WPTT23(DP) - REVIEW OF YELLOWFIN TUNA STATISTICAL DATA

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Purpose

To provide participants at the Data Preparatory meeting of the 23rd Session of the IOTC Working Party on Tropical Tunas (WPTT23(DP)) with a review of the status of the information available on yellowfin tuna (*Thunnus albacares*). The document provides an overview of the data available in the IOTC Secretariat databases as of May 2021 and describes the progress achieved in relation to the collection and verification of data, identifies problem areas and proposes actions that could be undertaken to improve them.

Materials

Several fisheries data sets shall be reported to the IOTC Secretariat by the Contracting Parties and Cooperating Non-Contracting Parties (CPCs) as per the IOTC Conservation and Management Measures (CMMs) and following the standards and formats defined 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.

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

i. By December 30th each year, updates 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 of 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.

It is to note that the IOTC definitions for nominal catch, bycatch, and discards may differ from those used in other areas and fisheries. In particular, the IOTC considers as bycatch all species other than the 16 IOTC listed in Annex B of the IOTC Agreement, whether caught or interacted with by fisheries for tuna and tuna-like species in the IOTC area of competence. Hence, early juveniles of tropical tunas (<1-1.5 kg) that are generally not marketable are not considered as a bycatch of tuna fisheries although they are not targeted in most cases.

Nominal catch data

Nominal catches correspond to the total retained catches (in live weight) estimated per year, IOTC area, fleet, and gear (IOTC Res. 15/02) and are generally reported through IOTC form 1RC. In addition, in order to support the monitoring of the catch limits implemented by some industrial fisheries as part of the rebuilding plan for yellowfin tuna, IOTC Res. 19/01 requests CPCs to submit their catches of yellowfin tuna from 2019 explicitly disaggregated by vessel length and area of operation (i.e., for vessel of 24 m overall length and over, and for those under 24 m if they fish outside the Exclusive Economic Zone (EEZ) of the flag state) (IOTC Form 1RC-YFT).

Discard data

The IOTC follows the definition of discards adopted by FAO in previous reports (Alverson et al. 1994, Kelleher 2005) which considers all non-retained catch, including individuals released alive or discarded dead. In both cases, the individual is released or discarded whole, i.e., no part of the organism is retained (Gilman et al. 2017).

Estimates of total annual discard levels in live weight (or number) by IOTC 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.

Catch and effort data

Catch and effort data refer to fine-scale data, usually from logbooks, reported in aggregated format and stratified per 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,m surface, longline, coastal gears). In addition, information on the use of fish aggregating devices (FADs) and activity of vessels that assist industrial purse seiners to locate tuna schools (support vessels) has also to be collected and reported to the Secretariat through IOTC form 3FA.

Size frequency data

Size frequency data correspond to individual body lengths or weights stratified by fleet, year, gear, type of school, month, grid and species. The IOTC Form 4SF includes all the mandatory fields requested for reporting size data to the Secretariat in agreement with IOTC Res. 15/02.

Observer data

Resolution 11/04 on a *Regional Observer Scheme* (ROS) makes provision for the development and implementation of national observer schemes among the IOTC CPCs, starting in July 2010 with the overarching objective of collecting *"verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence"*. The ROS aims to cover *"at least 5% of the number of operations/sets for each gear type by the fleet of each CPC while fishing in the IOTC Area of competence of 24 meters overall length and over, and under 24 meters if they fish outside their EEZs shall be covered by this observer scheme"*. Observer data collected as part of the ROS include: (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 (species composition and quantities, live and processed weight and location). A technical description of the ROS data requirements is available in Athayde & IOTC (2018).

Tagging data

Release and recovery data gathered in the framework of the Indian Ocean Tuna Tagging Programme (IOTTP), which encompass data gathered during the Regional Tuna Tagging Project – Indian Ocean (RTTP-IO) and data gathered during a series of small-scale tuna tagging projects in Maldives, India, Mayotte, Indonesia and by other institutions, e.g., the Southeast Asian Fisheries Development Center (SEAFDEC) and the National Research Institute of Far Seas Fisheries (NRIFSF), with the support of IOTC. In 2012, the data from past projects implemented in Maldives in the 1990s were added to the tagging database at the Secretariat.

Methods

The release of the curated public-domain data sets for yellowfin tuna is done following some processing data steps which are briefly summarized below.

Data processing

First, standard controls and checks are performed to ensure that the metadata and data submitted to the Secretariat are consistent and include all mandatory fields (e.g., dimensions of the strata, etc.). The controls depend on each type of data set and may require the submission of revised data from CPCs if the original one is found to be incomplete.

Second, a series of processing steps is applied to derive the best scientific estimates of nominal catches 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 (**Table 1**).

Table 1: List of species groups including yellowfin tuna

Species code	Name	Scientific name
TUN	Tunas nei	*Thunnini*
TUS	True tunas nei	*Thunnus spp*
TUX	Tuna-like fishes nei	*Scombroidei*
AG45	Albacore, yellowfin tuna and bigeye tuna	*Thunnus alalunga; Thunnus albacares; Thunnus obesus*
AG35	Yellowfin tuna and skipjack tuna	*Thunnus albacares; Katsuwonus pelamis*
AG45	Albacore, yellowfin tuna and bigeye tuna	*Thunnus alalunga; Thunnus albacares; Thunnus obesus*
TUN	Tunas nei	*Thunnini*

Third, and applying only to the five major IOTC species (albacore, bigeye tuna, skipjack tuna, swordfish, and yellowfin tuna), the geo-referenced catches are raised to the nominal catches (best scientific estimates) using available information and proxy data that combines expert knowledge with historical records, including size-frequency data to estimate catches in weight from catches in numbers. The resulting data set is comprised of catches in weight and number and stratified by year, month, fleet, gear, school type (when available) and 5x5 degrees grid, and covers the entire time series for which nominal catches of a given species are available. The mean weight of yellowfin tuna in the catch can be computed directly from the raised weights and numbers for each fishery. The accuracy of the results is directly proportional to the availability and quality of geo-referenced catch and size-frequency data.

Fourth, and applying to all 16 IOTC species plus the most common shark species, filtering and conversions are applied to the size-frequency data in order to harmonize their format and structure and remove data which are non compliant (at the source) with IOTC standards, e.g., because provided with size bins exceeding the maximum width considered meaningful for the species (IOTC 2020a).

Last, a specific process is applied to the tagging data collected for the three tropical tuna species, in particular to filter dubious records, correct for potential tag loss, and adjust for under-reporting of recaptures (IOTC 2020b).

Data quality

A scoring system has been designed to assess the quality of the nominal catch, catch-effort, and size-frequency data available at the Secretariat for all IOTC species. The determination of the score varies according to each type of data set and aims to account for reporting coverage and compliance with IOTC reporting standards (**Table 2**). Overall, the lower the score, the better the quality. It is to note that the quality scoring does not account for sources of uncertainty affecting the nominal catches such as under-reporting and misreporting.

Table 2: Key to IOTC quality scoring system

Data set	Criterion	By species	By gear
Nominal catch	Fully available	0	0
	Partially available	2	2
	Fully estimated	4	4
Catch and effort	Available according to standards	0	0
	Not available according to standards	2	2
	Low coverage (<30% logbooks)	2	
	Not available	8	
Size frequency	Available according to standards	0	0
	Not available according to standards	2	2
	Low coverage (<1 fish per ton caught)	2	
	Not available	8	

Results

Nominal catches

Historical trends (1950-2019)

Table 3: Best scientific estimates of nominal catches of yellowfin tuna by decade and fishery in metric tons (t) for the period 1950–2019. Data source: yellowfin tuna raised time-area catches

Fishery	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Purse seine | Other	0	4	143	1,170	2,185	3,590	7,222
Purse seine | FS	0	0	18	31,552	64,938	89,204	43,728
Purse seine | LS	0	0	17	17,597	56,278	61,890	90,214
Longline | Other	0	0	0	354	5,706	14,488	7,432
Longline | Fresh	0	0	615	4,286	47,612	34,150	20,482
Longline | Deep-freezing	21,990	41,352	29,589	33,824	66,077	56,671	17,702
Line | Coastal longline	168	1,262	1,771	3,489	6,161	11,107	27,874
Line | Trolling	1,005	1,822	4,194	6,850	11,485	13,429	17,679
Line | Handline	619	638	2,948	7,861	19,803	34,368	70,155
Baitboat	2,111	2,318	5,810	8,295	12,803	16,072	17,528
Gillnet	1,574	4,117	7,928	12,034	39,199	58,819	77,361
Other	80	189	310	674	1,133	1,746	2,566
Total	27,546	51,702	53,344	127,986	333,379	395,533	399,943

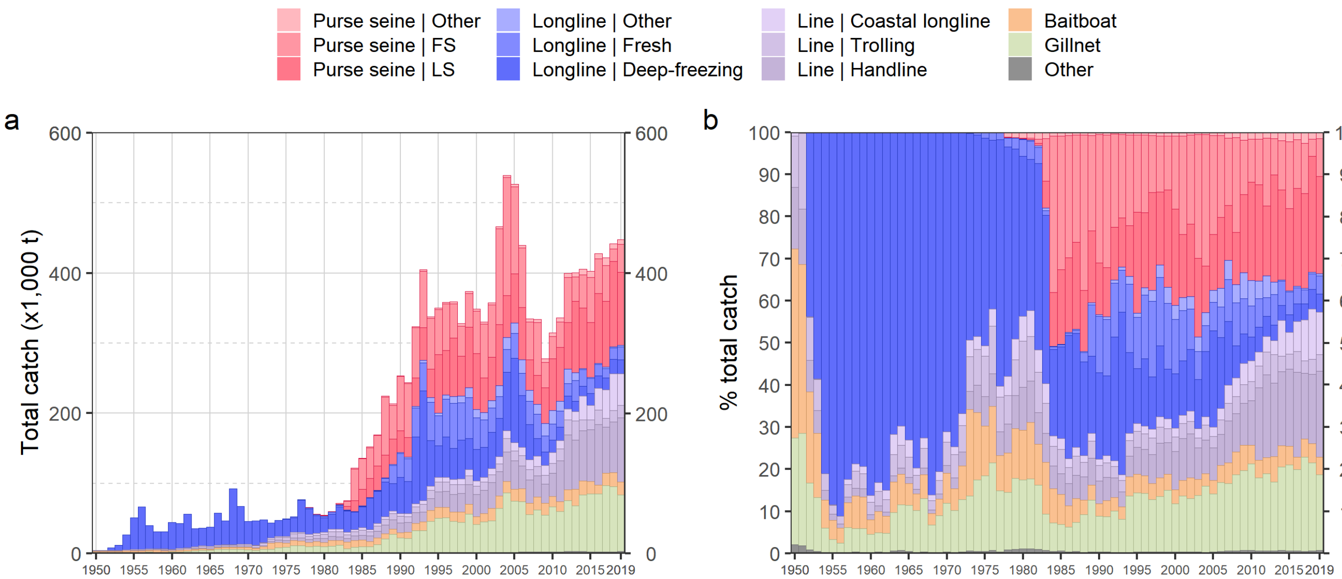

Figure 1: Annual time series of cumulative nominal absolute (a) and relative (b) catches of yellowfin tuna in metric tons (t) by fishery for the period 1950-2019. LS = schools associated with floating objects; FS = free-swimming schools. Data source: yellowfin tuna raised time-area catches

Table 4: Best scientific estimates of annual nominal catches of yellowfin tuna by fishery in metric tons (t) for the period 2010–2019. Data source: yellowfin tuna raised time-area catches

Fishery	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Purse seine | Other	5,317	5,516	5,479	6,235	8,323	9,102	7,390	10,855	7,145	6,856
Purse seine | FS	32,135	36,453	64,593	34,459	47,426	63,963	49,460	50,700	17,944	40,147
Purse seine | LS	73,383	76,659	66,166	101,898	86,417	78,395	99,268	94,479	121,699	103,774
Longline | Other	19,221	13,899	20,626	11,699	1,081	1,204	1,544	1,593	1,464	1,990
Longline | Fresh	23,240	22,709	17,808	28,981	23,763	21,987	16,749	13,915	16,506	19,159
Longline | Deep-freezing	17,863	19,814	18,849	15,028	14,523	16,608	17,740	16,482	20,687	19,430
Line | Coastal longline	15,470	11,255	15,167	13,245	34,072	20,866	30,484	40,560	52,555	45,072
Line | Trolling	14,115	17,359	21,379	27,320	15,096	14,150	21,135	12,728	15,767	17,742
Line | Handline	33,397	58,071	78,565	70,016	71,484	73,901	86,023	65,557	72,959	91,576
Baitboat	14,105	14,009	15,512	24,055	20,542	17,642	12,391	18,370	20,030	18,625
Gillnet	64,529	57,848	72,749	65,191	80,416	82,572	82,881	94,515	92,437	80,469
Other	2,355	2,318	2,744	2,748	2,839	2,397	2,484	1,994	2,626	3,161
Total	315,129	335,910	399,636	400,873	405,982	402,786	427,551	421,748	441,818	448,000

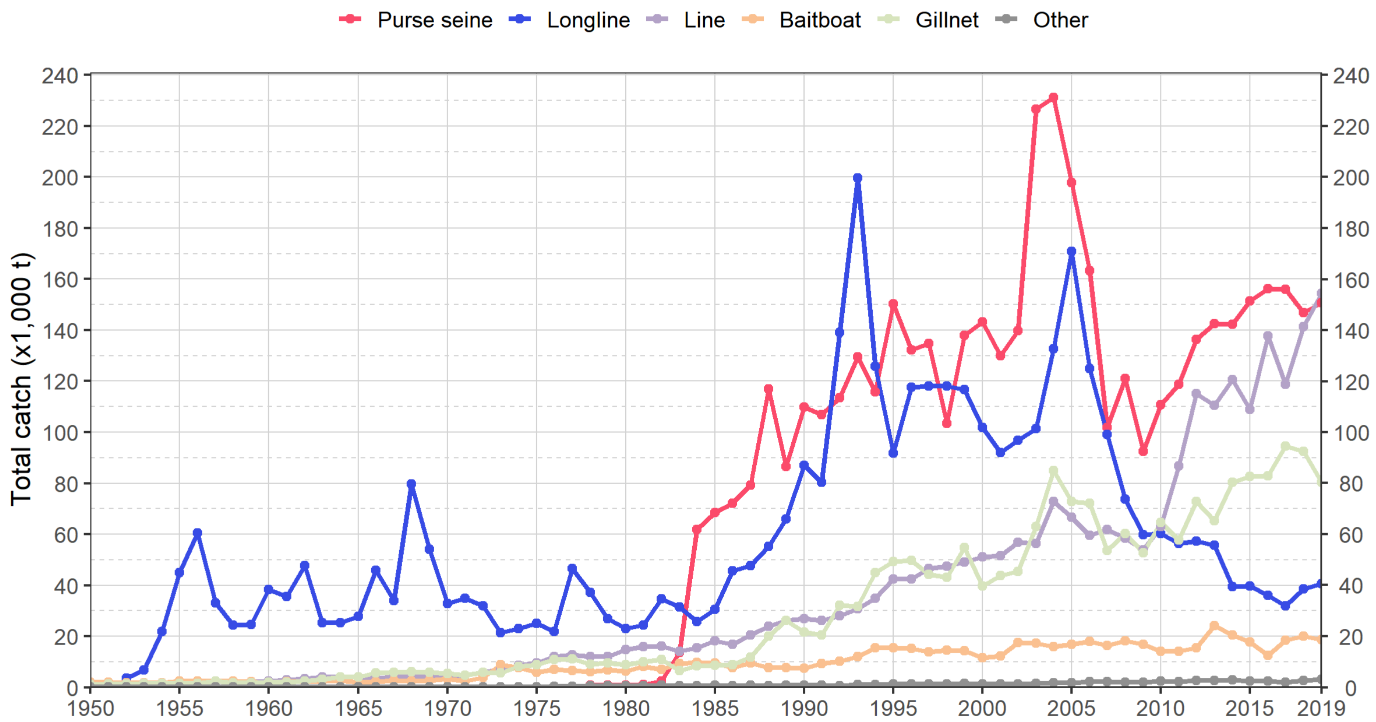

Figure 2: Annual time series of nominal catches of yellowfin tuna by fishery group in metric tons (t) between 1950 and 2019. Data source: latest best scientific estimate of nominal catches

Nominal catches of yellowfin tuna show an increasing trend over the last seven decades with some variability between years. The total catches showed a slow increase between the mid-1950s and early 1980s, ranging between 30,000 t and 70,000 t, with longliners and gillnetters as the main fisheries (**Table 3** & **Figs. 1-2**).

Catches increased rapidly in the early 1980s with the arrival of the purse seiners and increased activity of longliners and other fleets, reaching over 400,000 t by 1993 (**Figs. 1-2**). Exceptionally high catches were recorded between 2003 and 2006 – with the highest catches ever recorded in 2004 at over 525,000 t – while catches of bigeye tuna which are generally associated with the same fishing grounds as yellowfin tuna remained at average levels.

Between 2007 and 2011 catches dropped considerably (to around 40%, compared to 2004 levels) as longline fishing effort in the western Indian Ocean was displaced eastwards or reduced due to the threat of piracy in areas close to the EEZ of Somalia. Catches by purse seiners also declined over the same period – albeit not to the same extent as longliners – due to the presence of security personnel onboard purse seine vessels of the EU and Seychelles, which has enabled fishing operations to continue.

Since 2012, catches have steadily increased from 400,000 t to an average of 430,000 t between 2015 and 2019, and a maximum close to 450,000 t in 2019 (**Table 4**). Furthermore, catch levels of about 440,000 t reported for 2018 might be under-estimated (to some extent) because of changes in data processing methodology confirmed by EU,Spain for its purse seine fleet for that year (IOTC 2019a).

Contrary to other oceans, the artisanal fishery component of yellowfin catches in the Indian Ocean has always been substantial, accounting annually for more than 40% of the total catches from the mid-1970s to the early 1980s and since 2007. Between 2015 and 2019, the mean annual catches of artisanal fisheries were close to 200,000 t (47% of total catches) when the industrial fisheries caught more than 227,000 t every year (**Fig. 3**).

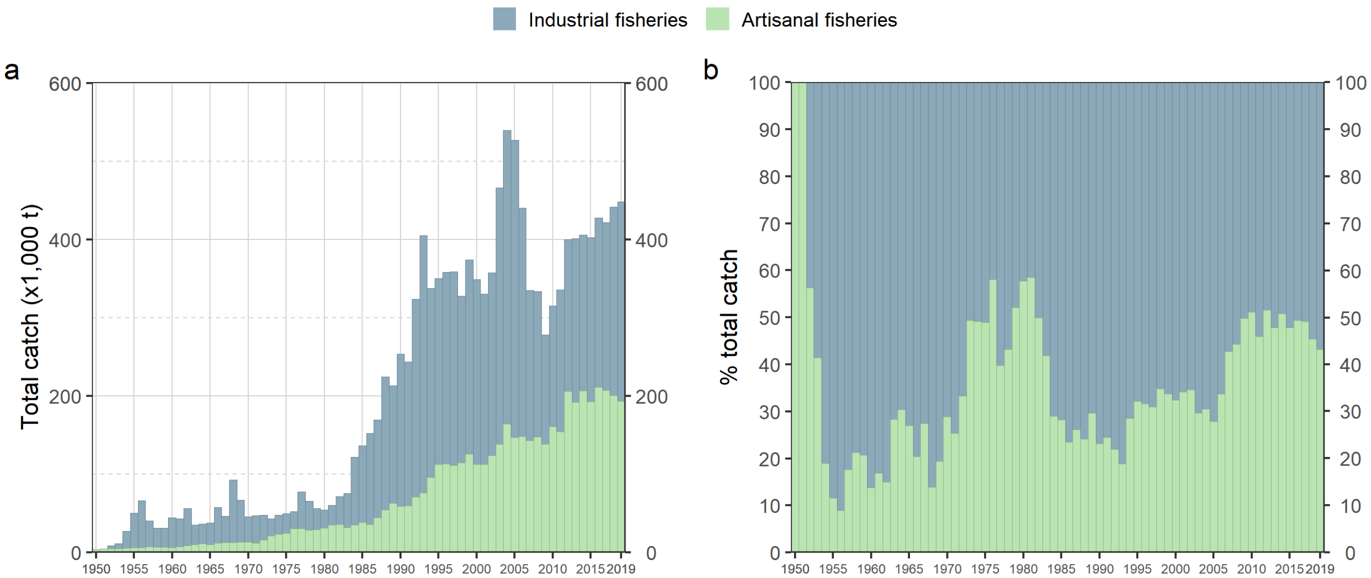

Figure 3: Annual time series of cumulative nominal absolute (a) and relative (b) catches of yellowfin tuna by type of fishery in metric tons (t) for the period 1950-2019. Data source: [latest best scientific estimate of nominal catches]

Regarding purse seine fisheries, historical captures of yellowfin tuna by fishing mode showed a general increasing trend in percentages of catches from log-associated schools from 2004 onward, accompanied by yearly fluctuations on the relative percentages of the two fishing modes, which can vary of up to 20% between two consecutive years. Regarding the main component flags of the EU purse seine fleet, EU,France appears to have generally relied less on catches from log-associated schools, to the point that the percentage over total yellowfin tuna catches for the flag exceeded 60% only in 2011 and from 2017 onwards. On the contrary, EU,Spain as well as Seychelles regularly reported over 60% of their yellowfin tuna catches from log-associated schools since 2009. Between 2015 and 2019, catches from all purse seine fleets combined showed a fluctuation between ~55% and ~90% in the fraction of catches from log-associated schools. Almost 90% of yellowfin tuna catches caught with purse seine came from log-associated schools in 2018 and more than 70% in 2019 (**Fig. 4**).

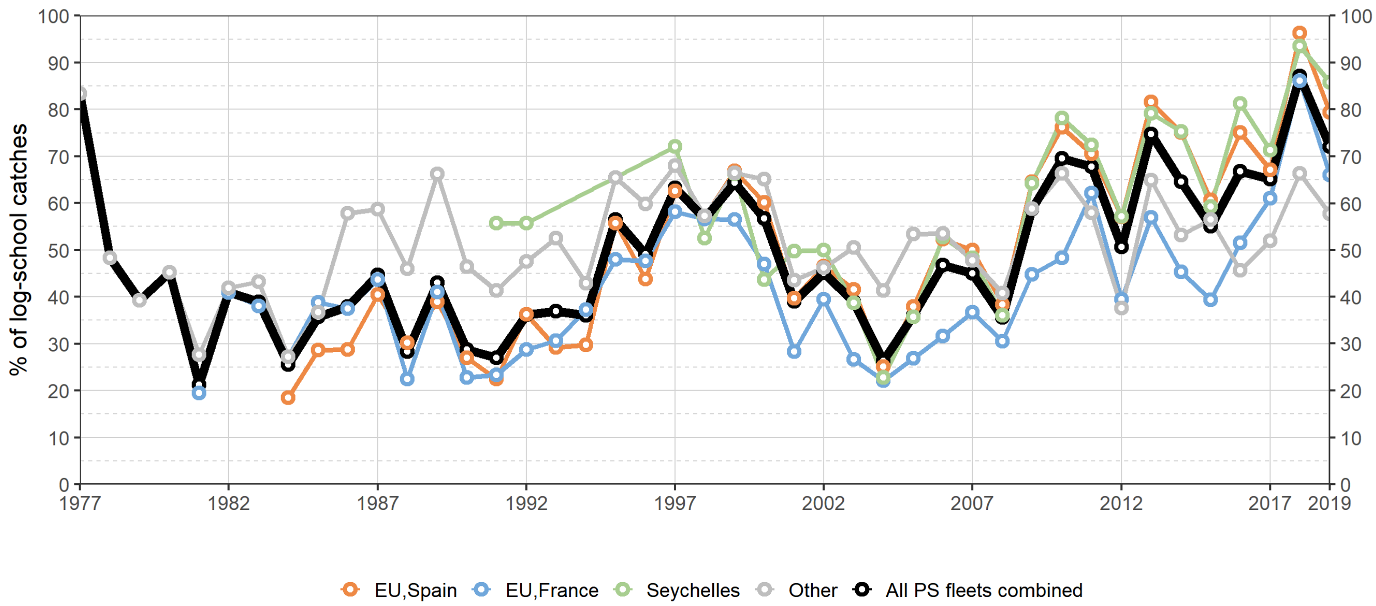

Figure 4: Annual percentages of purse seine log-associated catches of yellowfin tuna by fleet between 1977 and 2019. *Other* includes purse seine fleets such as ex-Soviet Union, I.R. Iran, France (Mayotte), Mauritius, Japan, Korea, Indonesia, Thailand, EU,Italy, Belize and others. Data source: latest time-area catch dataset for purse-seine fisheries (Res. 15/02)

Main fishery features (2015-2019)

Table 5: Mean annual catches of yellowfin tuna by fishery in metric tons (t) between 2015 and 2019. LS = schools associated with floating objects; FS = free-swimming schools. Data source: yellowfin tuna raised time-area catches

Fishery	Fishery code	Catch	Percentage
Purse seine | LS	PSLS	99,523	23.2
Gillnet	GN	86,575	20.2
Line | Handline	LIH	78,003	18.2
Purse seine | FS	PSFS	44,443	10.4
Line | Coastal longline	LIC	37,907	8.8
Longline | Deep-freezing	LLD	18,189	4.2
Longline | Fresh	LLF	17,663	4.1
Baitboat	BB	17,412	4.1
Line | Trolling	LIT	16,305	3.8
Purse seine | Other	PSOT	8,270	1.9
Other	OT	2,532	0.6
Longline | Other	LLO	1,559	0.4

Yellowfin tuna is caught by a large diversity of fisheries from many fleets operating all over the Indian Ocean. Between 2015 and 2019, purse seine fisheries caught annually more than 150,000 t of yellowfin tuna, contributing to

36% of the total nominal catches (**Table 5**). During the same period, line fisheries in coastal areas represented the second main contributor of yellowfin tuna catches, with about 78,000 t caught annually by handline, 38,000 t by coastal longline, and 16,000 t by trolling.

Between 2015 and 2019, gillnet fisheries represented 20% of the recent catches with more than 85,000 t caught annually. Industrial longline and baitboat fisheries represented less than 9% and about 4% of the yellowfin tuna catches, respectively (**Table 5 & Fig. 2**).

In recent years (2015-2019), average annual catches of yellowfin tuna have been shared between several CPCs, to the point that around 80% of all annual catches is accounted for by nine distinct fleets (with I.R. Iran, Maldives, EU,ESP and Seychelles reaching, or getting close to, 10% of average annual catches each) (**Fig. 5**)

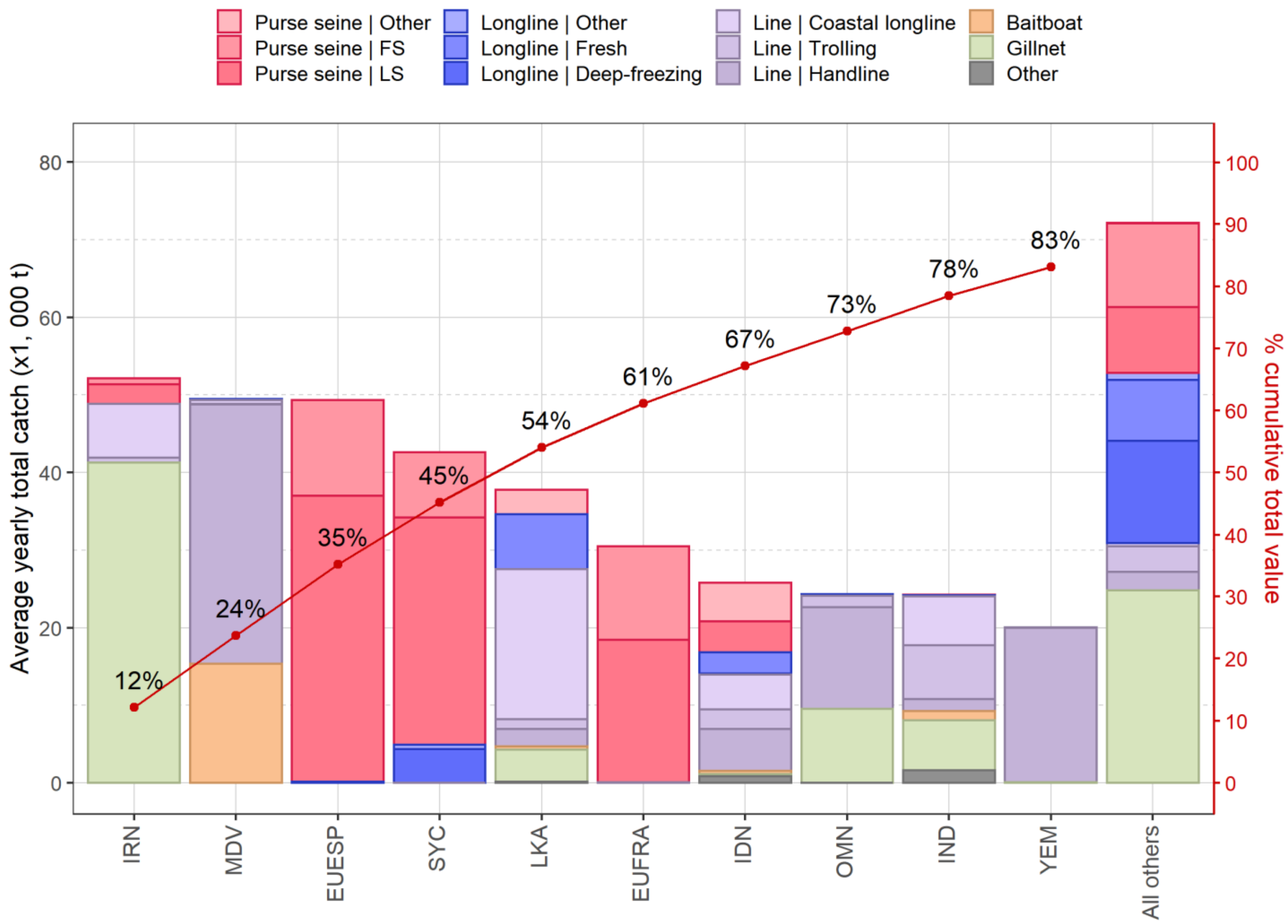

Figure 5: Mean annual catches of yellowfin tuna by fleet and fishery in metric tons (t) between 2015 and 2019, with indication of cumulative catches by fleet. LS = schools associated with floating objects; FS = free-swimming schools. Data source: yellowfin tuna raised time-area catches

Catch trends by fishery group in the same period (2015-2019) show a slight decrease in catches from purse seiners since 2015, a relatively stable trend in catches from longliners and baitboats (as well as from vessels using all other gears), a return to 2015 catch levels for gillnetters after two years of higher-than-average catches and a marked increasing trend in catches reported from line fisheries, that in 2019 recorded the peak in catches since the beginning of the period considered (**Fig. 6**).

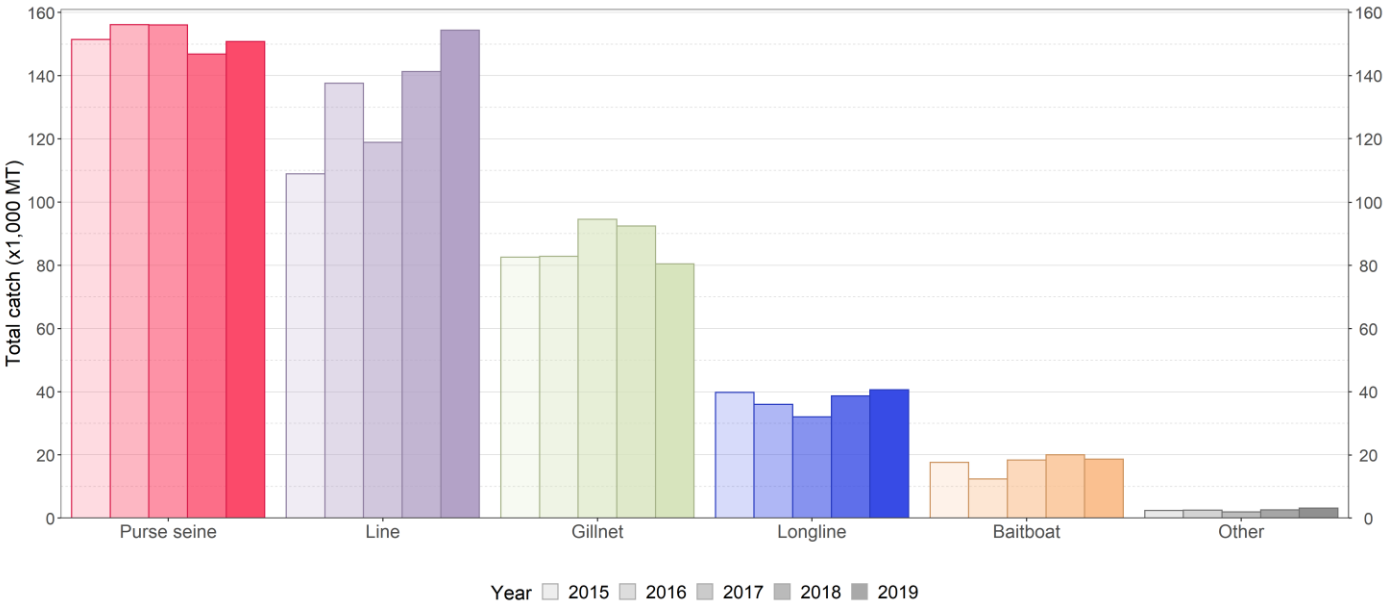

Figure 6: Annual catch trends of yellowfin tuna by fishery group in metric tons (t) between 2015 and 2019. Data source: [latest best scientific estimate of nominal catches]

Regarding purse seines, recent catch trends show that all the major fleets (EU,Spain, Seychelles and EU,France) have decreased their catch levels since 2015, with the only notable exception to this trend being Indonesia and Mauritius (aggregated under *All others*) which rank fourth and fifth respectively, in terms of total catches of yellowfin tuna in the period considered, and whose catches increased sensibly compared to 2015 levels (**Fig. 7a**).

Recent longline catch trends by fleet also show a mixed situation when focusing on the key fleets: while Taiwanese and Japanese longliners have maintained (or decreased) their yellowfin tuna catch levels since 2015, catches reported by Sri Lanka and Seychelles have increased consistently in the last five years. All other longline fleets have reported relatively stable catch levels in the period concerned (**Fig. 7b**).

Fleets using line or assimilated gears (handline, troll-line, coastal longlines) show a generally increasing trend in catch levels since 2015, with the only notable exception of Maldivian handlines which appear to be facing a contraction phase. Sri Lanka and India are among the main fleets whose catches of yellowfin tuna from their line fisheries increased sensibly during the last five years, as is also the case for all other line fleets combined (**Fig. 7c**).

Regarding the latter, the contribution to the increased catch levels for all the fleets aggregated as *All others* is mostly due to catches reported by handliners of Oman and by coastal longliners of I.R. Iran, which entered since a few years a transition phase during which the country expects to replace gillnets with coastal longlines.

Finally, catch trends for baitboat and gillnet fisheries (as well as fleets using all other gears) show a relatively stable situation over the last five years, with the only exception of Pakistani gillnetters that reported a marked decrease in catches since 2017 (**Fig. 7d-f**).

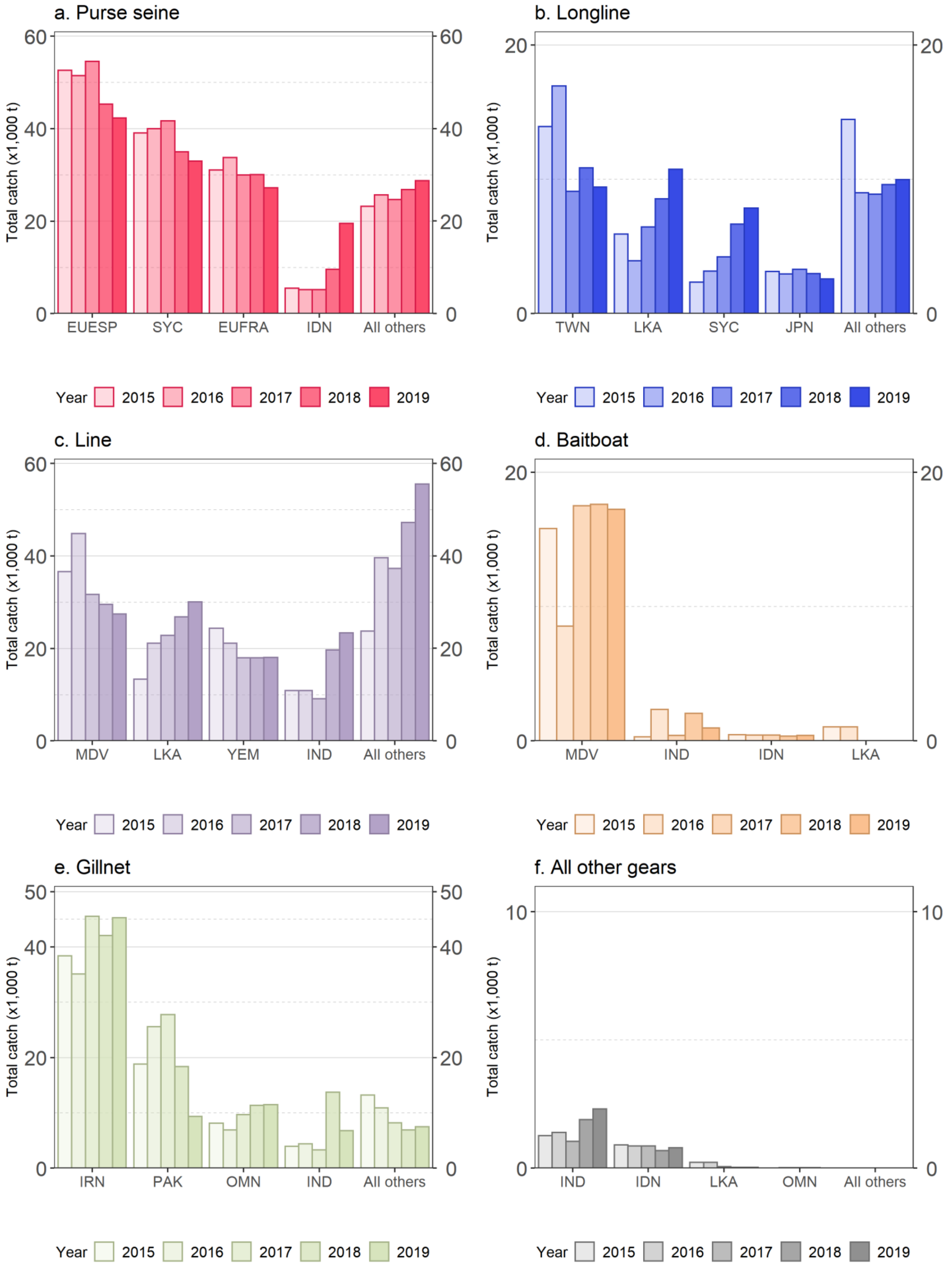

Figure 7: Annual catch trends of yellowfin tuna by fishery group and fleet in metric tons (t) between 2015 and 2019. Data source: [latest best scientific estimate of nominal catches]

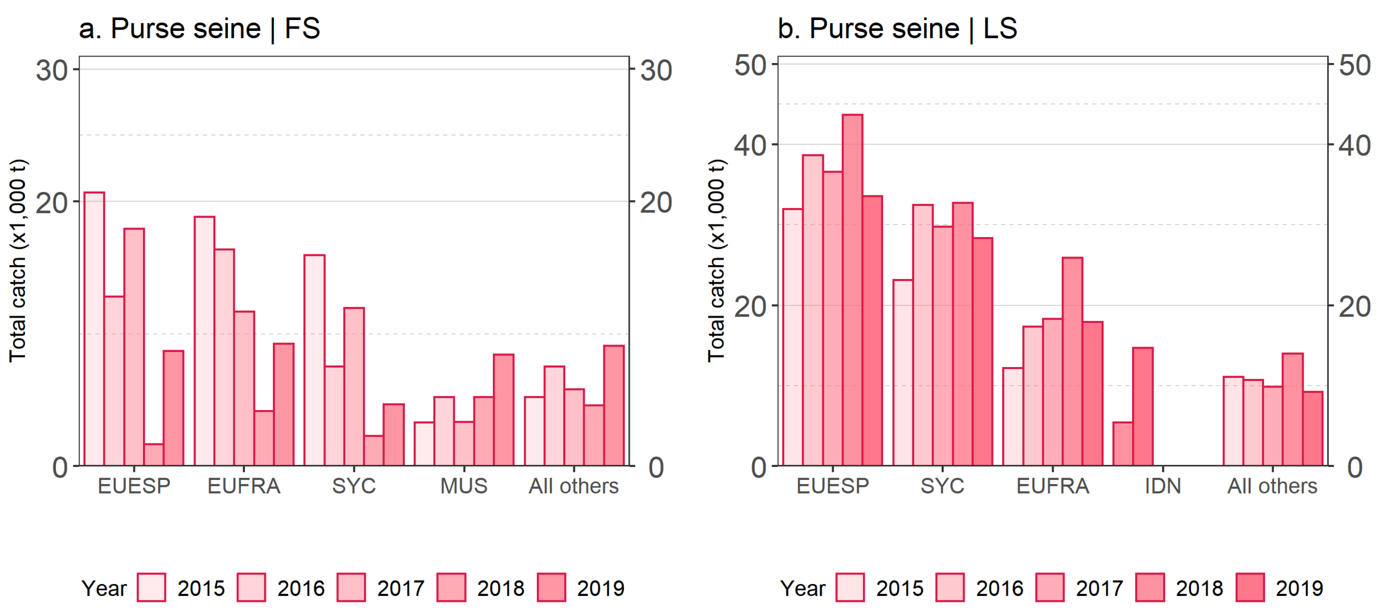

Figure 8: Annual purse seine catch trends of yellowfin tuna by fishing mode and fleet in metric tons (t) between 2015 and 2019. LS = schools associated with floating objects; FS = free-swimming schools

Changes from previous WPTT

Some changes occurred in the time series of catches of yellowfin tuna since the last release of the data set of best scientific estimates of nominal catches, representing an overall change of 28,000 t over the period 1950-2019 (**Fig. 9**). The main changes are an addition of about 1,000 t and 21,000 t of catches for the years 2018 and 2019, respectively, while small decreases in catches occurred for the period 2007-2017. The change observed in 2018 is due to an update of the catches of the Seychelles deep-freezing longline fishery. For 2019, the changes are due to:

i. revisions made to the catches for all Indonesian fisheries;

ii. final versions of the data for the longline fisheries of Japan and Seychelles; iii.late submissions of data for the purse seine fishery of EU,Italy, the gillnet and line fisheries of Comoros, and the longline fisheries of Kenya and Tanzania.

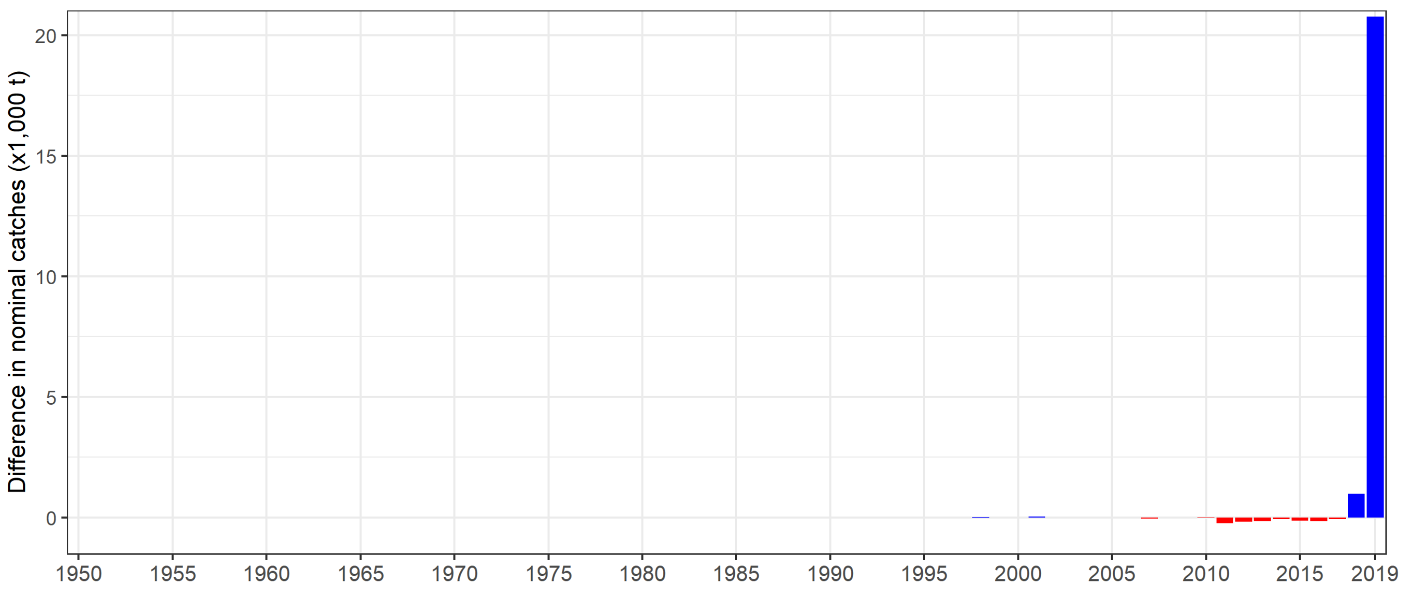

Figure 9: Differences in nominal catches of yellowfin tuna in metric tons (t) between the Data Preparatory meeting of the 23rd session of the WPTT and the 22nd session of the WPTT held in October 2020

Indonesia submitted three different data sets of nominal catches of yellowfin tuna for 2019, using the IOTC form 1RC in June and December, and through their national report (**Fig. 10**). The catches increased substantially for all fisheries between the forms submitted in June and December, e.g. from about 7,200 t to 16,400 t for purse seine and from 2,600 t to 4,260 t for longline. The data were overall consistent between the form and national report in December 2020, with the latter including an additional catch of about 1,000 t. Consequently, the estimates of yellowfin tuna made by the Secretariat increased from the previous WPTT by 12,000 t, with purse seine being the main fishery group affected (+9,767 t).

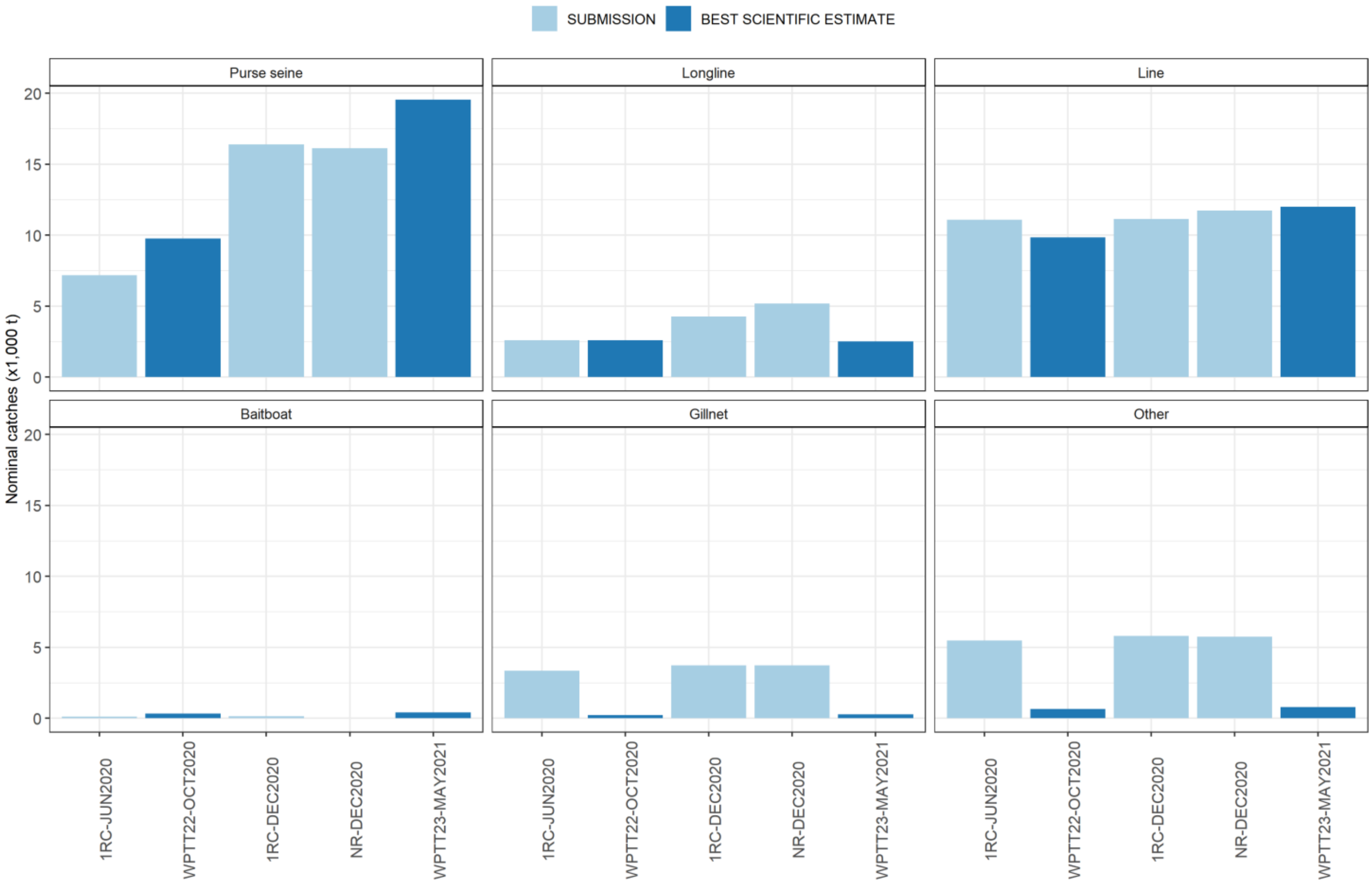

Figure 10: Differences in reported and estimated yellowfin tuna nominal catches in metric tons (t) for the various fisheries of Indonesia between June 2020 (data submission cycle) and May 2021 (WPTT23DP)

Uncertainties in nominal catch data

The overall quality of the nominal catches of yellowfin tuna shows some large variability between 1950 and 2019 (**Fig. 11**). In some years, a large portion of the nominal catches of yellowfin tuna had to be estimated through the breakdown of catches reported using species or gear aggregates. The data quality was particularly poor between 1994 and 2002 when less than 70% of the nominal catches were fully or partially reported, with most reporting issues coming from coastal fisheries. The quality has steadily improved over the last decade, to the point that around 83% of the catches was fully available from CPC submissions in 2019. Nevertheless, more than 35,000 t of nominal catches of yellowfin tuna (8% of the total catches) were scored between 6 and 8 and required to be mostly estimated by the Secretariat. In particular, the handline catches of Yemen were repeated from previous years at levels of about 18,000 t, based on information retrieved from the FAO global capture production database. Also, catches from the coastal longline fishery of India and gillnet fisheries of Tanzania and Pakistan contributed the most to the catch estimates.

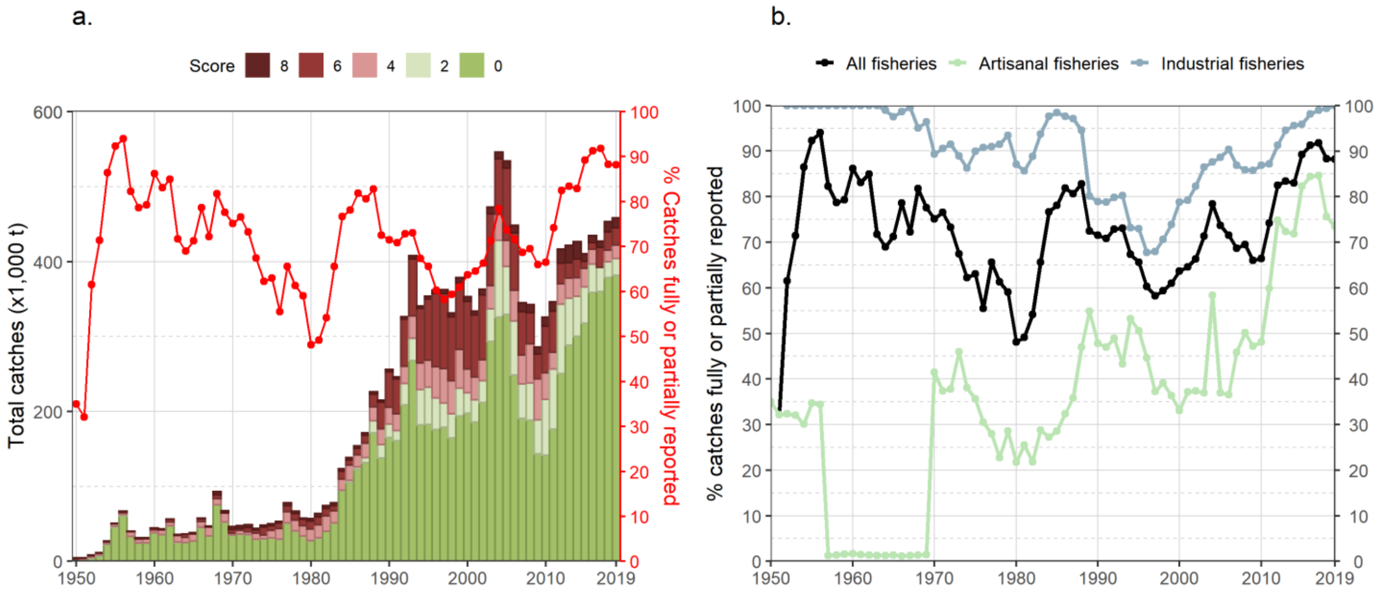

Figure 11: Annual nominal catches of yellowfin tuna in metric tons (t) estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950–2019

Some important issues have been identified in the past to affect the time series of nominal catches of yellowfin tuna:

- Coastal fisheries of Indonesia, Madagascar, Yemen, and Sri Lanka (other than gillnet/longline): the nominal catches of yellowfin tuna for these fisheries have been estimated by the IOTC Secretariat in recent years (until 2014 for Sri Lanka). The quality of the estimates is thought to be very poor due to the lack of information available about the artisanal fisheries operating in these countries;
- Drifting gillnet fishery of Pakistan: revised catch series spanning the period 1987-2018 have been officially endorsed by the 22nd session of the Scientific Committee, and are now included in the IOTC database. These revised catch series resulted in increased catches of yellowfin tuna by more than 6,200 t each year between 1987 and 2018. There are large uncertainties around the estimates (IOTC 2019b);
- Gillnet fishery of Tanzania: catches have been repeated since 2014 in absence of information;
- Purse seine fishery of EU,Spain: changes introduced in the methodology used to estimate the species composition of the catch for 2018 resulted in figures largely contrasting with other segments of the same fleet (IOTC 2019a). To date, no official revision for the catches reported by the EU purse-seine fishery in 2018 has been received by the IOTC Secretariat while the species composition for 2019 seems to have returned to levels comparable to 2017 and previous years;
- Longline fishery of Indonesia: no report of catches for national longliners that are not based in Indonesia (e.g., Port Louis, Mauritius).

Discard levels

The total amount of yellowfin tuna discarded at sea remains unknown for most fisheries and time periods despite the obligation to report these data as per IOTC Res. 15/02. Furthermore, and except for very specific situations (i.e., the fish caught is considered unfit for human consumption or there is insufficient storage capacity following the final set of a trip), all tropical tunas caught with purse seine have to be retained onboard since 2013 (IOTC Res. 19/05).

Discarding of tropical tunas is thought to be small in coastal fisheries and negligible in baitboat fisheries (Miller et al. 2017). Besides, data collected by observers at sea have shown that the level of discarding of tropical tunas is low in the Indian Ocean purse seine fishery, and to mostly occur in schools associated with floating objects (Amandè et al. 2012). Purse seine discards of yellowfin tuna are mainly composed of fish smaller than 50 cm (~1.3 kg) although a few larger fish may be discarded when damaged (**Fig. 12**). Estimates for the main component of the Indian Ocean purse seine fleet showed they amount to a few hundred tons annually (Ruiz et al. 2018).

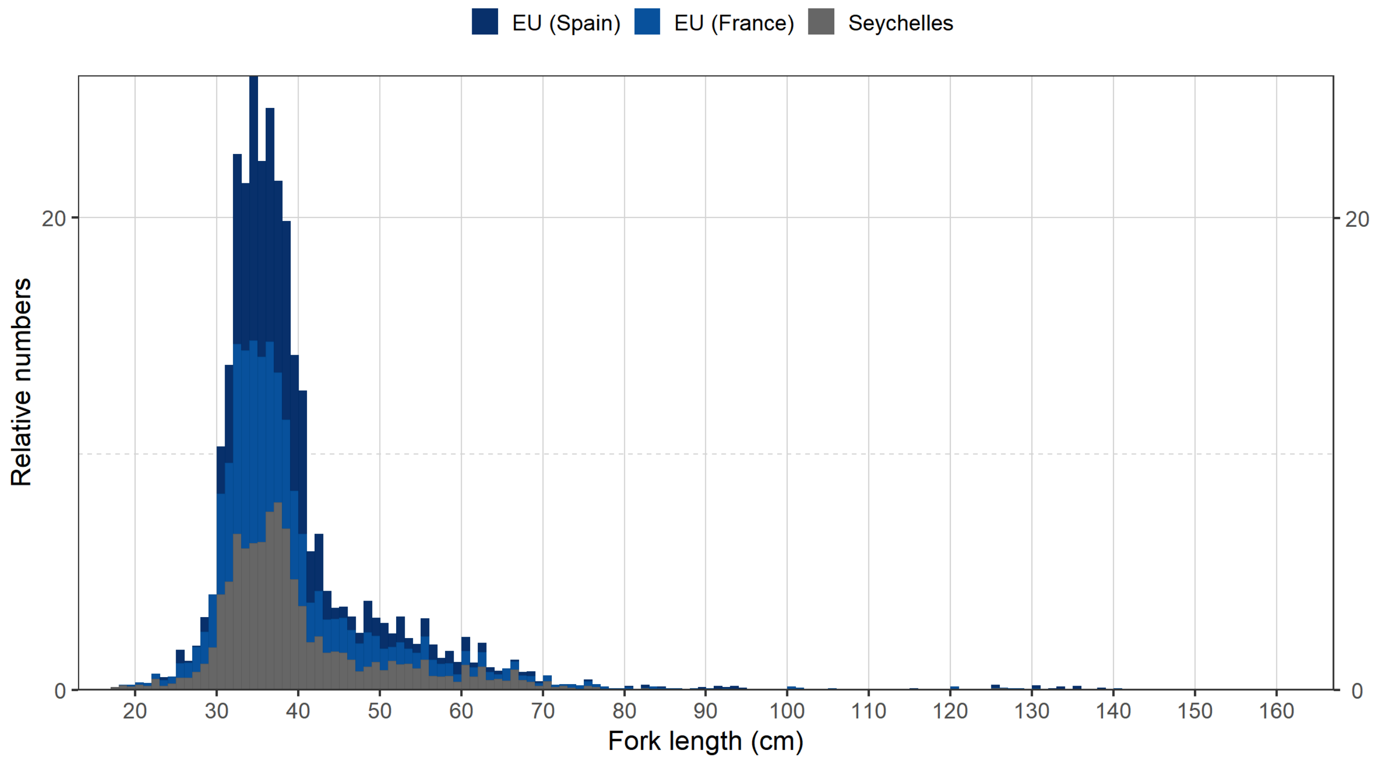

Figure 12: Fork length distribution of yellowfin tuna discarded at sea in purse seine fisheries during the period 2014-2019 (n = 82,172). Data source: IOTC ROS database

Discarding may also occur in tropical longline fisheries, mainly due to depredation by sharks and cetaceans (Rabearisoa et al. 2018). In the Taiwanese longline fishery of the Indian Ocean for instance, the discarding rate of yellowfin tuna has been estimated at 0.42% in the fleet targeting yellowfin tuna and 3.43% in the fleet targeting bigeye tuna during 2004-2008 (Huang & Liu 2010).

There is currently little information in the ROS database on discarding practices in longline fisheries except for a small sample of fish observed in French and Japanese longliners during 2009-2018. The data show no clear pattern in the size of the yellowfin tunas discarded at sea (since the depredation process might not be size-selective) although the discards in the Reunion-based fresh longline fishery are smaller than in the Japanese deep-freezing longline fishery, i.e. a median of 63.5 cm vs. 94.5 cm (**Fig. 13**). Recently, the practice of high grading in longline fisheries has been suggested to occur in some pelagic longline fisheries operating in the South of the Indian Ocean. Preliminary analysis conducted on size data of retained yellowfin tuna caught in Indian Ocean longline fisheries does not seem to support the hypothesis of major changes in discarding practice, e.g. linked to high grading in relation with the implementation of Res. 17/01 (Medley et al. 2021).

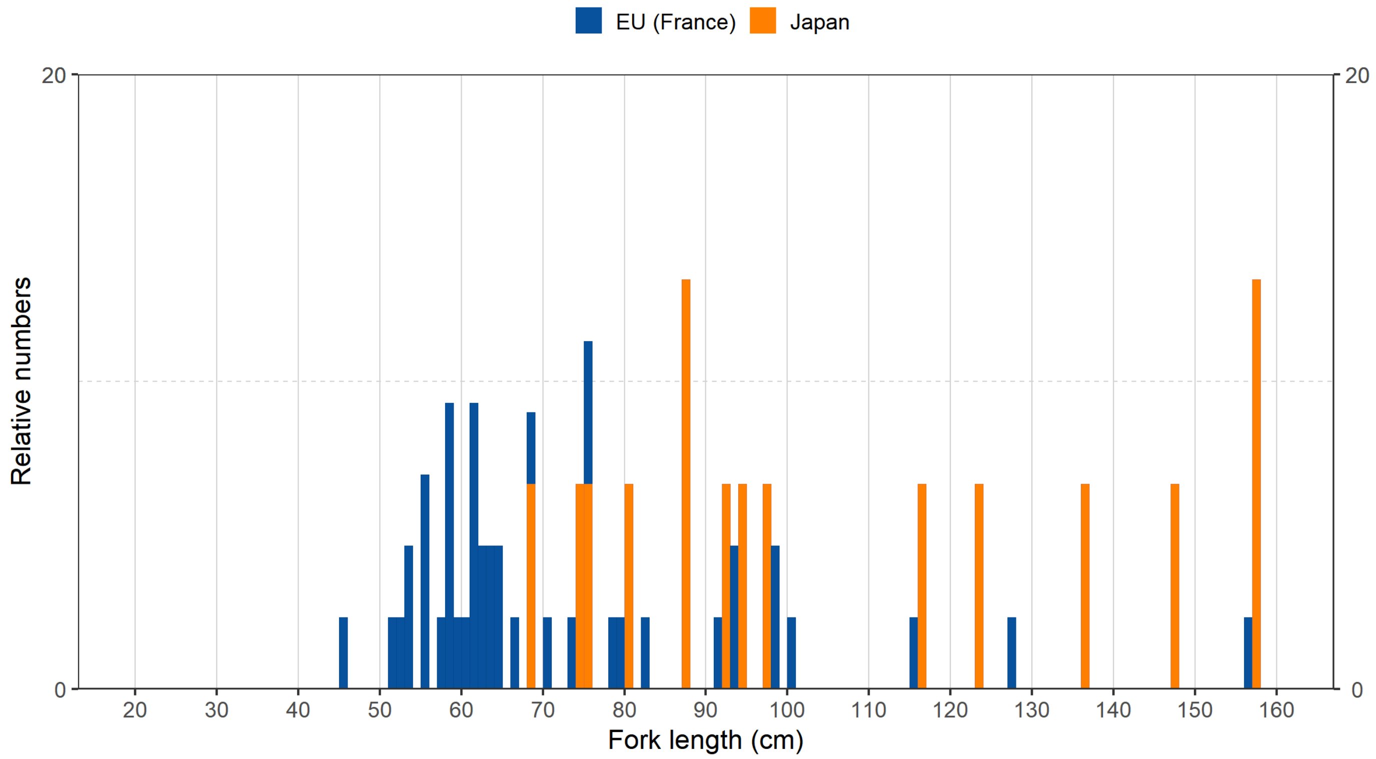

Figure 13: Fork length distribution of yellowfin tuna discarded at sea in longline fisheries during the period 2009-2018 (n = 232). Data source: IOTC ROS database

Overall, more data on discards collected from observers at sea are required to better assess the extent and variability of discarding practices in Indian Ocean longline fisheries. The IOTC Secretariat acknowledges that several of the CPCs currently submitting ROS trip reports have all the information and the technical knowledge to provide the original scientific data in a format more suitable for incorporation in the ROS database, and therefore the Secretariat is seeking active collaboration from all concerned CPCs to ensure that new and historical ROS data could be properly submitted and used for further analysis.

Geo-referenced catches

Spatial distribution of catches

Estimated geo-referenced catches show the spatial expansion and major changes that took place in the fisheries targeting yellowfin tuna over the last decades (**Fig. 14**). As early as the 1950s, yellowfin tuna was caught by large-scale longline fisheries across most of the Indian Ocean while coastal gillnet and line fisheries were active in the Arabian Sea and baitboats in the Maldives and off the south-western coast of India.

Throughout the 1960s and 1970s, the longline fisheries expanded in the south-western part of the Indian Ocean, including in the Mozambique Channel (**Fig. 14b-c**). From the 1980s, the purse seine fishery developed in the western Indian Ocean, with a majority of the yellowfin tuna caught in free-swimming schools (**Fig. 14d**).

During the 1990s and 2000s, the purse seine fishery increased its catches and expanded its fishing grounds in the western Indian Ocean while the coastal fisheries of the northern countries of the Indian Ocean grew substantially in importance and a large fresh longline fishery developed in the north eastern Indian Ocean (**Fig. 14e-f**).

The overall annual distribution of yellowfin tuna catches by fishery has changed little over the period 2014-2019 (**Fig. 15**). Most yellowfin tuna catches are located in the central and western Indian Ocean, with important catches also reported around Sri Lanka and along the coasts of Indonesia. Purse seine largely dominates in the western Indian Ocean around the Seychelles archipelago (between 20°S and 10°N), and the fishery showed an expansion towards the north between 2014 and 2019.

Georeferenced catches by fishery and decade (1950-2009)

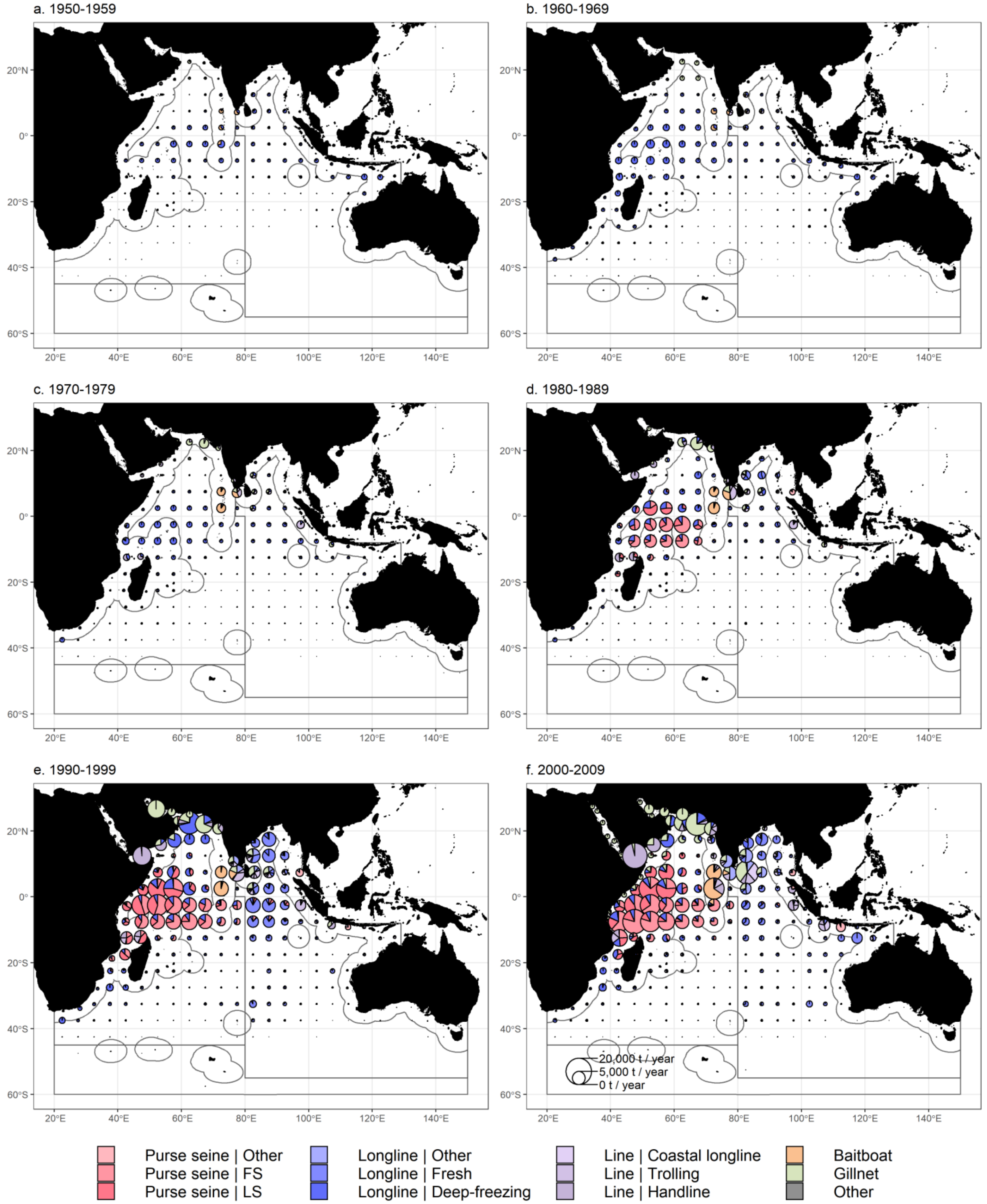

Figure 14: Estimated average annual time-area catches of yellowfin tuna in metric tons (t) / year, by decade, 5x5 grid and fishery. Data source: yellowfin tuna raised time-area catches

Georeferenced catches by fishery, last decade (2010-2019) and years (2015-2019)

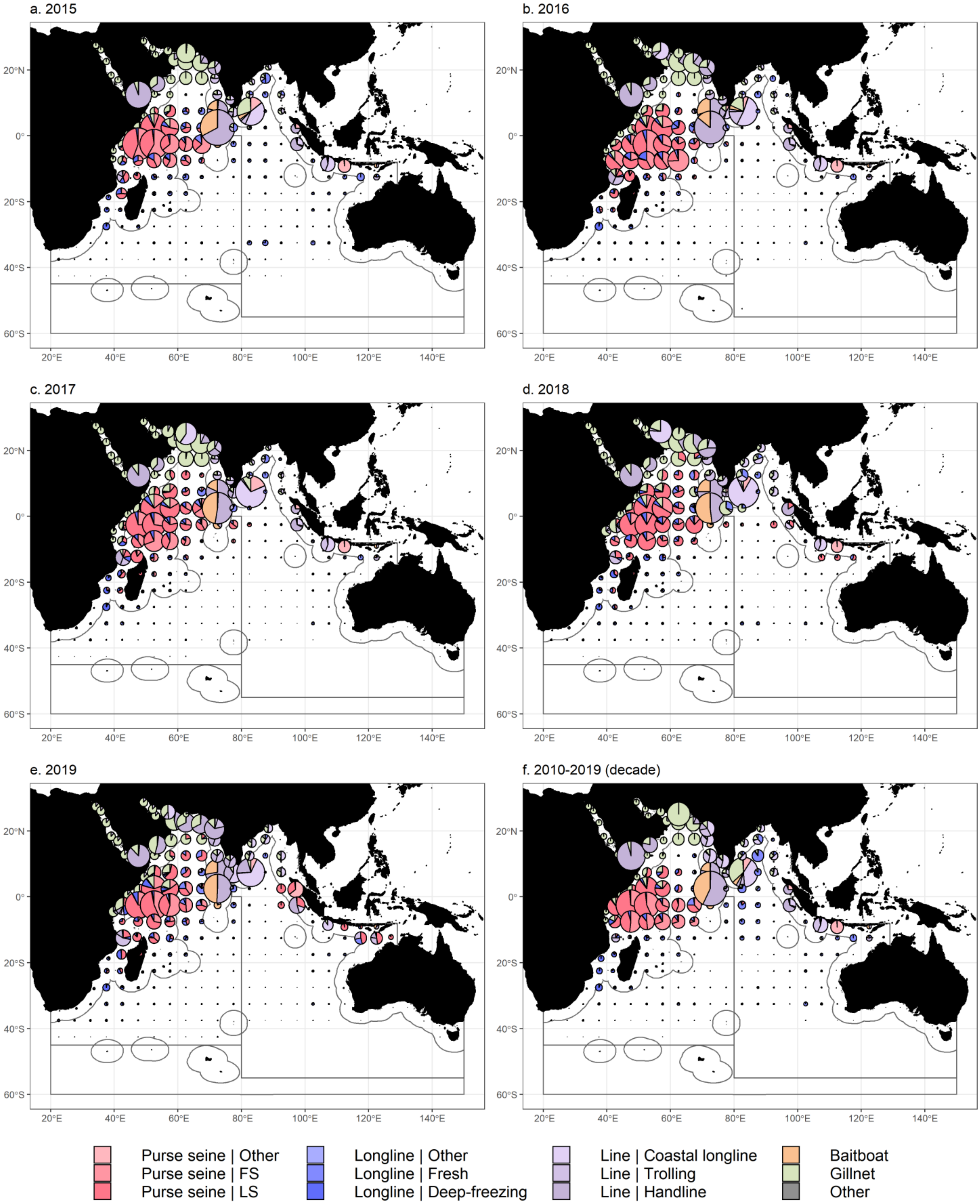

Figure 15: Estimated average annual time-area catches of yellowfin tuna in metric tons (t) / year, by year / decade, 5x5 grid and fishery. Data source: yellowfin tuna raised time-area catches

Indonesia appears to have developed an industrial purse seine fishery since 2018 (**Fig. 15d-e**), which mainly operates in coastal areas of the eastern Indian Ocean with vessels of LOA between 30 m and 40 m. Baitboat fishing is essentially concentrated in the Maldives archipelago while gillnet and line fisheries (handline, trolling and coastal longline) are widely used along the coasts of Yemen, Oman, Pakistan, India, Sri Lanka, and Indonesia.

Uncertainties in catch-and-effort data

Catch-and-effort series are available for most industrial fisheries and some important artisanal fisheries. However, for many artisanal fisheries, these data are either not available or are considered to be of poor quality. Consequently, the trend in quality of the catch-effort data is driven to some extent by the relative contribution of artisanal fisheries to the total catches of yellowfin tuna (**Fig. 16b**). The main issues identified in the past concern:

- the fresh-tuna longline fishery of Taiwan,China, for which data have only been available since 2006, and the fresh-tuna longline fishery of Indonesia, with data only available from 2018 onward (although logbook coverage is thought to be low);
- the gillnet fisheries of I.R. Iran (before 2007) and Pakistan, for which data are either incomplete or lacking;
- the gillnet-longline fishery of Sri Lanka (until 2014), described by poor quality effort data;
- important coastal fisheries using hand and/or troll lines, in particular: Oman, Yemen, Madagascar, India, and Indonesia (until 2018), for which no data (or incomplete data) have been reported to the Secretariat.

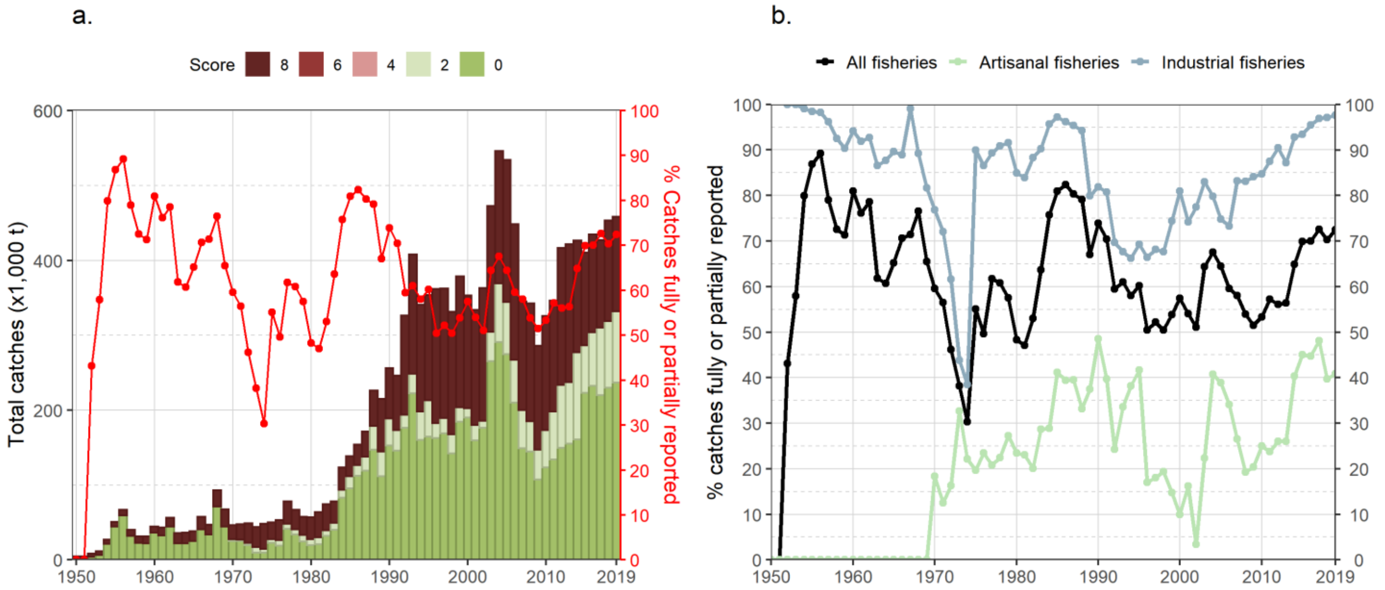

Figure 16: Annual nominal catches (t) of yellowfin tuna estimated by quality score (barplot) and percentage of geo-referenced catches reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950–2019

The percentage of data considered of good quality (scores of 0-2) varied between 50%-70% during the 1990s and 2000s, and has stabilized over the last decade showing an increasing trend from 51% in 2009 to 72% in 2019 (**Fig. 16a-b**). In particular, catch-effort data have progressively become available for some important fisheries such as coastal and fresh longline as well as hand line from Sri Lanka since 2014, coastal longline from I.R. Iran since 2016, small-scale purse seine and fresh longline from Indonesia since 2018, and some smaller fisheries such as trolling from Indonesia and hand line from Kenya since 2018.

Nevertheless, geo-referenced catch-effort data were not available for about 30% (i.e. more than 125,000 t) of the total nominal catches of yellowfin tuna in 2019. In particular, no information was available for several major coastal fisheries, in particular:

- the handline fisheries of Oman (~25,000 t), Yemen (~18,000 t), and India (~5,700 t);

- the gillnet fisheries of Oman (~11,500 t), Pakistan (~9,300 t), India (~6,800 t), and Tanzania (~3,800 t);
- the coastal longline and trolling fisheries of India.

In addition, no spatial information has been provided by a few industrial purse seine fisheries such as EU,Italy (since 2016) and I.R. Iran (since the beginning of the time series), with the two fleets accounting in 2019 for relatively low total catch levels of yellowfin tuna of ~2,300 t and ~3,400 t, respectively.

Size distribution and estimated weights

Temporal patterns and trends in size distributions

Industrial purse seine fisheries

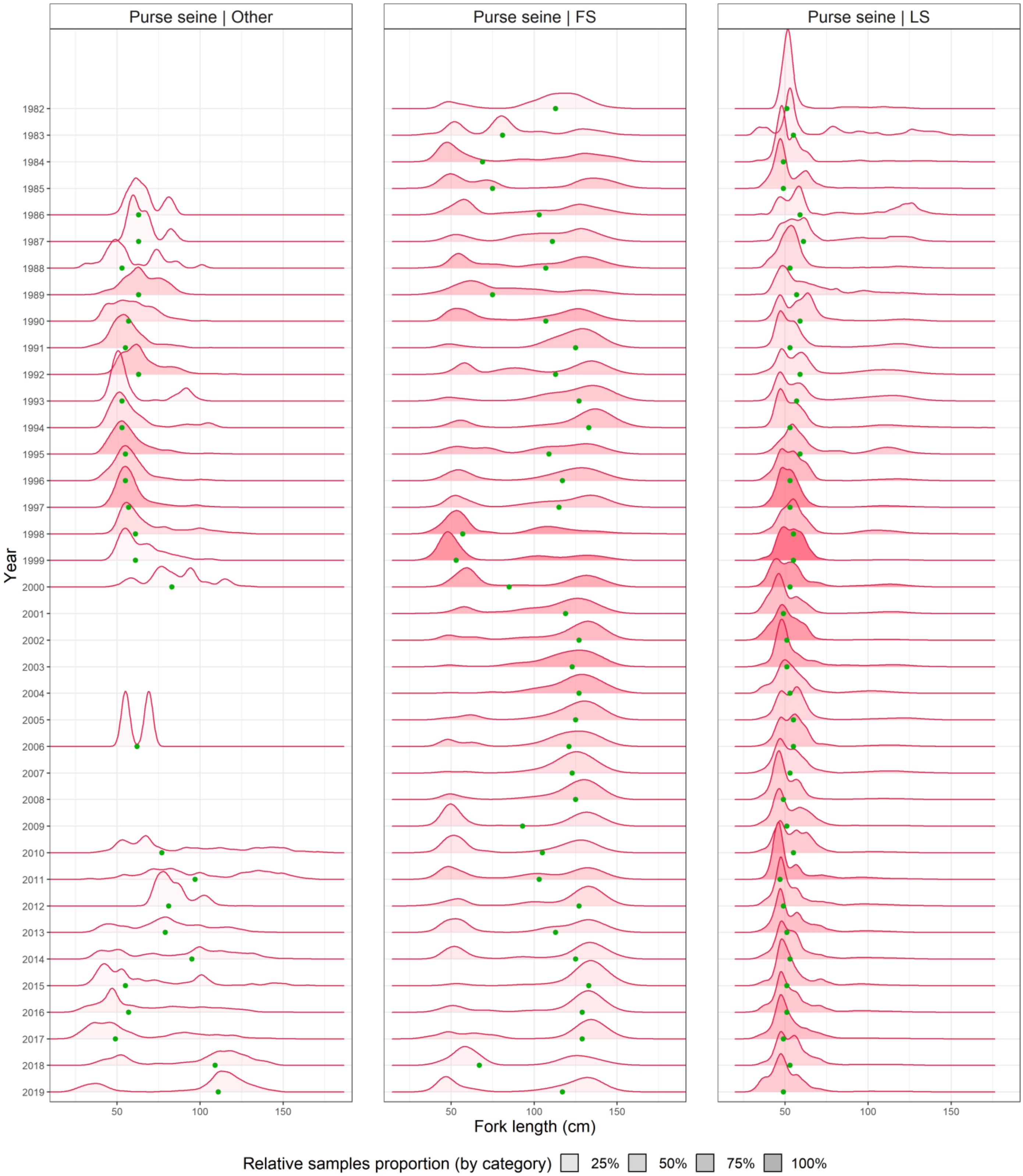

Figure 17: Relative size distribution (fork length in 2 cm size bins) of yellowfin tuna caught by all purse seine fleets between 1982 and 2019. Other = no information provided on the school association; LS = schools associated with floating objects; FS = free-swimming schools. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest yellowfin tuna standardized size-frequency dataset]() (Res. 15/02)

Industrial longline fisheries

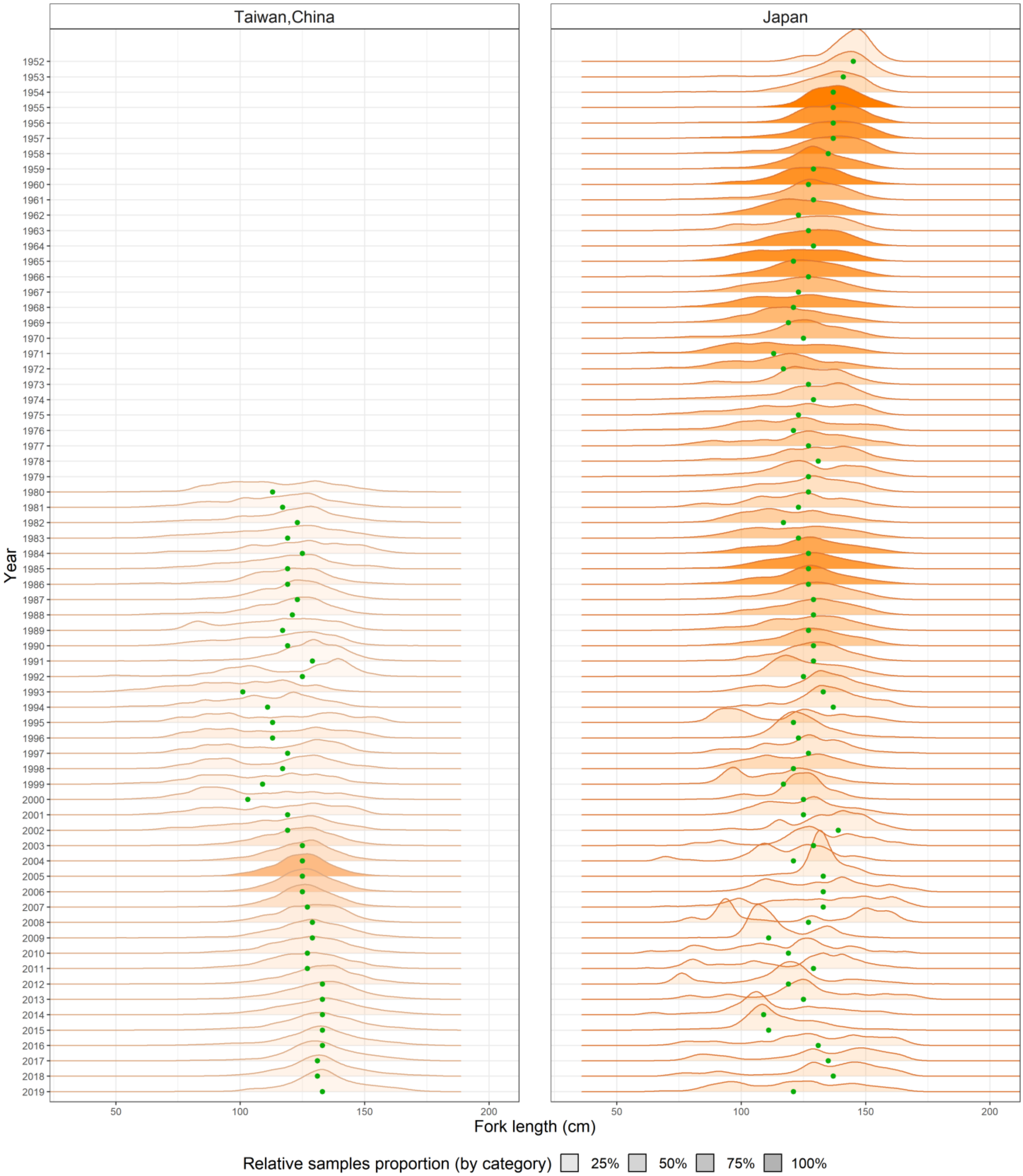

Figure 18: Relative size distribution (fork length in 2 cm size bins) of yellowfin tuna caught by the main deep-freezing longline fleets during 1952-2019. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest yellowfin tuna standardized size-frequency dataset](#) (Res. 15/02)

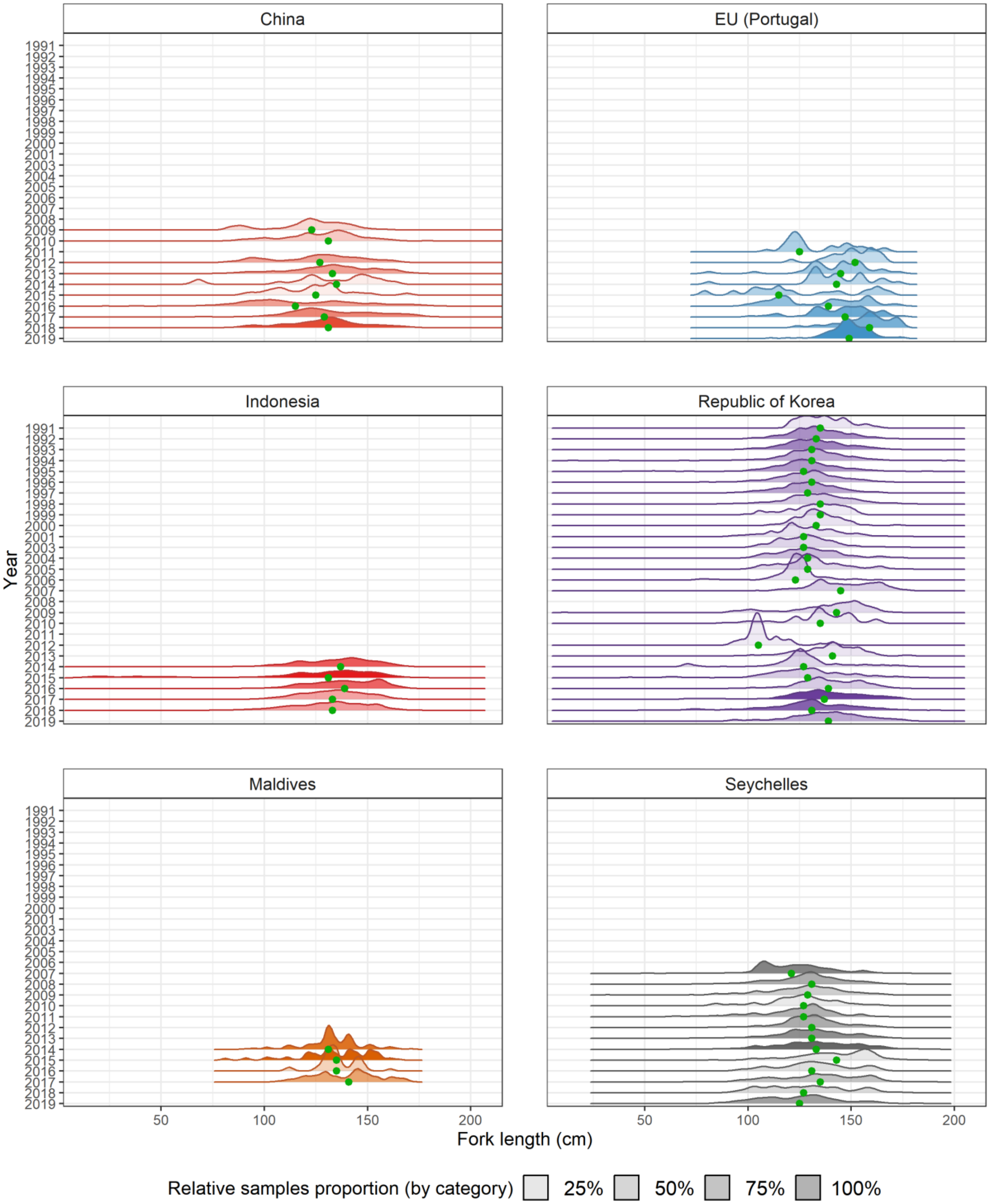

Figure 19: Relative size distribution (fork length in 2 cm size bins) of yellowfin tuna caught by the all other longline fleets (excluding Japan and Taiwan,China), by origin and fleet (2000-2019). Data source: [latest yellowfin tuna standardized size-frequency dataset](#) (Res. 15/02)

Temporal trends in estimated average weights

Trends in average weights of yellowfin tuna can be derived from the raised time-area catches in weight and numbers. While they can be estimated for the entire time series and for each fishery, due to the lack of original samples for several strata (especially in the early periods of the fisheries) they are considered accurate only for those periods for which actual samples are available and cover strata that correspond to at least 50 t of retained catches per year.

Considering the limitations in the original data and in the process that produces this estimation, it shall be noted that the average weights estimated for the longline fisheries of Japan and Taiwan,China are pretty stable at around 40-50 kg / fish (**Fig. 21**). On the contrary, average weights estimated for the log-associated school component of the purse seine fisheries show a declining trends from the mid 1990s onward, and the resulting estimated average weight of yellowfin tuna caught by this fishery is now as low as 5 kg / fish.

Trends in average weight for all other fisheries (baitboat, gillnet and all other gears) are more difficult to assess due to the inherently artisanal nature of several of them, which in turn implies a lower number of available samples which are often of lower quality compared to those provided by industrial fleets (recorded through logbooks or collected by scientific observers, in several cases).

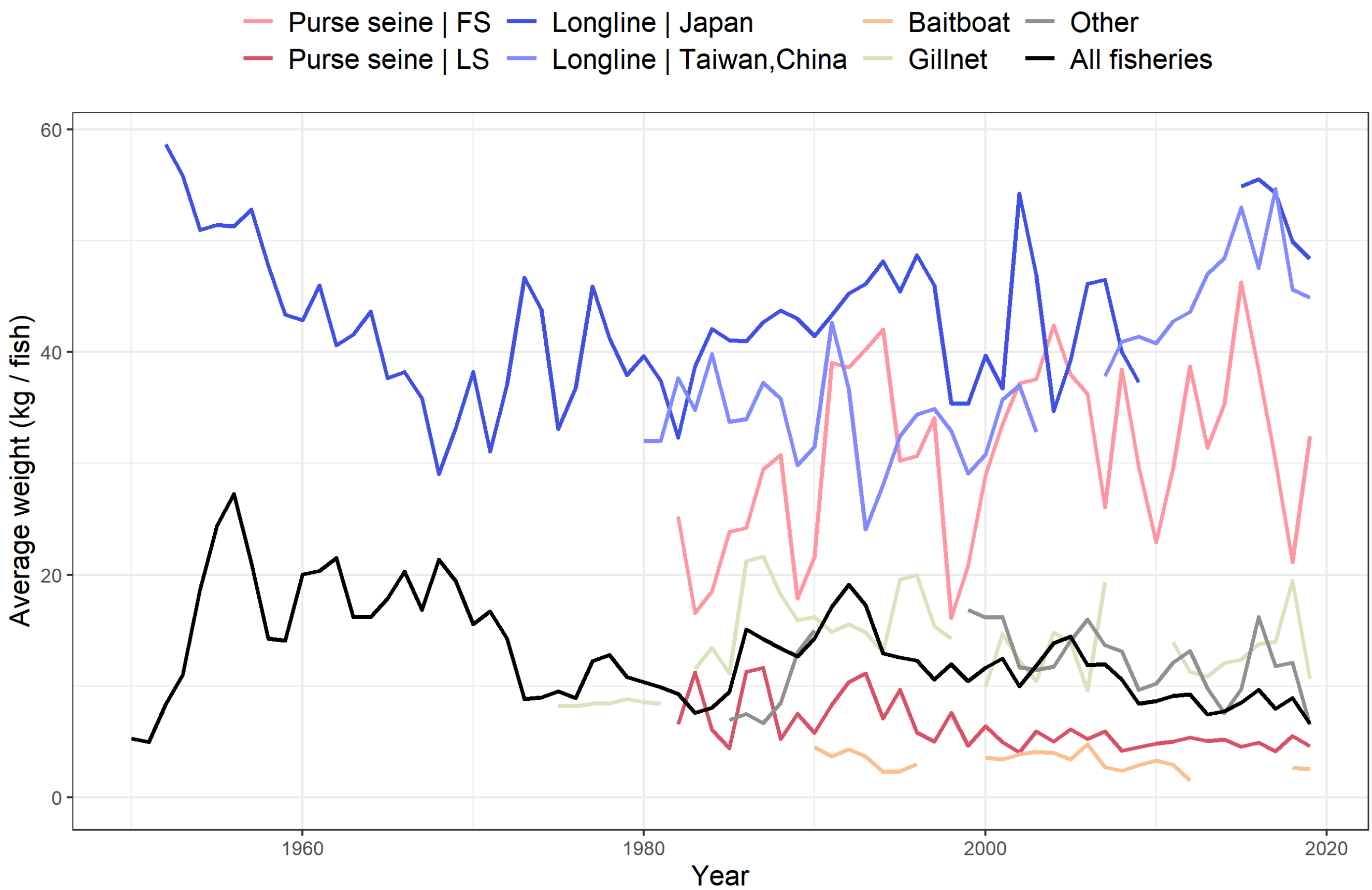

Figure 20: Combined estimated yellowfin tuna average weight (kg/fish) by fishery and year. Data are only shown for those years for which the original size samples cover strata with reported catches (by year and fishery) higher than 50 t. LS = schools associated with floating objects; FS = free-swimming schools. Longline | Japan = includes data from longlines flagged by Japan, Rep. of Korea and Thailand; Longline | Taiwan = includes data from longlines flagged by Taiwan,China and all other flags not otherwise mentioned. Data source: yellowfin tuna raised time-area catches

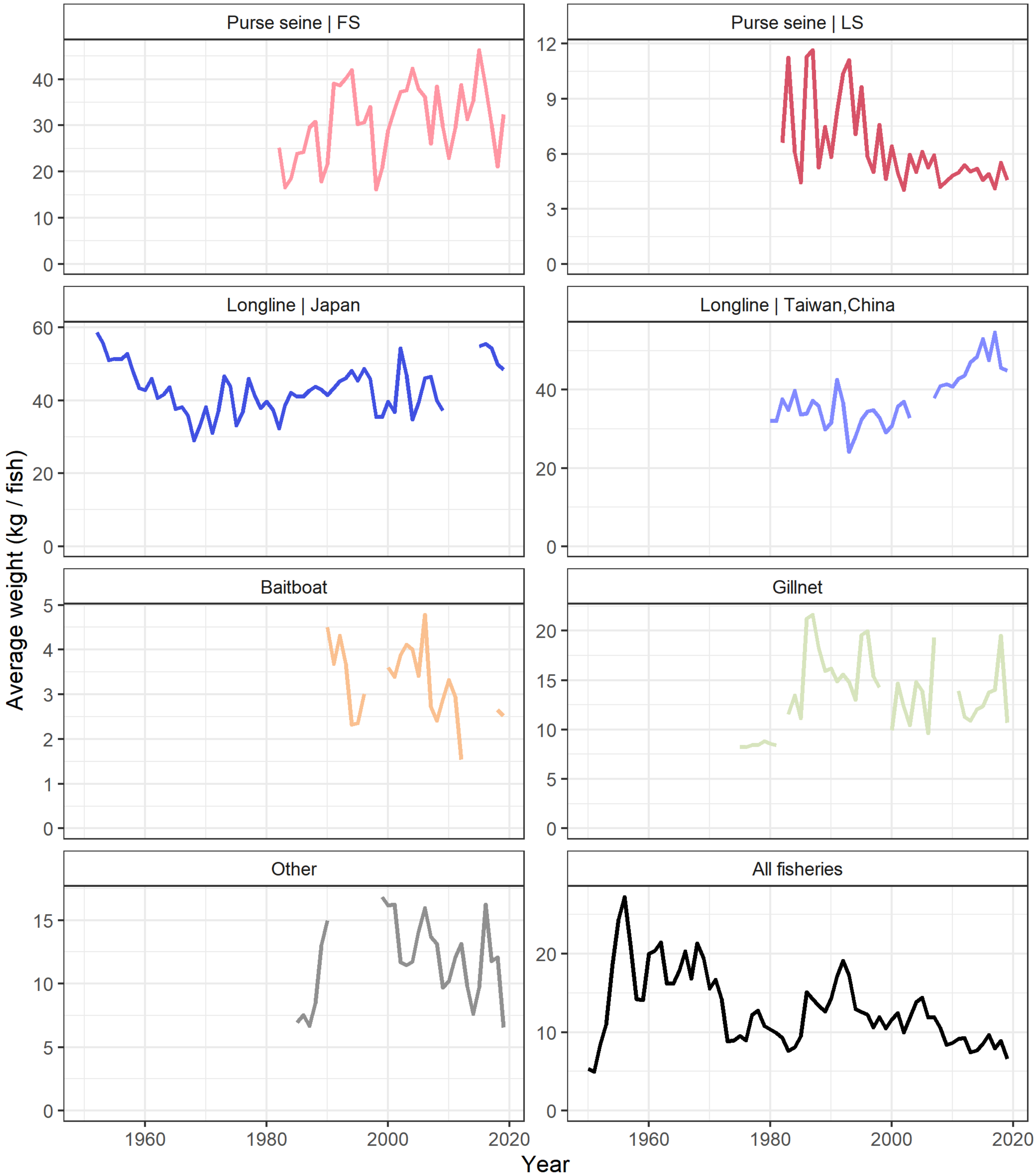

Figure 21: Estimated yellowfin tuna average weight (kg/fish) by fishery and year. Data are only shown for those years for which the original size samples cover strata with reported catches (by year and fishery) higher than 50 t. LS = schools associated with floating objects; FS = free-swimming schools. Longline | Japan = includes data from longlines flagged by Japan, Rep. of Korea and Thailand; Longline | Taiwan = includes data from longlines flagged by Taiwan,China and all other flags not otherwise mentioned. Data source: yellowfin tuna raised time-area catches

Overall, the trend in average weights that results from combining data for all fisheries together shows a clear and steady decrease in the size of fish caught since the beginning of the 1990s, which can be explained by the generalized decline in deployed efforts by several industrial longline fleets combined with the rapid increase in catches from log-associated schools in the purse seine fishery (**Fig. 20**).

Spatial distribution of average weights

Estimated average weights by decade (1950-2009)

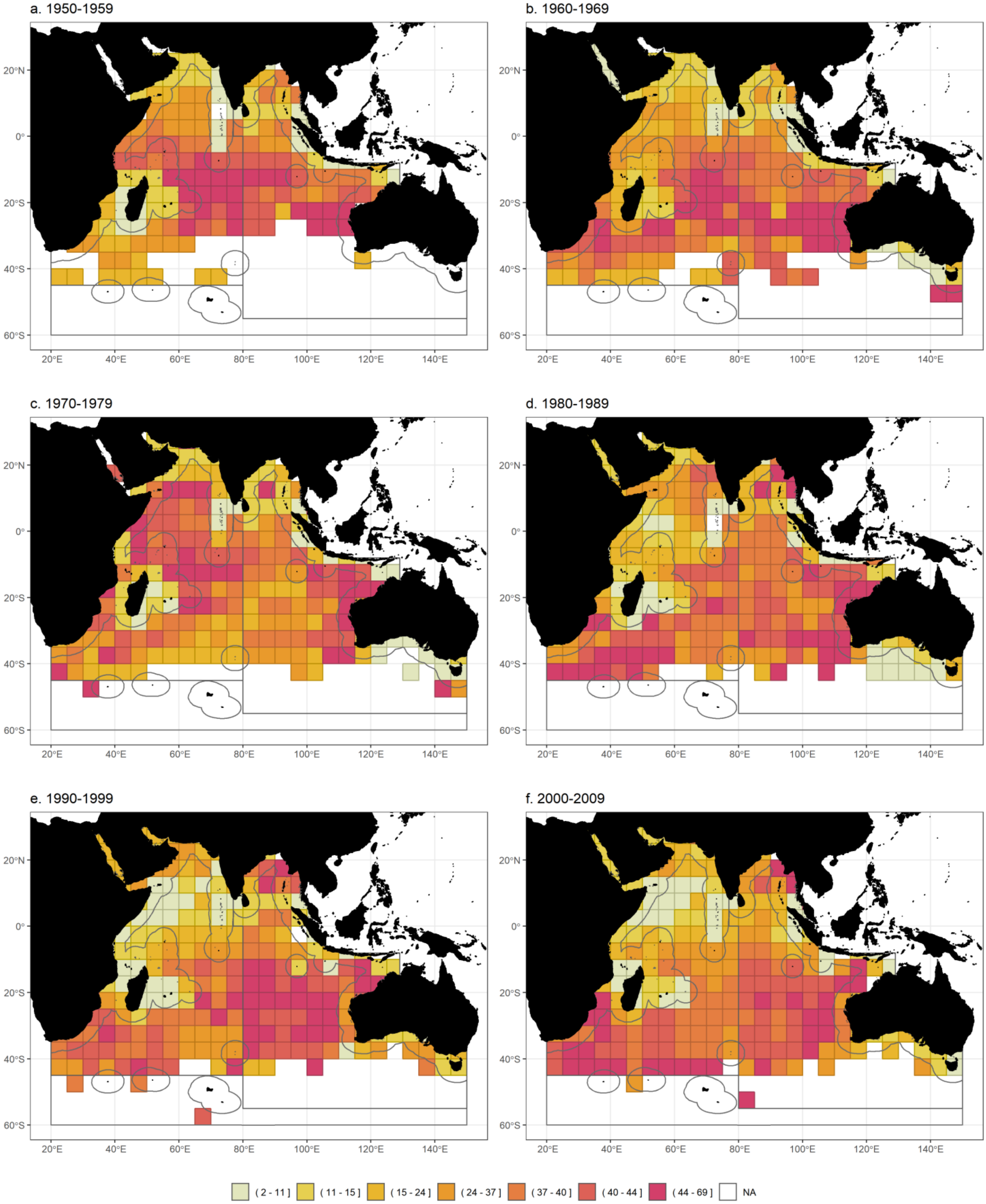

Figure 22: Estimated average weight (kg / fish) by decade and 5x5 grid, all fisheries combined. Data source: yellowfin tuna raised time-area catches

Estimated average weights by last decade (2010-2019) and years (2015-2019)

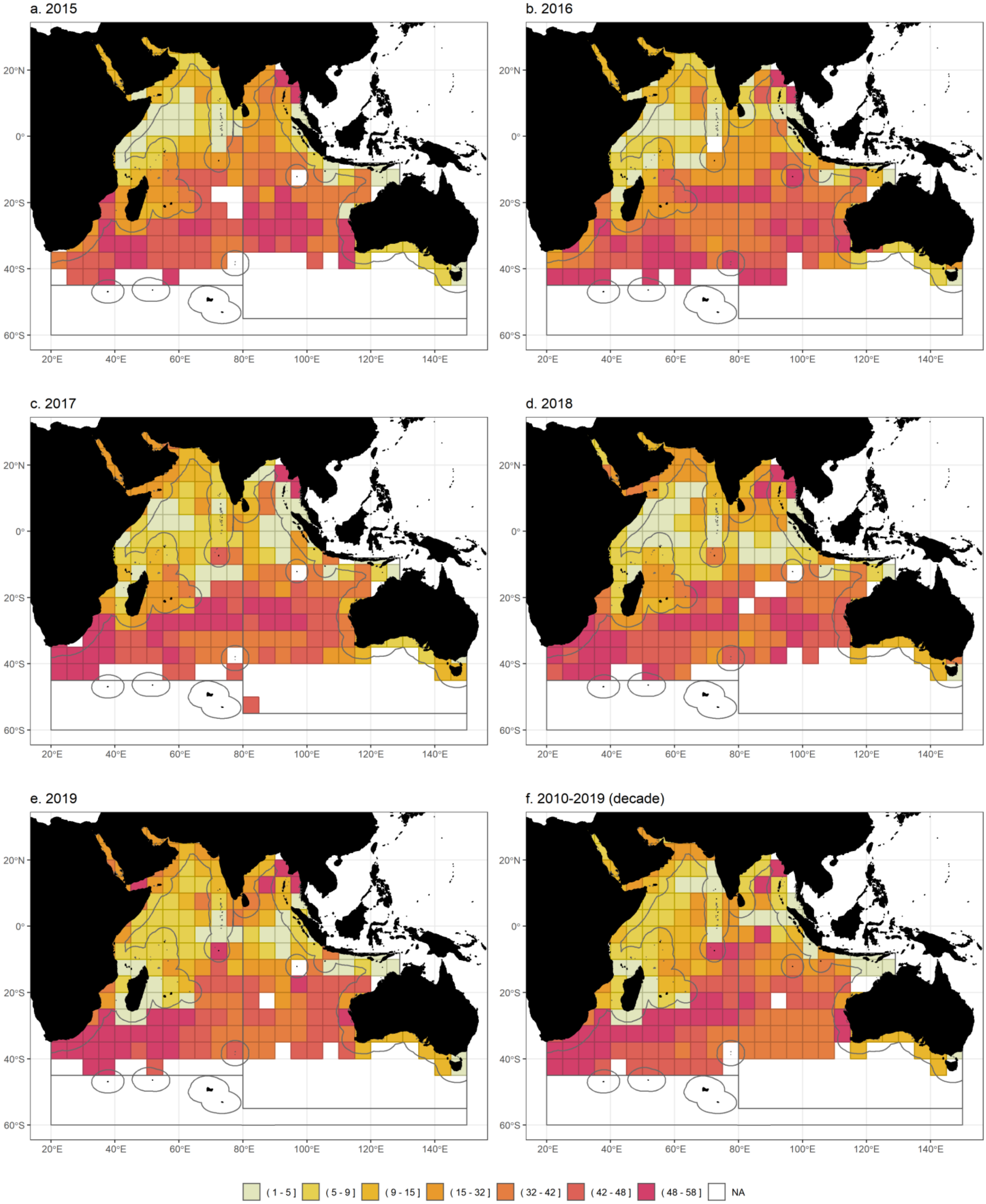

Figure 23: Estimated average weight (kg / fish) by year and 5x5 grid, all fisheries combined. Data source: yellowfin tuna raised time-area catches

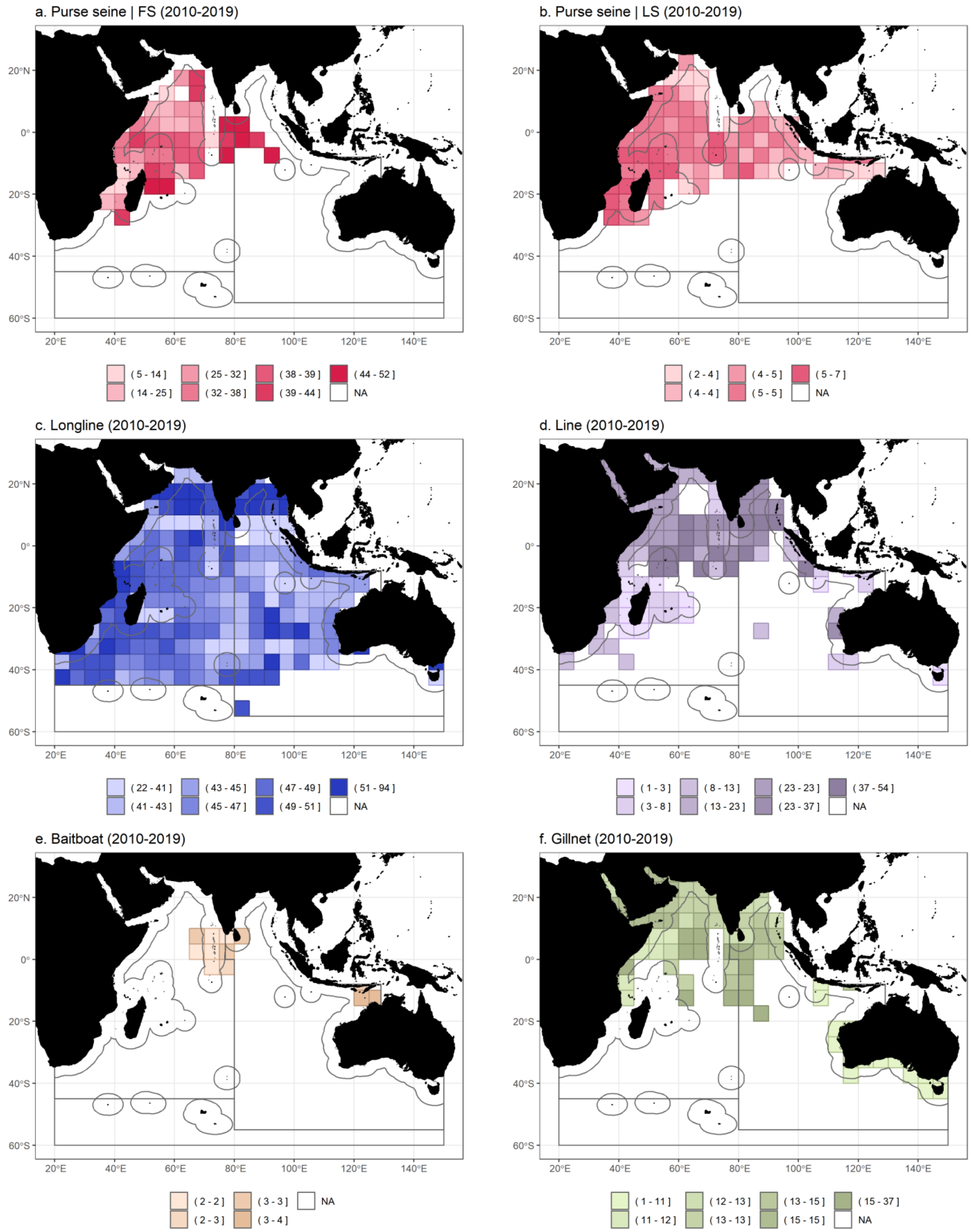

Figure 24: Estimated average weight (kg / fish) by 5x5 grid and fishery group in the period between 2010 and 2019. LS = schools associated with floating objects; FS = free-swimming schools. Data source: yellowfin tuna raised time-area catches

Uncertainties in size-frequency data

The overall quality – as measured by the percentage of nominal catches with size data of quality scores between 0-2 – of size data available for yellowfin tuna in IOTC databases is poor, particularly for artisanal fisheries. Almost no size data are available prior to the 1980s and the general quality has varied around 50% (range 36-63%) since 1984 (**Fig. 25a**). Following an increase in quality from about 40% in 2006-2007 to more than 60% in 2017, the quality substantially decreased to 52% in 2018 and 40% in 2019.

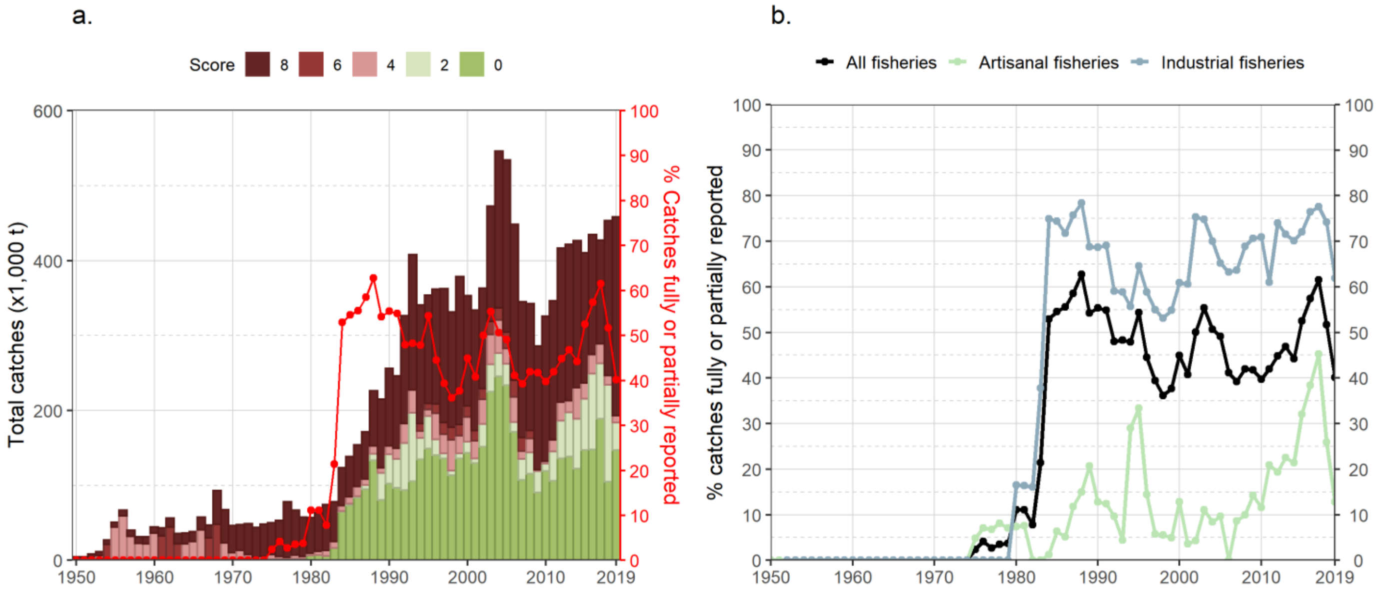

Figure 25: Annual nominal catches (t) of yellowfin tuna estimated by quality score (barplot) and percentage of geo-referenced size-frequency data reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950–2019

Industrial purse seine fisheries

Size-frequency data for yellowfin tuna are available for several years for the major industrial purse seine fleets. Depending on the fleet and year, though, the data can comprise a mix of raw (as recorded) and raised (to total catches) measurements, which in turn yield sensible differences in the magnitude of the fish sampled across fleets and years. Regarding the EU fleet (and assimilated flags, i.e. Seychelles and Mauritius), it has been suggested by national scientists that raw and raised samples differ only in total numbers of fish measured, and that actual differences in the resulting size distribution between the two types of records can be treated as negligible.

Considering the main purse-seine fleets, the difference in number of fish sampled between free-swimming schools (**Fig. 26**) and log-associated schools (**Fig. 27**) reflects the different percentages of sets taken on the two different fishing modes, with free-school sets being generally lower in numbers than log-associated ones.

Also, the length distributions for the two fishing modes tend to have very distinct characteristics, with fish measured from free-swimming schools showing two modes, of which the most marked is located at around 140 cm fork length, while fish measured from log-associated schools tends to have one single mode at around 50 cm fork length. For free-swimming schools, though, data shows some notable exceptions to this trend, specifically for EU,France (2018), EU,Spain (2019), Mauritius (2017) and Seychelles (2017, 2018 and 2019), which all show a much higher first mode in the lower part of the size distribution (at around 60 cm fork length) (**Fig. 26**).

Similar discrepancies can also be found in the case of size-frequencies from log-associated schools, with data showing sub-modes at around 100 and 130 cm fork length for EU,Spain (2018) and EU,France (2019): interestingly enough, data for these two strata have been provided as raw measurements, while all others are reported as raised to total catches (i.e., they can be considered to represent catch-at-size) (**Fig. 26**).

Considering the impracticalities of managing a mix of raw and raised size data, as it is currently the case, the IOTC Secretariat is liaising with concerned CPCs to ensure that either both data sets are provided at the same time, or preference is given to raw measurements for both historical and new data submissions.

It is also worth noting that data for the Italian-flagged component of the EU purse seine fleet are only available for the years 2015 and 2017. Also, data from Mauritian purse seiners with correct attribution of the fishing mode are only available for the year 2017, as data for 2018 and 2019 - collected by observers at sea - have been reported to the IOTC Secretariat without explicit information on the school type.

Size-frequency data for all other industrial purse-seine fleets include information from Indonesia, I.R. Iran, Japan, and Republic of Korea (**Fig. 28**). Unfortunately, with the exception of I.R. Iran in 2015, the size data submitted to the IOTC Secretariat by these fleets are not categorized by fishing mode and therefore cannot be directly compared with the corresponding information from all other fleets. At the same time, the characteristics of the size distributions available for each of these fleets are such to suggest that Indonesian purse-seiners as well as Japanese and Korean ones (to a lesser extent) are mostly fishing on log-associated schools, whereas Iranian purse seiners appear to have been fishing predominantly on free-swimming schools in recent years (**Fig. 28**).

The size-distribution of Indonesian samples is quite peculiar, and indicates that the fishery is catching smaller than average individuals as the very strong mode at around 30 cm fork length seems to suggest. Considering that the data are originally reported as sourced from the *small purse seine* component of the Indonesian fleet (IOTC gear code *PSS*, that includes vessels with a LOA well above 24 m, that appear to operate in coastal waters on the basis of the geo-referenced catches available to the IOTC Secretariat from 2018 onward) further clarification might be required to estimate the accuracy and representativeness of these samples and whether or not they could be properly used for scientific purposes.

Finally, size data reported by non-EU fleets do not always comply with the requirement of sampling at least one fish per metric ton of retained catches by species. In particular, data from Indonesia and the Republic of Korea (collected by observers at sea) are consistently below the threshold set by Res. 15/02 for all years concerned, and this further questions the representativeness of the length samples reported by the two fleets.

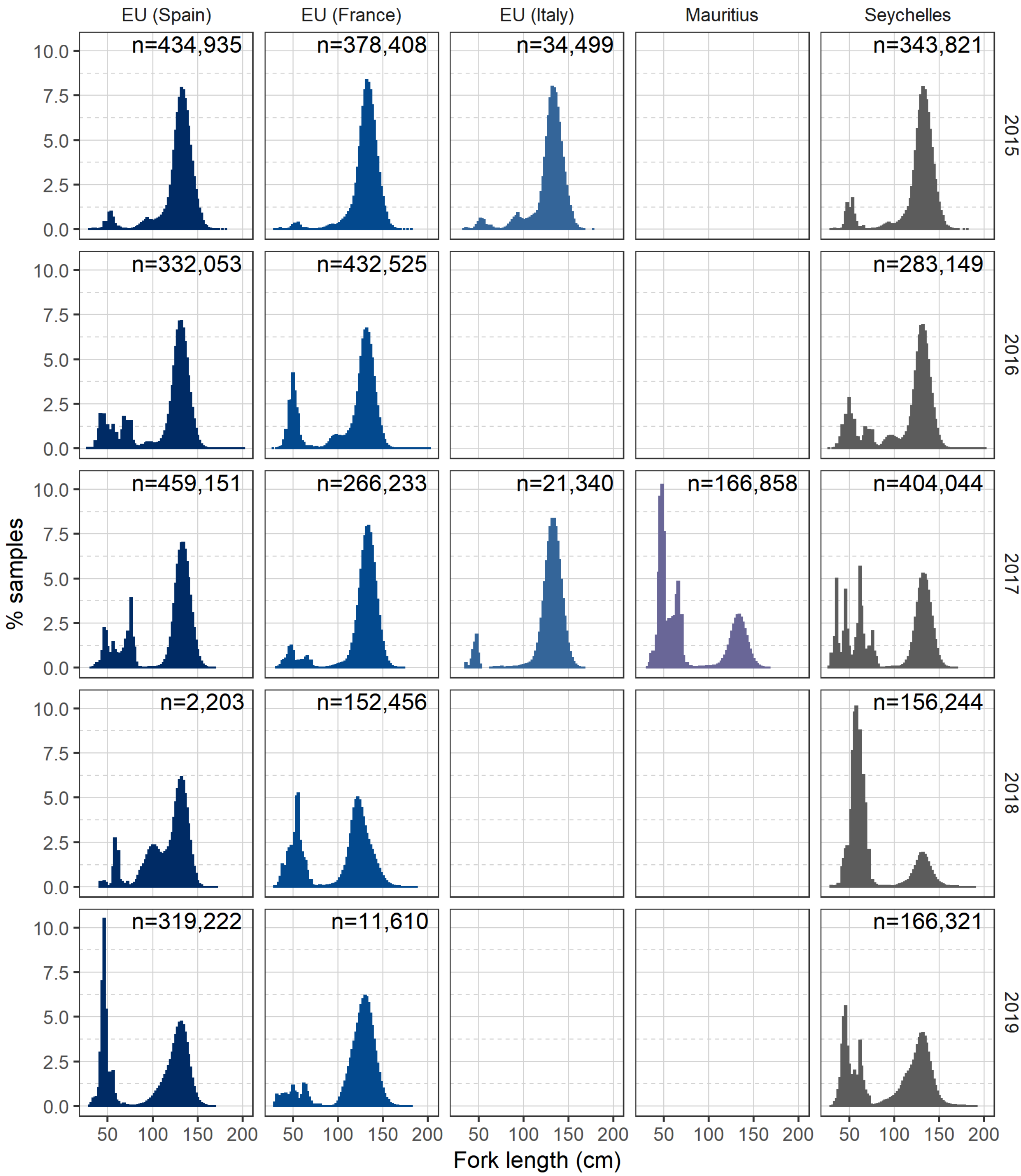

Figure 26: Relative size distribution of yellowfin tuna (fork length in centimeters) recorded for free-swimming schools, by year (2015-2019) and main purse seine fleet. Data source: latest yellowfin tuna standardized size-frequency dataset (Res. 15/02)

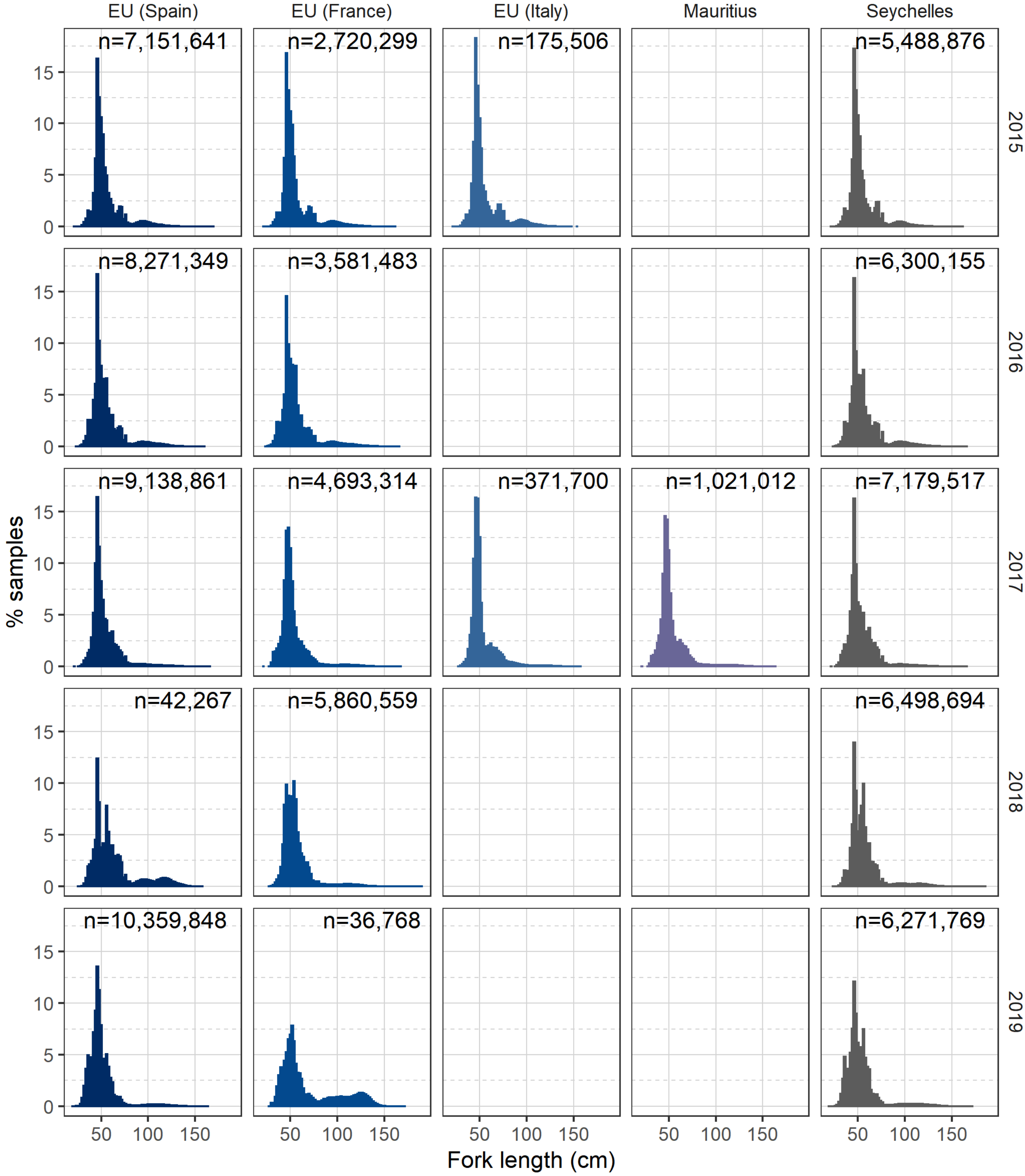

Figure 27: Relative size distribution of yellowfin tuna (fork length in centimeters) recorded for log-associated schools, by year (2015-2019) and major purse seine fleet. Data source: [latest yellowfin tuna standardized size-frequency dataset](#) (Res. 15/02)

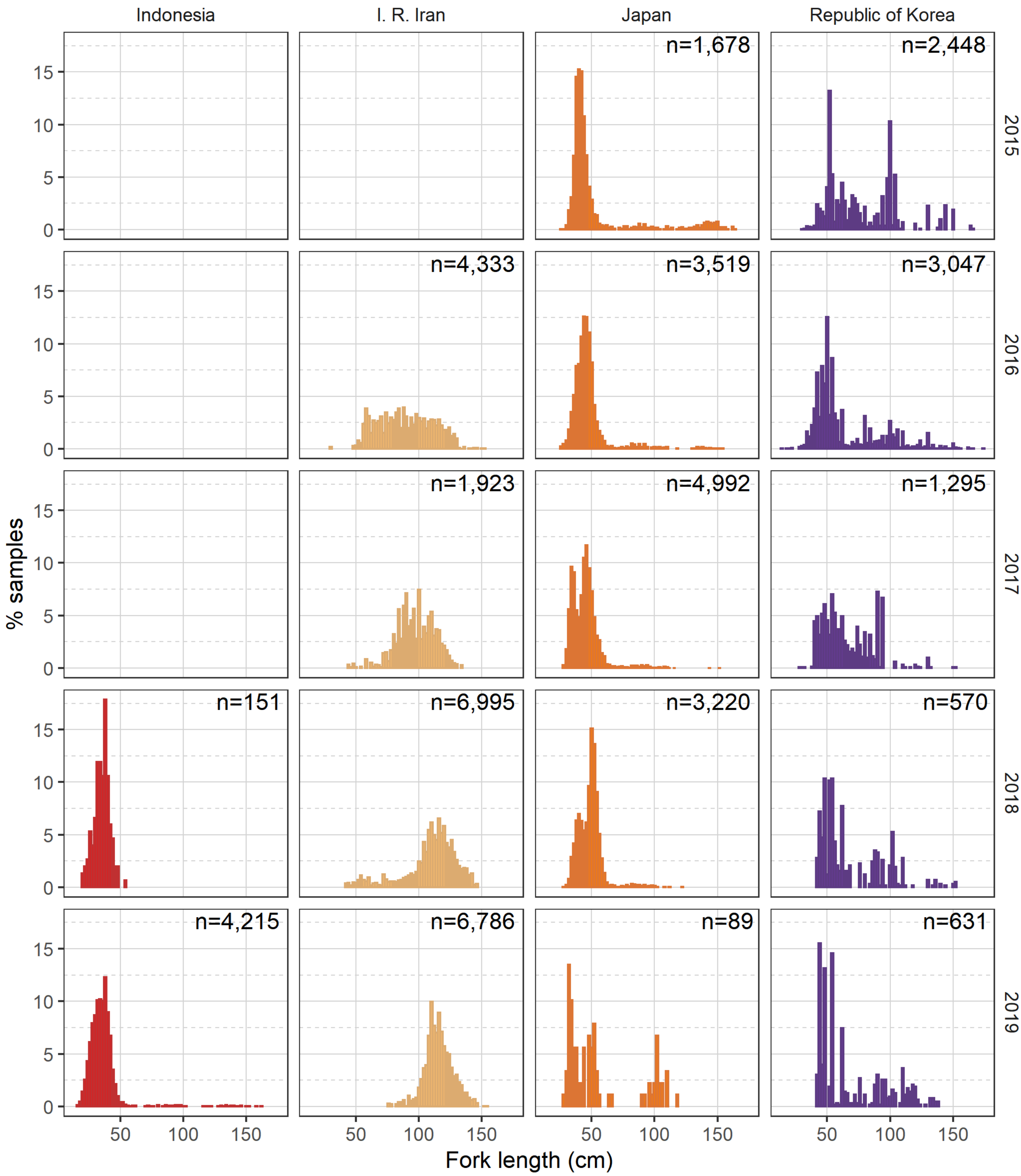

Figure 28: Relative size distribution of yellowfin tuna (fork length in centimeters) recorded for unclassified schools, by year (2015-2019) and other purse seine fleet. Data source: latest yellowfin tuna standardized size-frequency dataset (Res. 15/02)

Industrial longline fisheries

The major industrial longline fisheries appear to be well-sampled for several years and fleets, with some of them (Japan, Rep. of Korea, China, Taiwan,China and EU,Portugal) having consistently reporting data from observers at sea in recent periods. Nevertheless, ongoing discussions on potential bias in sampling involving the longline fleets of Japan and Taiwan,China (mostly) have not yet been resolved (Geehan & Hoyle 2013, Hoyle et al. 2021).

In the case of the Taiwanese deep-freezing longline fleet, the availability of well-sampled size-frequency data and of geo-referenced catches both in numbers and weights allows performing a comparison between the average weights calculated from the two data sets. Average weights from the size-frequency data set are calculated by applying the length-weight conversion equation to the number of samples reported for each size bin (IOTC-2021-WPTT23(DP)-DATA13). Average weights from the catch-and-effort data set are calculated by dividing the catch in weight by the catch in numbers available for the same strata.

The available size-frequency data for the Taiwanese fishery are sampled well-above the minimum level of 1 fish per ton of retained catches (as required by Res. 15/02), if not for the years between 1989 and 1993 (**Fig. 29**). The average weights calculated from the two data sets are in (variable) agreement only until 2002: from this point in time onward, the average weight calculated from the size-frequency data set is consistently higher than the average weight calculated from the catch-and-effort data set up to a maximum difference of around 15 kg / fish in favor of the former, as detected in 2019 (when the coverage level of the size-frequency data was of around 6.5 samples per metric ton) (**Fig. 29**).

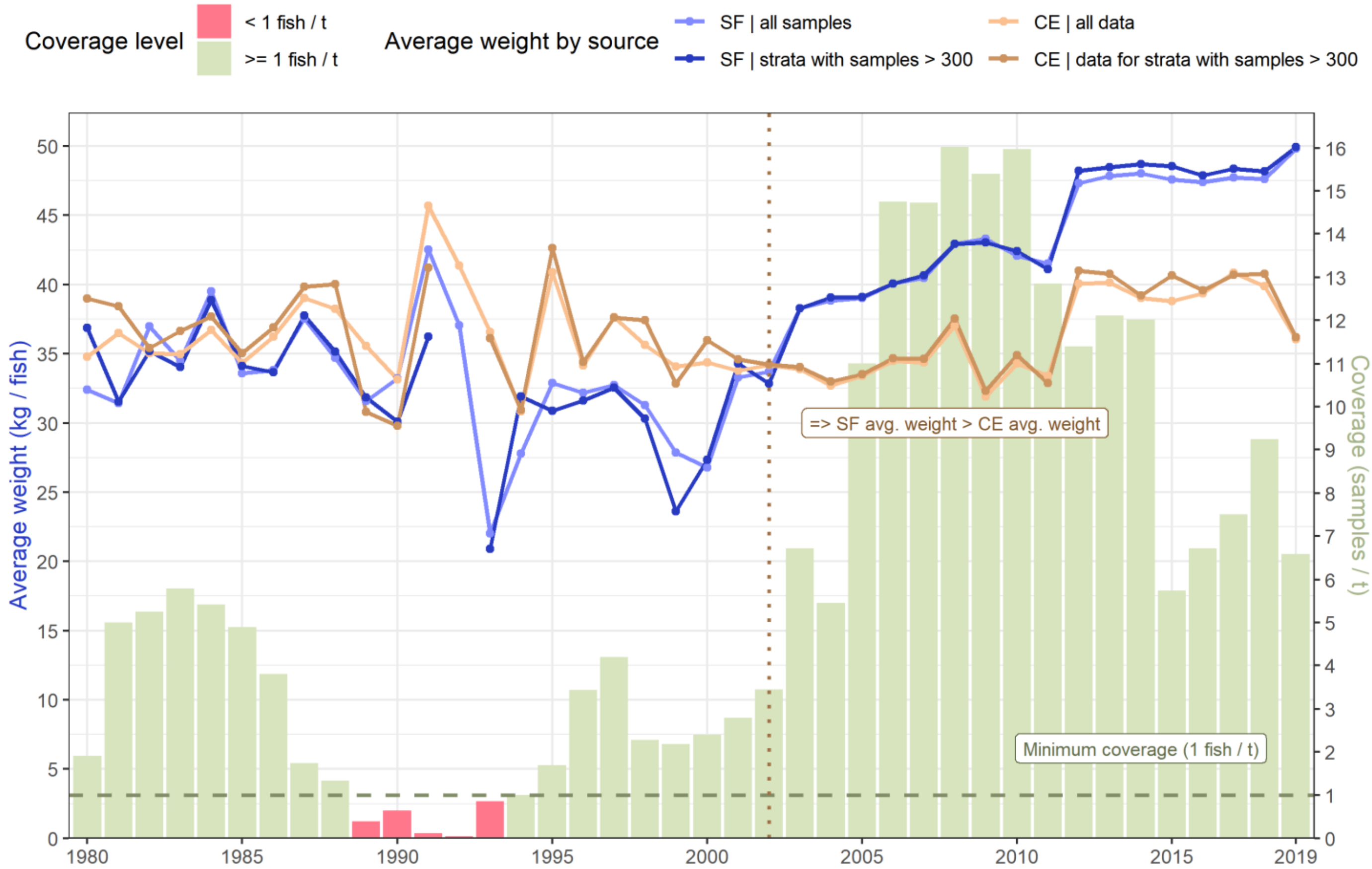

Figure 29: Difference in average weights of yellowfin tuna caught by the deep-freezing fleet of Taiwan,China as calculated from the available size-frequency and catch-and-effort data (1980-2019). Data source: latest yellowfin tuna standardized size-frequency dataset and latest time-area catch dataset for longline fisheries (Res. 15/02)

These results seem to imply that, from 2003 onward, either the size sampling is biased towards larger fish, or that the logbook data used to produce the catch-and-effort records submitted to the IOTC Secretariat are inaccurate. This, notwithstanding the fact that length measurements for the Taiwanese longline fleet include samples taken by scientific observers at sea (generally less than 5-10% of total annual samples since 2003).

Further analysis on the size distribution for both Japanese and Taiwanese longliners in the years for which measurements from logbook and observers were both available at the same time (2000-2019) shows that:

- Size data from Japanese logbooks and onboard observers is not in full agreement, with the latter (observer data) showing a higher number of smaller fish measured in the category between 60 and 100 cm fork length (**Fig. 30a**);
- Size data from Taiwanese logbooks and observers are in almost perfect agreement (**Fig. 30b**);
- Size data from logbooks are in reasonable agreement between the two fleets, with a mode at around 130 cm fork length and comparable tails (**Fig. 30c**);
- Size data from observers confirm a tendency in measuring smaller fish in the case of the Japanese fleet (**Fig. 30d**).

In the period considered (2000-2019), yellowfin tuna size-frequency records submitted by the Japanese fleet were comprised of 24,653 individuals recorded in logbooks and 24,891 individuals measured by onboard observers. In this case, the number of individuals measured by observers was slightly higher than the one recorded in logbooks, also because starting from 2012 Japan has been providing - in agreement with the requirements of Res. 15/02 - size-frequency data exclusively sourced from their observer program.

On the contrary, and in the same period considered, yellowfin tuna size-frequency records submitted by the Taiwanese fleet were comprised of 2,539,422 individuals recorded in logbooks, and 33,784 individuals measured by onboard observers. In this case, the magnitude of the size data collected by observers corresponds to ~ 1.3% of that reported in logbooks, even though Taiwan,China has been consistently providing both sources of information since 2002.

The heterogeneity between sources of information over the years (particularly for what concerns Japanese longliners) and the fact that the results presented in **Figs. 30-31** were derived from a combination of data that spans across several years and over the entire Indian Ocean (i.e., the spatial location of sampled individuals and variability in fishing grounds across decades were not taken into account) call for further investigations to confirm these preliminary findings.

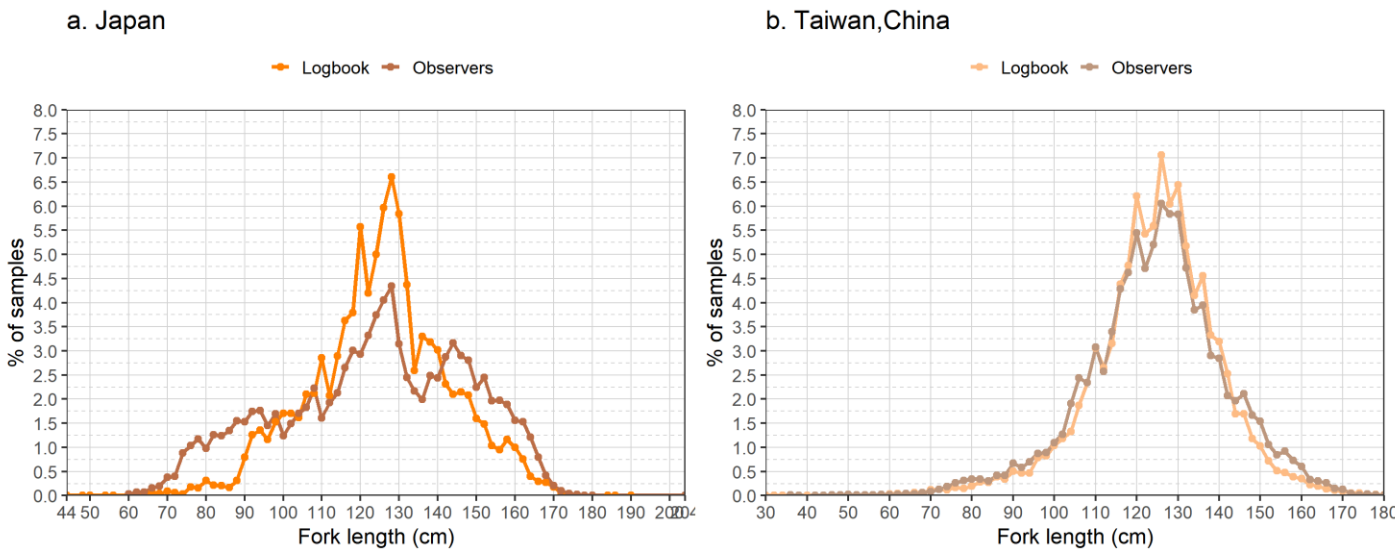

Figure 30: Relative size distribution (fork length in 2 cm size bins) of yellowfin tuna caught by the deep-freezing longline fleets of Japan and Taiwan,China, by fleet and origin. Data source: [latest yellowfin tuna standardized size-frequency dataset]() (Res. 15/02)

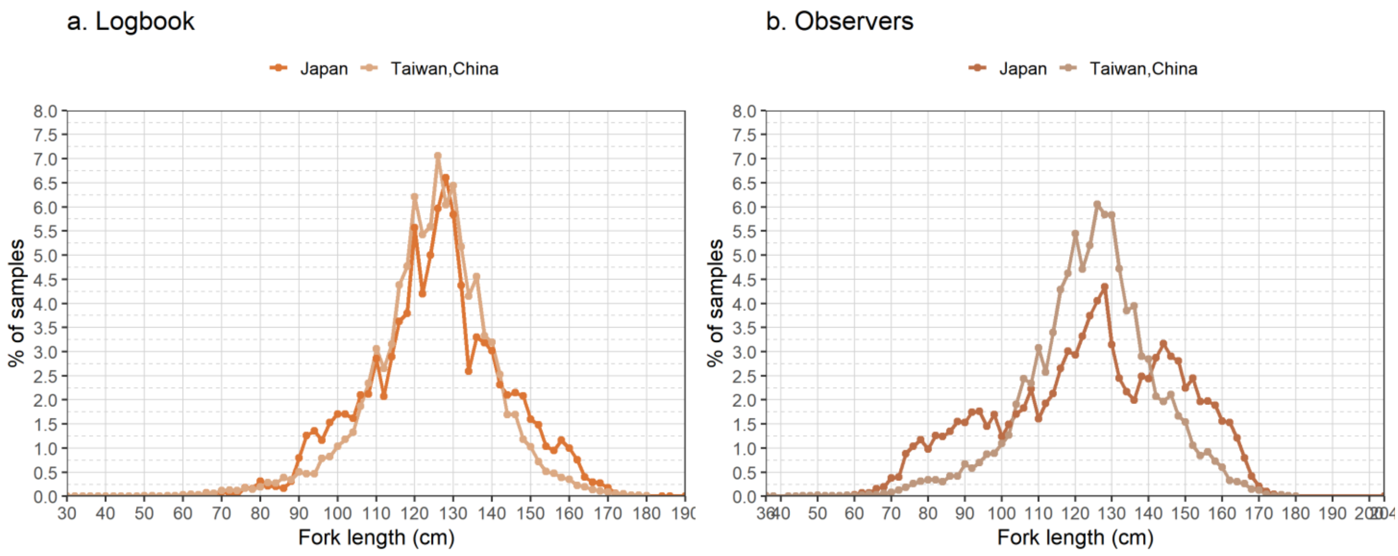

Figure 31: Relative size distribution (fork length in 2 cm size bins) of yellowfin tuna caught by the deep-freezing longline fleets of Japan and Taiwan,China, by origin and fleet (2000-2019). Data source: [latest yellowfin tuna standardized size-frequency dataset](#) (Res. 15/02)

Coverage levels of yellowfin tuna samples over the period considered indicate that Taiwanese longliners were regularly exceeding the minimum threshold of 1 measured fish per metric ton of retained catches. Japanese longliners, instead, reached or surpassed that level only in years from 2017 onward - which is an indication that the representativeness of yellowfin tuna samples from the Japanese deep-freezing longliners in previous years might not be optimal (**Fig. 32a-b**). Same considerations can be made for size-frequency data from the other longline fleets with the possible exception of those from Seychelles which are relatively well sampled (**Fig. 32c-e**).

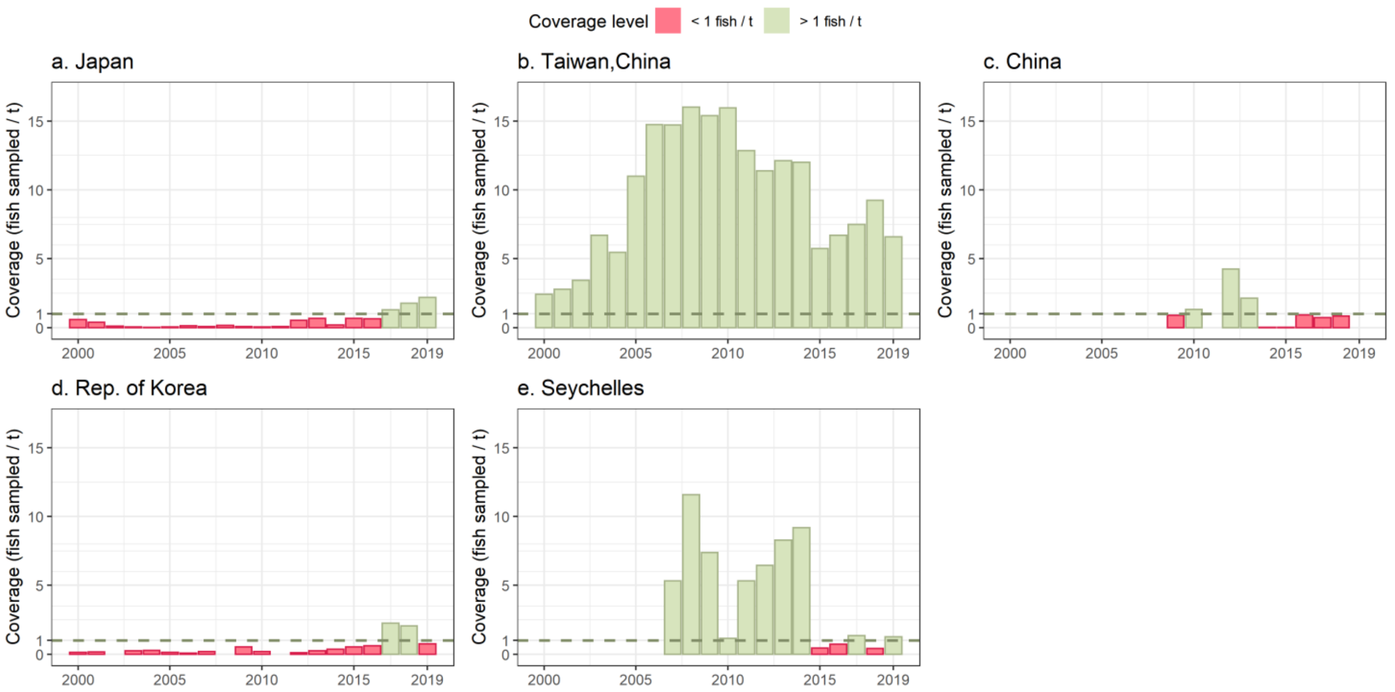

Figure 32: Size-frequency samples coverage (number of fish measured by ton of retained catches) of yellowfin tuna caught by the deep-freezing longline fleets of Japan (a), Taiwan,China (b), China (c), Rep. of Korea (d) and Seychelles (e), by fleet and year (2000-2019). Data source: [latest yellowfin tuna standardized size-frequency dataset](#) (Res. 15/02)

Appendix - effort trends for tropical tuna fisheries

Longline fisheries, by decade (1950-2009)

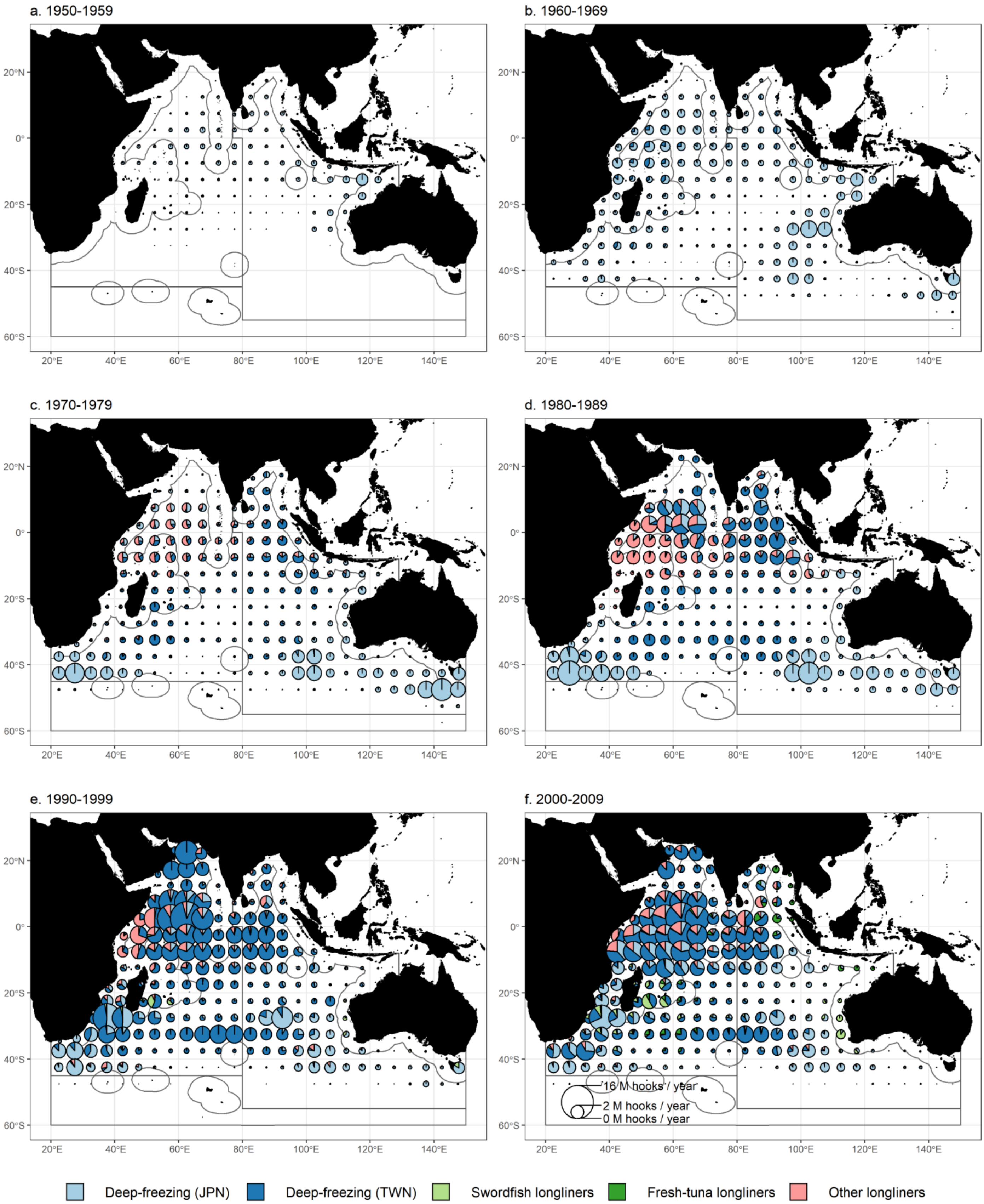

Figure 33: Average annual effort exerted by industrial longline fleets in millions of hooks set / year, by decade, 5x5 grid and fleet. Data source: [latest time-area effort dataset for longline fisheries]() (Res. 15/02)

Longline fisheries, by last decade (2010-2019) and years (2015-2019)

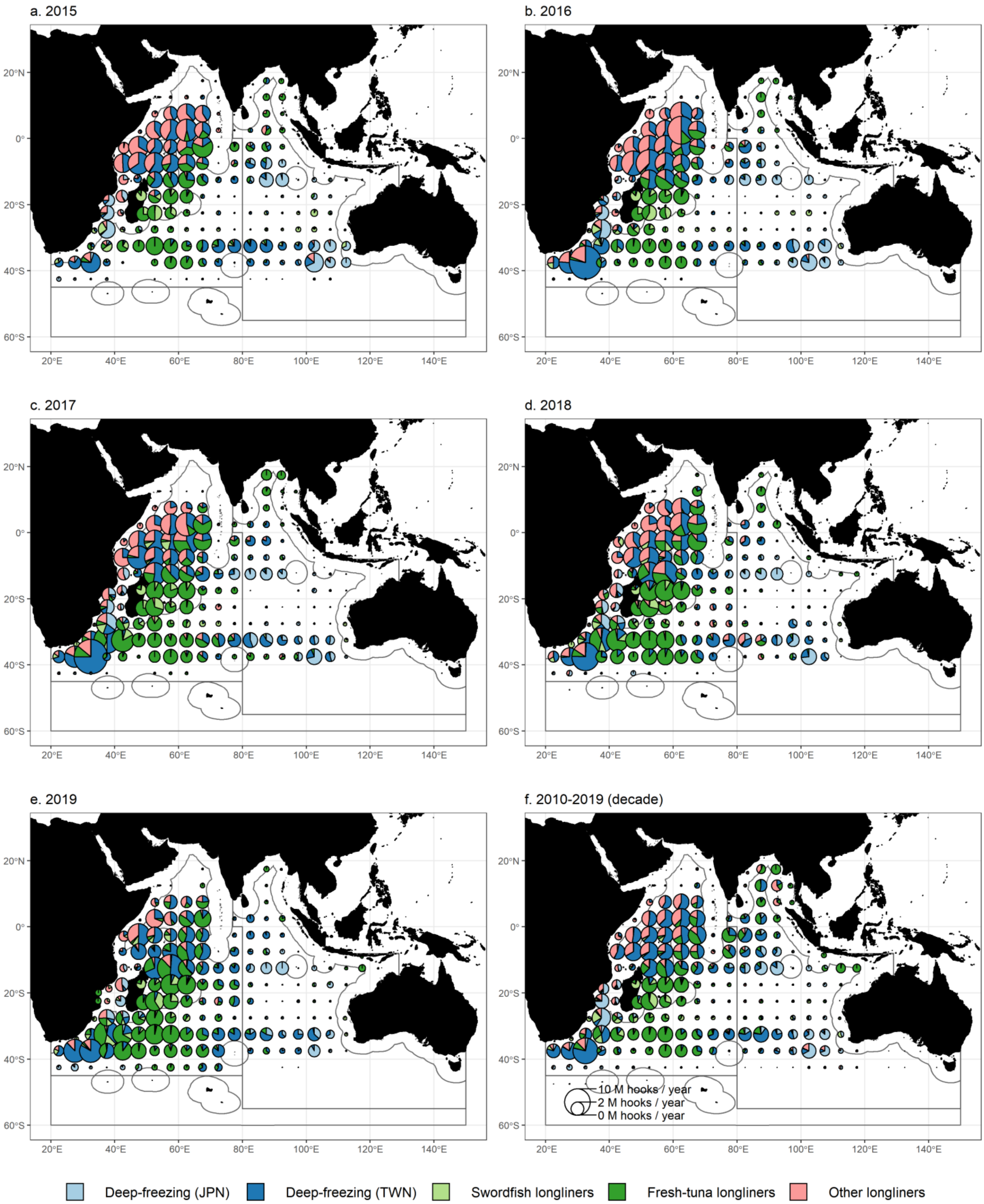

Figure 34: Average annual effort exerted by industrial longline fleets in millions of hooks set / year, by year / last decade, 5x5 grid and fleet. Data source: latest time-area effort dataset for longline fisheries (Res. 15/02)

Purse seine fisheries, by decade (1980-2009)

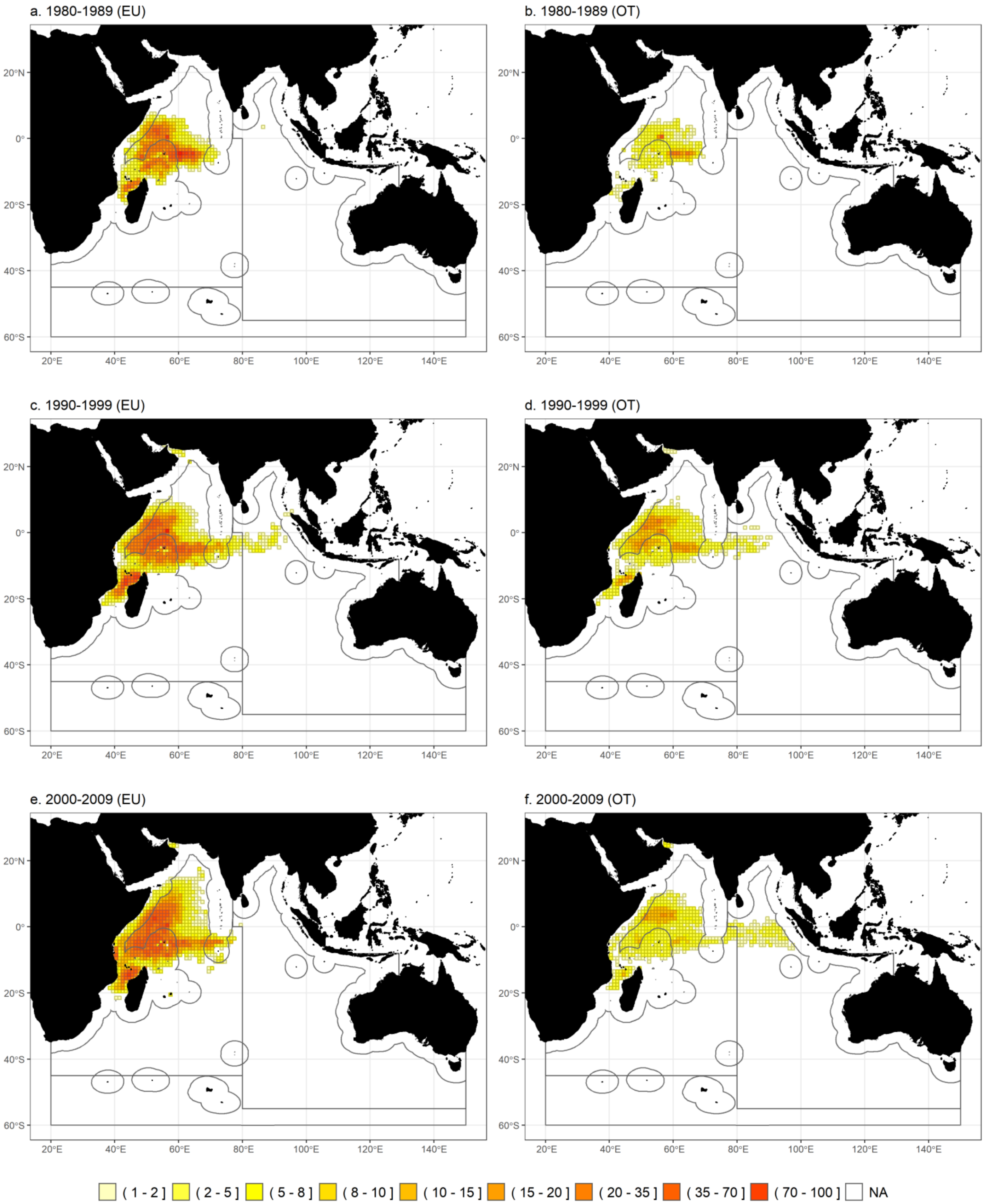

Figure 35: Average annual effort exerted by the industrial purse seine fleets of the European Union and assimilated flags (EU) vs. all other flags (OT) in fishing days / year, by decade, 1x1 grid and fleet. Data source: latest time-area effort dataset for purse-seine fisheries (Res. 15/02)

Purse seine fisheries (EU) by last decade (2010-2019) and years (2015-2019)

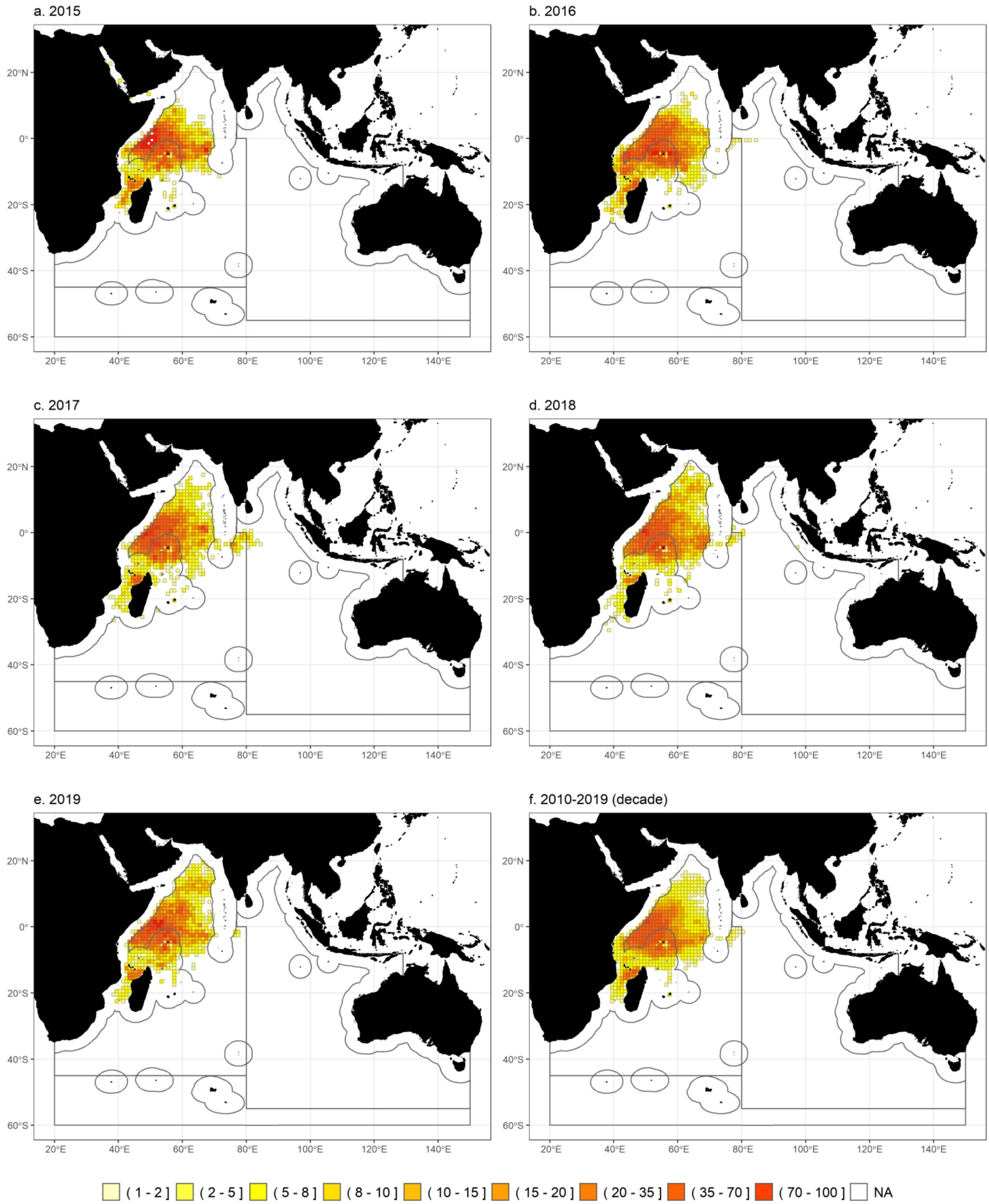

Figure 36: Average annual effort exerted by the industrial purse seine fleets of the European Union and assimilated flags (EU) in fishing days / year, by year / decade and 1x1 grid. Data source: latest time-area effort dataset for purse-seine fisheries (Res. 15/02)

Purse seine fisheries (OT) by last decade (2010-2019) and years (2015-2019)

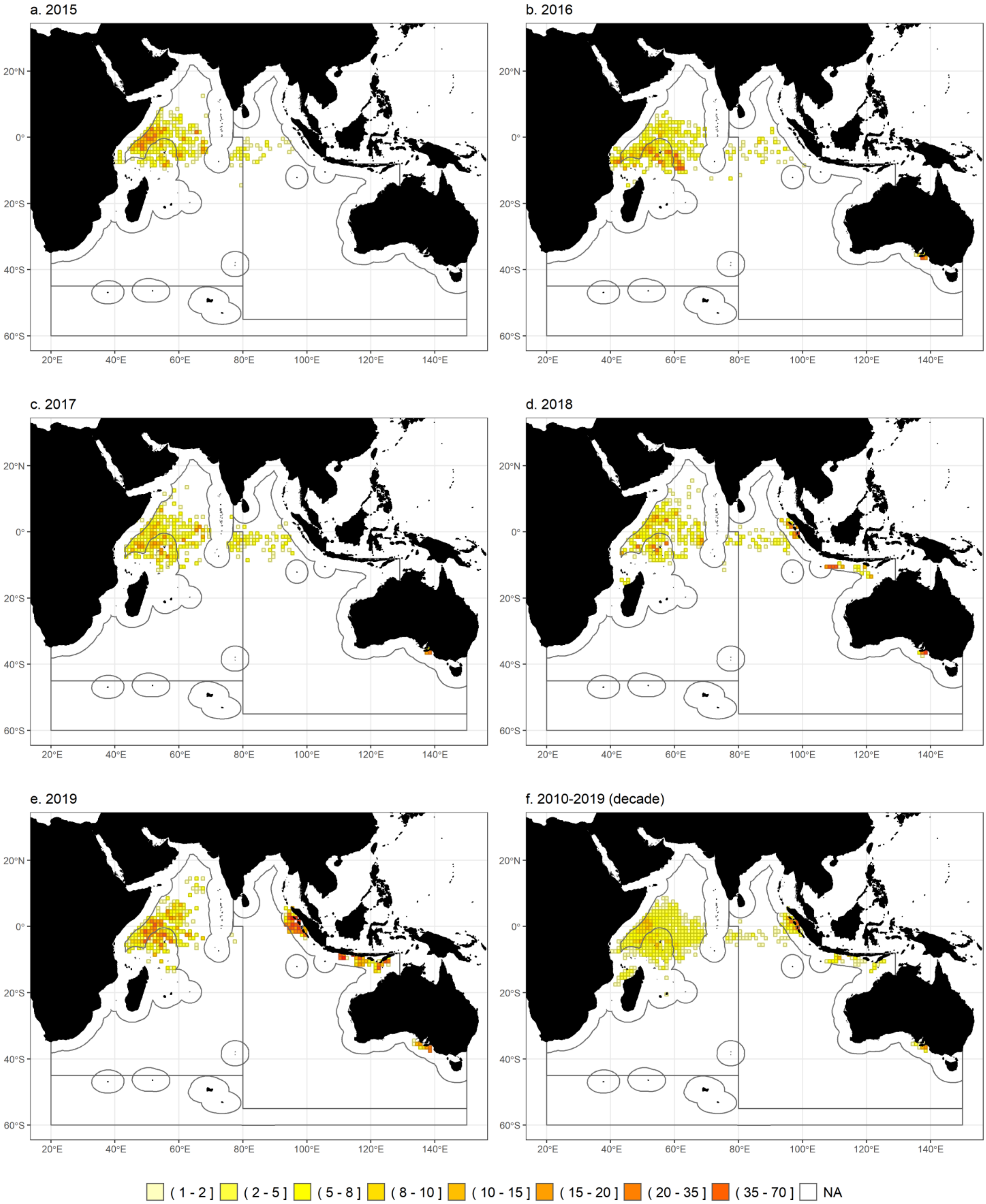

Figure 37: Average annual effort exerted by the industrial purse seine fleets from other flags (OT) in fishing days / year, by year / decade and 1x1 grid. Data source: [latest time-area effort dataset for purse-seine fisheries](#) (Res. 15/02)

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