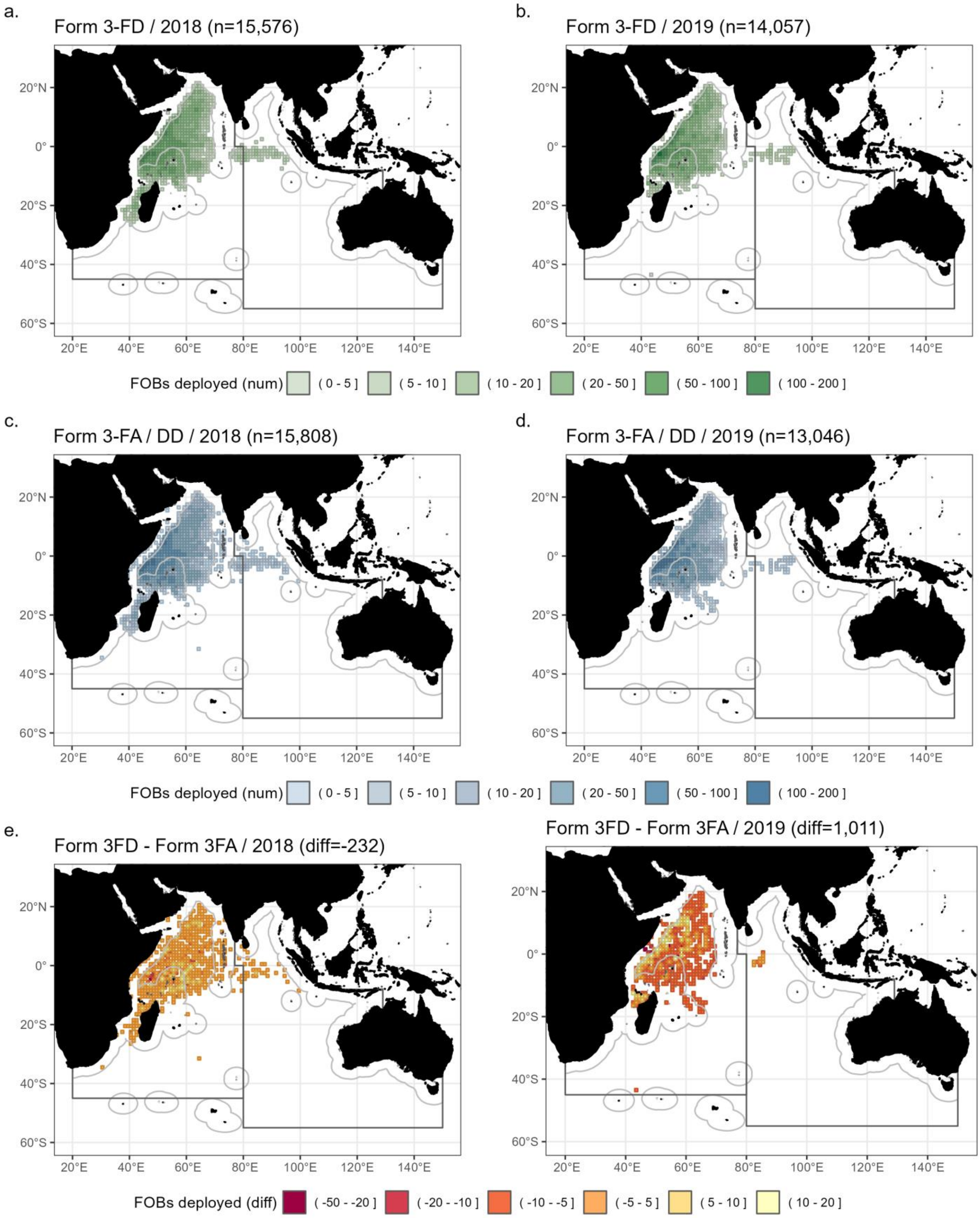

Figure 16: Comparison of annual number of FOBs deployed, as reported through IOTC form 3FD and IOTC form 3FA (activity type = DD) for all fleets and FOB types, for the years 2018 (a, c, e) and 2019 (b, d, f). Source: IOTC FAD deployment data (2018-2019) and IOTC collated FOB activity data

A comparison between the information (total number of FOBs deployed by year and grid) as reported through IOTC form 3FD and IOTC form 3FA for the years concerned shows relatively good agreement in terms of spatial distribution between the two data sets, with minor differences in the areas covered evident only in the Eastern Indian Ocean in 2018 (see **Fig. 16.a** and **Fig. 16.c**).

Overall, data received through IOTC form 3FA (records with activity type set to *DD*) appear to under-report the total number of FOBs deployed in comparison to the same data provided through form 3FD, with a total of around 3,500 more FOBs reported as deployed by the latter source in each of the two years considered.

The reasons for these differences are manifold, and include (but might not be limited to):

a) non-reporting of IOTC form 3FD for the years considered (SYC 2018, KOR 2018 and 2019);

b) non-reporting of FOB deployment activities (*DD*) through IOTC form 3FA for the years considered (JPN 2018, SYC 2018 and 2019);

c) errors in the interpretation of the reporting requirements of IOTC form 3FA, with the number of FOBs deployed potentially reported in place of the number of positive sets on FOBs (SYC 2019 to 2021) or data only reported for purse seine vessels (EU,FRA 2018 to 2021).

In light of the considerations above, great caution should be exercised when analysing FOB deployment data provided to the IOTC Secretariat through IOTC form 3FA: the quality of this information appears to be higher when provided through IOTC form 3FD, although severely limited by the temporal coverage and resolution of the data set (annual, limited to 2018 and 2019 only and lacking any information on the type of FOB deployed).

Sets on FOBs

Tables from **Table 7** to **12** summarize the information available for all concerned CPCs across the years for which data was submitted to the IOTC Secretariat via IOTC form 3CE and IOTC form 3FA.

The meaning of each column in these tables is as follows:

- **FLAG**: the flag of the fleet that reported the information;
- **YEAR**: the statistical year;
- **EF_LS**: the number of sets on FOBs (of whatever nature) recorded in the year by the reporting fleet, as derived from IOTC form 3CE;
- **FA**: the number of sets on FOBs (of whatever nature) recorded in the year by the reporting fleet, derived from IOTC form 3FA (records with *NUM_SETS_ON_FOB* greater than zero);
- **DIFF**: the arithmetic difference between **EF_LS** and **FA**;

Grayed-out cells correspond to strata for which there is no information available.

Summary by fleet

EU,Spain

Table 7: Summary of total number of FOB sets recorded by the Spanish component of the European Union purse seine fleet, as reported through IOTC form 3CE and IOTC form 3FA for the period 2015-2021

FLAG	YEAR	EF_LS	FA	DIFF
EU,ESP	2015		2,829	
EU,ESP	2016		3,931	
EU,ESP	2017		3,085	
EU,ESP	2018		4,439	
EU,ESP	2019		4,051	
EU,ESP	2020		4,092	
EU,ESP	2021		3,287	

The Spanish component of the European Union purse seine fleet submitted two efforts information to the Secretariat, *fishing hours* and *number of sets* through IOTC form 3CE in 2021. The analysis shows comparable number of sets between 3FA and 3CE (**Table 7**). Nonetheless, prior to 2021, EU.Spain reported only fishing hours as effort in 3CE, with no alternative effort information. Nevertheless, information from the 3FA shows for years between 2016 and 2021 that the number of sets on FOBs remains stable at an average of about 3,700 sets per year, with a detected decrease of around 20% in 2021 compared to the previous year.

EU,France

Table 8: Summary of total number of FOB sets recorded by the French component of the European Union purse seine fleet, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	EF_LS	FA	DIFF
EU,FRA	2013		1,860	
EU,FRA	2014		1,657	
EU,FRA	2015		1,518	
EU,FRA	2016		2,009	
EU,FRA	2017		2,160	
EU,FRA	2018	2,463	2,463	0
EU,FRA	2019	1,918	1,918	0
EU,FRA	2020	1,898	1,898	0
EU,FRA	2021	2,012	2,012	0

Effort information as *number of sets* from the French component of the European Union purse seine fleet is available from 2013 onwards through IOTC form 3FA, and from 2018 onwards through IOTC form 3CE. When data on FOB sets are available from both sources (i.e., for the statistical years 2018-2021) these show a perfect agreement in the number of reported sets (see the *DIFF* column in **Table 8**).

The general trend in annual number of FOB sets as reported through IOTC form 3FA appears relatively stable, with limited fluctuations around the average of about 1,900 sets per year.

Japan

Table 9: Summary of total number of FOB sets recorded by the Japanese purse seine fleet, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2020

FLAG	YEAR	EF_LS	FA	DIFF
JPN	2013			
JPN	2014	44	44	0
JPN	2015	142	137	5
JPN	2016	139	124	15
JPN	2017	196	104	92
JPN	2018	146	137	9
JPN	2019	9	7	2
JPN	2020	34	32	2

The Japanese purse seine fleet operating in the Indian Ocean has been regularly providing effort information as number of sets from 2014 onward: when comparing data from IOTC form 3CE with the same data from IOTC form 3FA, the differences are minor (when not negligible) for several years - namely 2014-2015, 2018-2020 - and range between 0 and 9 sets of difference detected each year (see the *DIFF* column in **Table 9**). Conversely, data from IOTC form 3FA for 2016 and 2017 appear to underestimate the annual effort by as much as 50% of the total FOB sets reported by Japan through IOTC form 3CE for the same years.

The number of sets on FOBs reported since 2018 by Japan through both IOTC form 3CE and 3FA are in good agreement with each other as well as with the available information on the operations of the fleet in the Indian Ocean, which has greatly reduced compared to previous years.

Republic of Korea

Table 10: Summary of total number of FOB sets recorded by the Korean purse seine fleet, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	EF_LS	FA	DIFF
KOR	2013	704		
KOR	2014	538		
KOR	2015	731		
KOR	2016	935		
KOR	2017	521		
KOR	2018	415		
KOR	2019	451		
KOR	2020	529		
KOR	2021	484	477	7

The Korean purse seine fleet operating in the Indian Ocean has been regularly providing effort information as number of sets from 2013 onward. Besides 2021 3FA data from Korea, where complete FOBs information are provided, unfortunately, there is no corresponding effort information available for the fleet through IOTC form 3FA (**Table 10**), and therefore a comparative analysis of the two data sources could only be performed for 2021 data.

When considering effort information from IOTC form 3CE only, the number of annual sets on FOBs shows a stable trend from 2017 onward, with values fluctuating between 415 and 521 FOB sets per year, which follows an all-time peak (in the period considered) of 935 FOB sets reported by the fleet for the statistical year 2016. In 2021, the number of sets on FOBs reported through the form 3FA was slightly higher (+7 sets) than reported in the form 3CE (**Table 10**).

Mauritius

Table 11: Summary of total number of FOB sets recorded by the Mauritian purse seine fleet, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	EF_LS	FA	DIFF
MUS	2013		44	
MUS	2014	351		
MUS	2015	273	408	-135
MUS	2016	262	271	-9
MUS	2017	496	510	-14
MUS	2018	452	464	-12
MUS	2019	421	429	-8
MUS	2020	452	460	-8
MUS	2021	580	581	-1

Mauritius has been regularly reporting efforts from its purse seiner fleet as number of sets since 2014, with official data from IOTC form 3CE showing a relatively stable trend in total annual sets on FOBs, whose values fluctuate between 421 and 580 sets each year from 2017 onward (**Table 11**).

Data from IOTC form 3FA for the fleet are available for 2013 and from 2016 onward, and show constant levels across time. Effort information from both sources is consistent from 2016 to 2021, with slightly higher number of sets on FOBs reported through IOTC form 3FA (**Table 11**).

In addition to the number of sets of FOBs reported for purse seiners, Mauritius also reported positive sets from its supply vessels from 2019 to 2021. Those were removed from the present analysis.

Seychelles

Table 12: Summary of total number of FOB sets recorded by the Seychellois purse seine fleet, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	EF_LS	FA	DIFF
SYC	2013		1,534	
SYC	2015		2,186	
SYC	2016		3,264	
SYC	2017		2,981	
SYC	2018		2,784	
SYC	2019		2,878	
SYC	2020		3,265	
SYC	2021		3,006	

The Seychellois purse seine fleet has never provided effort information as number of sets through IOTC form 3CE. In fact, this information is only available through IOTC form 3FA (since 2013, with the exception of 2014) and shows a relatively stable trend at around 3,000 sets on FOBs per year since 2016, with limited fluctuations that do not seem to suggest a marked decrease in fishing operations from the fleet (**Table 12**).

Geo-referenced annual efforts

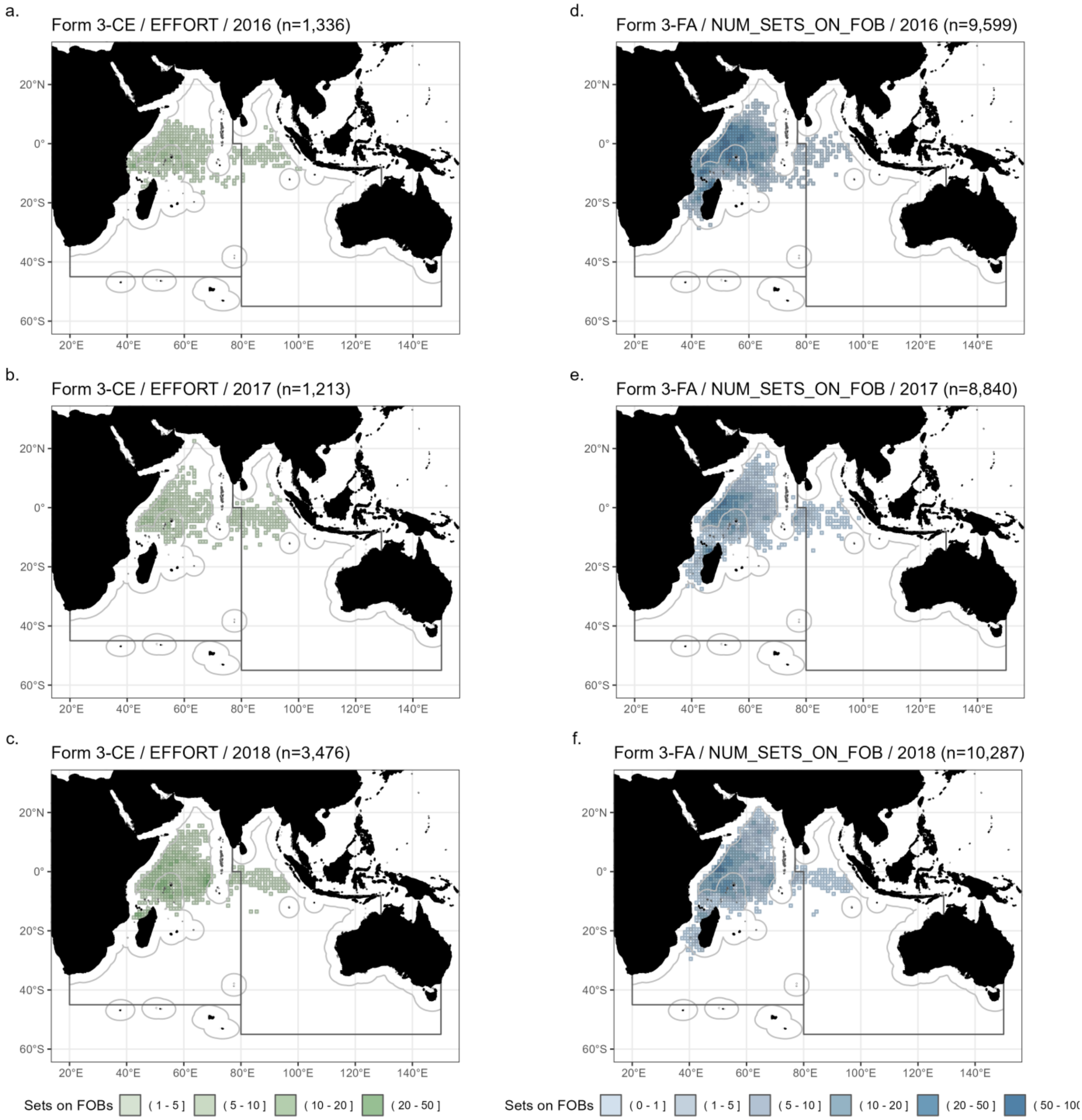

Figure 17: Comparison of total annual number of sets on FOBs for the years 2016-2018, as reported through IOTC form 3CE (a, c, e) and through IOTC form 3FA (b, d, f). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

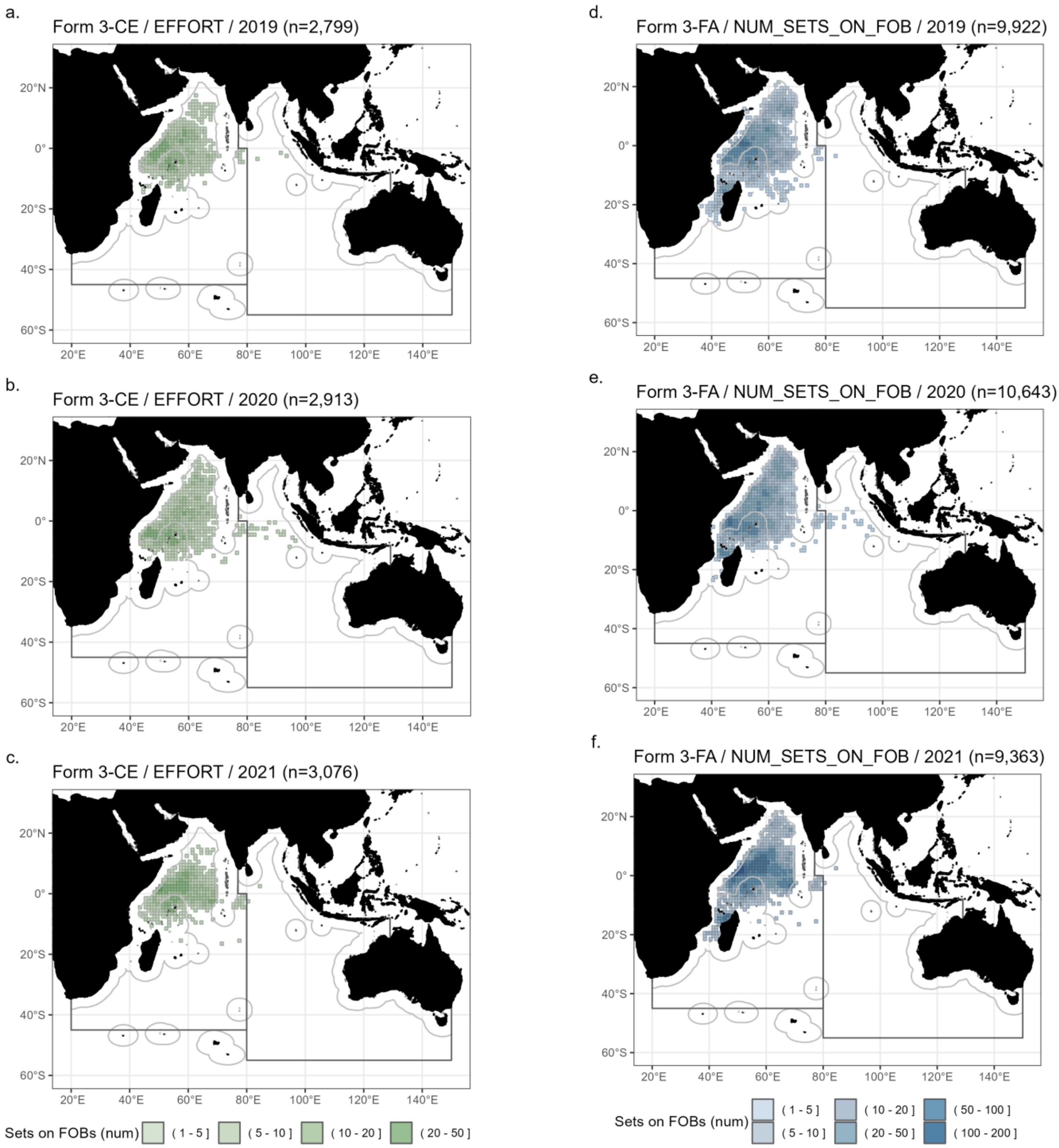

Figure 18: Comparison of total annual number of sets on FOBs for the years 2019-2021, as reported through IOTC form 3CE (a, c, e) and through IOTC form 3FA (b, d, f). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

Geo-referenced quarterly efforts

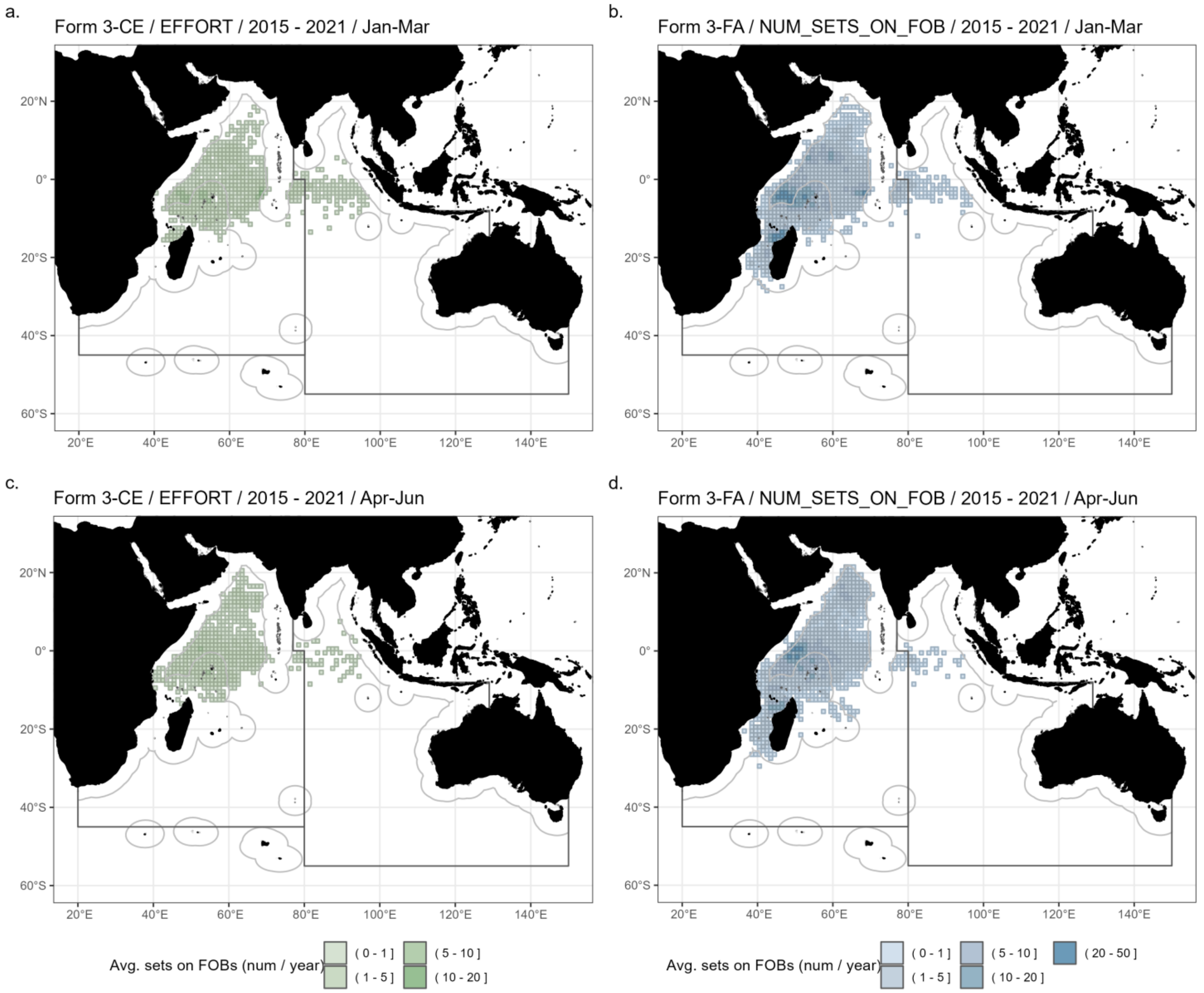

Figure 19: Comparison of average annual number of sets on FOBs for the 1st and 2nd quarter of the years 2015-2021, as reported through IOTC form 3CE (a, c) and through IOTC form 3FA (b, d). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

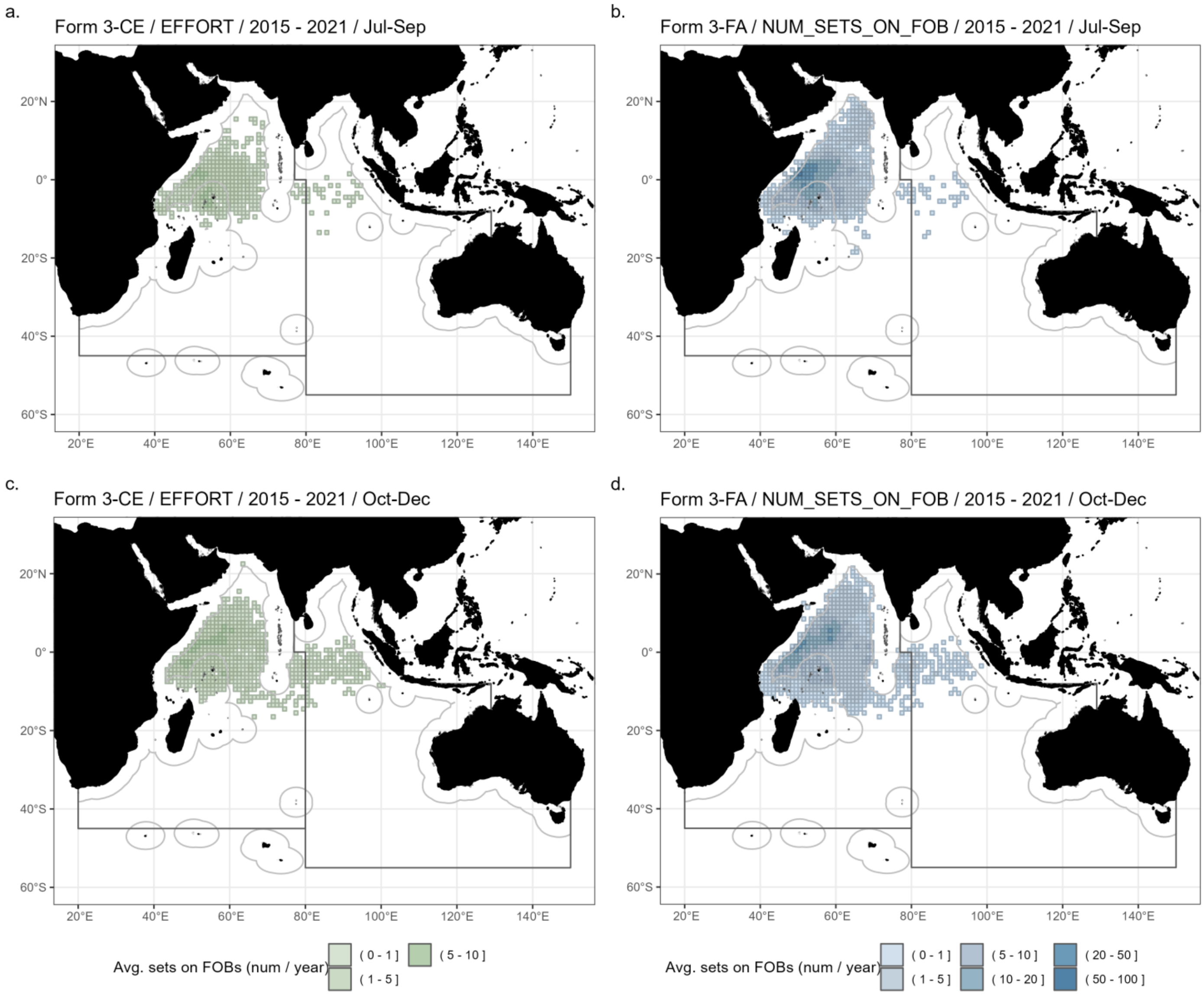

Figure 20: Comparison of average annual number of sets on FOBs for the 3rd and 4th quarter of the years 2015-2021, as reported through IOTC form 3CE (a, c) and through IOTC form 3FA (b, d). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

Catches on FOBs

Tables from **Table 13** to **18** summarize the information available for all concerned CPCs across the years for which geo-referenced catch data was submitted to the IOTC Secretariat via IOTC form 3CE and IOTC form 3FA.

The meaning of each column in these tables is as follows:

- **FLAG**: the flag of the fleet that reported the information;
- **YEAR**: the statistical year;
- **B_CA_LS**: total bigeye tuna catches (in metric tons) recorded in the year by the reporting fleet of purse seiners on schools associated with drifting FOBs, as derived from IOTC form 3CE;
- **B_FA**: total bigeye tuna catches (in metric tons) recorded in the year by the reporting fleet of purse seiners on schools associated with drifting FOBs, as derived from IOTC form 3FA (records with *NUMBER_OF_SETS_ON_FOB* greater than zero);
- **B_DIFF**: the arithmetic difference between **B_CA_LS** and **B_FA**;
- **S_CA_LS**: total skipjack tuna catches (in metric tons) recorded in the year by the reporting fleet of purse seiners on schools associated with drifting FOBs, as derived from IOTC form 3CE;
- **S_FA**: total skipjack tuna catches (in metric tons) recorded in the year by the reporting fleet of purse seiners on schools associated with drifting FOBs, as derived from IOTC form 3FA (records with *NUMBER_OF_SETS_ON_FOB* greater than zero);
- **S_DIFF**: the arithmetic difference between **S_CA_LS** and **S_FA**;
- **Y_CA_LS**: total yellowfin tuna catches (in metric tons) recorded in the year by the reporting fleet of purse seiners on schools associated with drifting FOBs, as derived from IOTC form 3CE;
- **Y_FA**: total yellowfin tuna catches (in metric tons) recorded in the year by the reporting fleet of purse seiners on schools associated with drifting FOBs, as derived from IOTC form 3FA (records with *NUMBER_OF_SETS_ON_FOB* greater than zero);
- **Y_DIFF**: the arithmetic difference between **Y_CA_LS** and **Y_FA**;

Grayed-out cells correspond to strata for which there is no information available.

Summary by fleet

EU,Spain

Table 13: Summary of total tropical tuna catches (in metric tons) recorded by the Spanish component of the European Union purse seine fleet fishing on schools associated with drifting FOBs, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	B_CA_LS	B_FA	B_DIFF	S_CA_LS	S_FA	S_DIFF	Y_CA_LS	Y_FA	Y_DIFF
EU,ESP	2013	12,430.60			61,364.06			55,757.81		
EU,ESP	2014	7,557.81			63,453.87			43,478.30		
EU,ESP	2015	6,694.50	6,665.43	29.07	55,289.66	55,100.50	189.16	31,948.32	31,936.34	11.98
EU,ESP	2016	8,461.29	8,507.31	-46.02	72,972.39	73,373.85	-401.46	38,662.11	38,873.62	-211.51
EU,ESP	2017	7,926.00	15,720.06	-7,794.06	83,426.19	69,729.59	13,696.60	36,583.47	18,800.78	17,782.69
EU,ESP	2018	10,619.20	24,508.10	-13,888.90	131,385.70	129,059.27	2,326.43	58,233.65	43,705.91	14,527.74
EU,ESP	2019	7,732.59	13,751.58	-6,018.99	104,965.74	98,251.67	6,714.07	33,575.79	33,553.08	22.71
EU,ESP	2020	10,659.48	10,659.20	0.28	80,749.57	80,749.94	-0.37	36,652.63	36,650.58	2.05
EU,ESP	2021	10,341.20	10,341.00	0.20	89,376.59	89,376.00	0.59	28,580.97	28,580.00	0.97

Overall catch data on associated schools with drifting FOBs for the three tropical tuna species are in relatively good agreement between IOTC forms 3CE and 3FA for the Spanish component of the European Union purse seine fleet, with the exception of data for the statistical year 2019, when information from IOTC form 3FA seems to severely under-report catches for bigeye and skipjack tunas when compared to data recorded through logbooks (**Table 13**). According to EU,Spain, the differences could be due to FA catches by species are from FAD logbook, which not necessary coincide with catches estimated elsewhere.

Potential over-reporting is detected for 2016, when catches from IOTC form 3FA are marginally higher than those from logbooks for the same species and year, but these might be considered by all means negligible when compared to the magnitude of catches reported for each species during the years.

Regarding the statistical year 2018, catches reported through form 3CE for the FOB-associated component of the EU,Spain purse seine fleet have been re-estimated by the IOTC Secretariat in agreement with (IOTC (2019)) to account for the anomalies in species composition first identified by the IOTC Working Party on Tropical Tunas in 2019. This re-estimation results in decreasing catch levels of bigeye tuna, in favour of yellowfin tuna and skipjack tuna (to a lesser extent) and explains the detected differences in catch levels (by species) between the re-estimated form 3CE and form 3FA for 2018.

EU,France

Table 14: Summary of total tropical tuna catches (in metric tons) recorded by the French component of the European Union purse seine fleet fishing on schools associated with drifting FOBs, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	B_CA_LS	B_FA	B_DIFF	S_CA_LS	S_FA	S_DIFF	Y_CA_LS	Y_FA	Y_DIFF
EU,FRA	2013	2,777.96	4,501.81	-1,723.85	12,954.06	20,809.68	-7,855.62	12,329.31	21,003.67	-8,674.36
EU,FRA	2014	2,333.77	2,330.86	2.91	18,540.50	18,537.38	3.12	15,180.00	15,177.51	2.49
EU,FRA	2015	2,105.03	2,102.40	2.63	17,499.98	17,497.40	2.58	12,216.21	12,213.14	3.07
EU,FRA	2016	2,775.31	2,771.52	3.79	28,750.32	28,746.45	3.87	17,360.32	17,355.94	4.38
EU,FRA	2017	2,909.76	2,905.78	3.98	31,399.86	31,395.72	4.14	18,279.50	18,276.03	3.47
EU,FRA	2018	4,445.92	4,428.24	17.68	46,275.25	46,298.33	-23.08	26,312.29	26,292.79	19.50
EU,FRA	2019	2,698.09	2,694.57	3.52	33,006.97	33,003.37	3.60	17,948.68	17,945.24	3.44
EU,FRA	2020	2,017.23	2,013.51	3.72	28,767.85	28,764.04	3.81	14,134.86	14,131.05	3.81
EU,FRA	2021	4,080.12	4,076.46	3.66	42,645.32	42,641.60	3.72	17,128.10	17,124.38	3.72

The information provided by the French component of the European Union purse seine fleet indicates, for the years in which data are available both from IOTC form 3CE and 3FA (2013-2021), that the two data sources are generally in very good agreement, with difference at species level not exceeding 25 t (in absolute values) except for the first year of the time series when a systematic (across all species) over-reporting of catches is reported through form 3FA (**Table 14**).

Japan

Table 15: Summary of total tropical tuna catches (in metric tons) recorded by the Japanese purse seine fleet fishing on schools associated with drifting FOBs, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2020

FLAG	YEAR	B_CA_LS	B_FA	B_DIFF	S_CA_LS	S_FA	S_DIFF	Y_CA_LS	Y_FA	Y_DIFF
JPN	2013	197.00	197.00	0.00	861.00	861.00	0.00	95.00	95.00	0.00
JPN	2014	97.00	98.00	-1.00	495.00	495.00	0.00	144.00	144.00	0.00
JPN	2015	280.00	297.30	-17.30	2,083.00	2,061.70	21.30	278.00	258.00	20.00
JPN	2016	256.00	297.30	-41.30	2,357.00	2,061.70	295.30	419.00	258.00	161.00
JPN	2017	369.00	208.00	161.00	3,121.10	1,304.00	1,817.10	570.10	238.00	332.10
JPN	2018	287.00	266.00	21.00	2,076.00	1,911.00	165.00	407.00	383.00	24.00
JPN	2019	24.00	24.00	0.00	187.00	187.00	0.00	24.00	24.00	0.00
JPN	2020	68.00	66.00	2.00	494.00	483.00	11.00	58.00	56.00	2.00

Catch levels reported by Japan are quite comparable across most of the years and species for the two data sources, with the notable exceptions of 2016 to 2018 when generalized under-reporting of catches of bigeye, skipjack and yellowfin tuna appear in the data from IOTC form 3FA (**Table 15**).

For several other years (i.e., 2013, 2014, 2015, 2019, 2020) catch levels are in almost perfect accordance between the two data sources.

Republic of Korea

Table 16: Summary of total tropical tuna catches (in metric tons) recorded by the Korean purse seine fleet fishing on schools associated with drifting FOBs, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	B_CA_LS	B_FA	B_DIFF	S_CA_LS	S_FA	S_DIFF	Y_CA_LS	Y_FA	Y_DIFF
KOR	2013	1,193.50			8,565.00			2,107.50		
KOR	2014	664.00			6,198.00			4,264.00		
KOR	2015	972.00			5,588.00			5,538.00		
KOR	2016	513.00			12,893.15			4,925.08		
KOR	2017	712.00	712.00	0.00	10,822.00	10,822.00	0.00	2,910.00	2,910.00	0.00
KOR	2018	1,058.00			12,412.00			2,828.00		
KOR	2019	855.00			8,464.00			1,881.00		
KOR	2020	632.00			10,627.00			1,313.00		
KOR	2021	1,304.00	1,283.00	21.00	13,793.00	13,685.00	108.00	1,799.00	1,798.00	1.00

The Republic of Korea only reported explicit catches of tropical tunas through IOTC form 3FA for the statistical years 2017 and 2021. In that case, the information provided for 2017 was in full accordance with the logbook-source data for the same statistical year, whereas for 2021 3CE catches were slightly higher, although no differences in the number of sets were observed for that year (**Table 16**). Catches of skipjack tuna, bigeye tuna, and yellowfin tuna reported through the form 3CE were higher by 108 t, 21 t, and 1 t, respectively (**Table 16**).

Mauritius

Table 17: Summary of total tropical tuna catches (in metric tons) recorded by the Mauritian purse seine fleet fishing on schools associated with drifting FOBs, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	B_CA_LS	B_FA	B_DIFF	S_CA_LS	S_FA	S_DIFF	Y_CA_LS	Y_FA	Y_DIFF
MUS	2014	253.09			2,406.52			1,748.38		
MUS	2015	489.00	1,421.50	-932.50	2,650.00	2,832.40	-182.40	2,116.50	5,416.90	-3,300.40
MUS	2016	357.91	357.91	0.00	3,496.74	3,496.78	-0.04	2,189.78	2,187.85	1.93
MUS	2017	722.23	722.23	0.00	8,135.71	8,135.71	0.00	4,402.51	4,402.51	0.00
MUS	2018	1,437.97	1,437.97	0.00	8,817.55	8,817.55	0.00	6,086.32	6,086.32	0.00
MUS	2019	1,332.97	1,332.97	0.00	10,059.37	10,059.37	0.00	3,876.76	3,876.76	0.00
MUS	2020	1,165.63	1,165.63	0.00	8,418.31	8,418.31	0.00	4,748.44	4,748.44	0.00
MUS	2021	1,572.14	1,572.14	0.00	12,198.85	12,198.85	0.00	5,510.54	5,510.54	0.00

Catch data of tropical tuna species from Mauritian-flagged vessels are only available, through IOTC form 3FA, for the years from 2015 onward. Besides 2015, for most of the years, the data are in perfect accordance with the information received from logbooks, and the negligible differences in catch levels detected in 2016 for skipjack and yellowfin tuna can be *de facto* considered as mere rounding errors (**Table 17**). Catches between CE and FA for 2015, show significant differences for the three species, whereby catches in 3FA for yellowfin tuna more than double catches in 3CE.

Seychelles

Table 18: Summary of total tropical tuna catches (in metric tons) recorded by the Seychellois purse seine fleet fishing on schools associated with drifting FOBs, as reported through IOTC form 3CE and IOTC form 3FA for the period 2013-2021

FLAG	YEAR	B_CA_LS	B_FA	B_DIFF	S_CA_LS	S_FA	S_DIFF	Y_CA_LS	Y_FA	Y_DIFF
SYC	2013	4,376.34	4,355.65	20.69	24,748.57	24,675.56	73.01	20,754.99	20,632.37	122.62
SYC	2014	3,870.30			30,672.99			17,656.60		
SYC	2015	4,724.86	4,763.10	-38.24	39,257.57	39,101.08	156.49	23,112.40	23,038.38	74.02
SYC	2016	6,785.64	6,068.20	717.44	59,430.03	54,889.24	4,540.79	32,501.95	29,556.51	2,945.44
SYC	2017	6,771.15	6,777.09	-5.94	66,317.36	66,345.93	-28.57	29,740.20	29,757.30	-17.10
SYC	2018	5,999.61	5,999.61	0.00	80,410.15	80,410.15	0.00	32,748.12	32,748.12	0.00
SYC	2019	5,730.91	5,730.91	0.00	63,457.23	63,457.23	0.00	28,328.53	28,328.53	0.00
SYC	2020	5,709.56	5,670.91	38.65	74,729.31	74,401.96	327.35	28,596.36	28,374.61	221.75
SYC	2021	10,071.51	10,006.62	64.89	79,327.18	79,091.77	235.41	24,809.83	24,628.60	181.23

The overall differences in catch levels of tropical tuna species detected between IOTC form 3CE and 3FA for Seychelles are somehow half way between what detected for EU,Spain and Mauritius. For some years (namely 2018 and 2019) there is perfect accordance in the information provided by the two data sources (**Table 18**). For other years (2013, 2015, 2017, 2020 and 2021) the differences are relatively minor, and mostly consisting in under-estimation of catch levels reported through IOTC form 3FA. Only in 2016 the two data sources seem to diverge, with catches from IOTC form 3FA systematically lower (by around 10%) of the corresponding catches by species reported by logbooks.

Overall, data from Seychelles can be considered in good agreement if not for 2014 (when no information was shared through IOTC form 3FA).

Geo-referenced annual catches

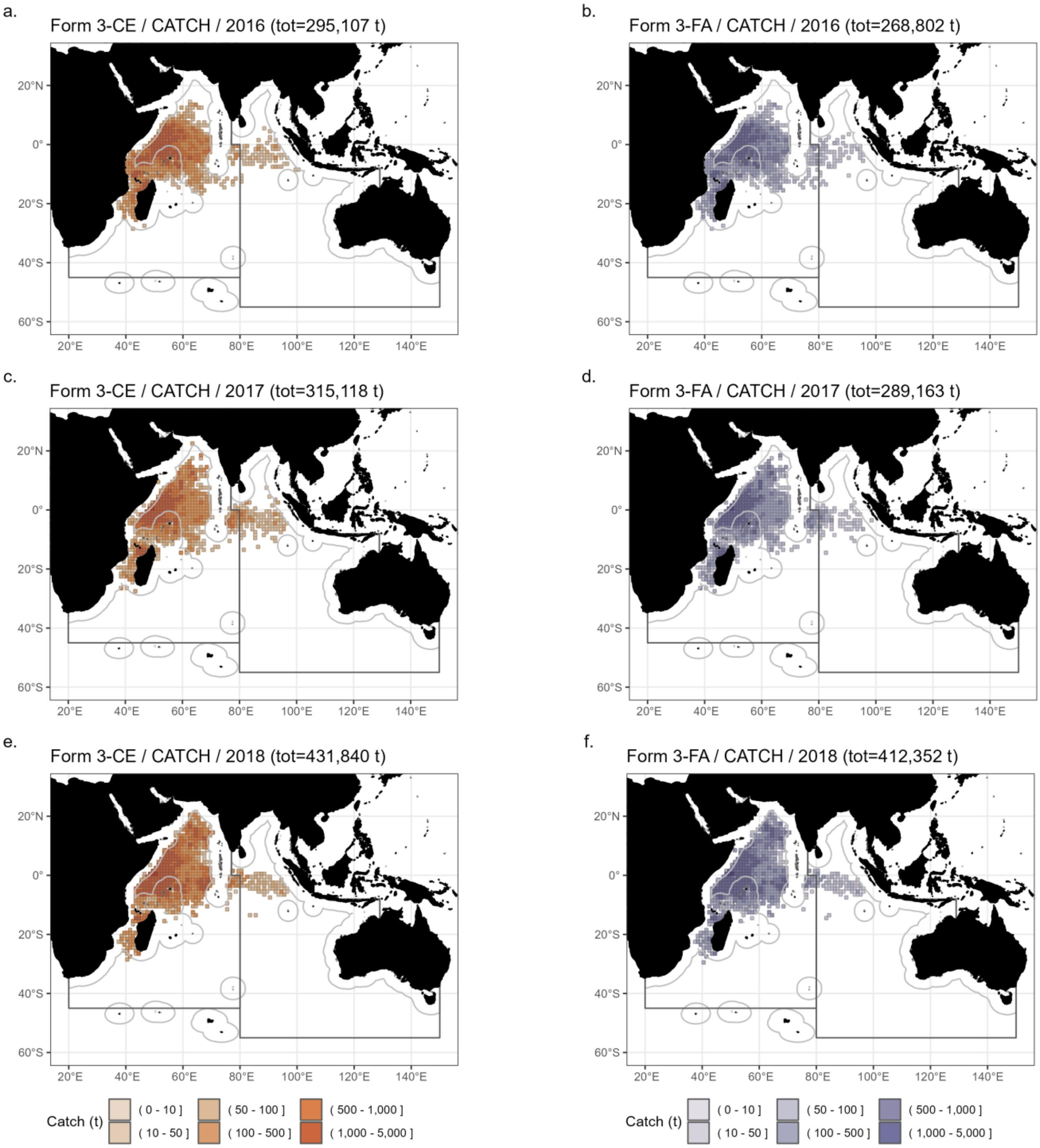

Figure 21: Comparison of total annual catches on FOBs for the years 2016-2018, as reported through IOTC form 3CE (a, c, e) and through IOTC form 3FA (b, d, f). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

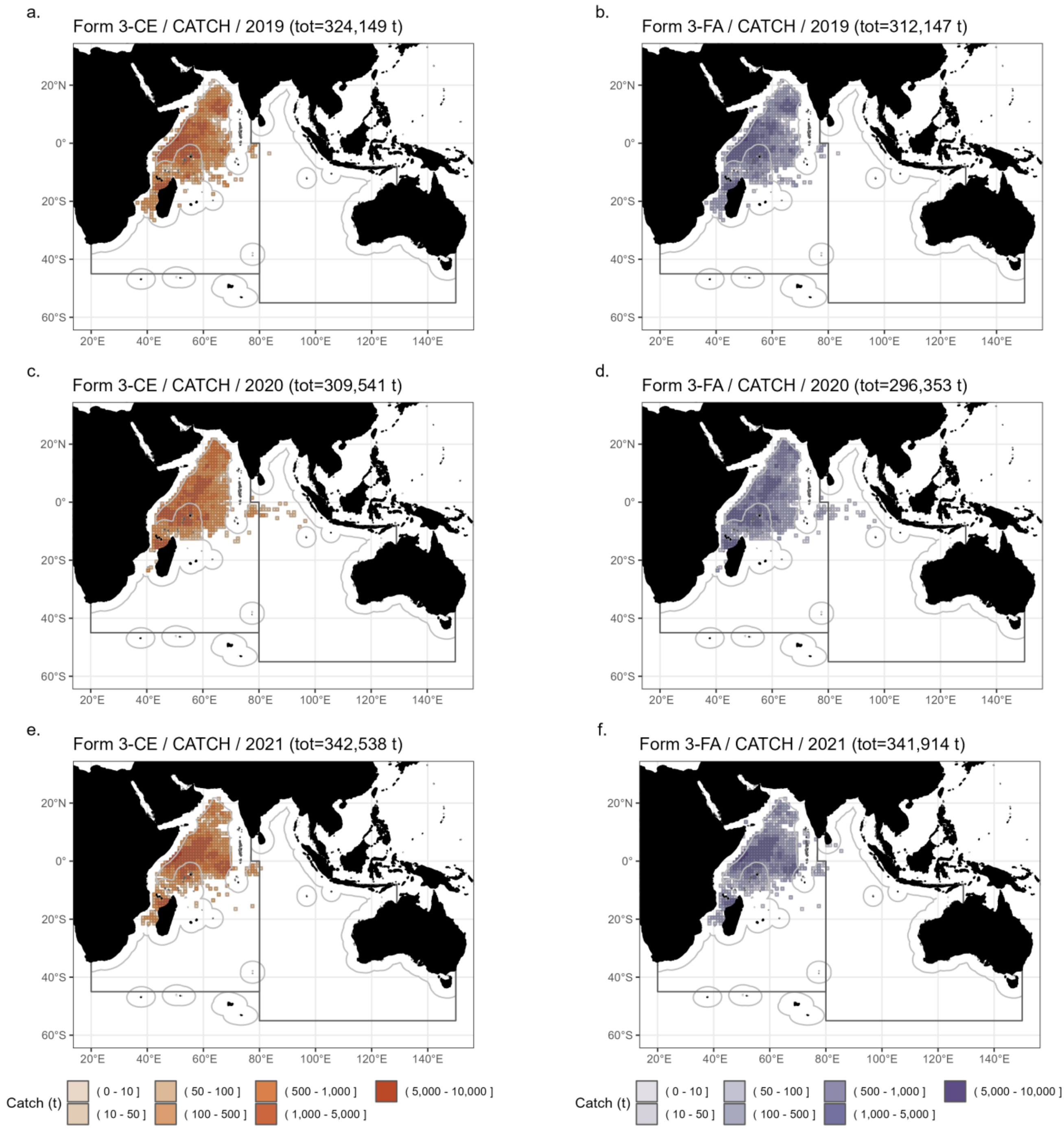

Figure 22: Comparison of total annual catches on FOBs for the years 2019-2021, as reported through IOTC form 3CE (a, c, e) and through IOTC form 3FA (b, d, f). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

Geospatial information on the distribution of annual catches for all three tropical tuna species shows a good agreement between the two data source across all years considered, with some minor problems in spatial coverage mostly in the Eastern Indian Ocean due to the lack of data for some years from the purse seine fleets operating in the area.

Overall, data from IOTC form 3FA provides an acceptable indication of the hot-spots for tropical tuna catches (on log-associated schools) and their general distribution by the main purse seine fleets operating in the Indian Ocean. The main differences between the two sources of data being in catch magnitudes, in particularly for 2019 and 2020, due to either lack of data from IOTC form 3FA for some fleets / years, or by severe over-reporting such as in the case of EU,France.

Geo-referenced quarterly catches

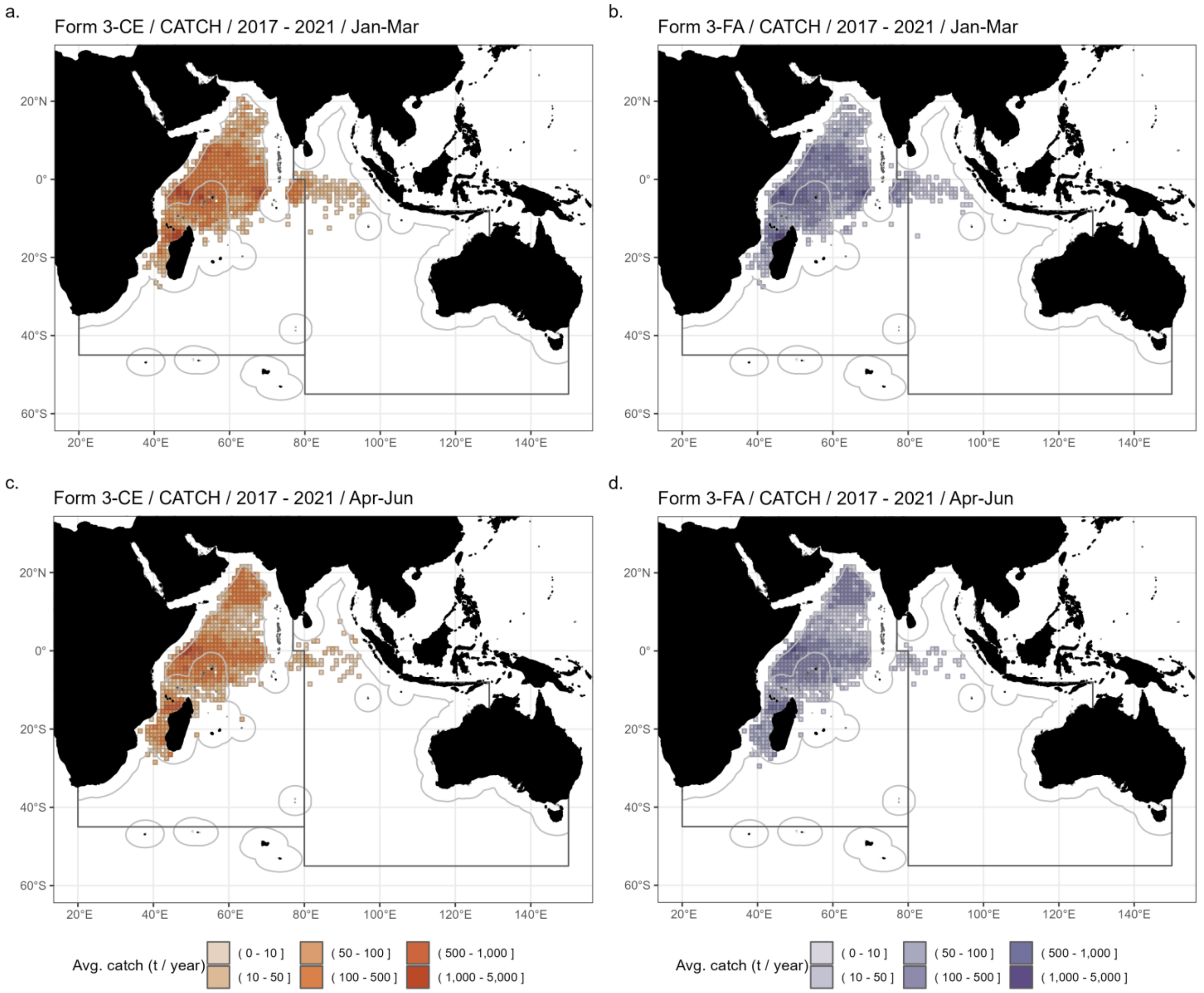

Figure 23: Comparison of average annual catches on FOBs for the 1st and 2nd quarter of the years 2016-2021, as reported through IOTC form 3CE (a, c) and through IOTC form 3FA (b, d). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

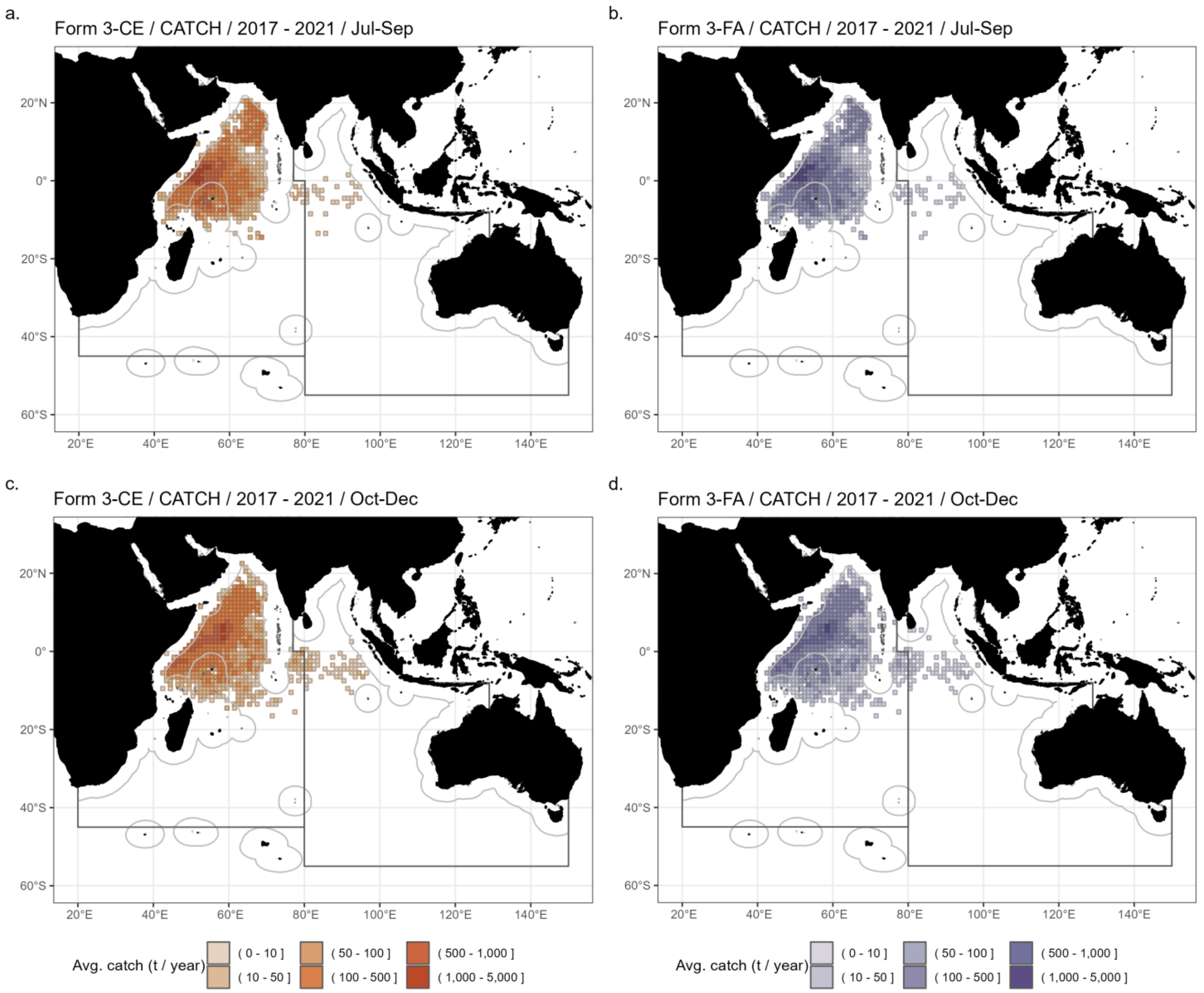

Figure 24: Comparison of average annual catches on FOBs for the 3rd and 4th quarter of the years 2017-2021, as reported through IOTC form 3CE (a, c) and through IOTC form 3FA (b, d). Source: IOTC catch-and-effort data for surface fisheries and IOTC collated FOB activity data

Supply vessels

Table 19 summarizes the information on the effort (number of days at sea) exerted by supply vessels as reported by all concerned CPCs for the years for which data was submitted to the IOTC Secretariat via IOTC form 3SU.

The meaning of each column in the table is as follows:

- ***FLAG***: the flag of the fleet that reported the information. *Total* corresponds to the accumulation of data across each flag for a given year;
- ***YEAR***: the statistical year for which information is collated, with the cell content corresponding to the total number of days at sea reported for the supply vessels of each fleet during the year concerned.

Blank cells correspond to strata for which there is no information available.

Summary by fleet

Data on the effort exerted by supply vessels begun to be regularly received by the Secretariat from the statistical year 2017 onward (**Table 19**), even though IOTC Resolution 15/02 called for its provision starting with the statistical year 2015 (data available for 2014 is the result of submission of historical information from the CPCs concerned).

All information on efforts from supply vessels should be cross-verified with the Active Vessels' List of IOTC (AVL), that provides data on the active vessels operating in the Indian Ocean by year, flag and vessel type, to understand whether the complete lack of effort for some strata is a consequence of non-reporting, or rather of the absence of active supply vessels for the flags and years concerned.

Table 19: Summary of total number of days at sea spent by supply vessels flagged by the major fleets with purse seiners operating, as reported through IOTC form 3SU

FLAG	2014	2015	2016	2017	2018	2019	2020	2021
EU,ESP	1,172	2,957	3,462	2,633	2,029	2,016	1,755	1,732
EU,FRA					383	1,329	1,248	427
JPN		20	19	17	20	27		
KOR				304	307	298	294	293
MUS				382	397	405	425	510
SYC			1,099		982	863	2,550	2,363
Total	1,172	2,977	4,580	3,336	4,118	4,938	6,272	5,325

In the case of Japan, for instance, the Active Vessels' List (AVL) of the IOTC indicates no supply vessel from the same fleet as actively operating during 2020, and besides, provided incomplete information in the 3SU form. Hence, total number of effort, 27 days, noting that the vessel operating in multiple grids per day.

For what concerns Mauritius, data in the AVL indicates no Mauritian supply vessel as actively operating in the Indian Ocean since 2014, where Mauritian supply vessels started operating in 2017. Indeed, information provided by Mauritius through their National Reports indicates the presence of active supply vessels since 2017, although the reported number of days at sea (for each year) is roughly half of what reported through IOTC form 3SU.

In the past not all CPCs with purse seiners had supply vessels registered under their flag. Supply vessels were commonly registered under European union member, particularly Spain. These supply vessels served European union and associated purse seiners, including Seychelles flagged purse seiners. The lack of registered supply vessels under some flags, could be one reason for the discrepancies between number of supply vessels by CPCs and Days at sea reported by some CPCs. In the past not all CPCs with purse seiners had supply vessels registered under their flag. Supply vessels were commonly registered under European union member, particularly Spain. These supply vessels served European union and associated purse seiners, including Seychelles flagged purse seiners. The lack of registered supply vessels under some flags, could be one reason for the discrepancies between number of supply vessels by CPCs and Days at sea reported by some CPCs.

In the case of EU,France, the AVL indicating no active supply vessels for the flag state until 2020 (when 2 of them were then reported as active), nonetheless EU,France provided data from IOTC form 3SU since 2018; and Seychelles, with fluctuated number of supply vessels in AVL, data from IOTC form 3SU shows increasing effort reported by the flag state from the year 2020.

Overall, the information collated from the submitted IOTC form 3SU is far from being considered complete or accurate, although it has the merit of providing rough figures on the total yearly effort as well as the fishing grounds where the activity from these vessels appears to be more concentrated.

Future analysis shall be attempted to cross-verify the effort information from IOTC form 3SU with data on activities by supply vessels (mostly deployments of FOBs) as reported through IOTC form 3FA, although with all the caveats required by the inherent inconsistency of the latter.

Geo-referenced annual efforts

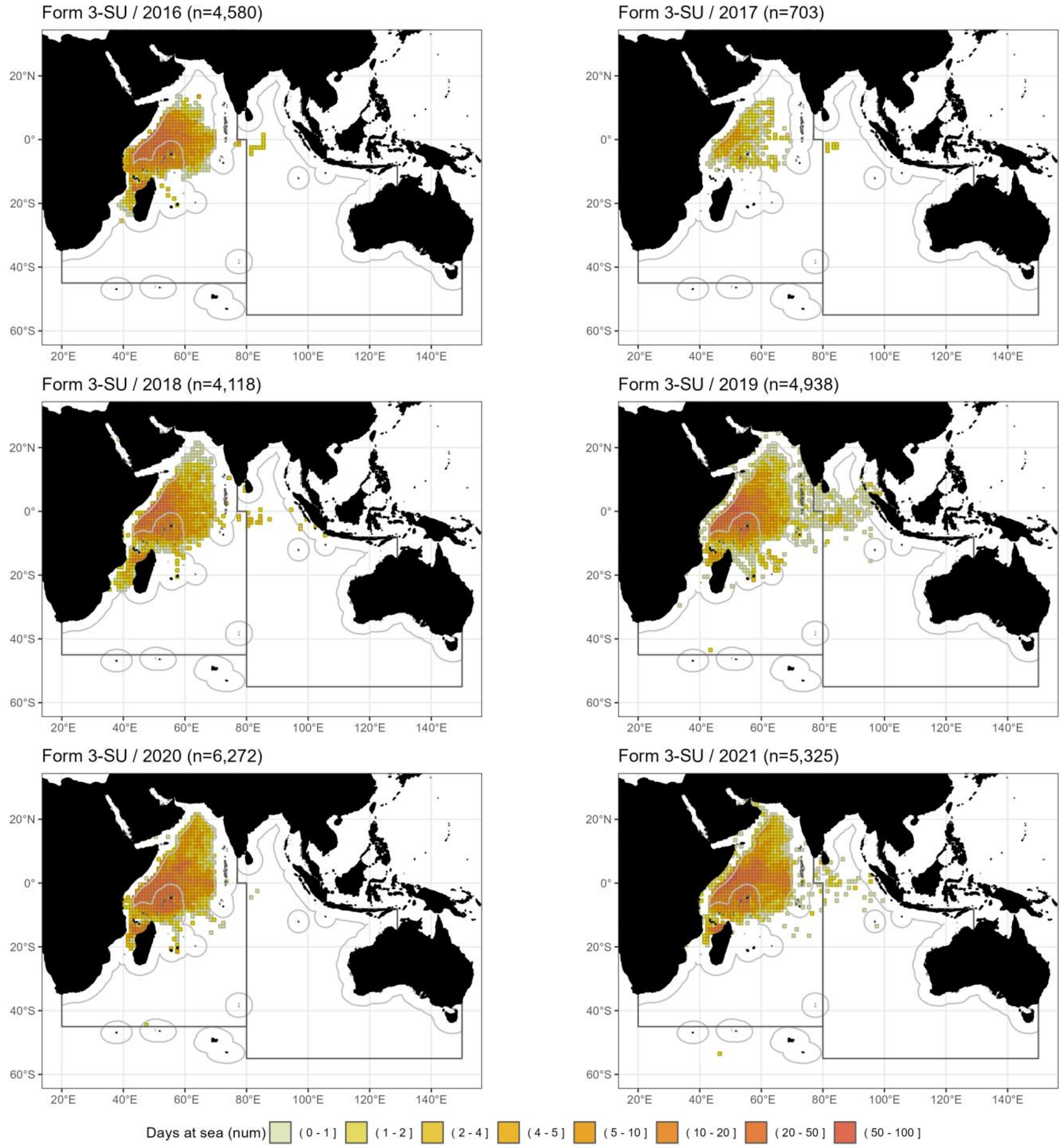

Figure 25: Total annual number of days at sea spent by supply vessels flagged by the major fleets with purse seiners operating in the Indian Ocean, as reported through IOTC form 3SU. Source: [Effort data for supply vessels (2016-2021)]

Geo-referenced quarterly efforts

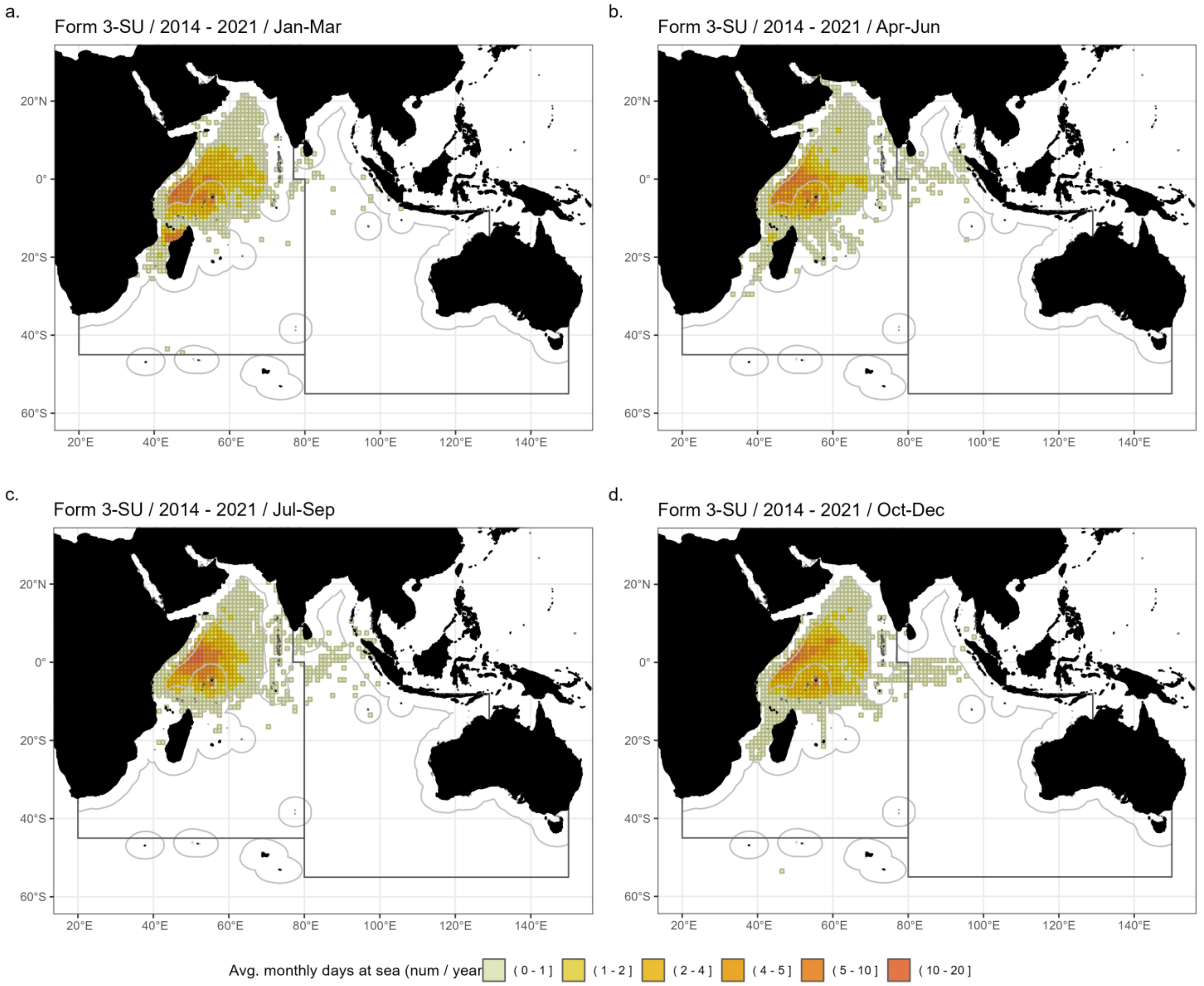

Figure 26: Average annual number of days at sea spent (by quarter) by supply vessels flagged by the major fleets with purse seiners operating in the Indian Ocean. Source: Effort data for supply vessels (2014-2021)

Quarterly effort trends from supply vessels show spatio-temporal patterns similar to those reported through IOTC form 3FA for purse seine vessels (and expressed as number of sets on FOBs), with little to no activity on average in the Southwest Indian Ocean / Mozambique Channel during the 3rd and 4th quarter of each year.

The areas with recorded peaks in total effort from supply vessels are also geographically close to the areas with recorded peaks in total effort from purse seine vessels reported through IOTC form 3FA (see **Fig. 19** and **20**) and this might be a direct consequence of the way in which purse seine and supply vessels operate.

FOB-tracking data

The current FOB-tracking database of the IOTC Secretariat hosts a total of distinct 17,181,115 daily positions transmitted through satellite communication from 71,047 buoys that were monitored at sea by 47 purse seiners between January 2020 and June 2022. The position data are of highly dynamic nature due to the high turn-over of the buoys at sea where deployments of new FADs and transfers of buoys on FOBs encountered at sea constantly compensate for the buoys stopping transmission (see Section At-sea deployments). **Table 20** provides a summary of the buoys' positions data set available for the period covering January 2020 to June 2022.

Table 20: Summary table of the IOTC daily position dataset of instrumented buoys equipping floating objects drifting at sea between January 2020 and June 2022. Buoys may be duplicated between national purse seine fisheries when information on buoys is shared among fleets and reported to the Secretariat

YEAR	CPC	FLAG	PS	DAYS	POSITIONS	BUOYS
2020	EU	EU,ESP	15	366	1,459,581	14,242
2020	EU	EU,FRA	11	366	3,086,904	8,546
2020	EU	EU,ITA	1	366	226,579	2,504
2020	JPN	JPN	2	88	4,353	109
2020	MUS	MUS	3	366	515,353	2,788
2020	SYC	SYC	13	366	1,406,849	13,394
2021	EU	EU,ESP	16	365	1,343,232	13,956
2021	EU	EU,FRA	10	365	3,088,548	9,000
2021	EU	EU,ITA	1	365	285,636	3,494
2021	MUS	MUS	3	365	975,284	3,933
2021	SYC	SYC	13	365	1,491,882	13,728
2022	EU	EU,ESP	15	181	650,394	8,880
2022	EU	EU,FRA	10	181	1,502,254	5,770
2022	EU	EU,ITA	1	181	135,700	1,990
2022	MUS	MUS	3	181	447,055	2,116
2022	SYC	SYC	13	181	542,638	7,766
2022	TZA	TZA	1	99	18,873	424

The daily number of buoys transmitting the position of FOBs drifting at sea in the Indian Ocean varies between CPCs and between the purse seiners of a same CPC (**Fig. 27**). The variability is particularly marked for the EU and the Seychelles for which some purse seiners permanently monitor a number of buoys close to the limit of 300 when others monitor less than 200 buoys at sea in some time periods. The daily number of buoys followed by the EU-flagged purse seiners show an overall declining trend between January 2020 and June 2022 with some variability. Purse seiners from Mauritius show a median range of monitored buoys that varied from a minimum of around 197 in November 2020 to a maximum of around 276 during July-August 2021. In June 2022, the daily number of monitored buoys in the Mauritian purse seine fleet was around 248. Seychelles purse seiners monitored more buoys at sea than Mauritius-flagged purse seiners between 2020 and 2021 but have shown a major decline in the number of monitored buoys at the end of 2021, likely due to the stop of the vessels that reached their annual individual total allowable catch in relation with the yellowfin tuna rebuilding plan (**Fig. 27**). The daily number of buoys monitored by each purse seiner re-increased in early 2022 and was around 233 in June 2022.

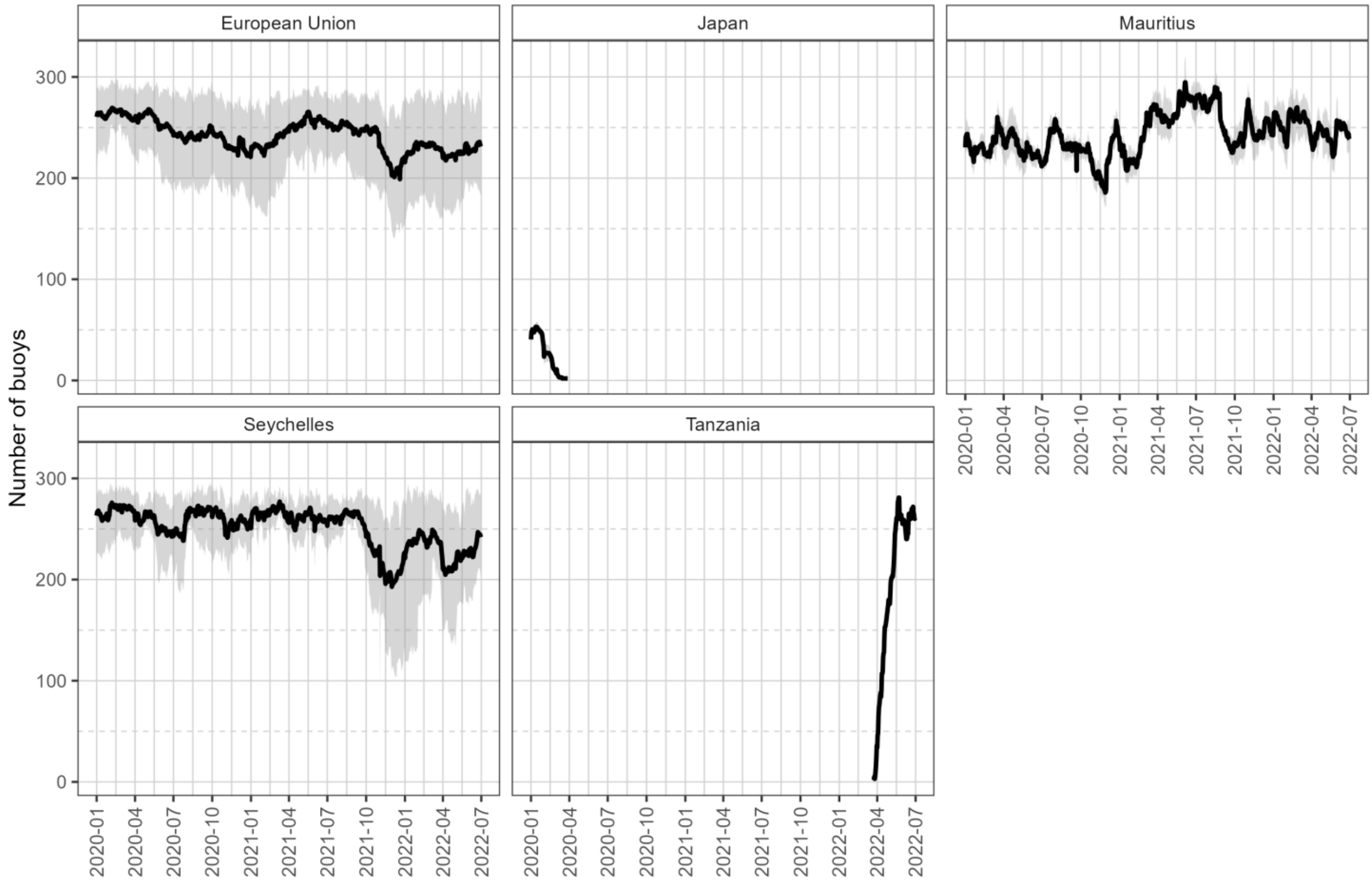

Figure 27: Mean daily number (solid black line) of operational buoys in the Indian Ocean monitored by each purse seiner between January 2020 and June 2022 for the CPCs having reported data to the Secretariat. The grey area indicates the 80% confidence interval computed from the purse seiners of each CPC

The spatial extent of the distribution of satellite-tracked buoys shows that the FADs used in the purse seine fishery occur across a large part of the Indian Ocean (**Fig. 28**). While buoys are to be found in higher densities within the fishing grounds of the western Indian Ocean, surface currents carry them towards the north where they cover the whole Arabian Sea, towards the east until the northern coasts of Indonesia, and towards the south and east of Madagascar. The distributions of the buoys appear overall very similar between quarters although the seasonal variability in ocean circulation may modify the FOBs spatial patterns as shown for instance by the west-east flow along the equator (from Mozambique to Indonesia) observed in the first quarter of 2021 (**Fig. 29**). Also, the seasonality in the purse seine fishing grounds may explain some spatial features such as the higher density of monitored FOBs in the Mozambique Channel in April-June 2020 (**Fig. 28**).

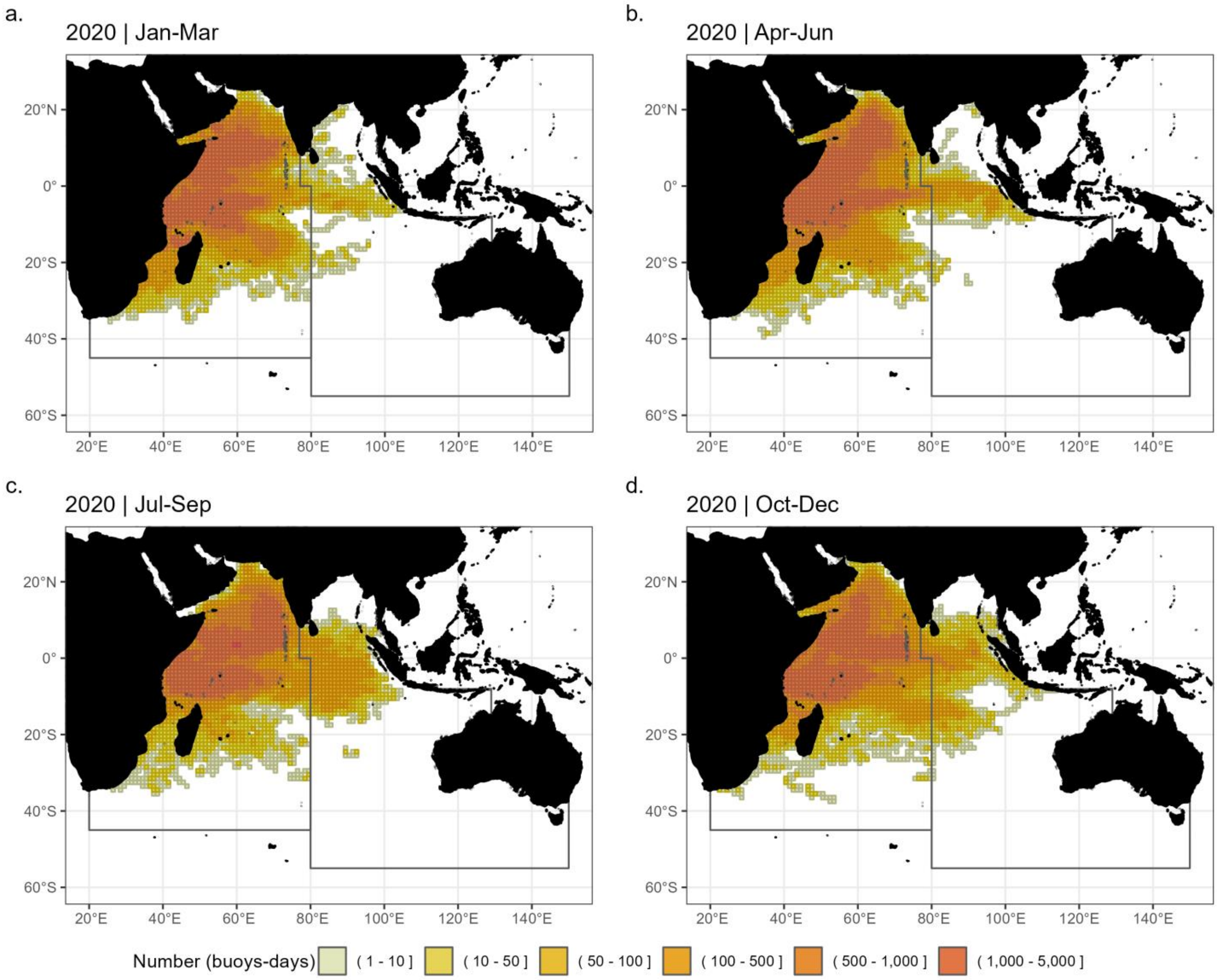

Figure 28: Quarterly density of operational buoys (buoys-days) in the Indian Ocean monitored by the Indian Ocean purse seine fishery between January 2020 and December 2020 for the CPCs having reported data to the Secretariat

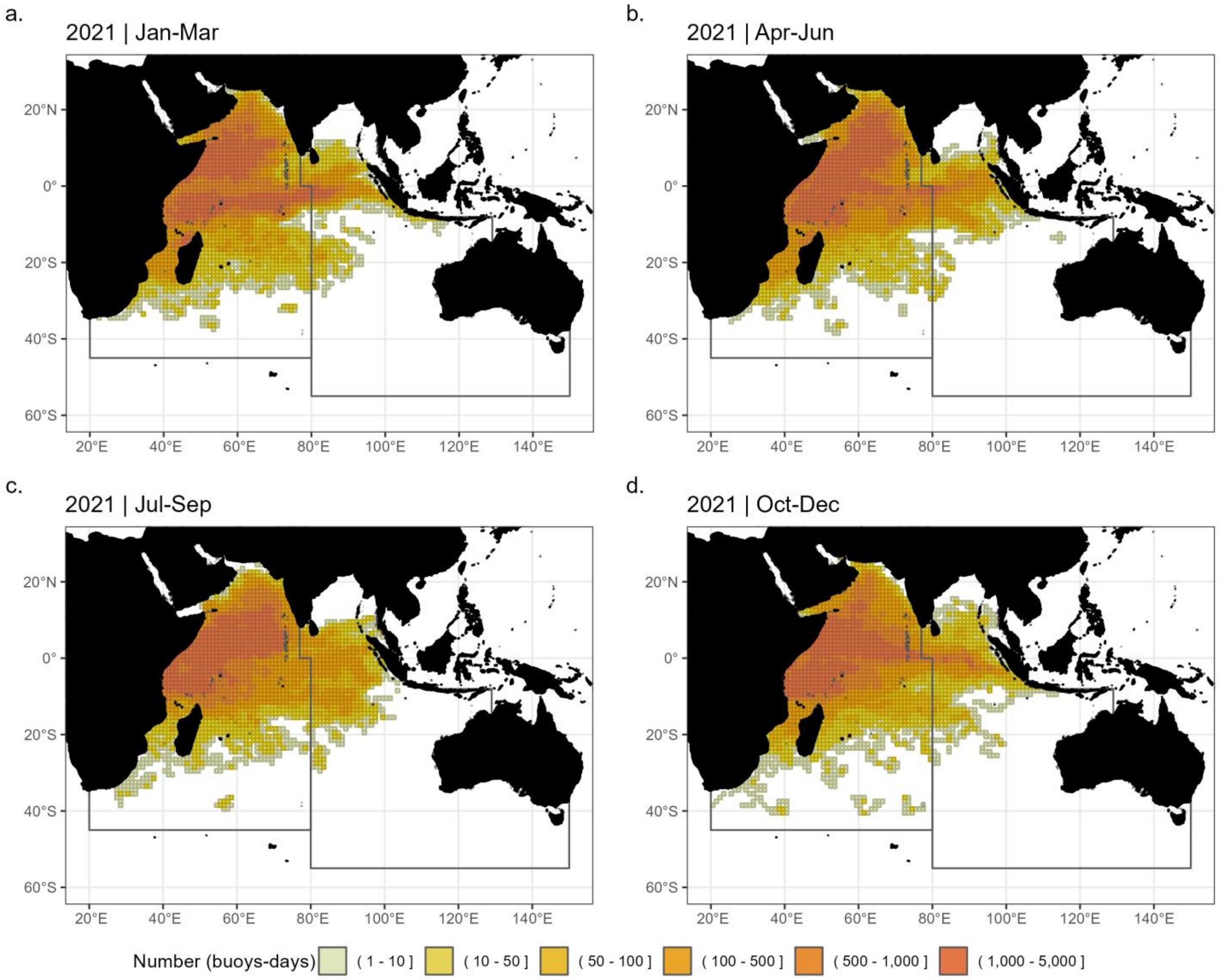

Figure 29: Quarterly density of operational buoys (buoys-days) in the Indian Ocean monitored by the Indian Ocean purse seine fishery between January 2021 and December 2021 for the CPCs having reported data to the Secretariat

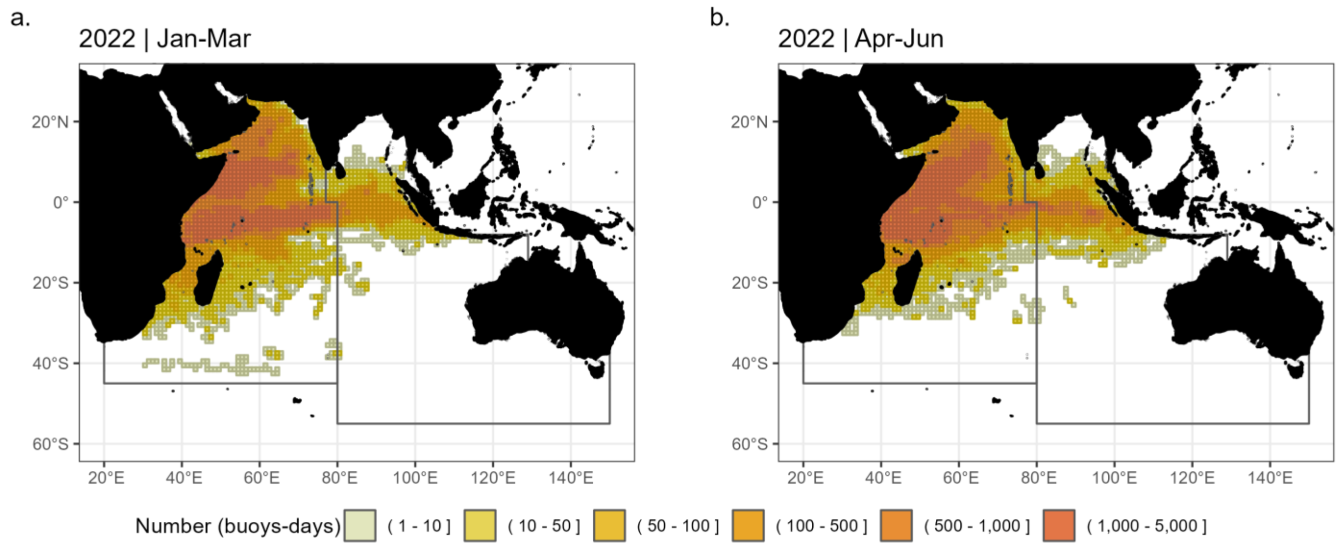

Figure 30: Quarterly density of operational buoys (buoys-days) in the Indian Ocean monitored by the Indian Ocean purse seine fishery between January 2022 and June 2022 for the CPCs having reported data to the Secretariat

Appendix I: Code lists in IOTC databases for FOB-related activities

Table 21: Classification of types of drifting floating objects in use at the IOTC Secretariat

Code	Description
DFR	Other drifting objects NOT located using a tracking system (radio or satellite transmission) (e.g. dead animal, etc.)
DRT	Other drifting objects located using a tracking system (radio or satellite transmission) (e.g. dead animal, etc)
FAD	Drifting raft or FAD without a net NOT located using a tracking system (radio or satellite transmission)
FDT	Drifting raft or FAD without a net located using a tracking system (radio or satellite transmission)
LGT	Drifting log or debris located using a tracking system (radio or satellite transmission)
LOG	Drifting log or debris NOT located using a tracking system (radio or satellite transmission)
NFD	Drifting raft or FAD with a net NOT located using a tracking system (radio or satellite transmission)
NFT	Drifting raft or FAD with a net located using a tracking system (radio or satellite transmission)

Appendix II: Classification of FOB-related activities in use at the IOTC

Table 22: Classification of activities related to drifting floating objects in use at the IOTC Secretariat

Code	Description
DD	Deployment of drifting FAD
DH	Retrieval/encounter and hauling of drifting FAD
DI	Retrieval/encounter, hauling, and intervention on electronic equipment of drifting FAD
DL	Loss of drifting FAD (tracking signal lost)
DR	Retrieval of drifting FAD

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