REVIEW OF INDIAN OCEAN SKIPJACK TUNA STATISTICAL DATA

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Introduction

The overarching objective of the paper is to provide participants at the preparatory meeting of the 24th Session of the IOTC Working Party on Tropical Tunas (WPTT24(AS)) with a review of the status of the information on skipjack tuna (*Katsuwonus pelamis*; SKJ) available at the IOTC Secretariat as of May 2022. The document provides an overview of the fisheries catching skipjack tuna in the Indian Ocean through temporal and spatial trends in catches and their main recent features, as well as an assessment of the reporting quality of the data sets. A full description of the data collated and curated by the Secretariat is available in IOTC (2022a).

Nominal catch

Historical trends (1950-2021)

Nominal catches of skipjack tuna show an increasing trend over the last seven decades, with annual levels ranging between 15,000 and 473,000 t (from the mid-1950s to the mid-2000s) and with some variability across years. Catches dropped considerably from the late-2000s, reaching an annual average of 457,000 t during the 2010s, i.e., around 5% less than what caught on average during the previous decade. Purse seiners, baitboat and gillnetters are the main fisheries for the species, and together comprise over 90% of the catches between the 1950s and 2000s, and over 90% in the last full decade (**Table 1** & **Figs. 1-2**).

Table 1: Best scientific estimates of average annual nominal catches (t) of skipjack tuna by decade and fishery for the period 1950-2019. The background intensity color of each cell is directly proportional to the catch level. Data source: raised time-area catches

Fishery	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s
Purse seine | Other		93	4,527	7,435	13,563	24,710	41,558	53,407
Purse seine | FS			137	15,252	30,776	25,672	9,516	9,603
Purse seine | LS			415	34,496	124,044	163,801	168,319	248,504
Longline | Other				45	625	1,812	859	1
Longline | Fresh					4	347	1,351	1,579
Longline | Deep-freezing	244	382	65	38	96	55	71	56
Line | Coastal longline	6	29	186	1,210	2,516	5,064	12,173	11,958
Line | Trolling	2,370	4,190	8,650	12,278	21,128	20,505	25,445	25,618
Line | Handline	22	37	554	1,363	2,825	4,013	5,944	9,232
Baitboat	10,007	15,148	24,688	41,705	76,933	109,622	88,490	121,293
Gillnet	2,309	6,774	11,188	14,521	43,154	111,688	96,041	107,637
Other	104	277	515	1,829	3,468	5,728	7,545	9,922
Total	15,062	26,929	50,926	130,172	319,132	473,017	457,312	598,810

Catches of skipjack tuna increased rapidly in the mid-1980s with the development of the industrial purse seine fishery. Furthermore, the development of gillnet offshore fisheries from Sri Lanka (Dayaratne & Maldeniya 1995), catching mostly skipjack tuna, shifted the catch of skipjack tuna in the 1990s.(**Figs. 1-2**). Exceptionally high catch levels were recorded from the early 2000s, with the highest catches ever recorded in 2021 at over 650,000 t.

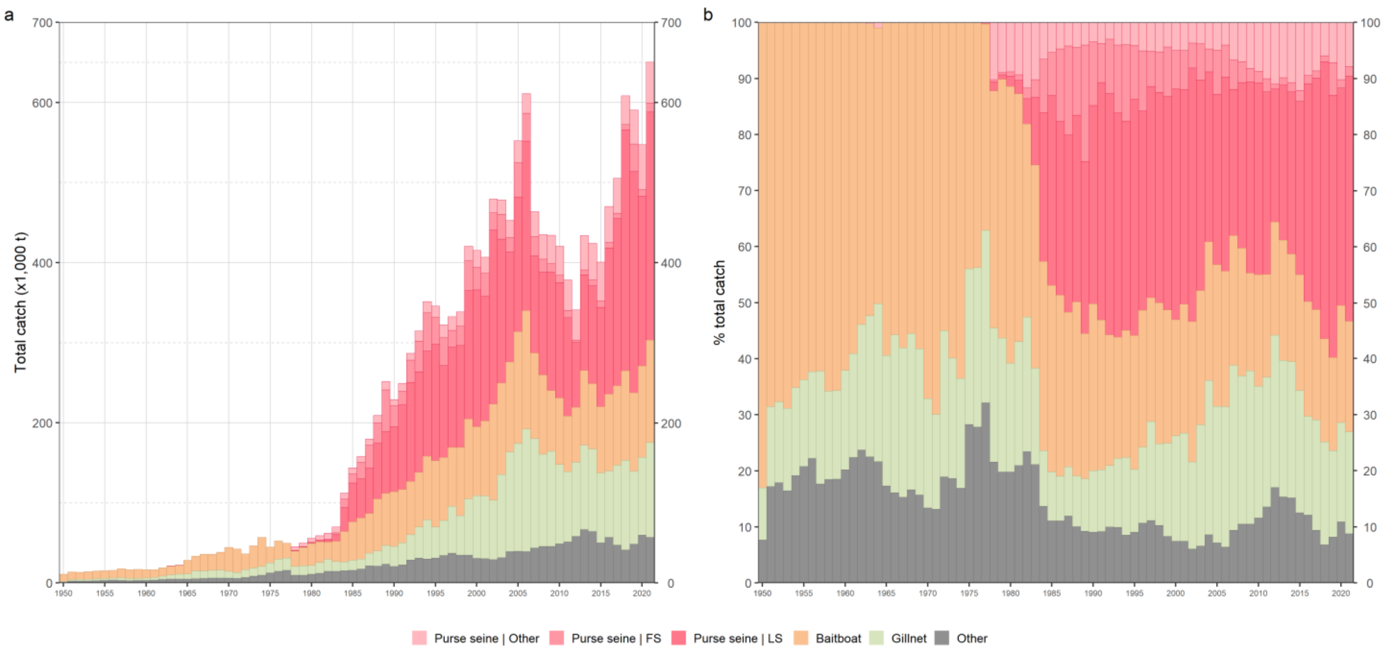

Figure 1: Annual time series of cumulative nominal absolute (a) and relative (b) catches (t) of skipjack tuna by fishery for the period 1950-2021. LS = schools associated with floating objects; FS = free-swimming schools. Data source: raised time-area catches

Catches of tropical tuna overall declined in 2011 and 2012 as a consequence of the piracy threats in the Western Indian Ocean from 2009. Catches of Skipjack tuna however, were least affected, as coastal fisheries contribute significantly to skipjack tuna catch, which were least effected by the piracy compared to large industrial fisheries, like purse seiners, which operated in the Somalia EEZ.

Catches of all purse seine fisheries combined show an increasing trend from 2013, after a slight decrease in 2012, with unusually high catches reported during 2019 (353,000 t). Potential biases caused by changes in data processing methodologies introduced by some important fleets could have affected the catch rate in 2019. More specifically, a change in the methodology used to estimate species composition by EU,Spain introduced unusually high catch figures for skipjack in 2018, but these have been temporarily re-estimated by the IOTC Secretariat under advice from the IOTC Working Party on Tropical Tunas (IOTC 2022b) and in agreement with IOTC (2019a).

Offshore and coastal fisheries like gillnet and baitboat, and more recently line fisheries, show an increasing trend in the skipjack catches, with gillnet reaching a peak of 118,000 t in 2021, and baitboat peaked at 128,000 t in 2021.

Table 2: Best scientific estimates of annual nominal catches (t) of skipjack tuna by fishery for the period 2012-2021. The background intensity color of each cell is directly proportional to the catch level. Data source: raised time-area catches

Fishery	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Purse seine | Other	37,431	42,859	45,411	48,513	44,534	43,821	36,178	42,313	55,938	50,875
Purse seine | FS	2,984	5,742	7,228	7,800	6,888	6,170	6,235	34,335	7,980	11,226
Purse seine | LS	80,989	119,864	122,490	123,994	182,735	208,876	300,877	276,212	212,329	284,678
Longline | Other	1,991	2,224	1	0	6	1	0	1	1	1
Longline | Fresh	5,536	2,303	476	767	537	678	1,546	1,663	1,995	1,163
Longline | Deep-freezing	72	88	65	58	138	67	59	59	64	47
Line | Coastal longline	13,244	20,396	21,530	8,926	10,786	10,830	9,126	11,495	12,793	11,124
Line | Trolling	22,080	27,086	29,186	27,686	32,195	24,732	21,102	21,410	25,228	26,007
Line | Handline	7,635	6,061	5,216	5,124	5,795	4,241	3,718	6,036	9,474	8,990
Baitboat	68,846	93,025	81,608	82,774	96,299	99,454	111,895	98,039	114,345	128,241
Gillnet	92,555	105,663	102,871	87,376	82,740	99,644	111,960	90,982	96,946	118,328
Other	7,551	8,502	7,967	7,617	7,498	6,976	5,789	7,899	10,195	9,650
Total	340,916	433,812	424,048	400,635	470,152	505,489	608,487	590,445	547,289	650,331

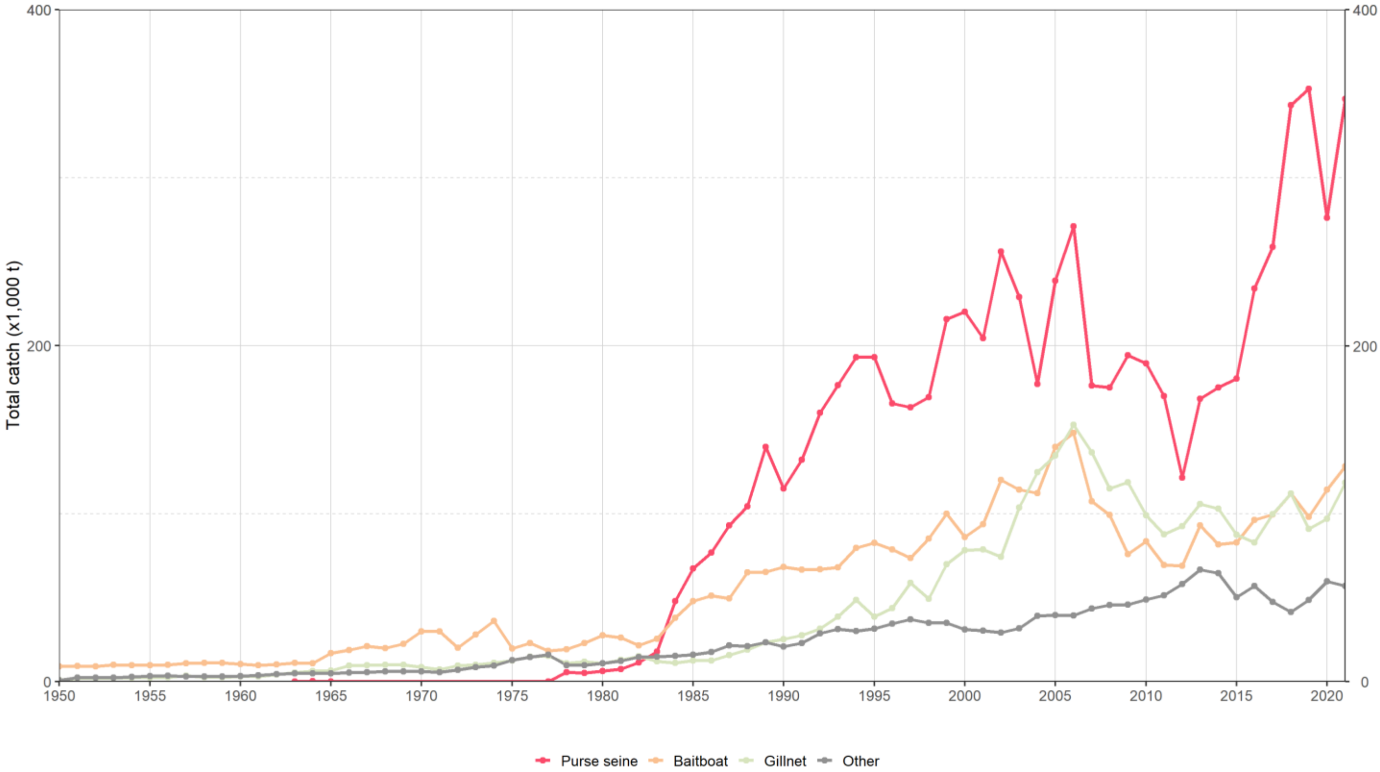

Figure 2: Annual time series of nominal catches (t) of skipjack tuna by fishery group for the period 1950-2021. Data source: [best scientific estimate of nominal catches]

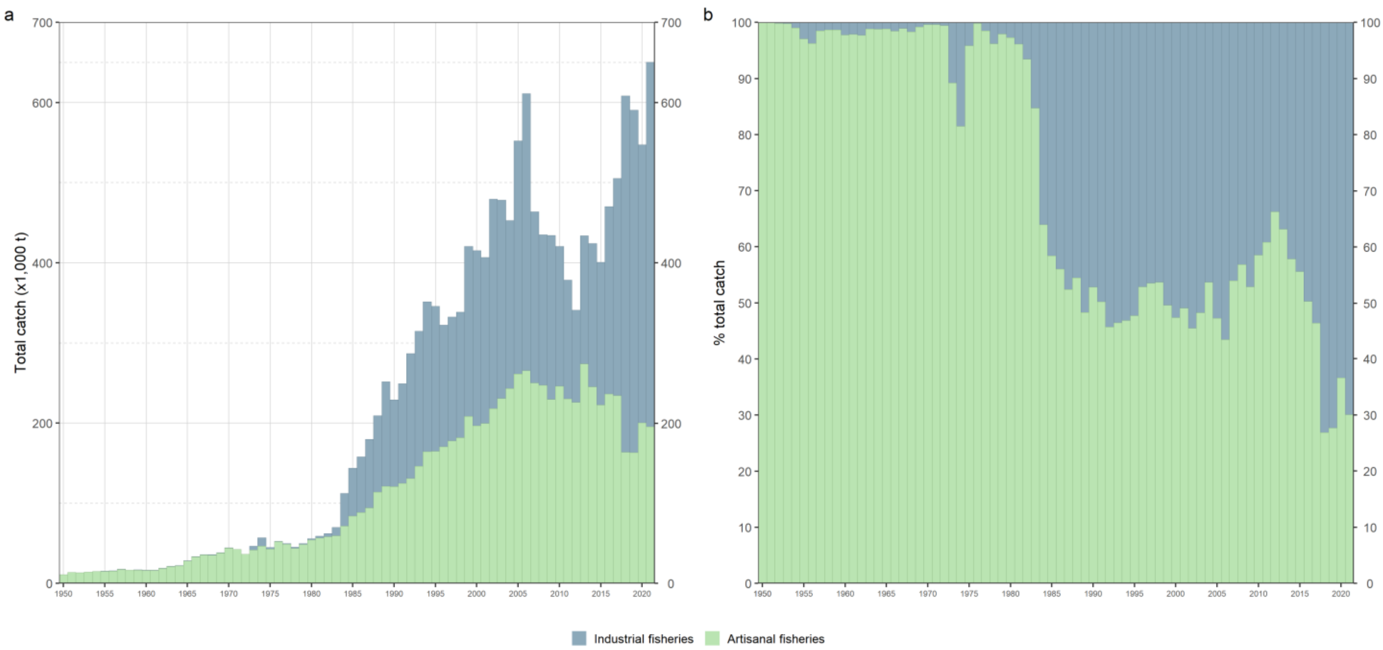

Figure 3: Annual time series of cumulative nominal absolute (a) and relative (b) catches (t) of skipjack tuna by type of fishery for the period 1950-2021. Data source: [best scientific estimate of nominal catches]

Trends in the artisanal fishery component of skipjack tuna catch in the Indian Ocean are characterized by fluctuation between the mid-2010s, after a stable increase from the early 1980s. Substantial decrease to a minimum of 27% of total catches reported by artisanal fisheries in 2018. The decline is a result of the reclassification of Maldives fisheries catches from 2018, particularly baitboat and handline fisheries, into offshore and coastal fisheries, which indicated that skipjack tuna were mainly caught in offshore fisheries. In recent years, some artisanal fisheries, such as Bangladesh and Yemen reported an increase of skipjack tuna catches in their coastal fisheries. Between 2017 and 2021, mean annual catches of artisanal fisheries were close to 190,000 t (33% of total catches), with industrial fisheries catching on average 390,000 t every year (**Fig. 3**).

Purse seine catch trends by fishing mode

Purse seine fisheries continued to catch huge quantity of skipjack tuna from schools associated with drifting floating objects (FOBs), accompanied by frequent yearly fluctuations on the relative percentages of the two fishing modes (i.e., free and associated schools). The Seychelles and EU purse seine fleets combined (limited to EU,Spain and EU,France, as little to no data is available for EU,Italy in recent years) reported over 80% of their skipjack tuna catches from FOB-associated schools since the early-2000s.

Between 2012 and 2021, catches from all purse seine fleets combined, fluctuated between 89% and 98% in the fraction of catches from FOB-associated schools, with around 98% of skipjack tuna catches reported from FOB-associated schools in 2018 and around 96% in 2021 (**Fig. 4**).

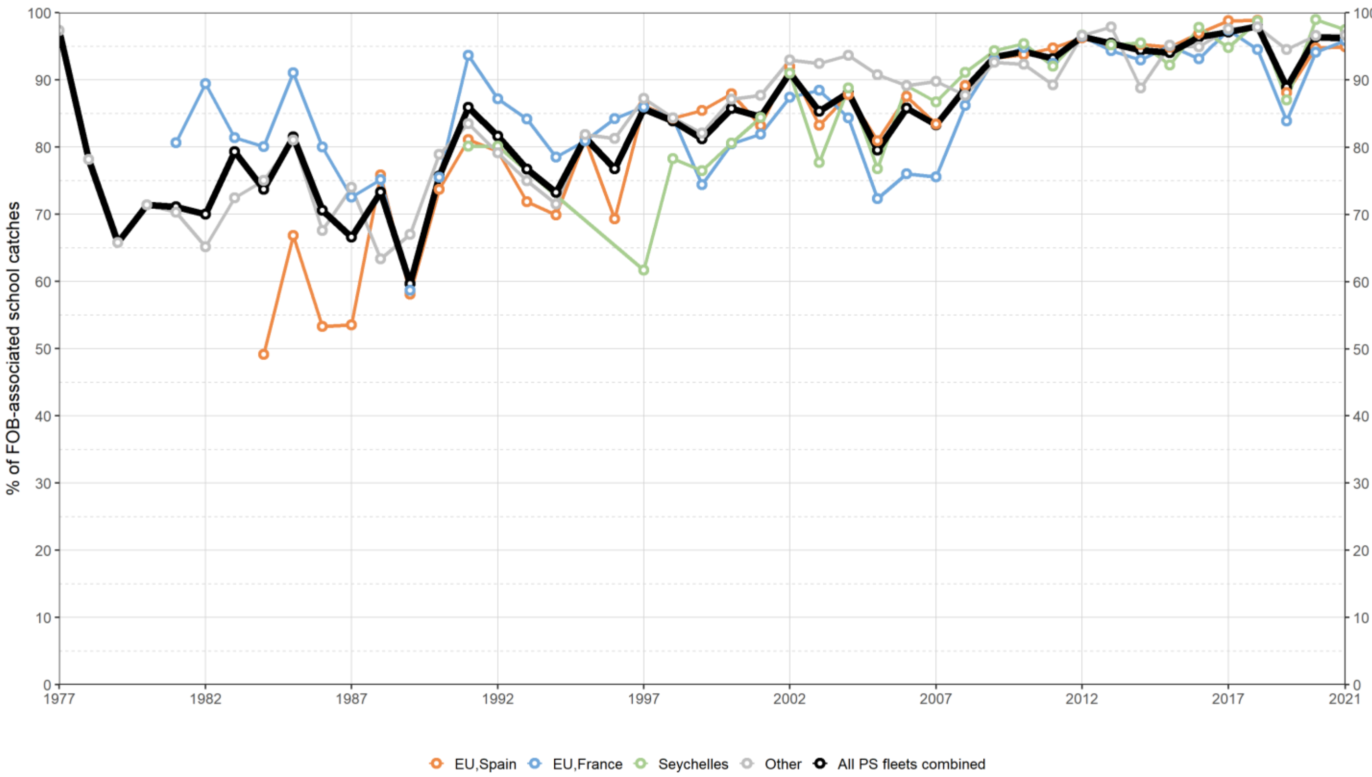

Figure 4: Annual percentages of purse seine FOB-associated catches of skipjack tuna by fleet for the period 1977-2021. *Other* includes purse seine fleets such as ex-Soviet Union, I.R. Iran, France (Mayotte), Mauritius, Japan, Korea, Indonesia, Thailand, EU,Italy, Belize, and others. Data source: time-area catch dataset for purse seine fisheries (Res. 15/02)

Main fishery features (2017-2021)

Skipjack tuna is caught mainly by purse seiner, baitboat and gillnet fisheries from different fleets operating all over the Indian Ocean. Between 2017 and 2021, purse seine fisheries (all fishing modes combined) caught an average of more than 316,000 t of skipjack tuna per year, contributing to around 54% of total nominal catches for the species (**Table 3**). During the same period, offshore fisheries of baitboat and gillnet fisheries represented the second main contributor of skipjack tuna catches, with about 110,000 t and 104,000 t, respectively caught annually (around 19% and 18% of the total). (**Table 3 & Fig. 2**).

Table 3: Mean annual catches of skipjack tuna (t) by fishery between 2017 and 2021. LS = schools associated with floating objects; FS = free-swimming schools. Data source: raised time-area catches

Fishery	Fishery code	Catch	Percentage
Purse seine | LS	PSLS	256,594	44.2
Baitboat	BB	110,395	19.0
Gillnet	GN	103,572	17.8
Other	OT	50,832	8.8
Purse seine | Other	PSOT	45,825	7.9
Purse seine | FS	PSFS	13,189	2.3

Average annual catches of skipjack tuna between 2017 and 2021 have been shared between several CPCs, with around 70% of all annual catches accounted for by coastal fleets, with Indonesia, Maldives, and Seychelles, contributing to 50% or more of average annual catches each (**Fig. 5**).

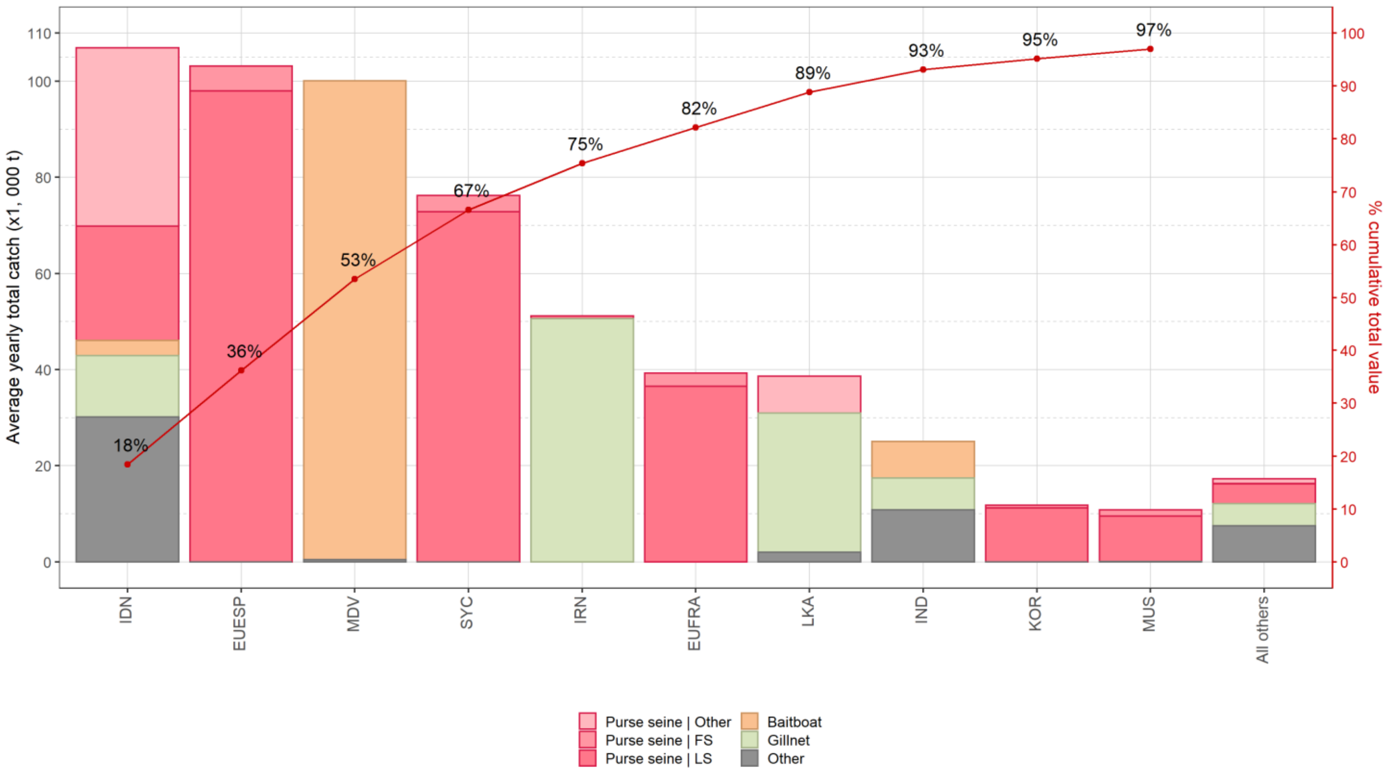

Figure 5: Mean annual catches of skipjack (t) tuna by fleet and fishery between 2017 and 2021, with indication of cumulative catches by fleet. FS = free-swimming schools; LS = schools associated with floating objects. Data source: raised time-area catches

Catch trends by fishery group in the same period (2017-2021) show different behaviors when comparing industrial purse seiner fisheries with other fishery groups, with fluctuated trends in catches from purse seine and continuous increase from the other fishery groups (**Fig. 6**).

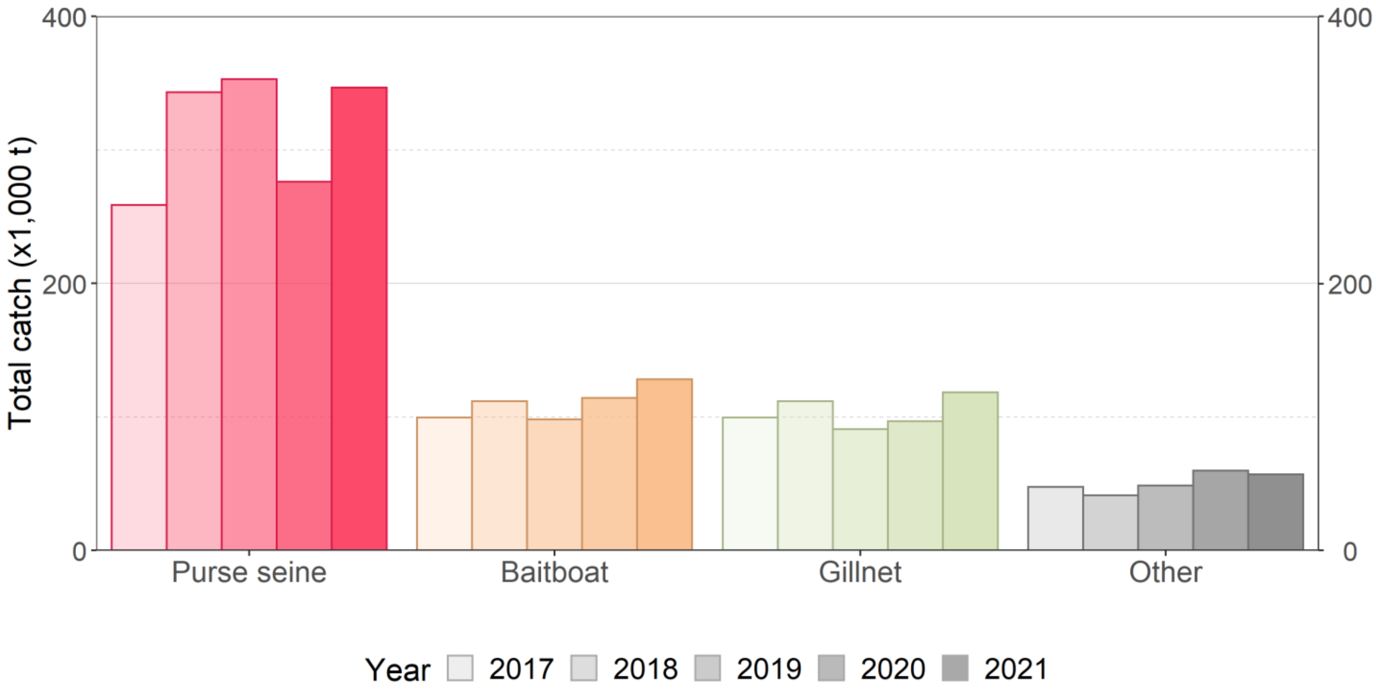

Figure 6: Annual catch (t) trends of skipjack tuna by fishery group between 2017 and 2021. Data source: [best scientific estimate of nominal catches]

Regarding industrial purse seine fisheries, catches from all fleets combined remain generally stable in the last five years, with a recent peak in catches identified in 2019 (**Fig. 6**). Recent catch trends by purse seine fleet (all fishing modes combined) show similar trends in the contribution from all major fleets, with generalized increases reported in 2019 (**Fig. 8a**).

Overall, changes in catches from purse seine fleets strongly vary with the type of school association. Catches on free-swimming schools (which are generally lower in magnitude) show a mixed situation with high variability across years for all fleets involved (**Fig. 7a**), while catches on FOB-associated schools have generally stable recent trends, with the exception of 2021 when unusually high catches were reported by Indonesia and EU,France on FOB-associated schools (**Fig. 7b**).

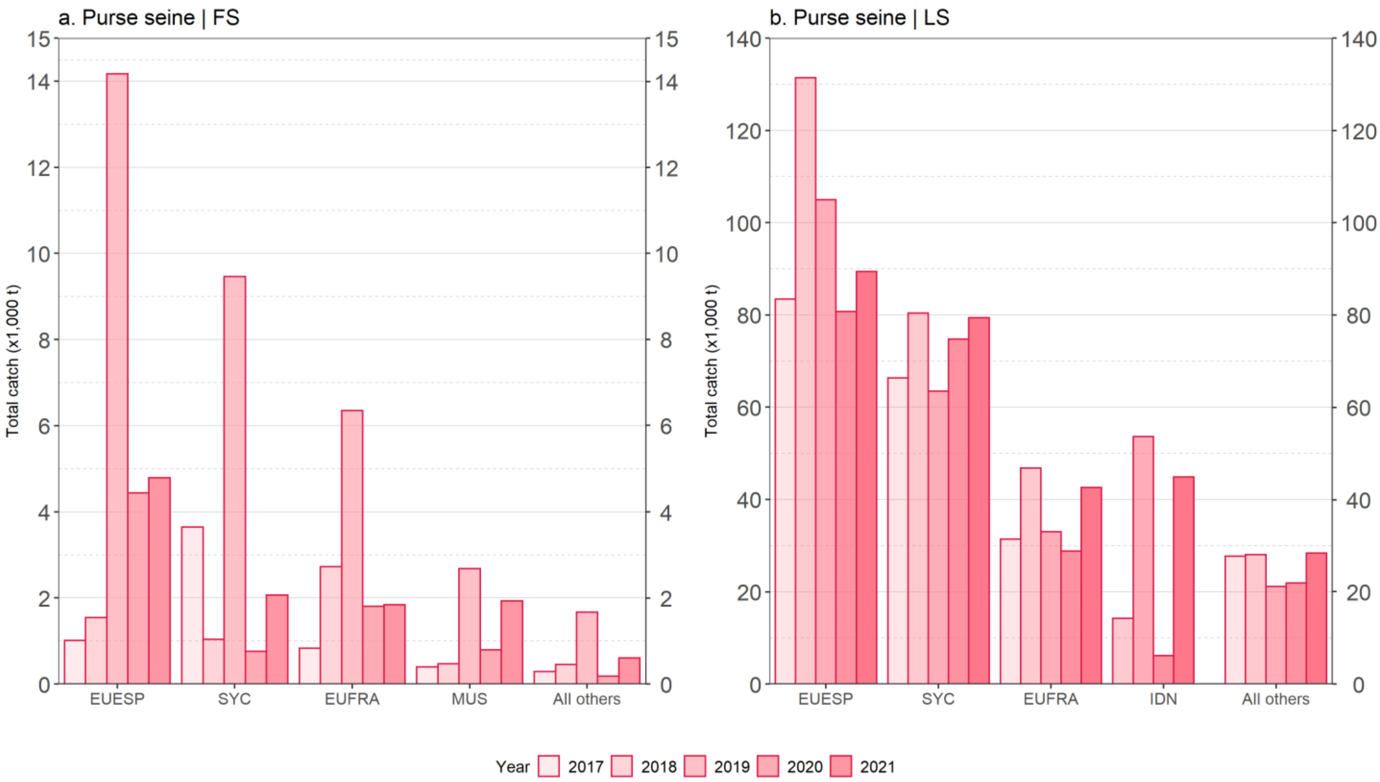

Figure 7: Annual purse seine catch (t) trends of skipjack tuna by fishing mode and fleet between 2017 and 2021. FS = free-swimming schools; LS = schools associated with floating objects. Data source: raised time-area catches

Recent data from baitboat fisheries, where majority of the catches are from Maldives, show an increasing trend in skipjack catches from 2018, with a slight drop in 2019, followed by a new increase in catches that brought the totals back to 2017 levels. Iranian gillnet in recent years contributed vastly to skipjack catch from gillnet fisheries of Indian Ocean, where in 2021 catch was over 50% of 2020 catch. (**Fig. 8**),

Fleets using line or assimilated gears (handline, troll-line, coastal longline) show an overall decline in catch since 2017. At fleet level, Indonesia, which is a major contributor appear to be in a phase of slight contractions compared to previous years, with catches in 2021 reported at lower levels than 2020 (**Fig. 8c**).

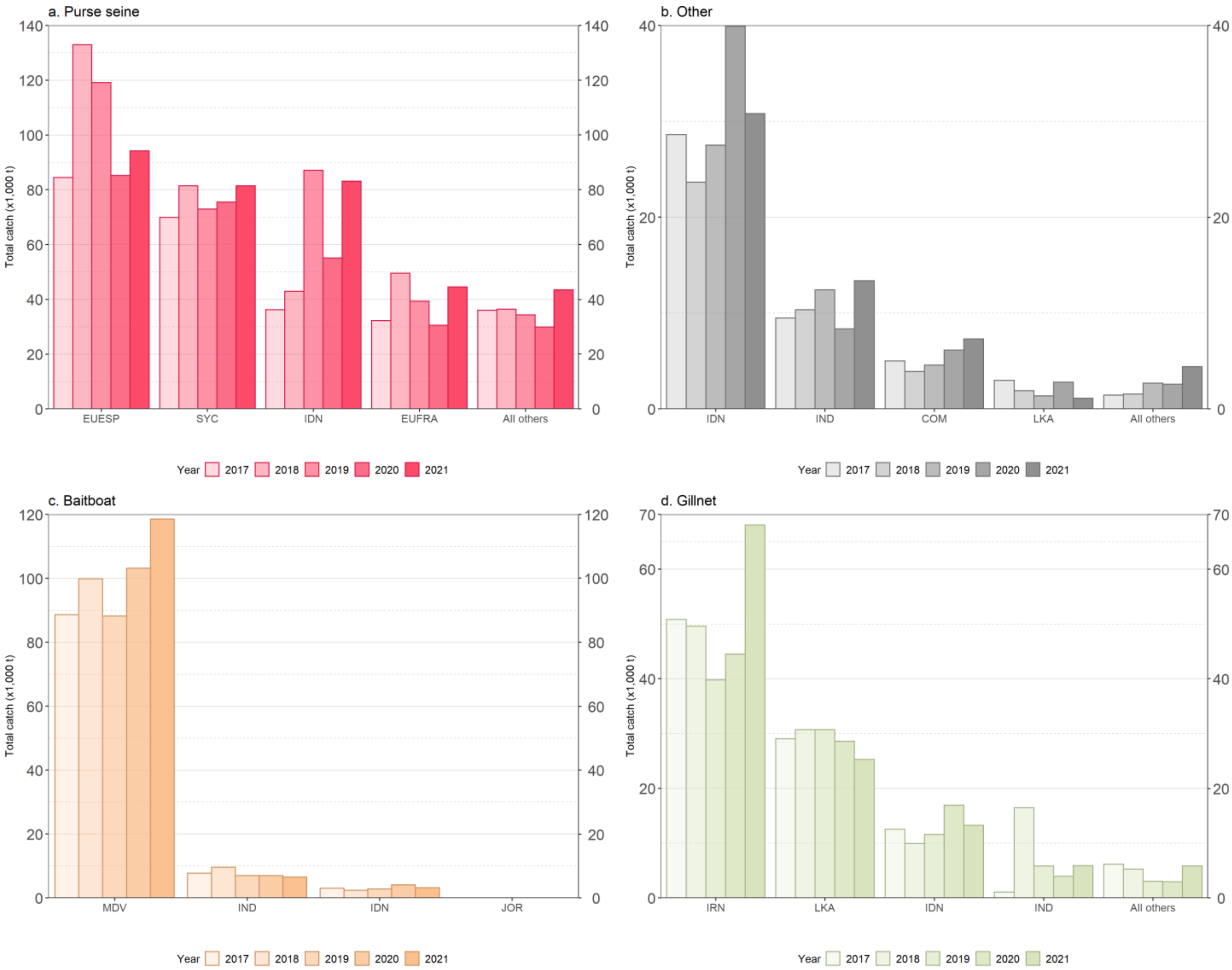

Figure 8: Annual catch (t) trends of skipjack tuna by fishery group and fleet between 2017 and 2021. Data source: [best scientific estimate of nominal catches]

Changes from previous WPTT

Limited but significant changes were detected in the latest time series of catches of skipjack tuna compared to the best scientific estimates of nominal catches available to the last data preparatory meeting of the Working Party on Tropical Tunas in May 2022, summing up to an overall annual change of -691 t for 2018 (**Fig. 9**).

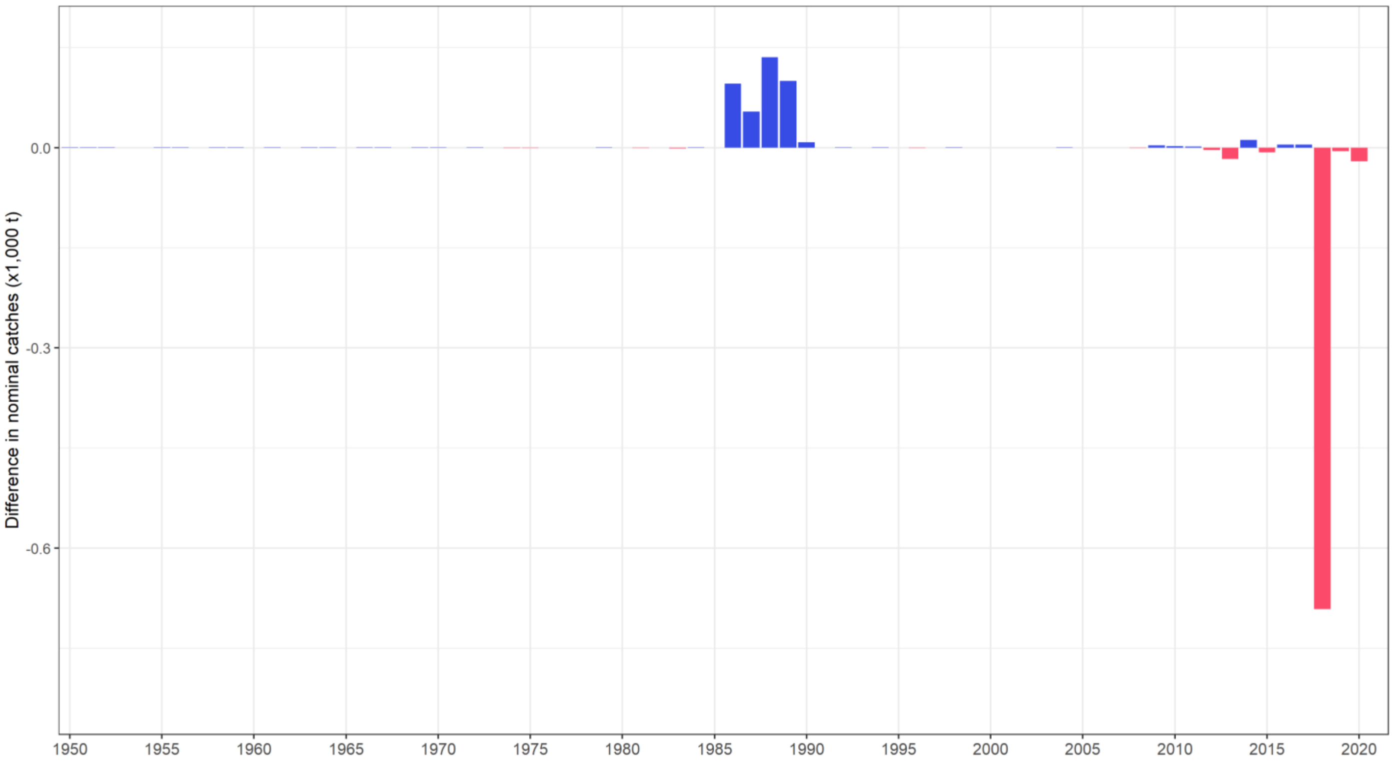

Figure 9: Differences in the available best scientific estimates of nominal catches (t) of skipjack tuna between this WPTT and its previous session (data preparatory meeting held in May 2021)

These changes are a consequence of the request made by the WPTT24(DP) to re-estimate the species composition of the Spanish component of the European Union purse-seine fleet for 2018 (IOTC 2022b) due to the differences introduced in the original estimates by a revision in the statistical procedures used by EU,Spain. The issue was first identified during the 21st session of the Working Party on Tropical Tunas held in 2019 (IOTC 2019c), and the approach for the current re-estimation was presented during the Working Party on Data Collection and Statistics in the same year (IOTC 2019b).

The re-estimation applied by the IOTC Secretariat resulted in a decrease of almost 600 t in catches of skipjack tuna recorded for 2018 (**Table 4**) while increasing by the same amount of EU,Spain overall catches of yellowfin tuna for the year concerned.

Besides the major changes in Spanish component of the European Union purse-seine fleet, minor changes in other fisheries from Jordan, resulting from the disaggregation process of aggregated catch in the database.

Table 4: Changes in best scientific estimates of average annual nominal catches of skipjack tuna by year, fleet, fishery group and main Indian Ocean area, limited to absolute values higher than 10 t. Data source: best scientific estimate of nominal catches 2020 and 2021

Year	Fleet	Fishery group	Area	Current (t)	Previous (t)	Difference (t)
2020	JOR	Gillnet	Western Indian Ocean	4	20	-16
		Line	Western Indian Ocean	3	14	-11
2019		Baitboat	Western Indian Ocean	22	0	22
		Line	Western Indian Ocean	5	28	-23
2018	EUESP	Purse seine	Western Indian Ocean	132,933	133,626	-693
	JOR	Baitboat	Western Indian Ocean	28	0	28
		Line	Western Indian Ocean	4	20	-16
2017		Baitboat	Western Indian Ocean	31	0	31
		Gillnet	Western Indian Ocean	4	23	-19
2016		Baitboat	Western Indian Ocean	31	0	31
		Gillnet	Western Indian Ocean	4	21	-17
2015		Baitboat	Western Indian Ocean	25	0	25
		Line	Western Indian Ocean	3	23	-20

Uncertainties in nominal catch data

Reporting quality

The quality of the nominal catches of skipjack tuna reported to the IOTC Secretariat varies over the years (**Fig. 10**), which are mostly driven by the contribution of coastal fisheries to the total catches. coastal fisheries quality catch showed a declining trend from the 1990s to the 2010s, where the introduction of new offshore fisheries were not complying with the data reporting requirement. From the mid-2010s, the situation started to improve, with Sri Lanka and Iran created new data collection systems. On the contrary, Indonesia and India, which are also key contributors, lack proper data collection system. Furthermore, NEI estimate of industrial fisheries reduced with the implementation of the Port State Measures, which progressively reduced the extent of illegal, unreported, and unregulated (IUU) fisheries in the Indian Ocean (**Fig. 10**).

Although the main coastal fisheries are progressing in the data collection, reporting of fisheries data by some artisanal fisheries is still an issue, hindered by lack of appropriate collection system. These include troll lines from Madagascar, small-scale purse seine and handline fisheries from Mozambique, as well as for the fisheries of Tanzania. Furthermore, catches of Indonesian artisanal fisheries have been annually re-estimated since the early 2010s based on fixed species compositions that depend on each fishing gear and were derived from samples primarily collected in the 2000s (Moreno et al. 2012). In 2021, the percentage of skipjack tuna catch fully or partially reported to the Secretariat was 86%.

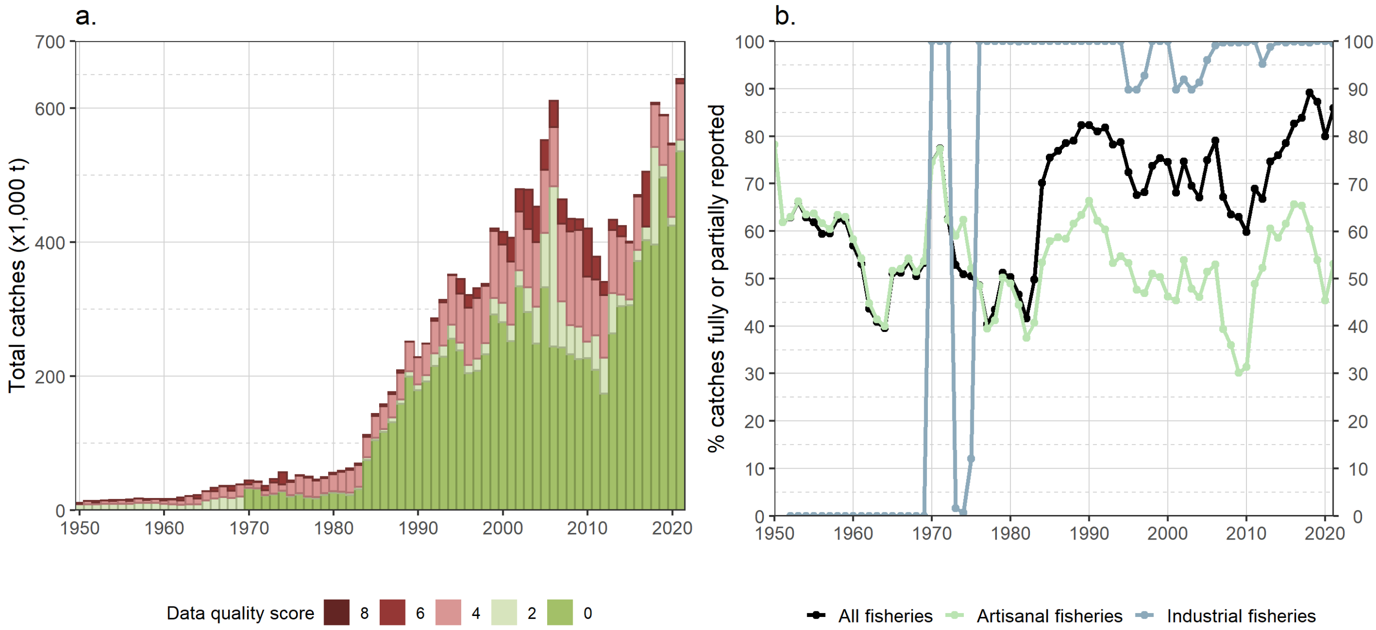

Figure 10: Annual nominal catches (t) of skipjack tuna estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950-2021

Discard levels

The total amount of skipjack 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 2018 (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 discarding mostly occurs in schools associated with floating objects (Amandè et al. 2012). Purse seine discards of skipjack tuna are mainly composed of fish smaller than 50 cm (~5.7 kg), although a few larger fish may be discarded when damaged (**Fig. 11**). 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).

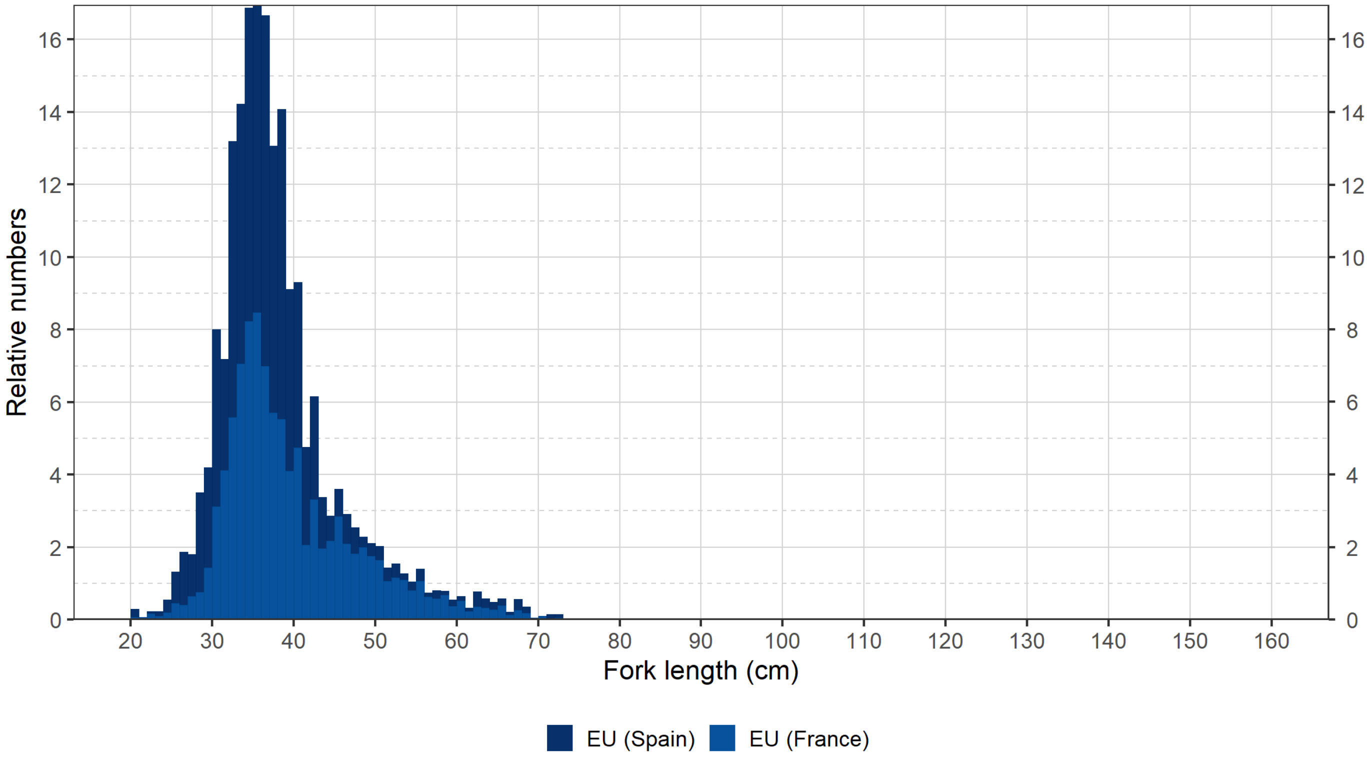

Figure 11: Fork length distribution of skipjack tuna discarded at sea in purse seine fisheries during the period 2016-2020 (n = 214,824). Data source: IOTC ROS database

Discarding may also occur in tropical longline fisheries, mainly due to depredation by sharks and cetaceans (Rabearisoa et al. 2018). In the Taiwan,China longline fishery of the Indian Ocean, for instance, the discarding rate of skipjack tuna has been estimated at 38.047% 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 2014-2020. almost no discard of skipjack tuna from the Japanese longline, whereas the size of the skipjack tunas discarded at sea by the Reunion-based fresh longline fisheries are small(**Fig. 12**).

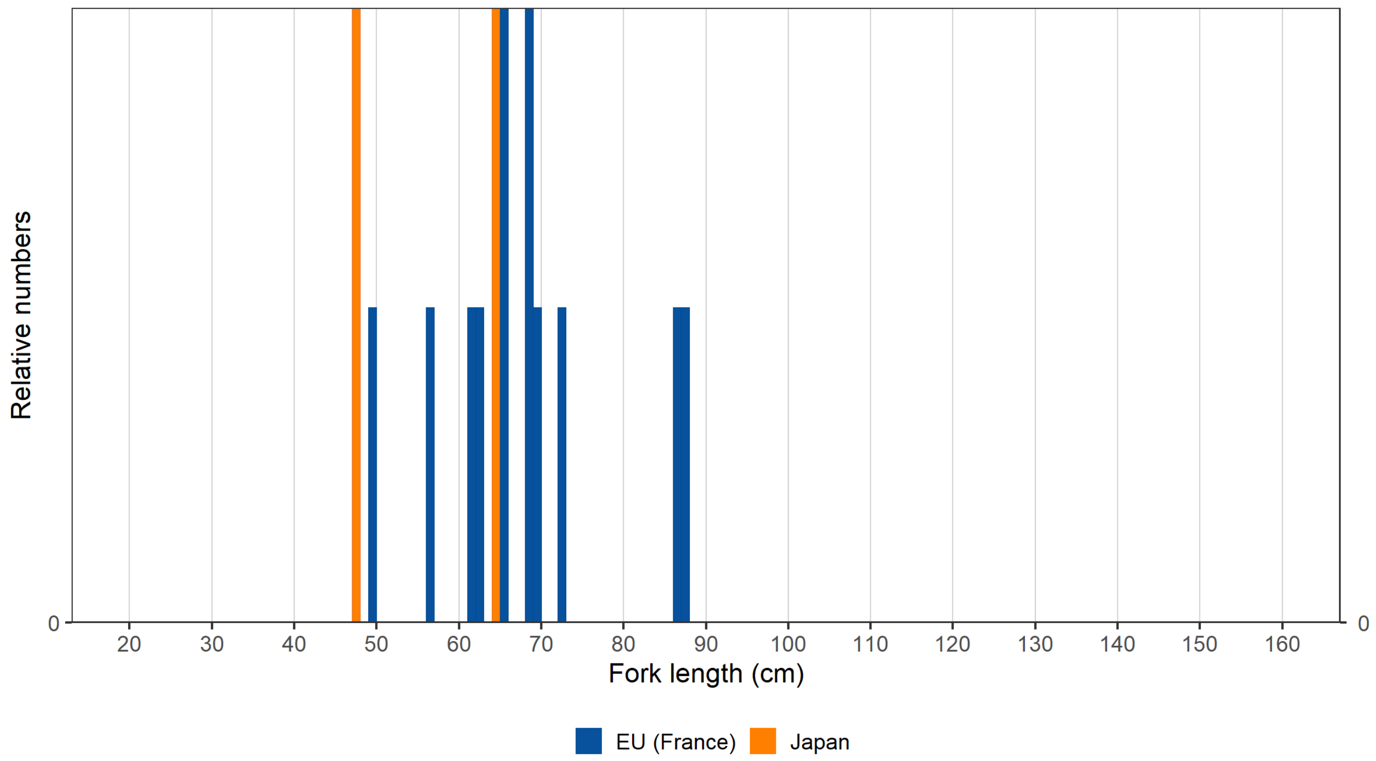

Figure 12: Fork length distribution of skipjack tuna discarded at sea in longline fisheries during the period 2014-2020 (n = 112). Data source: IOTC ROS database

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 catch

Spatial distribution of catches

Estimated geo-referenced catches show the spatial expansion and major changes that took place in the fisheries targeting skipjack tuna over the last decades (**Fig. 13**). As early as the 1950s, skipjack tuna was caught by baitboat fisheries in Maldives, Indian and Sri Lankan waters, while coastal gillnet and line fisheries were active in the Northwest Indian Ocean, includingthe Arabian sea.

From the 1980s, the purse seine fishery developed in the western Indian Ocean, with most of the skipjack tuna caught by log-associated schools, including some development of gillnet and line fisheries in the Eastern Indian Ocean (**Fig. 13d**). During the 1990s and 2000s, the purse seine and baitboat fisheries increased catches and expanded its fishing grounds in the western Indian Ocean while gillnet and line fishery developed further in the north-eastern Indian Ocean (**Fig. 13e-f**). The overall annual distribution of skipjack tuna catches by fishery has changed little over the period 2017-2021 (**Fig. 14**).

Georeferenced catches by fishery and decade (1950-2009)

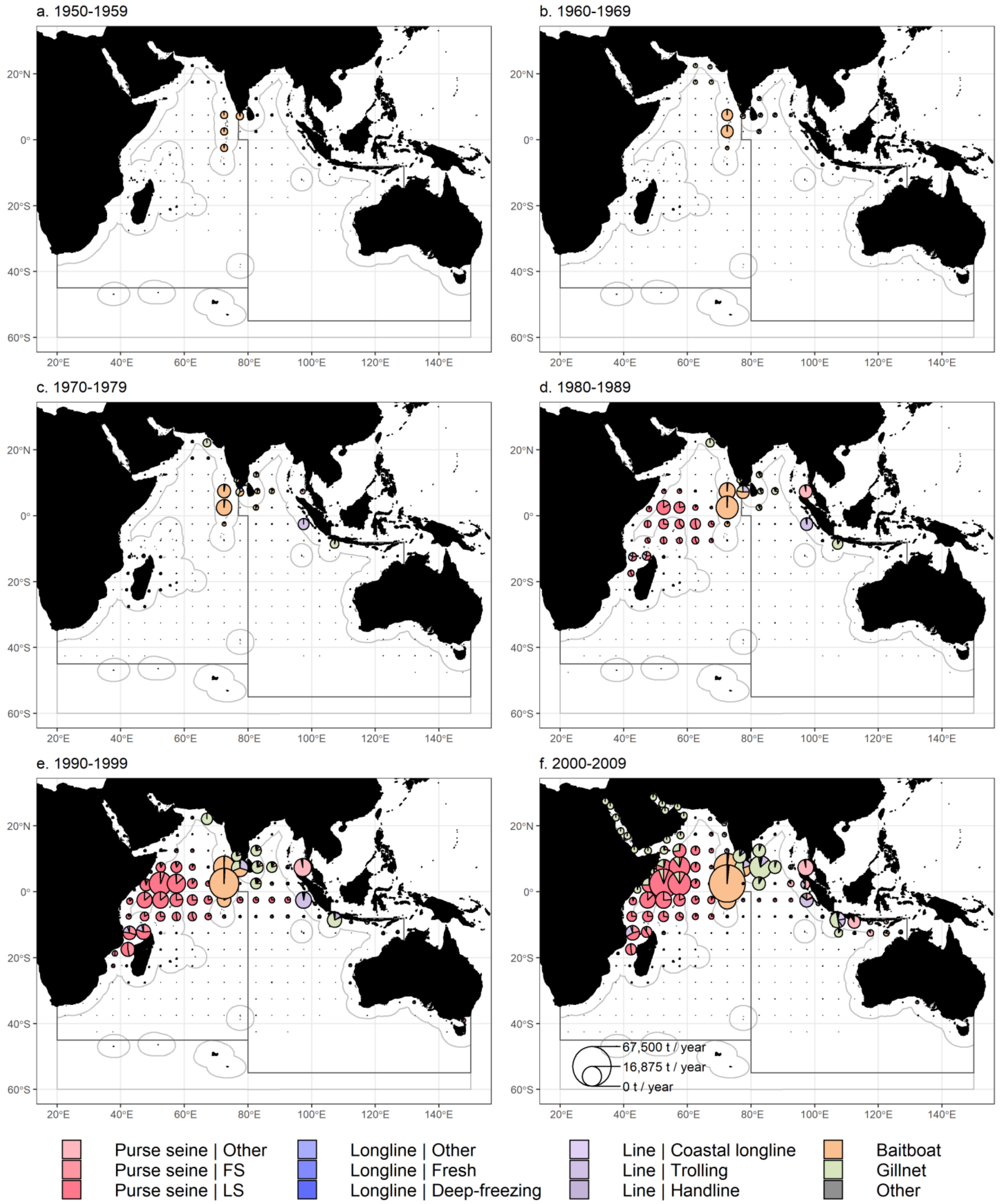

Figure 13: Estimated mean annual time-area catches (t) of skipjack tuna, by decade, 5x5 grid, and fishery. Data source: raised time-area catches

Georeferenced catches by fishery, last years (2017-2021) and decade (2010-2019)

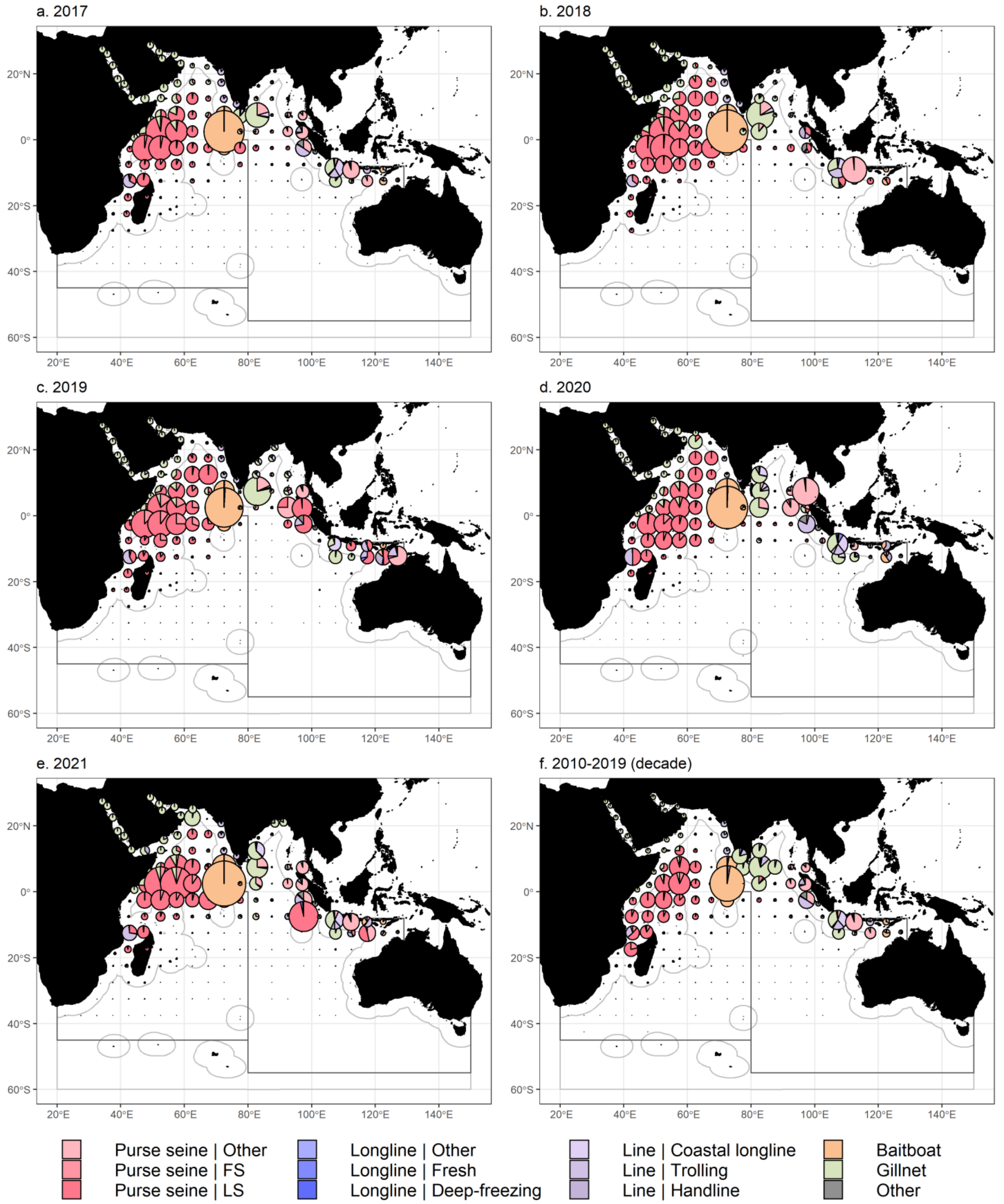

Figure 14: Estimated average annual time-area catches (t) of skipjack tuna, by year / decade, 5x5 grid, and fishery. Data source: raised time-area catches

Indonesia appears to have developed an industrial purse seine fishery since 2018 (**Fig. 14d-e**), which mainly operates in coastal areas of the eastern Indian Ocean with vessels of length overall (LOA) between 30 and 40 m. Baitboat fishing is essentially concentrated in the Maldives archipelago, while gillnet fisheries are widely used along the coasts of India, Sri Lanka, the Arabian sea and Indonesia. Line fisheries, on the other hand, are catching skipjack tuna mainly in the Sumatra area.

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 the quality of the catch and effort data is driven to some extent by the relative contribution of artisanal fisheries to the total catches of skipjack tuna (**Fig. 15b**). The main issues identified in the past concern:

- purse seine and other fisheries of Indonesia, with data only available from 2018 onward (although logbook coverage is thought to be low);
- the purse seine fisheries of I.R. Iran (until 2004) for which data are either incomplete or lacking;
- the fisheries of Sri Lanka (since 2014), described by poor quality effort data;
- some coastal fisheries for which no data (or incomplete data) have been reported to the Secretariat, in particular: Comoros (until 2018), Indonesia (2018 and 2020), India, Tanzania, and Pakistan (no catch).

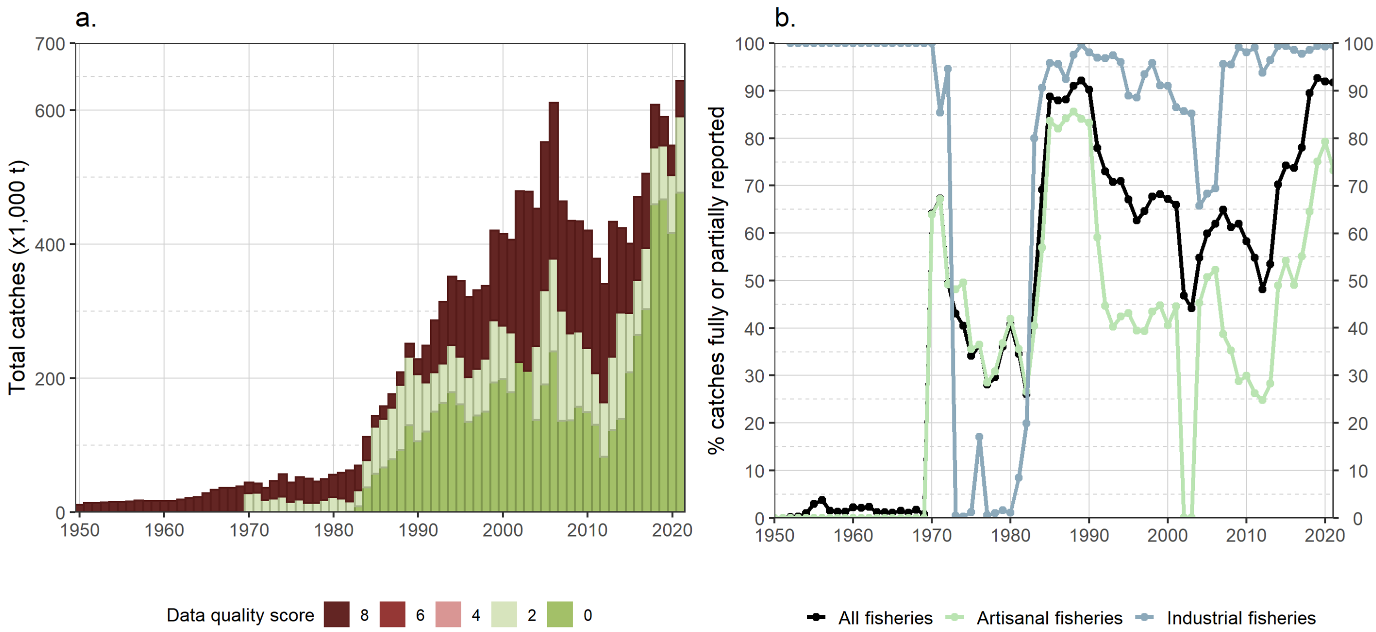

Figure 15: Annual nominal catches (t) of skipjack tuna estimated by quality score (barplot) and percentage of geo-referenced catches reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950-2021

The percentage of data considered of good quality (scores of 0-2) varied between 44%-90% during the 1990s and 2000s, and improved over the last decade, showing an overall increasing trend from 48% in 2012 to 93% in 2019, with a slight decline to 92% of good quality data available in 2021 (**Fig. 15a-b**). Catch and effort data have progressively become available for some important coastal fisheries, such as Sri Lanka since 2014, the I.R. Iran since 2007, and Indonesia since 2018.

Nevertheless, geo-referenced catch and effort data were unavailable for about 8% (i.e., around 50,000 t) of the total nominal catches of skipjack tuna in 2021. In addition, no spatial information has been provided by the EU,Italy industrial purse seine fishery (since 2016), accounting in 2021 for relatively low total catch levels of skipjack tuna of ~2,400.

Size composition of the catch

Samples availability

By fishery group

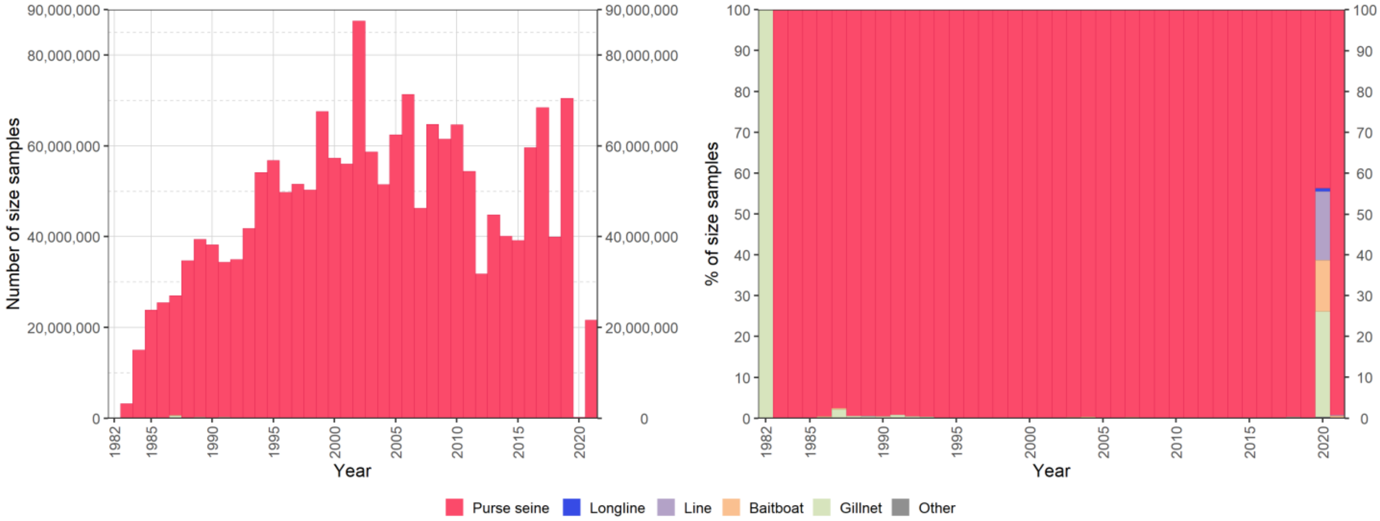

Figure 16: Availability of skipjack tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and fishery group. Data source: standardized size-frequency dataset (Res. 15/02)

Comprehensive size-frequency data for skipjack tuna are only available from the beginning of the 1980s (see also Uncertainties in size-frequency data).

Most of the samples available to the IOTC Secretariat have been collected since the development of the purse seine fishery in the Indian Ocean and reported as '*raised*' samples (i.e., processed at the source to represent *catch-at-size* for the fleets and years concerned). This explains the magnitude of the samples available from these fisheries, which at its peak reached over 30 million individual lengths reported for a single year (**Fig. 16**).

The contribution of other fisheries to the total available samples for the species is insignificant, with less than 5%, which does not reflect the actual level of catches from these fisheries. (**Fig. 27**).

Due to the CoViD-19 pandemic, size-frequency data of skipjack tuna collected by purse seine fisheries are basically unavailable for 2020, if not for a very limited number of individuals sampled by EU,France, Mauritius, and Seychelles.

The spatial distribution of the available samples by fishery type in the last five years (**Fig. 17**) is generally representative of the fishing grounds where the fisheries operate and proportional to the level of recorded captures.

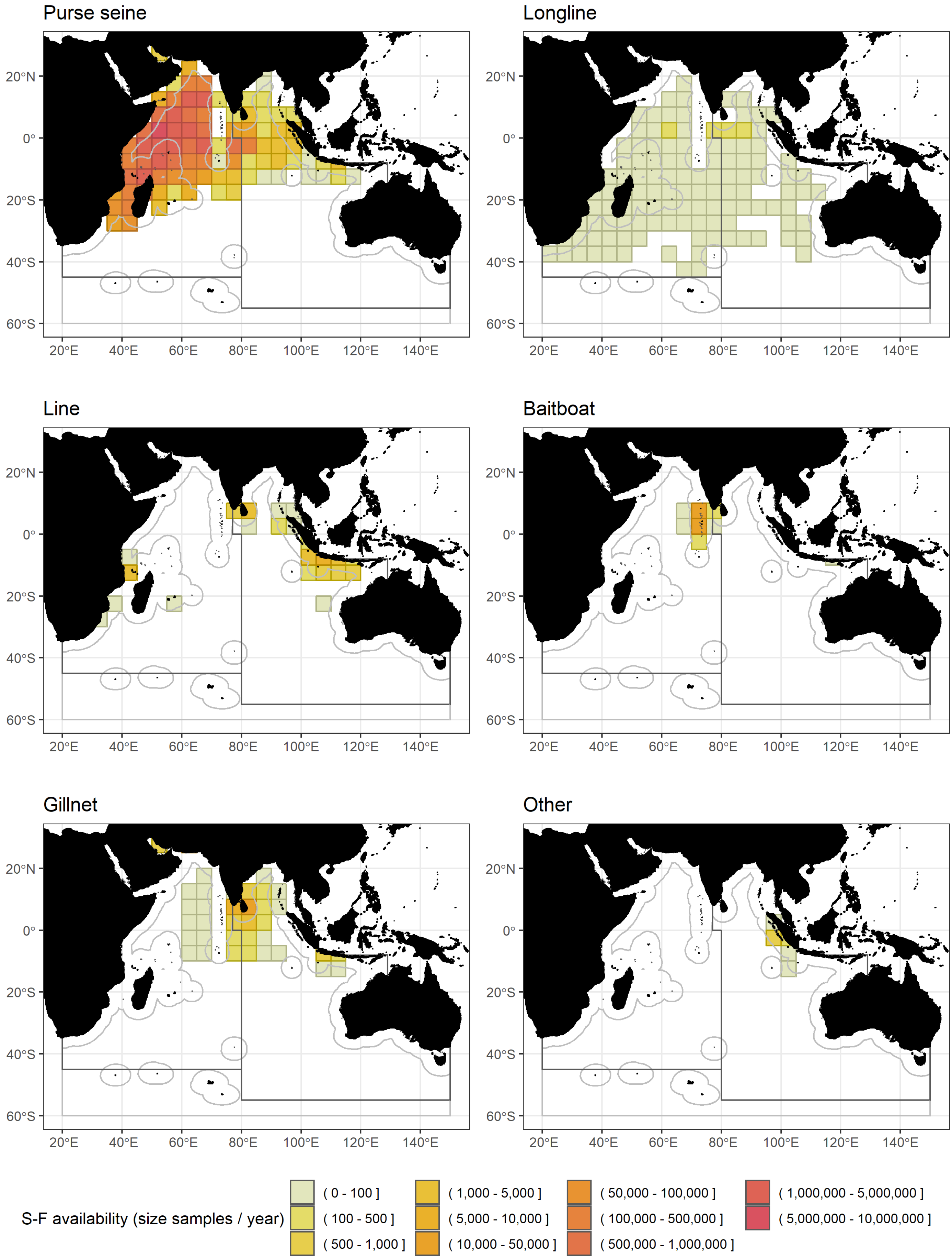

Figure 17: Spatial distribution (average number of samples per grid per year) of available skipjack tuna size-frequency data for each fishery group in the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

By fishery

Purse seine fisheries

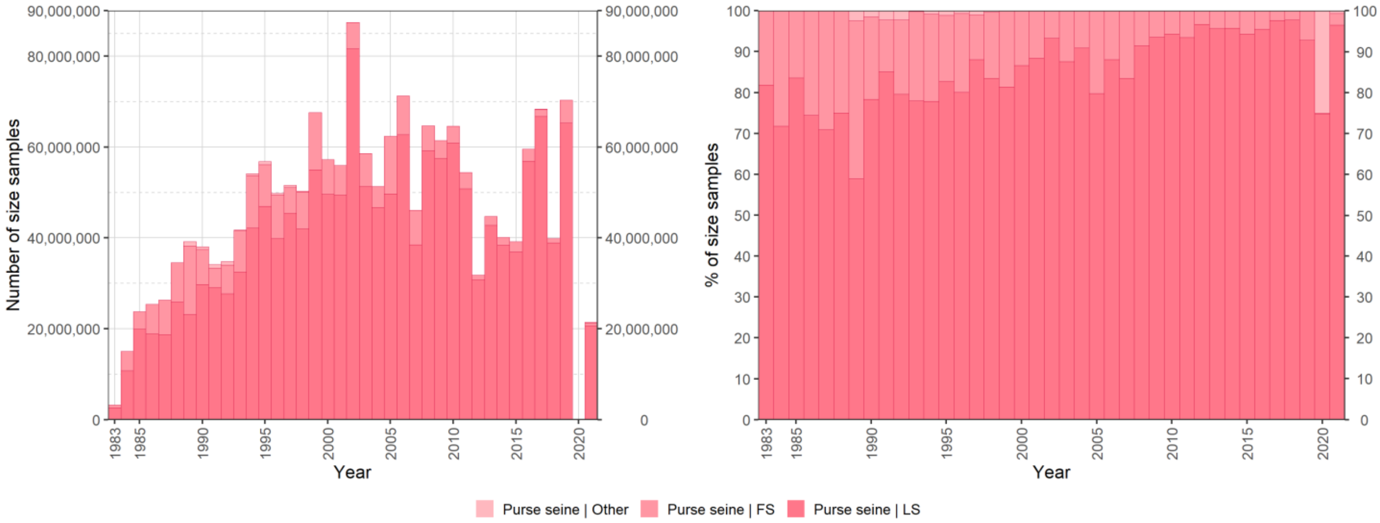

Figure 18: Availability of skipjack tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and purse seine fishery type. Data source: [standardized size-frequency dataset] (Res. 15/02)

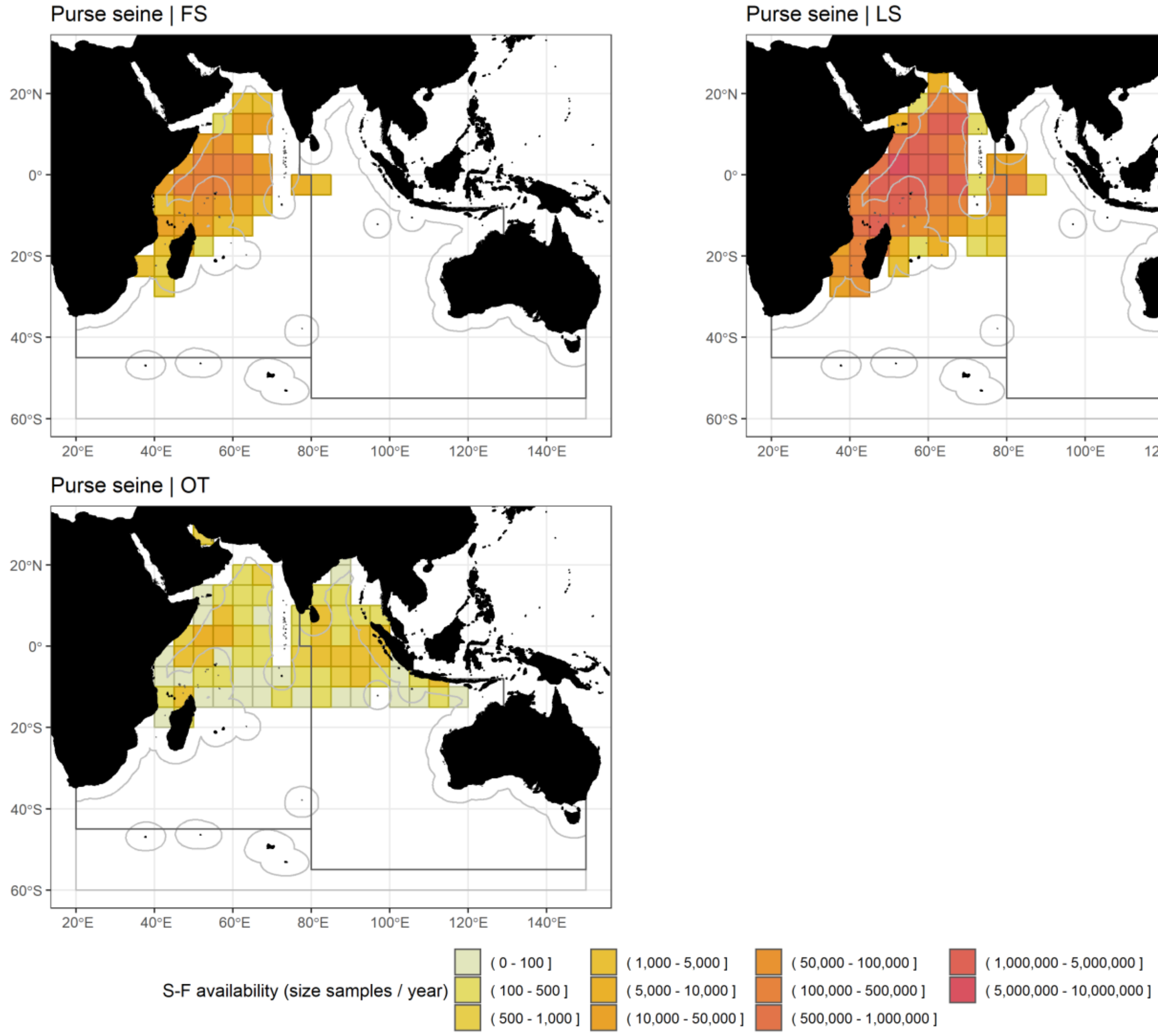

Figure 19: Spatial distribution (average number of samples per grid per year) of available skipjack tuna size-frequency data by purse seine fishery types in the period 2017-2021. Data source: [standardized size-frequency dataset] (Res. 15/02)

Longline fisheries

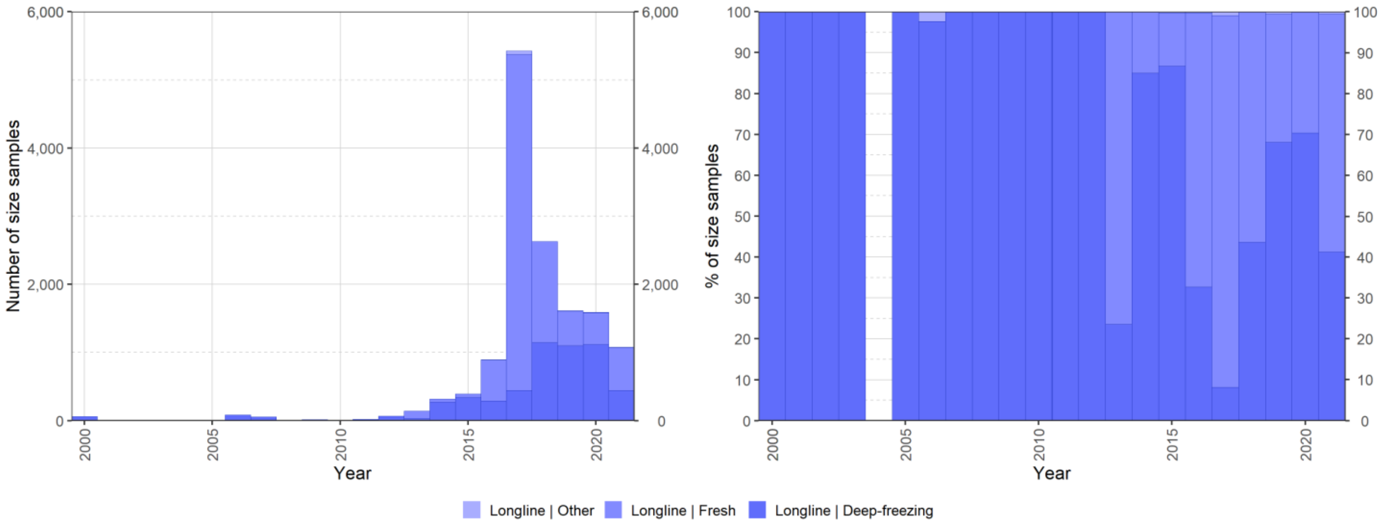

Figure 20: Availability of skipjack tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and longline fishery type. Data source: [standardized size-frequency dataset] (Res. 15/02)

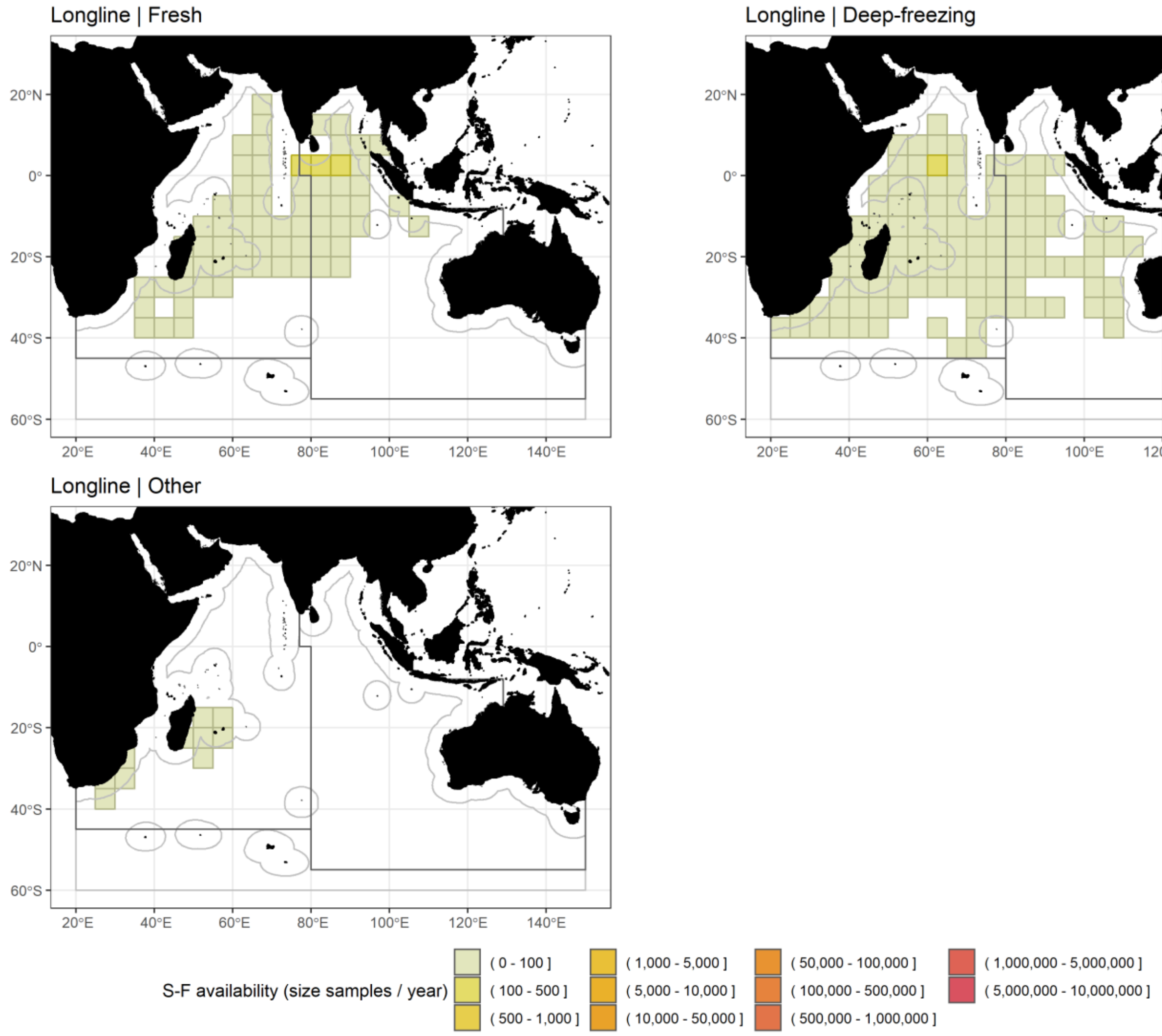

Figure 21: Spatial distribution (average number of samples per grid per year) of available skipjack tuna size-frequency data by longline fishery types in the period 2017-2021. Data source: [standardized size-frequency dataset] (Res. 15/02)

Line fisheries

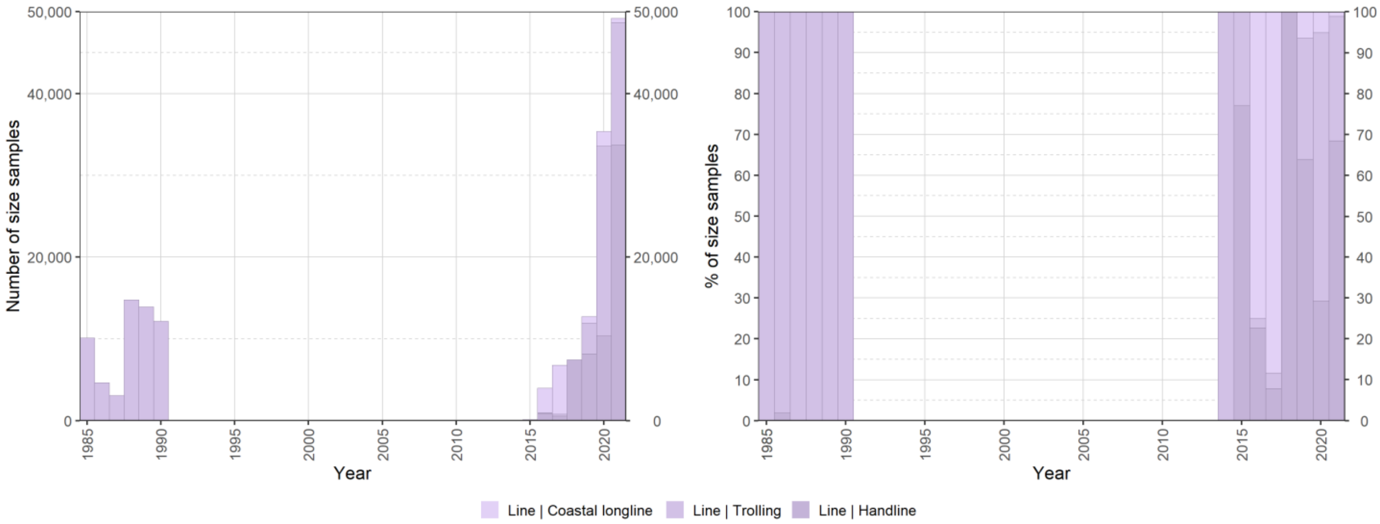

Figure 22: Availability of skipjack tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and line fishery type. Data source: standardized size-frequency dataset (Res. 15/02)

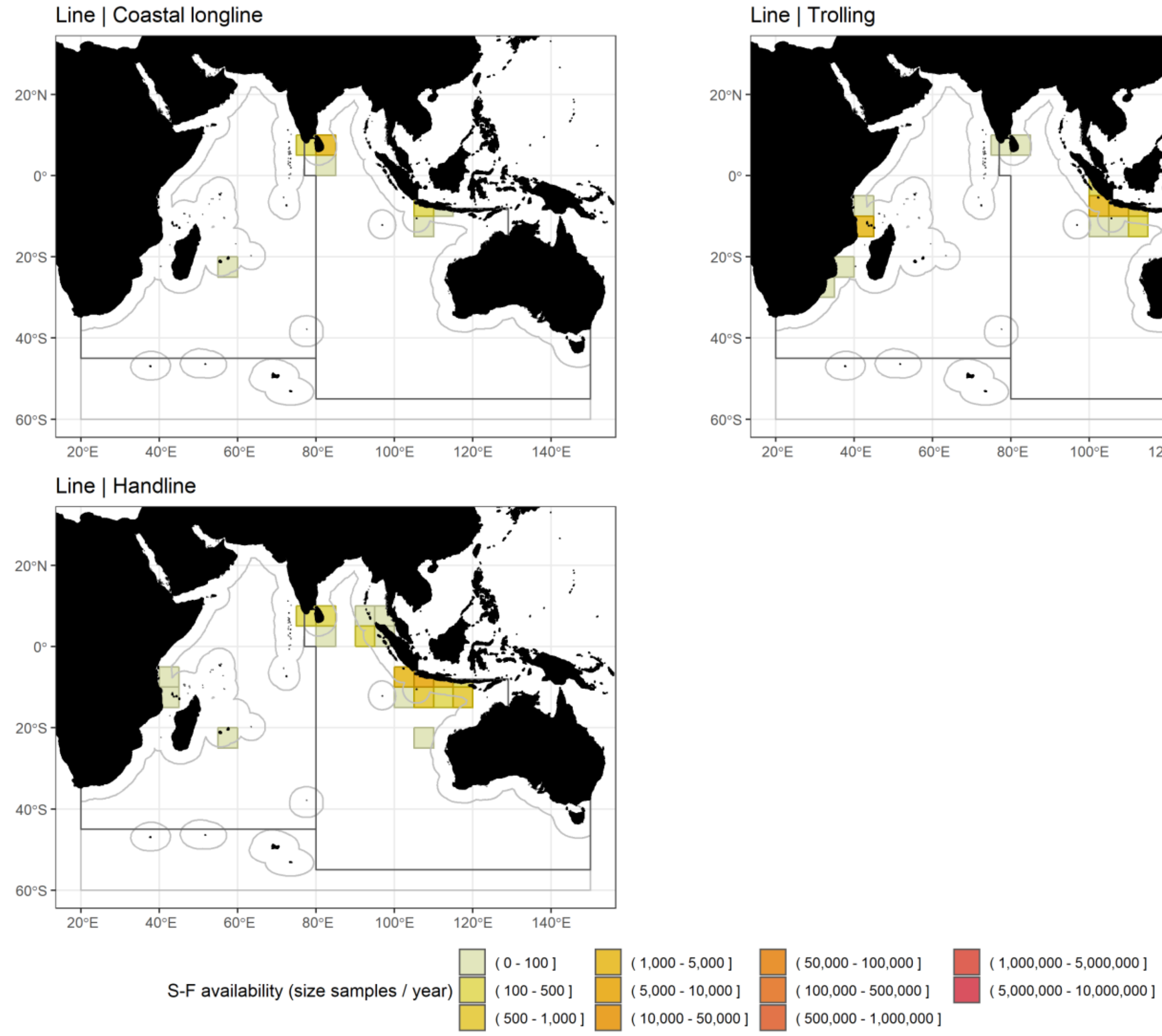

Figure 23: Spatial distribution (average number of samples per grid per year) of available skipjack tuna size-frequency data by line fishery types in the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

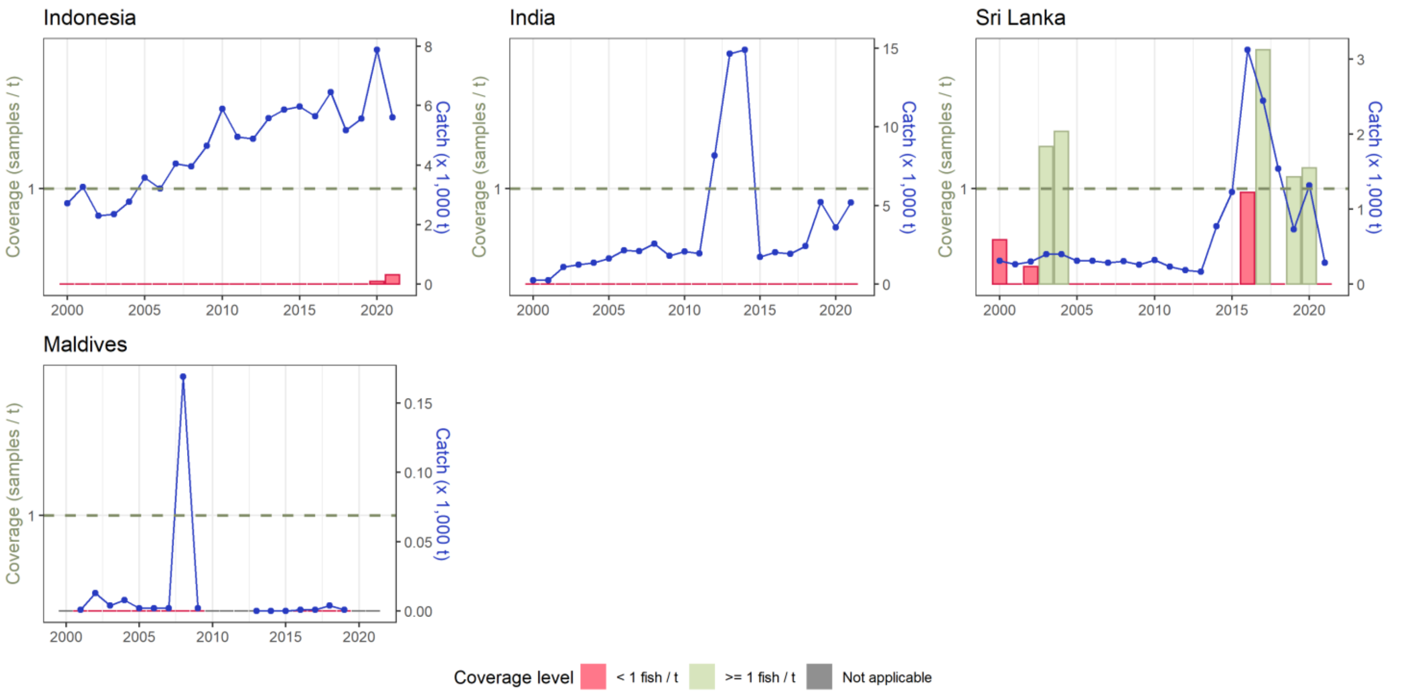

Figure 24: Size-frequency samples coverage (number of fish measured by t of retained catches) of skipjack tuna caught by the major coastal longline fleets, by fleet and year (2000-2021). Data source: [standardized size-frequency dataset] (Res. 15/02)

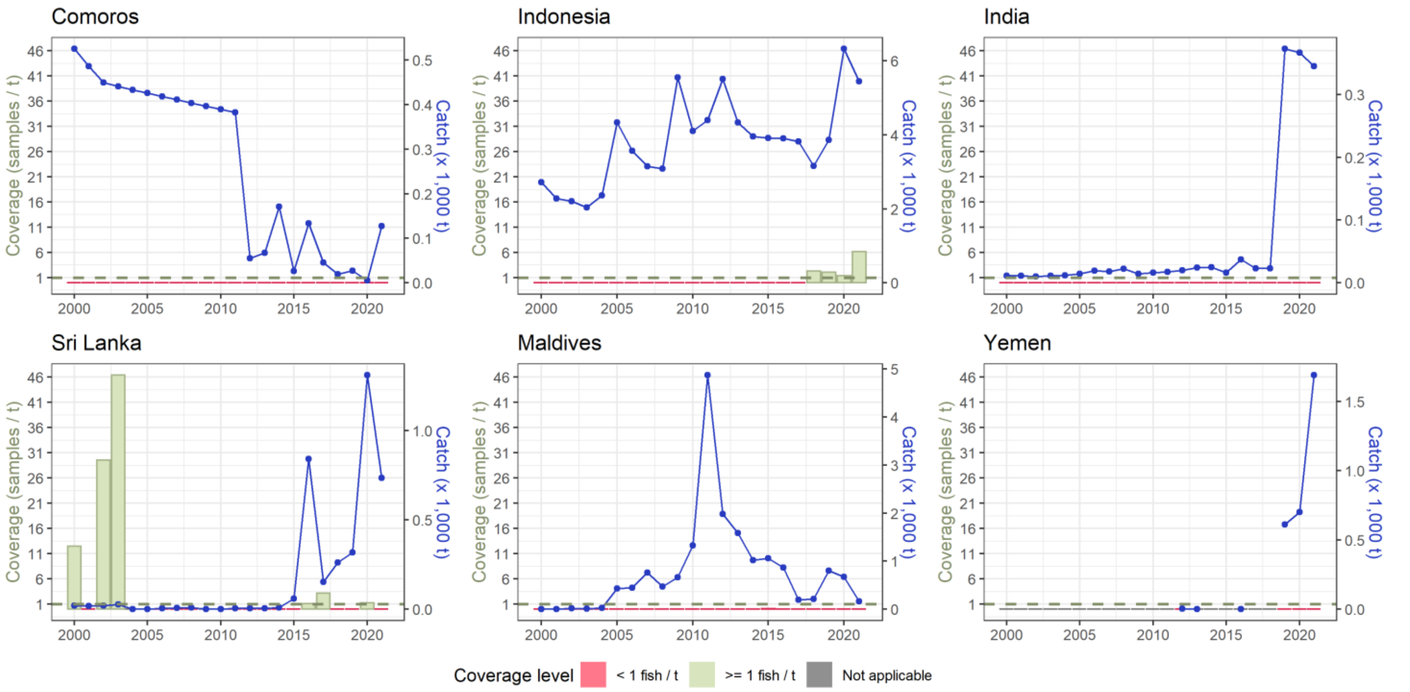

Figure 25: Size-frequency samples coverage (number of fish measured by t of retained catches) of skipjack tuna caught by the major handline fleets, by fleet and year (2000-2021). Data source: [standardized size-frequency dataset] (Res. 15/02)

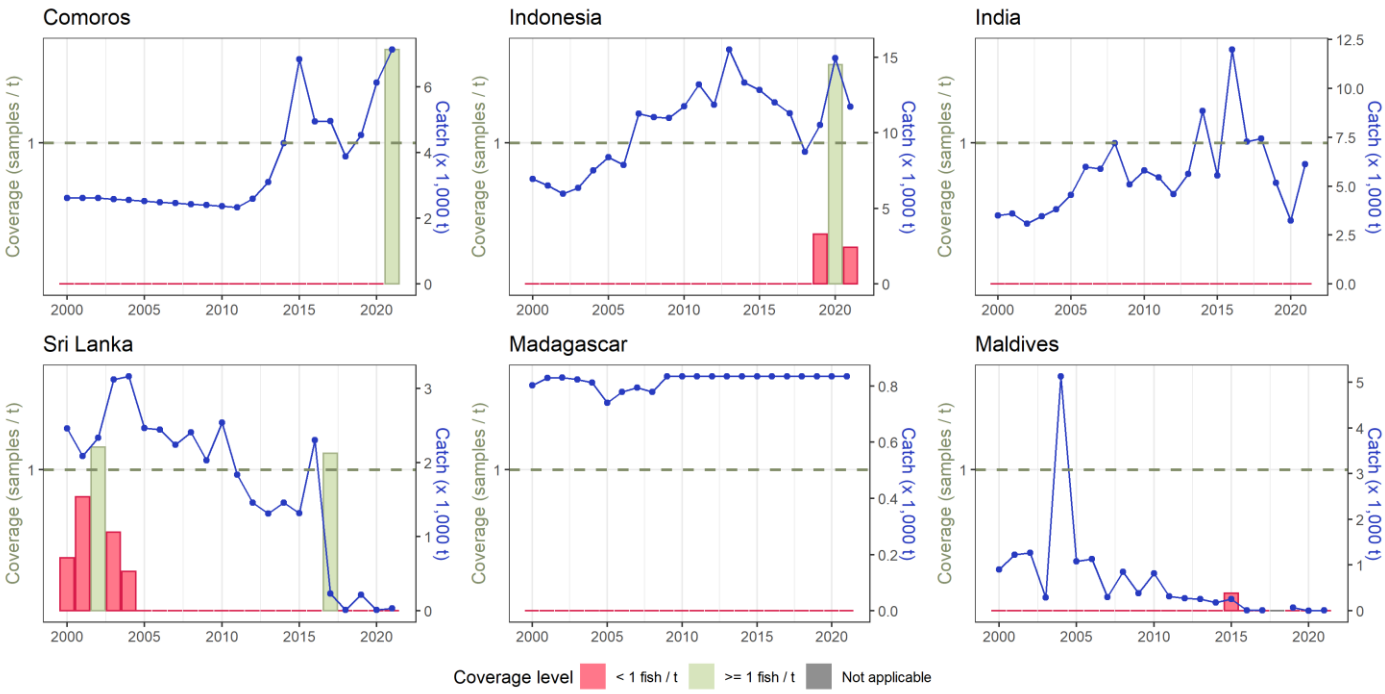

Figure 26: Size-frequency samples coverage (number of fish measured by t of retained catches) of skipjack tuna caught by the major trolling fleets, by fleet and year (2000-2021). Data source: [standardized size-frequency dataset](#) (Res. 15/02)

Other fisheries

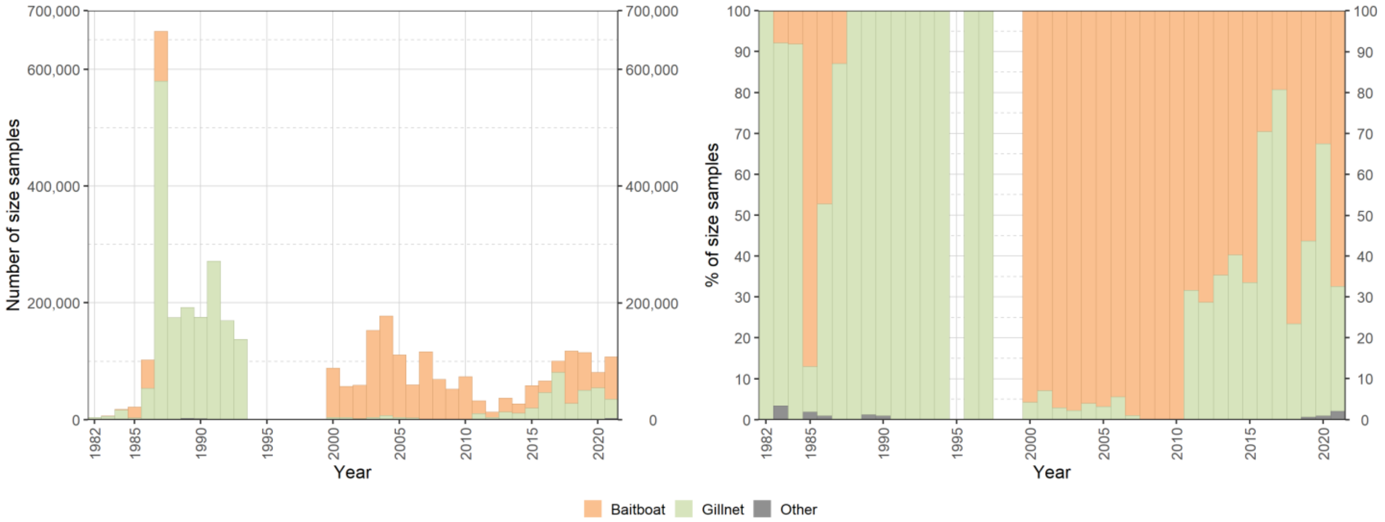

Figure 27: Availability of skipjack tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and all other fishery types. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

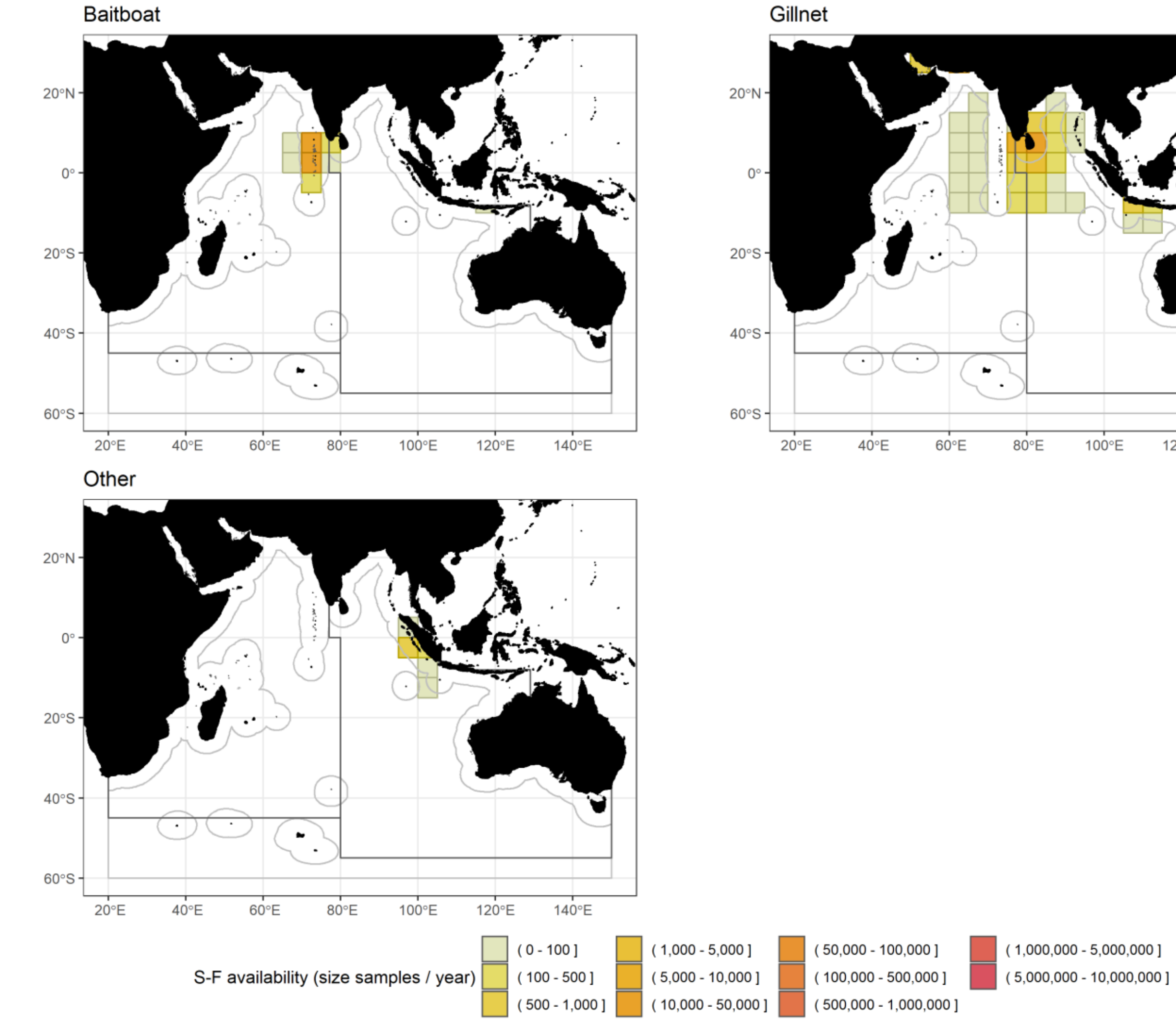

Figure 28: Spatial distribution (average number of samples per grid per year) of available skipjack tuna size-frequency data by all other fishery types in the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

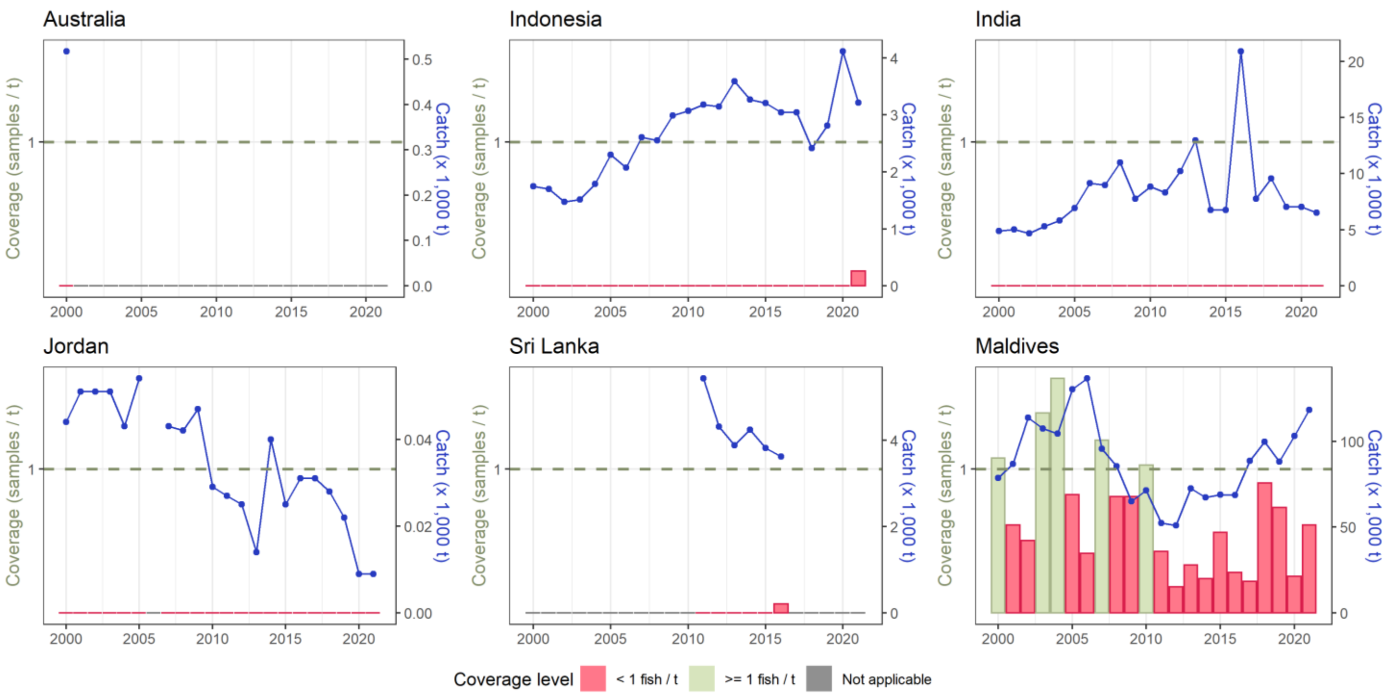

Figure 29: Size-frequency samples coverage (number of fish measured by t of retained catches) of skipjack tuna caught by the major baitboat fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

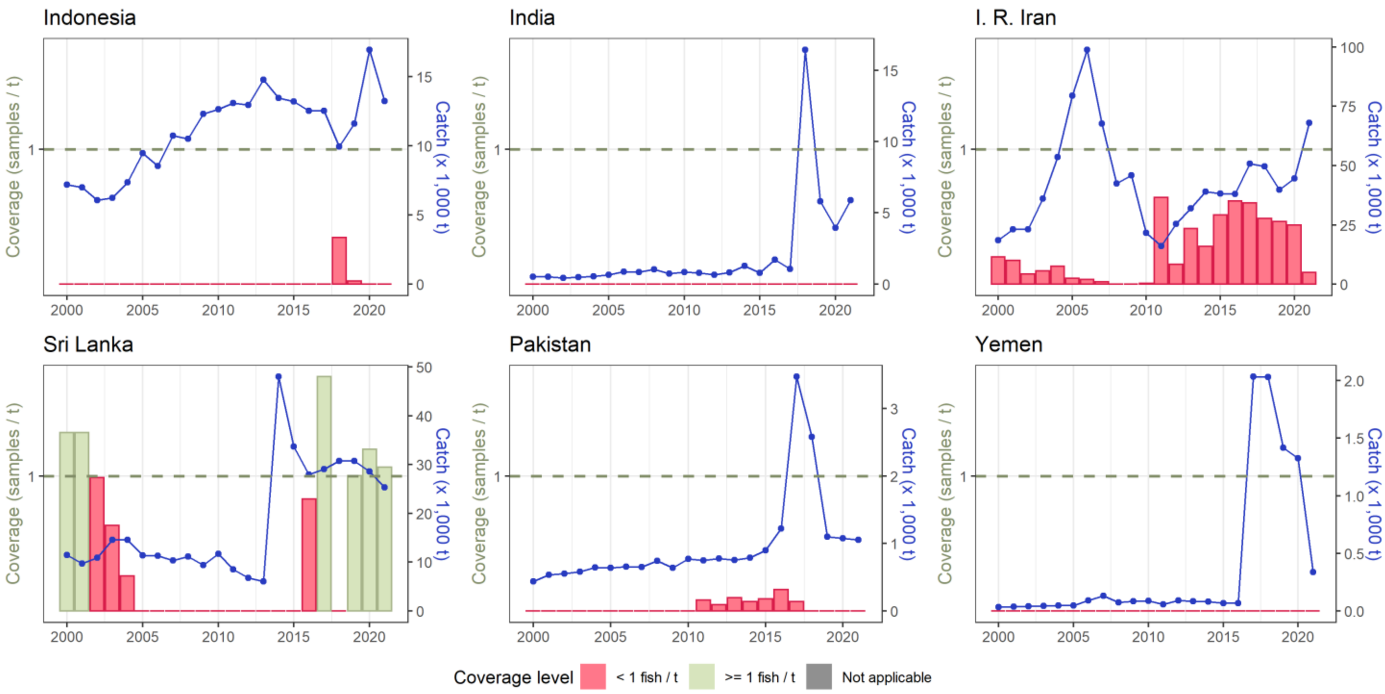

Figure 30: Size-frequency samples coverage (number of fish measured by t of retained catches) of skipjack tuna caught by the major gillnet fleets, by fleet and year (2000-2021). Data source: [standardized size-frequency dataset](#) (Res. 15/02)

The sampling levels reached by all other Indian Ocean fisheries are generally low, and in some cases (e.g., gillnet, handline and baitboat fisheries), might reflect the limited level of interactions with the species. Among all fisheries and fleet concerned, only Sri Lankan, Maldivian, Iranian and Indonesian appear to be sampled in recent years. Baitboat and gillnet fisheries, which are considered as the most relevant among all artisanal fisheries catching skipjack tuna, are instead very limited in terms of coverage levels and sample availability. It could also be possible that the limited availability of samples (which in the case of small-scale fisheries are to be recorded at the landing sites) reflects well known issues in the ability of identifying the species, with smaller individuals that might have been reported as other smaller tuna species instead.

Temporal patterns and trends in size distributions

Industrial purse seine fisheries

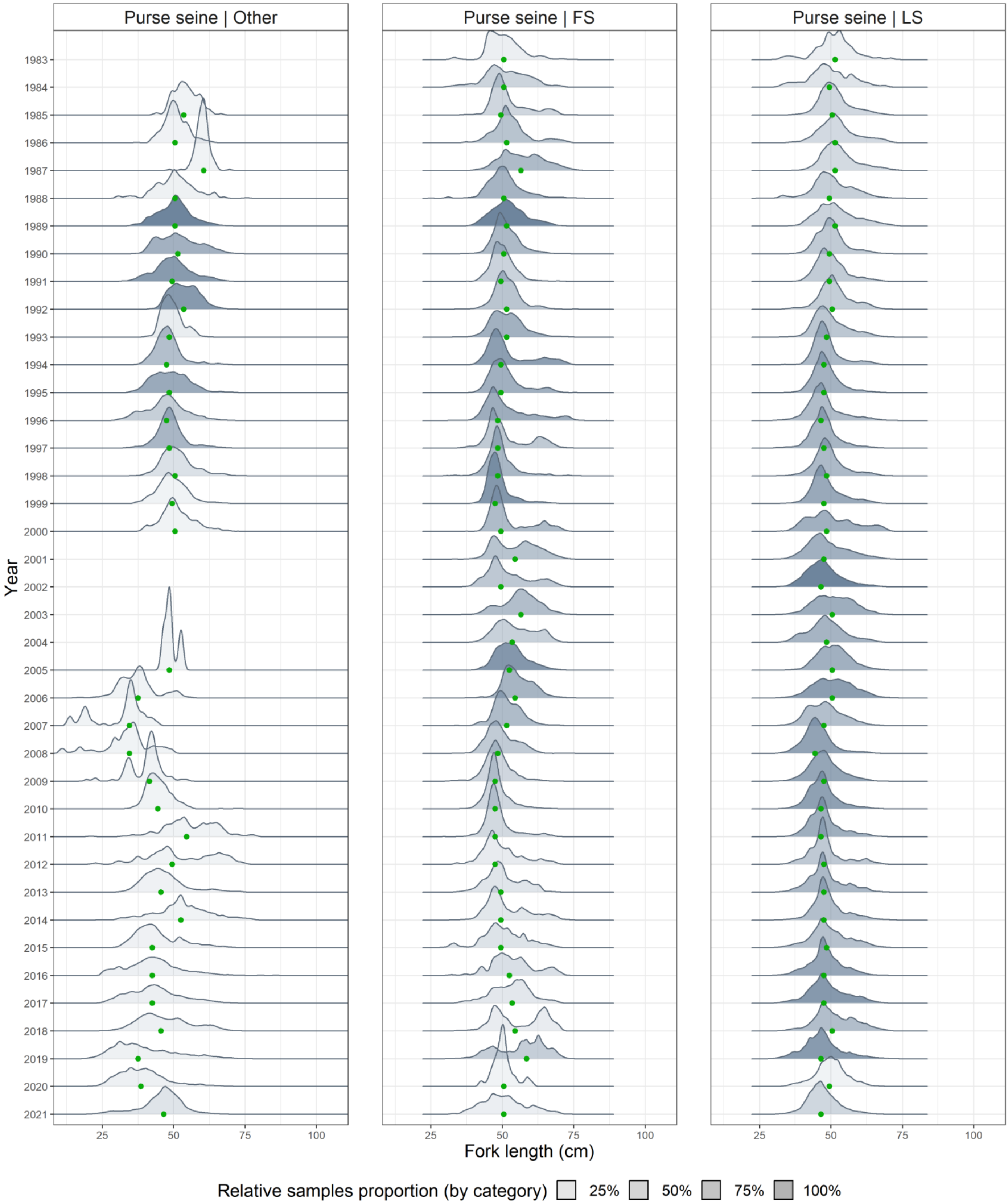

Figure 31: Relative size distribution (fork length in 2 cm size bins) of skipjack tuna caught by all purse seine fleets for the period 1983-2021. Other = no information provided on the school association; FS = free-swimming schools; LS = schools associated with floating objects. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

Coastal fisheries

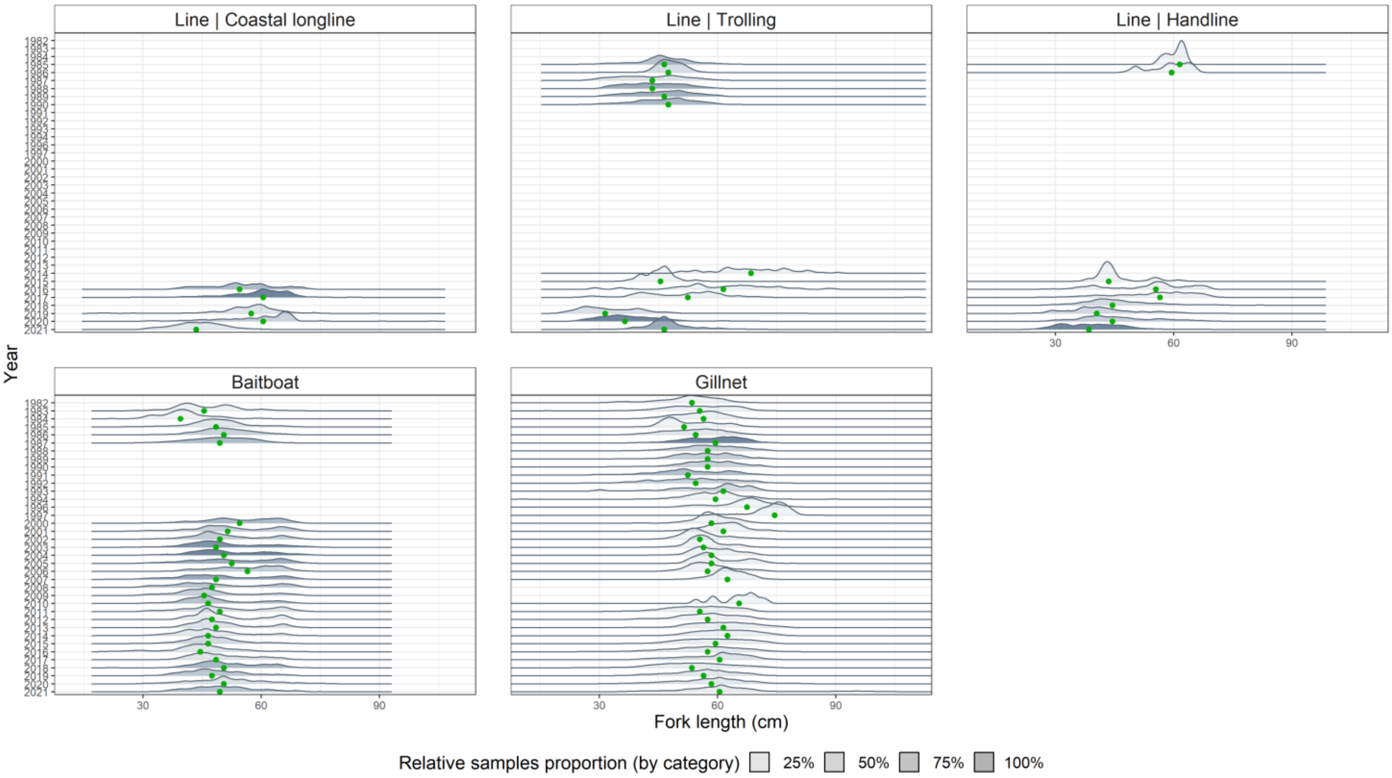

Figure 32: Relative size distribution (fork length in 2 cm size bins) of skipjack tuna caught by all coastal fisheries for the period 1983-2021. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: standardized size-frequency dataset (Res. 15/02)

Baitboat fisheries

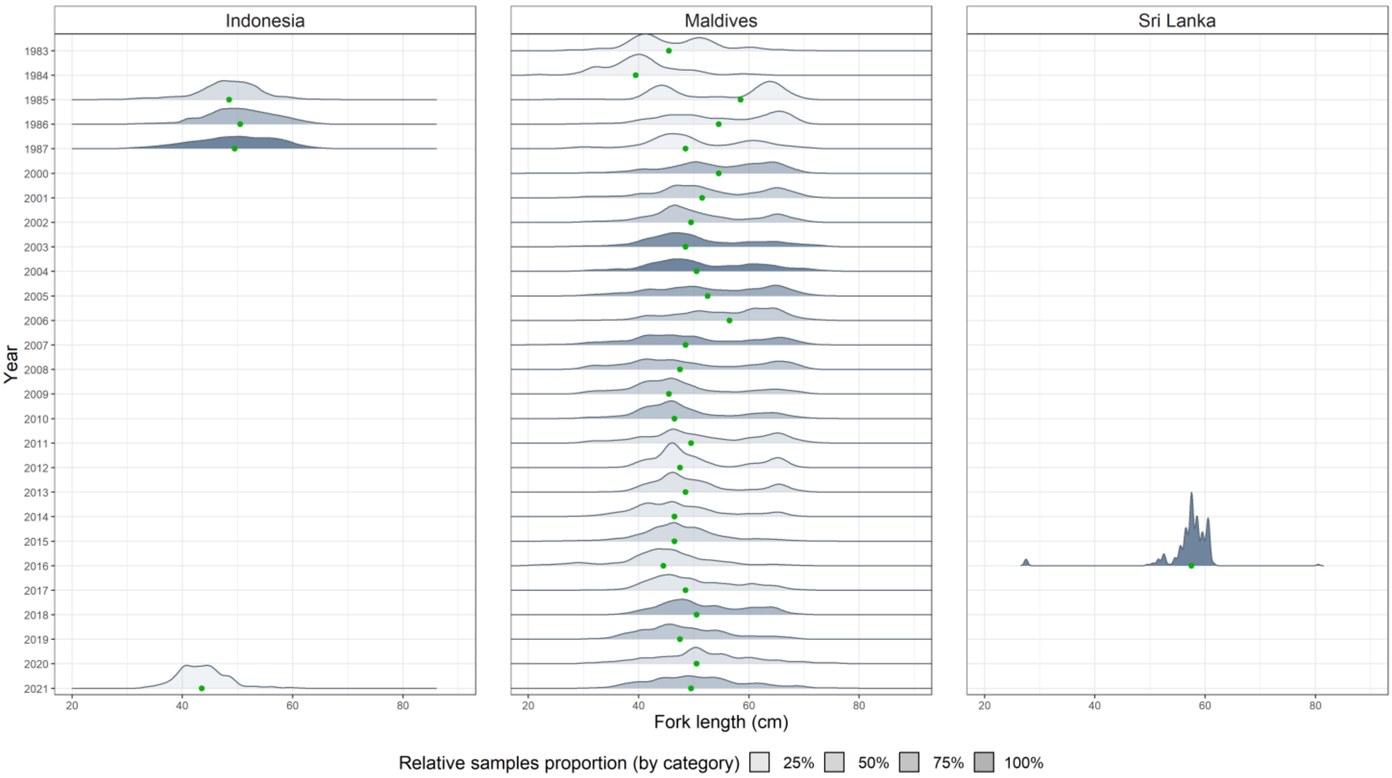

Figure 33: Relative size distribution (fork length in 2 cm size bins) of skipjack tuna caught by baitboat fleets for the period 1983-2021. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: standardized size-frequency dataset (Res. 15/02)

Gillnet fisheries

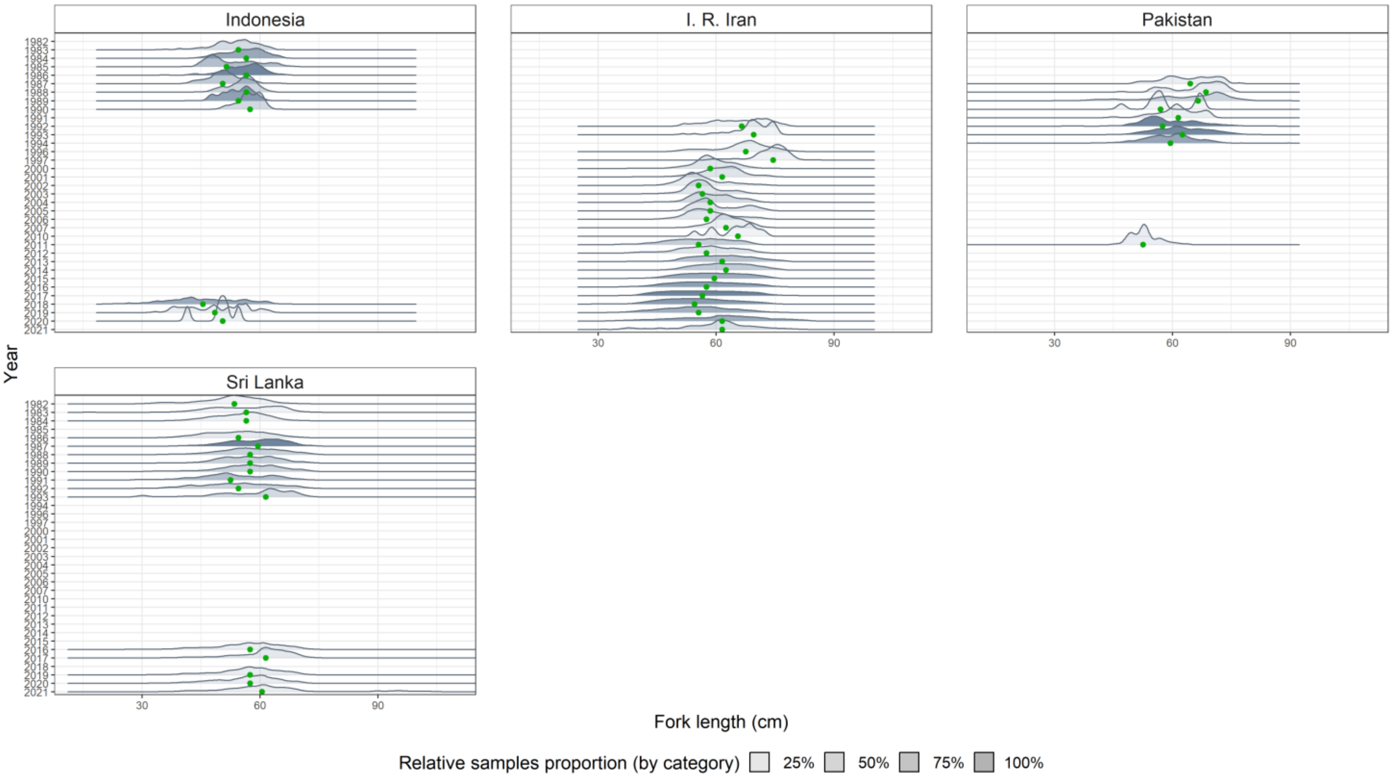

Figure 34: Relative size distribution (fork length in 2 cm size bins) of skipjack tuna caught by gillnet fleets for the period 1983-2021. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: standardized size-frequency dataset (Res. 15/02)

Temporal trends in estimated average weights

Trends in average weights of skipjack 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 calculated for the purse seine log associated and free school are relatively stable and fluctuate at around 2-4kg and 3-5 kg respectively (**Fig. 36**). The other purse seiners of all Indian Ocean, on the contrary, shows fluctuation, with higher estimated average weight of 4.5 kg in the 1980s, which declined to 0.8 kg in 2021. Lower than the estimated average for all fisheries combined, which in 2021 was estimated at 2.1 kg.

In fact, the overall estimated trend in average weights (**Fig. 36 - 'All fisheries'**) diminishes as average weights are stable for most fisheries, if not for the drastic decline from other purse seine (**Fig. 36 - 'Purse seine | OT'**).

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

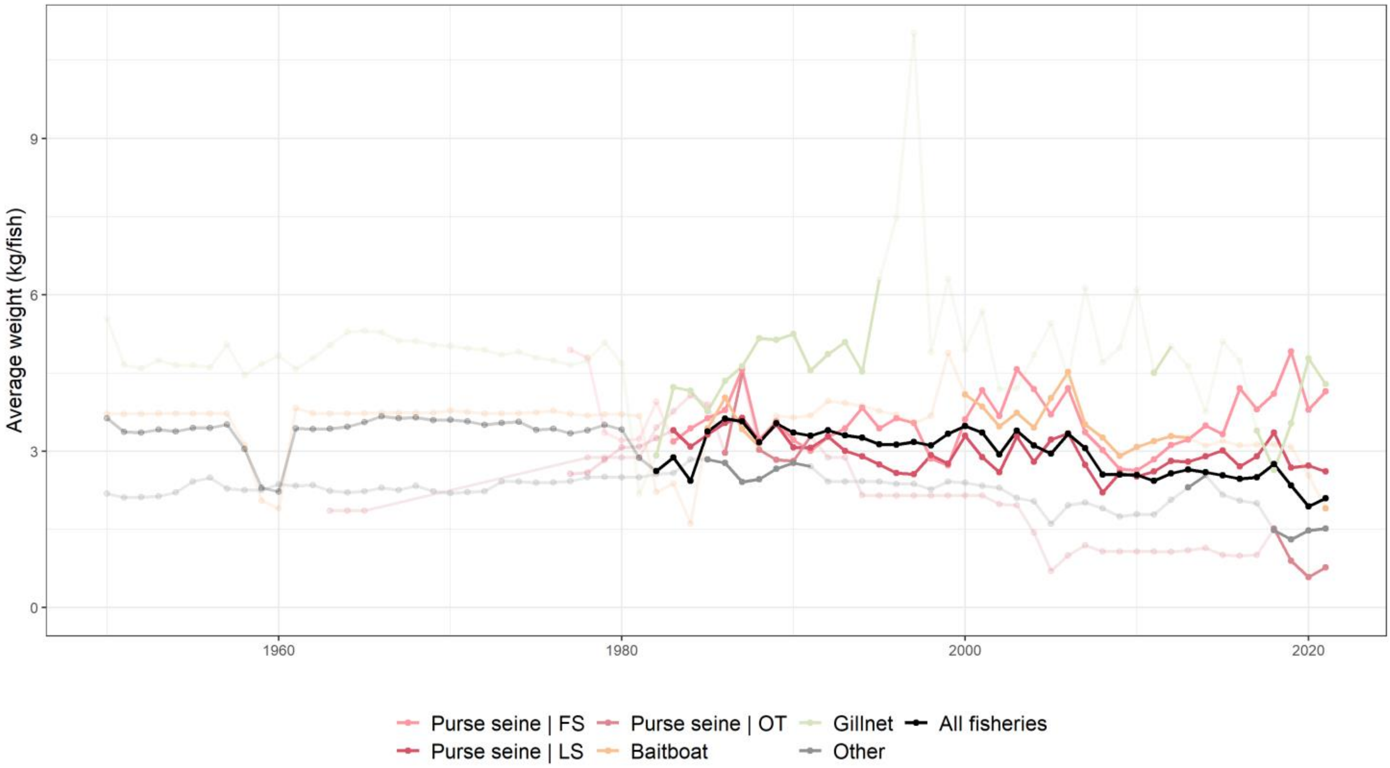

Figure 35: Combined estimated skipjack tuna average weight (kg/fish) in the catch by fishery and year. Semi-transparent points correspond to years for which the original size samples cover strata with reported catches (by year and fishery) **lower** than 50 t. LS = schools associated with floating objects; FS = free-swimming schools. Longline | Japan = includes data from longliners flagged by Japan, Rep. of Korea and Thailand; Longline | Taiwan = includes data from longliners flagged by Taiwan,China and all other flags not otherwise mentioned. Data source: raised time-area catches

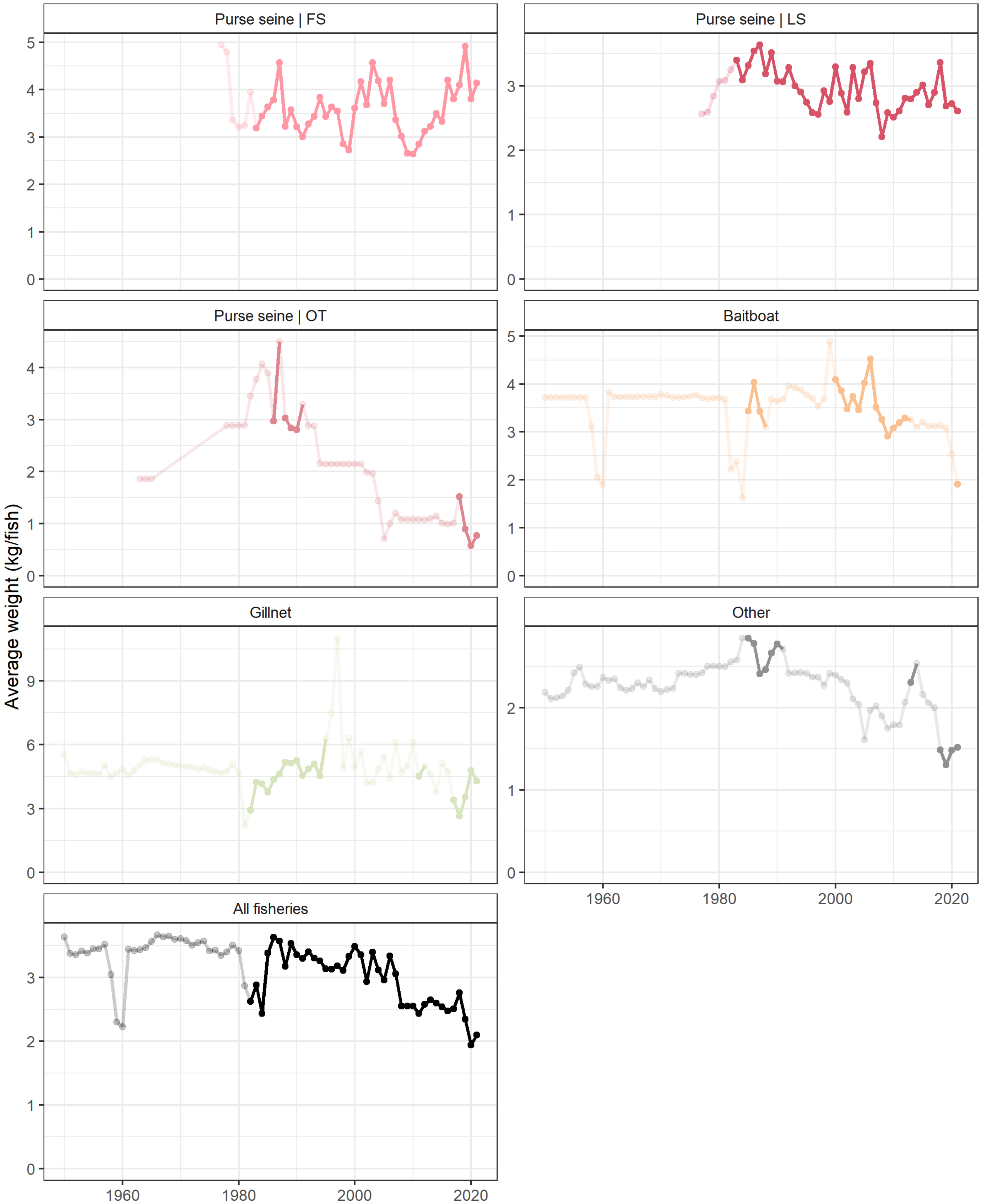

Figure 36: Estimated skipjack tuna average weight (kg/fish) in the catch by fishery and year. Semi-transparent points correspond to years for which the original size samples cover strata with reported catches (by year and fishery) **lower** than 50 t. LS = schools associated with floating objects; FS = free-swimming schools. Longline | Japan = includes data from longliners flagged by Japan, Rep. of Korea and Thailand; Longline | Taiwan = includes data from longliners flagged by Taiwan,China and all other flags not otherwise mentioned. Data source: 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 increase efforts by several coastal fleets combined with the rapid increase in catches from log-associated schools in the purse seine fishery (**Fig. 35**).

Spatial distribution of average weights

Estimated average weights by decade (1950-2019)

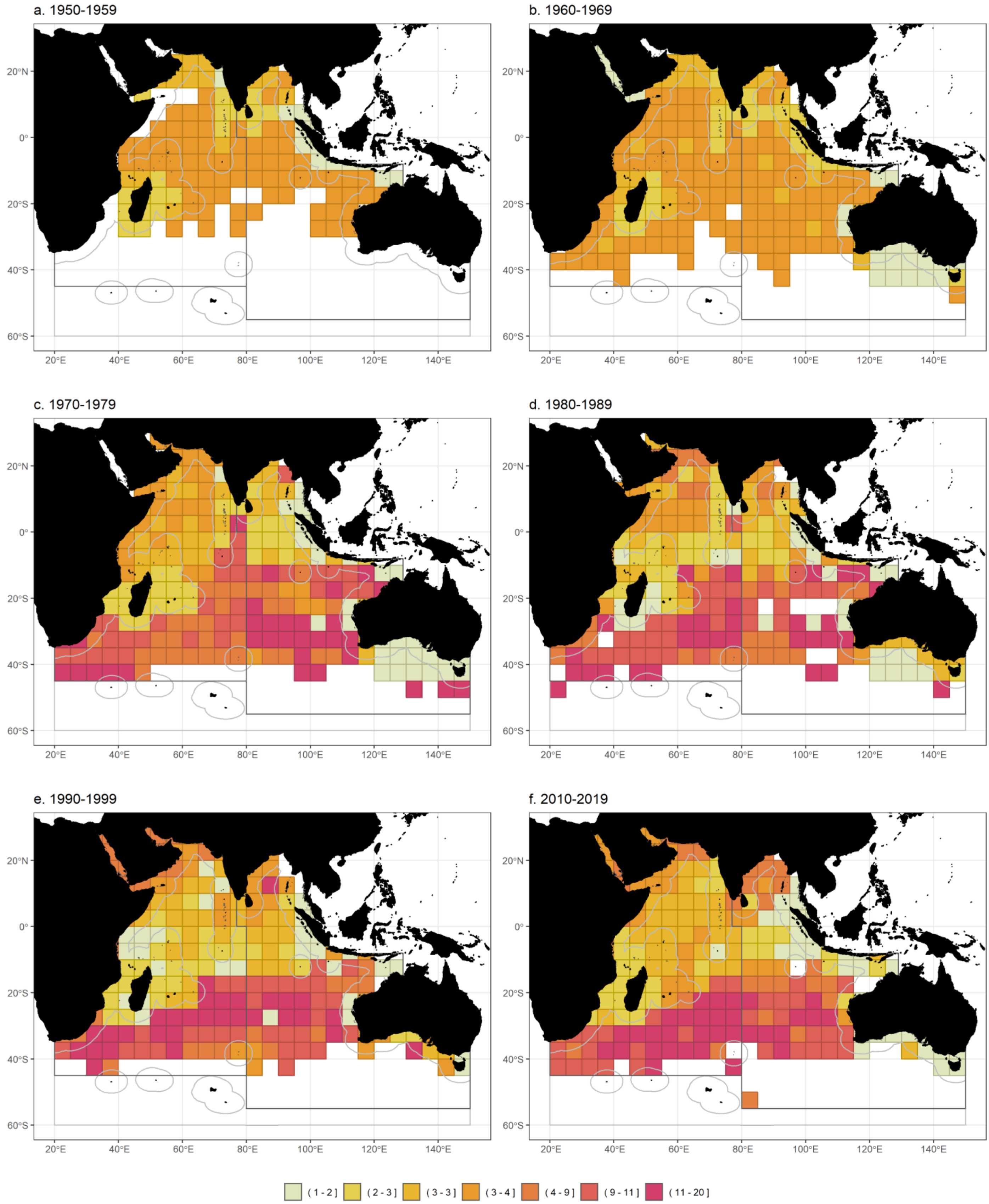

Figure 37: Estimated skipjack tuna average weight (kg/fish) in the catch by decade and 5x5 grid, for all fisheries combined for the period 1950-2019. Data source: raised time-area catches

Estimated average weights by year (2017-2021) and last decade (2010-2019)

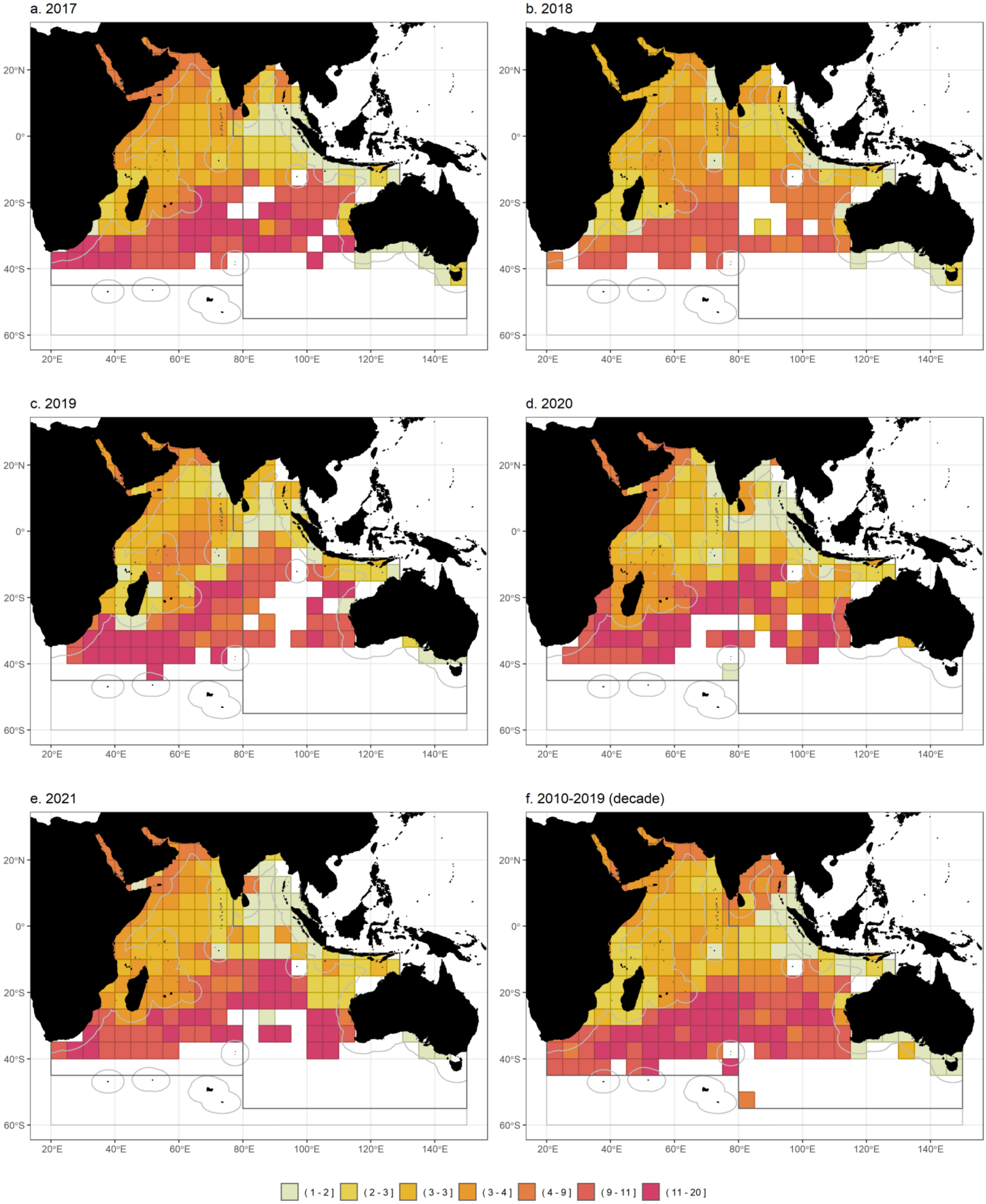

Figure 38: Estimated skipjack tuna average weight (kg/fish) in the catch by year and 5x5 grid, for all fisheries combined for the period 2017-2021 and for the decade 2010-2019. Data source: raised time-area catches

Estimated average weights by fishery group in recent years (2017-2021)

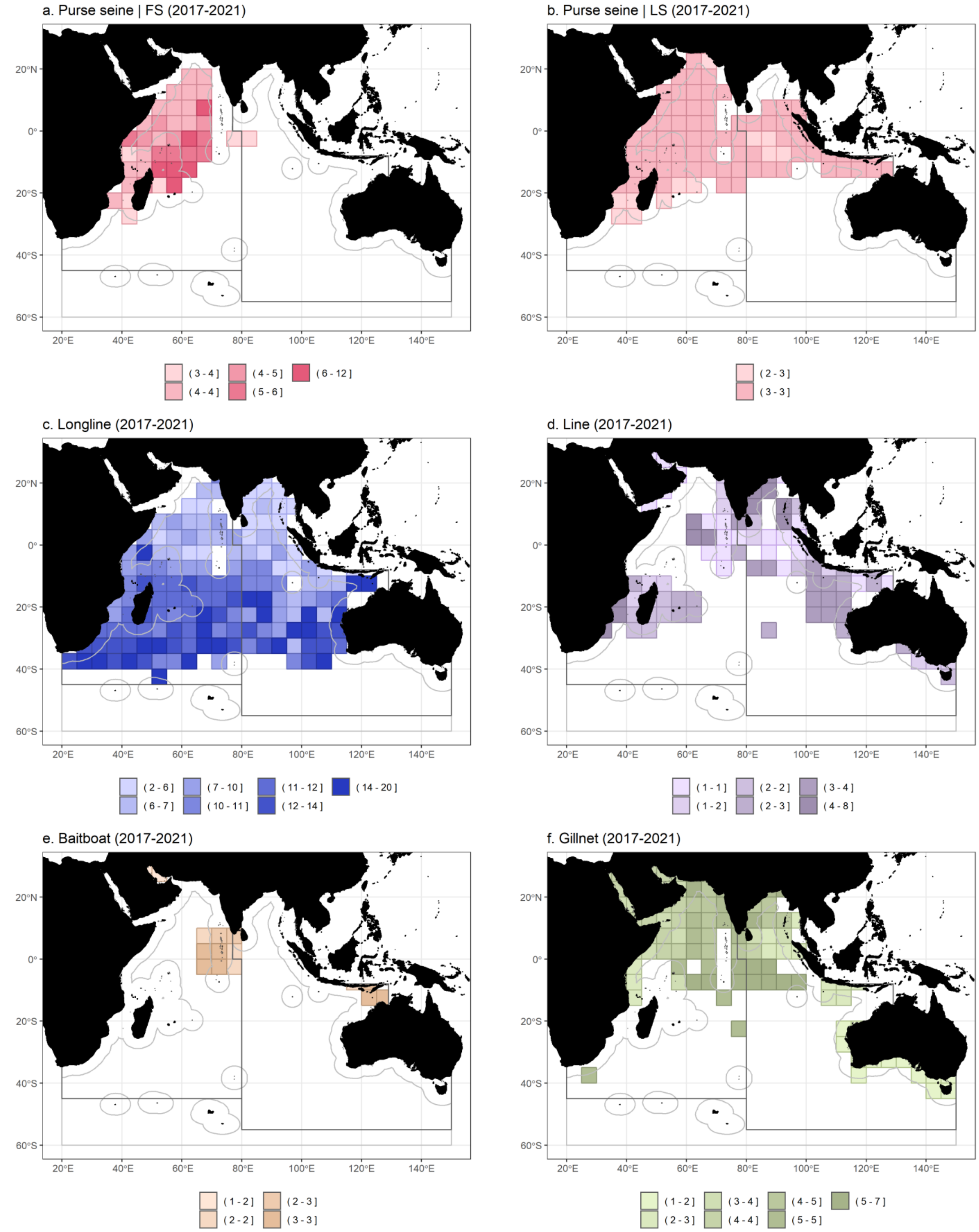

Figure 39: Estimated skipjack tuna average weight (kg/fish) in the catch by 5x5 grid and fishery group for the period 2017-2021. LS = schools associated with floating objects; FS = free-swimming schools. Data source: raised time-area catches

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 skipjack tuna in IOTC databases is poor, particularly for artisanal fisheries. Almost no size data are available prior to the 1980s, and the fraction of data of acceptable quality averages around 52% since 1984 (ranging between 29% and 80%), with a marked increase in quality from about 38% in 2012 to around 80% in 2021 (**Fig. 40a**).

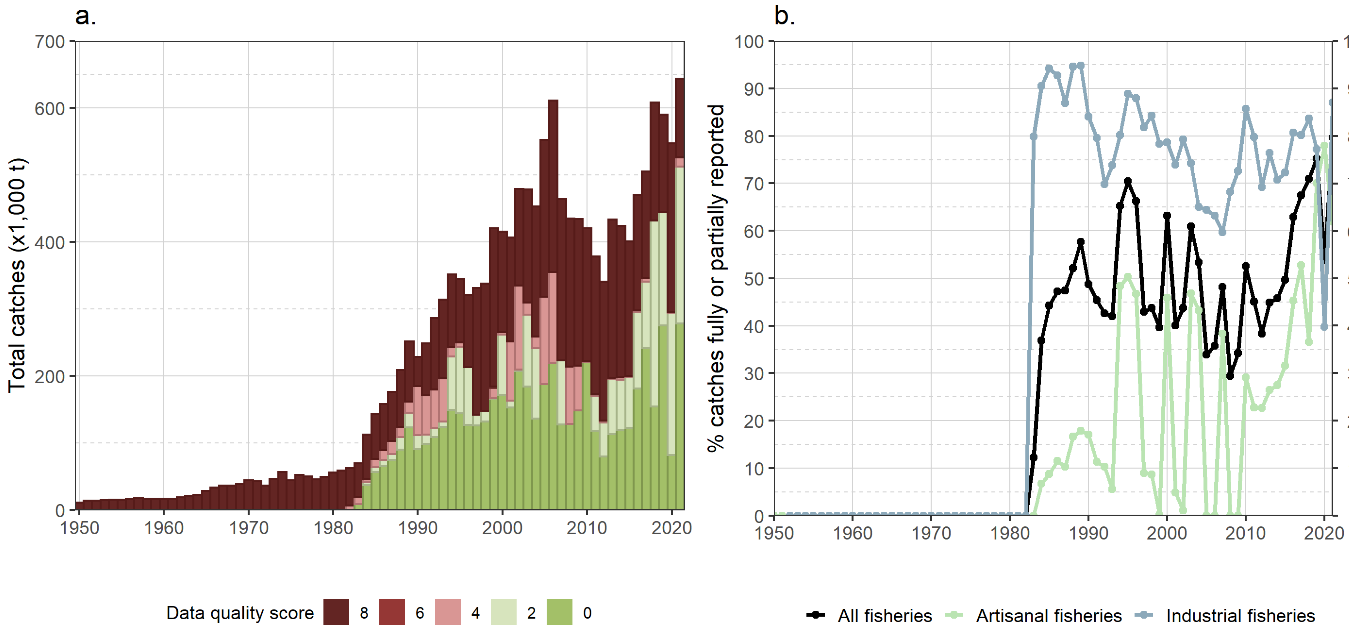

Figure 40: Annual nominal catches (t) of skipjack tuna estimated by quality score (barplot) and percentage of geo-referenced size-frequency data reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950–2021

Industrial purse seine fisheries

Size-frequency data for skipjack 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 in the last decade), 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. 41**) and FOB-associated schools (**Fig. 42**) reflects the different percentages of sets taken on the two different fishing modes, with free-school sets being generally lower in numbers than FOB-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 50 cm FL, while fish measured from FOB-associated schools tends to have one single mode at around 40 cm FL.

For free-swimming schools, in some instances, some fleets shows size distribution of above the threshold (**Table 5**), which all show a much higher first mode in the lower part of the size distribution (at above 50 cm FL) (**Fig. 41**).

In the case of size-frequencies from FOB-associated schools, the main mode is defined around 40 cm FL. Although some data showing values at around 60 cm FL for EU,Spain (2018), and Seychelles (2018) (**Table 6**). Data for these 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. 42**).

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 2015 and 2017. Also, data from Mauritian purse seiners with correct attribution of the fishing mode are only available for 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.

It has been challenging for several fleets to implement regular sampling programmes in 2020 due to the insurgence of the CoViD-19 pandemic, and therefore size data for 2020 is very limited in numbers, particularly when considering fish caught on free-swimming schools for which data is only available from EU,France albeit to levels corresponding to a negligible fraction of what usually provided in the past (**Fig. 41**).

Size-frequency data for 2020 is entirely absent for EU,Spain and only available in limited numbers for EU,France, Mauritius, and Seychelles (**Fig. 42**), with EU,Spain confirming their ongoing effort to recover size data from private companies and share it by the end of 2021 (IOTC, pers. comm.).

Size-frequency data are available in recent years for other industrial purse seine fleets, which include information from Indonesia, I.R. Iran, Japan, and the Republic of Korea (**Fig. 44**). Unfortunately, except for the 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 FOB-associated schools, whereas Iranian purse seiners appear to have been fishing predominantly on free-swimming schools in recent years. furthermore, the Sampling of skipjack tuna from Thailand is from coastal purse seiner fisheries (**Fig. 44**).

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.

Finally, these fleets seem to have been less affected by the CoViD-19 pandemic, as data were regularly provided by all of them (albeit in lower numbers for Indonesia and I.R. Iran) (**Fig. 44**).

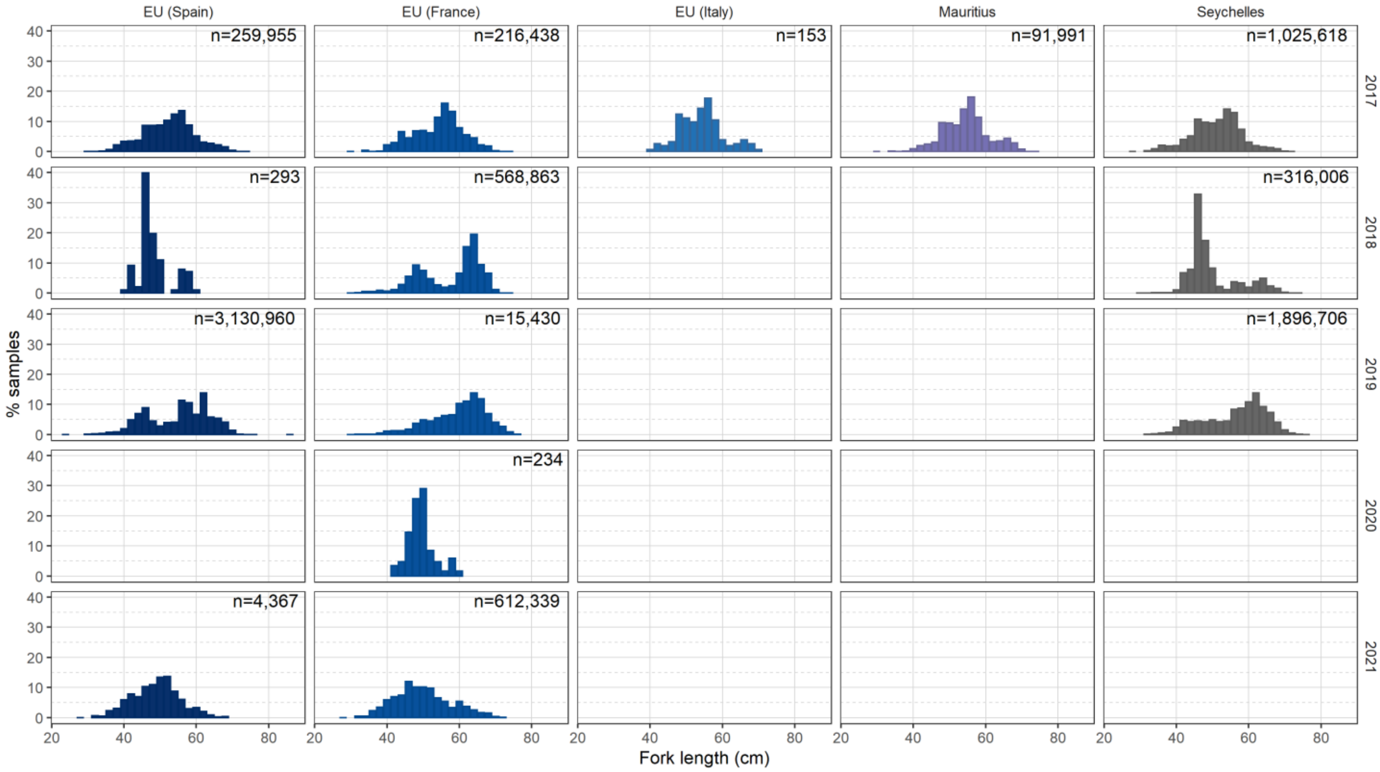

Figure 41: Relative size distribution of skipjack tuna (fork length in cm) recorded for free-swimming schools, by year (2017–2021) and main purse seine fleet. Data source: standardized size-frequency dataset (Res. 15/02)

Table 5: Percentage of sampled skipjack tuna with fork length below 40 cm recorded by the major purse seine fleets fishing on free-swimming schools, as reported for the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

Fleet	2017	2018	2019	2020	2021
EU (Spain)	3	0	2		6
EU (France)	0	2	1	0	7
Mauritius	0				
Seychelles	5	0	2		

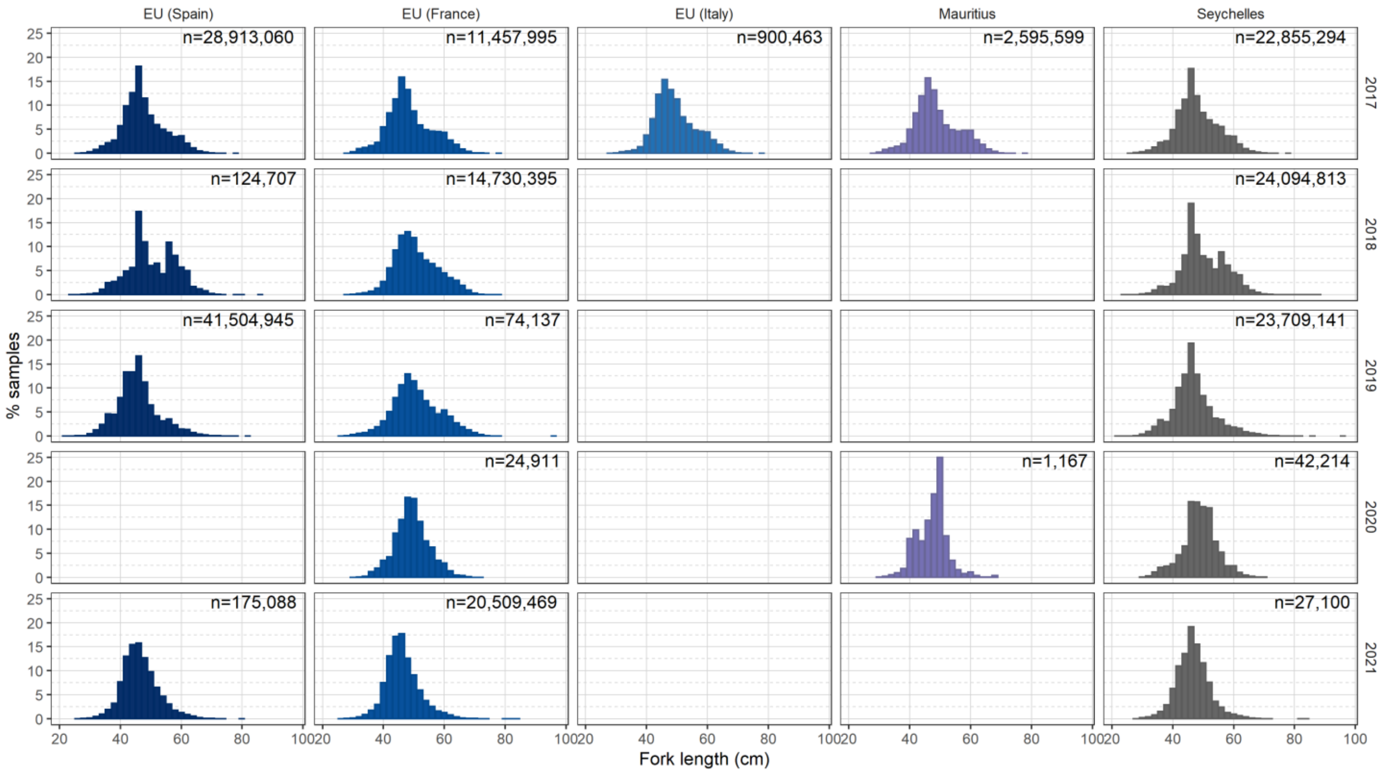

Figure 42: Relative size distribution of skipjack tuna (fork length in cm) recorded for FOB-associated schools, by year (2017–2021) and major purse seine fleet. Data source: standardized size-frequency dataset (Res. 15/02)

Table 6: Percentage of sampled skipjack tuna with fork length above 40 cm recorded by the major purse seine fleets fishing on FOB-associated schools, as reported for the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

Fleet	2017	2018	2019	2020	2021
EU (Spain)	92	93	87		93
EU (France)	94	97	95	97	94
Mauritius	94			96	
Seychelles	93	95	90	94	94

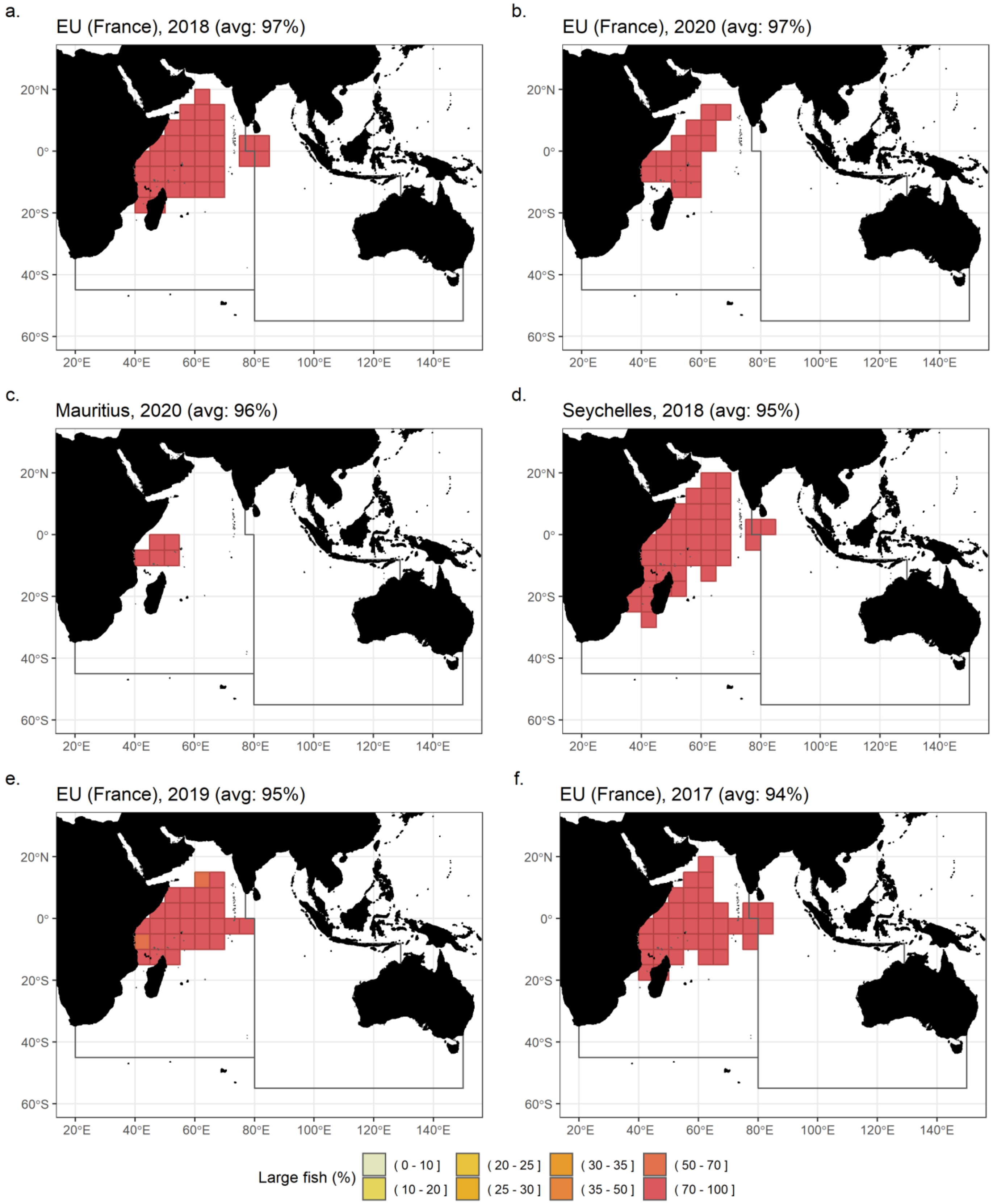

Figure 43: Spatial distribution of sampled skipjack tuna with fork length above 40 cm recorded by the major purse seine fleets fishing on FOB-associated schools, as reported for the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

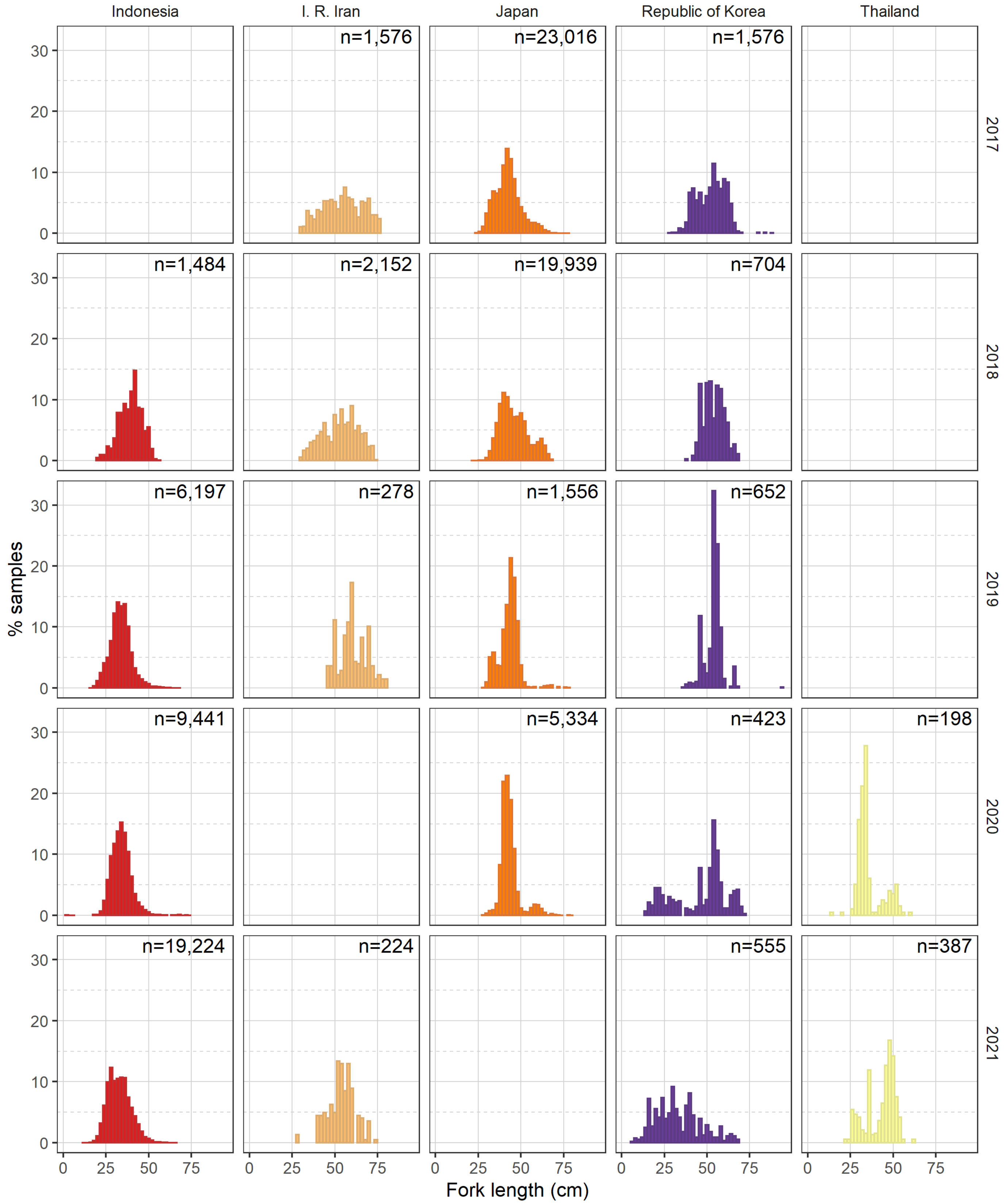

Figure 44: Relative size distribution of skipjack tuna (fork length in cm) recorded for unclassified schools, by year (2017–2021) and other purse seine fleet. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

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