REVIEW OF INDIAN OCEAN BIGEYE TUNA STATISTICAL DATA

Author: IOTC Secretariat

Introduction

The overarching objective of the paper is to provide participants to the 24th Session of the IOTC Working Party on Tropical Tunas (WPTT24) with a review of the status of the information on bigeye tuna (*Thunnus obesus*; BET) available to the IOTC Secretariat as of October 2022. The document provides an overview of the fisheries catching bigeye 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)

Indian Ocean fisheries

Nominal catches of bigeye tuna show an increasing trend over the last seven decades, with annual levels ranging between 7,000 and 136,000 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 95,000 t during the 2010s, i.e., around 30% less than what caught on average during the previous decade. Longliners and purse seiners are the main fisheries for the species, and together comprise over 90% of the catches between the 1950s and 2000s, and over 80% in the last full decade (**Table 1** & **Figs. 1-2**).

Table 1: Best scientific estimates of average annual nominal catches (metric tonnes; t) of bigeye tuna by decade and fishery for the period 1950-2021. FS = free-swimming schools. LS = school associated with floating objects. The background intensity colour 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			772	1,268	2,388	4,012	6,068	7,190
Purse seine | FS			1	2,340	4,824	6,196	6,033	6,447
Purse seine | LS			2	4,855	18,315	20,273	18,585	24,440
Longline | Other				106	359	1,101	1,293	433
Longline | Fresh			312	3,066	26,282	23,490	11,333	9,022
Longline | Deep-freezing	8,110	21,861	30,413	42,972	61,577	70,315	33,649	25,206
Line | Coastal longline	111	287	548	2,204	4,137	5,819	8,456	9,923
Line | Trolling	23	39	87	261	533	870	1,500	2,229
Line | Handline	9	8	110	181	163	226	1,158	1,132
Baitboat	69	50	110	249	544	997	513	638
Gillnet	15	25	77	597	785	1,492	3,970	3,057
Other			12	19	124	1,386	2,058	2,920
Total	8,337	22,269	32,443	58,119	120,031	136,178	94,616	92,637

Catches of bigeye tuna increased rapidly in the early 1980s with the development of the industrial purse seine fishery and the increased activity of vessels using longline and other gears (**Figs. 1-2**). Exceptionally high catch levels were recorded between 1997 and 2007, with the highest catches ever recorded in 1999 at over 160,000 t.

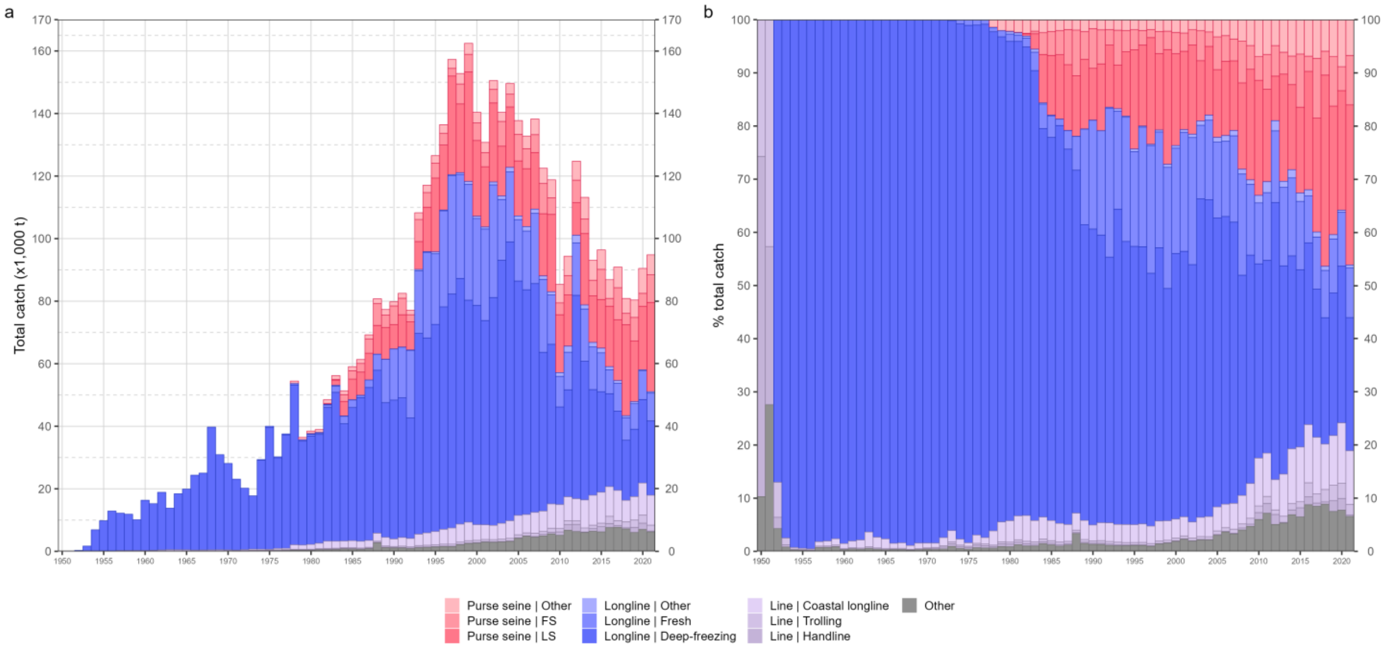

Figure 1: Annual time series of cumulative nominal absolute (a) and relative (b) catches (metric tonnes; t) of bigeye tuna by fishery for the period 1950-2021. LS = schools associated with floating objects; FS = free-swimming schools. Data source: raised time-area catches

Between 2010 and 2011 catches dropped considerably to around 53% of 1999 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 areas of national jurisdiction of Somalia. Catches by purse seiners also declined over the same period, albeit not to the same extent as longliners thanks to the presence of security personnel onboard purse seine vessels of the EU and Seychelles, which enabled fishing operations to continue.

Catches of all purse seine fisheries combined were variable since 2011, with unusually high catches reported during 2021 (44,000 t) and potentially affected by changes in data processing methodologies introduced by some important fleets which might affect recent estimates. More specifically, a change in the methodology used to estimate species composition by EU,Spain introduced unusually high catch figures for bigeye tuna 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).

Longline fisheries, on the contrary, showed marked increasing trends in reported catches of bigeye tuna in post-piracy years, reaching a peak of 84,000 t in 2012 before initiating a new decline that brought catch levels down to the recent minimum of 27,000 t reported in 2018 (**Fig. 2**).

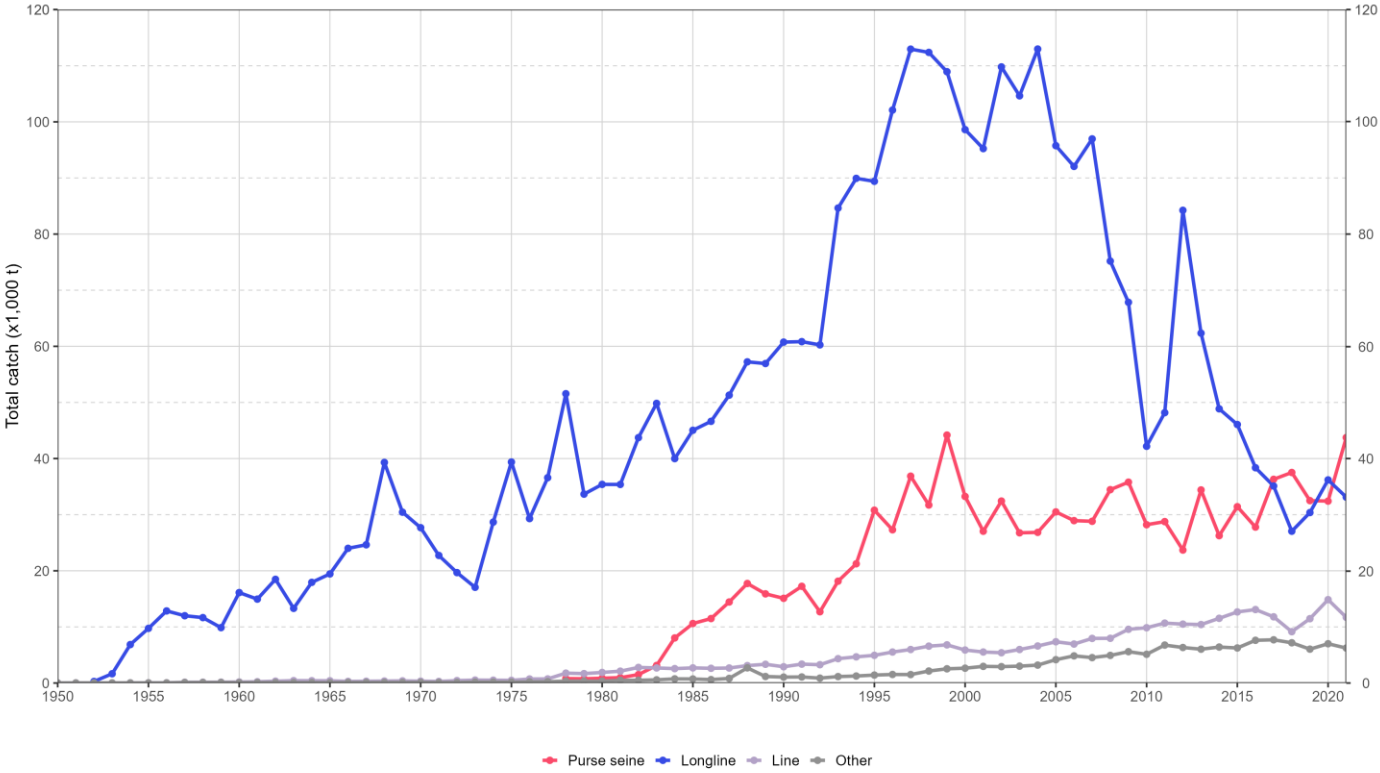

Figure 2: Annual time series of catches (metric tonnes; t) of bigeye tuna by fishery group for the period 1950-2021. Data source: best scientific estimate of nominal catches

Table 2: Best scientific estimates of annual nominal catches (metric tonnes; t) of bigeye tuna by fishery for the period 2012-2021. The background intensity colour 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	6,078	6,938	6,375	6,240	5,966	6,604	4,805	5,586	7,995	6,386
Purse seine | FS	7,180	4,659	5,000	9,633	2,489	10,242	3,634	7,479	4,086	8,808
Purse seine | LS	10,434	22,809	14,882	15,547	19,330	19,456	29,076	19,440	20,334	28,546
Longline | Other	2,408	1,297	1,442	1,511	985	869	633	643	383	483
Longline | Fresh	16,816	16,725	13,650	12,401	7,672	8,895	7,196	8,166	9,151	8,893
Longline | Deep-freezing	65,015	44,320	33,768	32,153	29,706	25,343	19,220	21,562	26,664	23,748
Line | Coastal longline	7,114	8,965	9,581	9,917	9,509	9,695	6,912	7,504	10,276	9,569
Line | Trolling	1,075	1,303	1,113	1,100	2,299	1,549	1,888	2,344	2,579	1,878
Line | Handline	2,308	151	836	1,647	1,282	552	347	1,616	2,003	261
Baitboat	716	345	304	184	844	269	436	632	569	706
Gillnet	3,515	3,286	3,925	3,920	4,734	5,378	5,114	3,525	3,682	2,432
Other	2,100	2,397	2,183	2,142	2,033	2,053	1,621	1,881	2,748	3,093
Total	124,759	113,193	93,058	96,396	86,849	90,905	80,884	80,378	90,471	94,803

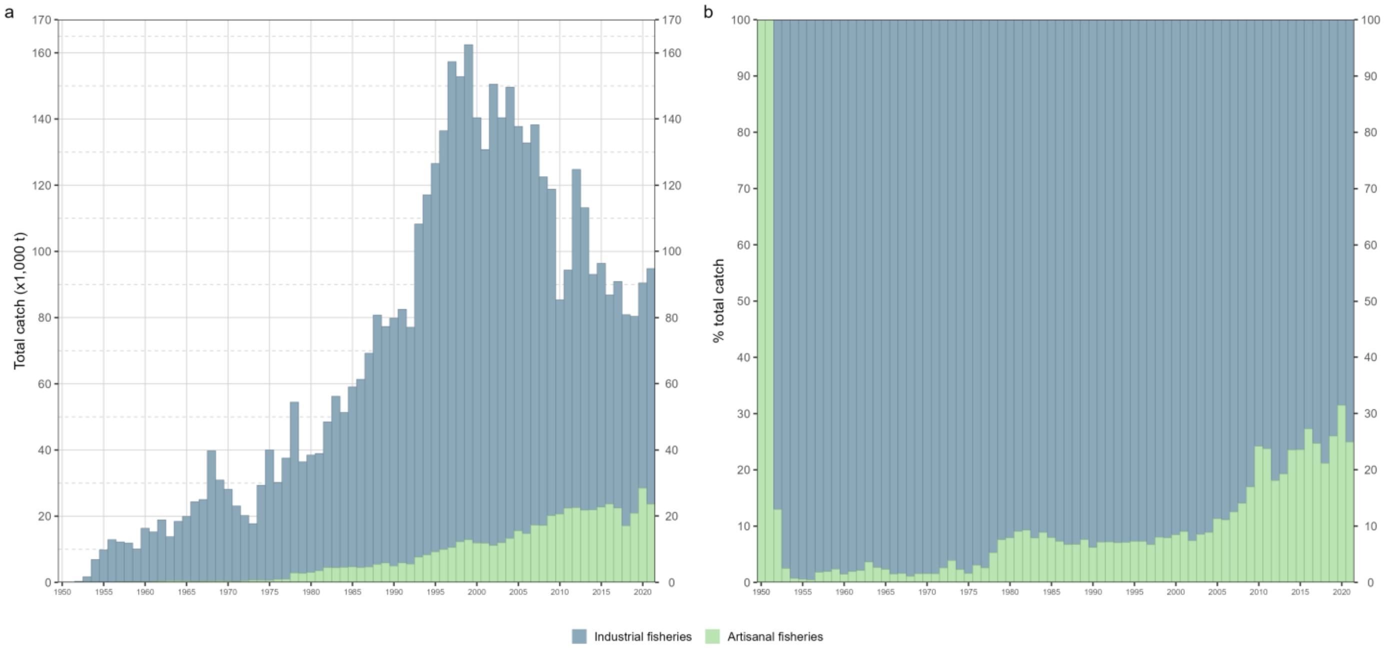

Figure 3: Annual time series of cumulative nominal absolute (a) and relative (b) catches (metric tonnes; t) of bigeye tuna by type of fishery for the period 1950-2021. Data source: best scientific estimate of nominal catches

Trends in the artisanal fishery component of bigeye tuna catches in the Indian Ocean are characterized by relative stable levels between the early-1980s and the mid-2000s, followed by an increase to a maximum of 31% of total catches reported by artisanal fisheries in 2020. Between 2017 and 2021 mean annual catches of artisanal fisheries were close to 20,000 t (26% of total catches), with industrial fisheries catching on average 60,000 t every year (**Fig. 3**).

Regarding purse seine fisheries, historical catches of bigeye tuna by fishing mode showed a general dominance in percentages of catches 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 60% of their bigeye tuna catches from FOB-associated schools since the early-2000s.

Between 2012 and 2021, catches from all purse seine fleets combined showed a fluctuation between 59% and 89% in the fraction of catches from FOB-associated schools, with around 89% of bigeye tuna catches reported from FOB-associated schools in 2016 and around 76% in 2021 (**Fig. 4**).

Among the flag-specific components of the EU purse seine fleet, EU,France appears the less dependent on catches of bigeye tuna on FOB-associated schools. This was particularly true until 2017, whereas in following years catches appeared to be split between the two fishing modes in similar proportion as what reported by the rest of the EU (and assimilated) fleets.

Starting with 2019, the purse seine fishery of Seychelles began reporting a generally higher fraction of bigeye tuna caught on FOB-associated schools compared to all other fleets, reaching a peak of almost 98% of catches on FOB-associated schools reported for 2020.

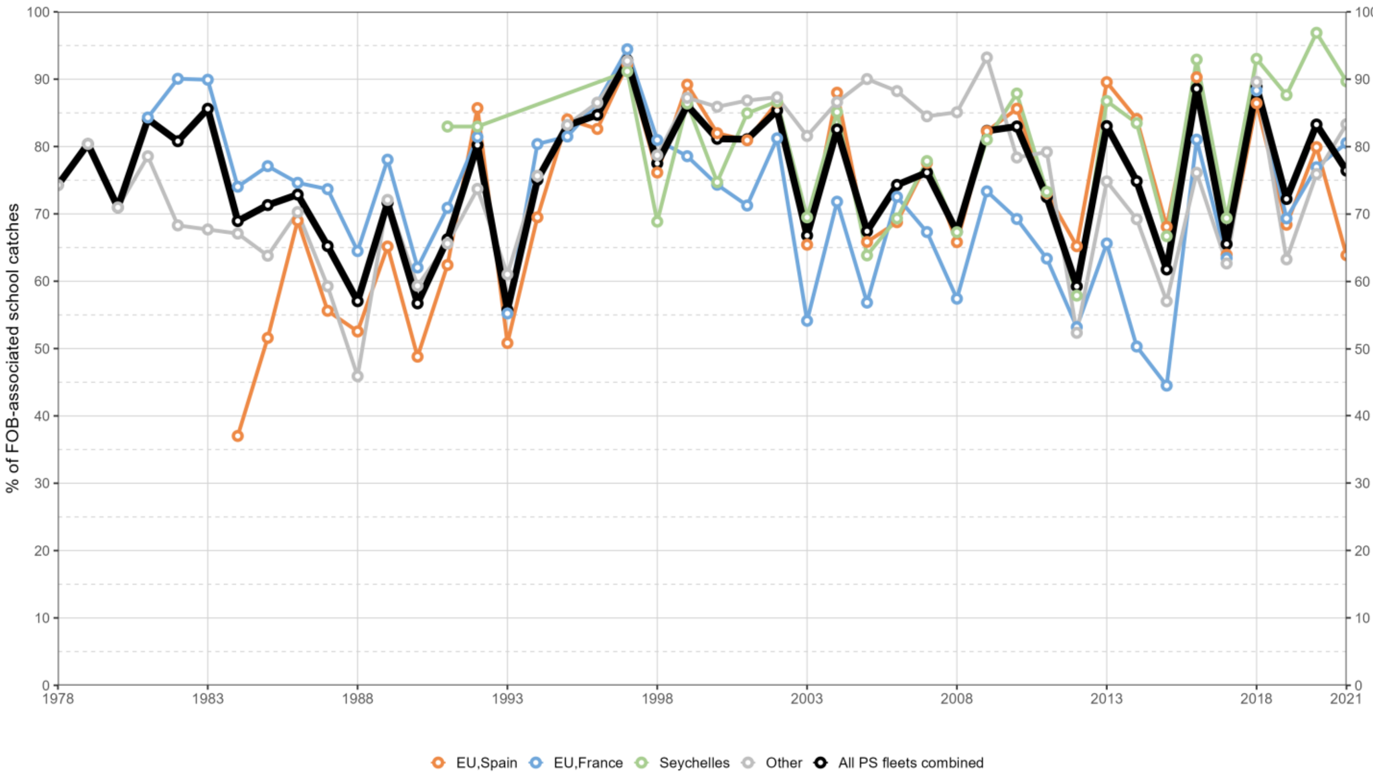

Figure 4: Annual percentages of purse seine FOB-associated catches of bigeye tuna by fleet for the period 1977-2021. *Other* includes purse seine fleets such as ex-Soviet Union, I.R. Iran, France (Mayotte), Mauritius, Japan, Korea, Indonesia, Thailand, EU,Italy, Belize and others. Data source: time-area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

Regional fishing grounds

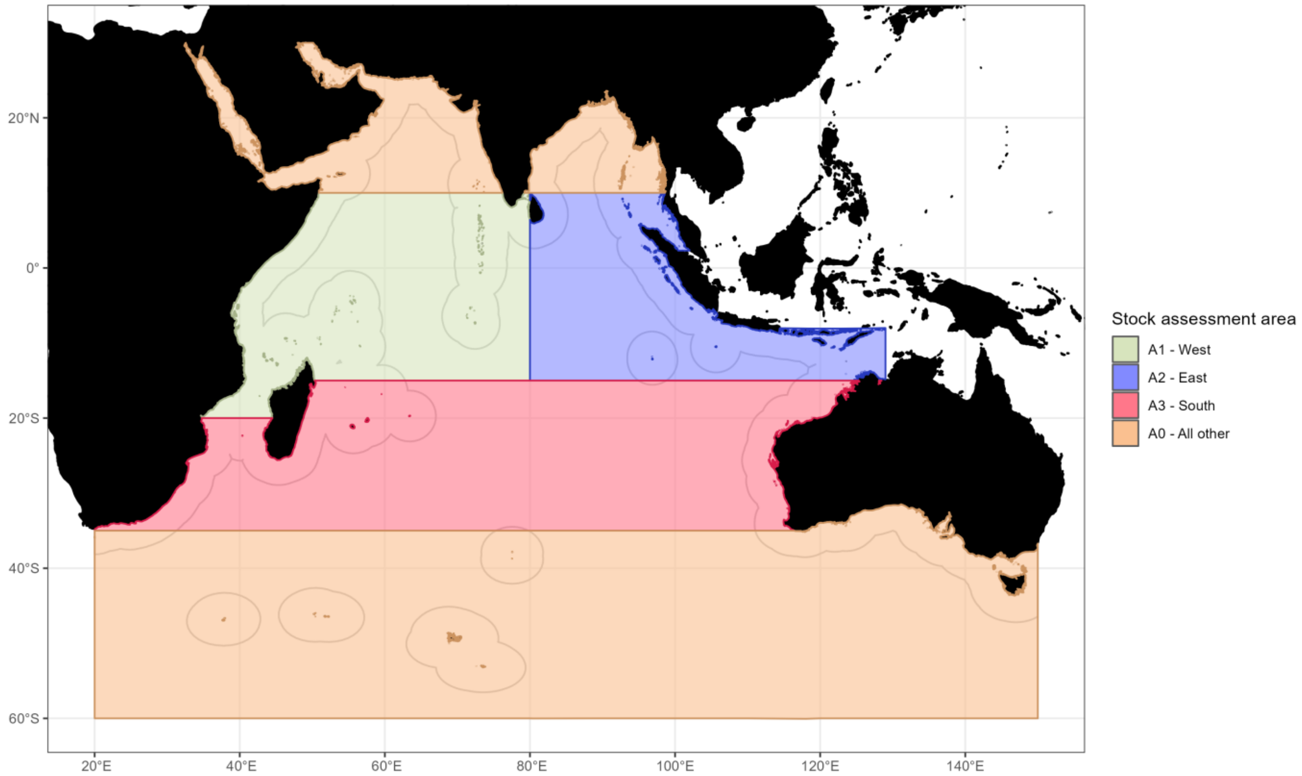

Figure 5: The four bigeye tuna stock assessment areas as defined in IOTC (2019b)

Table 3: Best scientific estimates of average annual nominal catches (metric tonnes; t) of bigeye tuna by decade and stock assessment area for the period 1950-2021. The background intensity colour of each cell is directly proportional to the catch level. Data source: raised time-area catches

SA area	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s
A1 - West	2,432	11,692	17,392	34,824	56,689	76,647	51,512	55,434
A2 - East	3,593	6,908	9,964	18,156	43,731	41,191	30,945	27,520
A3 - South	198	2,587	2,847	2,664	14,743	14,822	8,890	5,652
A0 - All other	366	1,082	1,517	2,476	4,867	3,518	3,269	4,031
Total	6,589	22,269	31,720	58,119	120,031	136,178	94,616	92,637

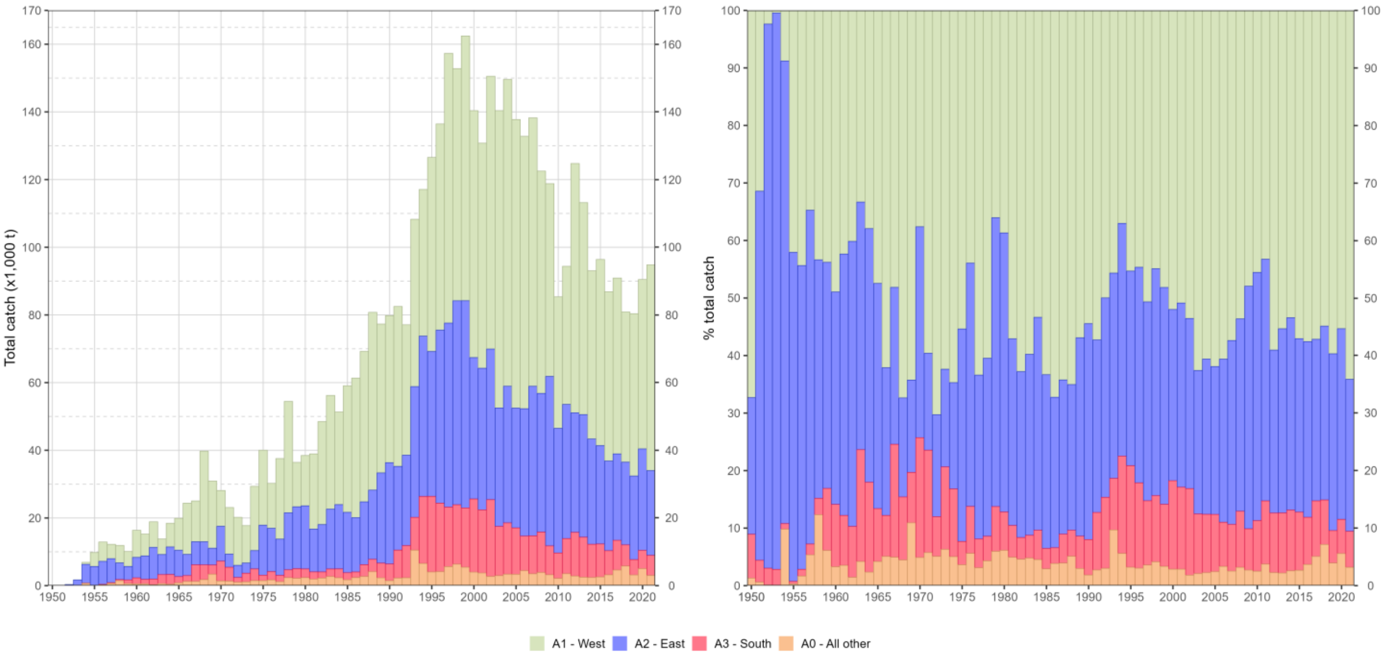

Figure 6: Annual time series of cumulative nominal absolute (a) and relative (b) catches (metric tonnes; t) of bigeye tuna by stock assessment area for the period 1950-2021. Data source: raised time-area catches

Catches of bigeye tuna by stock assessment area were computed from the estimated raised catches for the species: as such, they include information provided *as is* by the major industrial fleets (which generally report raised catch and effort data in agreement with IOTC requirements, raised to total catch and stratified by month, grid, and fishing mode) as well as estimated time-area catches computed for those fisheries (mostly of *artisanal* nature) for which no catch and effort information is available at all, or is missing for large periods of time.

The most recent bigeye tuna stock assessment further breaks area A1 (*West*) into two sub-regions, i.e., R1N (*North*) and R1S (*South*) while excluding area A0 (*All other*) from the analysis, and re-allocating catches from the latter to the corresponding adjacent areas (IOTC 2019b). In terms of catch trends by area, longline catches are mostly taken within the two equatorial regions (15°S to 10°N), while purse seine catches are predominantly taken within the western equatorial region. A seasonal longline fishery targeting albacore tuna operates in the southern region, where bigeye tuna is taken mostly as a bycatch species.

Main fishery features (2017-2021)

Bigeye tuna is caught mainly by longline and purse seiner 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 36,000 t of bigeye tuna per year, contributing to around 42% of total nominal catches for the species (**Table 4**). During the same period, industrial longline fisheries represented the second main contributor of bigeye tuna catches, with about 32,000 t caught annually (around 37% of the total). Line fisheries are the third contributor of catches for the species in recent years, with more than 10,000 t caught annually (around 13% of the total) (**Table 4 & Fig. 2**).

Table 4: Mean annual catches (metric tonnes; t) of bigeye tuna 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	23,371	26.7
Longline | Deep-freezing	LLD	23,307	26.6
Line | Coastal longline	LIC	8,791	10.0
Longline | Fresh	LLF	8,460	9.7
Purse seine | FS	PSFS	6,850	7.8
Other	OT	6,828	7.8
Purse seine | Other	PSOT	6,275	7.2
Line | Trolling	LIT	2,048	2.3
Line | Handline	LIH	956	1.1
Longline | Other	LLO	602	0.7

Average annual catches of bigeye tuna between 2017 and 2021 have been shared between several CPCs, with around 94% of all annual catches accounted for by ten distinct fleets, with Indonesia, Taiwan,China, Seychelles, and EU,Spain contributing to 15% or more of average annual catches each (**Fig. 7**).

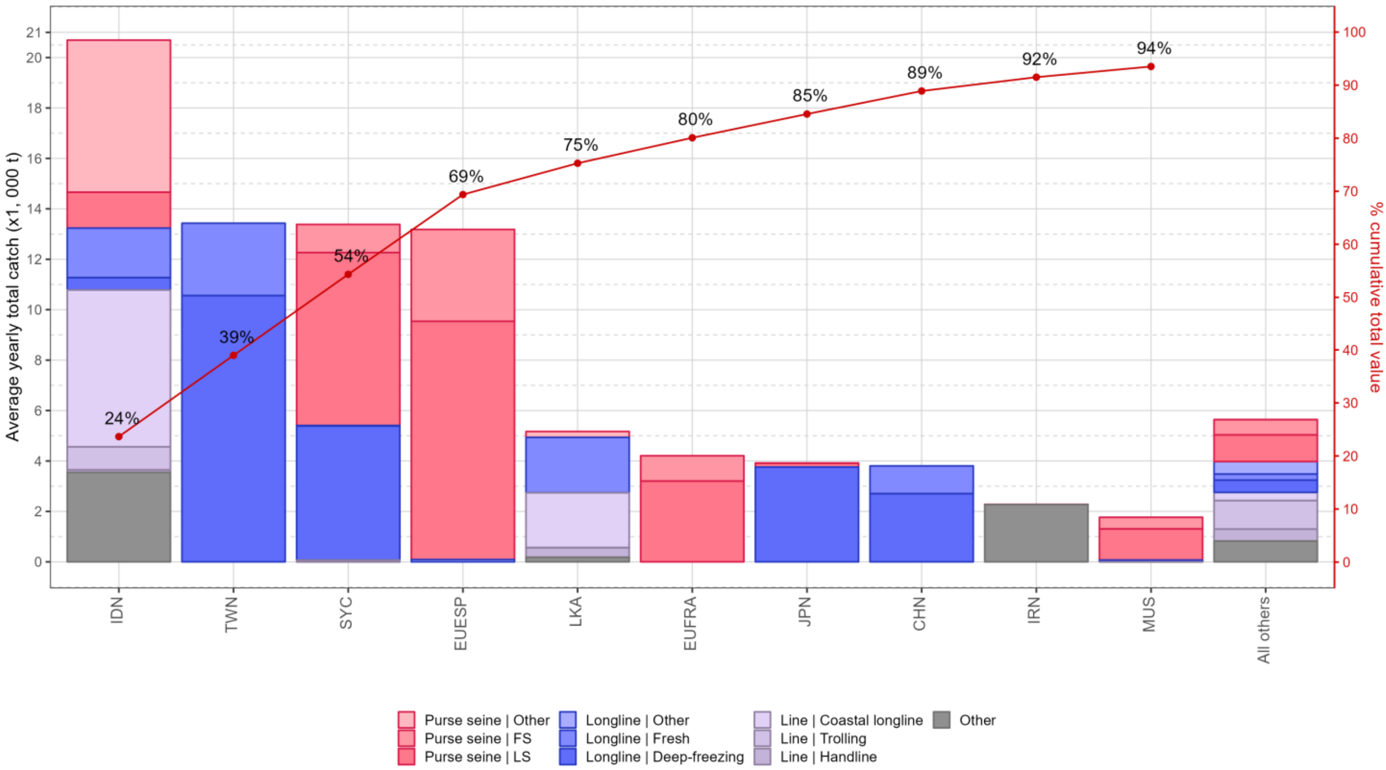

Figure 7: Mean annual catches (metric tonnes; t) of bigeye tuna by fleet and fishery between 2017 and 2021, with indication of cumulative catches by fleet. FS = free-swimming schools; LS = schools associated with floating objects. Data source: raised time-area catches

Catch trends by fishery group in the same period (2017-2021) show different behaviors when comparing industrial longline and purse seiner fisheries, with (relatively) stable trends in catches from lines as well as from vessels using all other gears (**Fig. 8**).

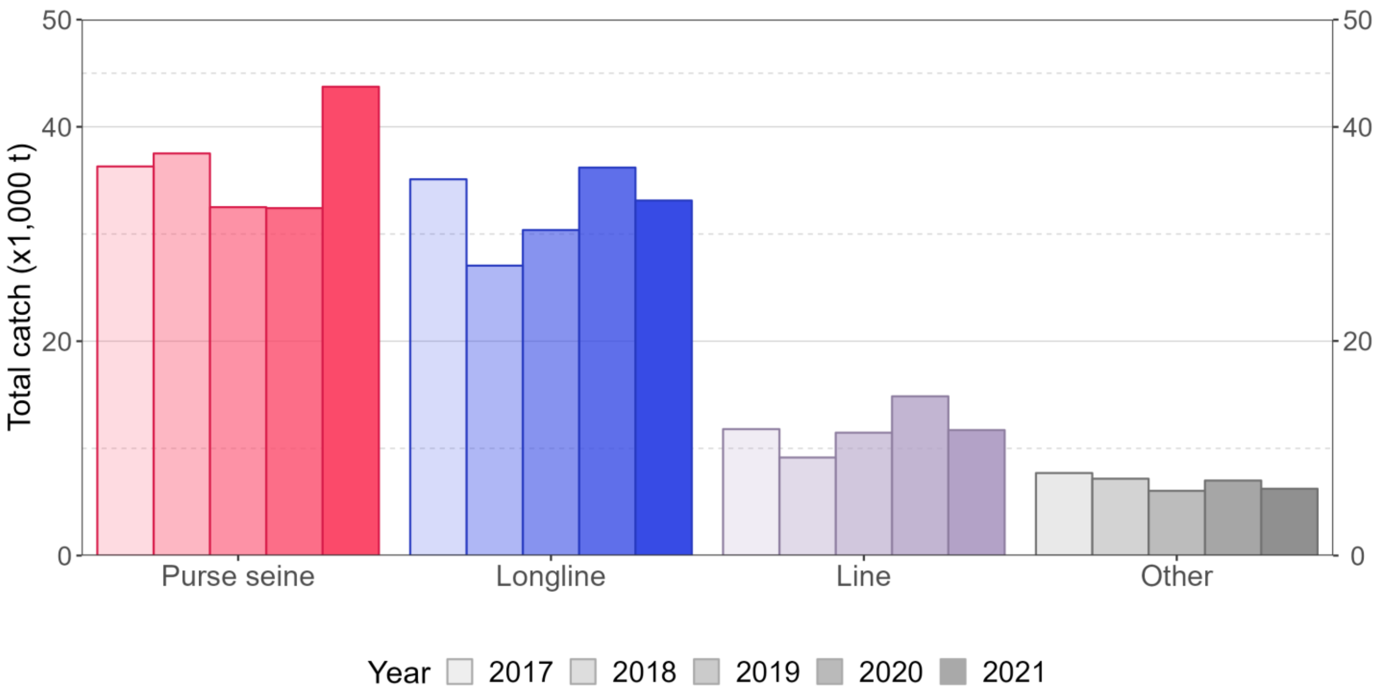

Figure 8: Annual catch (metric tonnes; t) trends of bigeye tuna by fishery group between 2017 and 2021. Data source: best scientific estimate of nominal catches

Regarding industrial purse seine fisheries, catches from all fleets combined remained generally stable in the last five years, with a recent peak in catches identified in 2021 (**Fig. 8**). 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 2021 (**Fig. 10a**).

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. 9a**), while catches on FOB-associated schools have generally stable recent trends, with the exception of 2021 when unusually high catches were reported by Seychelles and EU,France on FOB-associated schools (**Fig. 9b**).

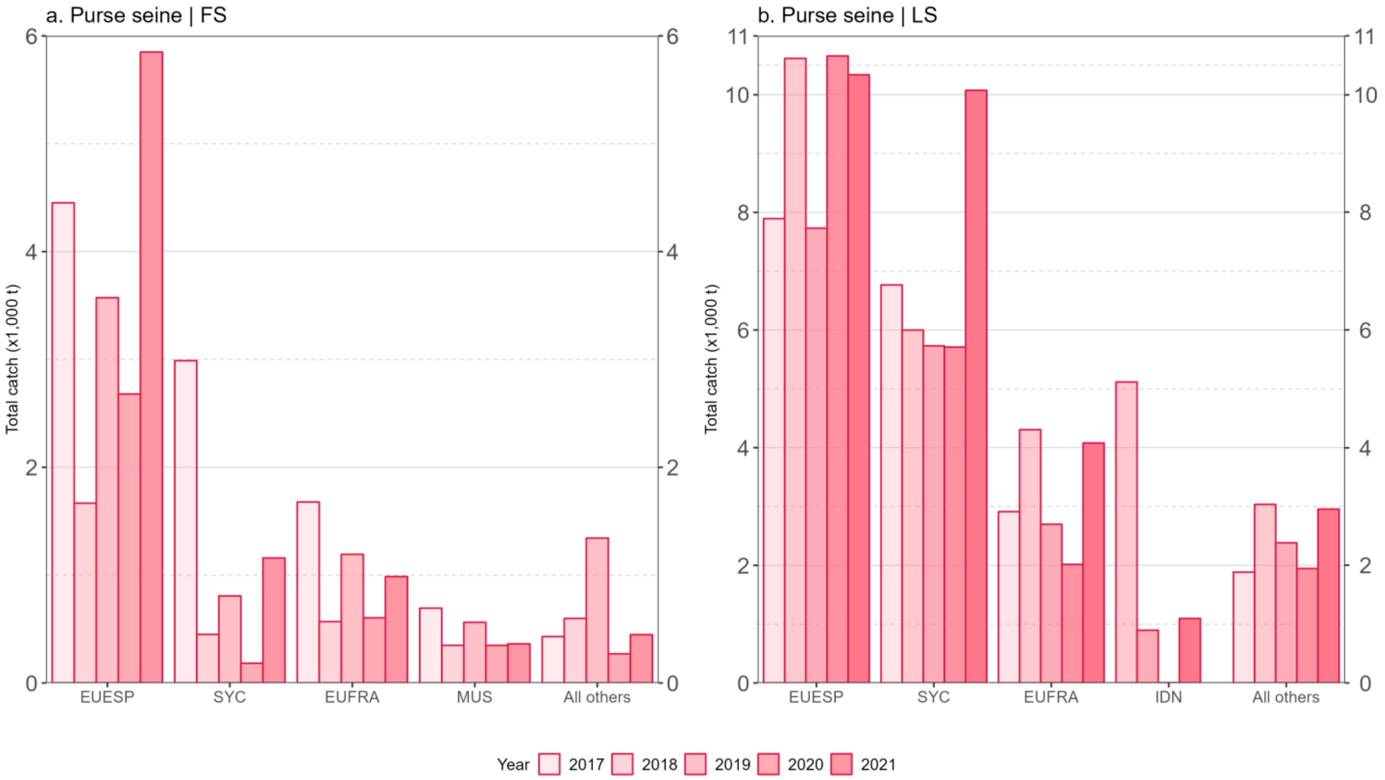

Figure 9: Annual purse seine catch (metric tonnes; t) trends of bigeye tuna by fishing mode and fleet between 2017 and 2021. FS = free-swimming schools; LS = schools associated with floating objects. Data source: raised time-area catches

Recent data from longline fleets show a decreasing trend in bigeye tuna catches until 2018, followed by a new increase in catches that brought the totals back to 2017 levels (**Fig. 8**), thanks in particular to contributions from the deep-freezing and fresh longline fisheries of Taiwan,China, Seychelles, Japan, and China. All other longline fleets (including those targeting swordfish or bycatch species) are aggregated under *All others* and have decreased their bigeye tuna catch levels since 2017 (**Fig. 10b**).

Fleets using line or assimilated gears (handline, troll-line, and coastal longline) show similar trends in catch levels as those identified for the industrial longline fisheries since 2017 (**Fig. 8**). At fleet level, all major contributors appear to be in a phase of slight contractions compared to previous years, with catches in 2021 reported at lower levels than for 2020 (**Fig. 10c**).

Finally, contributions to catch levels from all remaining fisheries (which include gears such as gillnets, liftnets, and pole-and-lines and are aggregated as *All others*) have been basically stable since 2017, with the marked decreases in catches reported by Iranian fisheries complemented by recent increasing trends reported by the fisheries of Indonesia as well as by some other minor fleets (**Fig. 10c-d**) in 2021.

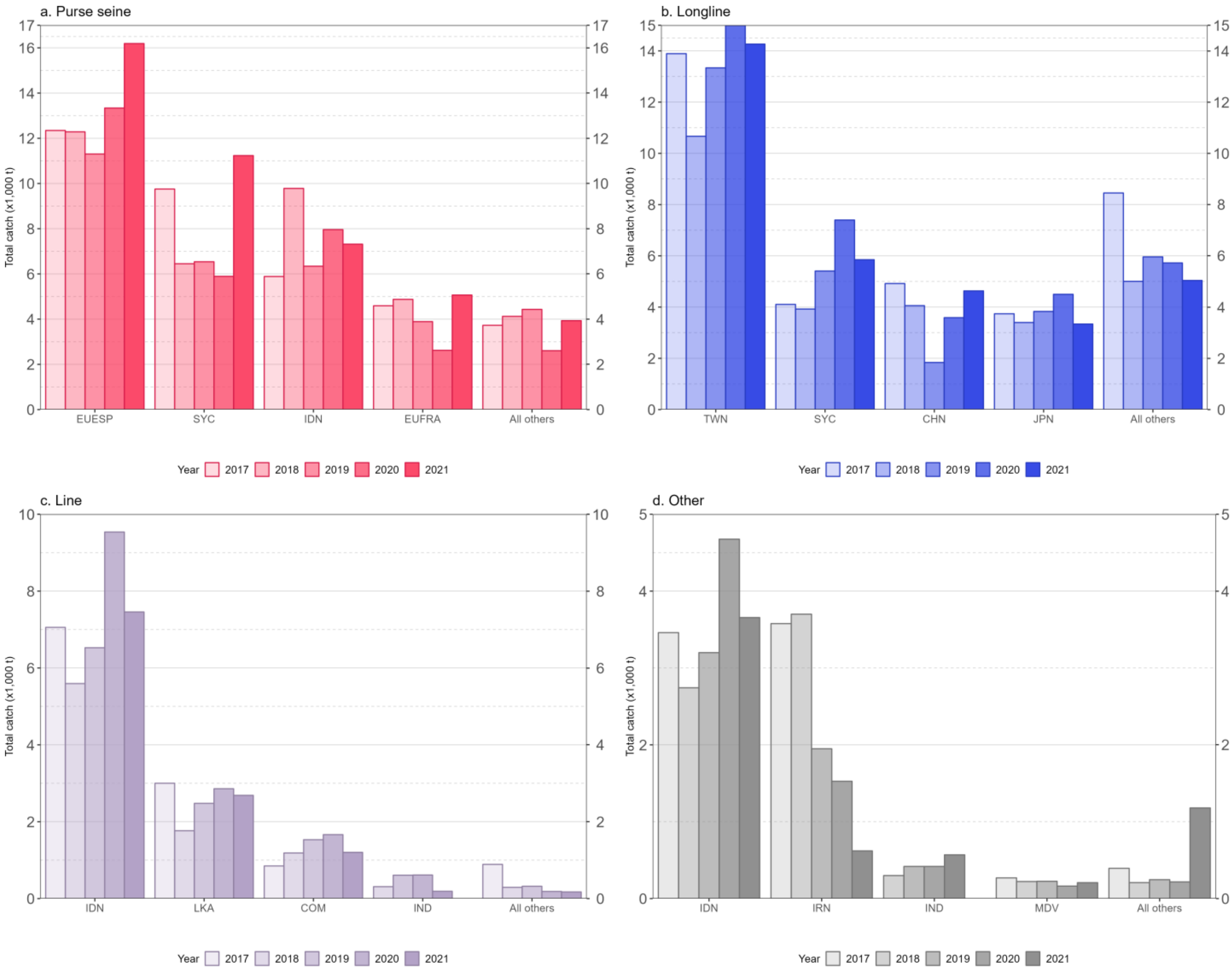

Figure 10: Annual catch trends of bigeye tuna by fishery group and fleet (metric tonnes; t) between 2017 and 2021. Data source: best scientific estimate of nominal catches

Changes from previous WPTT

Limited but significant changes were detected in the latest time series of catches of bigeye tuna compared to the best scientific estimates of nominal catches available to the last data preparatory meeting of the the Working Party on Tropical Tunas in May 2022, summing up to an overall annual change of -13,888 t for 2018 (**Fig. 11**).

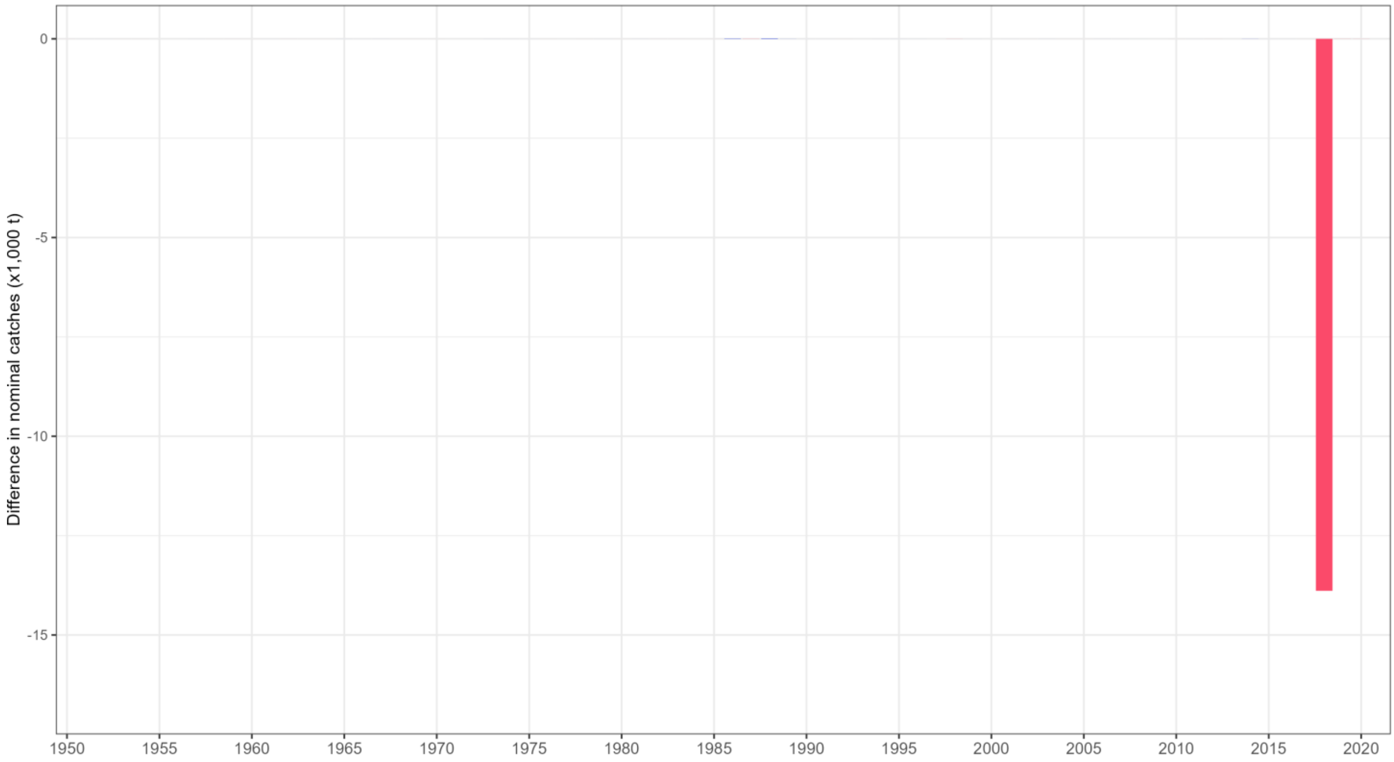

Figure 11: Differences in the available best scientific estimates of nominal catches (metric tonnes; t) of bigeye tuna in between this WPTT and its previous session (data preparatory meeting held in May 2022)

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 2019d), and the approach for the current re-estimation was presented during the Working Party on Data Collection and Statistics in the same year (IOTC 2019c).

The re-estimation applied by the IOTC Secretariat resulted in a decrease of almost 14,000 t in catches of bigeye tuna recorded for 2018 (**Table 5**), while increasing by the same amount EU,Spain overall catches of yellowfin tuna and skipjack tuna for the year concerned.

Table 5: Changes in best scientific estimates of average annual nominal catches (metric tonnes; t) of bigeye 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)
2018	EUESP	Purse seine	Western Indian Ocean	12,286	26,174	-13,888

Uncertainties in nominal catch data

Reporting quality

The quality of the nominal catches of bigeye tuna reported to the IOTC Secretariat shows major variability over the years (**Fig. 12**). The quality is mostly driven by the contribution of industrial fisheries to the total catches and showed a major declining trend from the 1970s to the 1990s when a substantial part of the catch had to be estimated for non-reporting (NEI) and Indonesian longline fleets (Herrera 2002). The situation improved throughout the 2000s although some estimation was still performed for NEI, Indonesian, and Indian longline fleets. The reporting quality has shown an increasing trend since the early 2010s due to increased reporting of nominal catch data for some artisanal fleets and implementation of Port State Measures which progressively reduced the extent of illegal, unreported, and unregulated (IUU) fisheries in the Indian Ocean (**Fig. 12**).

Some issues in reporting have been identified over the last decade for some artisanal fleets, including troll lines from Madagascar, small-scale purse seine and handline fisheries from Mozambique, as well as for the fresh longline fishery of Tanzania which operated between 2011 and 2014. 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 mostly collected in the 2000s (Moreno et al. 2012). In 2021, the percentage of bigeye tuna catch fully or partially reported to the Secretariat was 81%.

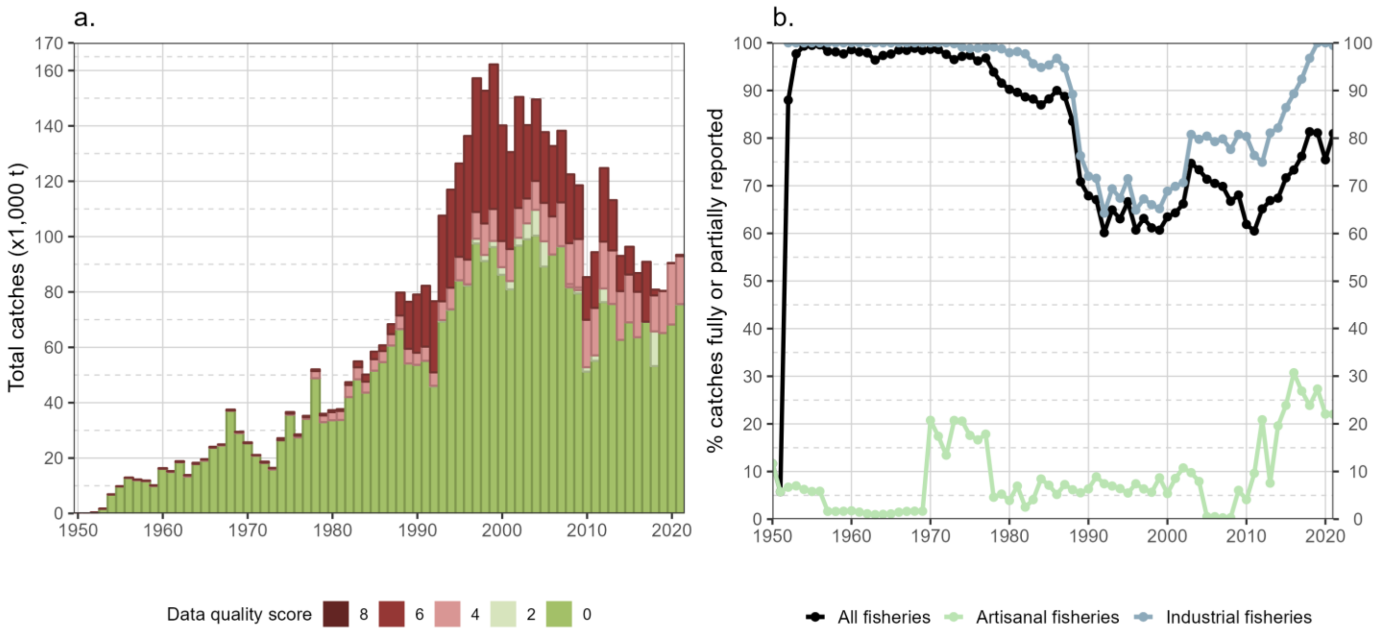

Figure 12: Annual nominal catches (metric tonnes; t) of bigeye tuna estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950-2021

Discard levels

The total amount of bigeye 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 bigeye tuna are mainly composed of fish smaller than 60 cm (~5.7 kg) although a few larger fish may be discarded when damaged (**Fig. 13**). Estimates for the main component of the Indian Ocean purse seine fleet available for the period 2008-2017 show they amounted to a few hundred tonnes annually in that period (Ruiz et al. 2018).

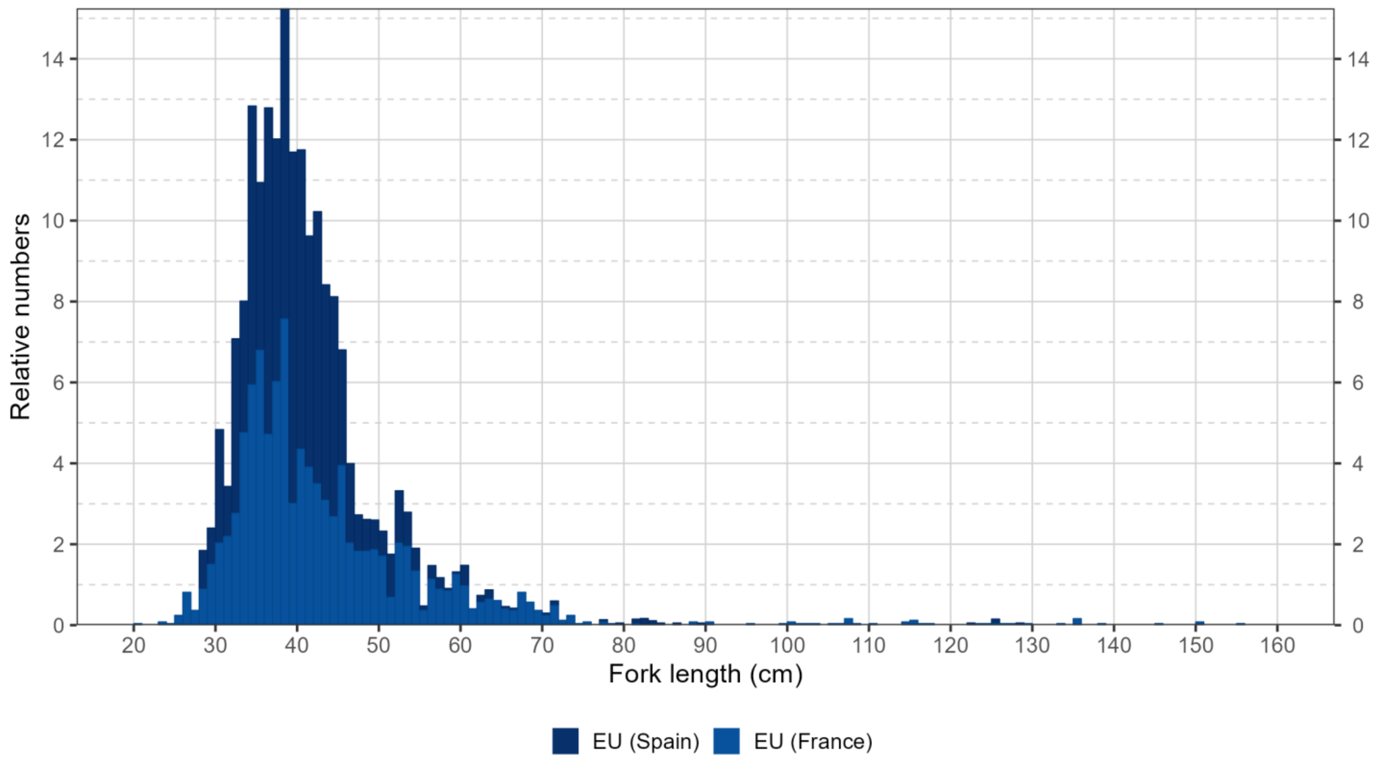

Figure 13: Fork length distribution of bigeye tuna discarded at sea in purse seine fisheries during the period 2016-2020 (n = 8,482). Data source: IOTC ROS database

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 bigeye tuna has been estimated at 4.97% 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 size of the bigeye tunas discarded at sea by the Reunion-based fresh longline fishery are smaller than in the Japanese deep-freezing longline fishery, i.e., a median of 77.5 cm vs. 87.5 cm (**Fig. 14**). 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 bigeye tuna caught in Indian Ocean longline fisheries did support the hypothesis of major changes in discarding practice, e.g., that would be linked to high grading in relation with the implementation of Res. 17/01 (Medley et al. 2021).

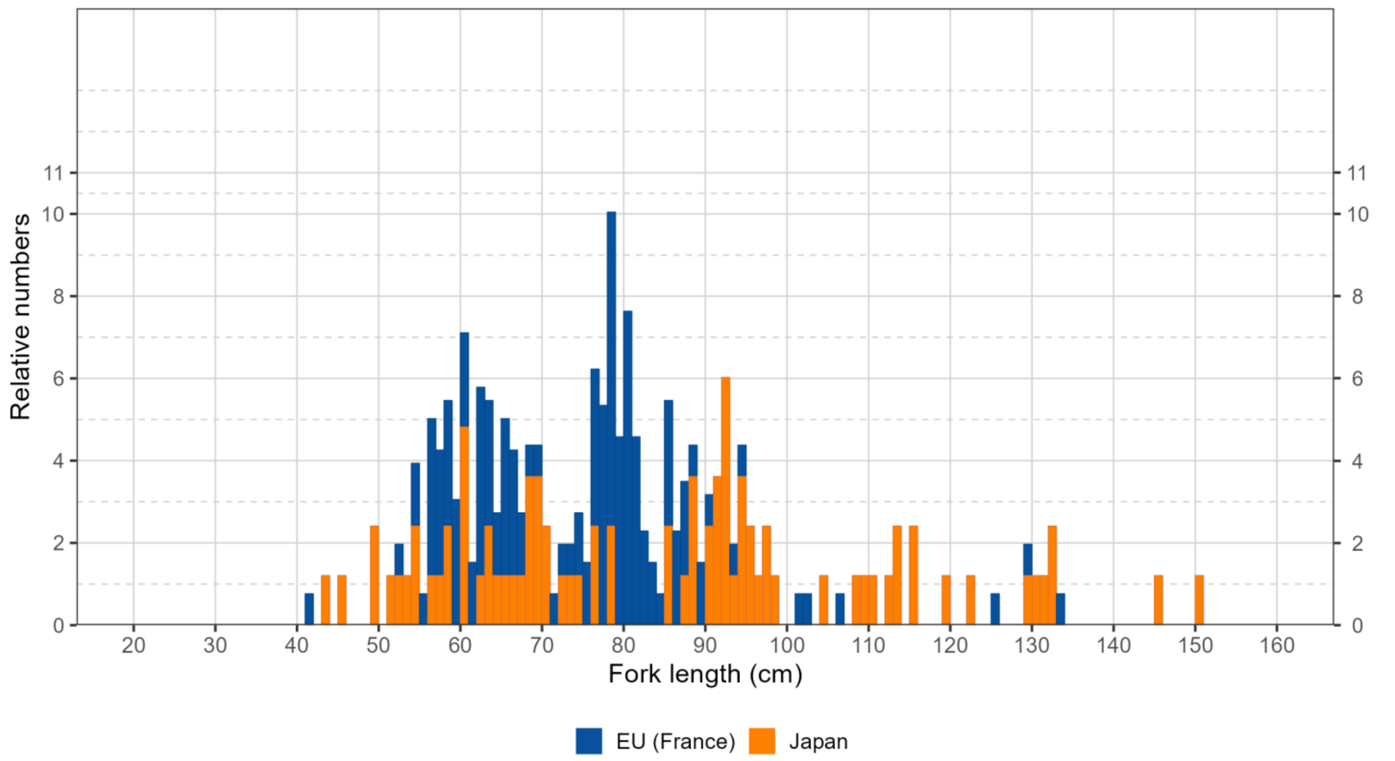

Figure 14: Fork length (cm) distribution of bigeye tuna discarded at sea in longline fisheries during the period 2009-2020 (n = 345). Data source: IOTC ROS database

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 bigeye tuna over the last decades (**Fig. 15**). As early as the 1950s, bigeye 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 representing a small contribution to the bigeye tuna total catches.

Throughout the 1960s and 1970s, the longline fisheries expanded in the south-western part of the Indian Ocean, including in the Mozambique Channel (**Fig. 15b-c**). From the 1980s, the purse seine fishery developed in the western Indian Ocean, with most of the bigeye tuna caught by FOB-associated schools (**Fig. 15d**).

During the 1990s and 2000s, the purse seine fishery increased its catches and expanded its fishing grounds in the western Indian Ocean while a large fresh longline and line fishery developed in the north-eastern Indian Ocean (**Fig. 15e-f**).

The overall annual distribution of bigeye tuna catches by fishery has changed little over the period 2017-2021 (**Fig. 16**).

Geo-referenced catches by fishery and decade (1950-2009)

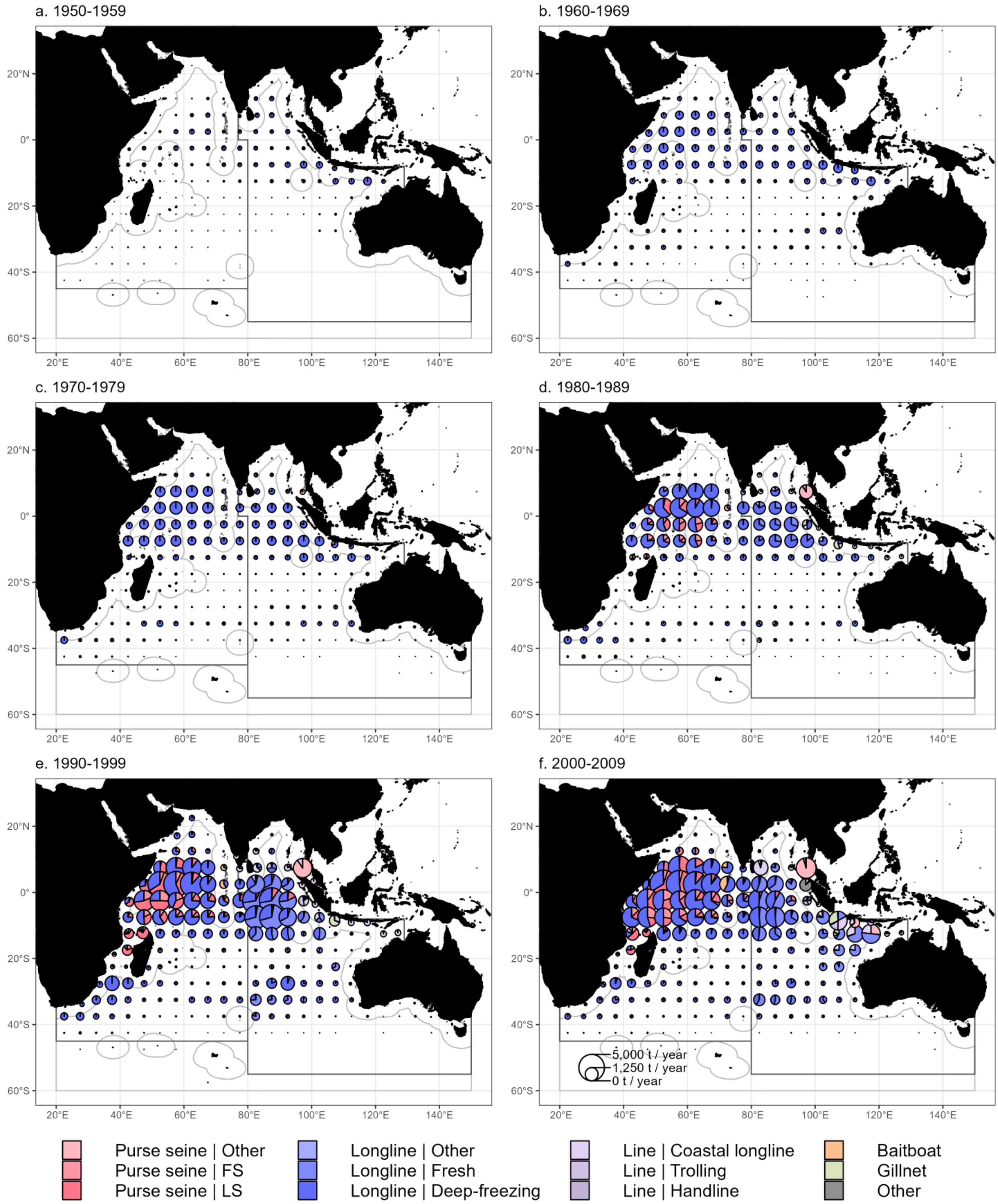

Figure 15: Estimated mean annual time-area catches (metric tonnes; t) of bigeye tuna by decade, 5x5 grid, and fishery. Data source: raised time-area catches

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

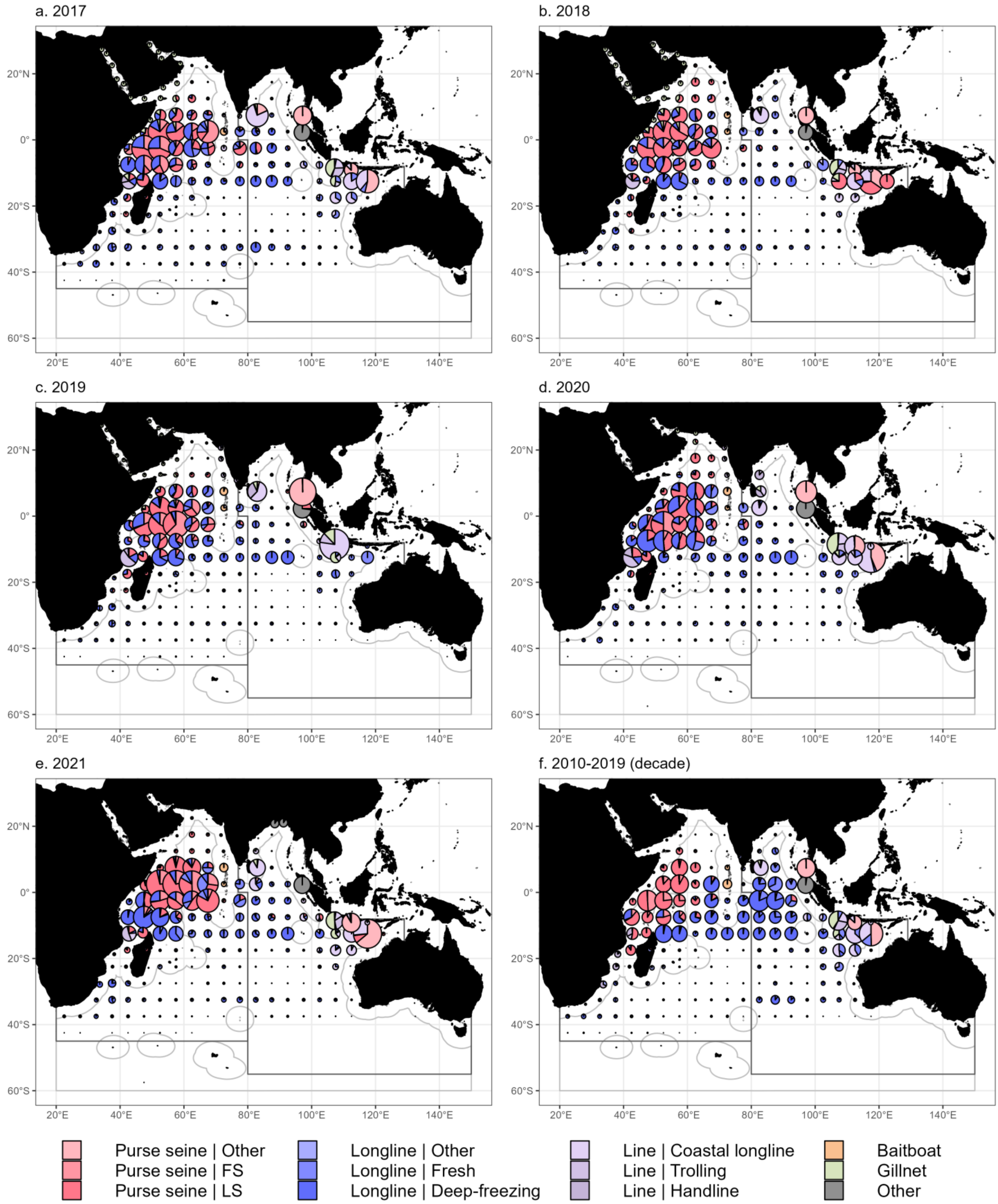

Figure 16: Estimated mean annual time-area catches (metric tonnes; t) of bigeye tuna by year / decade, 5x5 grid, and fishery. Data source: raised time-area catches

Indonesia appears to have developed an industrial purse seine fishery since 2018 (**Fig. 16d-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 line fisheries (handline, trolling and coastal longline) are widely used along the coasts of 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 and effort data is driven to some extent by the relative contribution of artisanal fisheries to the total catches of bigeye tuna (**Fig. 17b**). The main issues identified in the past concern:

- the fresh-tuna longline fisheries of China and Taiwan,China, for which geo-referenced catch and effort data have only been available since 2006 and 2007 when nominal catch data have been reported since 1995 and 2001, respectively;
- purse seine and fresh-tuna longline 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 longline fisheries of Sri Lanka (since 2014), described by poor quality effort data;
- some coastal fisheries using hand and/or troll lines for which no data (or incomplete data) have been reported to the Secretariat, in particular: Comoros (until 2018), Indonesia (2018 and 2020), Mauritius (since 2011 but without data from 2013 to 2015), and France,Reunion (until 2012).

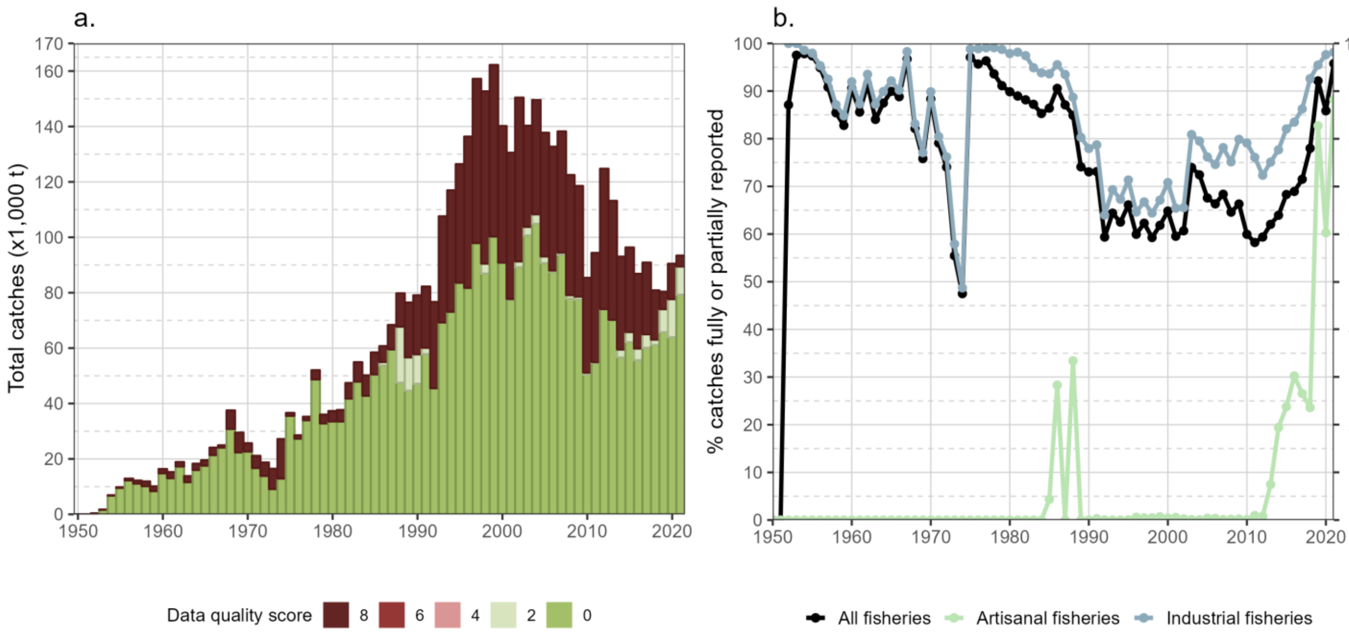

Figure 17: (a) Annual nominal catches (metric tonnes; t) of bigeye tuna estimated by quality score and (b) percentage of geo-referenced catches reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 for all fisheries and by type of fishery, in the period 1950-2021

The percentage of data considered of good quality (scores of 0-2) varied between 59%-74% during the 1990s and 2000s, and has stabilized over the last decade showing an overall increasing trend from 59% in 2012 to 96% in 2021, with 96% of good quality data available in 2021 (**Fig. 17a-b**). Catch and effort data have progressively become available for some important fisheries such as coastal and fresh longlines as well as hand lines from Sri Lanka since 2014, coastal longlines from I.R. Iran since 2016, small-scale purse seines and fresh longlines from Indonesia since 2018, and some smaller fisheries such as trolling from Indonesia and hand line from Kenya since 2018.

Nevertheless, geo-referenced catch and effort data were not available for about 4% (i.e., around 3,900 t) of the total nominal catches of bigeye 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 bigeye tuna of ~300 t.

Size composition of the catch

Samples availability

By fishery group

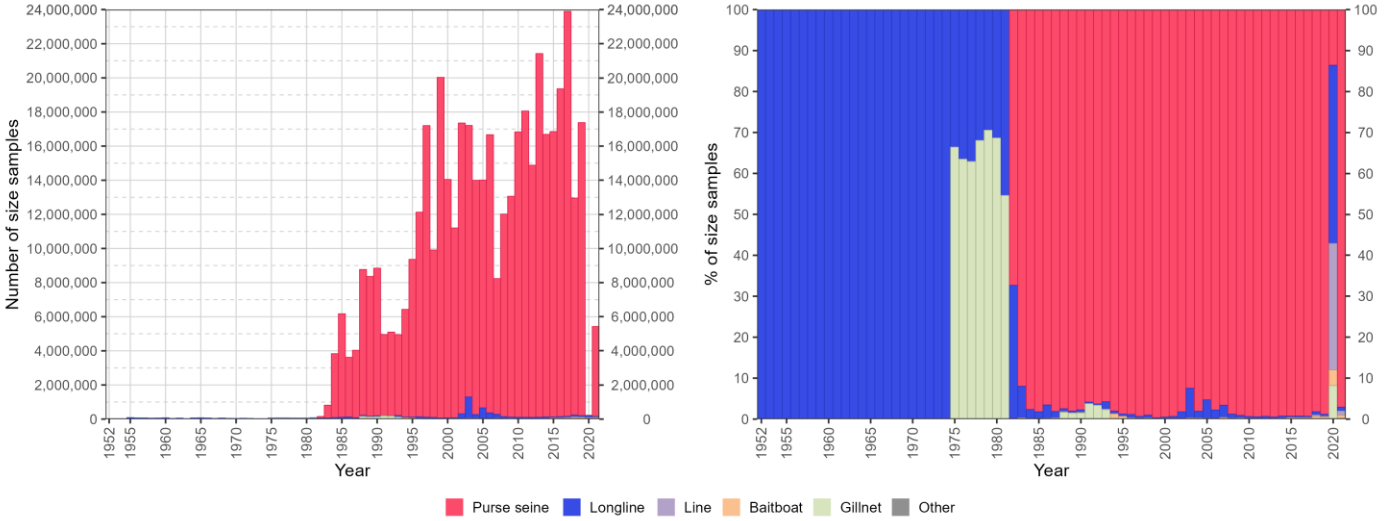

Figure 18: Availability of bigeye tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and fishery group. Data source: standardized size-frequency dataset (Res. 15/02)

Comprehensive size-frequency data for bigeye 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 20 million individual lengths reported for a single year (**Fig. 18**).

The contribution of longline fisheries to the total available samples for the species became more evident during the 2000s, and reflects the actual level of catches from these fisheries. In general, samples from all other fisheries (using baitboats, gillnets and miscellaneous gears mostly of artisanal nature) are limited and highly dependent on the fleet (**Fig. 32**).

Due to the CoViD-19 pandemic, size-frequency data of bigeye 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 is generally representative of the fishing grounds where the fisheries operate, and proportional to the level of recorded captures (**Fig. 19**).

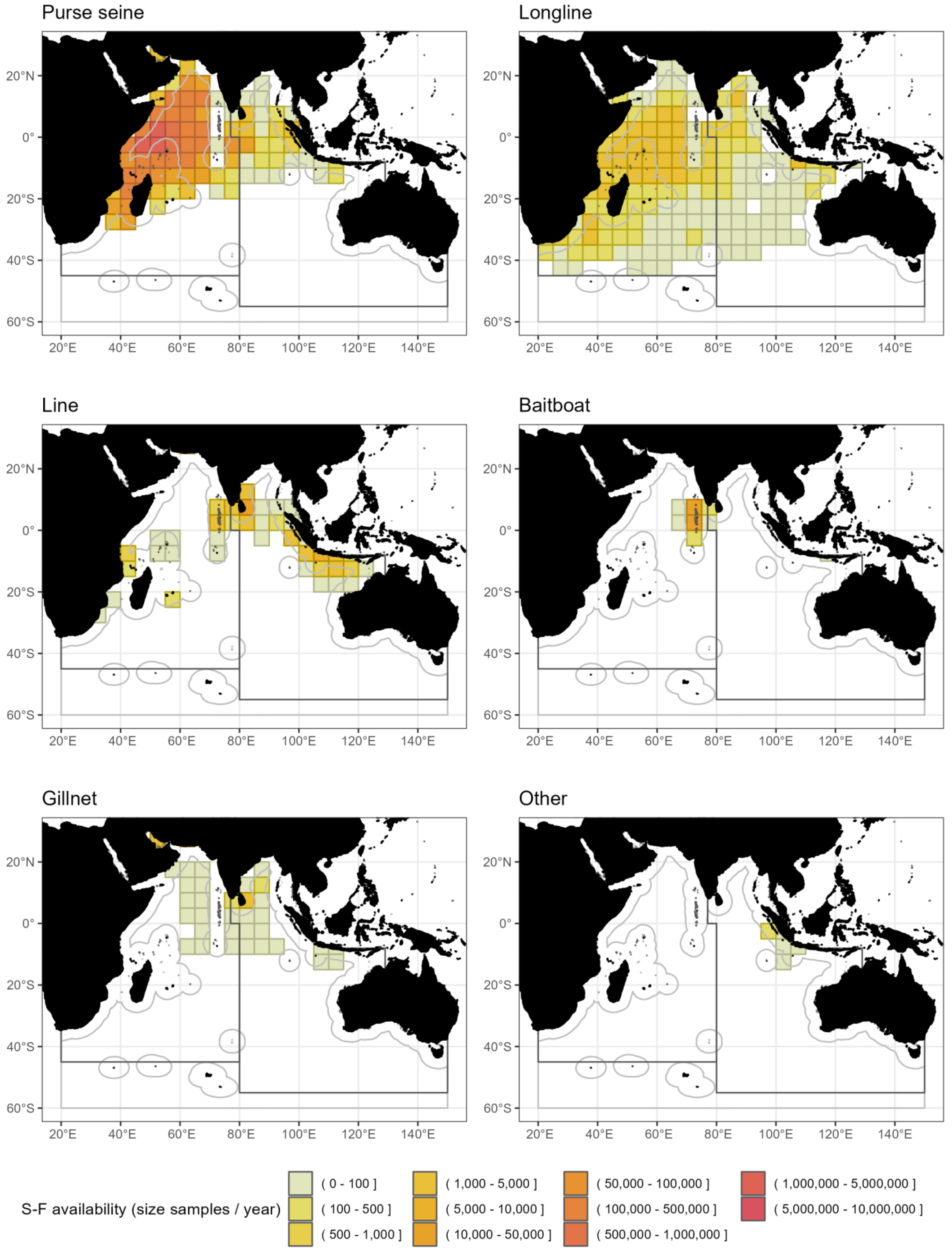

Figure 19: Spatial distribution (average number of samples per grid per year) of available bigeye tuna size-frequency data for each fishery group in the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

By fishery

Purse seine fisheries

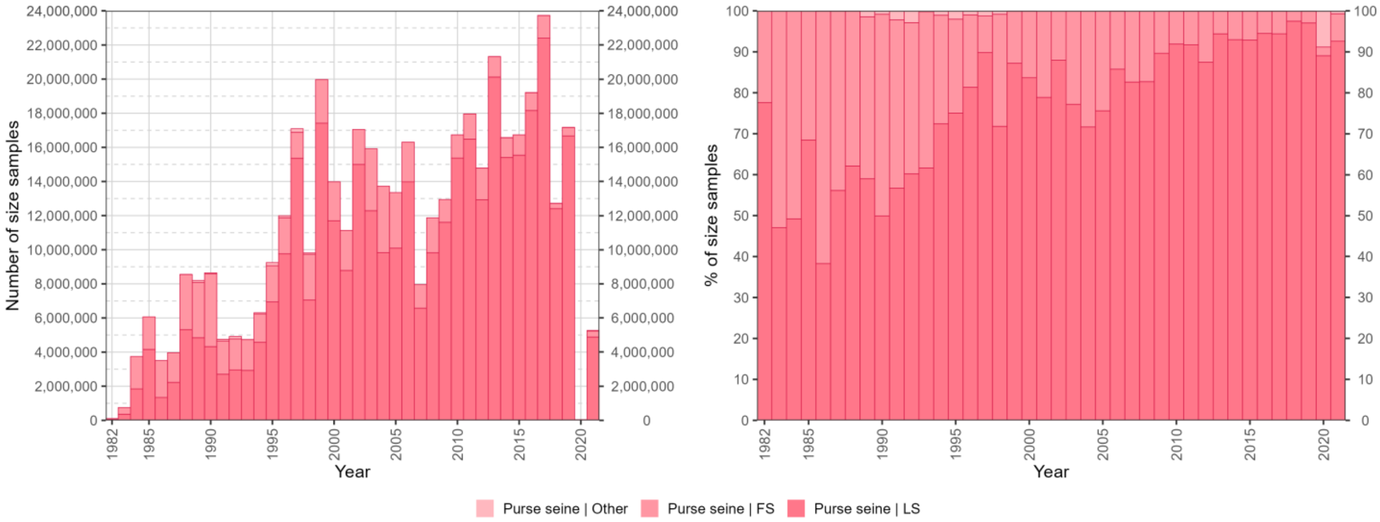

Figure 20: Availability of bigeye tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and purse seine fishery type. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

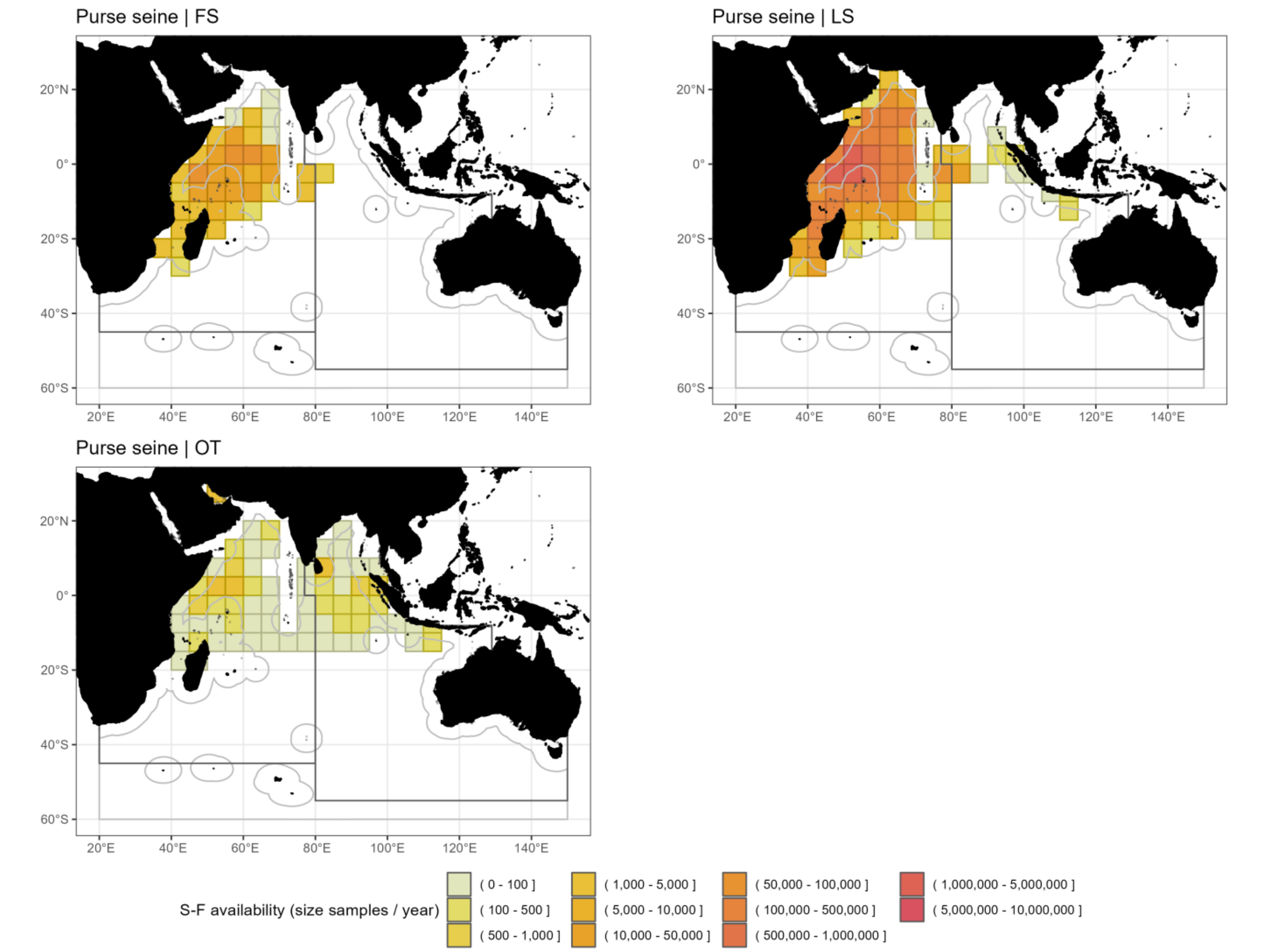

Figure 21: Spatial distribution (average number of samples per grid per year) of available bigeye tuna size-frequency data by purse seine fishery types in the period 2017-2021. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

Longline fisheries

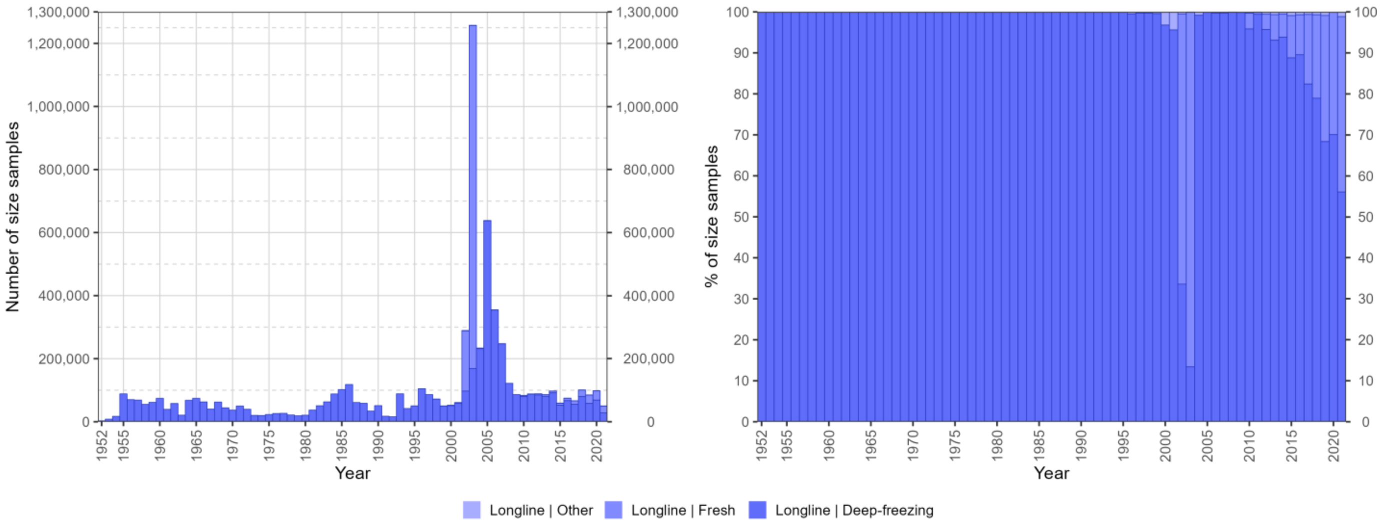

Figure 22: Availability of bigeye tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and longline fishery type. Data source: standardized size-frequency dataset (Res. 15/02)

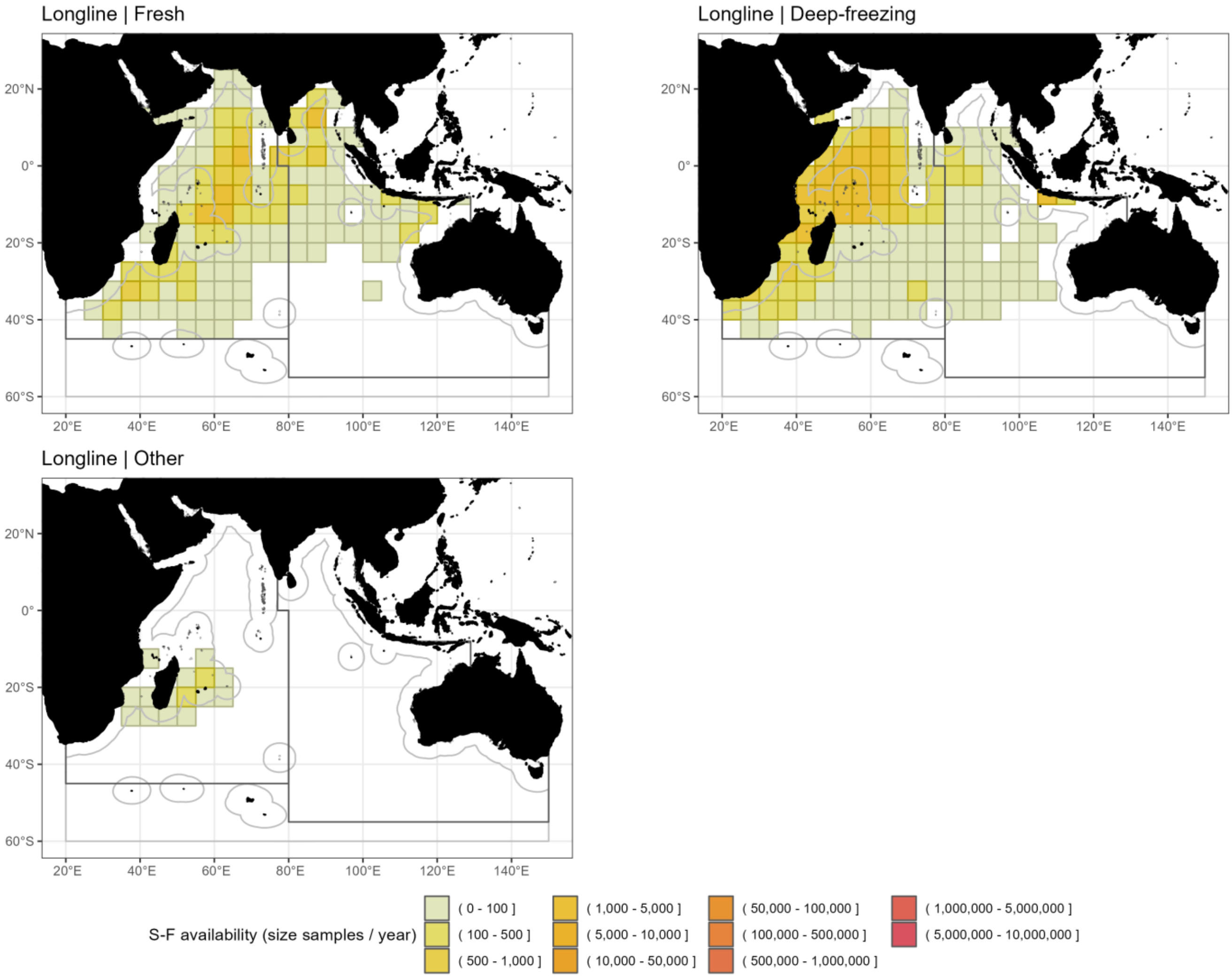

Figure 23: Spatial distribution (average number of samples per grid per year) of available bigeye tuna size-frequency data by longline fishery types in the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

Coverage levels of bigeye tuna samples over the considered timeframe confirm how deep-freezing longliners from Taiwan,China are regularly exceeding the minimum threshold of 1 measured fish per metric tonne of retained catches. Size-frequency data from the other major deep-freezing longline fleets reached or surpassed that level only in a few years over the same period with the exception of those from Seychelles which are relatively well sampled (**Fig. 24**).

Information provided by the Seychelles Fishing Authority indicates that complementary size-frequency data collected throughout the period 2015-2021 should be submitted to the Secretariat in 2023. However, it is important to note that a comprehensive analysis of the longline size-frequency data available at the IOTC Secretariat showed some strong variability in the quality and reliability of the data available from Taiwan,China and Seychelles over time and space, with the recommendation to omit all these data from stock assessments until the issues have been addressed (Hoyle et al. 2021) (see also details in section Uncertainties in size-frequency data).

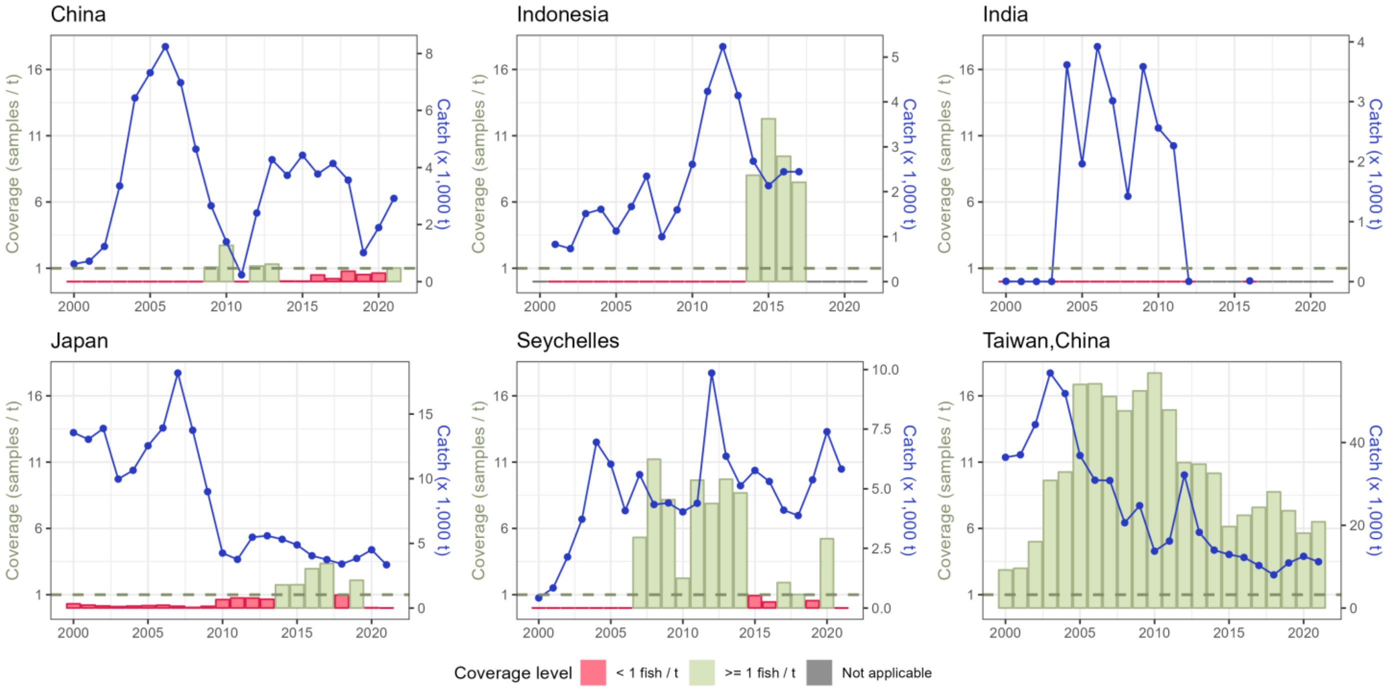

Figure 24: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major deep-freezing longline fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

In the case of fresh-tuna longliners, the level of coverage (and more in general the availability of samples) varies greatly with the fleet and years considered. In recent years, only Taiwan,China managed to consistently reach the minimum level of coverage, while all other fleets alternate several years for which no samples are available with sporadic peaks in sampling rate (e.g., Mauritius in 2019, Seychelles in 2020, Malaysia in 2020-2021) (**Fig. 25**).

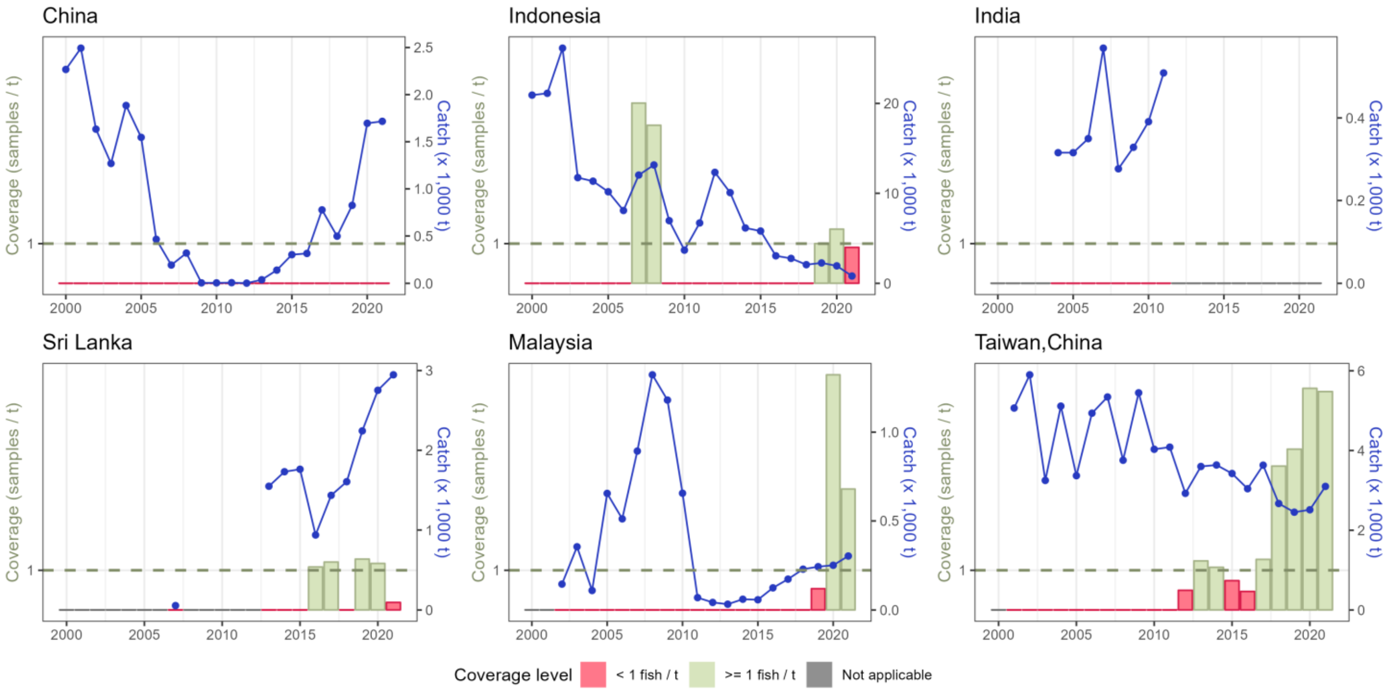

Figure 25: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major fresh-tuna longline fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

Longliners targeting swordfish are also known to interact frequently with the species. Among the major fleets involved, Australia is the one that has been generally sampling the species at very good levels, well above the minimum threshold required by IOTC in recent years, except 2021 for which no information was received. All other fleets tend to alternate years of sufficient sampling with years in which no information was collected or reported to the Secretariat. The swordfish longline fishery of EU,Spain ranks worst in terms of coverage level, with no single year in the considered timeframe where the minimum coverage was reached (**Fig. 25**).

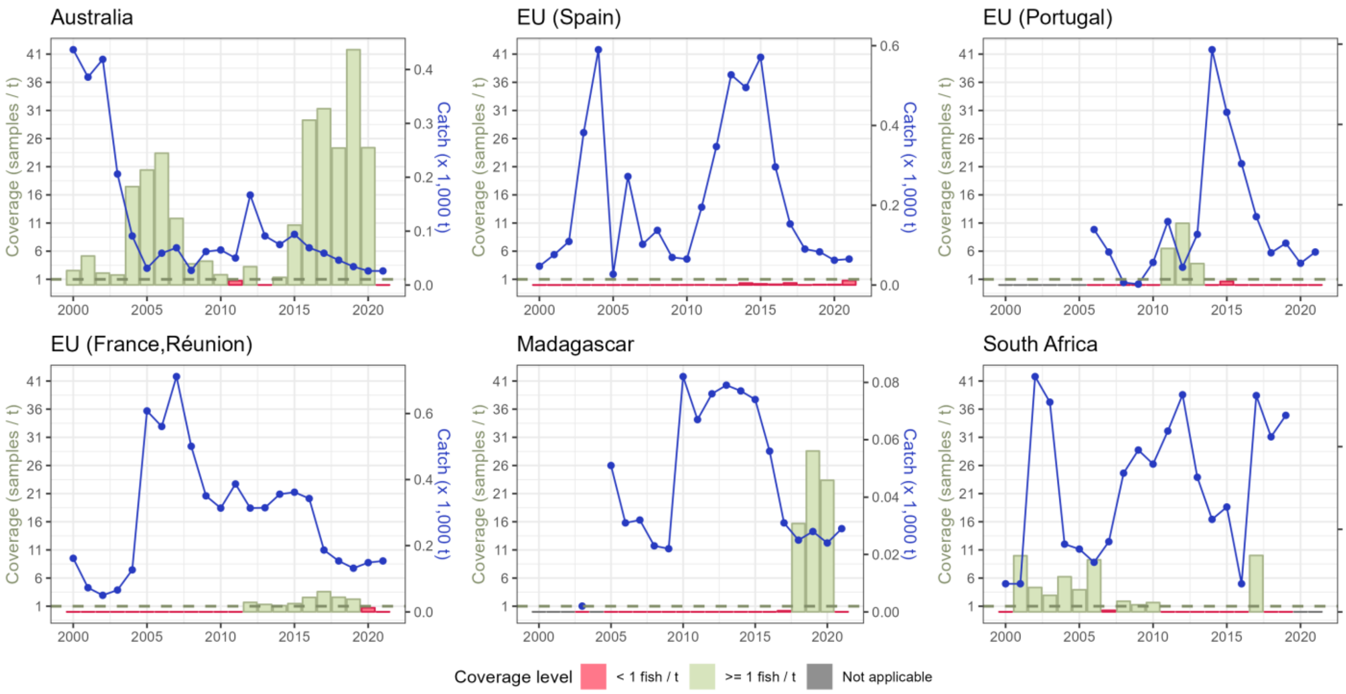

Figure 26: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major swordfish targeting longline fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

Line fisheries

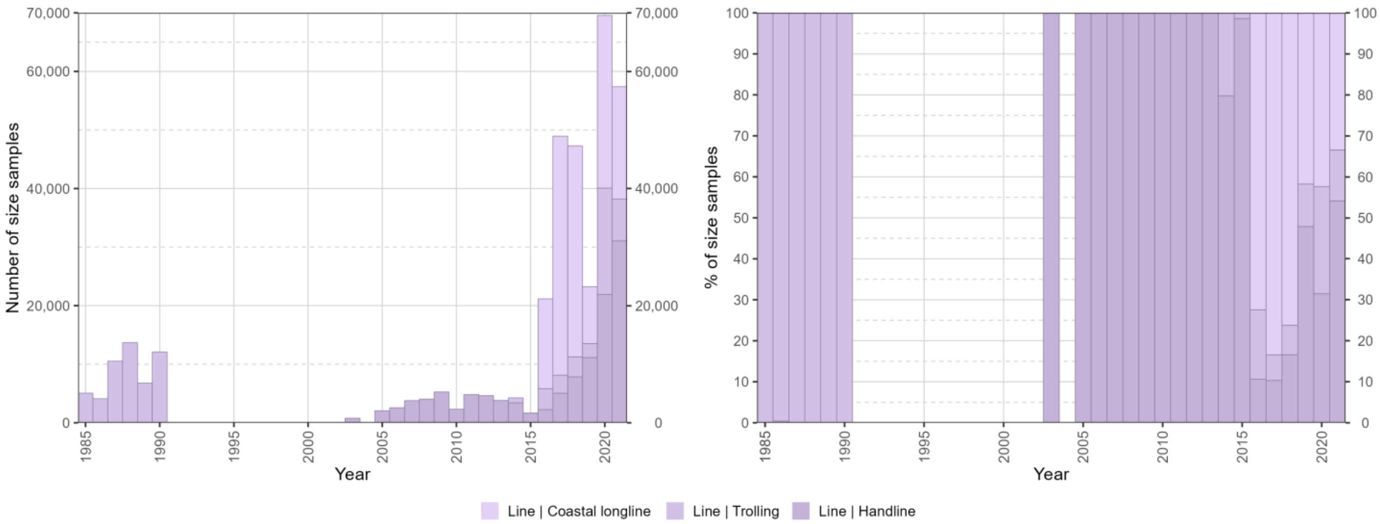

Figure 27: Availability of bigeye tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and line fishery type. Data source: standardized size-frequency dataset (Res. 15/02)

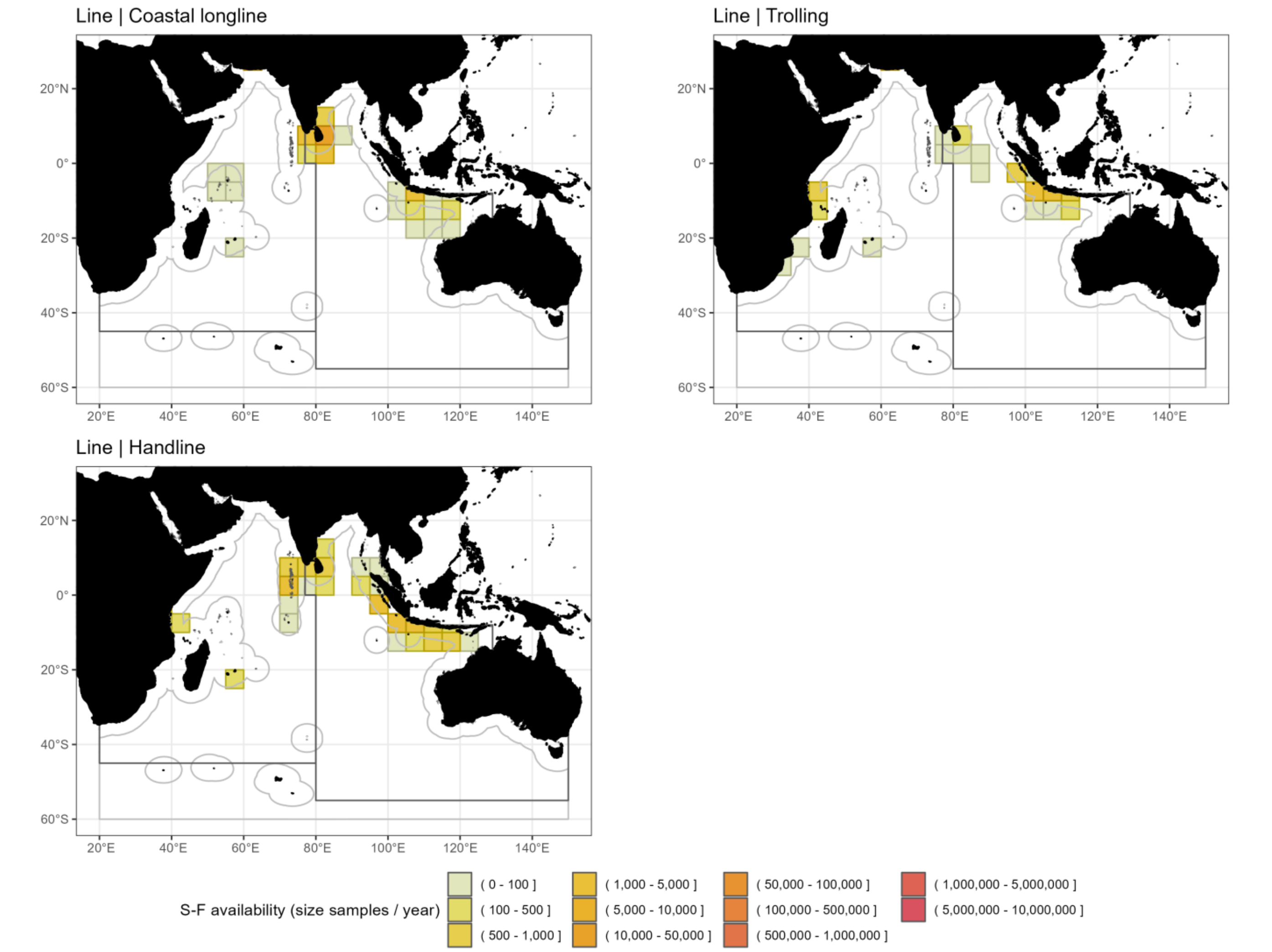

Figure 28: Spatial distribution (average number of samples per grid per year) of available bigeye tuna size-frequency data by line fishery types in the period 2017-2021. Data source: [standardized size-frequency dataset] (Res. 15/02)

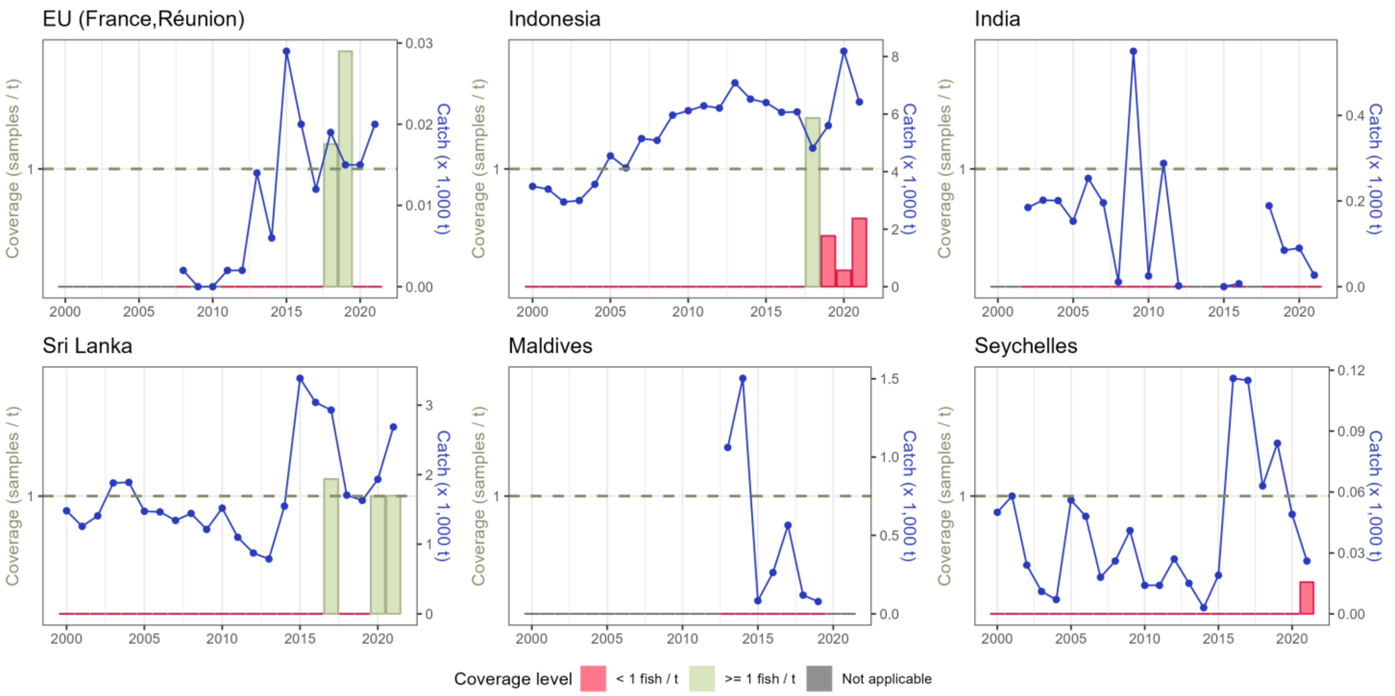

Figure 29: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major coastal longline fleets, by fleet and year (2000-2021). Data source: [standardized size-frequency dataset] (Res. 15/02)

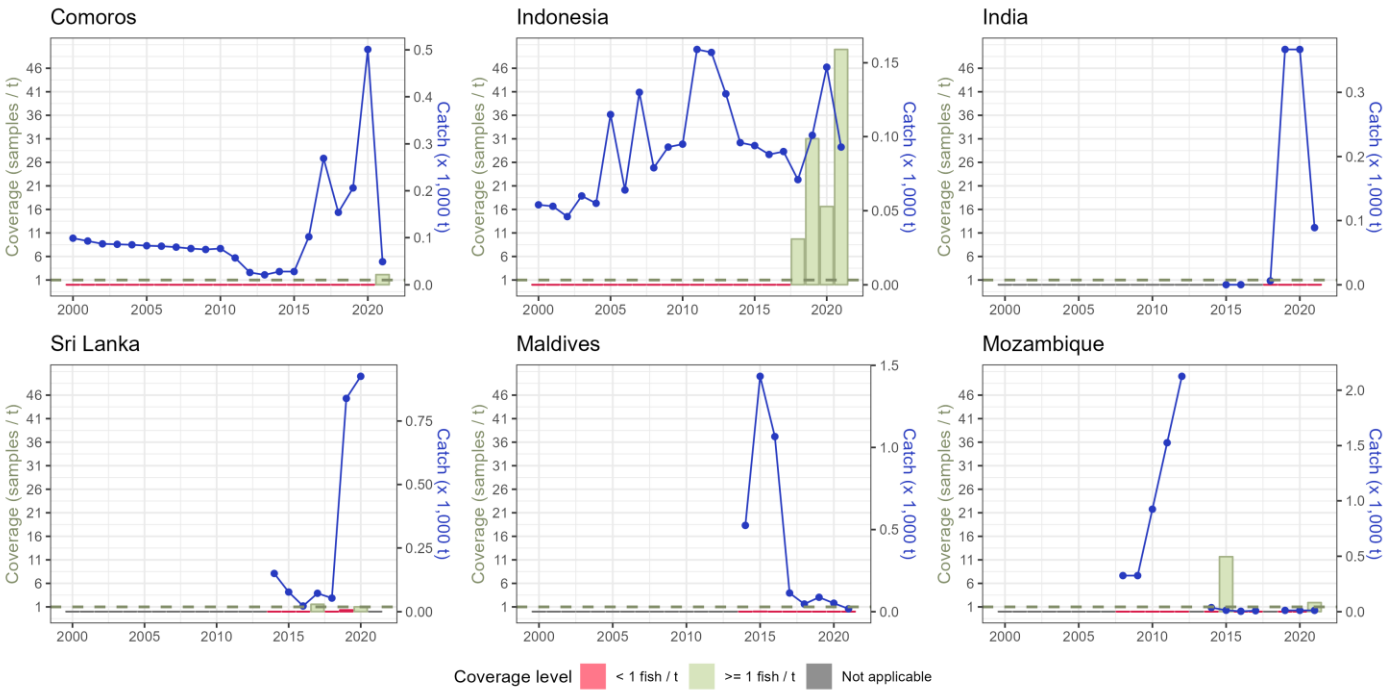

Figure 30: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major handline fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

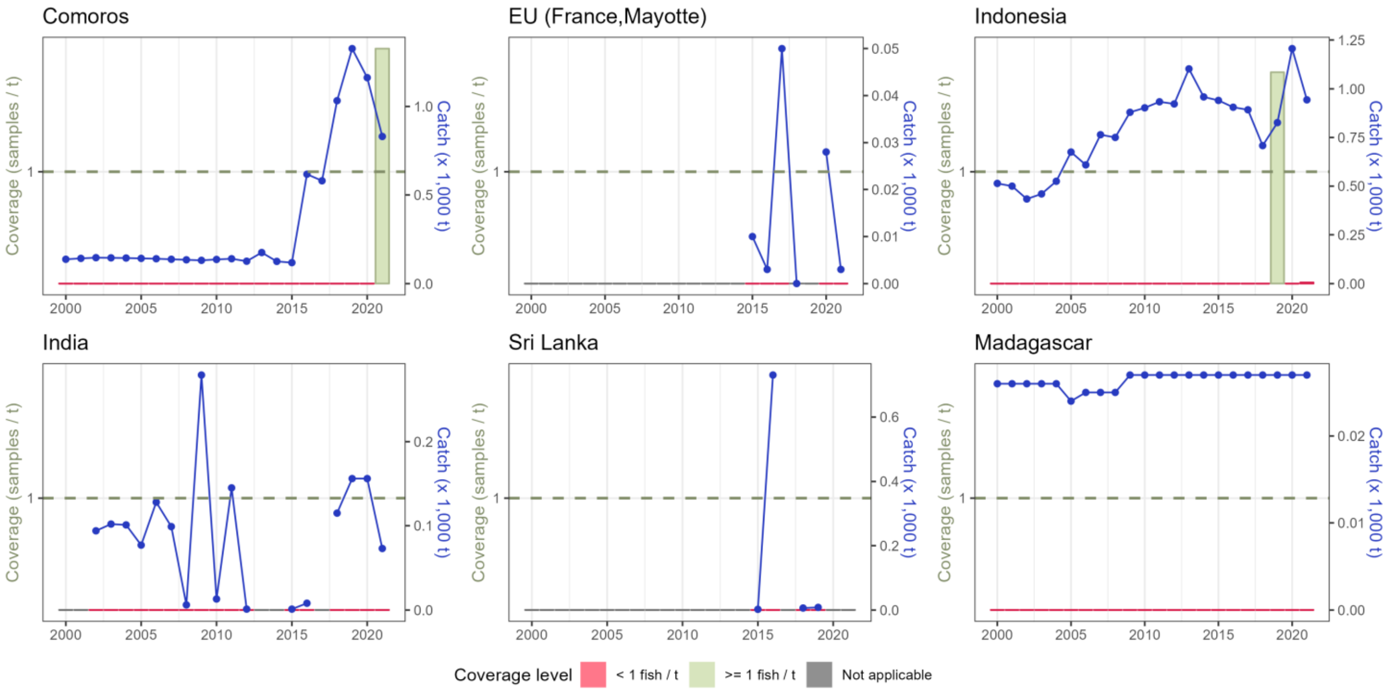

Figure 31: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major troll line fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

Other fisheries

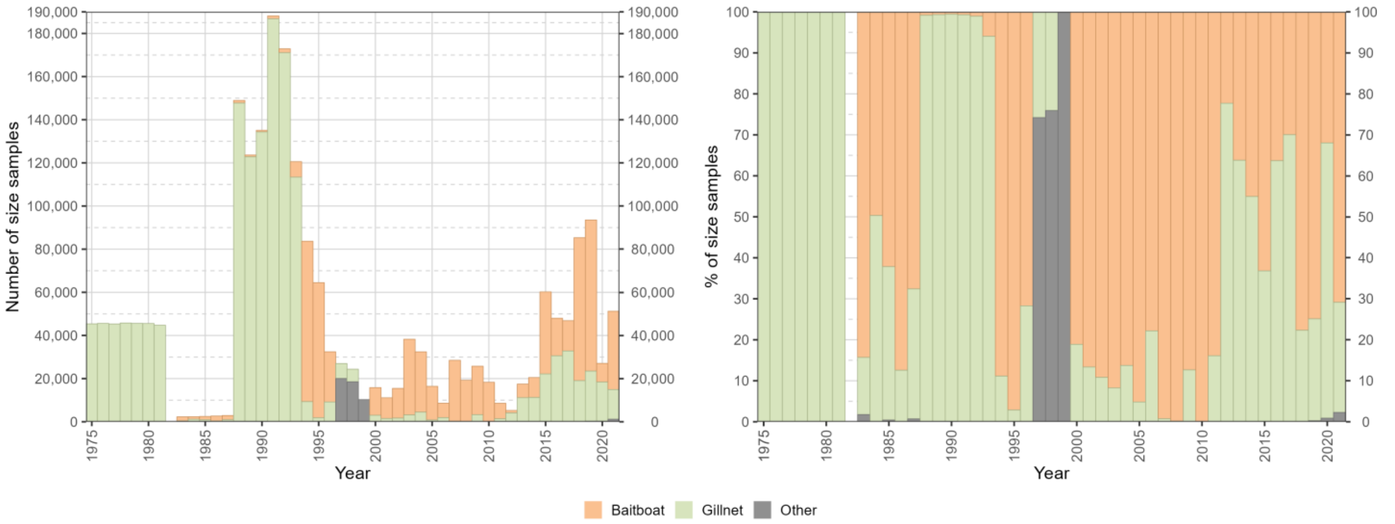

Figure 32: Availability of bigeye tuna size-frequency data as absolute number of samples (left) and relative number of samples (right) per year and all other fishery types. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

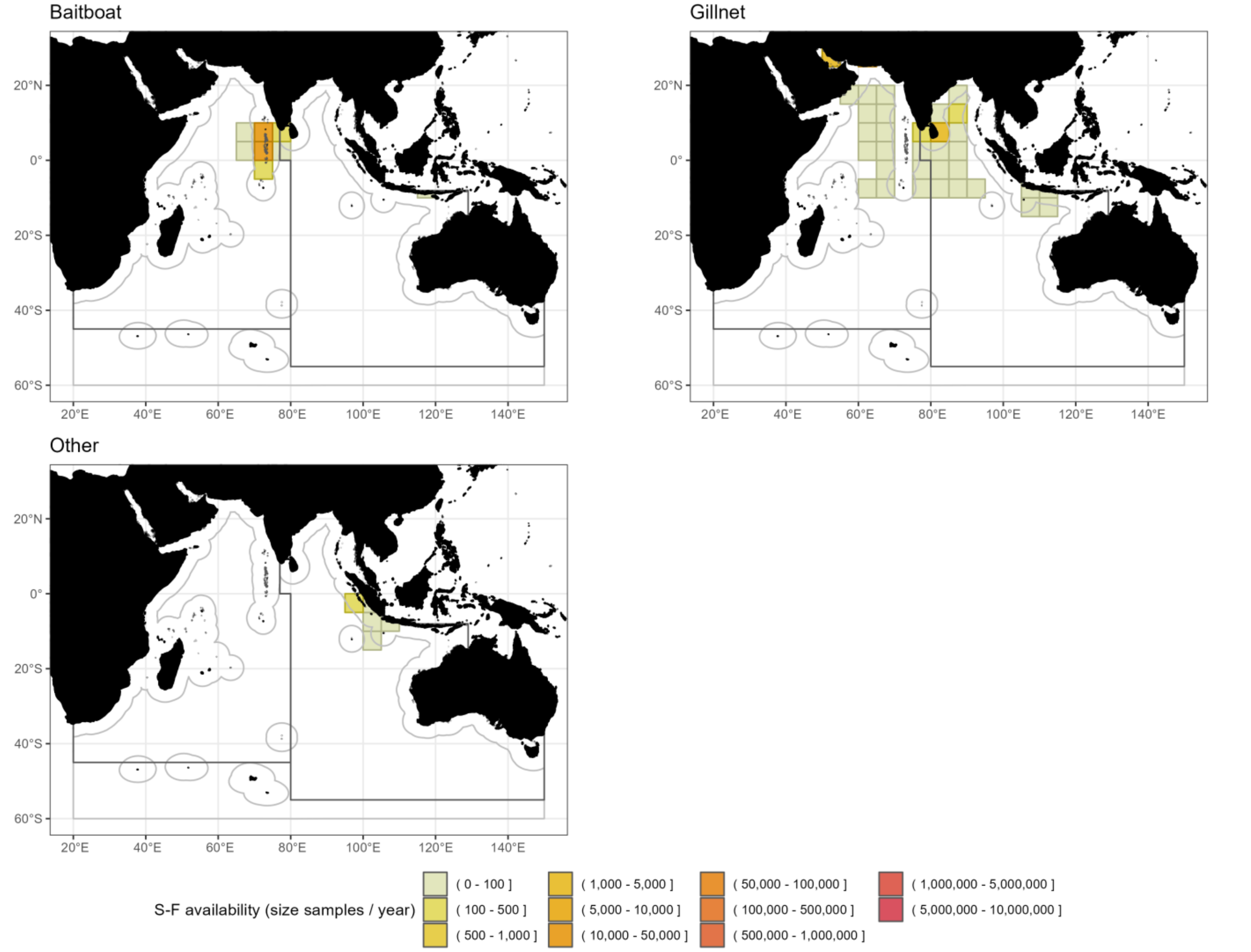

Figure 33: Spatial distribution (average number of samples per grid per year) of available bigeye tuna size-frequency data by all other fishery types in the period 2017-2021. Data source: [standardized size-frequency dataset](#) (Res. 15/02)

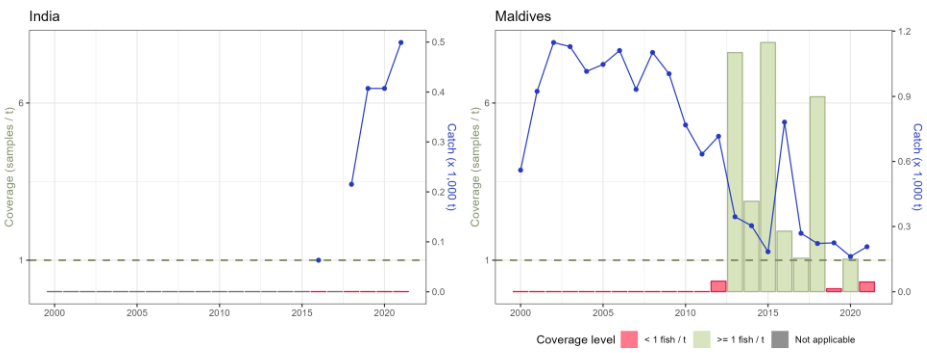

Figure 34: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major baitboat fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

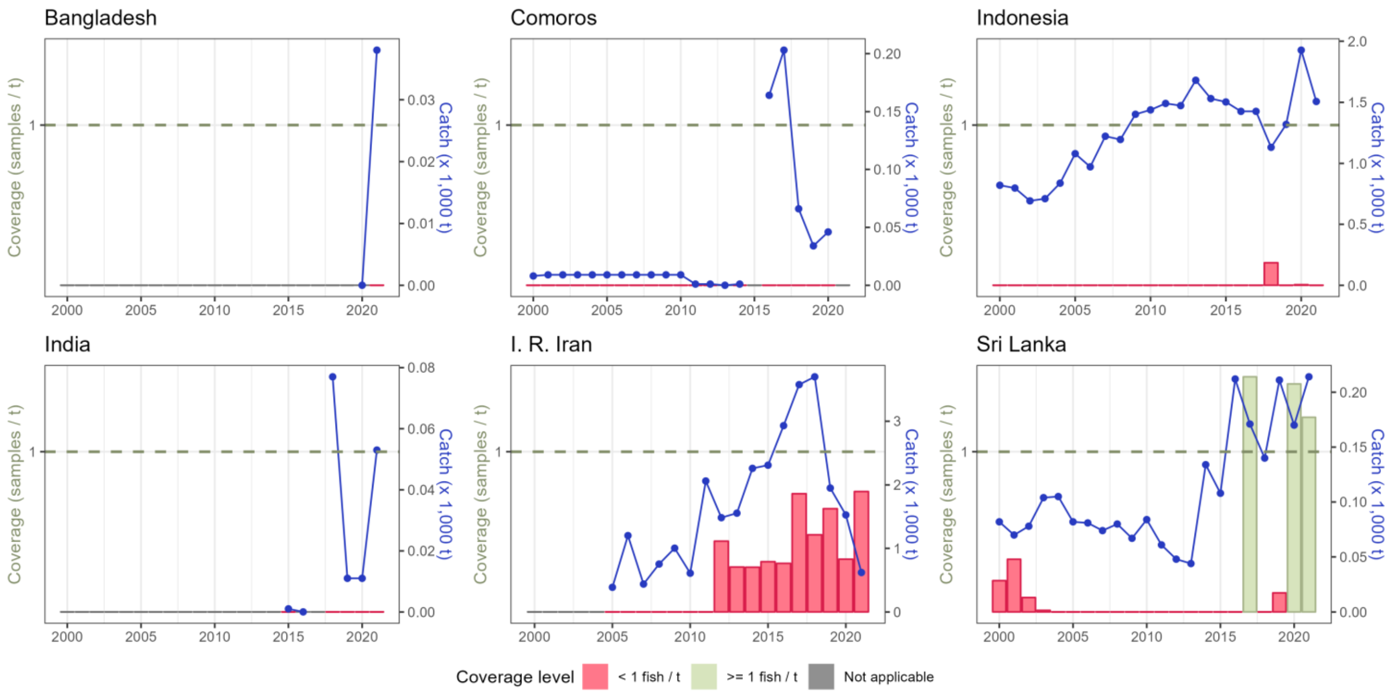

Figure 35: Size-frequency samples coverage (number of fish measured by t of retained catches) of bigeye tuna caught by the major gillnet fleets, by fleet and year (2000-2021). Data source: standardized size-frequency dataset (Res. 15/02)

The sampling levels reached by coastal fisheries are generally low, and in some cases (e.g., handline and baitboat fisheries) this might reflect the limited level of interactions with the species. Among all fisheries and fleet concerned, only Indonesian handlines appear to be well sampled in recent years. Coastal longline fisheries, which are considered as the most relevant among all artisanal fisheries catching bigeye 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 yellowfin tuna instead.

Temporal patterns and trends in size distributions

Industrial purse seine fisheries

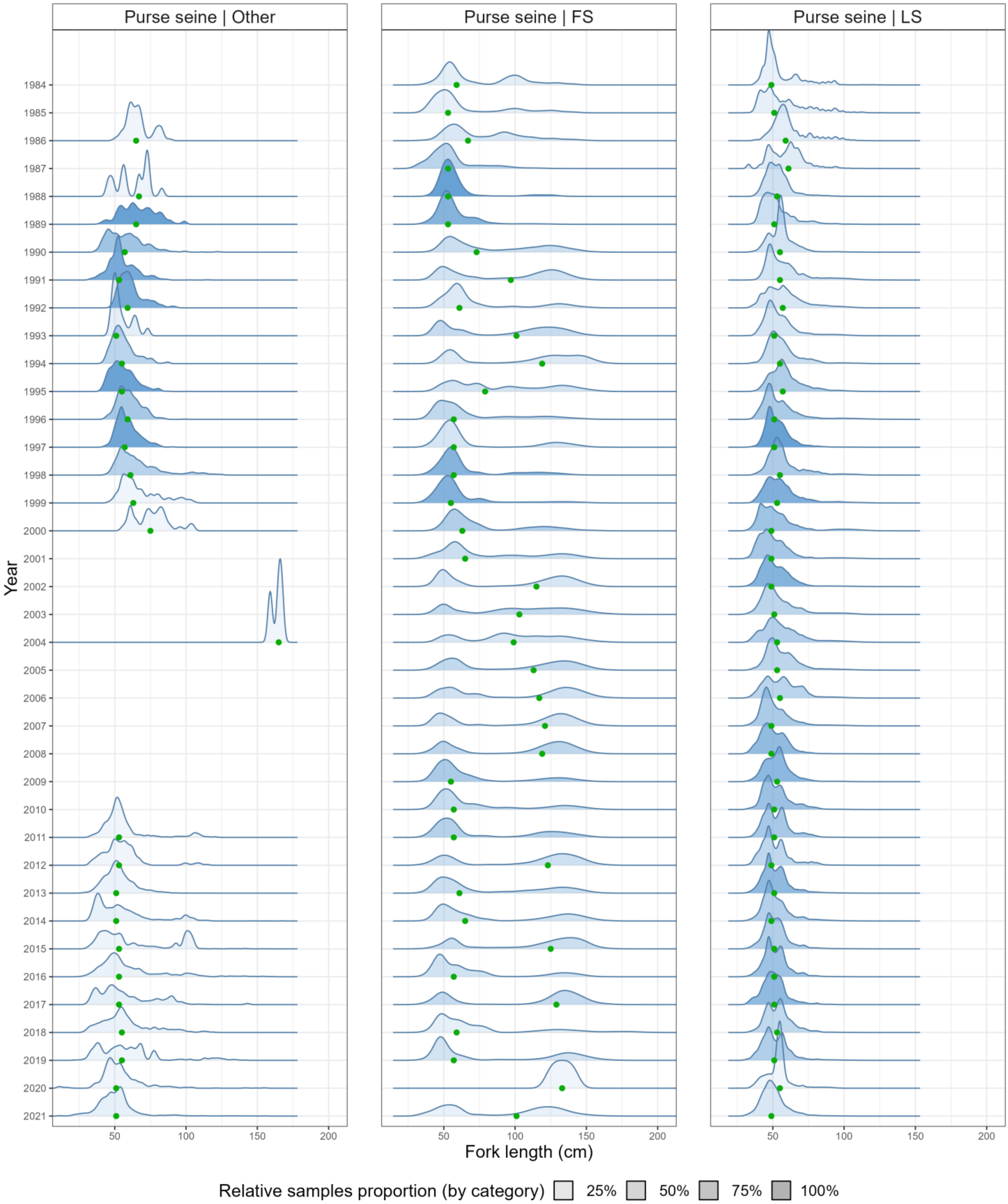

Figure 36: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna caught by all purse seine fleets for the period 1984-2021. Other = no information provided on the school association; FS = free-swimming schools; LS = schools associated with floating objects. Fill intensity is proportional 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)

Industrial longline fisheries

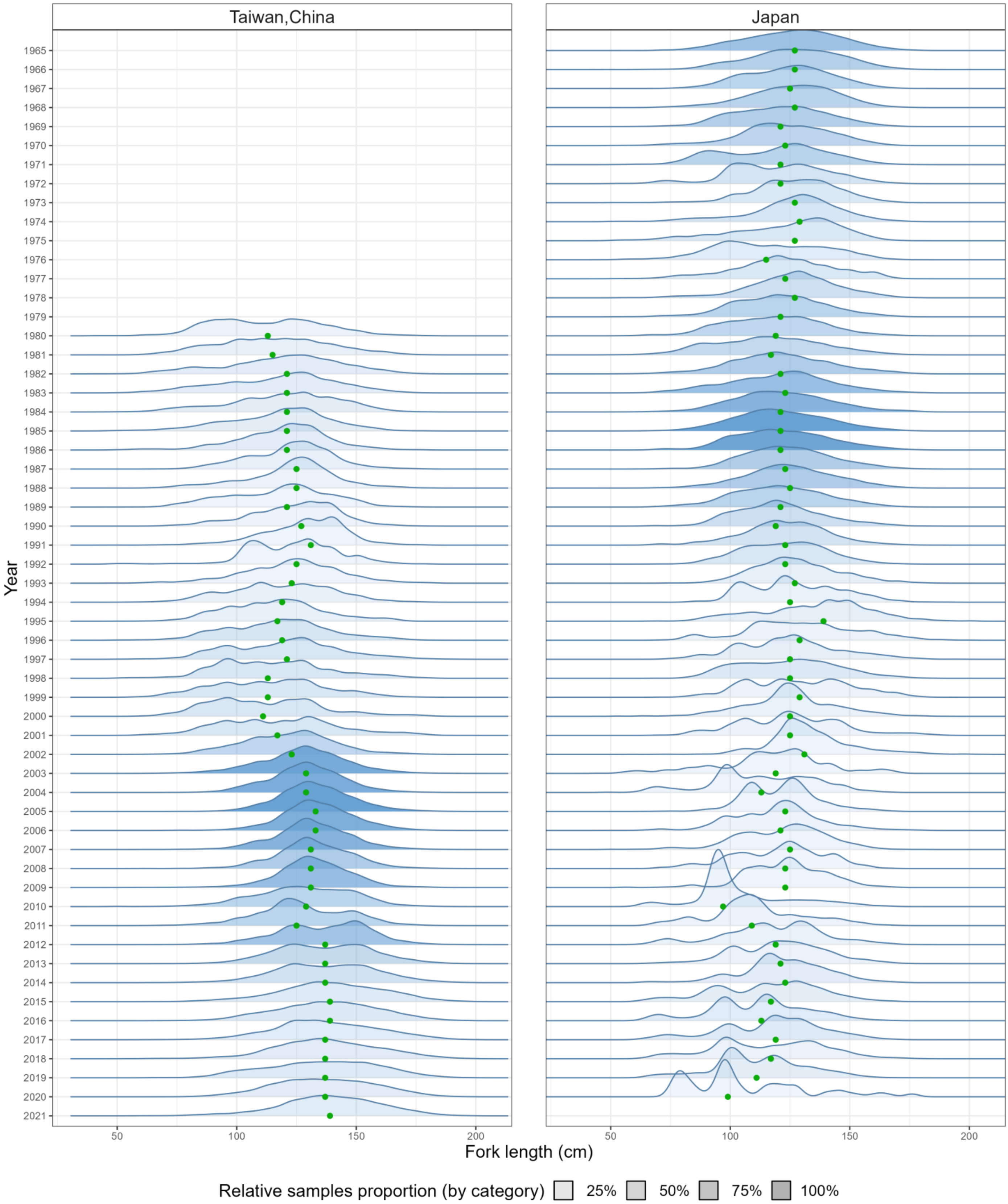

Figure 37: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna caught by the main deep-freezing longline fleets for the period 1965-2021. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: standardized size-frequency dataset (Res. 15/02)

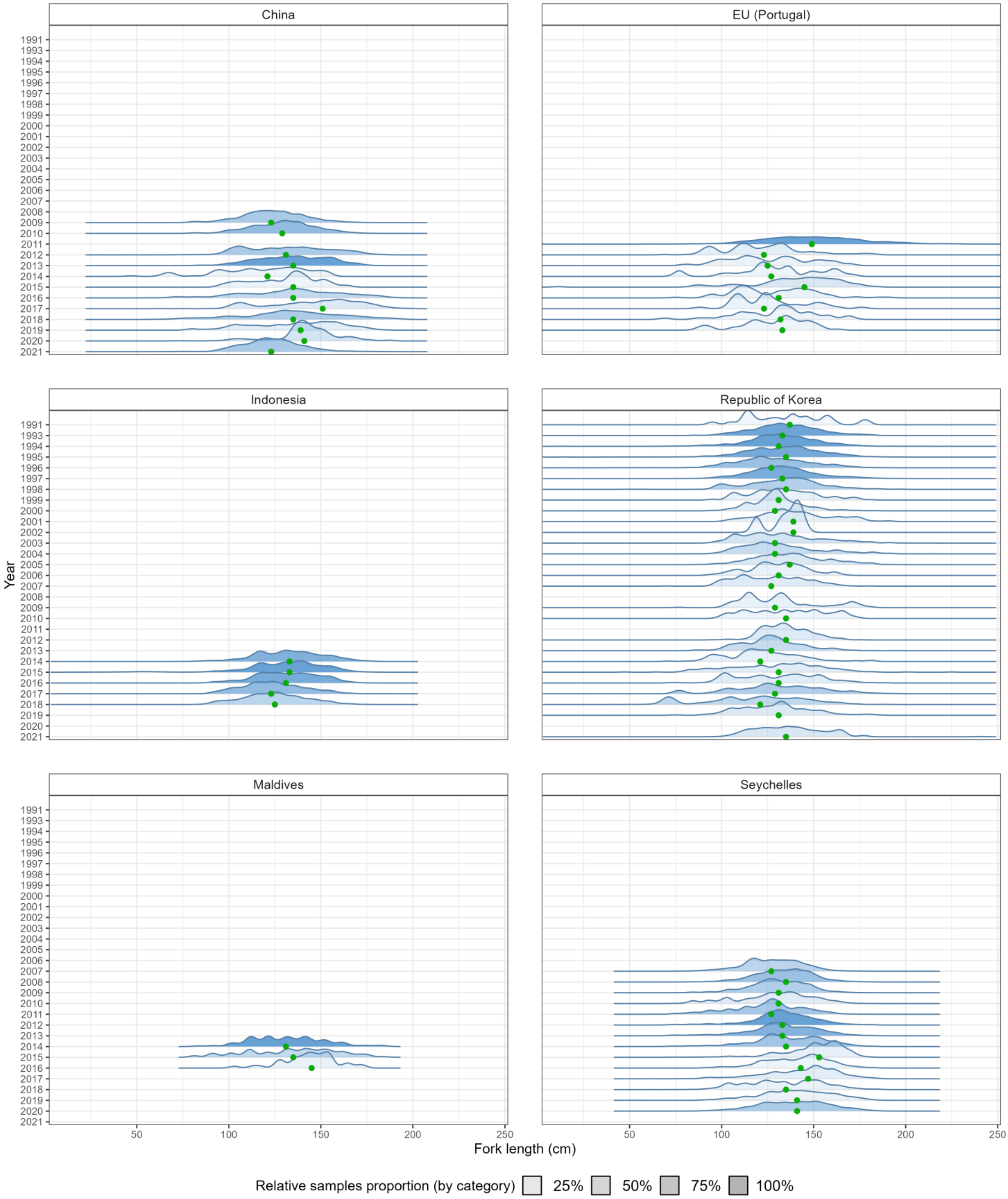

Figure 38: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna caught by all other longline fleets (excluding Japan and Taiwan,China), by fleet for the period 1991-2021. Data source: standardized size-frequency dataset (Res. 15/02)

Temporal trends in estimated average weights

Trends in average weights of bigeye 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 longline fisheries of Japan and Taiwan,China are relatively stable and fluctuate at around 40-60 kg (**Fig. 40**). The FOB-associated component of all Indian Ocean purse seine fisheries shows a relative stable trend since the mid-1980s, with an estimated average weight of 3.8 kg in 2021 which is very close to the estimated average for all fisheries combined, which in 2021 was estimated at 4.1 kg.

In fact, the overall estimated trend in average weights (**Fig. 40 - 'All fisheries'**) shows a clear decreasing pattern, driven in recent years by the analogous behavior of average weights estimated for the FOB-associated component of the purse seine fisheries (**Fig. 40 - 'Purse seine | LS'**), which is the fishery accounting for the majority of catches for the species in the same period.

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).

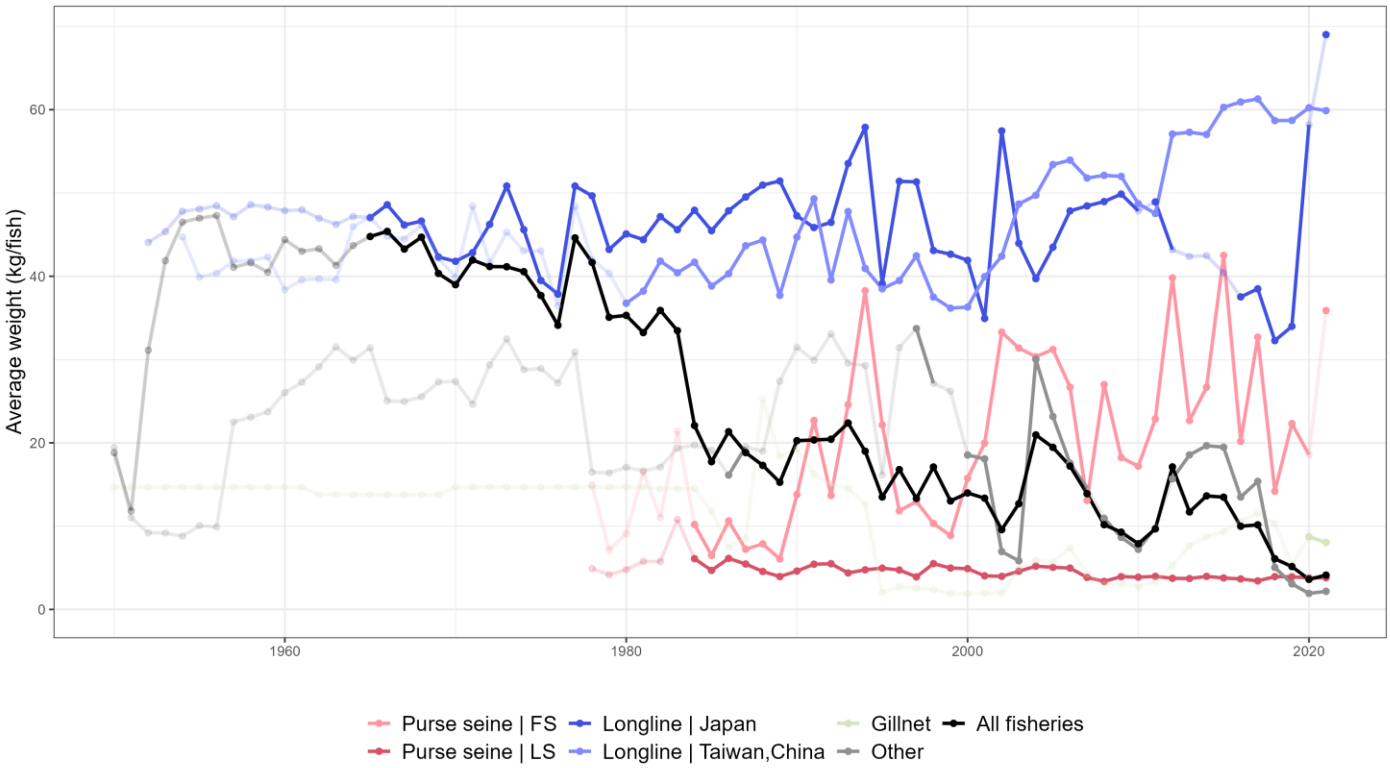

Figure 39: Combined estimated bigeye tuna average weight (kg/fish) in the catch by fishery and year. Semi-transparent points correspond to years for which the original size samples cover strata with reported catches (by year and fishery) **lower** than 50 t. LS = schools associated with floating objects; 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

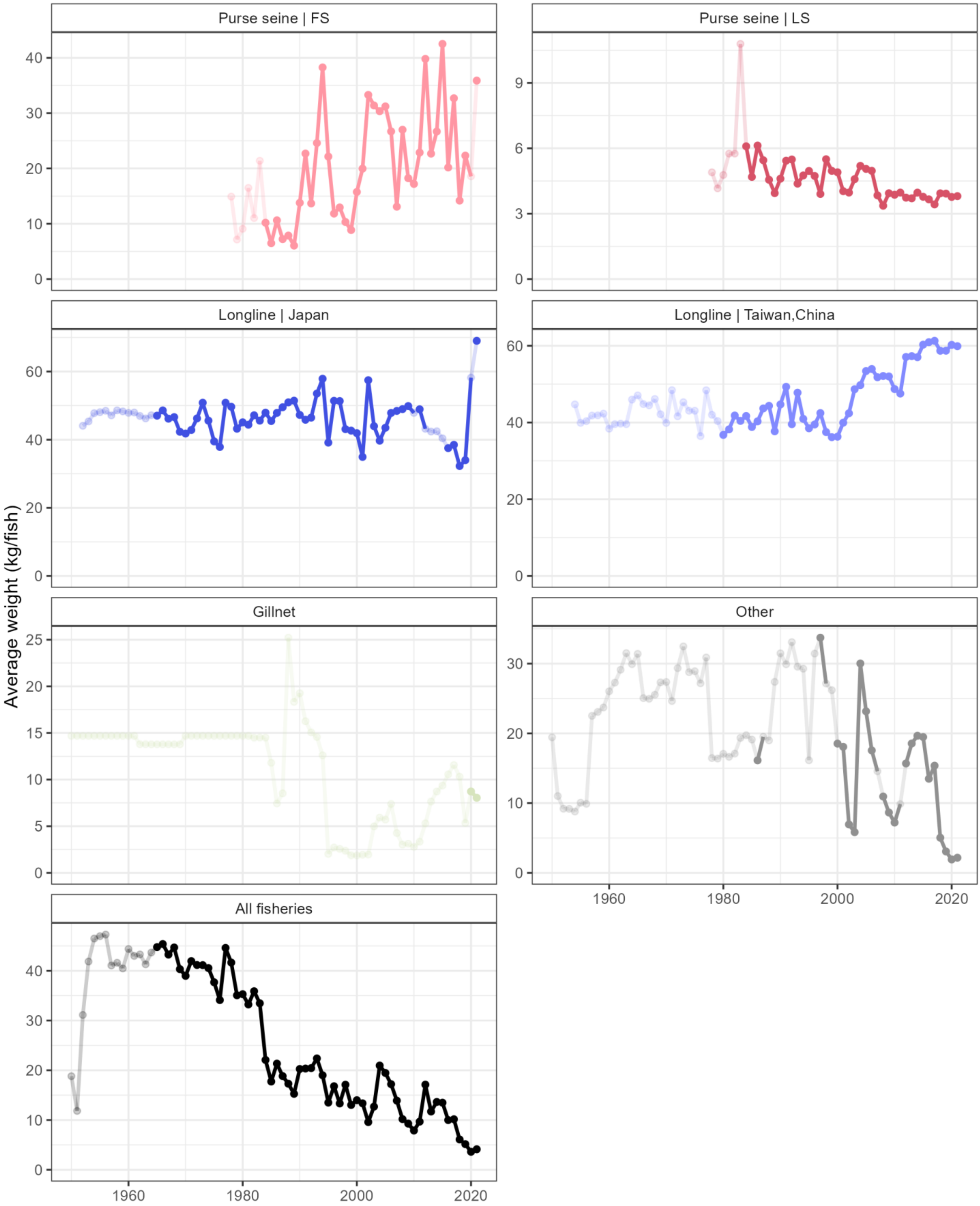

Figure 40: Estimated bigeye tuna average weight (kg/fish) in the catch by fishery and year. Semi-transparent points correspond to years for which the original size samples cover strata with reported catches (by year and fishery) **lower** than 50 t. LS = schools associated with floating objects; FS = free-swimming schools. Longline | Japan = includes data from 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: 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 FOB-associated schools in the purse seine fishery (**Fig. 39**).

Spatial distribution of average weights

Estimated average weights by decade (1950-2019)

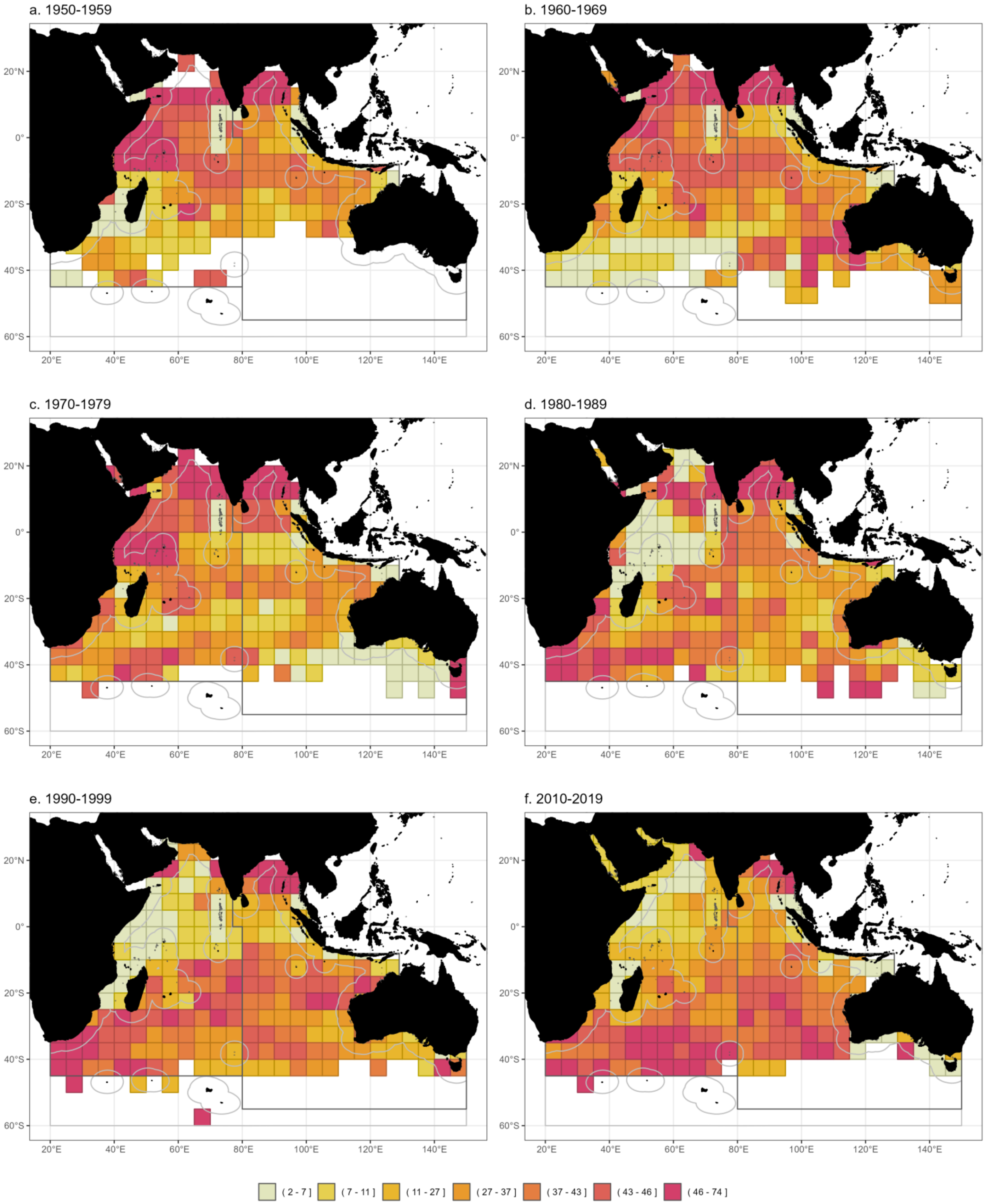

Figure 41: Estimated bigeye tuna average weight (kg/fish) in the catch by decade and 5x5 grid, for all fisheries combined for the period 1950-2019. Data source: raised time-area catches

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

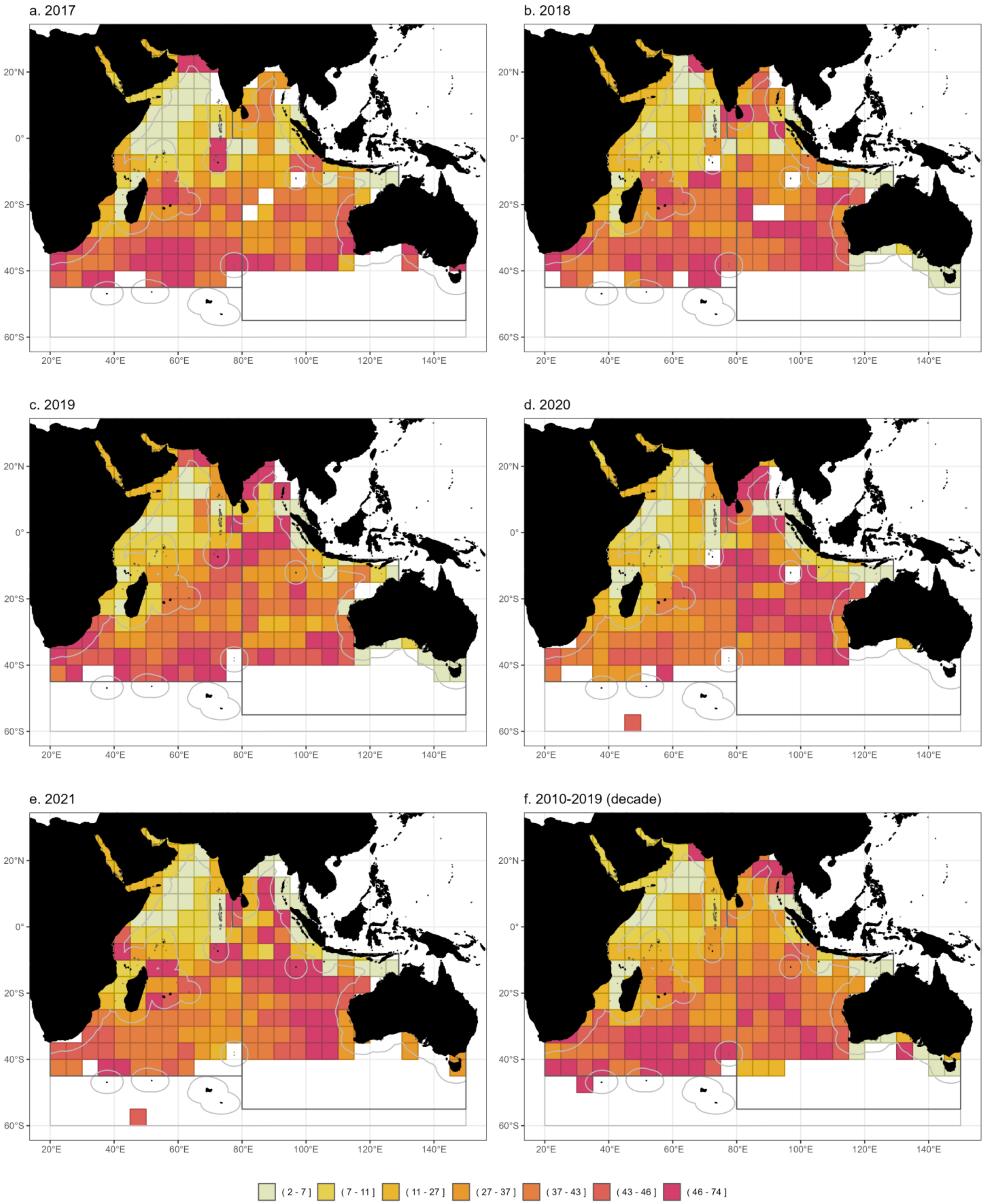

Figure 42: Estimated bigeye tuna average weight (kg/fish) in the catch by year and 5x5 grid, for all fisheries combined for the period 2017-2021 and for the decade 2010-2019. Data source: raised time-area catches

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

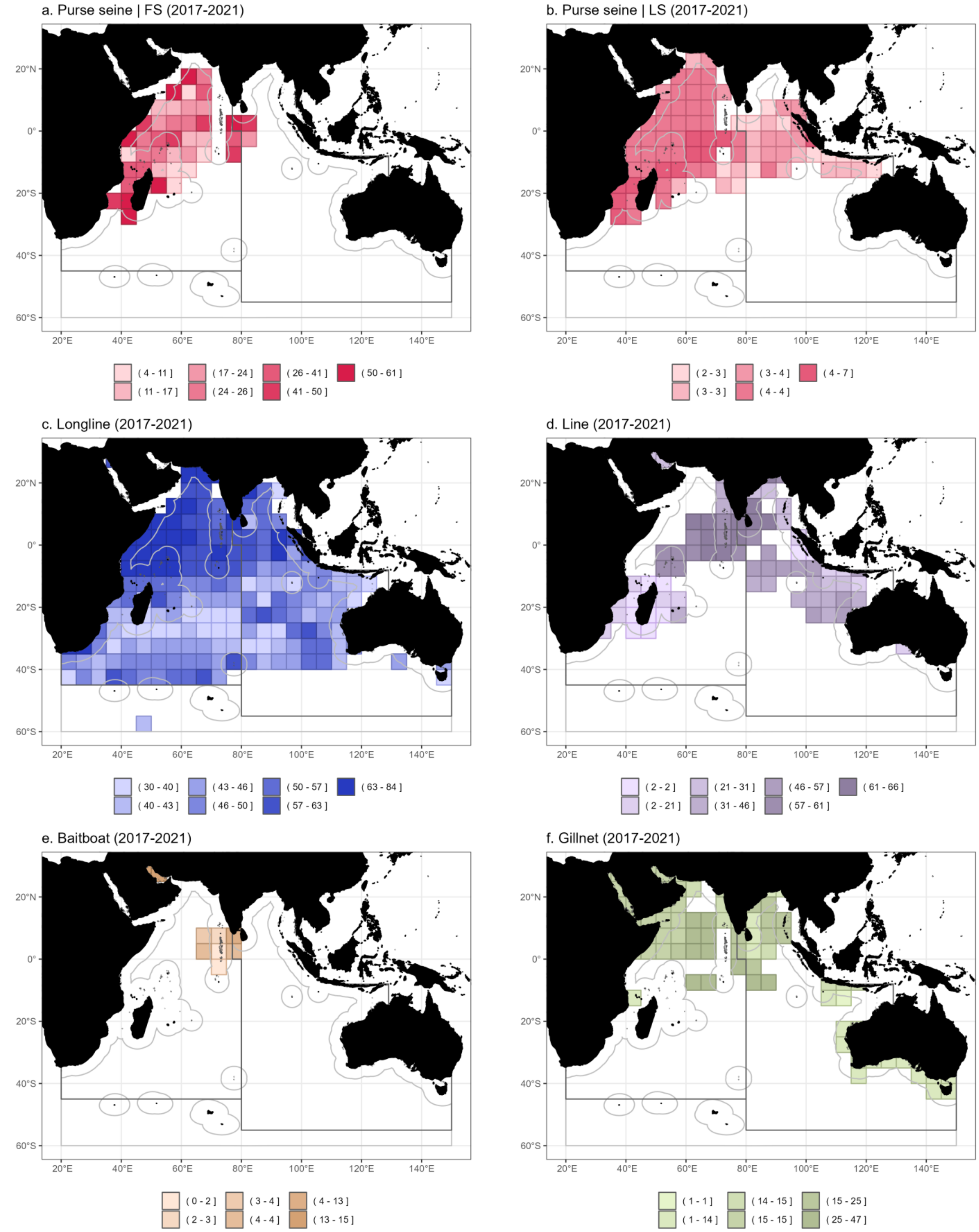

Figure 43: Estimated bigeye tuna average weight (kg/fish) in the catch by 5x5 grid and fishery group for the period 2017-2021. LS = schools associated with floating objects; FS = free-swimming schools. Data source: raised time-area catches

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 bigeye 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 33% and 86%) with a marked increase in quality from about 59% in 2012 to around 86% in 2019 (**Fig. 44**).

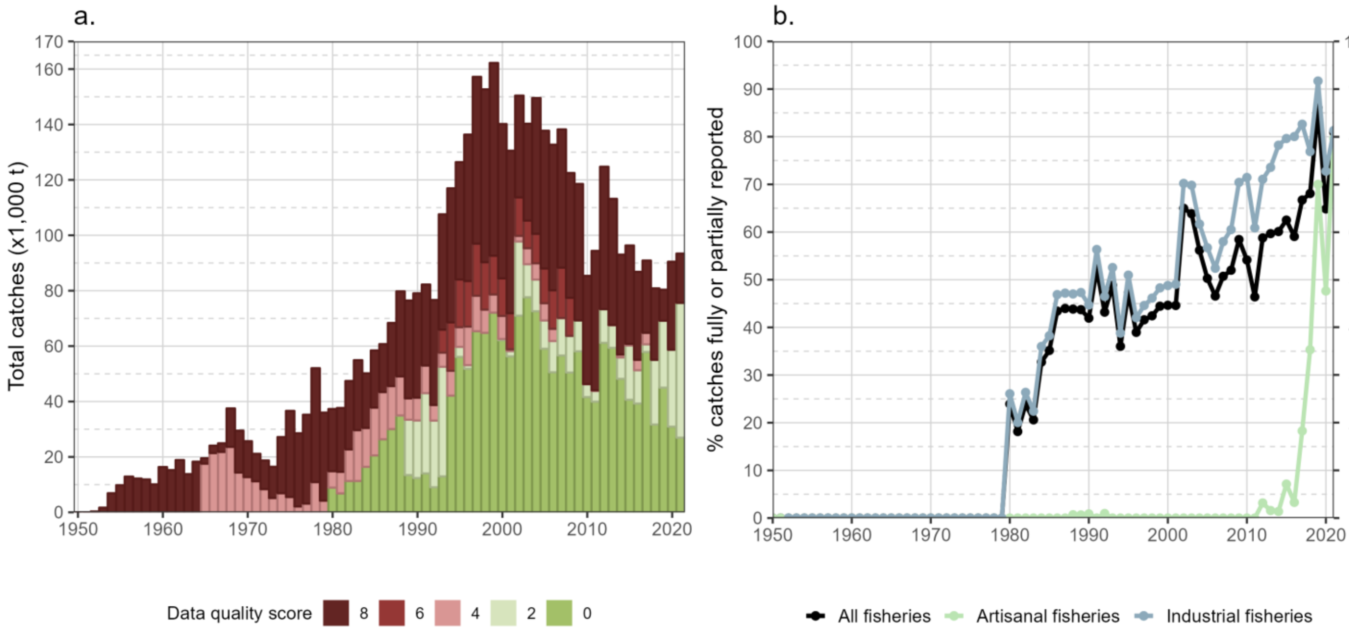

Figure 44: (a) Annual nominal catches (metric tonnes; t) of bigeye tuna estimated by quality score and (b) percentage of geo-referenced size-frequency data reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries and by type of fishery, in the period 1950–2021

Industrial purse seine fisheries

Size-frequency data for bigeye 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. 45**) and FOB-associated schools (**Fig. 47**) 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 140 cm FL, while fish measured from FOB-associated schools tends to have one single mode at around 50 cm FL.

For free-swimming schools, though, data show some notable exceptions to this trend, specifically for EU,France (2016 and 2018), EU,Spain (2016 and 2019), Mauritius (2017), and Seychelles (2016, 2018 and 2019) (**Table 6**), which all show a much higher first mode in the lower part of the size distribution (at around 50 cm FL) (**Fig. 45**).

In the case of size-frequencies from FOB-associated schools, the main mode is defined around 50 cm FL. Altought some data showing values at around 100 and 130 cm FL for EU,Spain (2018) and EU,France (2019, 2020) not really represent a sub-mode as in free-swimming schools (**Table 7**). 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. 47**).

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.

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 are very limited in numbers, particularly when considering fish caught on free-swimming schools for which data are only available from EU,France albeit to levels corresponding to a negligible fraction of what usually provided in the past (**Fig. 45**).

Size-frequency data for 2020 are completely absent for EU,Spain and only available in limited numbers for EU,France, Mauritius, and Seychelles (**Fig. 47**), with EU,Spain confirming their ongoing effort to recover size data from private companies and share it by the end of 2022 (IOTC, pers. comm.).

Size-frequency data for all other industrial purse seine fleets include information from Indonesia, I.R. Iran, Japan, and Republic of Korea (**Fig. 49**). Unfortunately, except for 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 (**Fig. 49**).

Size data reported by non-EU fleets do not always comply with the requirement of sampling at least one fish per metric tonne 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).

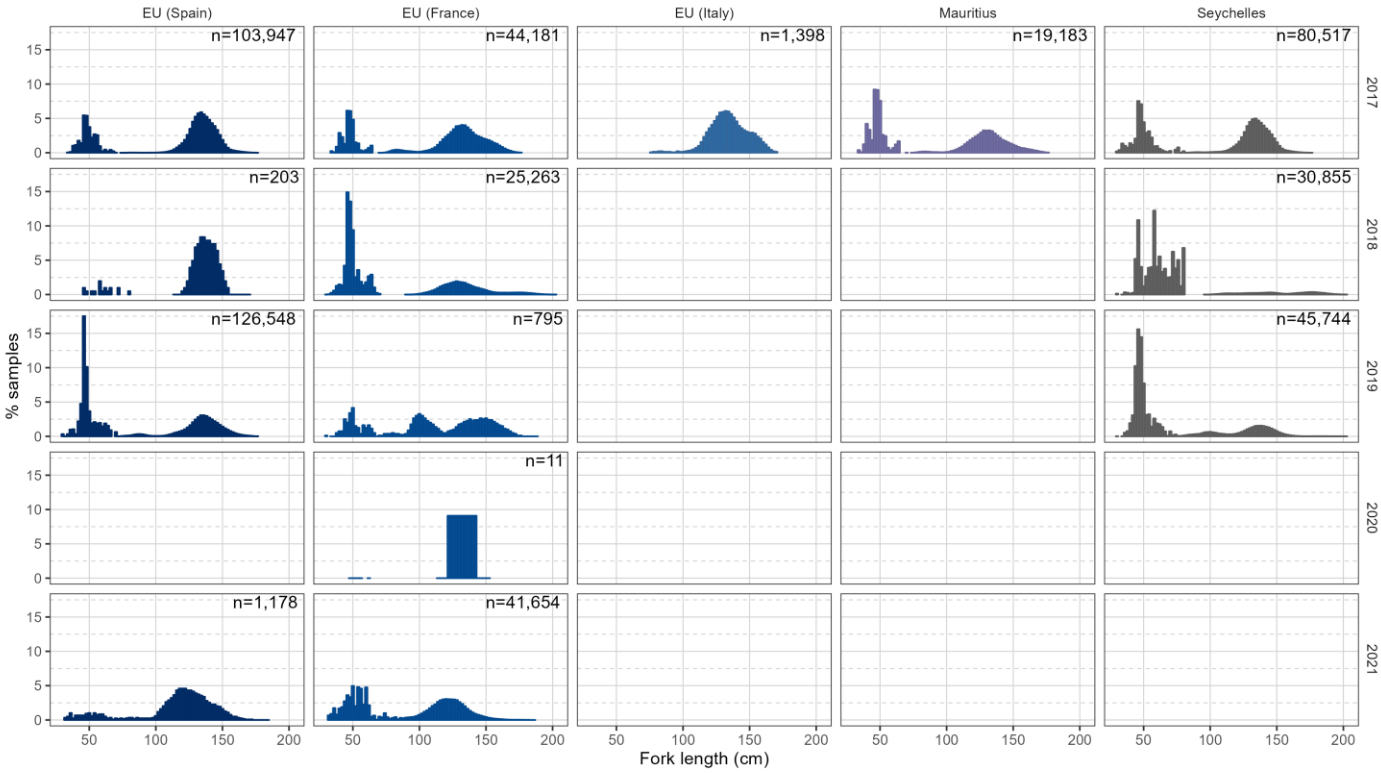

Figure 45: Relative size distribution of bigeye tuna (fork length; cm) recorded for free-swimming schools, by year (2017–2021) and main purse seine fleet. Data source: standardized size-frequency dataset (Res. 15/02)

Table 6: Percentage of sampled bigeye tuna with fork length below 75 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)	30	8	56		13
EU (France)	30	65	24	0	46
Mauritius	47				
Seychelles	40	77	72		

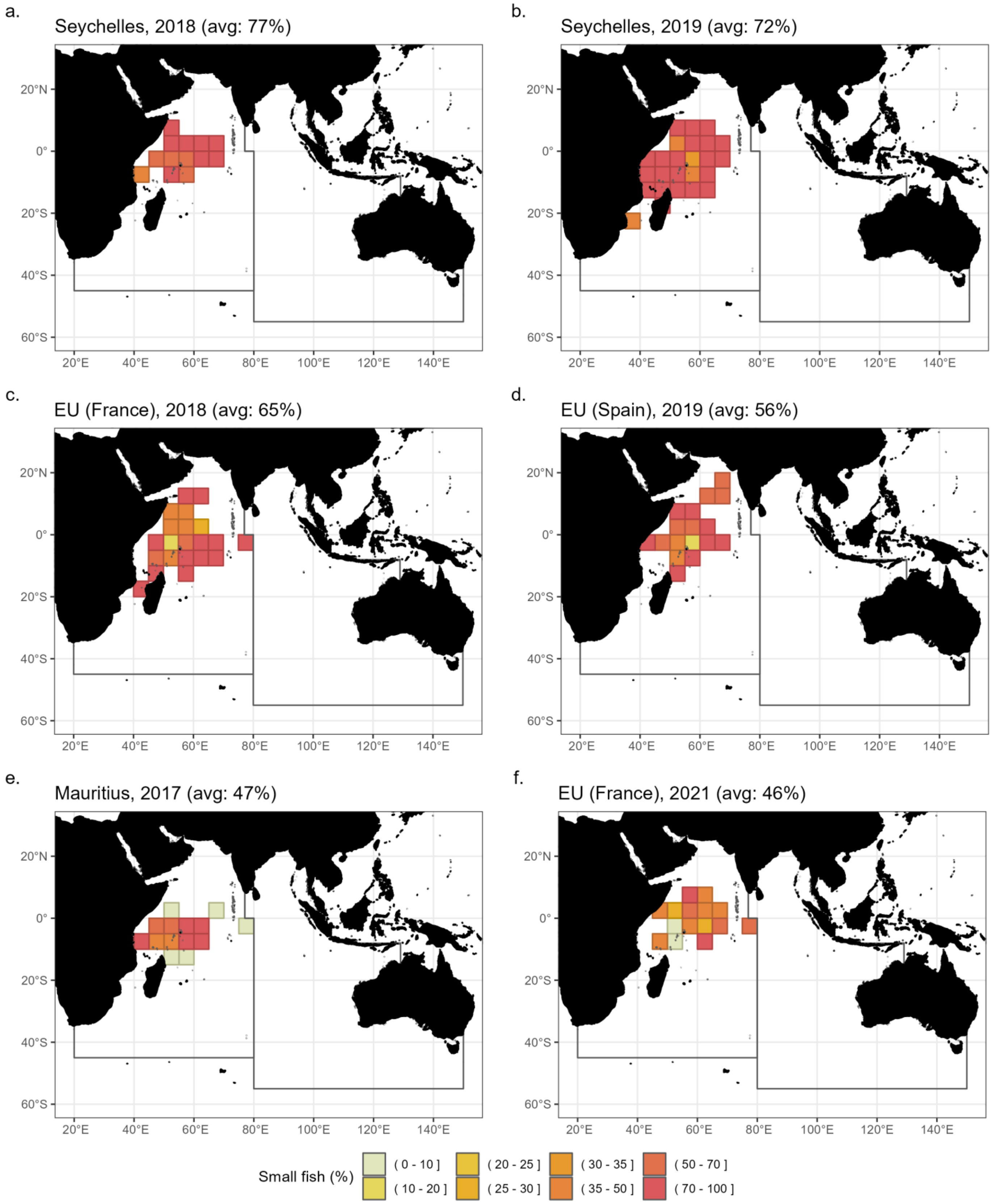

Figure 46: Spatial distribution of sampled bigeye tuna with fork length below 75 cm recorded by the major purse seine fleets fishing on free-swimming schools, as reported for the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

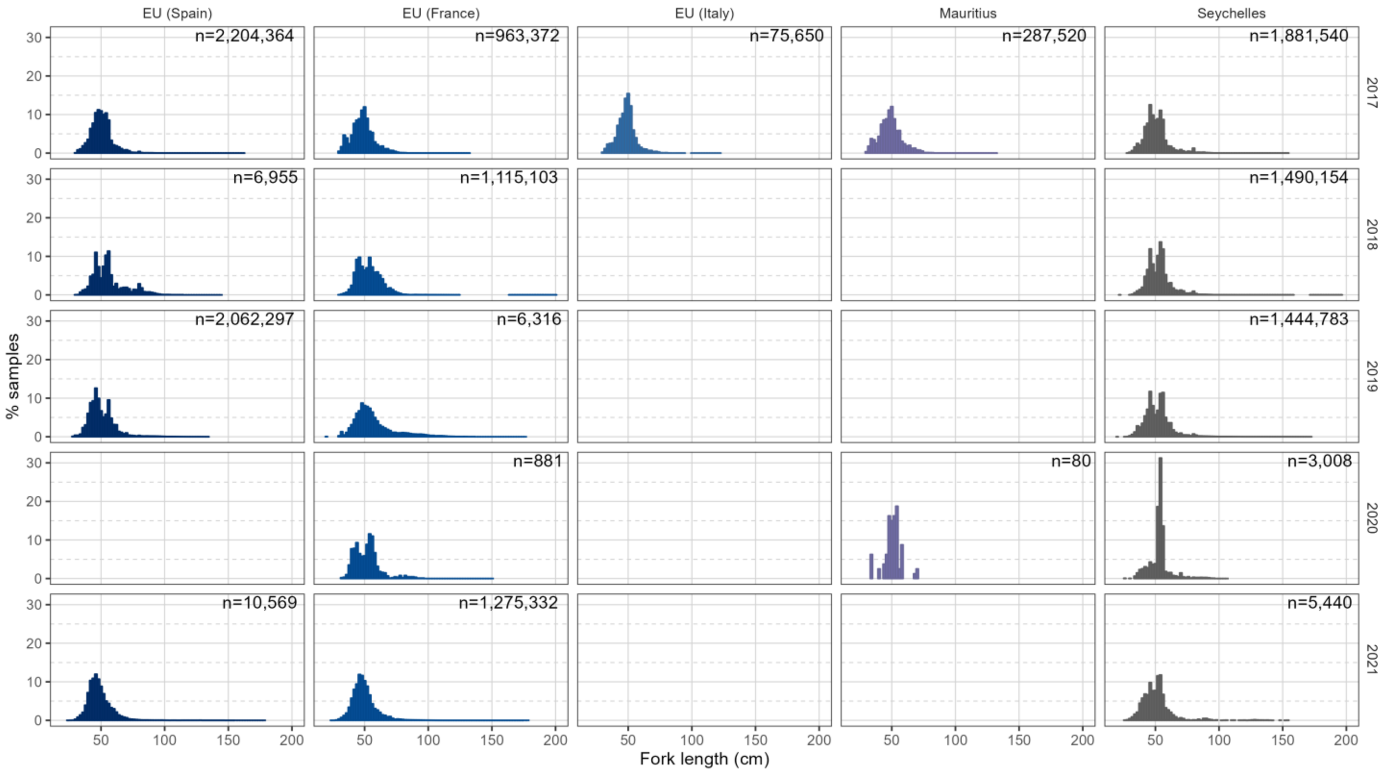

Figure 47: Relative size distribution of bigeye tuna (fork length in cm) recorded for FOB-associated schools, by year (2017–2021) and major purse seine fleet. Data source: standardized size-frequency dataset (Res. 15/02)

Table 7: Percentage of sampled bigeye tuna with fork length above 75 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)	1	12	3		2
EU (France)	1	2	13	4	2
Mauritius	1			0	
Seychelles	4	3	4	3	4

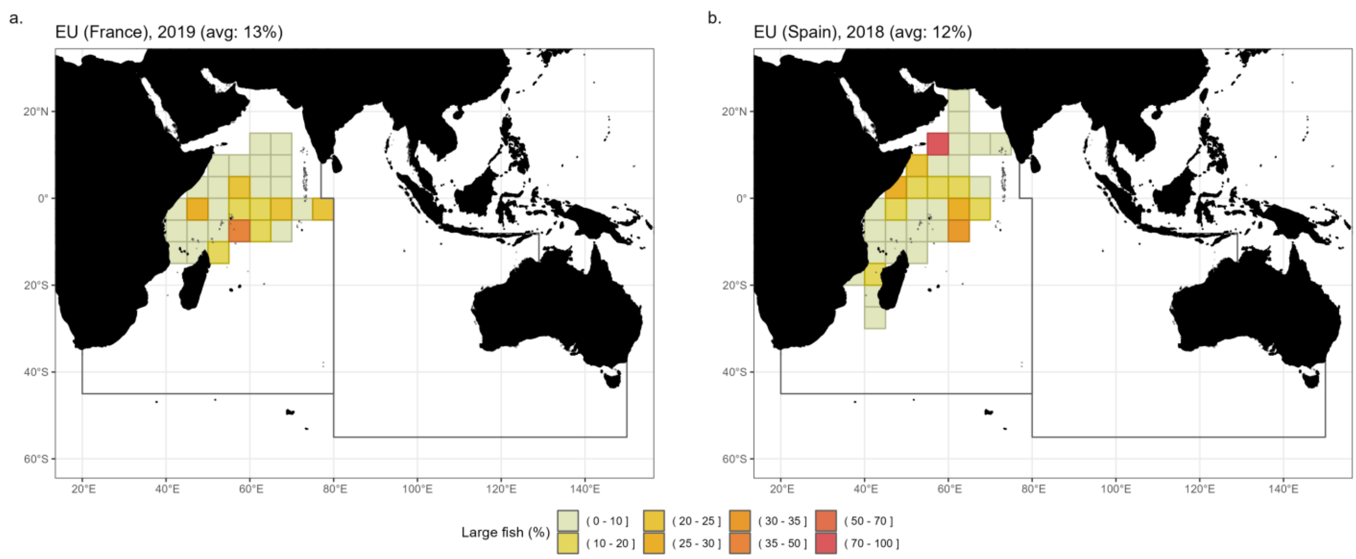

Figure 48: Spatial distribution of sampled bigeye tuna with fork length above 75 cm recorded by the major purse seine fleets fishing on FOB-associated schools, as reported for the period 2017-2021. Data source: standardized size-frequency dataset (Res. 15/02)

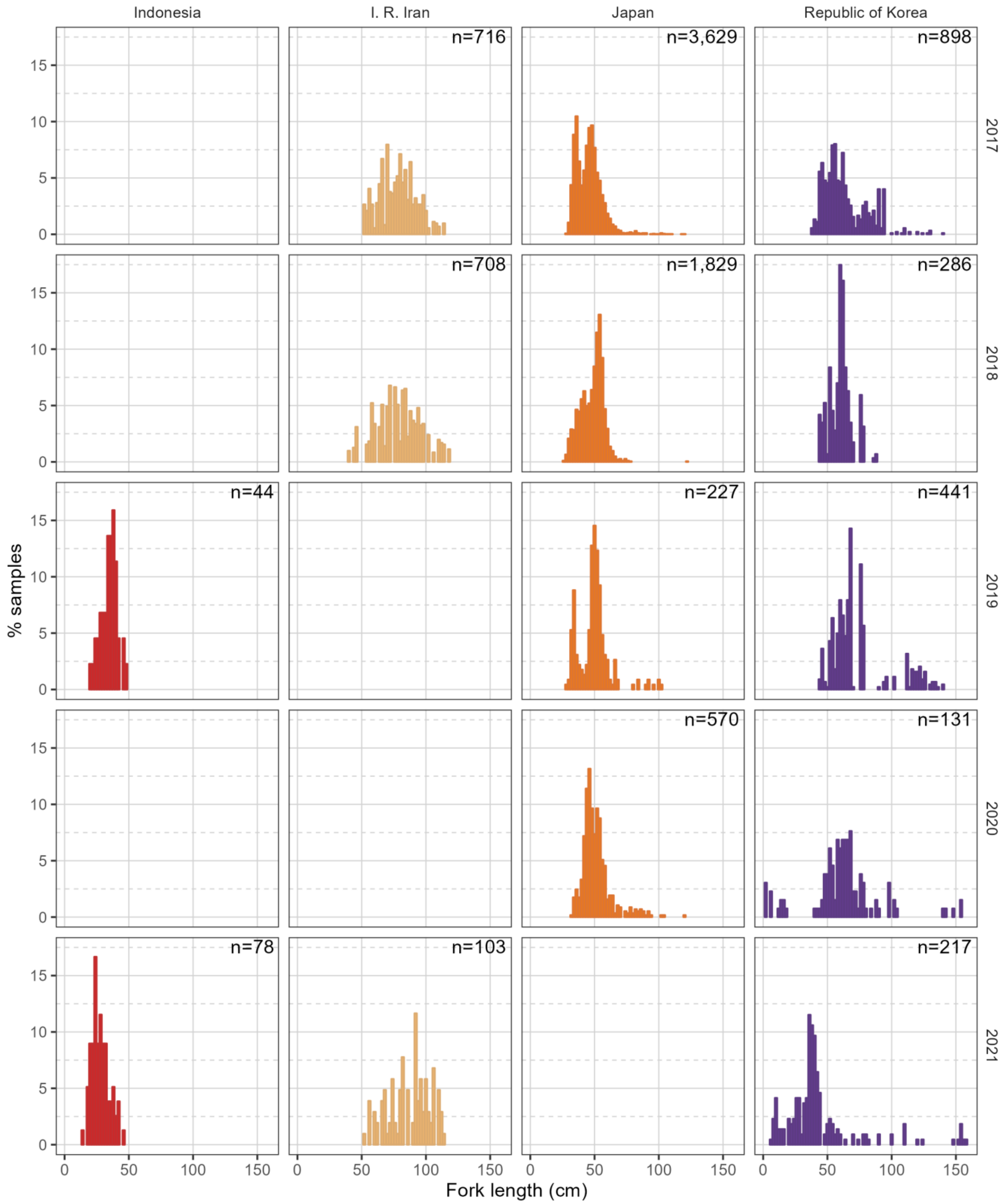

Figure 49: Relative size distribution of bigeye tuna (fork length; cm) recorded for unclassified schools, by year (2017–2021) and other purse seine fleet. Data source: standardized size-frequency dataset (Res. 15/02)

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 reported 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 deep-freezing longline fleet of Taiwan,China, the availability of well-sampled size-frequency data and of geo-referenced catches (both in numbers and weights) enables the comparison of 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-2022-WPTT24-DATA13), while 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. Furthermore, size-frequency data for the longline fishery of Taiwan,China are sampled well-above the minimum level of 1 fish per tonne of retained catches (as required by Res. 15/02), if not for the years between 1989 and 1993.

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 10 kg / fish in favour of the former, as detected in 2021 (when the coverage level of the size-frequency data was of around 6.5 samples per metric tonne) (**Fig. 50**).

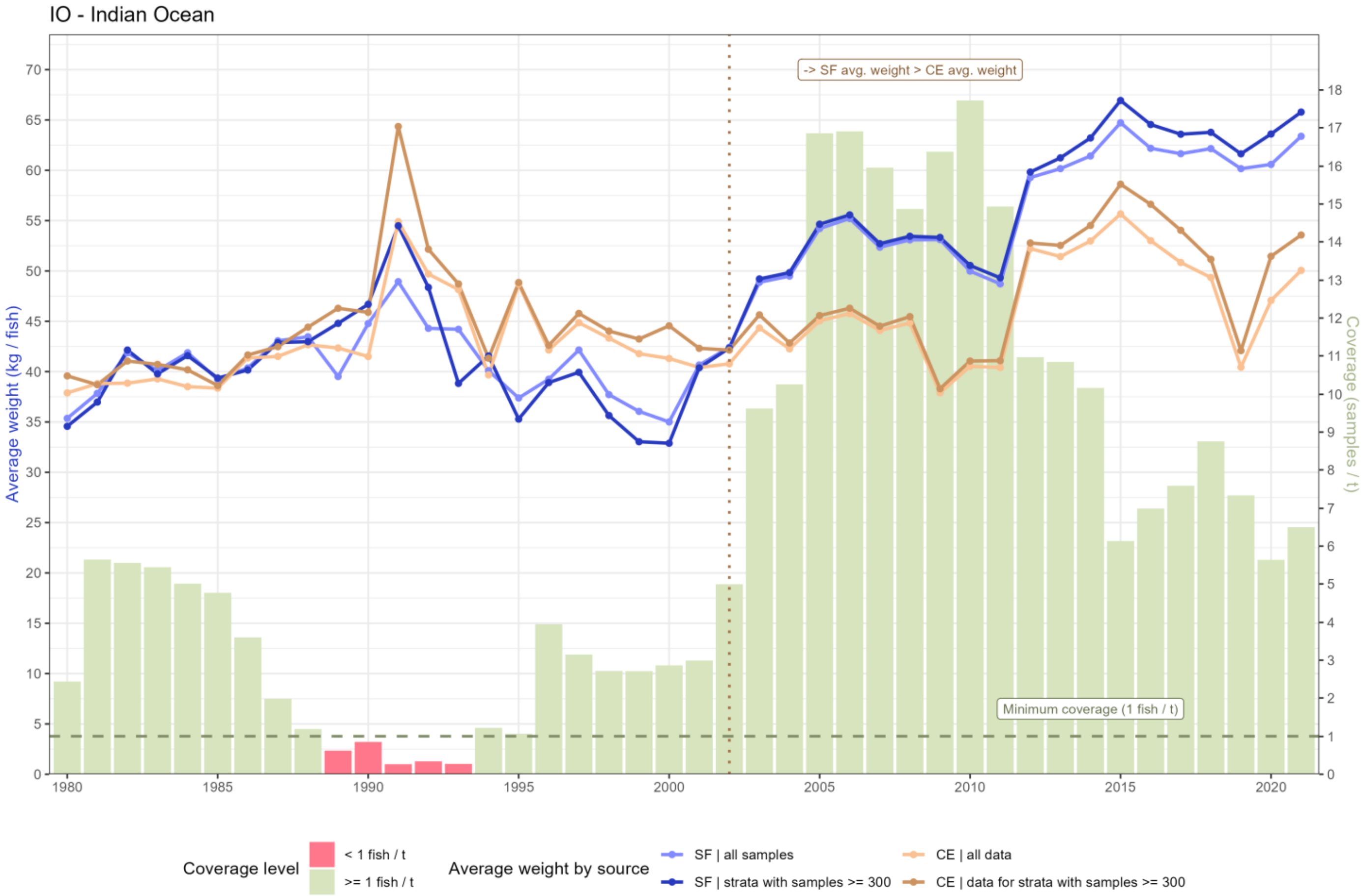

Figure 50: Difference in average weights (all Indian Ocean areas) of bigeye tuna caught by the deep-freezing fleet of Taiwan,China as calculated from the available size-frequency and catch and effort data (1980-2021). Data source: standardized size-frequency dataset and time-area catch dataset for longline fisheries (Res. 15/02)

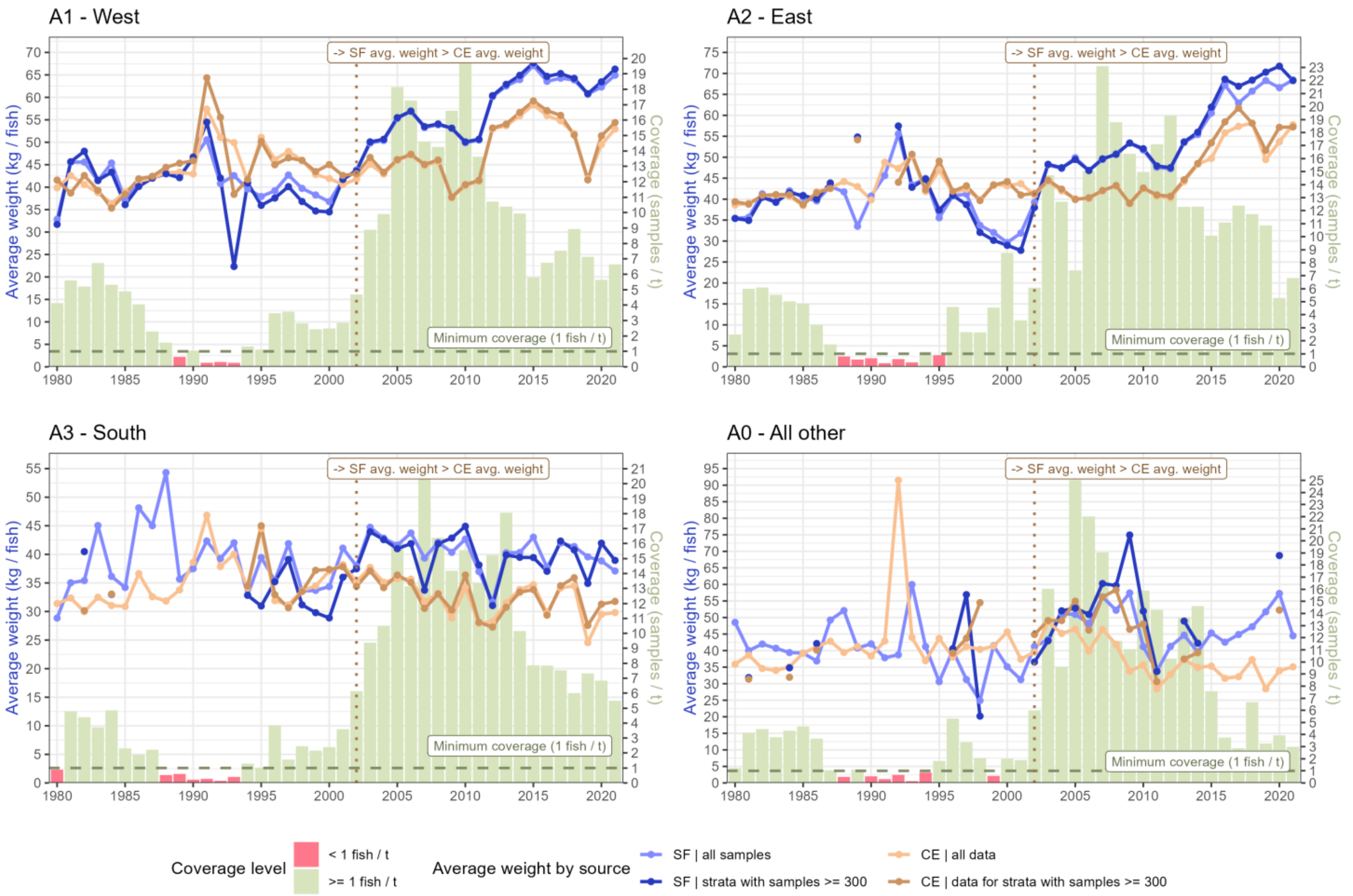

Figure 51: Difference in average weights by stock-assessment areas of bigeye tuna caught by the deep-freezing fleet of Taiwan,China as calculated from the available size-frequency and catch and effort data (1980-2021). Data source: standardized size-frequency dataset and time-area catch dataset for longline fisheries (Res. 15/02)

These results suggest that, from 2002 onward, either the size sampling was biased towards larger fish (blue lines), or that the logbook data used to produce the catch and effort records submitted to the IOTC Secretariat are inaccurate (orange lines). This, notwithstanding the fact that length measurements for the Taiwan,China longline fleet include samples taken by scientific observers at sea (generally less than 5-10% of total annual samples since 2002).

In the period considered (2000-2021), bigeye tuna size-frequency records submitted by the Japanese fleet were comprised of 20,964 individuals recorded in logbooks and 66,901 individuals measured by onboard observers. In this case, the number of individuals measured by observers amounted to ~320% of those 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 through their national observer programme.

On the contrary, and in the same period considered, bigeye tuna size-frequency records submitted by the Taiwan,China fleet were comprised of 5,440,439 individuals recorded in logbooks, and 133,155 individuals measured by onboard observers. In this case, the magnitude of the size data collected by observers corresponds to ~2.4% of that reported in logbooks, even though Taiwan,China has been consistently providing both sources of information since 2002.

Further analysis on the size distribution of bigeye tuna reported by longliners from Japan and Taiwan,China in the years for which measurements from logbook and observers were both available at the same time (2000-2021) shows that:

- logbook size data for Japan and Taiwan,China can only be compared during the 2000s, as the former was completely replaced by scientific observer data from 2010 onwards. Nevertheless, when data are available for both fleets, these appear to be in relatively good agreement only in the early 2000s, and specifically in the southern (A3) and northernmost / southernmost areas of the Indian Ocean (A0) (**Fig. 52**)

- size data from scientific observers are available from both fleets for a longer period of time (from 2010 onwards) and in relatively good agreement during the 2010s, and more specifically in the eastern (A2) and southern (A3) areas of the Indian Ocean during the early 2010s, and in the western (A1) and southern (A3) areas of the Indian Ocean during the late 2010s (**Fig. 53**);
- size data for Taiwan,China deep-freezing longliners are generally available to the IOTC Secretariat as data recorded both by scientific observers and through logbooks, except for some strata in the 2000s when observers were only deployed in the eastern (A2) and southern (A3) areas of the Indian Ocean (**Fig. 54**);
- when size data for Taiwan,China deep-freezing longliners are available in good numbers through both scientific observers and logbook data, the two sources are generally in agreement, particularly from 2010 onwards and more specifically in the eastern (A2) and southern (A3) areas of the Indian Ocean (**Fig. 54**);
- for previous years, and in particular in the western (A1) and northernmost / southernmost (A0) areas of the Indian Ocean, data from logbooks seems to be biased towards larger fish, with a mode set approximately at around 140-150 cm in fork length, while data from logbook shows a second mode at around 100 cm in fork length (**Fig. 54**);
- size data for Japanese deep-freezing longliners from the 2010s onwards is available to the IOTC Secretariat almost exclusively as data collected by scientific observers (**Fig. 55**);
- very few samples have been recorded by Japanese deep-freezing longliners in the last two years (2020-2021) and these originate exclusively from the southern (A3) areas of the Indian Ocean (**Fig. 55**);
- as in the case of Taiwan,China, size data from Japanese observers also confirm a tendency in measuring smaller fish compared to the information recorded on logbooks during the late 2000s, when the latter were still available (**Fig. 55**).

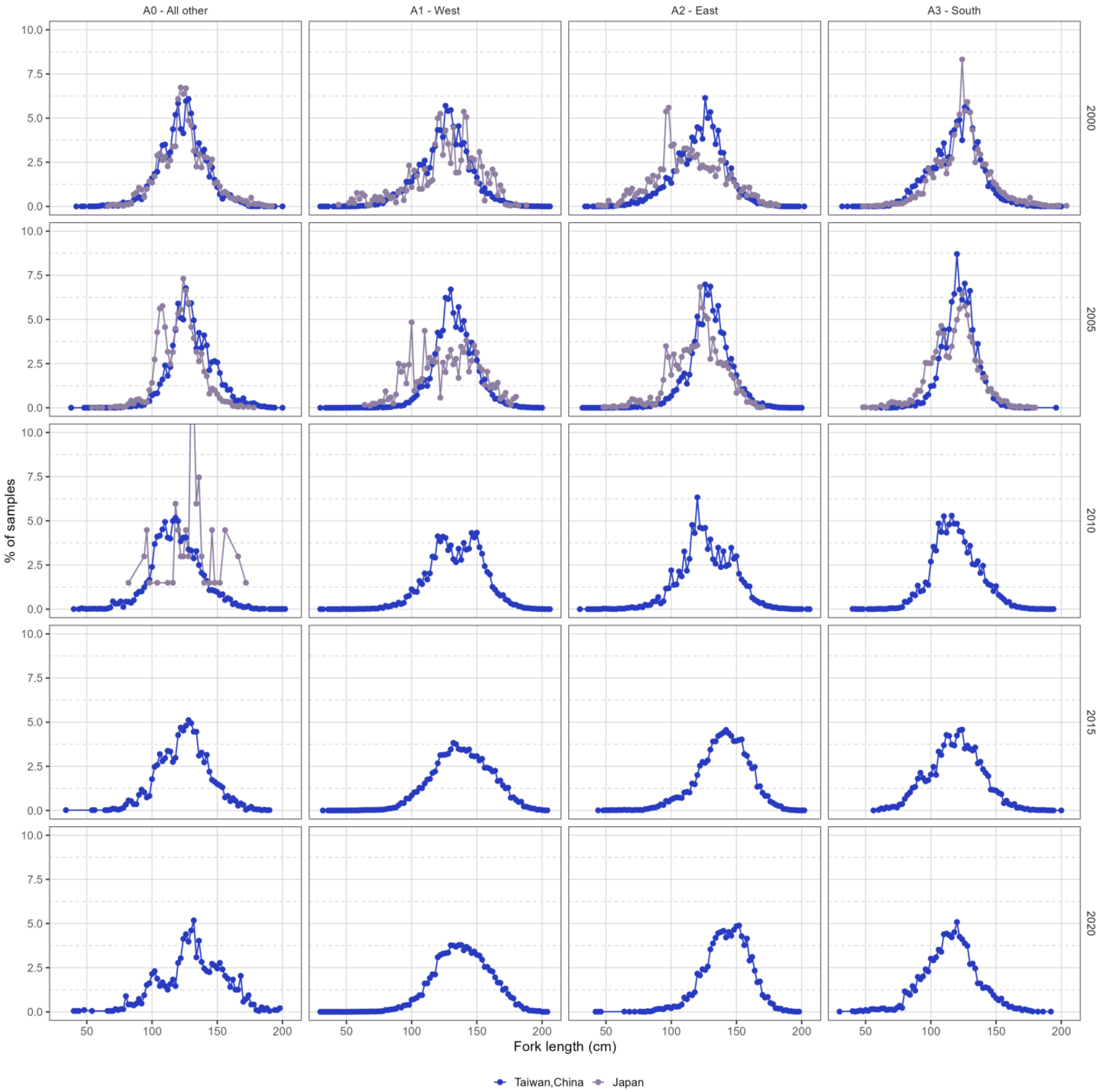

Figure 52: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna reported through logbooks by the deep-freezing longline fleets of Japan and Taiwan,China, by stock assessment area and five-year periods. Data source: standardized size-frequency dataset (Res. 15/02)

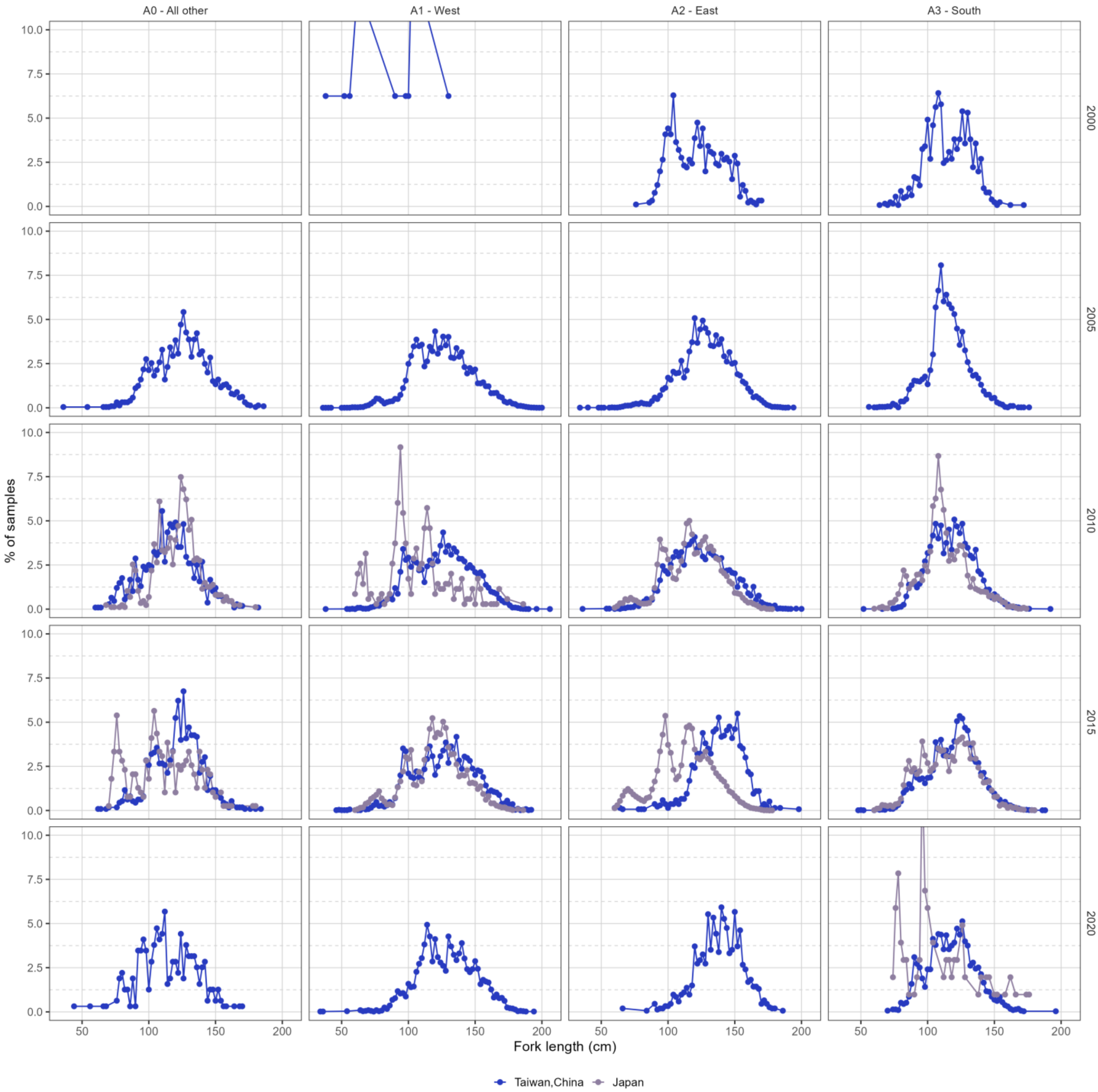

Figure 53: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna reported through scientific observers by the deep-freezing longline fleets of Japan and Taiwan,China, by stock assessment area and five-year periods. Data source: standardized size-frequency dataset (Res. 15/02)

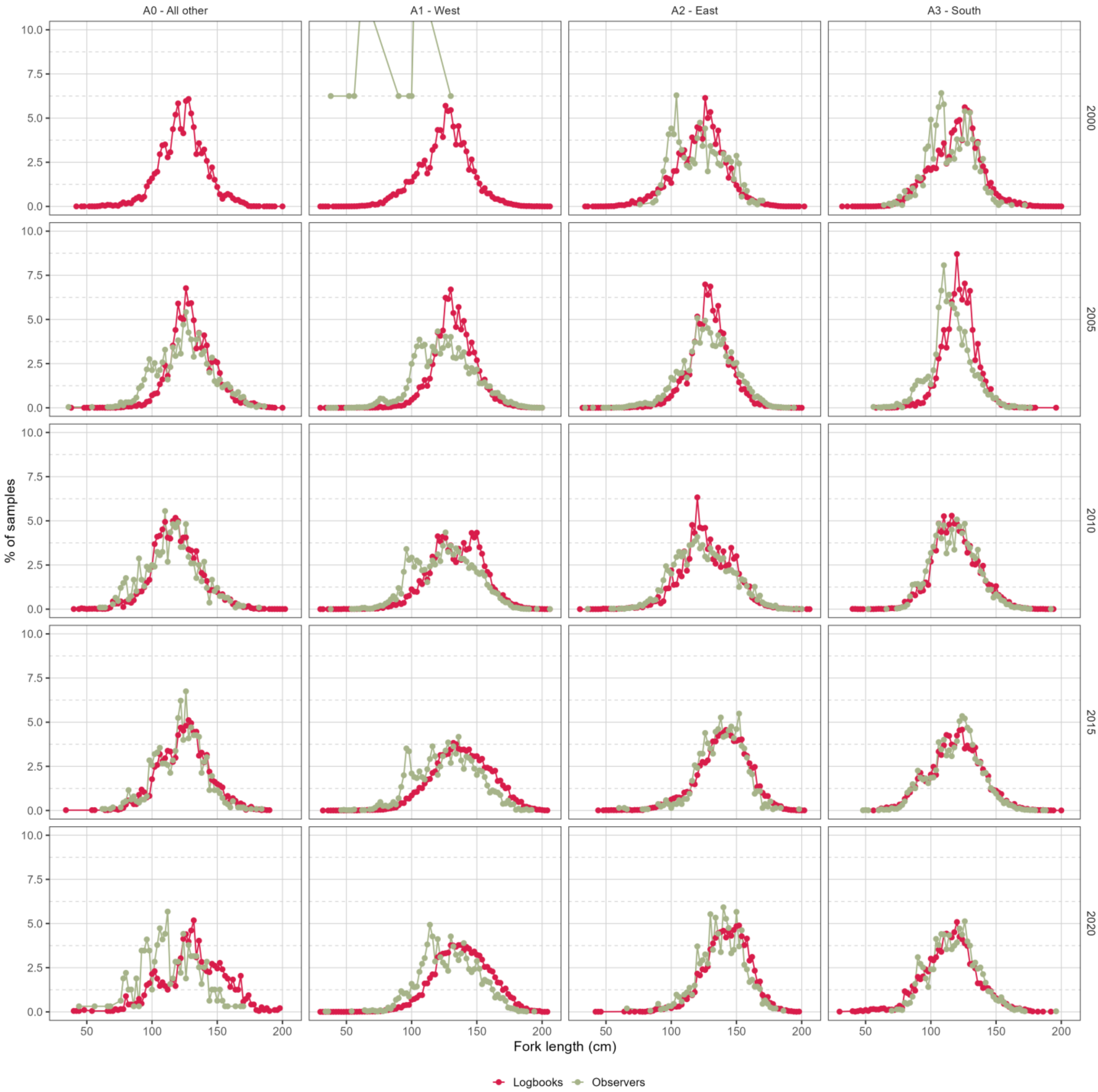

Figure 54: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna reported by the deep-freezing longline fleets of Taiwan,China, by source (scientific observers vs. logbooks), stock assessment area and five-year periods. Data source: standardized size-frequency dataset (Res. 15/02)

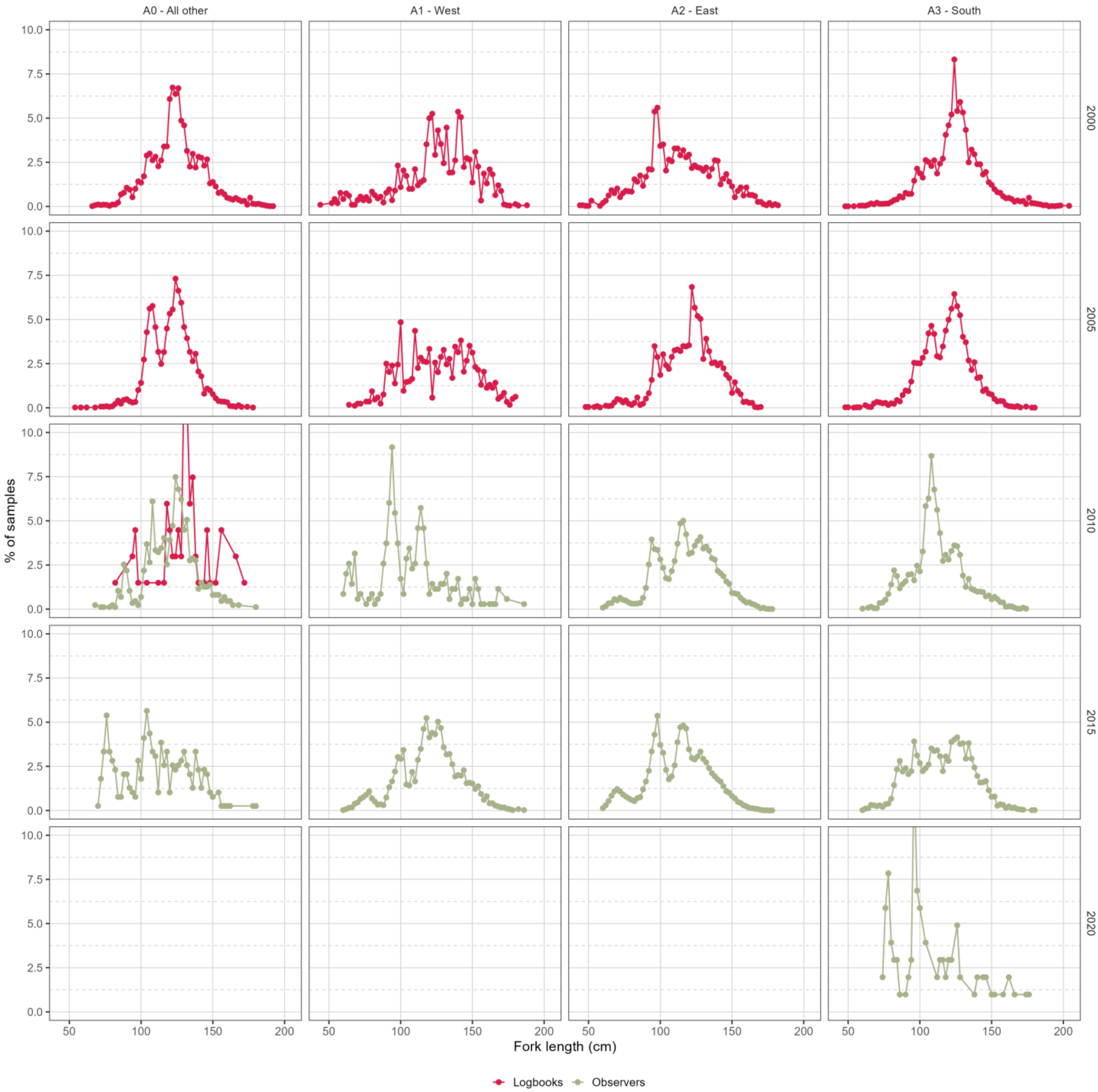

Figure 55: Relative size distribution (fork length; 2-cm size bins) of bigeye tuna reported by the deep-freezing longline fleets of Japan, by source (scientific observers vs. logbooks), stock assessment area and five-year periods. Data source: standardized size-frequency dataset (Res. 15/02)

References

Amandè MJ, Chassot E, Chavance P, Murua H, Molina AD de, Bez N (2012) Precision in Bycatch Estimates: The Case of Tuna Purse-Seine Fisheries in the Indian Ocean. ICES Journal of Marine Science 69:1501–1510.

Geehan J, Hoyle S (2013) Review of length frequency data of the Taiwanese distant water longline fleet. IOTC, San Sebastian, Spain, 23-28 October 2013, p 30

Herrera M (2002) Catches of industrial fleets operating under flags of non-reporting countries in the IOTC area of competence: An update. In: *IOTC Proceedings*. IOTC, Shanghai, China, 03-11 June 2002, p 125–157

Hoyle S, Chang S-T, Fu D, Itoh T, Lee S-I, Lucas J, Matsumoto T, Yeh Y-M, Wu R-F, Lee MK (2021) Review of size data from Indian Ocean longline fleets, and its utility for stock assessment. IOTC, Virtual meeting, 25-30 October 2021, p 95

Huang H-W, Liu K-M (2010) Bycatch and Discards by Taiwanese Large-Scale Tuna Longline Fleets in the Indian Ocean. Fisheries Research 106:261–270.

IOTC (2019a) Alternative approaches to the revision of official species composition for the Spanish log-associated catch-and-effort data for tropical tuna species in 2018. IOTC, Karachi, Pakistan, 27-30 November 2019, p 27

IOTC (2022a) Overview of Indian Ocean tropical tuna fisheries. IOTC, Virtual meeting, 30 May - 03 June 2022, p 26

IOTC (2019b) Preliminary Indian Ocean Bigeye Tuna Stock Assessment 1950 - 2018 (SS3). IOTC, Donostia - San Sebastian, Spain, 21-26 October 2019, p 94

IOTC (2019c) Report of the 15th Session of the IOTC Working Party on Data Collection and Statistics. IOTC, Karachi, Pakistan, 27-30 November 2019.

IOTC (2019d) Report of the 21st Session of the IOTC Working Party on Tropical Tunas. IOTC, Donostia-San Sebastian, Spain, 21-26 October 2019.

IOTC (2022b) Report of the 24th Session of the IOTC Working Party on Tropical Tunas, Data Preparatory Meeting. IOTC, Virtual meeting, 30 May-3 June 2022.

Medley P, Defaux V, Huntington T (2021) Exploratory analysis of tropical tuna longline selectivity and its implications for stock assessment. IOTC, Virtual meeting, 10-14 May 2021, p 13

Miller KI, Nadheeh I, Jauharee AR, Anderson RC, Adam MS (2017) Bycatch in the Maldivian Pole-and-Line Tuna Fishery. PLOS ONE 12:e0177391.

Moreno G, Herrera M, Pierre L (2012) Pilot project to improve data collection for tuna, sharks and billfish from artisanal fisheries in the Indian Ocean. Part II: Revision of catch statistics for India, Indonesia and Sri Lanka (1950-2011). Assignment of species and gears to the total catch and issues on data quality. IOTC, Victoria, Seychelles, 10-15 December 2012, p 6

Rabearisoa N, Sabarros PS, Romanov EV, Lucas V, Bach P (2018) Toothed Whale and Shark Depredation Indicators: A Case Study from the Reunion Island and Seychelles Pelagic Longline Fisheries. PLOS ONE 13:e0202037.

Ruiz J, Abascal F, Bach P, Baez J-C, Cauquil P, Grande M, Krug I, Lucas J, Murua H, Lourdes Alonso ML, Sabarros PS (2018) Bycatch of the European, and associated flag, purse seine tuna fishery in the Indian Ocean for the period 2008-2017. IOTC, Cape Town, South Africa, 10-17 September 2018, p 15