REVIEW OF THE STATISTICAL DATA AND FISHERY TRENDS FOR BILLFISH

Prepared by IOTC Secretariat[1]

Purpose

To provide participants at the 19th Working Party on Billfish (WPB19) with a review of the data and information available on billfish species under IOTC mandate as available in the IOTC databases as of August 2021 (**Table 1**). The document summarises data on retained (nominal) catches, catch-and-effort, size-frequency and other related data available for the period 1950-2019 and provides a range of fishery indicators for fisheries catching the five IOTC billfish species occurring in the IOTC area of competence (**Table 1**).

Table 1: List of billfish species under IOTC mandate

Species code	Name	Scientific name	IUCN status
BLM	Black marlin	*Istiompax indica*	Unclassified
BUM	Blue marlin	*Makaira nigricans*	Vulnerable
MLS	Striped marlin	*Tetrapturus audax*	Unclassified
SFA	Indo-Pacific sailfish	*Istiophorus platypterus*	Least concern
SWO	Swordfish	*Xiphias gladius*	Least concern

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Materials

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

Nominal catch data

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

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

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

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

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

Geo-referenced catch and effort data

Catch and effort data refer to fine-scale data, usually from logbooks, reported in aggregated format and stratified per year, month, grid, fleet, gear, type of school, and species (IOTC Res. 15/02). The IOTC forms designed for reporting geo-referenced catch and effort data vary according to the nature of the fishing gear (e.g., surface, longline, and coastal gears). In addition, information on the use of fish aggregating devices (FADs) and activity of the support vessels that assist industrial purse seiners also has to be collected and reported to the Secretariat through IOTC forms 3FA and 3SU.

Discard data

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

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

Size frequency data

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

Socio-economic data

The IOTC Form 7PR has been designed to voluntarily report prices of fish per type of product and market for the target species of Indian Ocean tuna and tuna-like species. To date, very little information is available on the socio-economics of tuna and tuna-like fisheries (e.g., sale price, operating costs, jobs) at the IOTC Secretariat.

Regional Observer Scheme

Resolution 11/04 on a *Regional Observer Scheme* (ROS) makes provision for the development and implementation of national observer schemes among the IOTC CPCs starting from July 2010 with the overarching objective of collecting *"verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence"*. The ROS aims to cover *"at least 5% of the number of operations/sets for each gear type by the fleet of each CPC while fishing in the IOTC Area of competence of 24 meters overall length and over, and under 24 meters if they fish outside their EEZs shall be covered by this observer scheme"*. Observer data collected as part of the ROS include: (i) fishing activities and vessel positions, (ii) catch estimates with a view to identifying catch composition and monitoring discards, bycatch and size frequency, (iii) gear type, mesh size and attachments employed by the master, and (iv) information to enable the cross-checking of entries made to the logbooks (i.e., species composition and quantities, live and processed weight and location). A first technical description of the ROS data requirements is available in the document IOTC–2018–WPDCS-35 Rev_2.

The document IOTC-2020-WPEB16-08 provides a comprehensive description of the current status, coverage and data collected as part of the ROS. Although incomplete and characterized by a large variability in coverage between fisheries and over space and time, observer data include information on the fate of the catches (i.e. retained or discarded at sea) as well as on the condition of the discards. Observer data are also the main source of spatial information on interactions between IOTC fisheries and seabirds, marine turtles, cetaceans, as well as any other species encountered.

To date, the ROS regional database contains information for a total of 1,492 commercial fishing trips (845 from purse seine vessels and 647 from longline vessels of various types) made during the period 2005-2019 from 7 fleets: Japan, EU,France and Sri Lanka for longline fisheries and EU,Spain, EU,France, Japan, Korea, Mauritius, and Seychelles for purse seine fisheries. In addition, some observer reports have been submitted to the Secretariat by some CPCs (e.g., Taiwan,China) but data sets were not provided in electronic format at the operational level following the ROS standards, *de facto* preventing the entry of the data in the ROS regional database.

Methods

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

Data processing

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

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

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

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

c. Finally, a disaggregation process is performed to break down the catches by species and gear when they are reported as aggregates (IOTC 2016). Briefly, the process estimates the catch proportion of each IOTC species of an aggregate in a given stratum from past reports of catches where the species and gears were reported separately, following a substitution scheme. A total of 5 species aggregates including IOTC billfish species have been used by some CPCs for reporting nominal catch data between 1950 and 2019 (**Table 2**).

Table 2: Species groups including billfish species and used for reporting nominal catches to the IOTC Secretariat between 1950 and 2019

Species code	Name	Scientific name
AG03	Marlins nei	*Tetrapturus audax; Makaira spp*
AG14	Billfish nei	*Xiphioidei*
BIL	Marlins,sailfishes,etc. nei	*Istiophoridae*
BXQ	Marlins nei	*Makaira spp*
TUX	Tuna-like fishes nei	*Scombroidei*

Third, and applying only to swordfish among all billfish species, geo-referenced catches are raised to the best scientific estimates of nominal catches using available information and by either leveraging data from proxy fleets or adopting substitution schemes when the spatio-temporal information is not available for a given stratum. For this reason, the raised data set represents the best scientific estimate of the geo-referenced catches of swordfish given the information available to the Secretariat and the well-known issues with data availability and data quality affecting several artisanal fisheries.

The resulting data set is comprised of catches in weight and number and stratified by year, month, fleet, gear, school type (when available) and 5x5 degrees grid, and covers the entire time series for which nominal catches of swordfish are available. The average weight of swordfish in the catch can be computed directly from the raised weights and numbers for each fishery, with the accuracy of the results being directly proportional to the availability and quality of geo-referenced catch and size-frequency data for the stratum.

Fourth, and applying to all 16 IOTC species plus the most common shark species, filtering and conversions are applied to the size-frequency data in order to harmonize their format and structure and remove data which are non compliant with IOTC standards, such as those provided with size bins exceeding the maximum width considered meaningful for the species (IOTC 2020). The standard length measurements considered are the fork length (FL; straight distance from the tip of the lower jaw to the fork of the tail) for striped marlin, Indo-Pacific sailfish, and swordfish and the eye fork length (EFL; straight distance from the orbit of the eye to the fork of the tail) for blue marlin and black marlin. All size samples collected using other types of measurements are converted into FL and EFL by using the IOTC equations, considering a common range of 15-462 cm and constant size interval of 3 cm. If no IOTC-endorsed equations exist to convert from a given length measurement for a species to the standard FL and EFL measurements, the original size data are not disseminated but kept within the IOTC databases for future reference.

Details on the results of the estimation process for deriving the 2019 best scientific estimates and changes in time series of nominal catches relative to the previous Working Party on Billfish are provided in Appendix I and Appendix II, respectively.

Data quality

A scoring system has been designed to assess the reporting quality of nominal catch, catch-effort, and size-frequency data submitted to the Secretariat for all IOTC species. The determination of the score varies according to each type of data set and reflects data availability as well as resolution, coverage, and compliance with IOTC reporting standards (**Table 3**). Overall, the lower the score, the better the quality. It is to note that the quality scoring does not account for sources of uncertainty affecting the data such as issues in sampling and processing as well as under- or misreporting.

Table 3: Key to IOTC quality scoring system

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

Results

Nominal catches

Historical trends (1950-2019)

The best scientific estimates of nominal catches provide an annual view on the history of the fisheries catching billfish species in the Indian Ocean. These species are caught with a large diversity of fishing gears all over the region and are targeted by some longline fisheries, in particular swordfish. The contribution of catches of billfish to the total catches of IOTC species has remained fairly stable over the last decades, oscillating between 4-5% from the mid-1950s onwards (**Fig. 1**). In recent years, the five species of billfish under IOTC mandate represented 5.2% of the total catches of the 16 IOTC species.

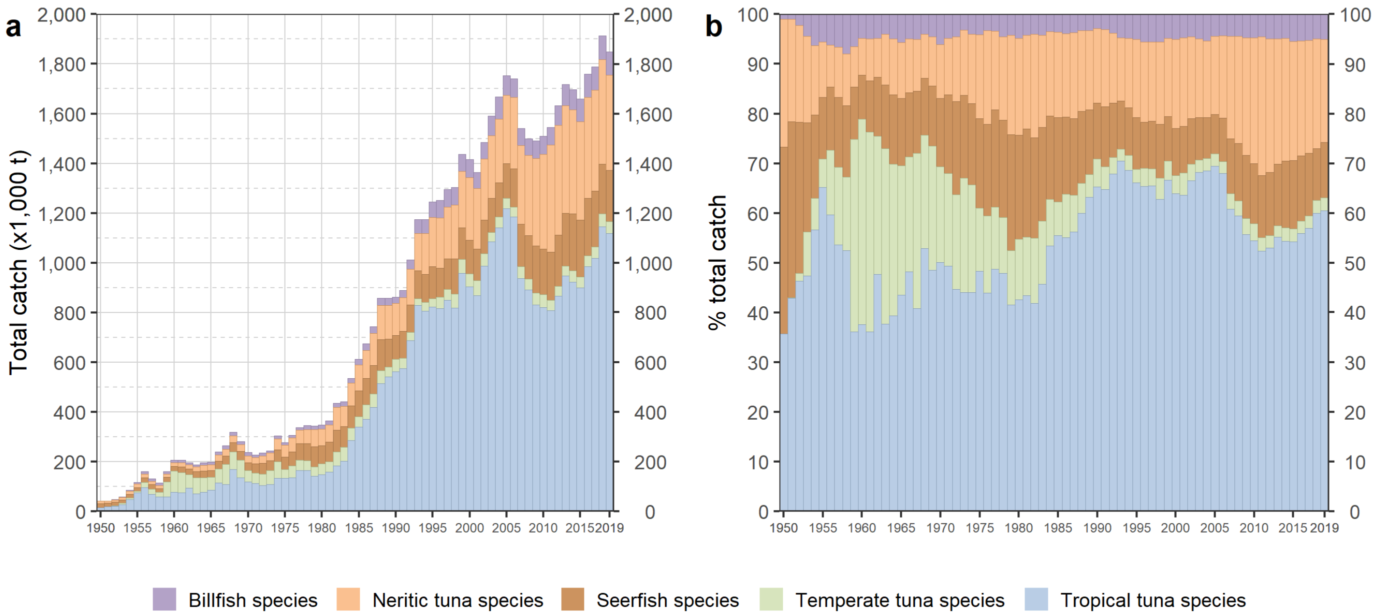

Figure 1: Annual time series of cumulative nominal absolute (a) and relative (b) catches of all IOTC tuna and tuna-like species in metric tons (t) by species cateory for the period 1950-2019

Billfish are mainly caught by industrial fisheries using longline and gillnet, but they are also taken by purse seiners and more artisanal gears such as troll line and hand line. The total nominal catches of the IOTC billfish species showed a major increase over the last seven decades, from an average of 5,451 t per year in the 1950s to an average of 85,800 t per year in the 2010s (**Table 4**). The annual catches of billfish species by industrial fisheries showed a marked increase between the 1990s and the 2000s, which was mainly driven by the longline fisheries from Taiwan,China (**Fig. 2a**). Since then, they showed large variations between a maximum of 58,734 t in 2004 and a minimum of 32,658 t in 2010. Catches from artisanal fisheries have steadily increased over time, with their contribution to the total catch of billfish increasing from less than 10% prior to the 1970s to more than 50% in recent years (**Fig. 2b**).

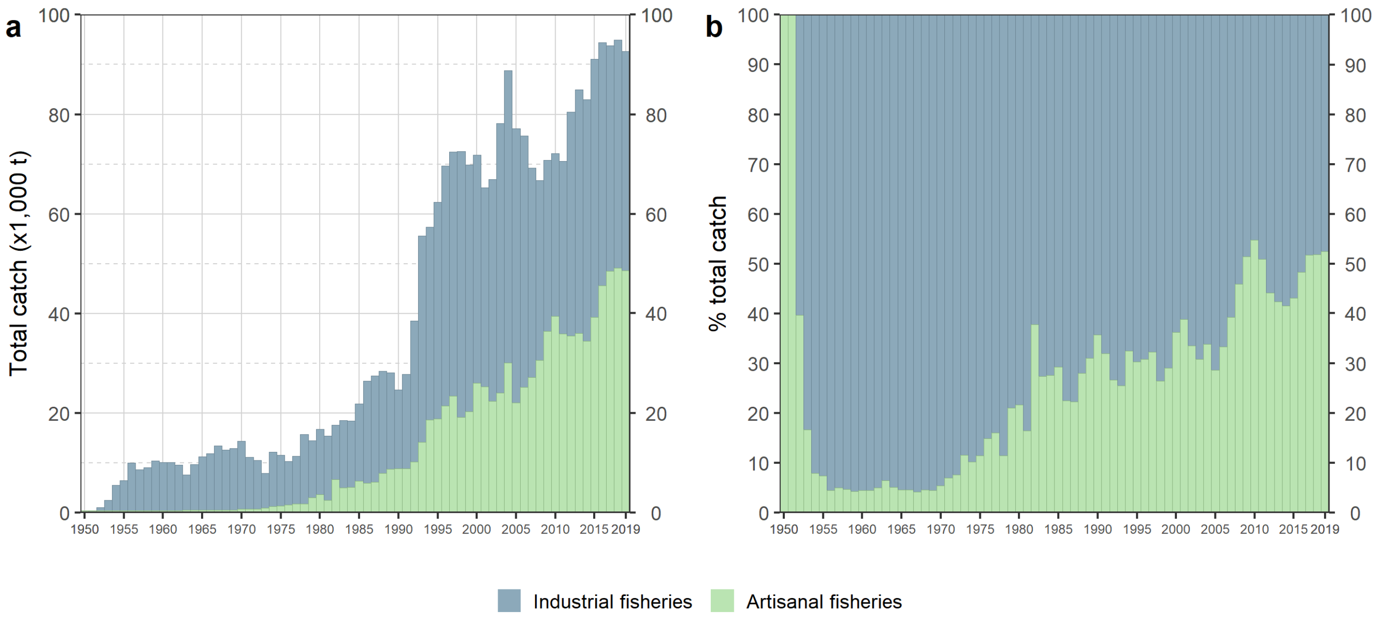

Figure 2: Annual time series of cumulative nominal absolute (a) and relative (b) catches of IOTC billfish in metric tons (t) by fishery type for the period 1950-2019

The composition of the fisheries catching billfish varies over time and between species. While billfish have mainly been reported to be caught by longliners until the early 1990s, the contribution of gillnet and coastal line fisheries has substantially increased over the last two decades (**Table 4 & Fig. 3**). In particular, gillnet catches of billfish have steadily increased since the early 1980s to reach 40,200 t in 2019, representing 43% of the total catches of billfish in that year.

Table 4: Best scientific estimates of nominal catches of the IOTC billfish species by decade and fishery in metric tons (t) for the period 1950–2019

FISHERY	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Purse seine | Other	0	0	7	107	166	337	1,030
Longline | Other	0	0	0	115	4,606	15,571	9,368
Longline | Fresh	0	0	112	569	6,326	9,052	10,918
Longline | Deep-freezing	5,015	10,404	10,451	15,360	30,031	22,227	13,702
Line | Coastal longline	94	93	113	758	1,404	3,083	12,361
Line | Trolling	97	149	273	627	1,240	1,900	2,230
Line | Handline	33	33	271	1,217	1,711	1,279	2,088
Baitboat	0	0	29	0	0	0	34
Gillnet	213	241	713	3,092	9,576	19,558	33,964
Other	0	0	4	56	23	45	103
Total	5,451	10,920	11,972	21,900	55,083	73,052	85,800

Total catches of billfish reported for line fisheries showed a marked increase from the early 2010s (**Fig. 3**) reflecting in particular the increased reporting of billfish species caught by the coastal longline fishery of Sri Lanka, that went from 37 t in 2013 to 4,426 t in 2014. This sharp increase is thought to be mainly due to an improvement in the fisheries statistics of Sri Lanka starting with the early 2010s, when a closer monitoring of the catches in multi-gear fisheries (e.g., gillnet and longline operated during the same trip) was combined with a better break-down of longline fisheries data (i.e., separation between coastal and offshore components). In parallel, the catches of billfish taken by coastal longliners operating in the Indian EEZ have doubled over the last decade, increasing from 3,607 t in 2013 to 6,929 t in 2019.

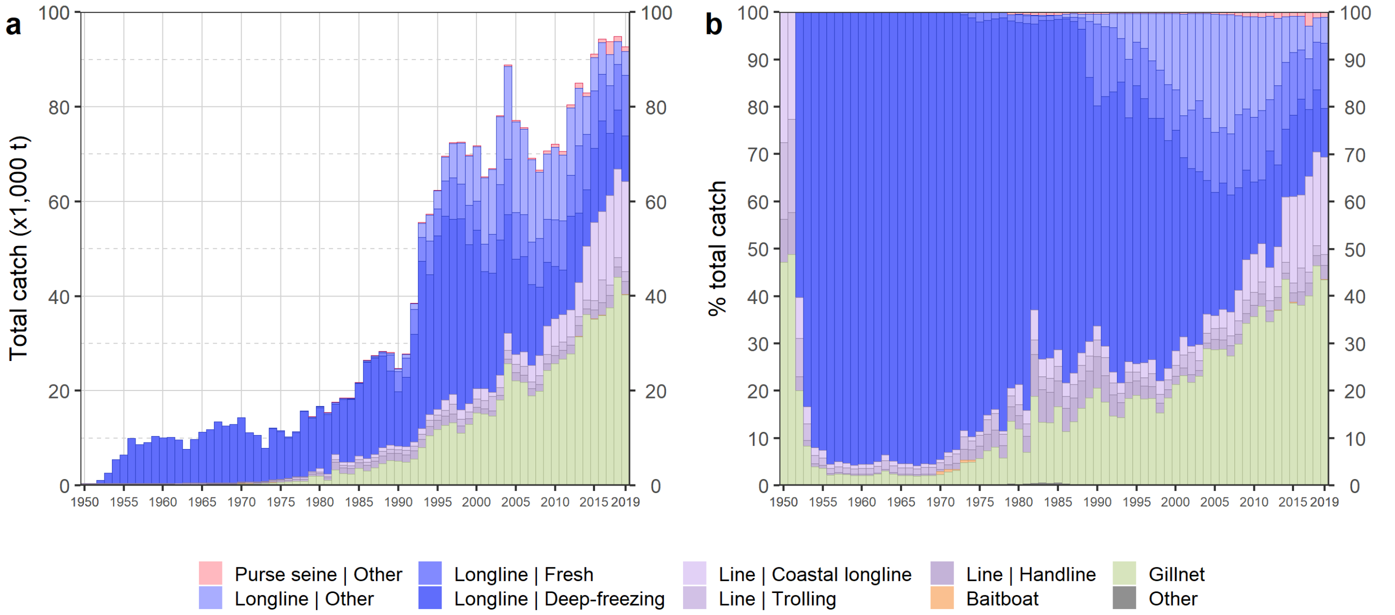

Figure 3: Annual time series of cumulative nominal absolute (a) and relative (b) catches of IOTC billfish in metric tons (t) by fishery for the period 1950-2019

A total of 2.6 million metric tons of billfish have been reported to have been caught in the Indian Ocean since the 1950s. In terms of total catches, swordfish (SWO) represents the main billfish species, contributing to 36% of the cumulative catches of billfish available in the IOTC database, followed by Indo-Pacific sailfish (SFA) with a contribution of 24% (**Fig. 4**). Blue marlin (BUM) and black marlin (BLM) contributed about equally with cumulative catches of about 400,000 t, roughly corresponding to 15% of total billfish catches taken during that period. Striped marlin (MLS) appears to be less abundant in the catches of IOTC billfish with a maximum annual catch of 8,730 t observed between 1950 and 2019 and a total cumulative catch of about 256,000 t reported as caught over that period.

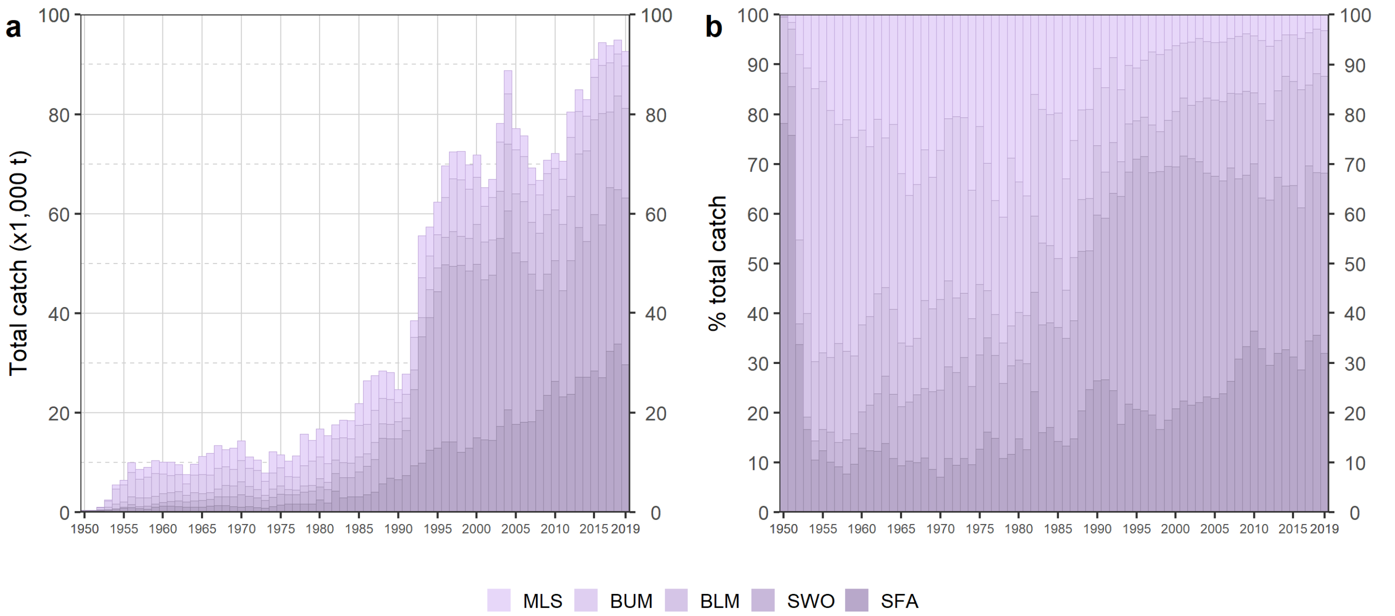

Figure 4: Annual time series of cumulative nominal absolute (a) and relative (b) catches of IOTC billfish in metric tons (t) by species for the period 1950-2019

The five IOTC billfish species show different temporal trends between 1950 and 2019. Black marlin (BLM) shows an increasing trend, which brought catches of the species from 3,000 t in 1991 to around 13,000 t in 2004. In recent years catches have increased sharply from around 13,000 t in 2012 to over 22,000 t in 2016 – the highest catches recorded in the Indian Ocean for the species – largely due to increases reported by the offshore gillnet fisheries of I.R. Iran. Catches decreased again to 15,000 t in 2017 and re-increased to about 18,000 t in 2019. Catches in Sri Lanka have also risen steadily since the beginning of the 1990s, from around 1,000 t in 1991 to an average of around 4,000 t in recent years, as a result of the development of the fishery using a combination of drifting gillnets and longlines (**Fig. 5**).

Blue marlin (BUM) shows a two-phase increase, with an average catch of about 4,000 t per year between 1955 and 1990 and about 9,000 t per year between 1995 and 2019 (**Fig. 5**). Some of the highest catches of blue marlin reported by longliners in recent years have been recorded between 2012 and 2016, and are likely to be the consequence of higher catch rates by some longline fleets which resumed operations in the western tropical Indian Ocean following the reduction of piracy threat. Overall, catches of blue marlin are mostly dominated by longline fisheries although the contribution of line and gillnet fisheries in recent years became more marked (**Fig. 5**).

Striped marlin (MLS) shows some strong interannual variability in the nominal catches between 1950 and 2019, with a progressive increase from the 1950s to the 1990s followed by a decreasing trend from a high catch of about 8,000 t of fish in 1993 to 3,000 t in 2019. Catch trends range from 2,000 t to 8,000 t per year, which may reflect the level of reporting and the status of striped marlin as a non-target species rather than actual catches. In particular, catches reported under drifting longlines are highly variable, with lower catch levels between and 2011 largely due to declining catches reported by Taiwanese deep-freezing and fresh-tuna longliners. Since 2012, catches of striped marlin have fluctuated between 3,000 t – 5,000 t per year (**Fig. 5**).

Similar to black marlin, Indo-Pacific sailfish (SFA) shows a continuous increasing trend between 1950 and 2019, driven by the gillnet fisheries that represent the large majority of the catches for this species over the entire period, with catches increasing from about 6,550 t in 1990 to 29,657 t in 2019 (**Fig. 5**).

With regards to swordfish (SWO), after a period of slow increase between 1950 and the early 1990s, catches of the species showed a massive increase from about 8,000 t in 1990 to about 35,000 t per year between 1995 and 2005, to decrease again to 21,000 t in 2011 before re-increasing over the last decade and reach 34,000 t in 2019.

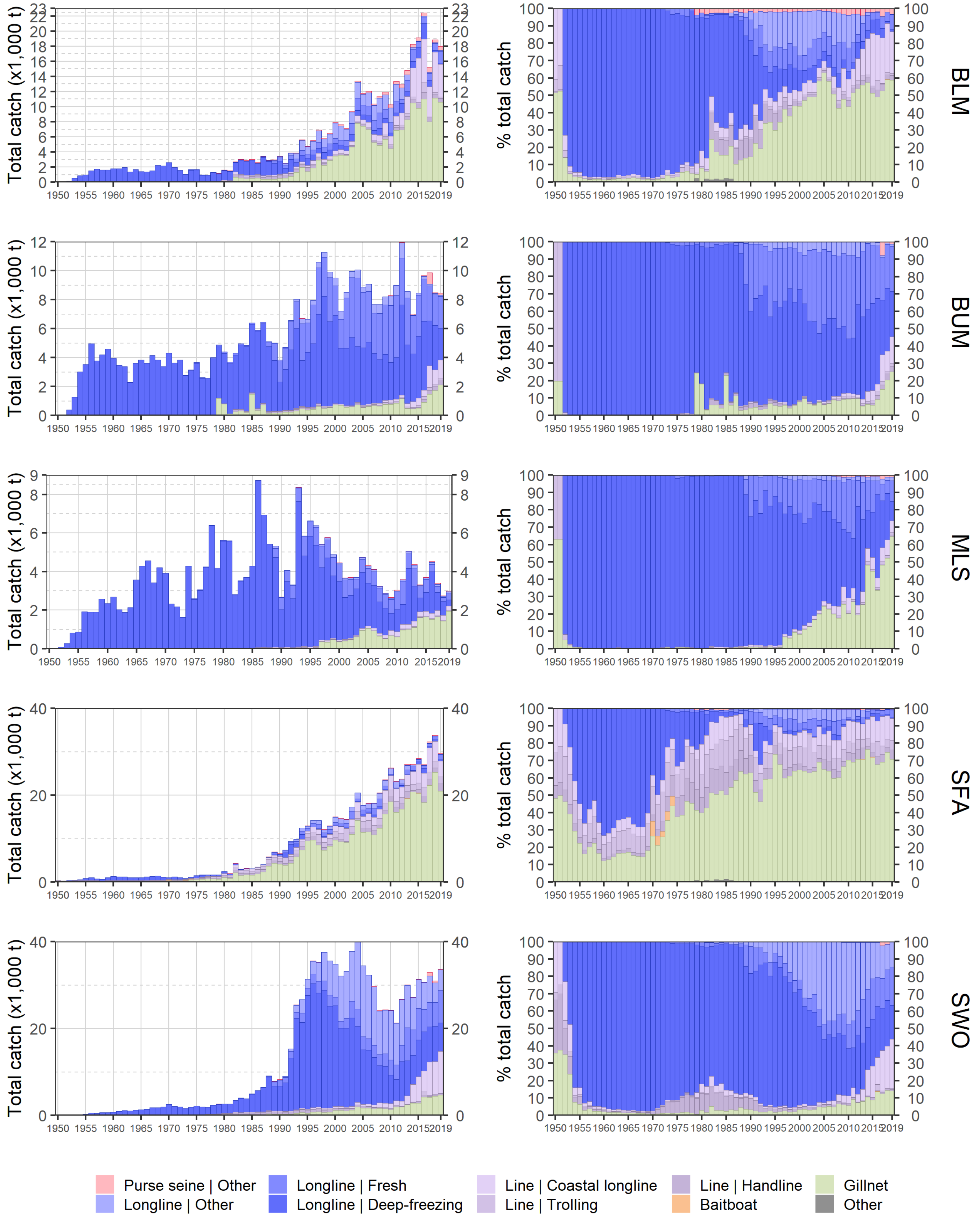

Figure 5: Annual time series of cumulative nominal absolute (a) and relative (b) catches of IOTC billfish in metric tons (t) by species for the period 1950-2019

Recent fishery features (2015-2019)

In recent years (2015-2019), total nominal catches of all IOTC billfish species combined were about 93,376 t per year, with gillnet, longline, and line fisheries contributing to 41.2%, 33.1%, and 24.2% of all catches, respectively (**Table 5**).

Table 5: Mean annual nominal catches of the IOTC billfish species by fishery in metric tons (t) and contribution (%) to the total catches of all IOTC billfish species between 2015 and 2019

Fishery	Fishery code	Catch	Percentage
Gillnet	GN	38,471	41.2
Line | Coastal longline	LIC	17,561	18.8
Longline | Deep-freezing	LLD	14,028	15.0
Longline | Fresh	LLF	10,867	11.6
Longline | Other	LLO	6,020	6.4
Line | Trolling	LIT	2,606	2.8
Line | Handline	LIH	2,394	2.6
Purse seine | Other	PSOT	1,271	1.4
Other	OT	105	0.1
Baitboat	BB	53	0.1

Between 2015 and 2019, the mean annual catches of IOTC billfish have been dominated by a few CPCs, to the point that about two thirds of all catches were accounted for by four distinct fleets: I.R. Iran (mostly composed of gillnet fisheries), Sri Lanka and India (described by a large diversity of fisheries and gears), and Taiwan,China (composed of an equal mix of fresh and deep-freezing longliners) (**Fig. 6**).

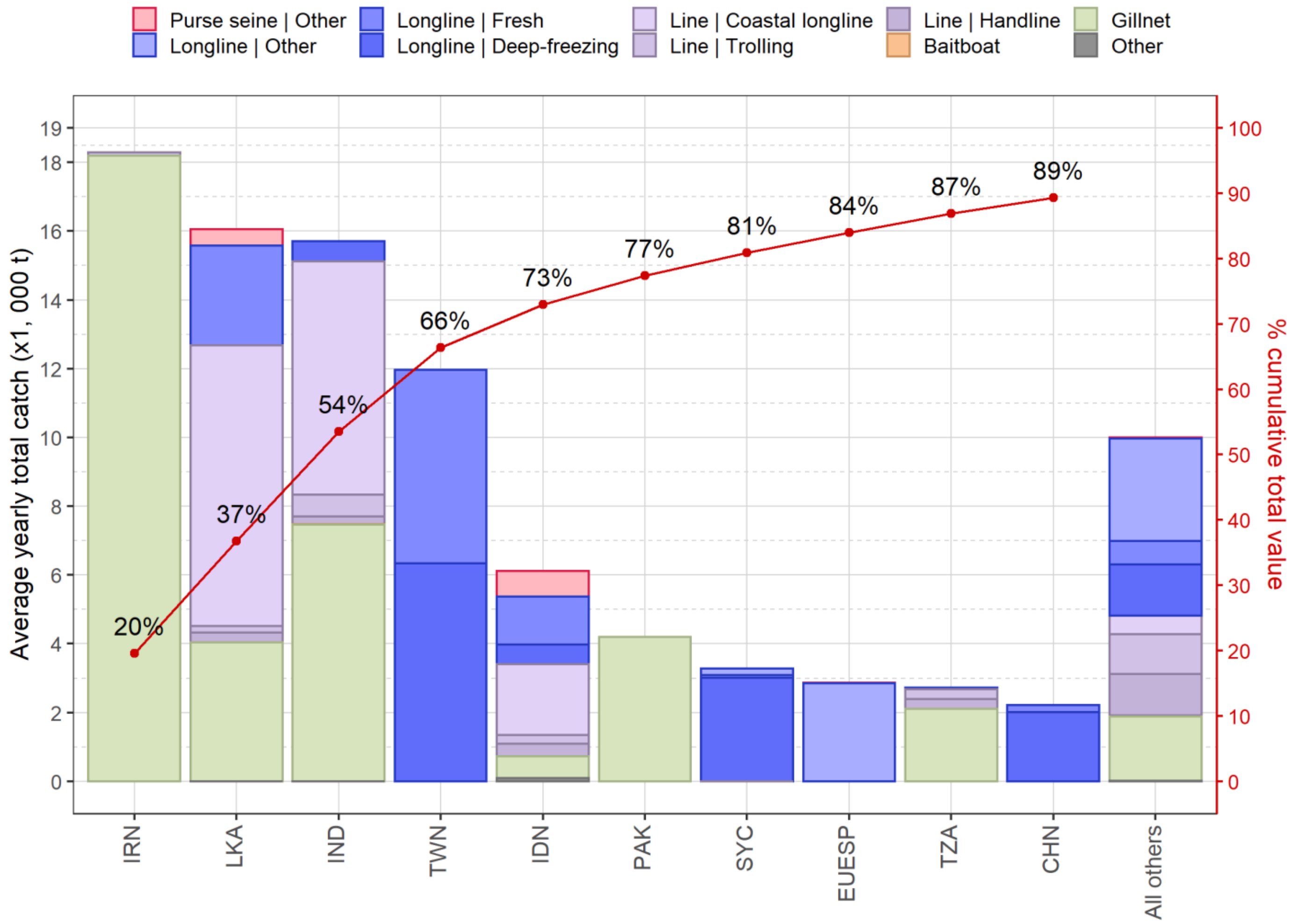

Figure 6: Mean annual catches of IOTC billfish species by fleet and fishery in metric tons (t) between 2015 and 2019, with indication of cumulative catches by fleet

The contribution of fleets to the total catches varies across the five IOTC billfish species. In recent years catches of black marlin were dominated by a few fleets, with three CPCs, namely I.R. Iran, India, and Sri Lanka, accountable for about three quarters of the total catches (**Fig. 7**) and with most of the catches taken by gillnet and coastal line fisheries.

For blue marlin, striped marlin, and sailfish, the three main fleets contributed to about 60% of the catches in recent years (**Fig. 7**) with catches of blue marlin from the longline fleets from Taiwan,China representing more than 40% of its total catches reported to the secretariat between 2015 and 2019.

Finally, in the case of swordfish, the catches are more evenly distributed between fleets, and it takes ten countries to reach 90% of the total catches compared to the seven or less for the four other billfish species. Sri Lanka and Taiwan,China currently dominate catches of the species with a respective contribution of 25% and 20% of total catches of swordfish reported during the period 2015-2019.

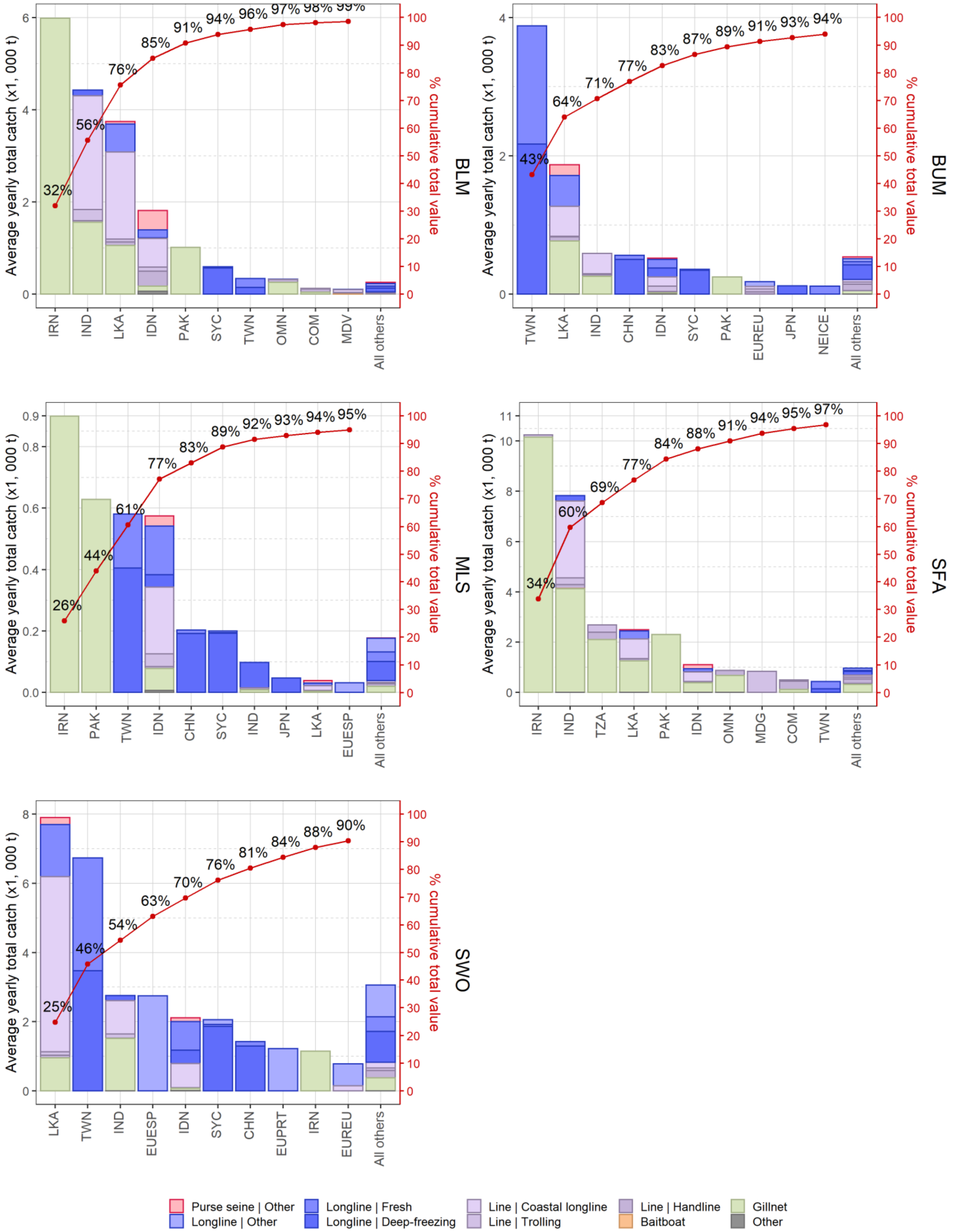

Figure 7: Mean annual catches of each IOTC billfish species by fleet and fishery in metric tons (t) between 2015 and 2019, with indication of cumulative catches by fleet

Over the last five years of the time series (2015-2019), the gillnet and line catches of billfish species showed increasing trends, while catches reported by longline fisheries decreased and catches from other fishery groups (i.e., purse seine, baitboat, and other fisheries) were small or negligible (**Fig. 8**). Between 2015 and 2019, the catches of billfish taken by gillnet and line fisheries increased from 35,045 t to 40,200 t and from 20,367 t to 23,947 t respectively, while catches of billfish taken by longline fisheries decreased from 34,729 t to 27,435 t (**Fig. 8**).

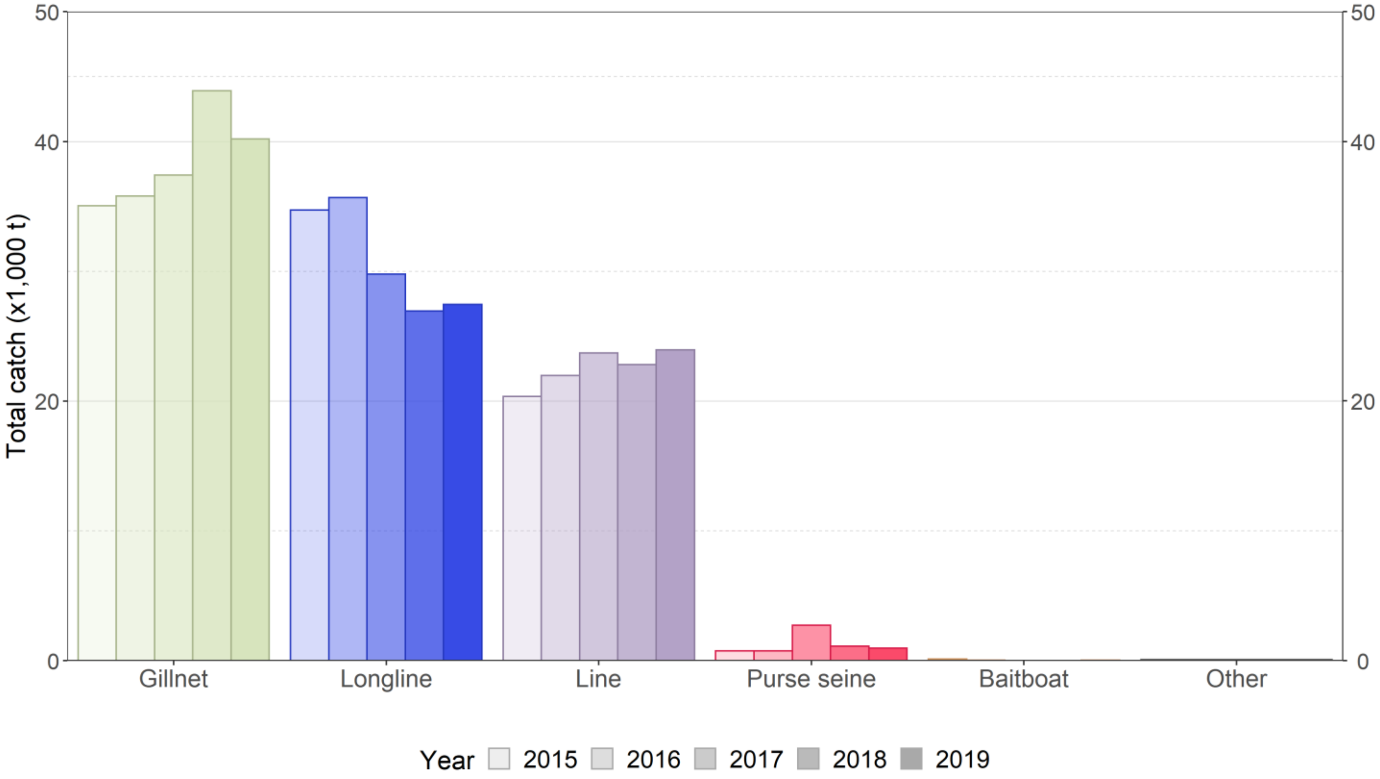

Figure 8: Annual catch trends of IOTC billfish species by fishery group in metric tons (t) between 2015 and 2019

Annual trends observed in the catches of billfish in recent years vary between fleets and fishery groups. The recent overall increase in gillnet catches is mainly driven by the fisheries of India and Sri Lanka while catches from I. R. Iran and Pakistan showed some inter-annual variability between 2015 and 2019 without any underlying trend (**Fig. 9a**). The decrease in longline catches of billfish is explained by the decrease in the catches of the fisheries of Taiwan,China, EU,Spain, and all longline fisheries other than Seychelles and Sri Lanka (**Fig. 9c**). Except for an increase in Sri Lankan line fisheries, catches of billfish by the main CPCs with line fisheries have remained fairly stable between 2015 and 2019 (**Fig. 9b**).

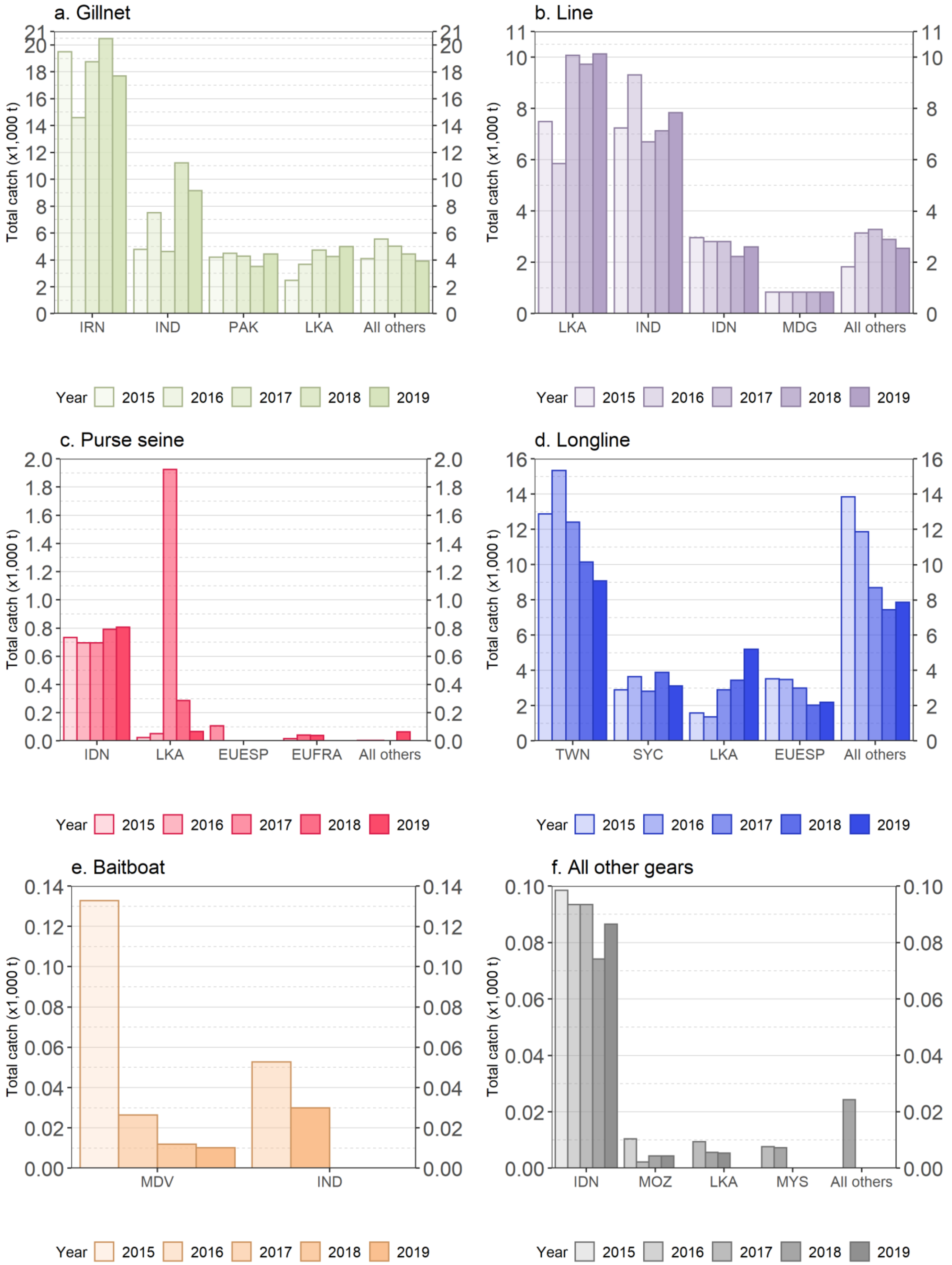

Figure 9: Annual catch trends of IOTC billfish species by fishery group and fleet in metric tons (t) between 2015 and 2019

Uncertainties in nominal catch data

Different processes may affect the quality of the statistical data reported to the IOTC Secretariat, depending on the complexity of the fisheries and the systems in place to collect, process, and manage the data at national level. The accuracy and precision of the catches may be affected by under-reporting or misreporting, low sampling coverage, poor data resolution (e.g., due to mis-identification of species), and errors in processing and reporting.

The overall quality of nominal catches for the five IOTC billfish species with regards to IOTC reporting standards has strongly varied between 1950 and 2019, and improved substantially over the last decade. The percentage of nominal catches fully or partially reported to the Secretariat i.e., scores between 0 and 2; **Table 3**) showed large variations over time, decreasing from more than 90% prior to the 1970s, when the catches were dominated by industrial longline fisheries, to less than 40% in the late 2000s (**Fig. 10**). Since then, the reporting quality improved for both industrial and artisanal fisheries with the overall percentage of data fully or partially reported to the Secretariat reaching 80% in 2019 (**Fig. 10**).

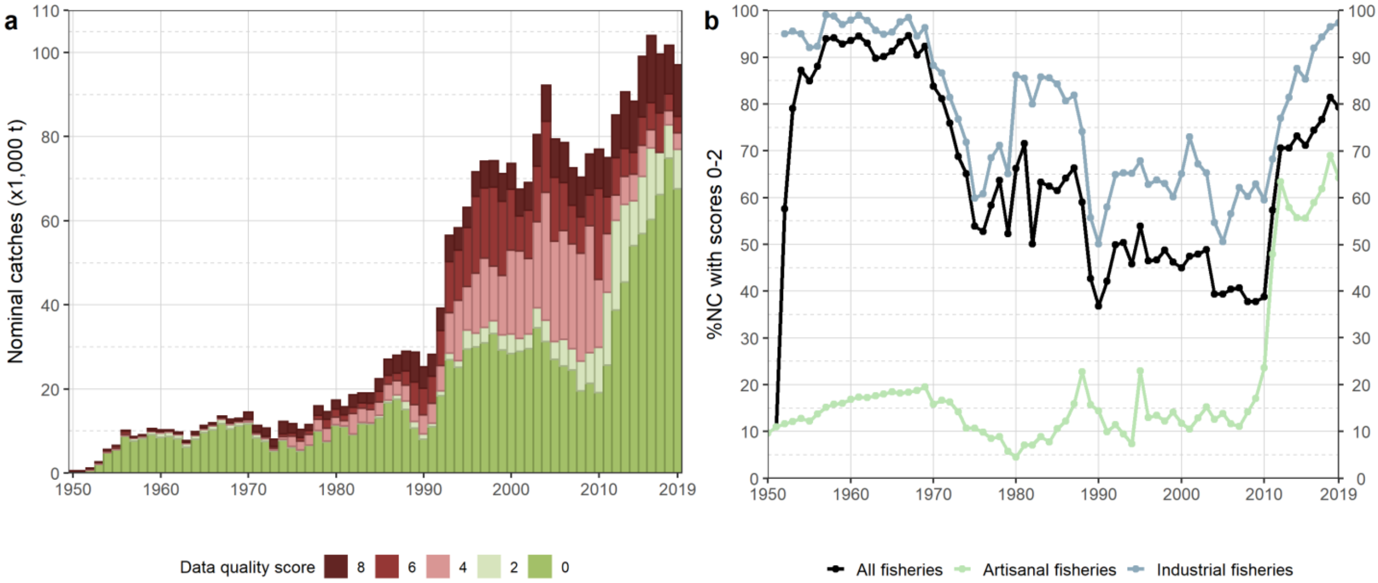

Figure 10: (a) Annual nominal catches of IOTC billfish species in metric tons (t) estimated by quality score and (b) percentage of nominal catches by type of fishery fully and partially reported to the IOTC Secretariat according to IOTC standards

The reporting quality varies between species and over time, with the five species showing rather similar trends in quality levels between the 1950s and 1980s, driven by the relatively low amount of catches from artisanal fisheries. The overall data quality was very low in the early 1950s, prior to the development and expansion of the industrial longline fisheries that resulted in turn in a sharp increase in quality recorded until the early 1970s, when the contribution of artisanal fisheries started to increase (**Fig. 11**). From then, the trends in quality started to show differences between species, with sailfish remaining at very low quality levels (<25% of catches fully or partially reported) until the early 2010s. By contrast, nominal catches of swordfish are characterized by the highest reporting quality among all billfish species, with more than 60% of total catches having been fully or partially reported between 1980 and 2019. The three marlin species show overall similar patterns although the quality of the data for black marlin appears as very low throughout the 1990s and 2000s, when only about 10% of the nominal catches were determined to be properly reported to the Secretariat

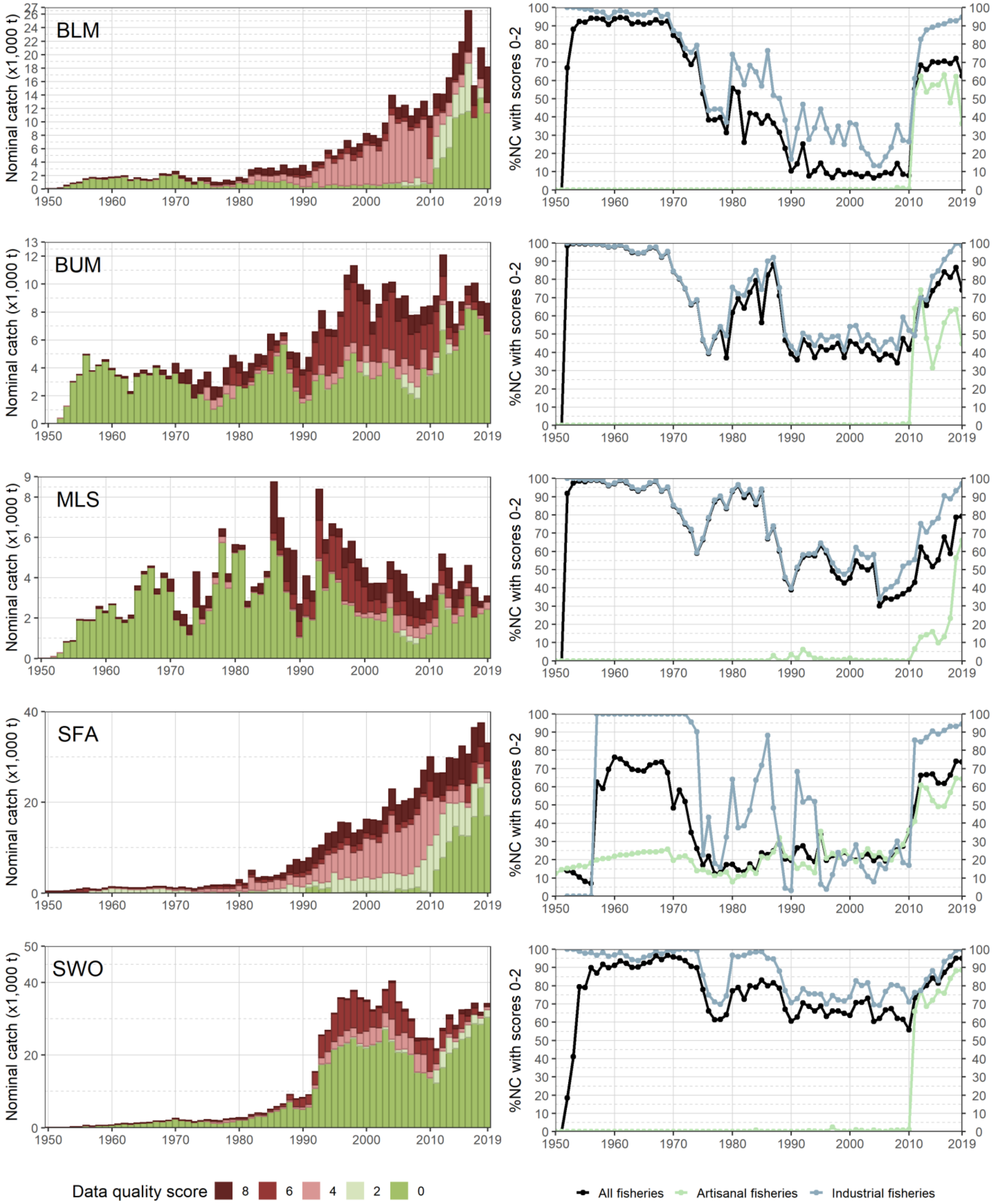

Figure 11: (left panel) Annual nominal catches in metric tons (t) estimated by quality score and (right panel) percentage of nominal catches by type of fishery fully and partially reported to the IOTC Secretariat according to IOTC standards for each IOTC billfish species

In 2019, 69.7% of the nominal catches of billfish were fully reported to the Secretariat while the rest had to be partially or fully estimated. Part of the nominal catches was derived from alternative sources of catch data for the CPCs and non-members of the IOTC that did not report data to the Secretariat (Appendix I - Table 6). In addition, a re-estimation process was applied to the catches from the artisanal fisheries of India and Indonesia, which are known to be affected by data quality issues and also by a tendency to include catch data for species and gear aggregates (Appendix I).

In addition to the issues in reporting, several other key issues emerge from the available nominal catches of some CPCs, that need to be noted and addressed to improve the fisheries statistics of the five IOTC billfish species:

- Artisanal fisheries (including sport fisheries)
  - Catches of billfish reported by Indonesia for its artisanal fisheries in the last decade have been very high, at around 15-19% of the total catches of billfish in the Indian Ocean. In 2012 the Secretariat revised the nominal catch dataset for Indonesia, using information from various sources, including official reports. While Indonesia is implementing a number of improvements to the collection and validation of data for artisanal fisheries, such as electronic logbooks and complete enumeration of catches at key landing sites, catches are still considered to be uncertain for Indonesian small-scale fisheries;
  - Sport fisheries of Australia, France (La Réunion), India, Indonesia, Madagascar, Mauritius, Oman, Seychelles, Sri Lanka, Tanzania, Thailand and United Arab Emirates: data have either never been submitted, or are available for only a limited number of years for sport fisheries in each of the referred CPCs. Sport fisheries are known to catch billfish species, and are particularly important for catches of blue marlin, black marlin and Indo-Pacific sailfish. Although some data are available from sport fisheries in the region (e.g., Kenya, Mauritius, Mozambique, South Africa), the information cannot be used to estimate levels of catch for other fisheries. In 2017 the IOTC Secretariat commissioned a pilot project to develop tools and training materials for CPCs to improve the collection and reporting of catch-and-effort and size frequency from sport fisheries in the Western Indian Ocean (Pepperell et al. 2017). The project focused on trialling specifically-developed data collection tools on a small number of CPCs, including La Réunion, Kenya, Mauritius and Seychelles – however data reporting continues to be an on-going issue for sports and recreational fisheries.
- The drifting gillnet fisheries of I.R. Iran and Pakistan are estimated to account for around 22,000 t of catches of billfish (equivalent to about 24% of the total billfish catches in the Indian Ocean). However, catches for these components remain uncertain:
  - In recent years I.R. Iran has reported catches of marlins and swordfish for their gillnet fishery (from 2012 onwards) which significantly revises the catch-by-species previously estimated by the IOTC Secretariat. While the IOTC Secretariat has used the new catch reports to re-build the historical series for its offshore gillnet fishery (pre-2012), the resulting estimates are thought to be highly uncertain;
  - In 2019, the IOTC WPDCS and SC endorsed the revised catch series (from 1987 onwards) provided by the Pakistan government for its gillnet fleet, and based on the results of the work from the data collection programme supported by WWF-Pakistan. These revised catch series introduced large differences in the reported catches of billfish species, in particular for what concerns swordfish, striped marlin and Indo-Pacific sailfish that are now far lower than what originally reported. As a consequence, current catch estimates for Pakistan account for around 6% of the total catches of billfish in the Indian Ocean, and still suffer from the lack of detailed per-species information until 2017 (catches are reported as “generic” billfish species until that year, with some explicit records of Indo-Pacific sailfish appearing throughout the revised time series).
- Industrial longline fisheries
  - Following issues with the reliability of catch estimates of Indonesia’s fresh longline fleet in recent years, in 2018 the IOTC Secretariat developed in collaboration with Indonesia a new methodology of catch estimation that mostly affects Indonesia’s catches of swordfish, striped marlin, and blue marlin (Geehan 2018). The revised catches are significantly lower for Indonesia’s fresh longline fleet in

recent years, compared to previous IOTC estimates, while total catches across all fleets have also been revised downwards by as much as 30% for each species as a consequence of the new estimation methodology. The methodology was not applied to the catches for 2019;

- Despite a decrease in the number of Taiwanese fresh-longline vessels of around 30% between 2013-2016, catches have remained at similar levels, or even marginally increased as average catches per vessel have risen from 100 t per vessel in 2013 to around 175 t per vessel in 2016. Over the same period, the proportion of swordfish reported by the Taiwanese fresh longline fleet has risen from around 8% to over 30% - due to improvements in the estimation of catches by species, according to official sources. Both these issues (i.e., the sharp increase in average catches per vessel and changes to the species composition) require further clarification to ensure that the recent increase in average catches is valid.

- Industrial purse seine fisheries
  - Catches of billfish recorded by all industrial purse seiners are thought to be a fraction of those retained on board. Due to the species being a bycatch, catches are seldom recorded in the logbooks although information collected through the ROS shows that some purse seine fleets do retain billfish for marketing.

Discard levels

The total amount of billfish species 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, the implementation of IOTC Res. 18/05 that bans the release of specimens of billfish smaller than 60 cm FL may have modified discarding practices in recent years. Despite the lack of information available, discarding of billfish species is overall considered to be limited in most coastal and industrial fisheries targeting tuna and tuna-like species in the IOTC area of competence.

Purse seine fisheries

In large-scale purse seine fisheries, part of the billfish has been shown to be discarded at sea despite the entry in force of IOTC Res. 19/05 that bans the discard of non-targeted species caught with purse seine. The levels of bycatch of billfish in Indian Ocean purse seine fisheries have been shown to be low and dominated by marlins, although sailfish may occasionally be caught (Romanov 2002; Ruiz et al. 2018). Based on a large data set of observations at sea collected during the period 2008-2017, the annual catch levels of billfish in the main component of the Indian Ocean purse seine fishery were estimated to vary between 100 and 400 t per year (Ruiz et al. 2018), providing an upper limit for the discard levels.

Information available in the ROS regional database for purse seine fisheries covers the period 2005-2019 and the whole fishing grounds of the purse seine fishery (**Fig. 12**). The discards are dominated by black and blue marlins while discards of sailfish and swordfish are very small, in line with the levels of bycatch for each species. Data show that 27% of all billfish for which the fate was known was discarded at sea, with the very large majority of the fish ending up dead (~94.9%). Interestingly, the data also show that the level of discarding of billfish in purse seine fisheries depends on the fleet, with an overall percentage of discarding of 47.4% for purse seiners from France and 13.5% and 15.5% for Seychelles and Spain, respectively. For the three fleets, the proportion of discards shows a decrease over time, indicating the growing tendency of the industry for marketing billfish species.

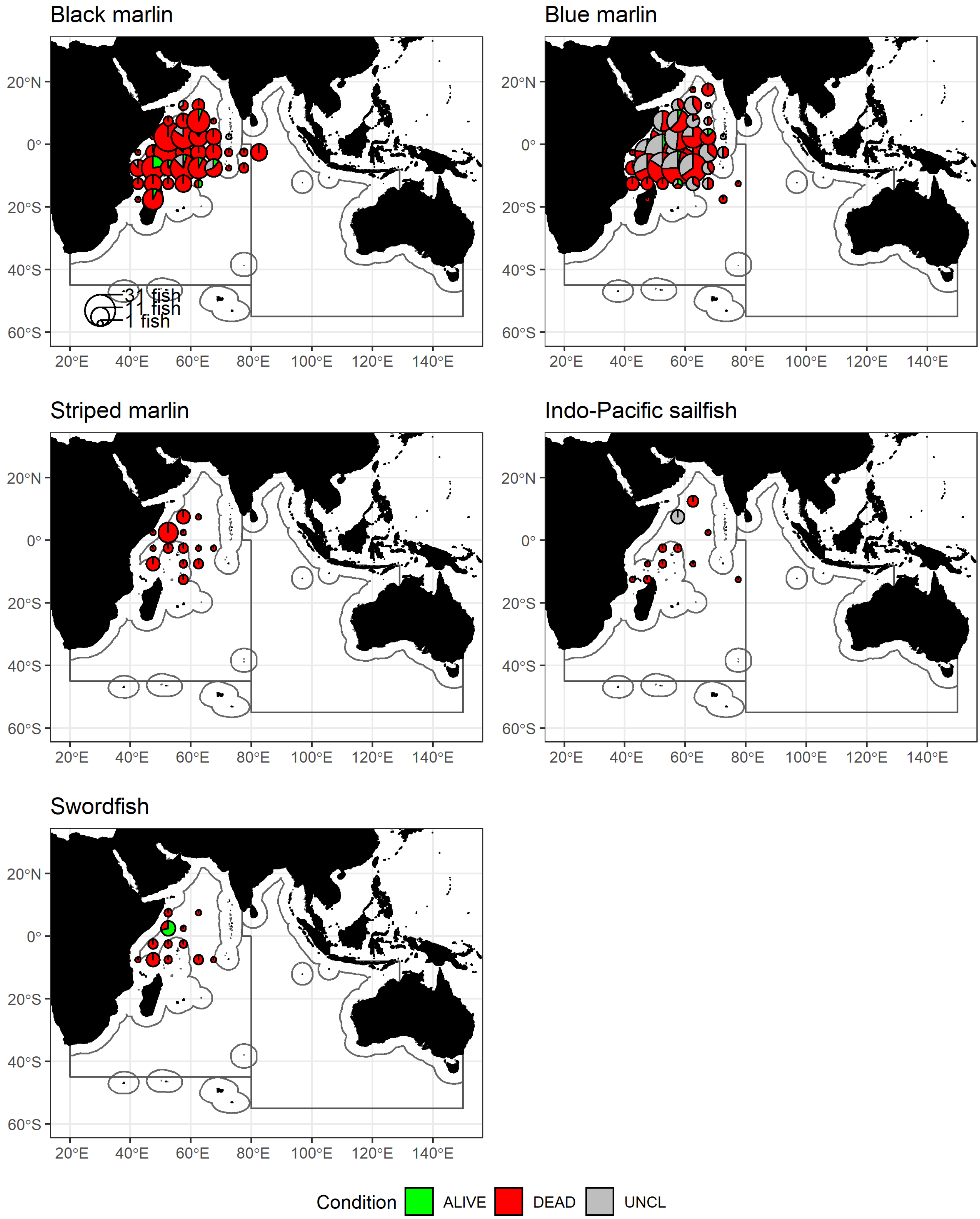

Figure 12: Distribution of all observations of billfish discarded at sea in the Western Indian Ocean purse seine fishery with information on fate as available in the ROS regional database

Size data collected by observers at sea for billfish caught in the purse seine fishery show no significant difference between retained and discarded specimens (**Fig. 13**). The size of the three marlin species is very similar across species. The median fork length is about 215-230 cm, with the capture of the largest individuals showing larger sizes in black marlin (75% quantile = ~270 cm FL), followed by blue marlin (75% quantile ~250 cm FL), and striped marlin (75% quantile = ~235 cm FL). The median sizes of sailfish and swordfish are 184.5 cm FL and 204.5 cm FL, respectively.

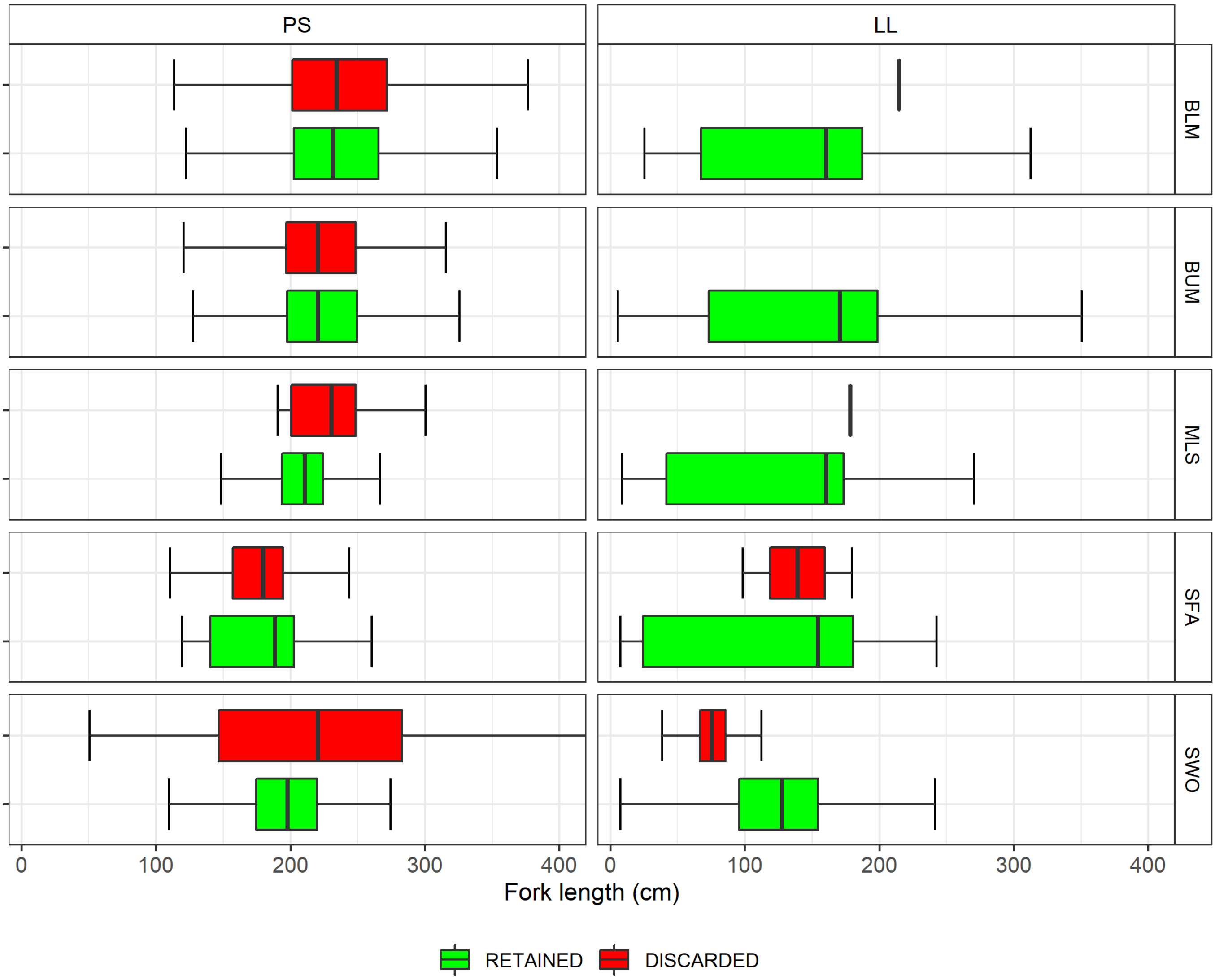

Figure 13: Boxplots of fork length measurements of billfish species caught and discarded at sea in purse seine and longline fisheries as available in the ROS regional database

Longline fisheries

Information from the literature indicates that levels of discards of billfish are low in Indian Ocean longline fisheries (Huang and Liu 2010; Gao and Dai 2016). Discarding is mainly due to under size, damaged condition, and depredation by whales and sharks that has been shown to be substantial in some longline fisheries of the western Indian Ocean (Munoz-Lechuga et al. 2016; Rabearisoa et al. 2018).

Information available in the ROS regional database for longline fisheries covers the period 2009-2019 and a small part of the longline fishing grounds as the data are limited to EU,France, Japan, and Sri Lanka. The discards of billfish in these fisheries appear to be low for billfishes and sailfish, i.e., from 0% discard in the longline fishery of Sri Lanka to a maximum of about 5% for blue marlin and swordfish in the longline fishery of Japan. Discarding appears to be the highest for swordfish in the swordfish-targeted longline of Reunion Island where the overall discarding rate during 2009-2019 was about 13.7%. This apparent high discard rate may be partly explained by the high levels of depredation observed in this fishery (Romanov et al. 2013; Rabearisoa et al. 2018). However, size data available in the ROS show a significant difference between the swordfish retained and discarded in the fishery, with the latter ones being about 60 cm smaller than the ones retained (**Fig. 13**). Further analysis accounting for the variability of discarding in space and time, differences in vessel attributes (e.g., size), etc. is required to accurately assess the extent of and causes of discarding in this fishery and other longline fisheries when data become available.

Gillnet fisheries

In absence of market value, marlins and swordfish have been assumed to be discarded in some gillnet fisheries such as in I.R. Iran although information available for this fishery suggests that billfish are retained and landed (Rajaei 2013; Shahifar et al. 2013).

Geo-referenced catches

Geo-referenced catch data for billfish species have been reported to the Secretariat in numbers, weights, or both. Furthermore, the data provided by the CPCs have not been systematically raised to the total catches although IOTC Res. 15/02 explicitly calls for data raising and documents describing extrapolation procedures. In the case of swordfish, the geo-referenced catches available for its fisheries are raised by the Secretariat to provide a comprehensive estimation of their distribution, although several assumptions are required to process the data (see section Methods). By contrast, and due to their scarcity, geo-referenced catches for the four other IOTC billfish species were not raised and maps of catch distribution in numbers presented below mainly aim at describing the spatial patterns of the fisheries and should be interpreted with care as the reporting coverage might vary between years and catches only reported in weight are not included in the results.

Swordfish (SWO, *Xiphias gladius*)

The distribution of raised catches for swordfish shows that the species occurs across the entire Indian Ocean, from 45°S to 25°N, and from the coasts off South Africa to the south of Australia (**Fig. 14**). Although catches of swordfish by deep-sea longline fisheries covered a large spatial extent as early as in the 1950s and 1960s, the catch levels of swordfish during this period were much lower than for marlins and Indo-Pacific sailfish. The fishery showed a major increase from the 1980s and was particularly developed during the 1990s and 2000s, with the bulk of the catches coming from longliners operating in the the southwestern and central-westerh Indian Ocean, and from gillnetters and coastal longliners around Sri Lanka and along the eastern coast of India (**Fig. 14**).

Although the longline catches of swordfish have dramatically decreased since the mid-2000s, the general spatial patterns of catches for this fishery group have remained fairly stable in the last decade, with the main catches coming from the southwestern and central tropical Indian Ocean (**Fig. 15**). During this period, catches of swordfish steadily increased for the coastal longliners of Sri Lanka and coastal gillnetters of both Sri Lanka and India, with the Bay of Bengal becoming the main fishing ground for swordfish in recent years (**Fig. 15**).

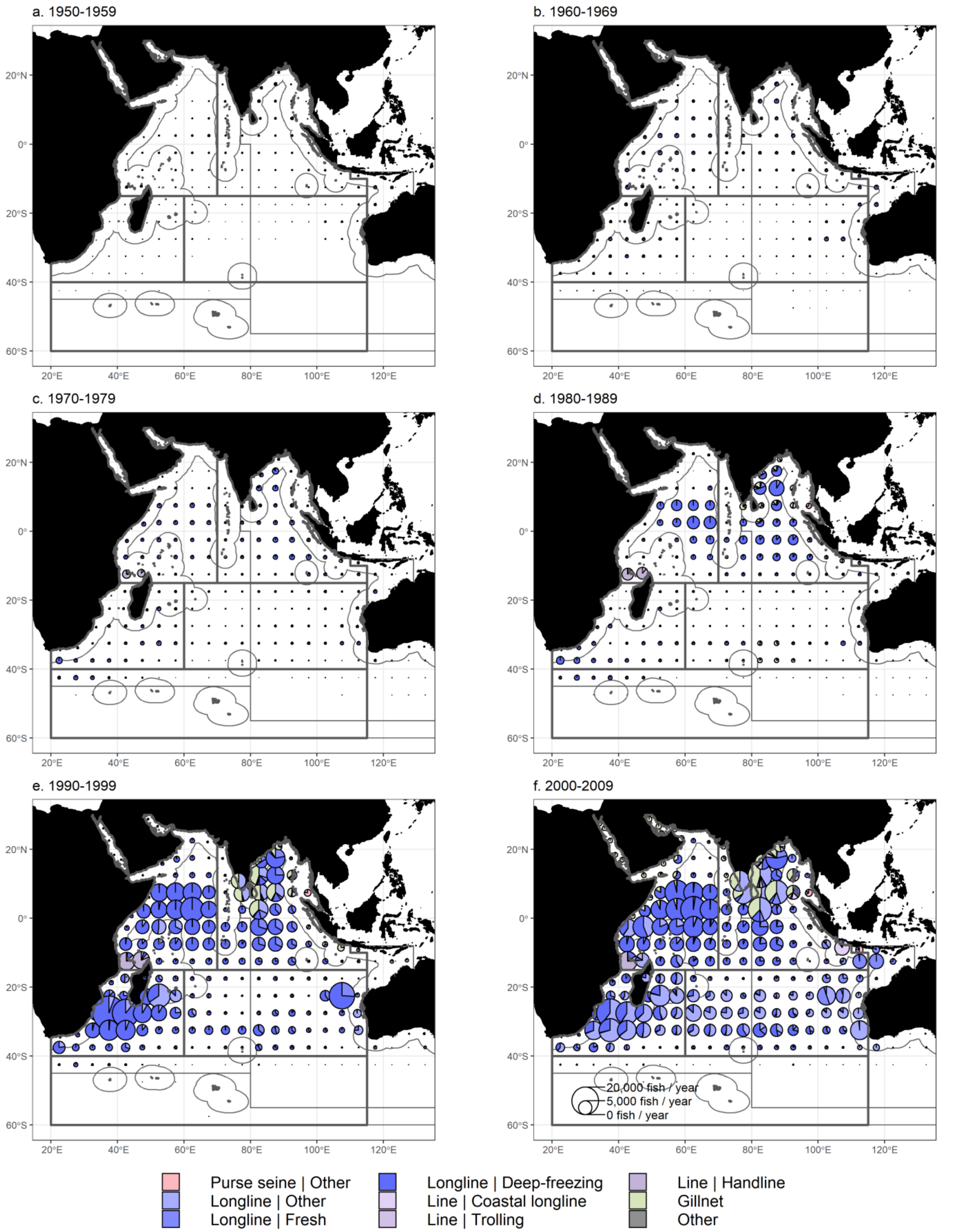

Figure 14: Mean annual time-area catches (in number of fish) of swordfish raised to the nominal catches for the period 1950-2009, by decade and fishery. Black solid lines represent the swordfish stock assessment areas

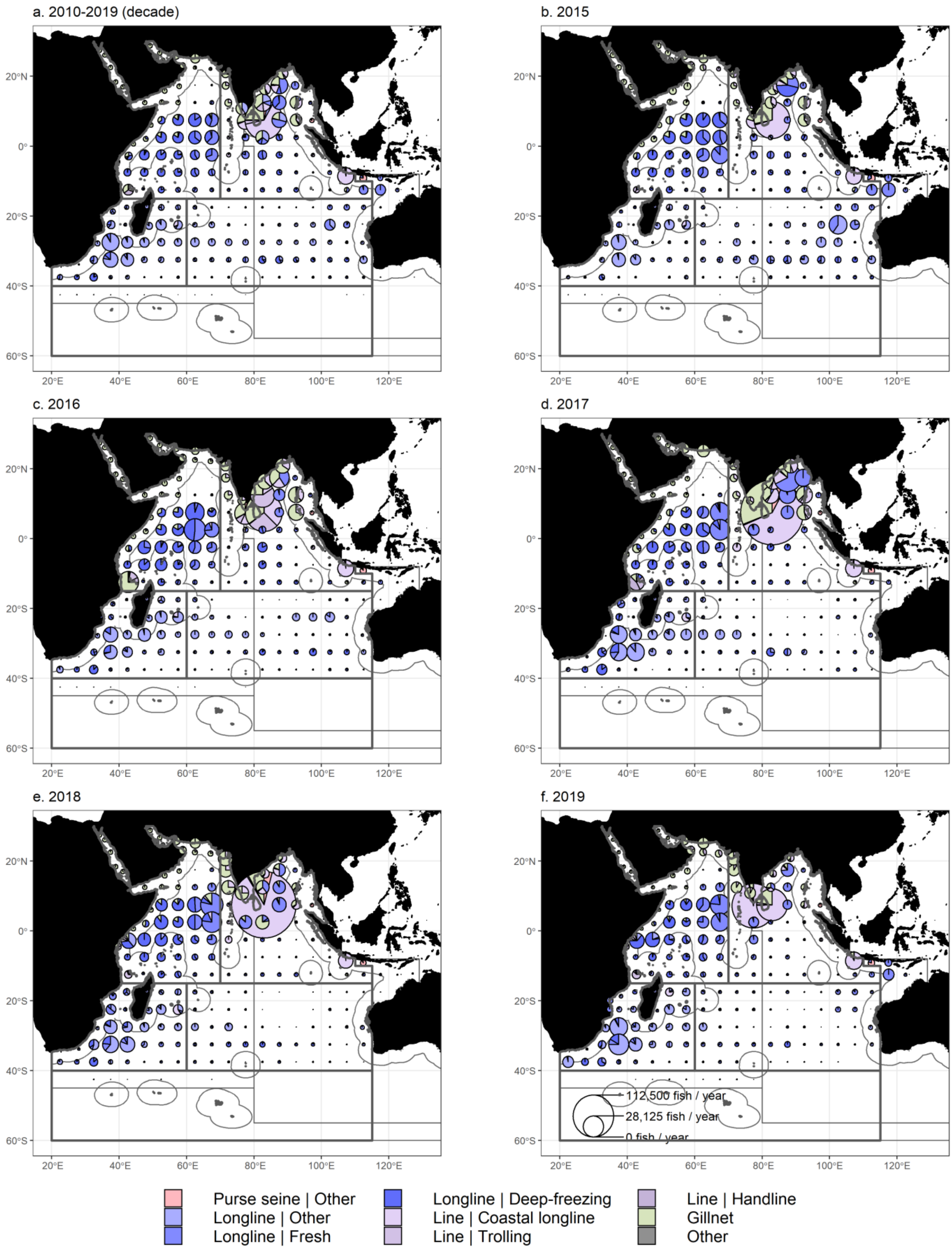

Figure 15: Mean annual time-area catches (in number of fish) of swordfish raised to the nominal catches for the last decade 2010-2019 and each year during the recent period 2015-2019. Black solid lines represent the swordfish stock assessment areas

Black marlin (BLM, *Istiompax indica*)

Black marlin are caught all over the Indian Ocean and information on the distribution of catches for this species is almost exclusively available from longline fisheries between the 1950s and the 2000s, with some geo-referenced catch data by weight available from gillnet and line fisheries over the last decade. Catch data reported by longline fisheries of Japan and Taiwan,China throughout the 1950s and 1960s (and 1970s, to a lesser extent), show a concentration of the catches along the coasts of Indonesia and northwestern part of Australia (**Fig. 16**). The importance of this “hotspot” decreased throughout the following decades, while catch levels started to become particularly high off the coasts of Somalia during the 1990s and 2000s.

In the last decade, reported geo-referenced catches of black marlin caught with longline have been mainly concentrated off the coasts of Somalia and around the Seychelles (**Fig. 17**). However, there has been a major decline in catches of the species during recent years in the area identified as a marlin “hotspot,” with the main longline fishing grounds appearing to be located now more south of the area in 2018-2019 (i.e., between 20°S and the equator and 40-70°E) (**Fig. 17**).

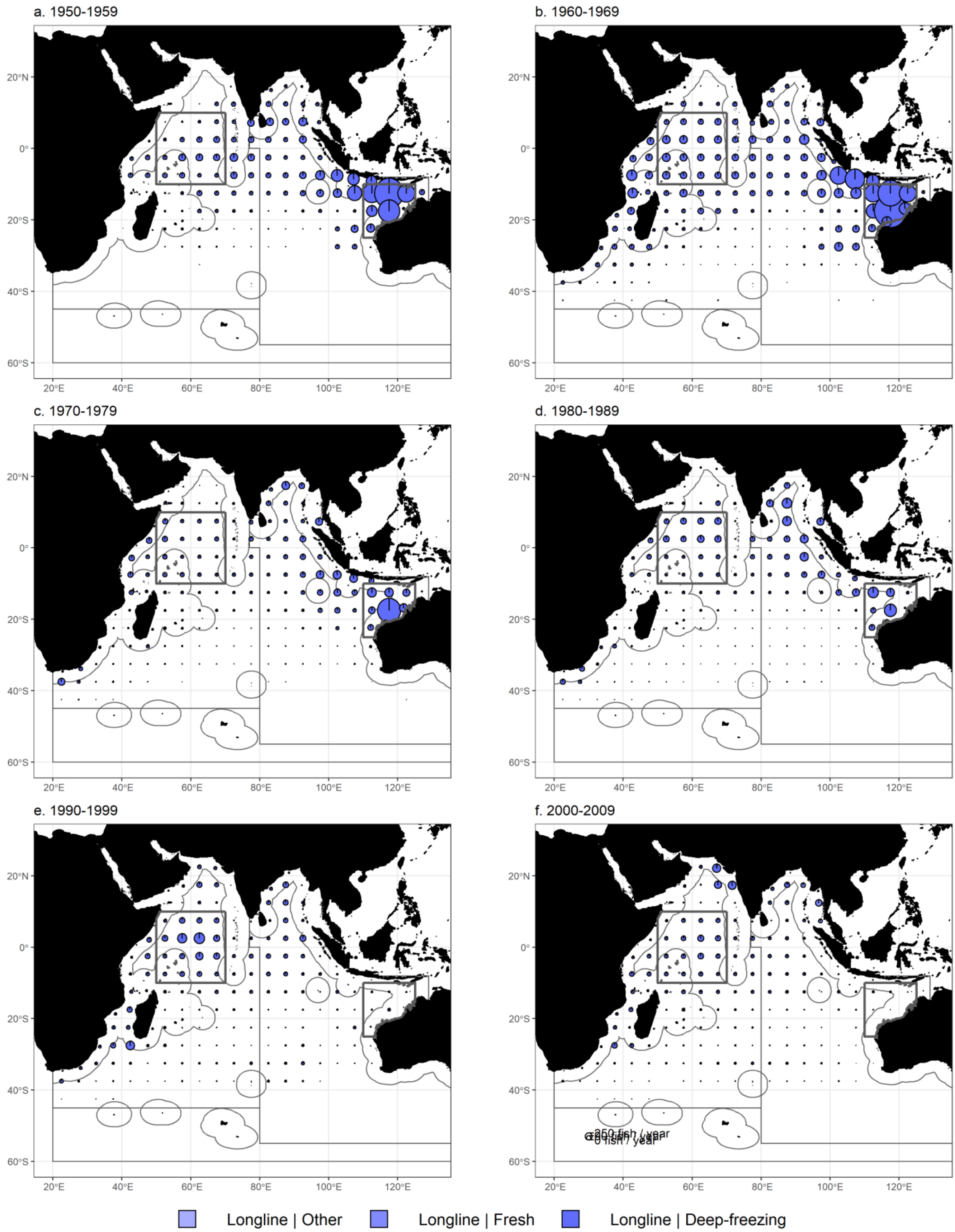

Figure 16: Mean annual time-area catches (in number of fish) of black marlin as reported for the period 1950-2009, by decade and fishery. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

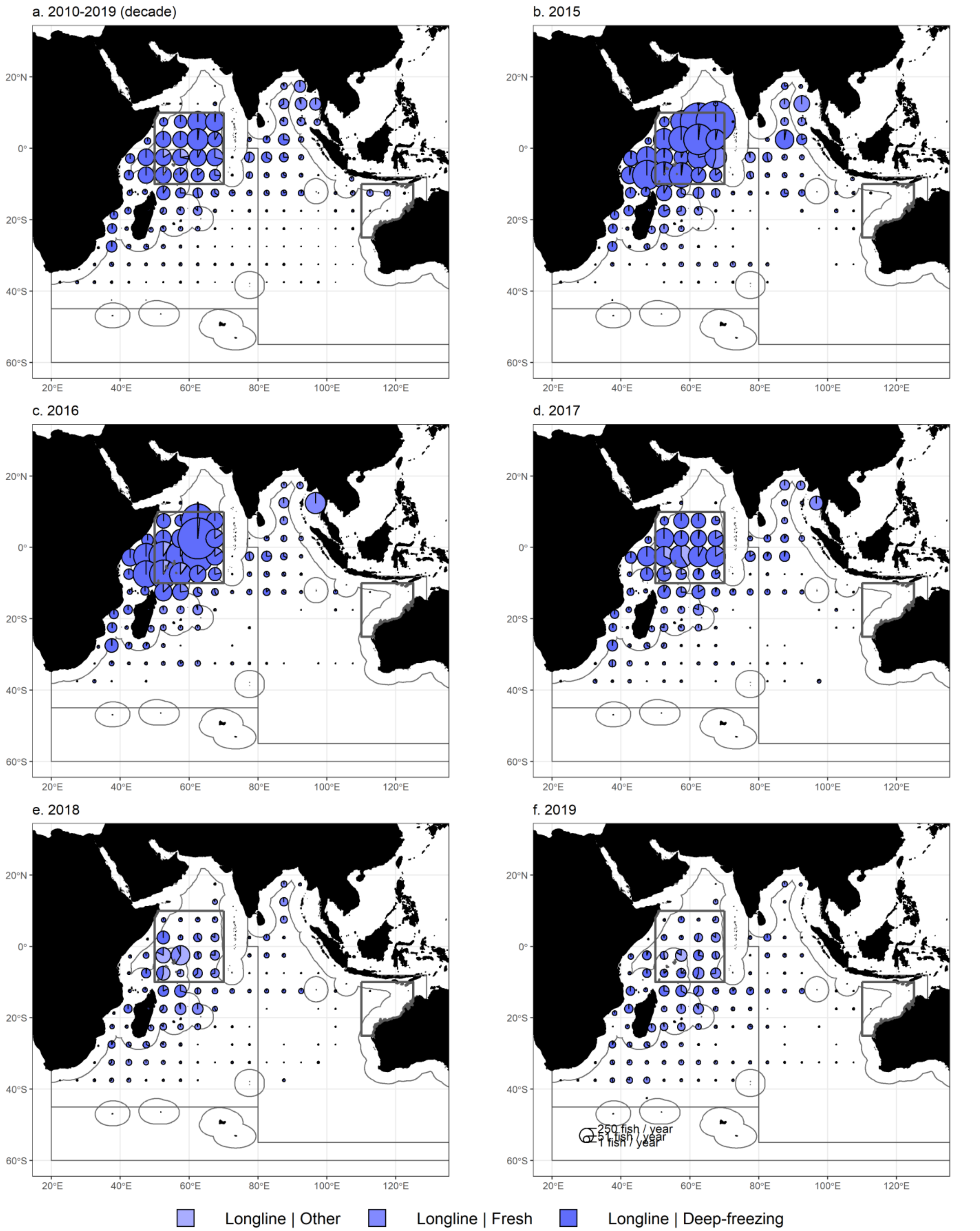

Figure 17: Mean annual time-area catches (in number of fish) of black marlin by fishery as reported for the last decade 2010-2019 and each year during the recent period 2015-2019. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

Blue marlin (BUM, *Makaira nigricans*)

Catches of blue marlin by longline fisheries over several decades show the large spatial extent of the habitat of this species that ranges from 45°S to 20°N latitude and across the whole Indian Ocean, from 20°E to 130°E (**Fig. 18**). As early as the 1950s, catches of blue marlin by Japanese longliners covered a large portion of the Indian Ocean, with the main fishing grounds being located north of 20°S. The fishery expanded throughout the following decades, and catches were particularly high in the "hotspot" area located off the Somalia coast and around Seychelles between the 1980s and 2000s (**Fig. 18**).

In the last decade, catches of blue marlin have remained high in the north-western marlin "hotspot" while they decreased in most other areas of the Indian Ocean (**Fig. 19**), with spatial patterns of the longline fishery remaining fairly stable during the period 2015-2019 (**Fig. 19**).

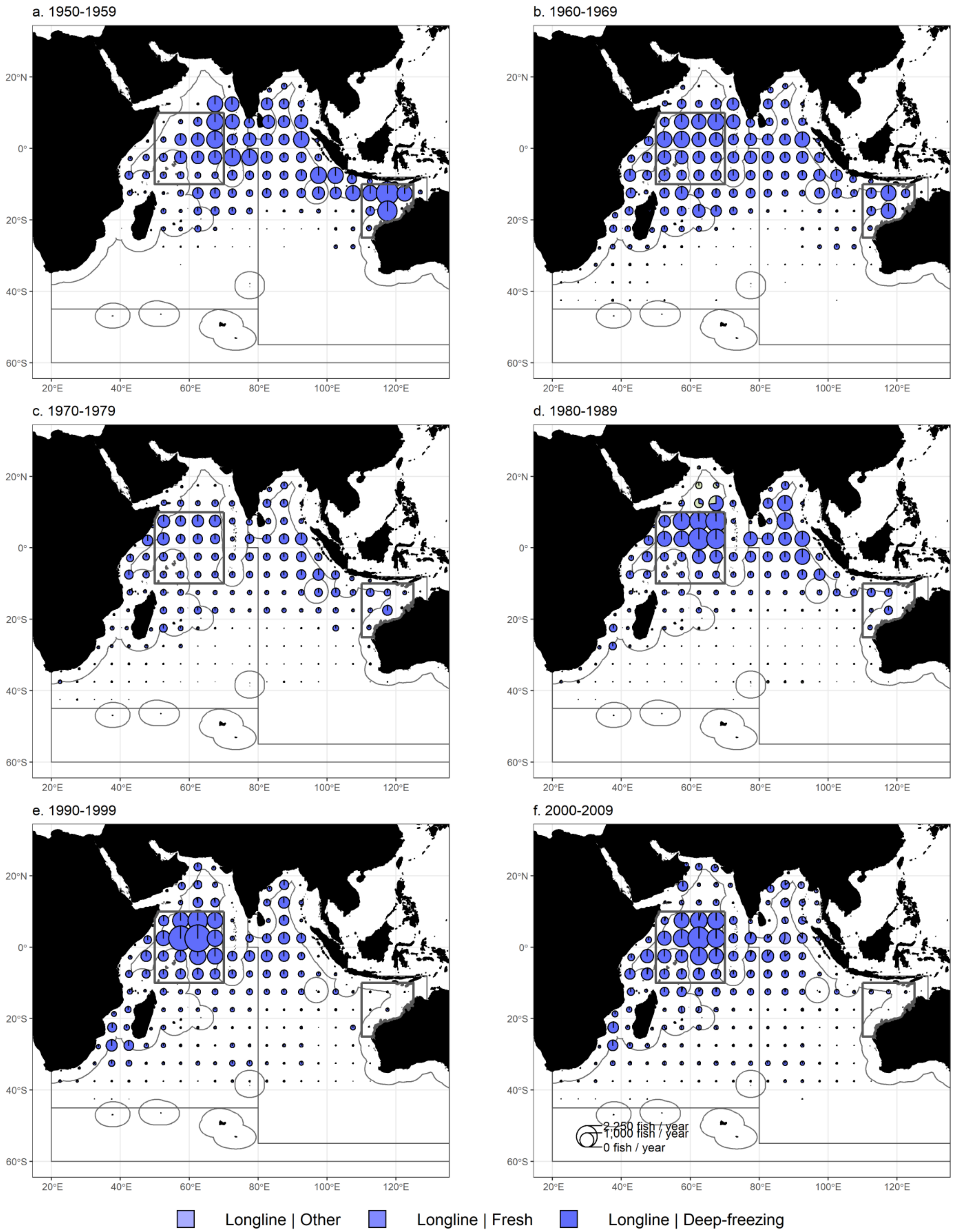

Figure 18: Mean annual time-area catches (in number of fish) of blue marlin as reported for the period 1950-2009, by decade and fishery. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

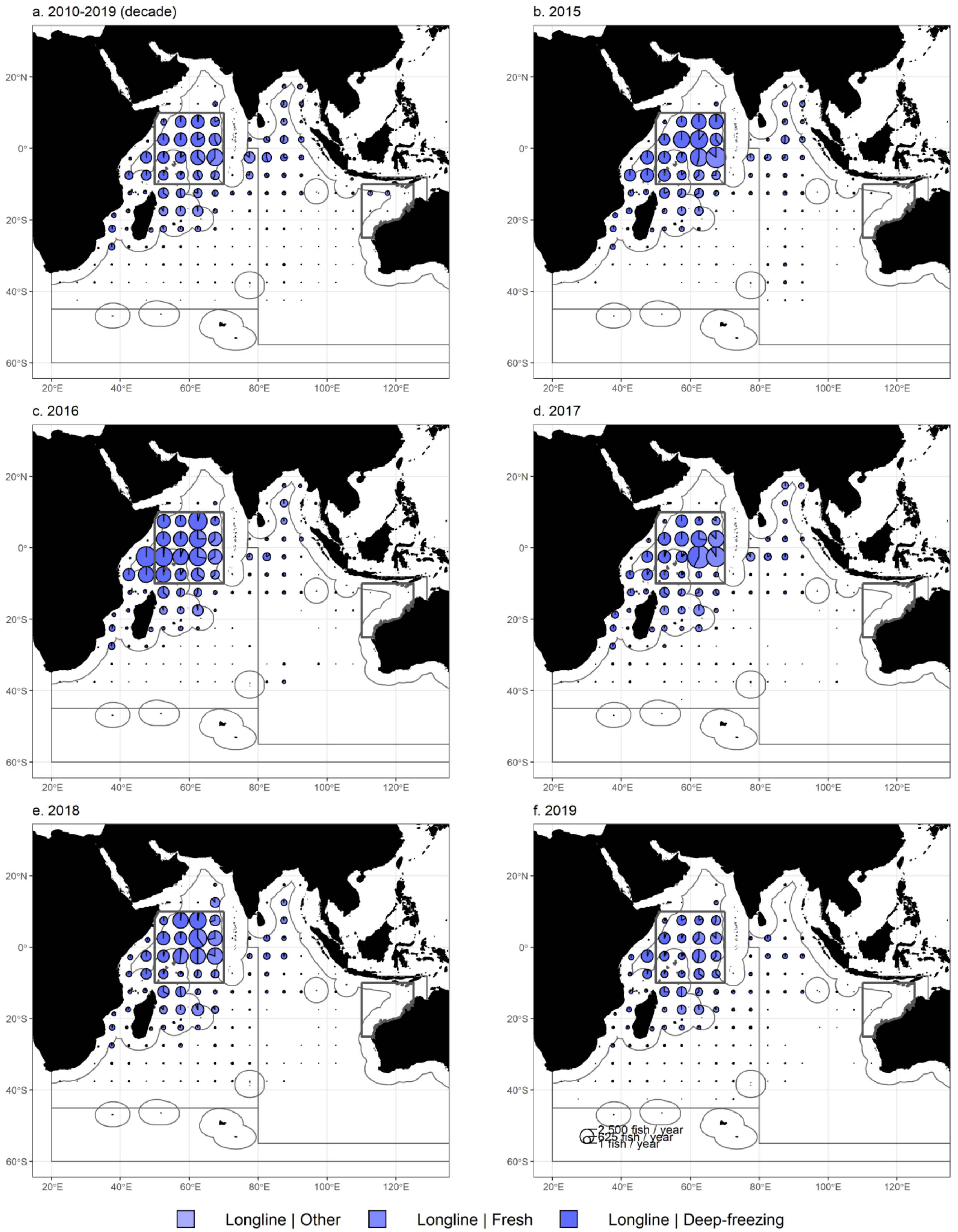

Figure 19: Mean annual time-area catches (in number of fish) of blue marlin by fishery as reported for the last decade 2010-2019 and each year during the recent period 2015-2019. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

Striped marlin (MLS, *Tetrapturus audax*)

As for black and blue marlins, most of the spatial information available on the fishing grounds of striped marlin comes from the geo-referenced catch data reported by the deep-sea longline fisheries which have been operating since the 1950s. The decadal view catches by fishery show that striped marlins also occupy a very large pelagic habitat that covers the entire Indian Ocean. In contrast with the two other marlin species however, data show that longline catches of striped marlin have always been limited east of 100°E and were almost absent from the northwestern Australian "hotspot" of billfish catches (**Fig. 20**). Also, catches of striped marlin were high in the Bay of Bengal from the 1960s to the 1990s and high catches were also reported in the Arabian Sea in the 1990s (and 2000s, to a lesser extent) (**Fig. 20**), while catches of blue and black marlins were overall limited in these two areas of the north of the Indian Ocean (**Figs. 16, 18**).

In the last decade, catches of striped marlin reported by longline fisheries have been mainly located in the western Indian Ocean, along the coasts of Kenya and Somalia in particular (**Fig. 21**). The spatial pattern in catch has not varied much varied between 2015 and 2019, although overall catch levels have decreased substantially between 2016 and 2019.

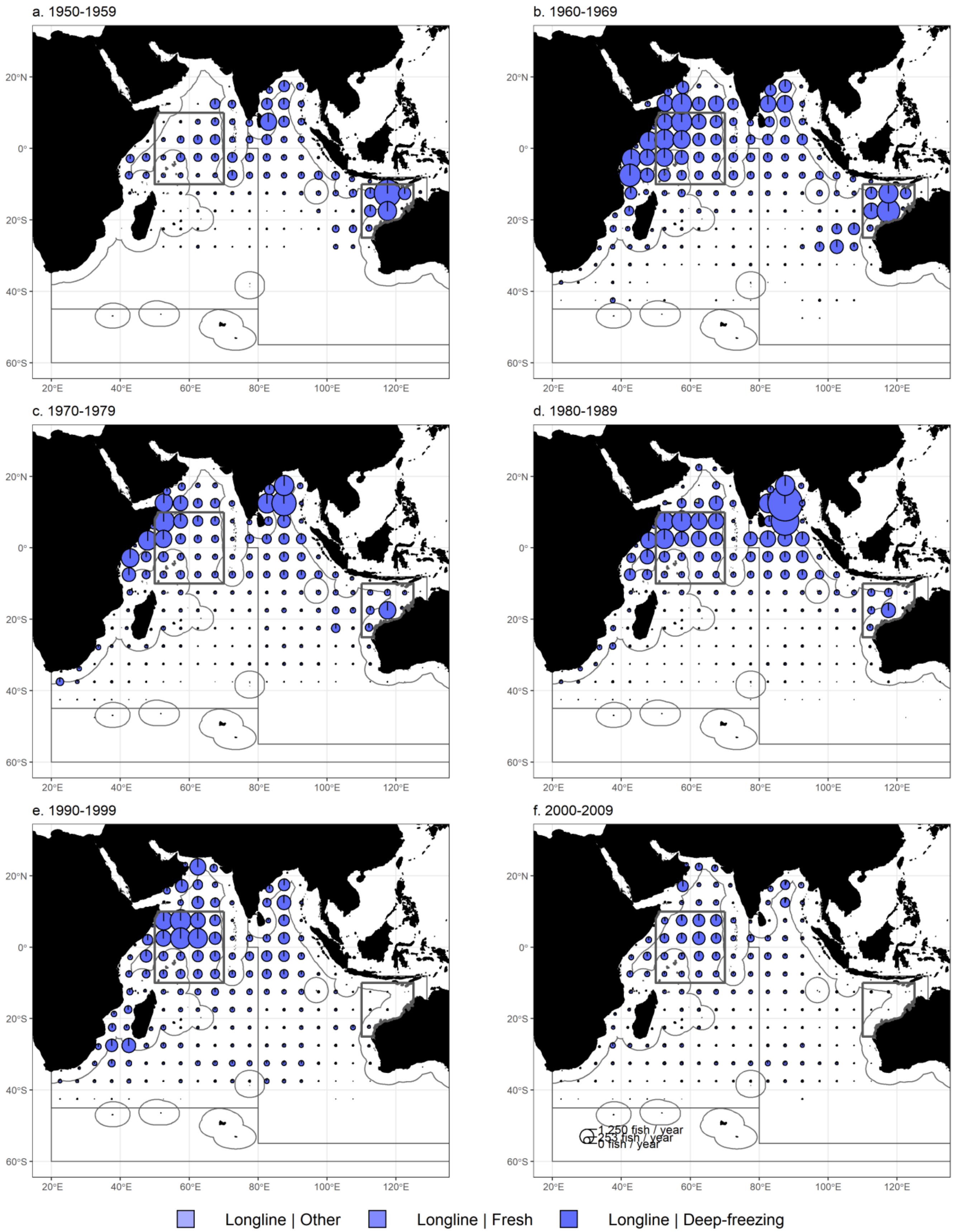

Figure 20: Mean annual time-area catches (in number of fish) of striped marlin as reported for the period 1950-2009, by decade and fishery. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

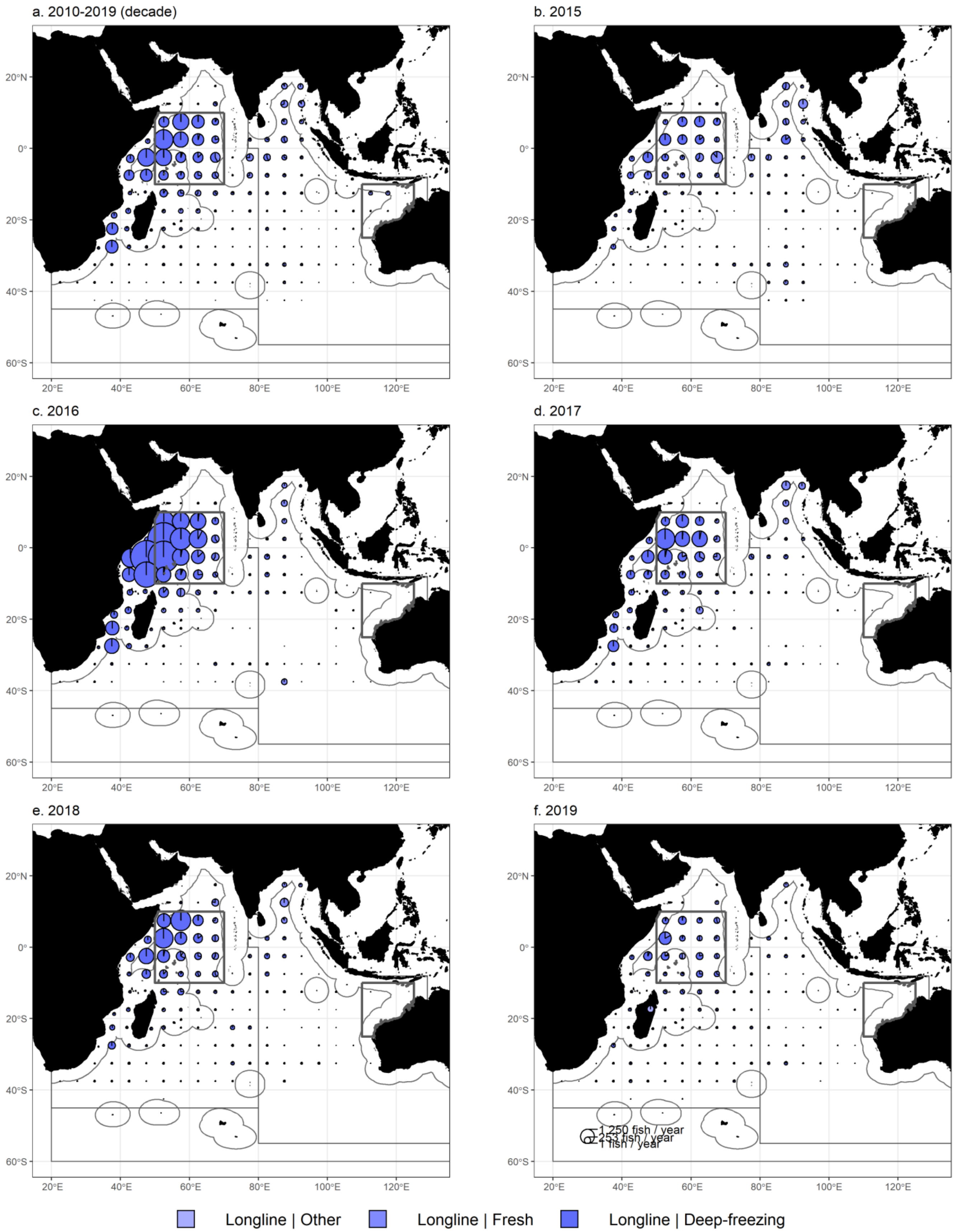

Figure 21: Mean annual time-area catches (in number of fish) of striped marlin by fishery as reported for the last decade 2010-2019 and each year during the recent period 2015-2019. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

Indo-Pacific sailfish (SFA, *Istiophorus platypterus*)

No geo-referenced catch data for Indo-Pacific sailfish are available to the IOTC for the 1950s and 1960s, although deep-sea longline fisheries operated across the entire Indian Ocean during this period. Before 1970, the annual nominal catches of Indo-Pacific sailfish reported for all longline fisheries were less than 1,000 t and this might indicate negligible levels of catch as well as systematic discarding of the species due to an absence of markets. Information on the location of catches of Indo-Pacific sailfish available from 1975 onwards suggests that the extent of their habitat might be smaller than for the other IOTC billfish species. In particular, few occurrences of Indo-Pacific sailfish were found south of 20°S between the 1970s and 2000s, with the notable exception of the south of the Mozambique Channel and along the coasts of South Africa (**Fig. 18**). The general expansion of the longline fishery throughout the 1990s and 2000s saw an increasing concentration of the catches of Indo-Pacific sailfish in the western Indian Ocean, and particularly in the Mozambique Channel (**Fig. 18**).

Although catch levels decreased in the last decade, the overall spatial pattern of the catches of Indo-Pacific sailfish by longliners remained fairly stable between 2015 and 2019, confirming the highest catch levels in the Mozambique Channel (**Fig. 22**). It is to note that the apparent expansion of the longline fishing grounds for Indo-Pacific sailfish observed in 2018-2019 in the western Indian Ocean, in the area south of 20°S and between 40-80°E, is related to an increased level of reporting of geo-referenced catch data for the longline fisheries of China.

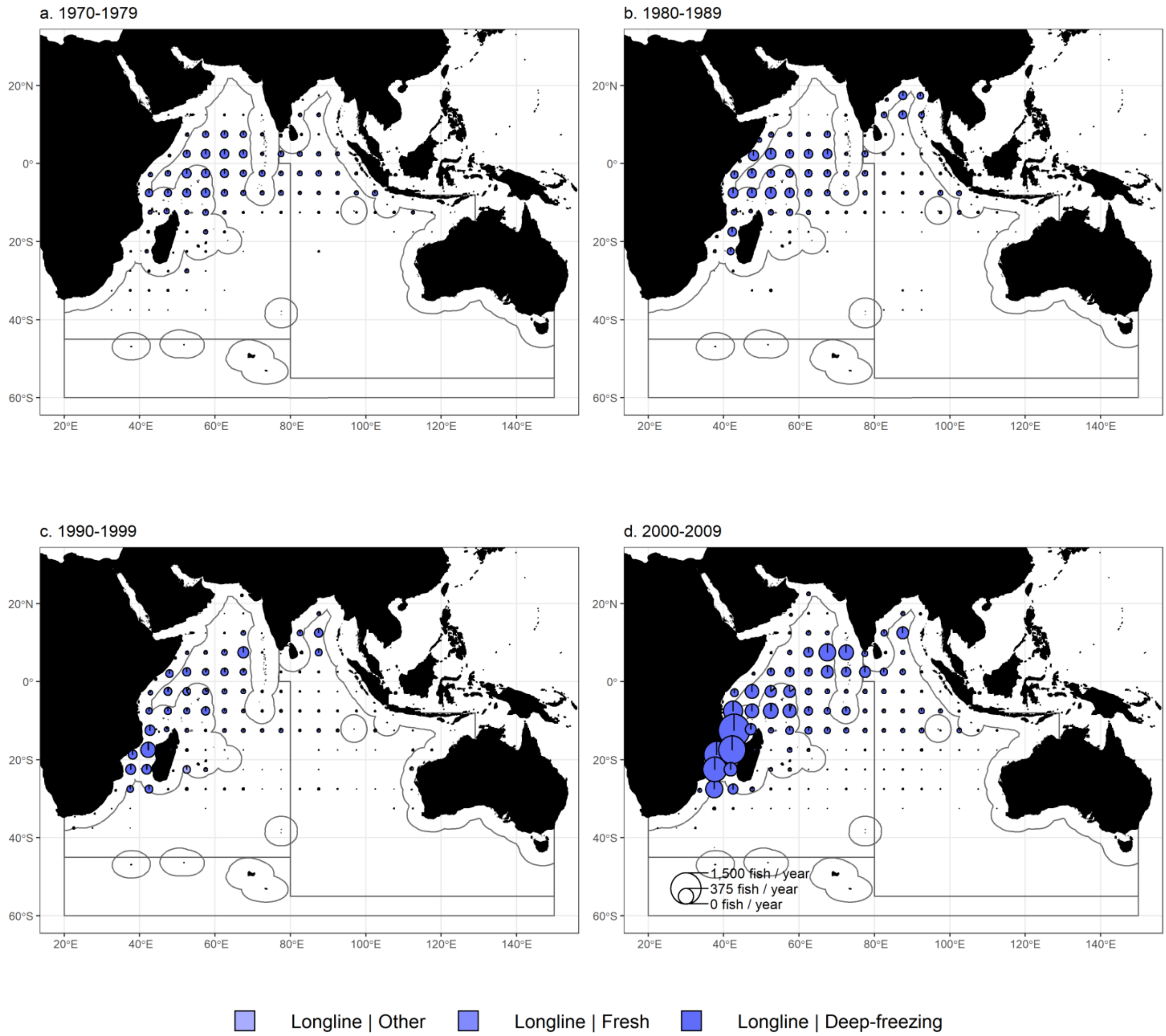

Figure 22: Mean annual time-area catches (in number of fish) of Indo-Pacific sailfish as reported for the period 1970-2009, by decade and fishery

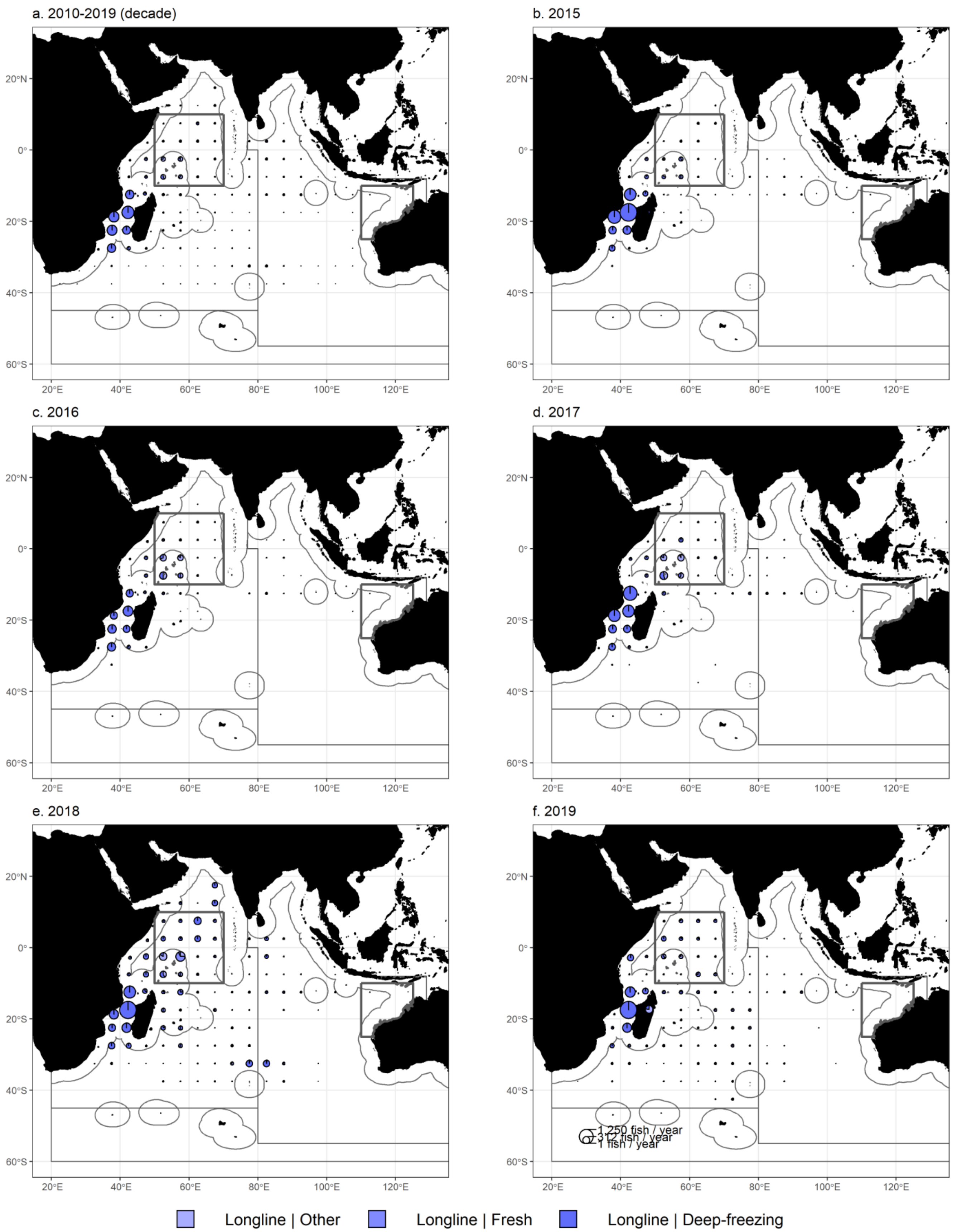

Figure 23: Mean annual time-area catches (in number of fish) of Indo-Pacific sailfish by fishery as reported for the last decade 2010-2019 and each year during the recent period 2015-2019. Black solid lines represent the marlin main longline fishing grounds identified by the IOTC WPB

Uncertainties in geo-referenced catch-effort data

Overall, few geo-referenced data on catch and effort have been reported for billfish species until recent years and most of the available spatial information comes from industrial longline fisheries. Consequently, the general trend in quality is driven by the changes in fishing patterns that occurred in the Indian Ocean over the last decades, and reflects the increased contribution of artisanal fisheries to the total catches of billfish species over time (**Fig. 2**).

Hence, no geo-referenced catches were available for a large part of the nominal catches of billfish species between the 1990s and 2010s (**Fig. 24**), with the percentage of good-quality catch and effort data (scores of 0-2; **Table 3**) decreasing from more than 80% in the late 1950s to a minimum of about 30% in the mid-2000s (**Fig. 24**). The situation has however improved over the last decade with the increasing reporting of catch and effort for some artisanal fisheries (e.g., Indonesia, Sri Lanka), although the logbook coverage used to derive the spatial distribution of the catch for these fisheries is generally reported to be low (<30%).

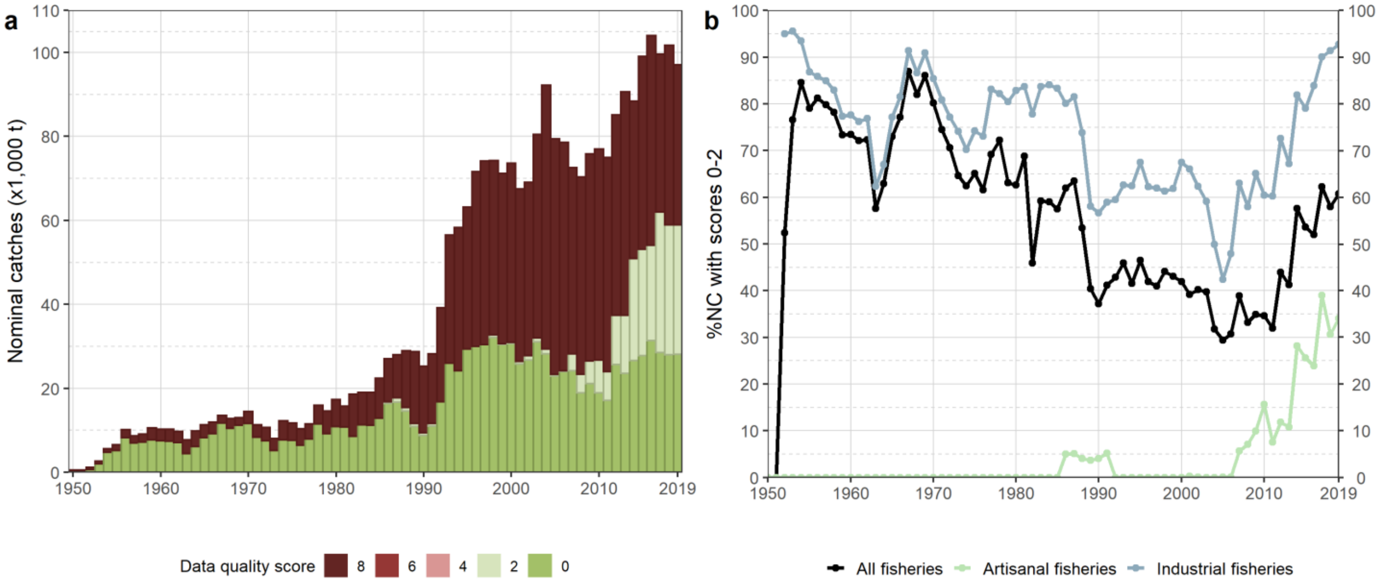

Figure 24: (a) Annual nominal catches of IOTC billfish species in metric tons (t) estimated by quality score and (b) percentage of nominal catches by type of fishery with good quality information (i.e., logbook coverage>30% and compliant with IOTC standards) for the corresponding geo-referenced catch and effort data reported to the IOTC Secretariat

The reporting quality for the geo-referenced catch-effort data greatly varies between species and over time. Indo-Pacific sailfish (SFA) and black marlin (BLM) show the worst quality, with their geo-referenced information missing for a very large proportion of the corresponding nominal catches between the 1990s and 2010s (**Fig. 25**). The situation is the worst for Indo-Pacific sailfish which is mostly caught by artisanal fisheries and for which spatial information is lacking for most of years between 1950 and 2010. For BLM and SFA, minor improvements have been observed over the last decade, with some information reported to the Secretariat even though characterized by a low logbook coverage (<30%). In 2019, the percentage of nominal catches for which some geo-referenced catch data for black marlin and Indo-Pacific sailfish were available was 58.3% and 38.8%, respectively.

The overall reporting quality is better for blue marlin (BUM) and striped marlin (MLS) but it shows a major decrease during the 1990s and 2000s, again in consequence of the increasing contribution of artisanal fisheries to the total catches of marlin species over time. The quality has improved for blue marlin over the last decade, with the percentage of nominal catches with scores of 0-2 reaching 68.4% in 2019. By contrast, the reporting quality for the catch and effort data for striped marlin has steadily decreased since the 1980s because of the concomitant decrease in catches of MLS by longline fisheries, and the increasing catches by gillnet fisheries. In 2019, the fraction of nominal catches described by good quality information for the corresponding geo-referenced catches was 24.2%.

Finally, as was the case with nominal catch data, the quality of swordfish catch and effort data appears to be the best among the IOTC billfish species although showing a decreasing trend between the 1970s and mid-2010s, in relation with the expansion of gillnet and line fisheries from India, Sri Lanka, and Indonesia (**Fig. 25**). The quality of the spatial data has increased in recent years due to the increasing catch by longliners from Taiwan,China and the recent reporting of geo-referenced catch and effort data by Sri Lanka for its coastal longline fishery.

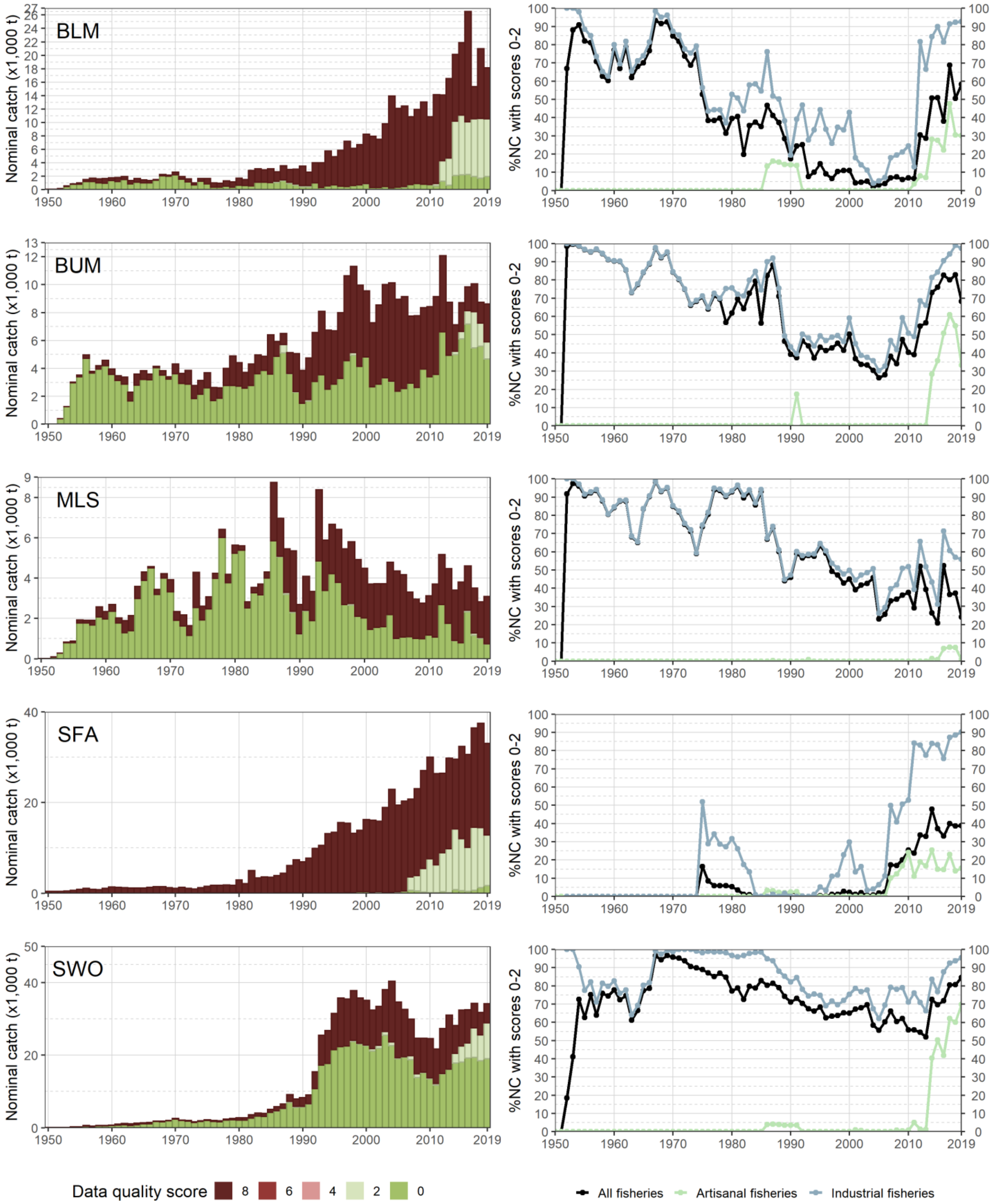

Figure 25: (left panel) Annual nominal catches in metric tons (t) estimated by quality score and (right panel) percentage of nominal catches by type of fishery with good-quality information (quality score of 0-2) for the geo-referenced catches reported to the IOTC Secretariat for each IOTC billfish species

In addition to the issues in reporting, conflicting catch reports have been observed for some fisheries. In particular, nominal catches from the deep-sea longline fishery of the Republic of Korea are in conflict with the catch-and-effort information reported for the same fleet, with the latter appearing higher than the former. For this reason, the Secretariat revised the catches of black marlin for the Republic of Korea over the time-series using both data sets and although the new catches estimated by the Secretariat are thought to be more accurate, catches of black marlin remain uncertain for this fleet.

Size distribution and estimated average weights

Temporal patterns and trends in size distribution

Swordfish (SWO, *Xiphias gladius*)

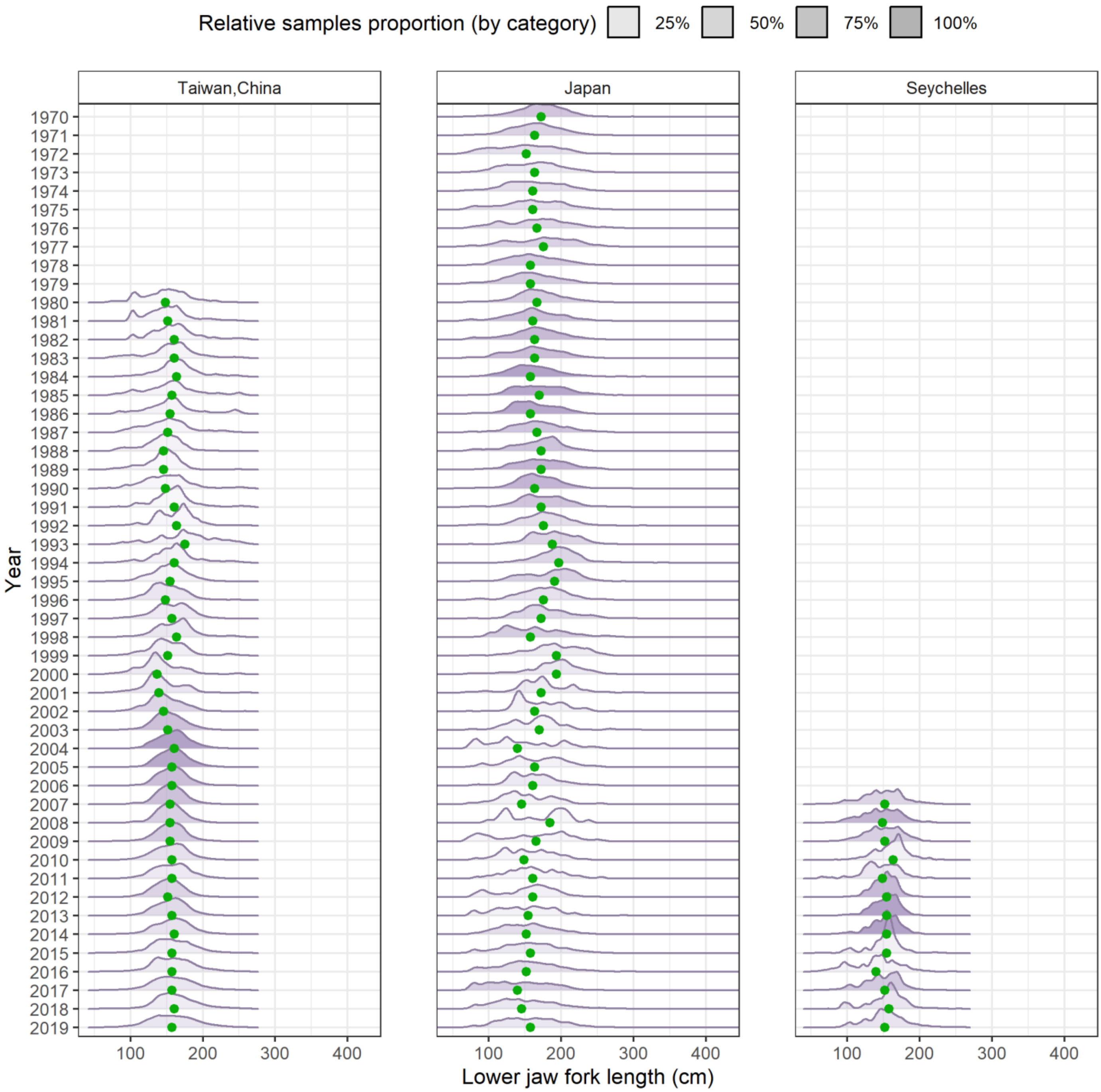

Figure 26: Yearly reported swordfish length-frequency data (lower jaw fork length) for the deep-freezing longline fisheries of Taiwan,China, Indonesia, Mauritius, and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

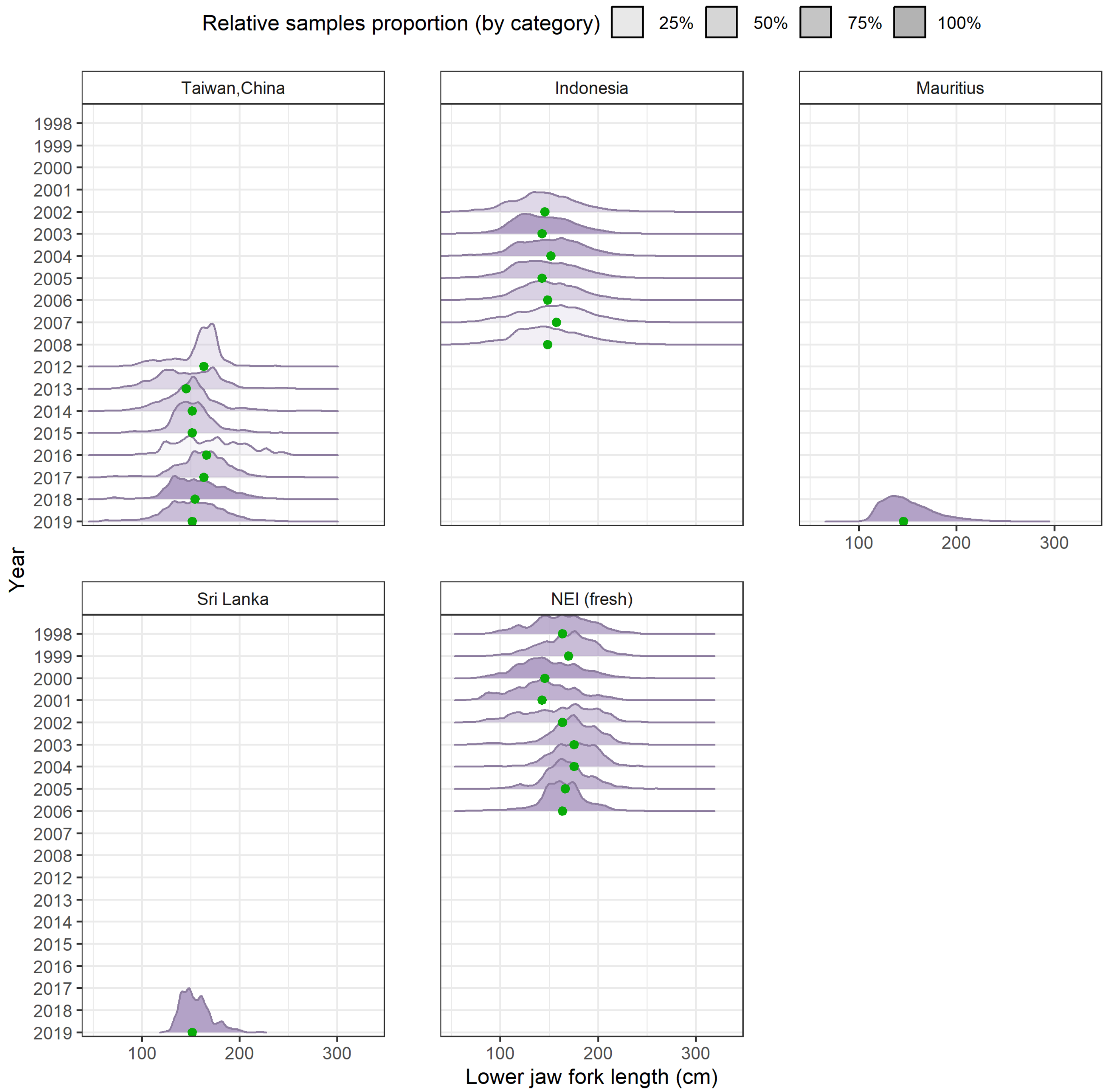

Figure 27: Yearly reported swordfish length-frequency data (lower jaw fork length) for the fresh tuna longline fisheries of Taiwan,China, Japan and Seychelles. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset] (Res. 15/02)

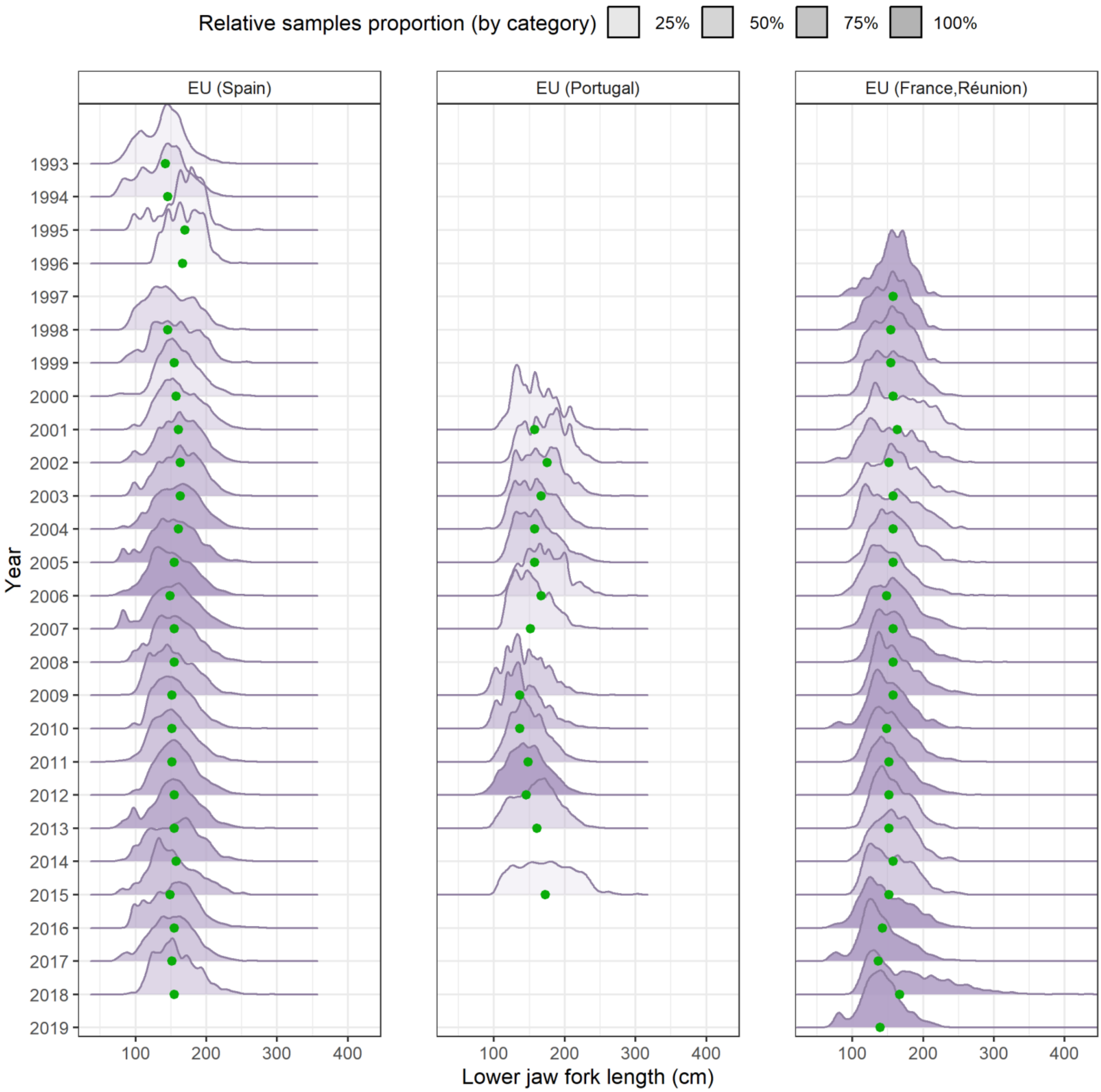

Figure 28: Yearly reported swordfish length-frequency data (lower jaw fork length) for the swordfish-targeting fisheries of EU,Spain, EU,Portugal and EU,France (Réunion based). Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

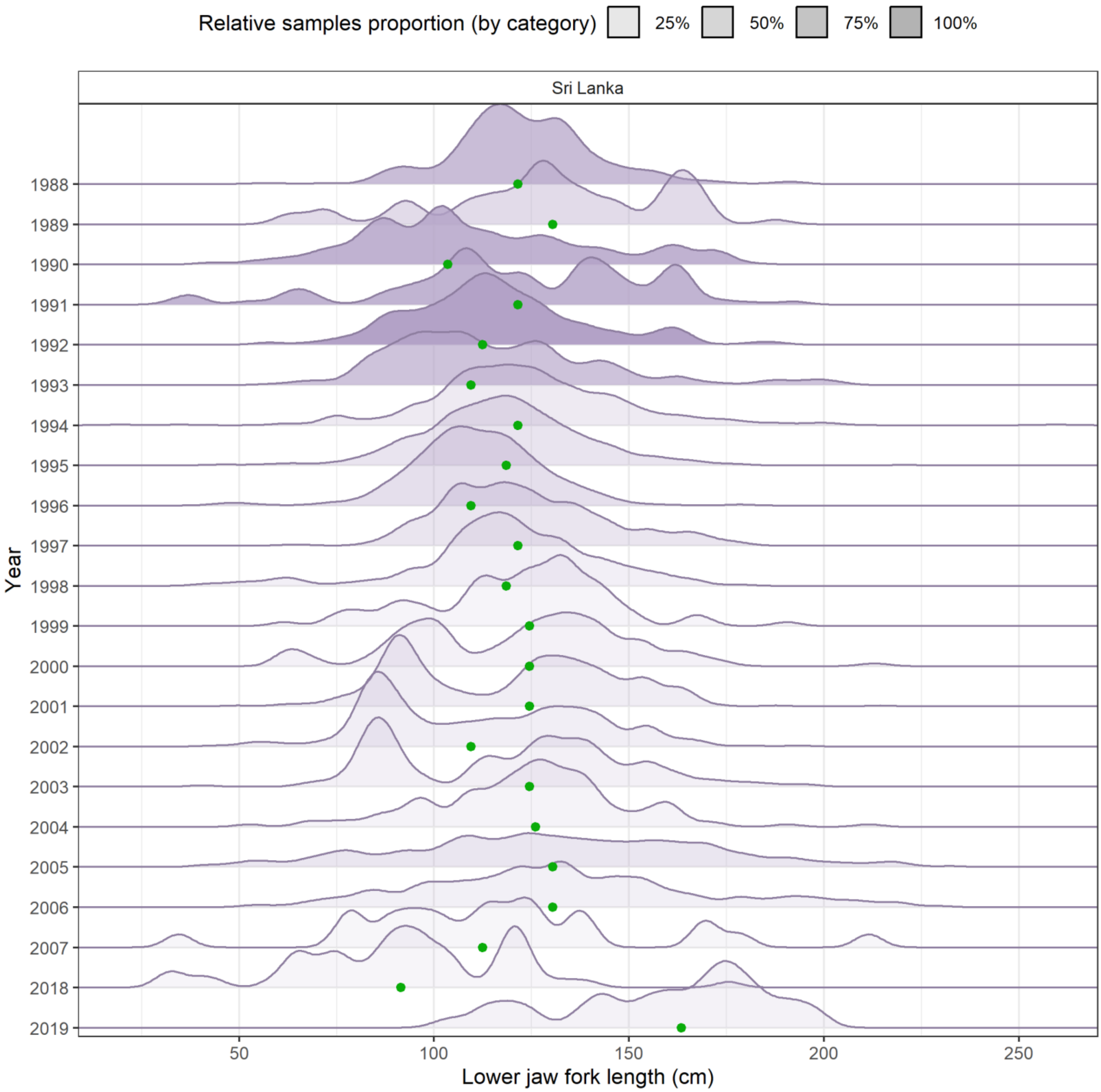

Figure 29: Yearly reported swordfish length-frequency data (lower jaw fork length) for the gillnet fisheries of Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

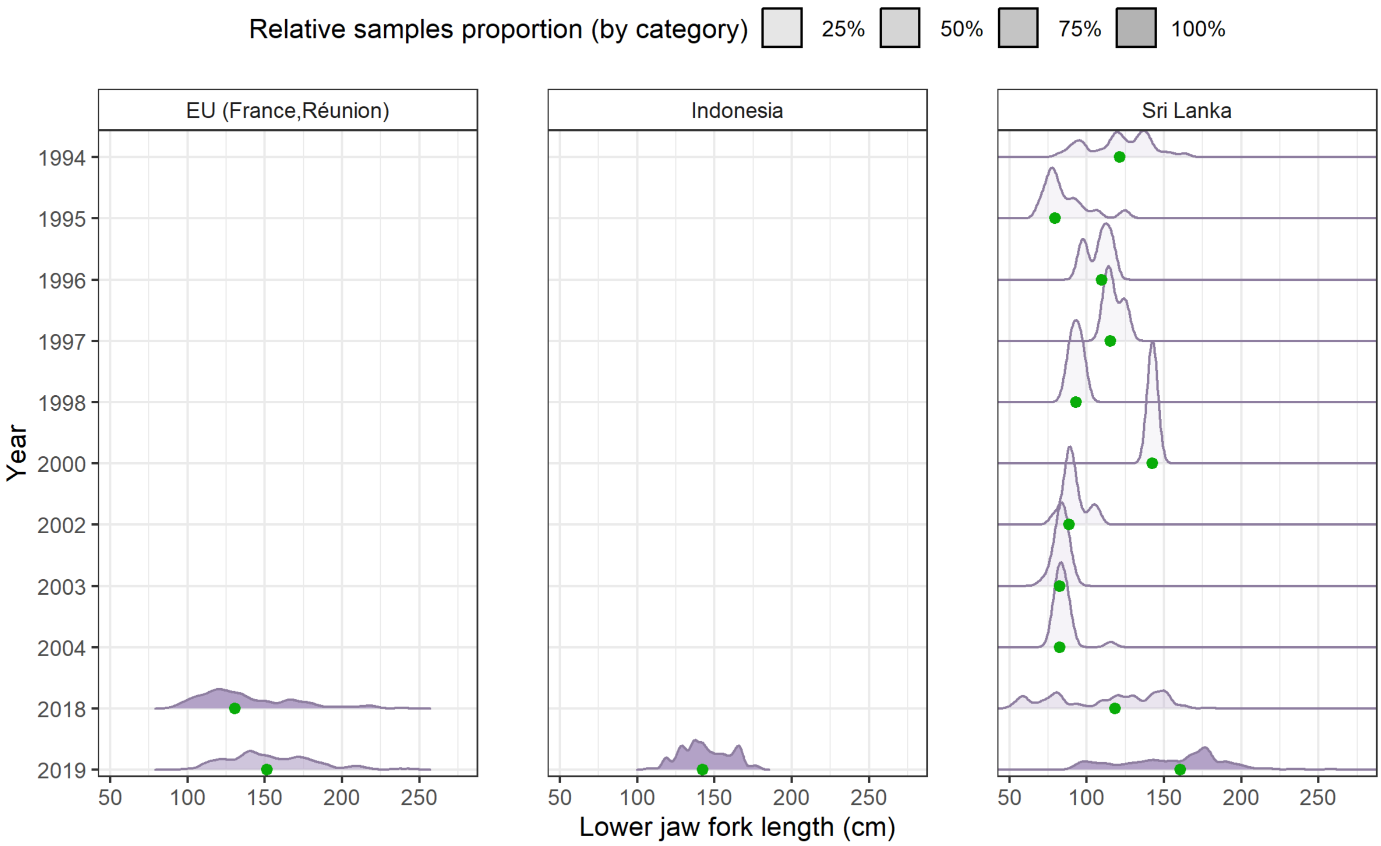

Figure 30: Yearly reported swordfish length-frequency data (lower jaw fork length) for the line fisheries of EU,France (Réunion based), Indonesia and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset](#) (Res. 15/02)

Black marlin (BLM, *Istiompax indica*)

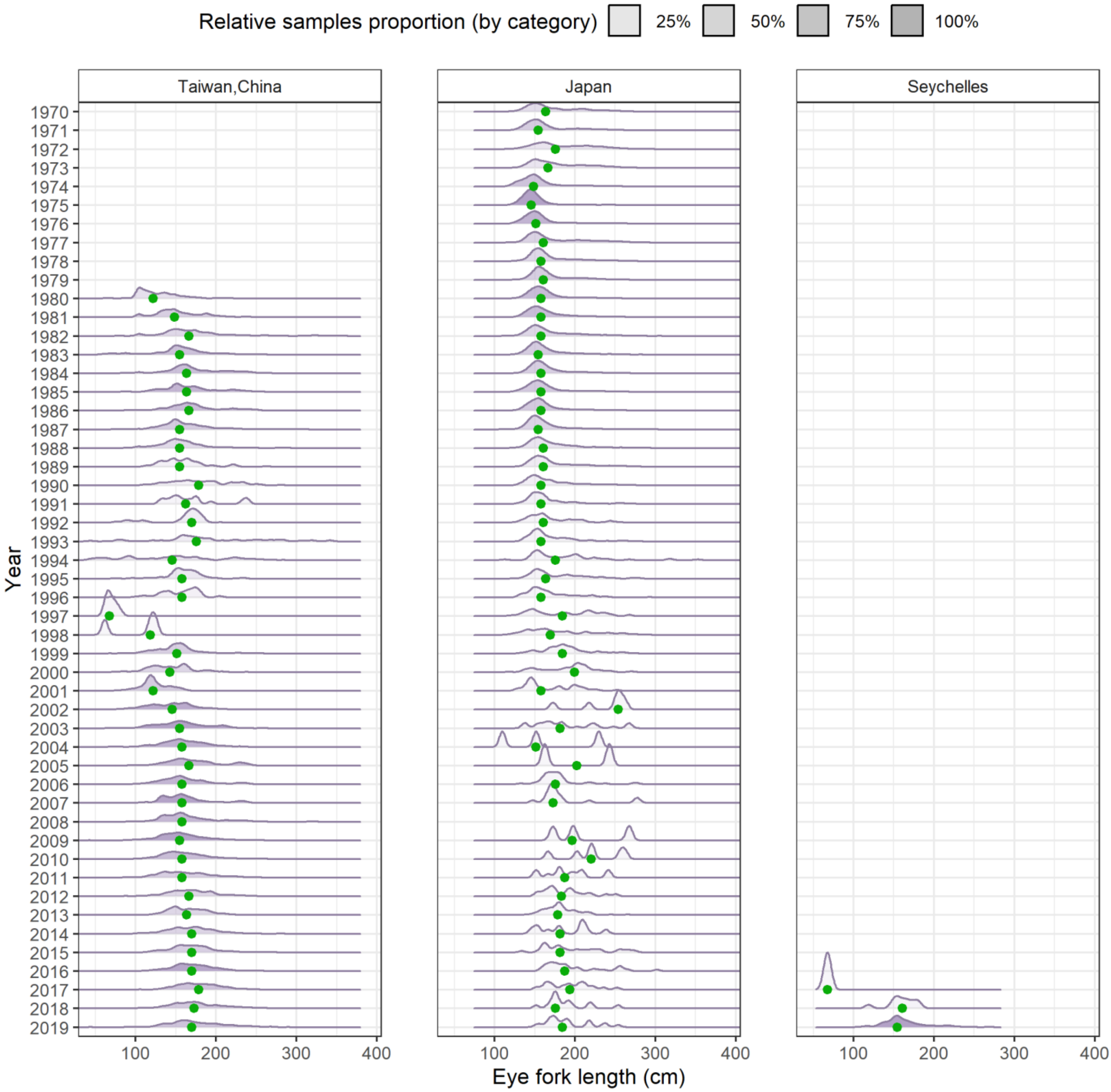

Figure 31: Yearly reported black marlin length-frequency data (eye fork length) for the deep-freezing longline fisheries of Taiwan,China, Japan and Seychelles. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

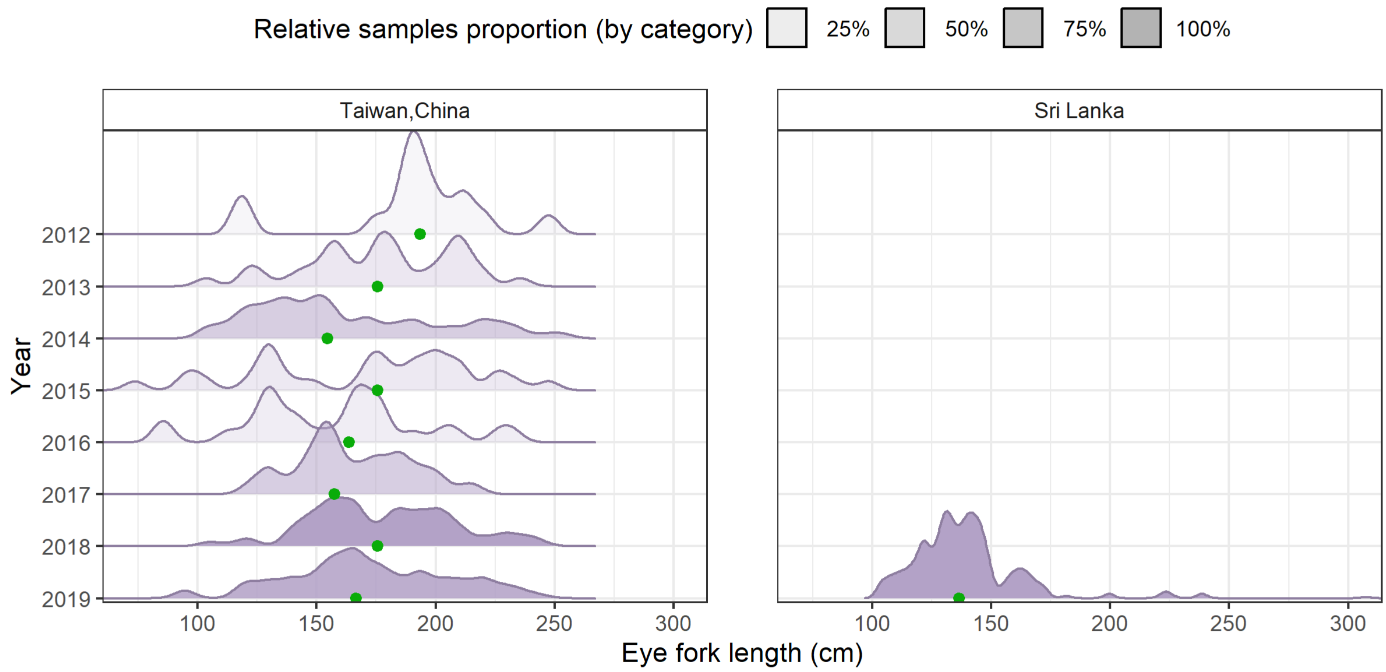

Figure 32: Yearly reported black marlin length-frequency data (eye fork length) for the fresh tuna longline fisheries of Taiwan,China and Sri Lanka Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

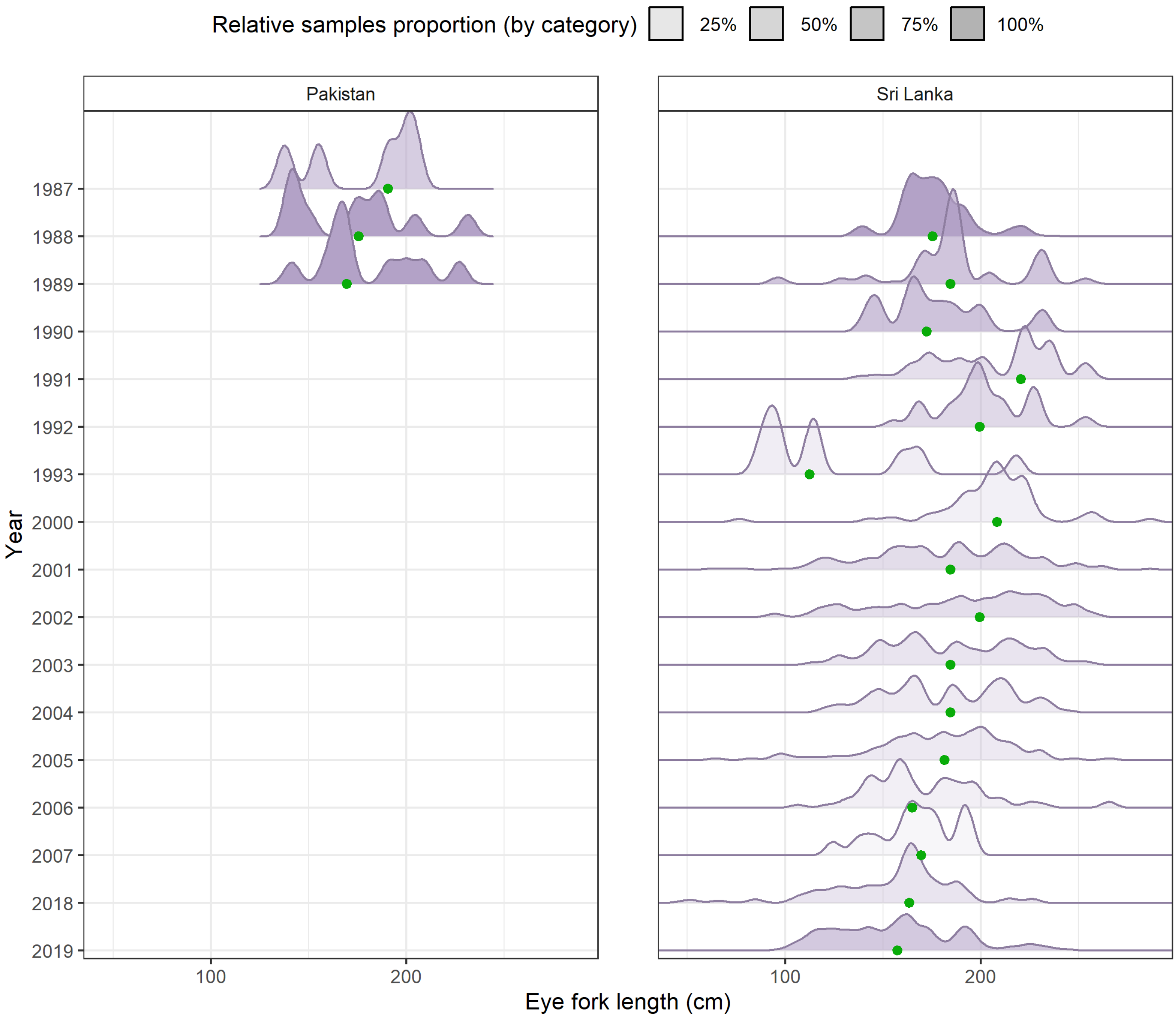

Figure 33: Yearly reported black marlin length-frequency data (eye fork length) for the gillnet fisheries of Pakistan and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset]() (Res. 15/02)

Blue marlin (BUM, *Makaira nigricans*)

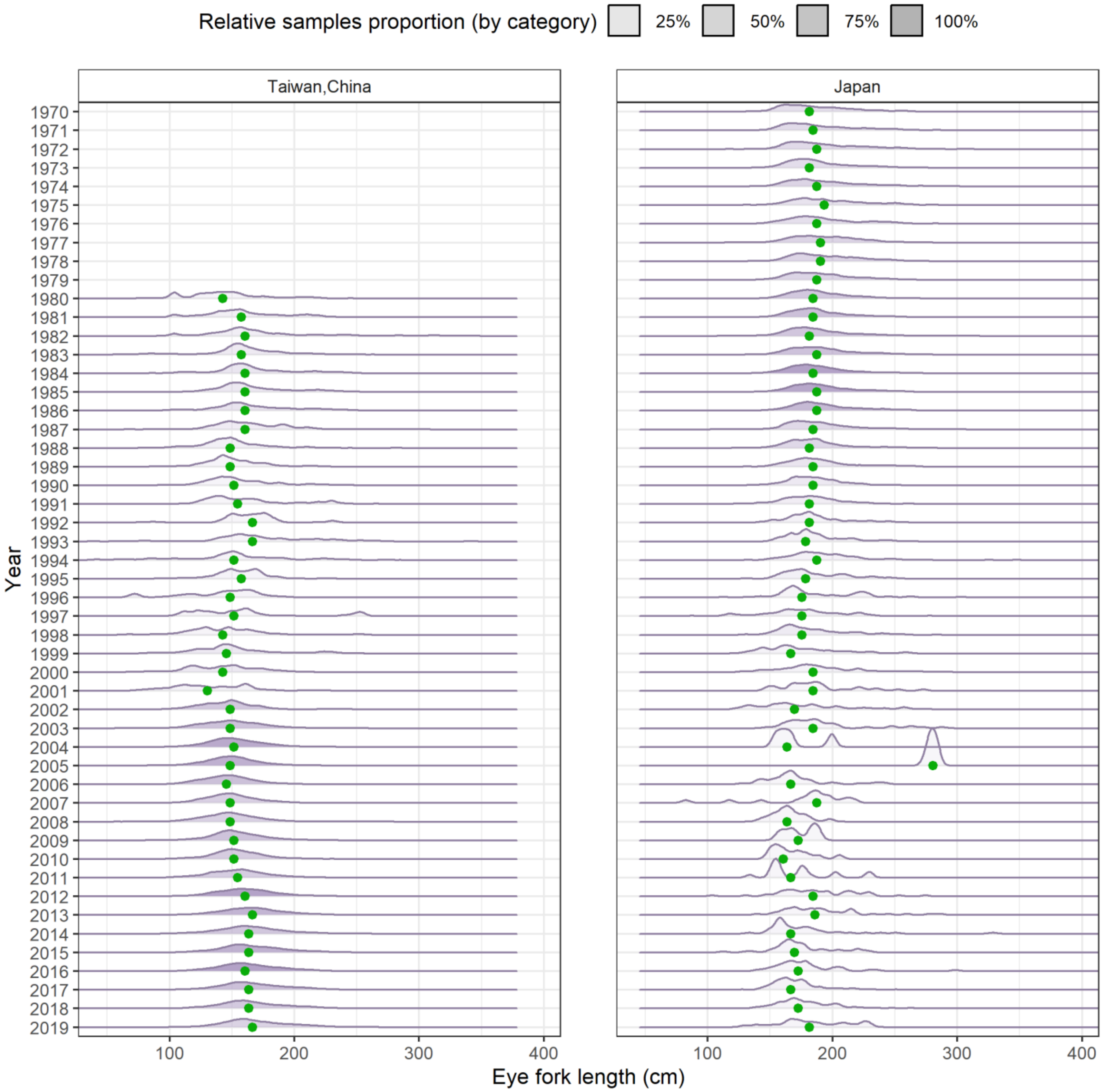

Figure 34: Yearly reported blue marlin length-frequency data (eye fork length) for the deep-freezing longline fisheries of Taiwan,China and Japan. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

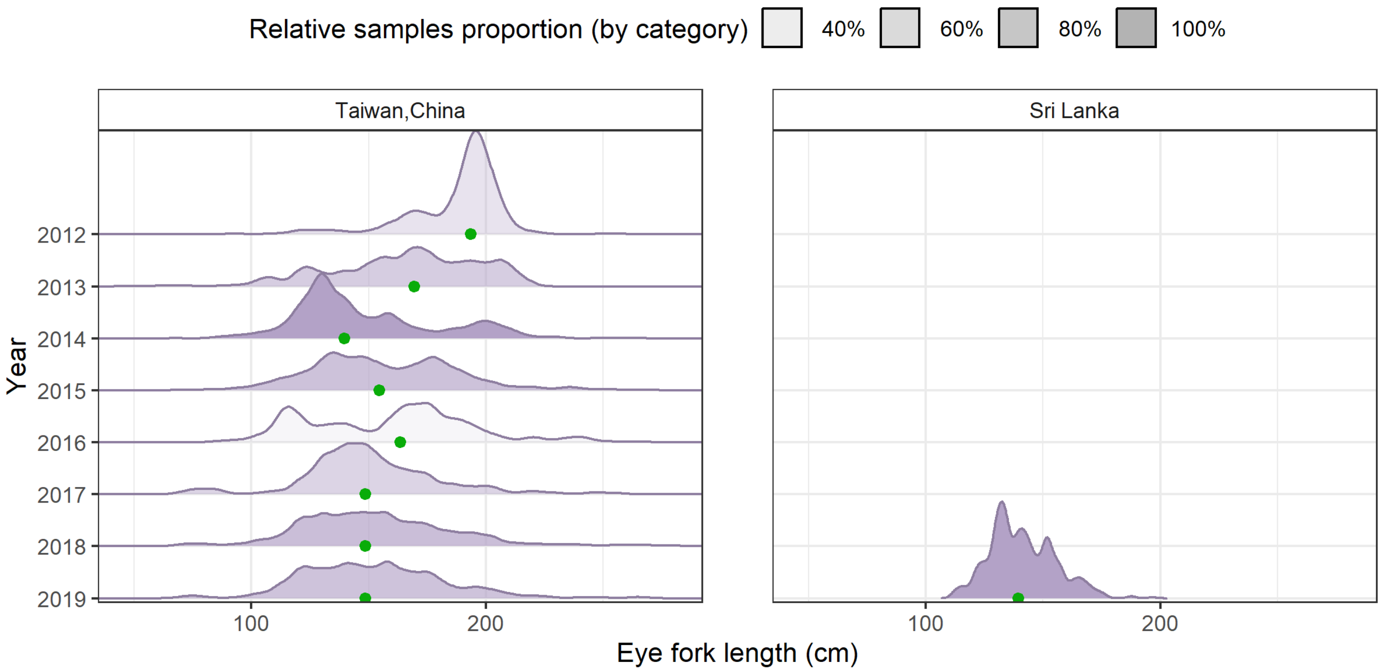

Figure 35: Yearly reported blue marlin length-frequency data (eye fork length) for the fresh tuna longline fisheries of Taiwan,China and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

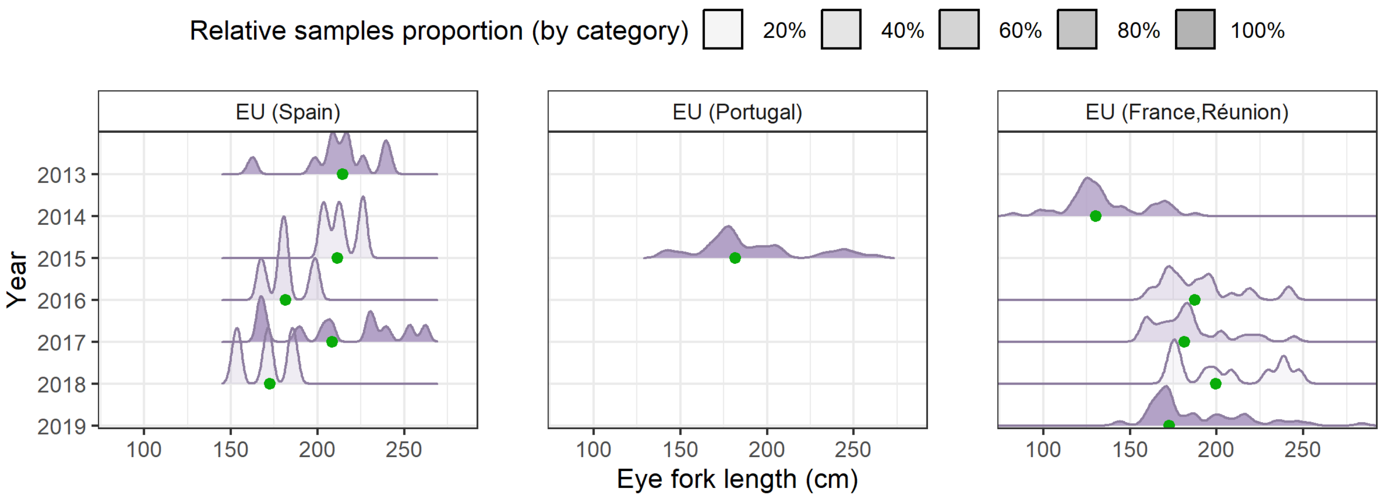

Figure 36: Yearly reported blue marlin length-frequency data (eye fork length) for the swordfish-targeting fisheries of EU,Spain, EU,Portugal and EU,France (Réunion based). Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

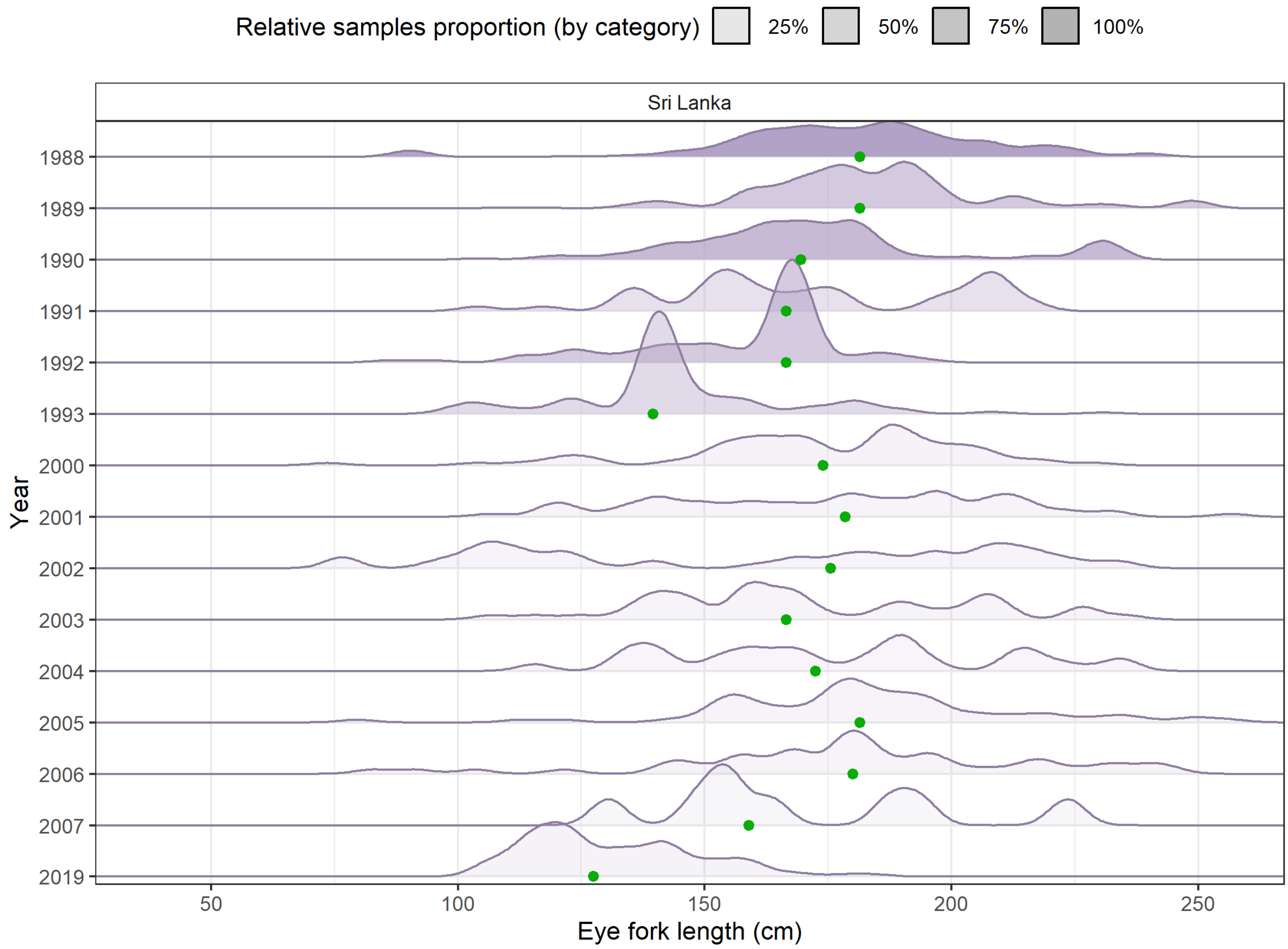

Figure 37: Yearly reported blue marlin length-frequency data (eye fork length) for the gillnet fisheries of Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset](#) (Res. 15/02)

Striped marlin (MLS, *Tetrapturus audax*)

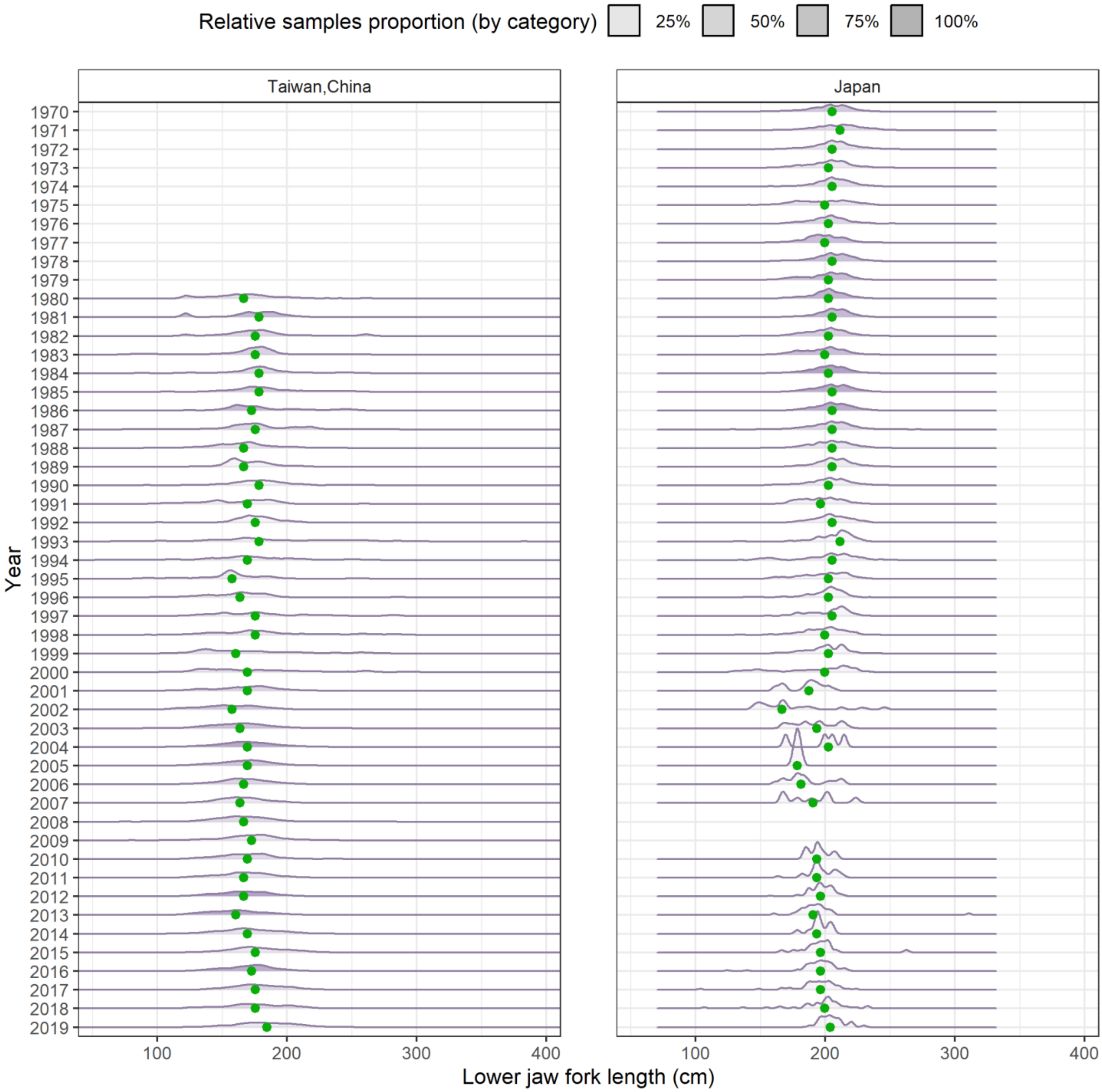

Figure 38: Yearly reported striped marlin length-frequency data (lower jaw fork length) for the deep-freezing longline fisheries of Taiwan,China and Japan. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

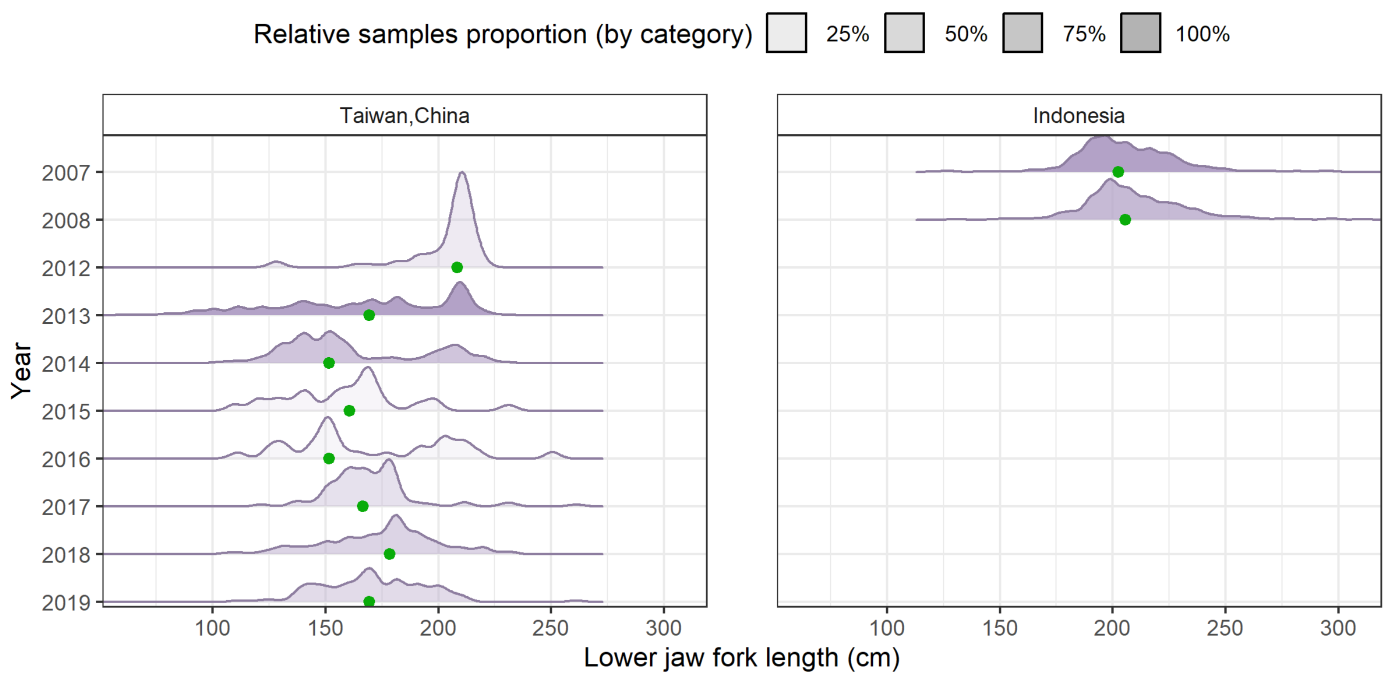

Figure 39: Yearly reported striped marlin length-frequency data (lower jaw fork length) for the fresh tuna longline fisheries of Taiwan,China and Indonesia. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset](#) (Res. 15/02)

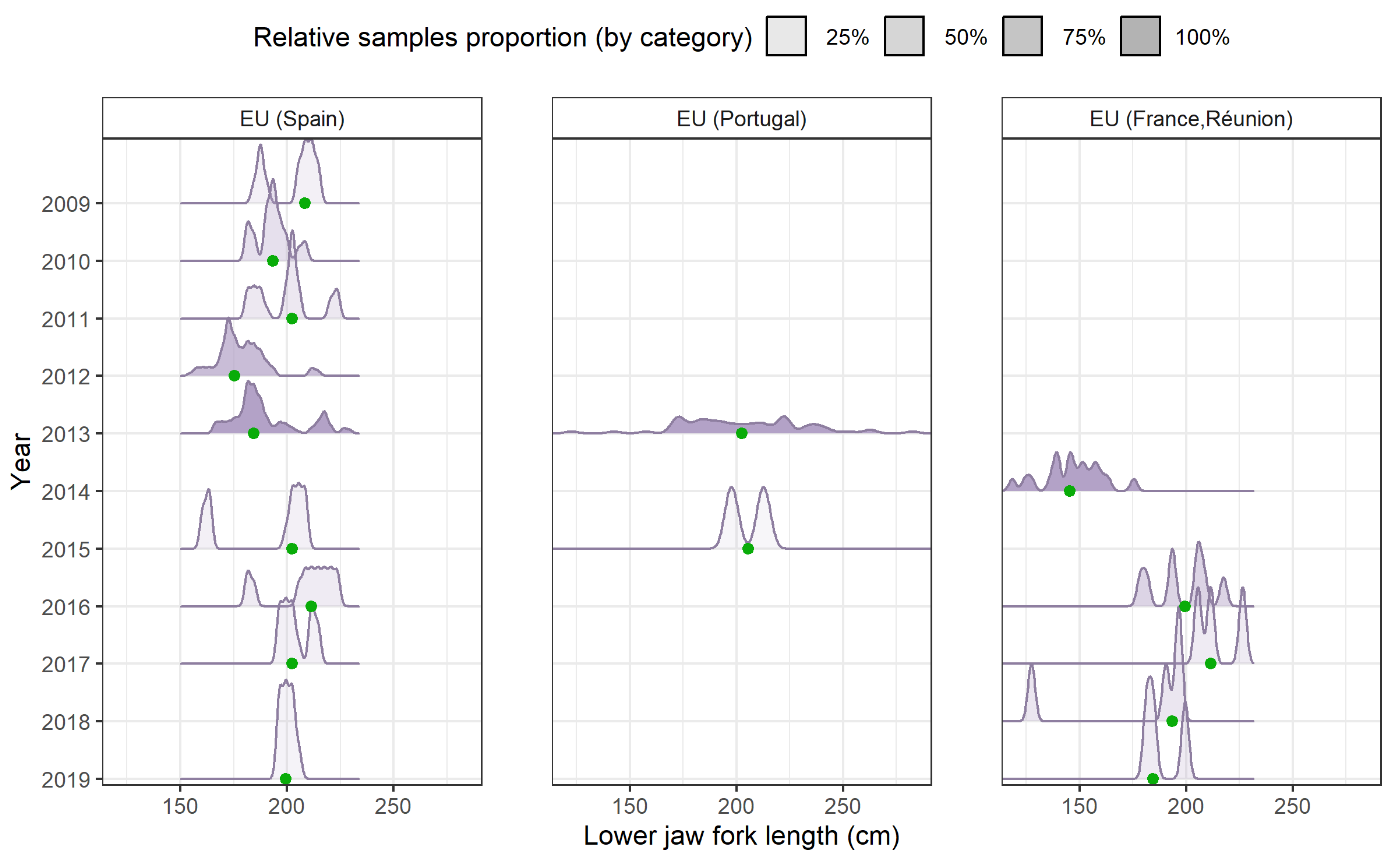

Figure 40: Yearly reported striped marlin length-frequency data (lower jaw fork length) for the swordfish-targeting fisheries of EU,Spain, EU,Portugal and EU,France (Réunion based). Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset](#) (Res. 15/02)

Indo-Pacific sailfish (SFA, *Istiophorus platypterus*)

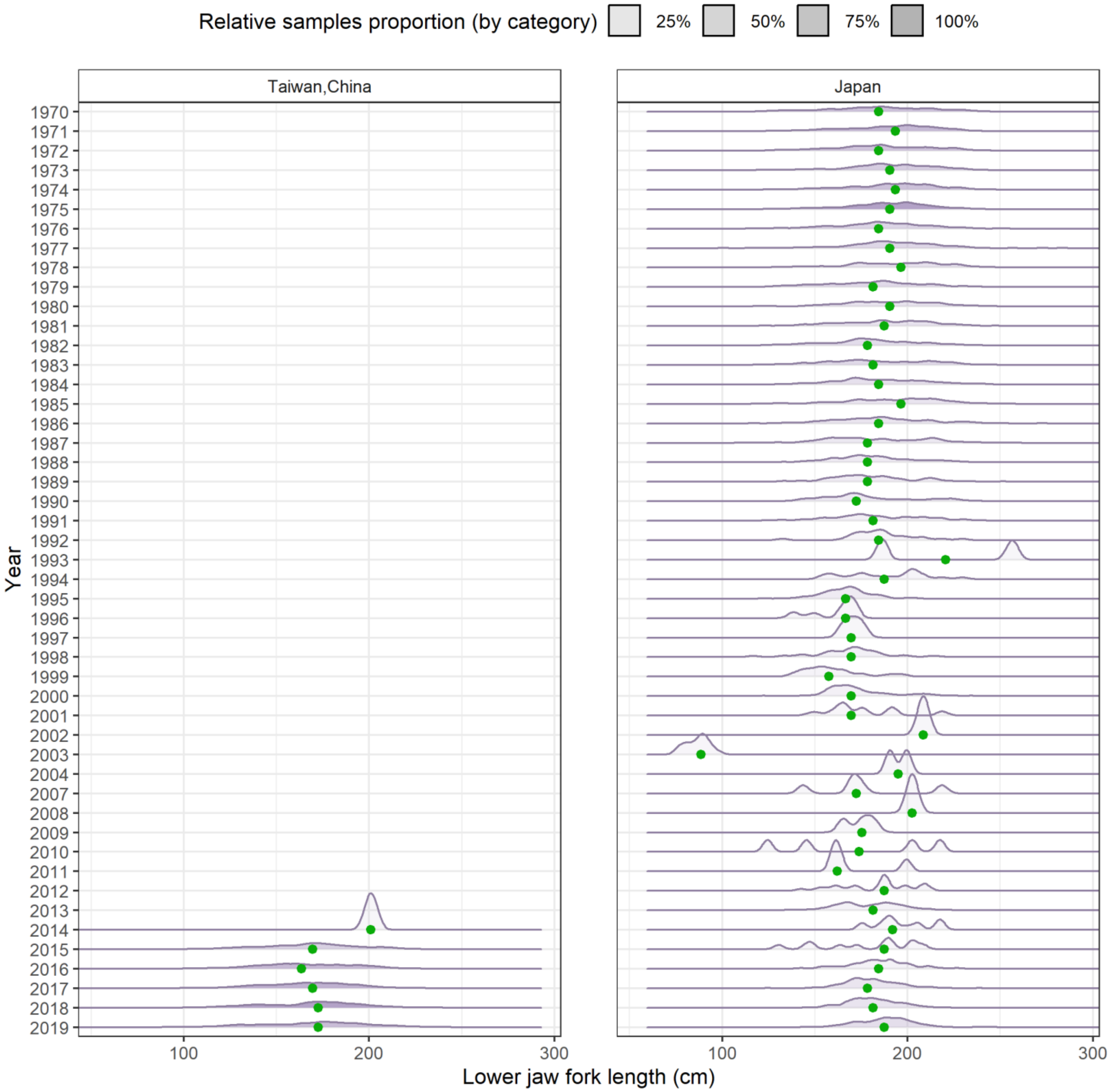

Figure 41: Yearly reported Indo-Pacific sailfish length-frequency data (lower jaw fork length) for the deep-freezing longline fisheries of Taiwan,China and Japan. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

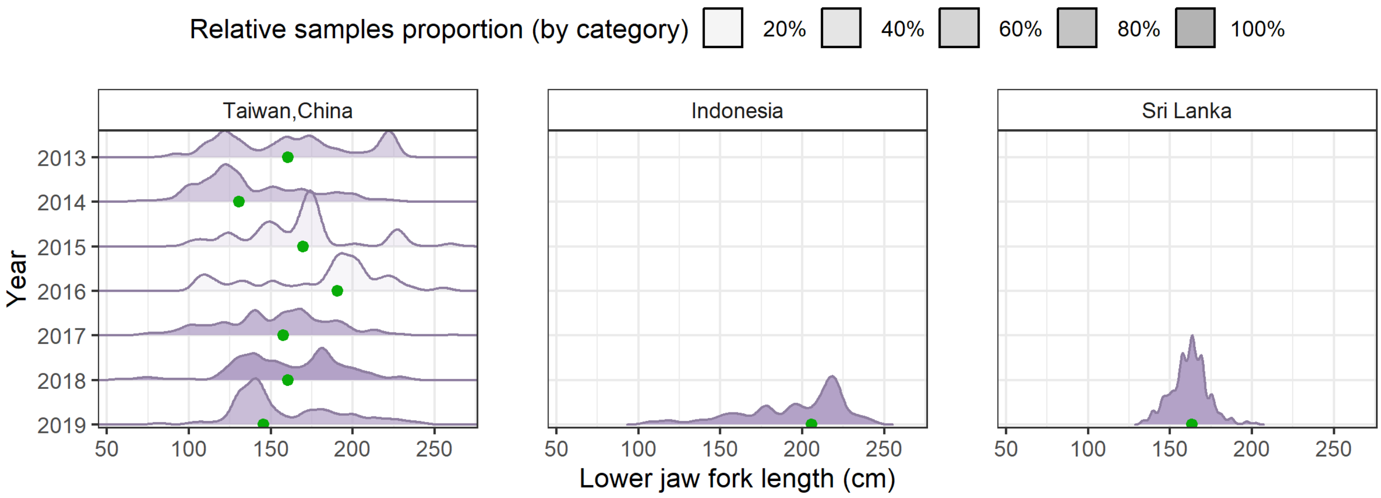

Figure 42: Yearly reported Indo-Pacific sailfish length-frequency data (lower jaw fork length) for the deep-freezing longline fisheries of Taiwan,China, Indonesia and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: latest billfish standardized size-frequency dataset (Res. 15/02)

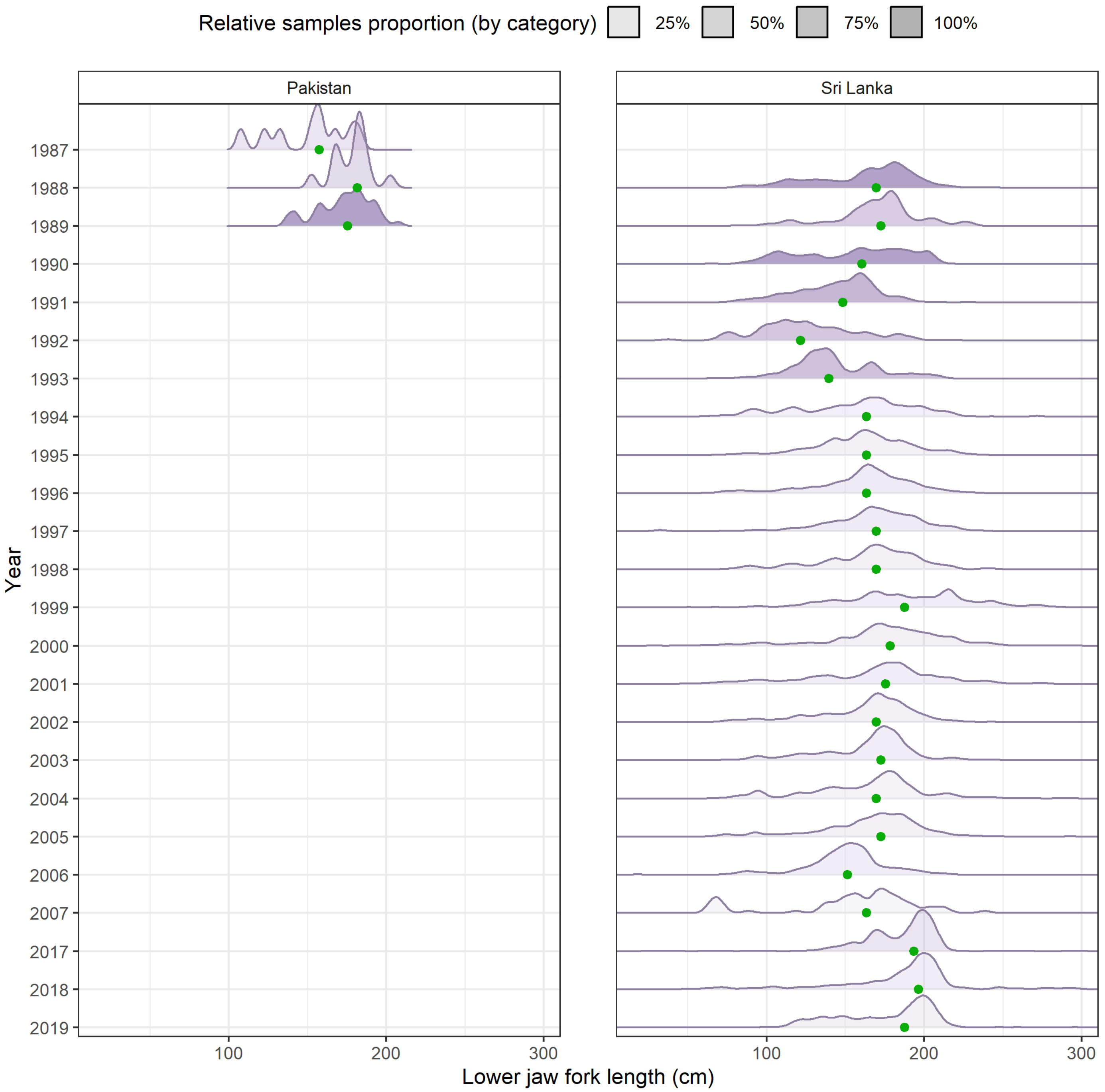

Figure 43: Yearly reported Indo-Pacific sailfish length-frequency data (lower jaw fork length) for the gillnet fisheries of Pakistan and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset]() (Res. 15/02)

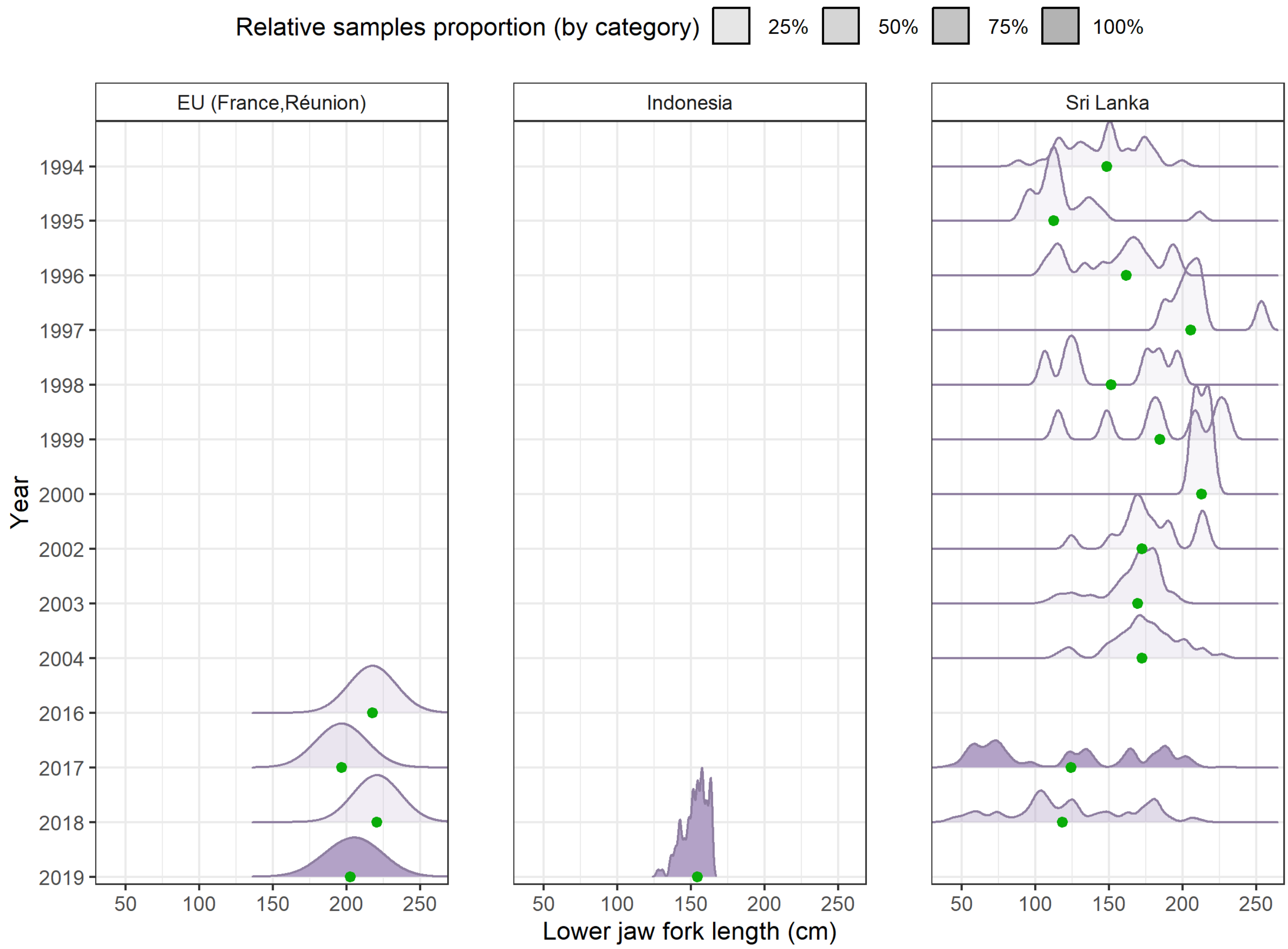

Figure 44: Yearly reported Indo-Pacific sailfish length-frequency data (lower jaw fork length) for the line fisheries of EU,France (Réunion based), Indonesia and Sri Lanka. Fill intensity is proportional to the number of samples recorded for the year, while the green dot corresponds to the median value. Data source: [latest billfish standardized size-frequency dataset](#) (Res. 15/02)

Temporal patterns and trends in estimated average weights

Swordfish (SWO, *Xiphias gladius*)

This information is derived from the raised catches of swordfish by fleet, gear, fishing mode, year, month and grid that the Secretariat produces for the assessment of the species.

These catches are fully spatialized, sum up to the total catches recorded for each fleet, gear and year, and are estimated through a variety of techniques that use the reported geospatial catches - together with the available size-frequency data - to produce catches in weight and numbers by grid and month, leveraging data from proxy fleets or adopting substitution schemes when the spatio-temporal information is not available for a given strata.

Considering the limitations in the original data and in the process that produces this estimation, it shall be noted that the average weights estimated for the deep-freezing and for the "other" type of longline fisheries are pretty stable at around 50 kg / fish, with a slightly lower value for the average weight estimated for fresh tuna longline fisheries, which fluctuates between 30 and 50 kg / fish in recent years (**Fig. 45**).

On the contrary, average weights estimated for all types of line fisheries (coastal longline, handlines and trolling) appear to be extremely stable at the beginning of the time series, as a consequence of the lack of size-frequency information in the period concerned, and quite unstable in years from 1990 onwards, with the exception of handline fisheries for which the lack of reliable size data persists and yields an almost *flat* average weight trend also in the remaining part of the time series.

The sharp change in average weight trends estimated for the line fisheries reflects a) the lack of information (at the beginning of the time series) and b) issues with data collection and reporting (at the end of the time series) which are both a direct consequence of the artisanal nature of these fisheries.

The average weights estimated for gillnet fisheries is mostly (if not exclusively, for the majority of the time series) derived from the information provided by Sri Lanka, and as such it reflects the marked variability in median lengths reported in recent years (**Fig. 29**).

Although estimated, trends in average weights for all other fisheries (purse seine, baitboat, and all other gears) are not shown here because inherently more difficult to assess due to the species not being targeted (e.g., purse seine, baitboat) or to the lack of accurate and comprehensive size-frequency data.

Overall, the trend in average weights that results from combining data for all fisheries together shows a close correspondence with the average weights estimated for all longline fleets combined, and therefore a mild decrease in the (estimated) size of fish caught since the mid-1990s, which can be partially explained by the generalized decline in the efforts exerted by several industrial longline fleets (which are the major contributors of catches for the species) in the productive fishing grounds close to Somali waters (**Fig. 46**).

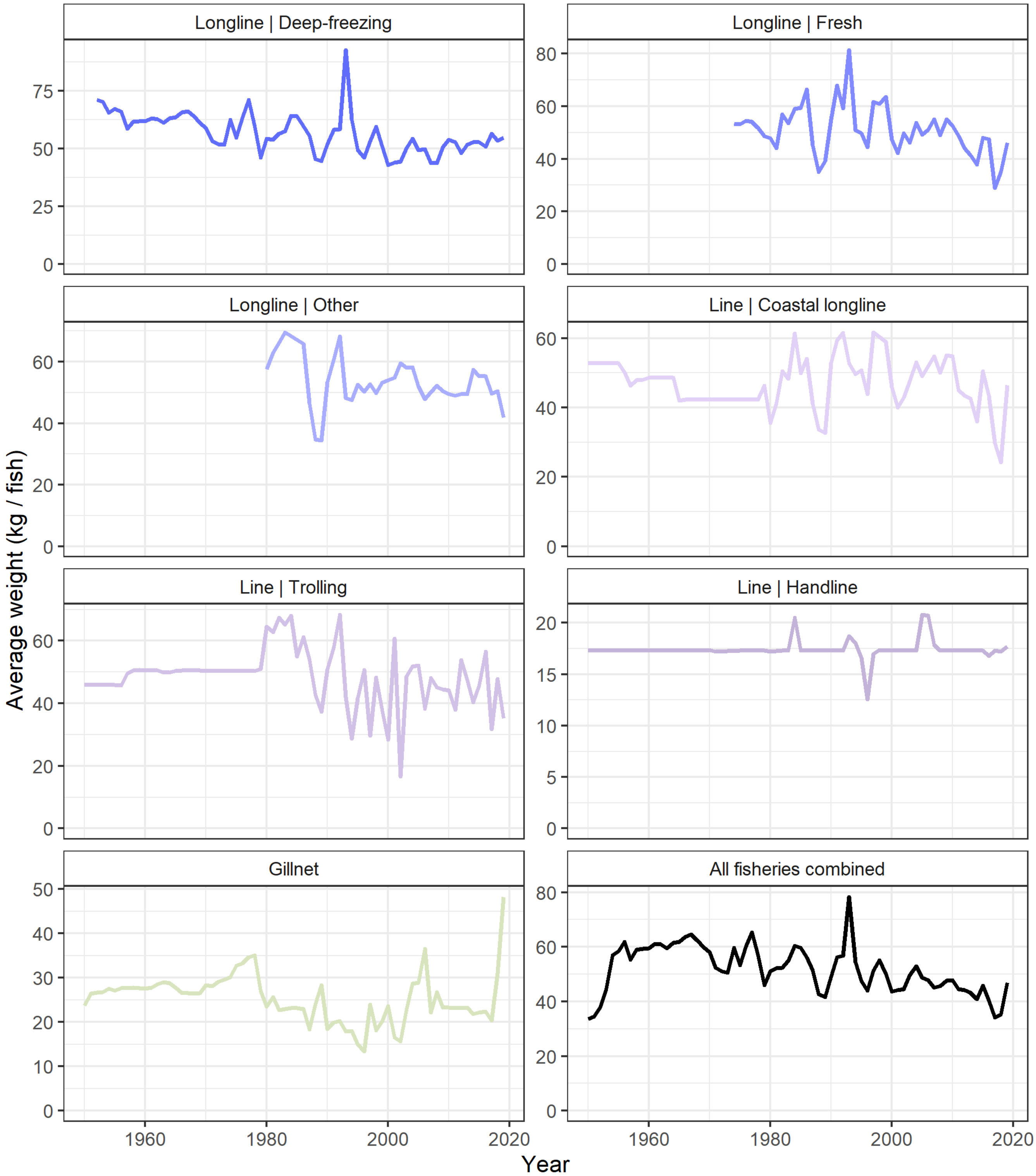

Figure 45: Estimated swordfish average weight (kg/fish) by fishery and year. Longline | Other includes swordfish and shark-targeting longlines. Data source: swordfish raised time-area catches

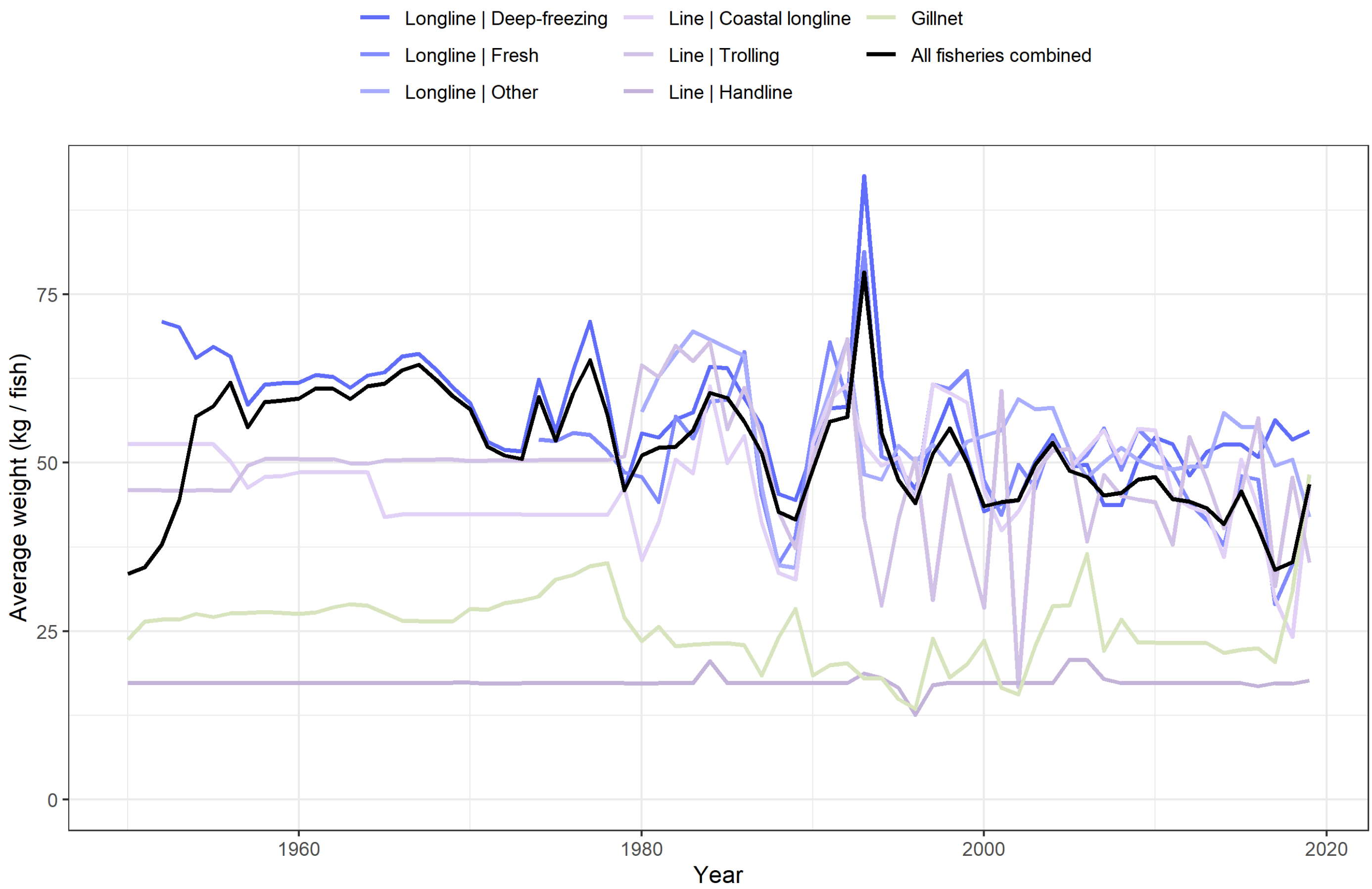

Figure 46: Combined estimated swordfish average weight (kg/fish) by fishery and year. Longline | Other includes swordfish and shark-targeting longlines. Data source: swordfish raised time-area catches

Spatial distribution of estimated average weights

Swordfish (SWO, *Xiphias gladius*)

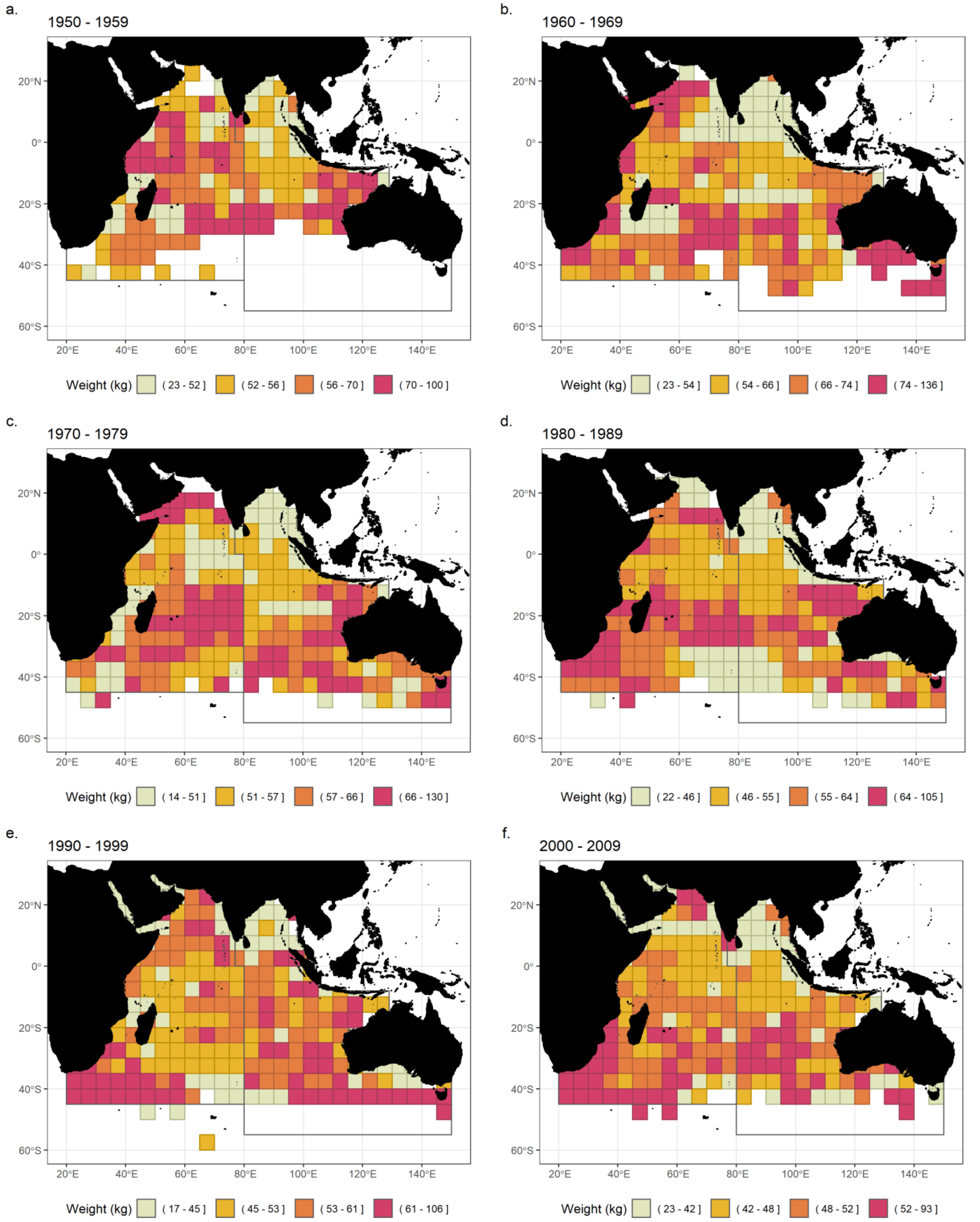

Figure 47: Estimated average weight (kg / fish) by decade and 5x5 grid, all fisheries (longline, line and gillnet) combined. Data source: swordfish raised time-area catches

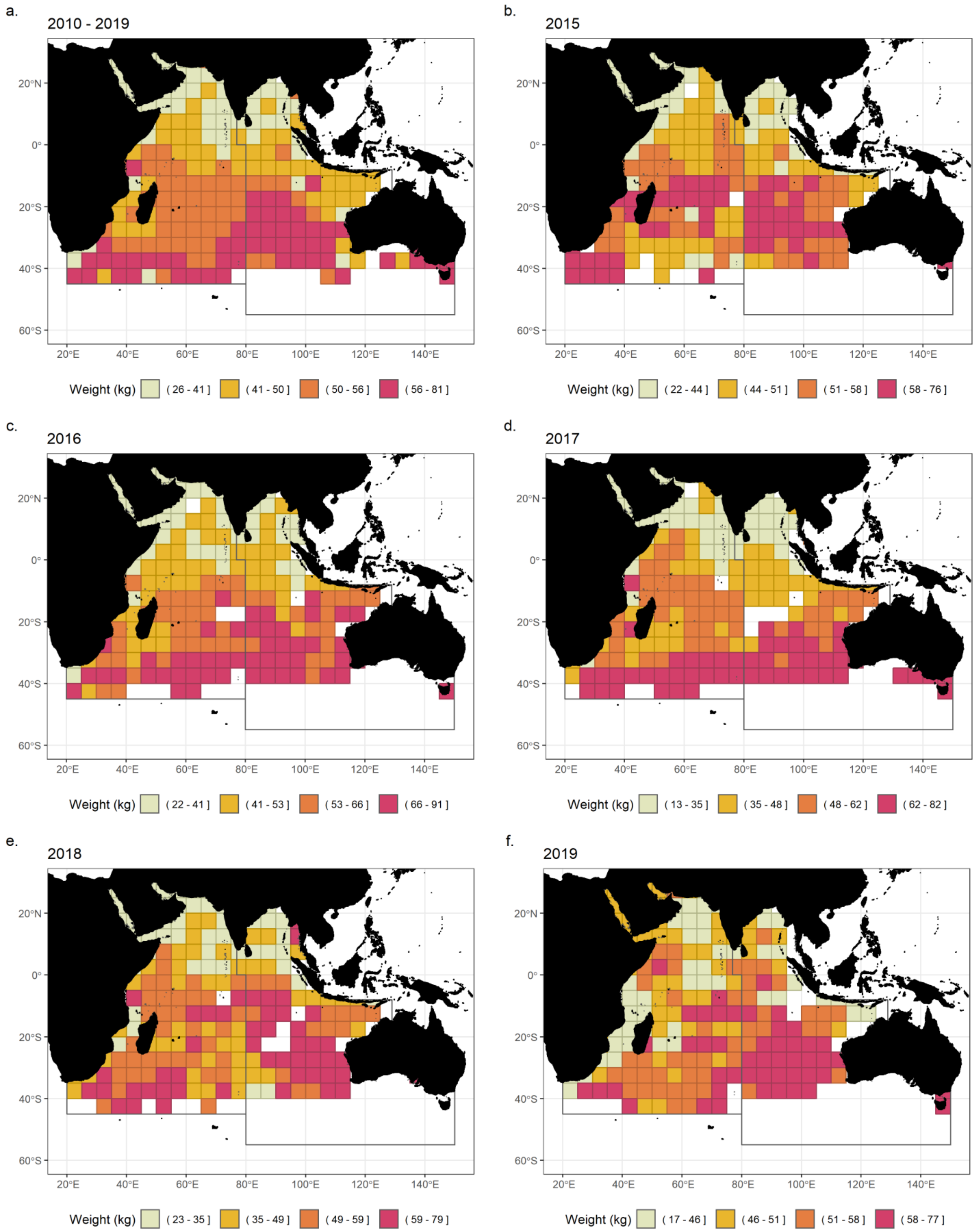

Figure 48: Estimated average weight (kg / fish) by last decade, year and 5x5 grid, all fisheries (longline, line and gillnet) combined. (a) last decade, (b-f) last five years. Data source: swordfish raised time-area catches

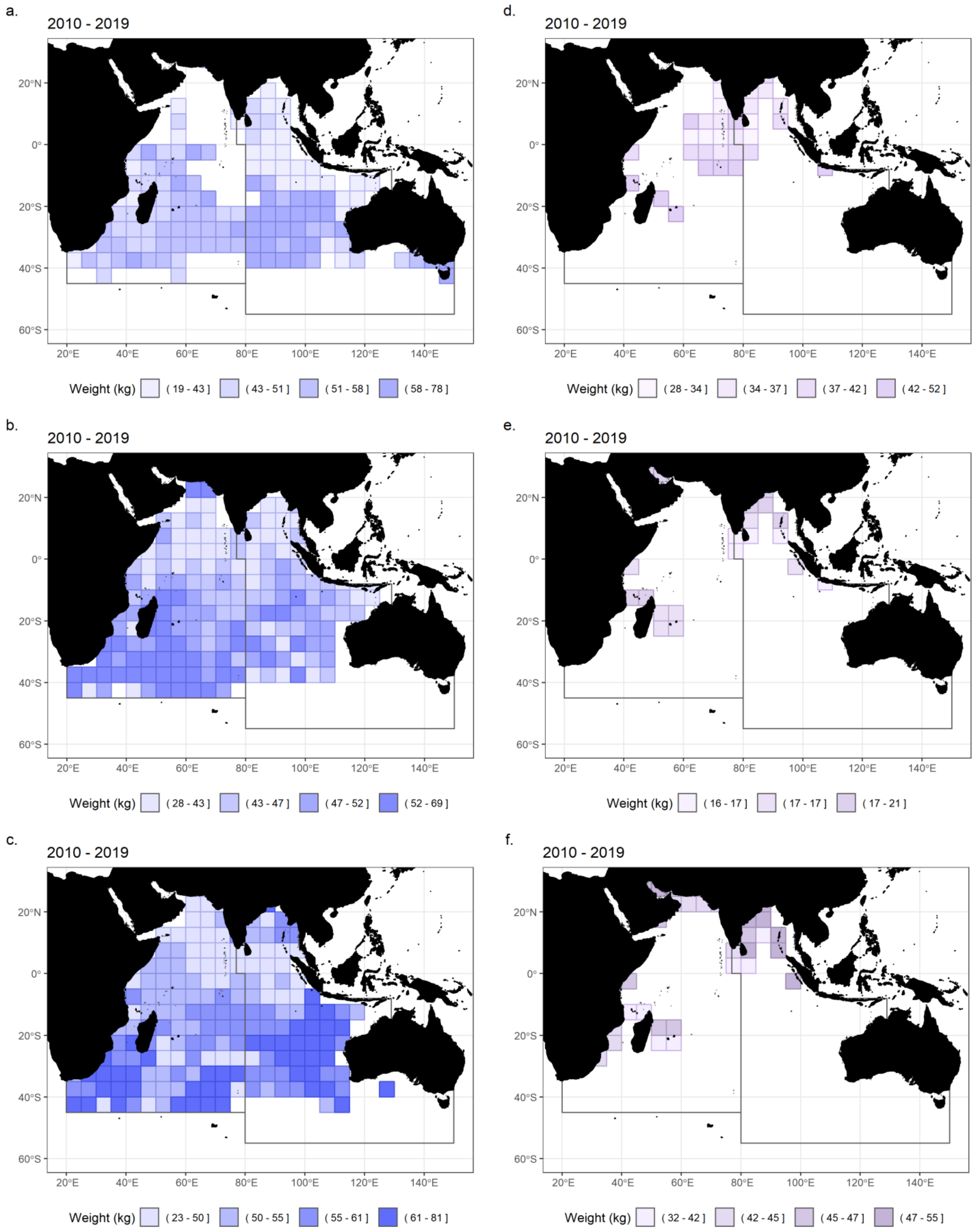

Figure 49: Estimated average weight (kg / fish) by last decade, fishery and 5x5 grid. (a) Longline (others), including swordfish and shark-targeting longlines, (b) Fresh tuna longline, (c) Deep-freezing longline, (d) Coastal longline, (e) Trolling, (f) Handline. Data source: swordfish raised time-area catches

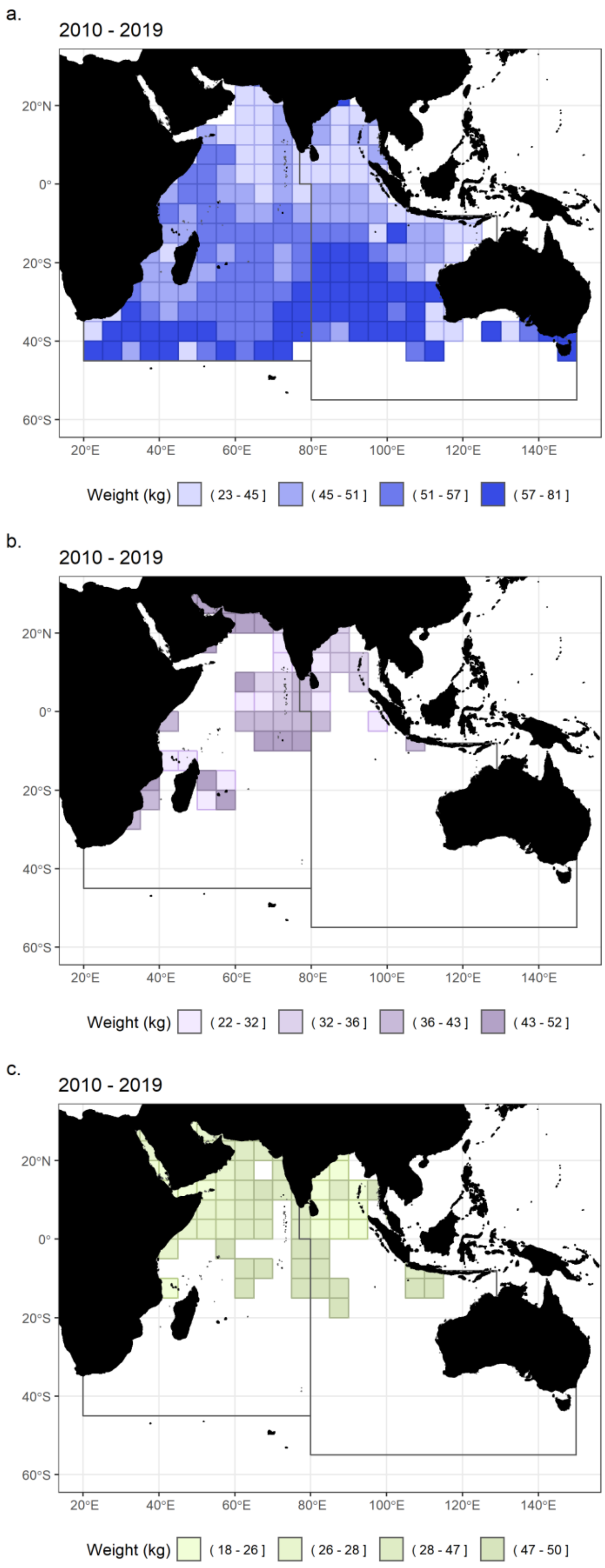

Figure 50: Estimated average weight (kg / fish) by last decade, fishery group and 5x5 grid. (a) Longline, (b) Line, (c) Gillnet. Data source: swordfish raised time-area catches

Uncertainties in size data

The overall reporting quality for geo-referenced size data is poor for all five IOTC billfish species. In fact, almost no size data is available prior to the 1980s and the few data available during the 1970s for industrial longliners from

Japan are characterized by low sampling coverage (<1 fish per metric ton) and are not compliant with IOTC reporting standards (**Fig. 51**). Some size data of good reporting quality became available from longliners from Taiwan,China and gillnetters from Sri Lanka during the 1980s and later on from the swordfish-targeting fresh longline fisheries of EU,Spain, EU,France (La Réunion) and Seychelles, which developed and expanded throughout the 1990s. The availability of good quality size data sharply declined from the mid-2000s, mostly due to the major decrease in catches of swordfish reported by the deep-sea longline fisheries of Taiwan,China (**Fig. 51**). It increased in very recent years with the reporting of size data by Sri Lanka for its coastal longline fishery.

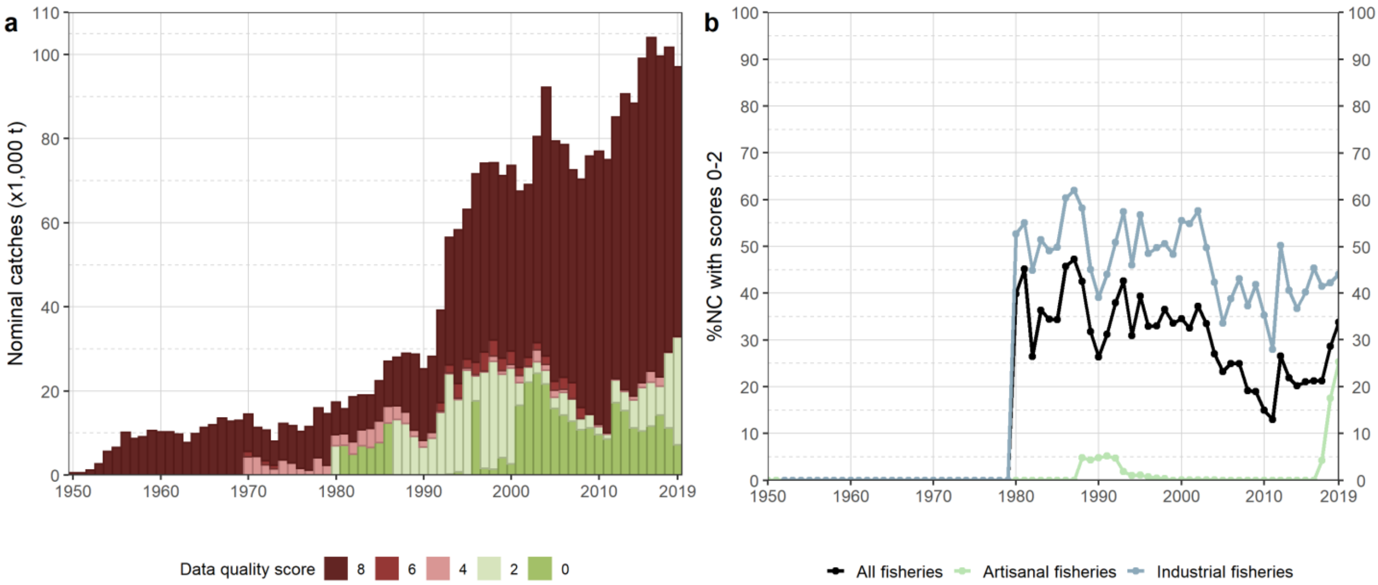

Figure 51: (a) Annual nominal catches of IOTC billfish species in metric tons (t) estimated by quality score and (b) percentage of nominal catches by type of fishery with good quality information (i.e., >1 fish per metric ton caught and compliant with IOTC standards) for the corresponding geo-referenced size frequency data reported to the IOTC Secretariat

The availability and reporting quality of size data varies according to species and over time. There are almost no size data available for black marlin (BLM) and Indo-Pacific sailfish (SFA) (**Fig. 52**). The amount of size data available at the IOTC Secretariat decreased substantially for blue marlin (BUM) and striped marlin (MLS) from the 1980s to the early 2010s with the decline of the deep-sea longline fishery from Taiwan,China, but increased thereafter to the point that the percentage of nominal catches for which good reporting size data have been reported (scores 0-2; **Table 3**) reached 48.2% and 11.5% in 2019 for BUM and MLS, respectively (**Fig. 52**). For swordfish (SWO), the percentage of nominal catches with scores 0-2 remained stable at about 50% since the 1980s. Some size data have been reported by Sri Lanka for its gillnet fishery since 2018, increasing the percentage of good quality to 64% of the total nominal catches of swordfish in 2019 (**Fig. 52**).

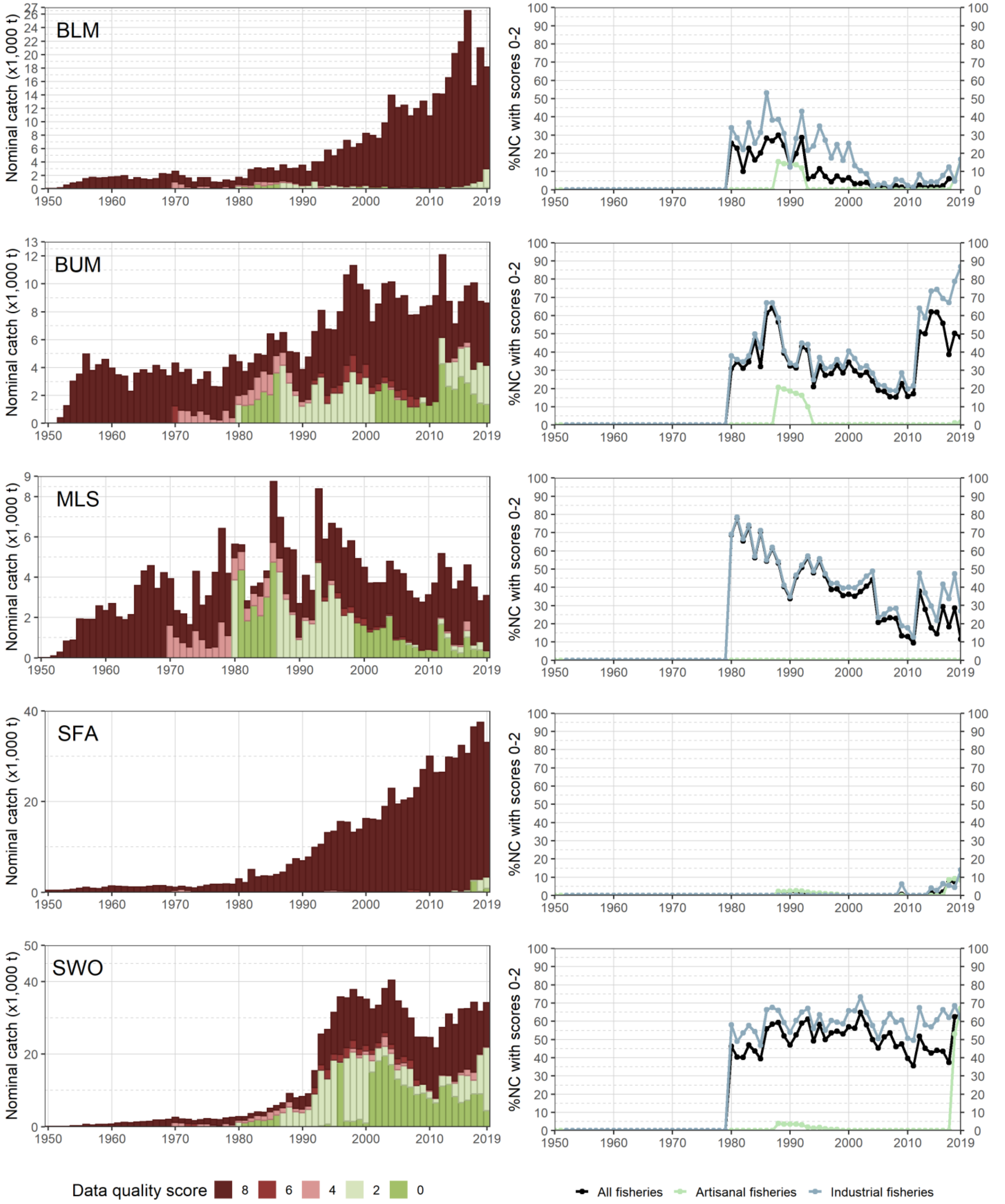

Figure 52: (left panel) Annual nominal catches in metric tons (t) estimated by quality score and (right panel) percentage of nominal catches by type of fishery with good-quality information (quality score of 0-2) for the geo-referenced size frequency data reported to the IOTC Secretariat for each IOTC billfish species

Appendix I: Best scientific estimates for 2019

Overall, the amount of nominal catches fully estimated in 2019 correspond to 6,999 t for 9 distinct fleets, representing 7.6% of all catches of IOTC billfish species for the year (**Table 6**).

The estimation of the catch data includes three processing steps. First, nominal catches are estimated by the Secretariat for IOTC CPCs as well as non-members that either did not report any catch for 2019 or whose catches were available from other sources. For non-members, catches were preferentially extracted from the FAO Global Capture Production database and further broken down into species (when necessary) and fishing gears based on knowledge of the fisheries present in each of the countries (**Table 6**). As no catch data were available for the United Arab Emirates and Jordan from the FAO database for 2019, nominal catches by gear and species available in the IOTC database for 2018 were repeated for 2019 for these two countries. It is to note that the catches of billfish species taken by fisheries of the United Arab Emirates have been repeated in the FAO database since 2014 as well, while the catches of billfish for Jordan were derived from the species group 'Tuna-like fishes nei' (also repeated in the FAO database since 2014) and estimated to be less than 500 kg in 2019.

For non-reporting IOTC members, nominal catches were generally repeated from 2018 with the exception of Eritrea, which never reported any data to the IOTC Secretariat since its accession to the IOTC in 1994, and for which data were extracted from the FAO database and fully assigned to the gillnet fishery (**Table 6**). In the case of Seychelles, Mozambique, and Madagascar, only data for the coastal fisheries (dominated by handline and trolling) were repeated from 2018 while data reported for the longline fisheries were considered accurate.

Table 6: Data source and final estimates of catches (t) of IOTC billfish species in 2019 for non-members (NM) and members (MP) of the IOTC that did not report catches for some or all of their fisheries for the year 2019. RAW_CATCH considers all available catch information for the fleet and year concerned, including catches from species other than billfish, while CATCH corresponds to the catches of billfish estimated by the IOTC Secretariat for the same fleet and year

FLEET_CODE	FLEET	STATUS	SOURCE	SOURCE_YEAR	RAW_CATCH	CATCH
ARE	United Arab Emirates	NM	IOTC	2018	100.0	100.0
DJI	Djibouti	NM	FAO	2019	10.7	10.7
ERI	Eritrea	MP	FAO	2019	207.1	4.3
JOR	Jordan	NM	IOTC	2018	12.0	0.4
MDG	Madagascar	MP	IOTC	2018	842.3	869.7
SAU	Saudi Arabia	NM	FAO	2019	134.6	5.3
SYC	Seychelles	MP	IOTC	2018	4.2	3,129.5
TZA	Tanzania	MP	IOTC	2018	2,682.3	2,683.1
YEM	Yemen	MP	IOTC	2018	196.0	196.0

Second, a re-estimation process was performed for the artisanal fisheries of India, Indonesia and Sri Lanka, which builds on a comprehensive review conducted in the early 2010s with the purpose of revising the time series of catch from their artisanal fisheries and improve the information available to the IOTC (Moreno et al. 2012). In the case of India, the process modifies the catch composition of the gears by Indian Ocean major area for the gillnet, hook and line, and trolling fisheries. In 2019, the total catches reported by India for the IOTC billfish species were 17,037 t, with about half of them taken in the gillnet fishery. In the case of Indonesian coastal fisheries, a fixed proportion of total catch for each species and fishing gear is used to derive the catches of each of the IOTC billfish species based on samples of catch composition available for the period 2003-2011 (Moreno et al. 2012). In 2019, about 6,400 t of fish were estimated to be caught in Indonesian fisheries for the billfish species, predominantly by gillnetters and coastal purse seiners.

Third, nominal catches reported as species aggregates including IOTC billfish species were further broken down into their single species components to generate the IOTC best scientific estimates (**Table 2**). In 2019, this breakdown by species resulted in the addition of a total of 7,935 t to the catches reported at species level for the five species of interest, corresponding to 8.6% of the final catch estimates.

Table 7: Total catches (t) of IOTC billfish species as reported (Raw) and estimated (Est) after accounting for the catches added through the breakdown of species aggregates

Species code	Raw	Est	Added	%Added
BLM	334,818	383,113	48,295	12.61
BUM	355,184	400,501	45,317	11.32
MLS	215,257	256,107	40,850	15.95
SFA	565,832	641,327	75,495	11.77
SWO	958,353	960,741	2,388	0.25

Appendix II: Changes from previous WPB

Some very small changes occurred in the time series of catches of the IOTC billfish species since the last release of the data set of best scientific estimates of nominal catches at the 18th Session of the Working Party on Billfish in 2020, representing an annual variation less than 50 t of fish over the period 1950-2017, and an increase by 156 t in 2018 (**Fig. 53**). Most of the changes are due to a revision of the time series of nominal catches for the longline fisheries of Seychelles since 1996, while the very minor annual changes (<1 t) observed prior to 1996 stem from the use of proxy fleets in the estimation process.

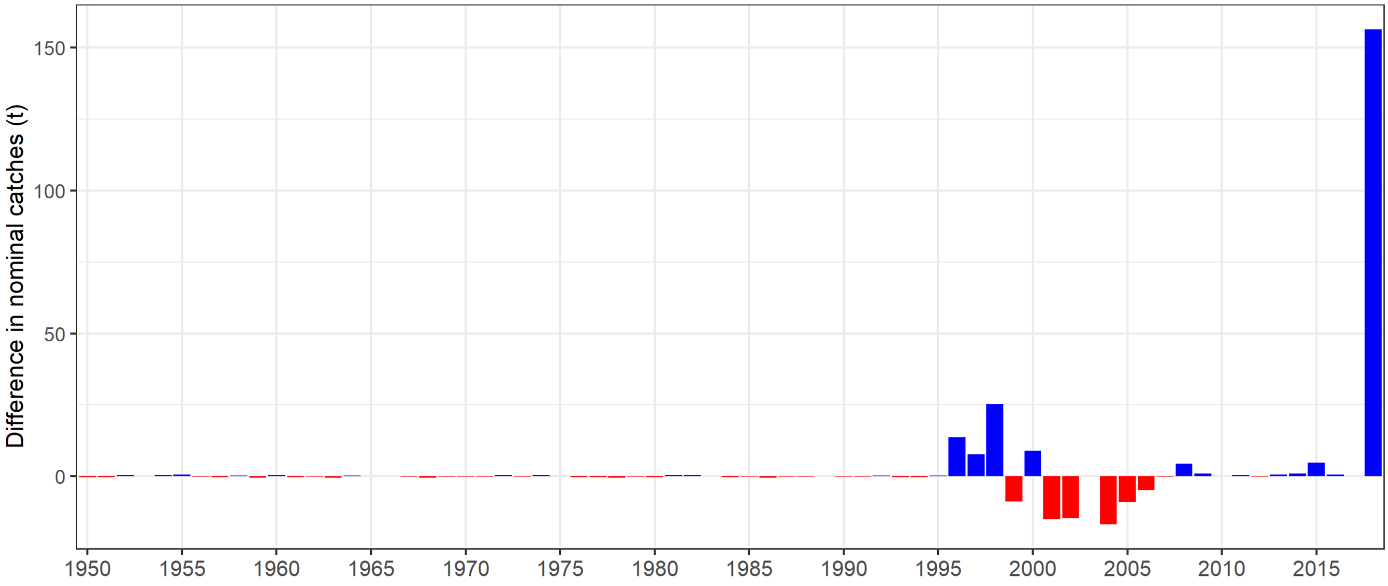

Figure 53: Differences in nominal catches of IOTC billfish in metric tons (t) between the 18th and 19th sessions of the IOTC Working Parties on Billfish

Appendix III: Review of fisheries trends for all billfish species

Assessment areas and common billfish fishing grounds

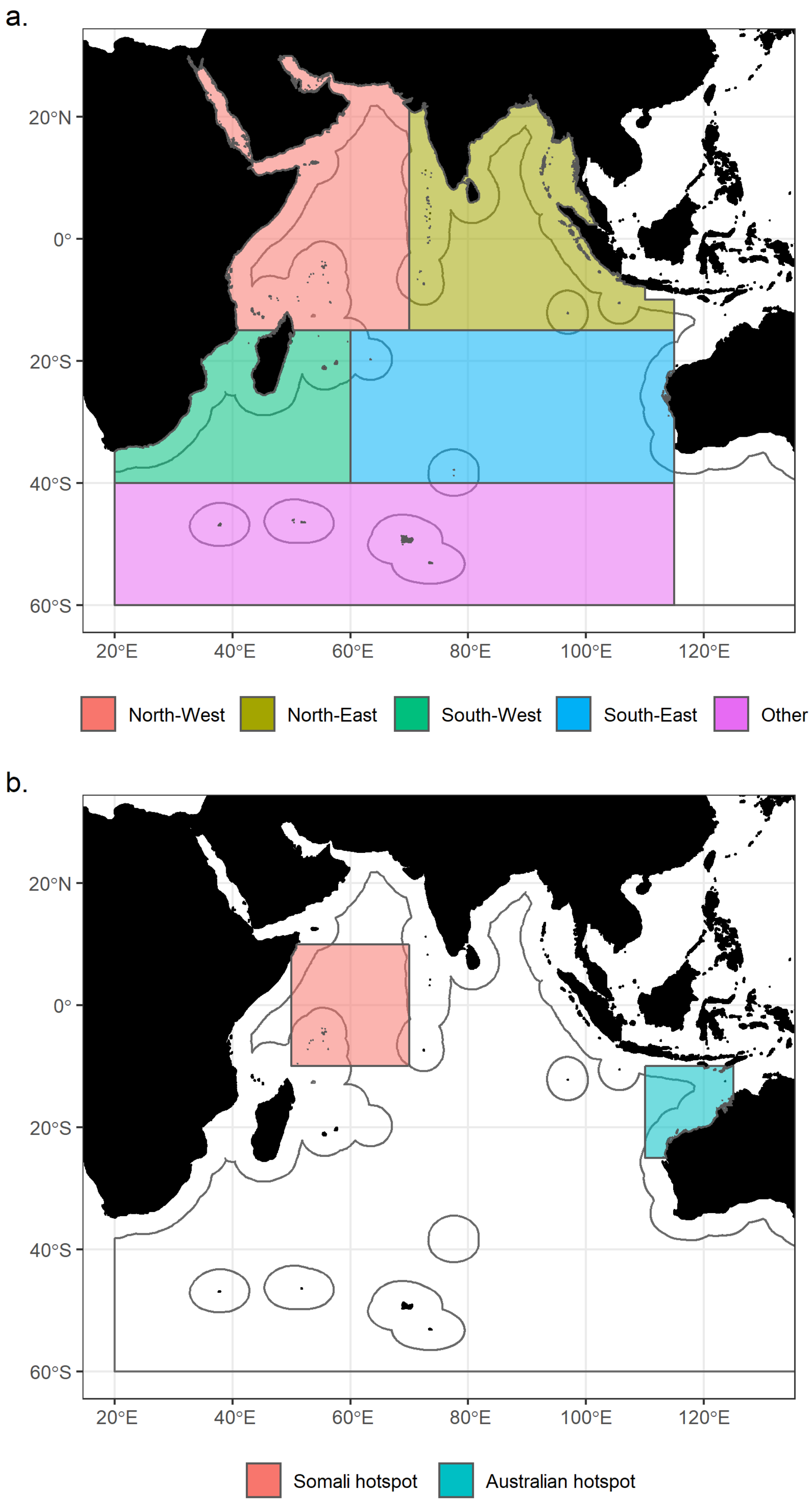

Figure 54: Relevant fishing grounds for swordfish and billfish species: (a) areas used for the assessment of the Indian Ocean swordfish stock, (b) hotspots for all other billfish species

Nominal efforts by area (longline fleets)

Swordfish North-West assessment area

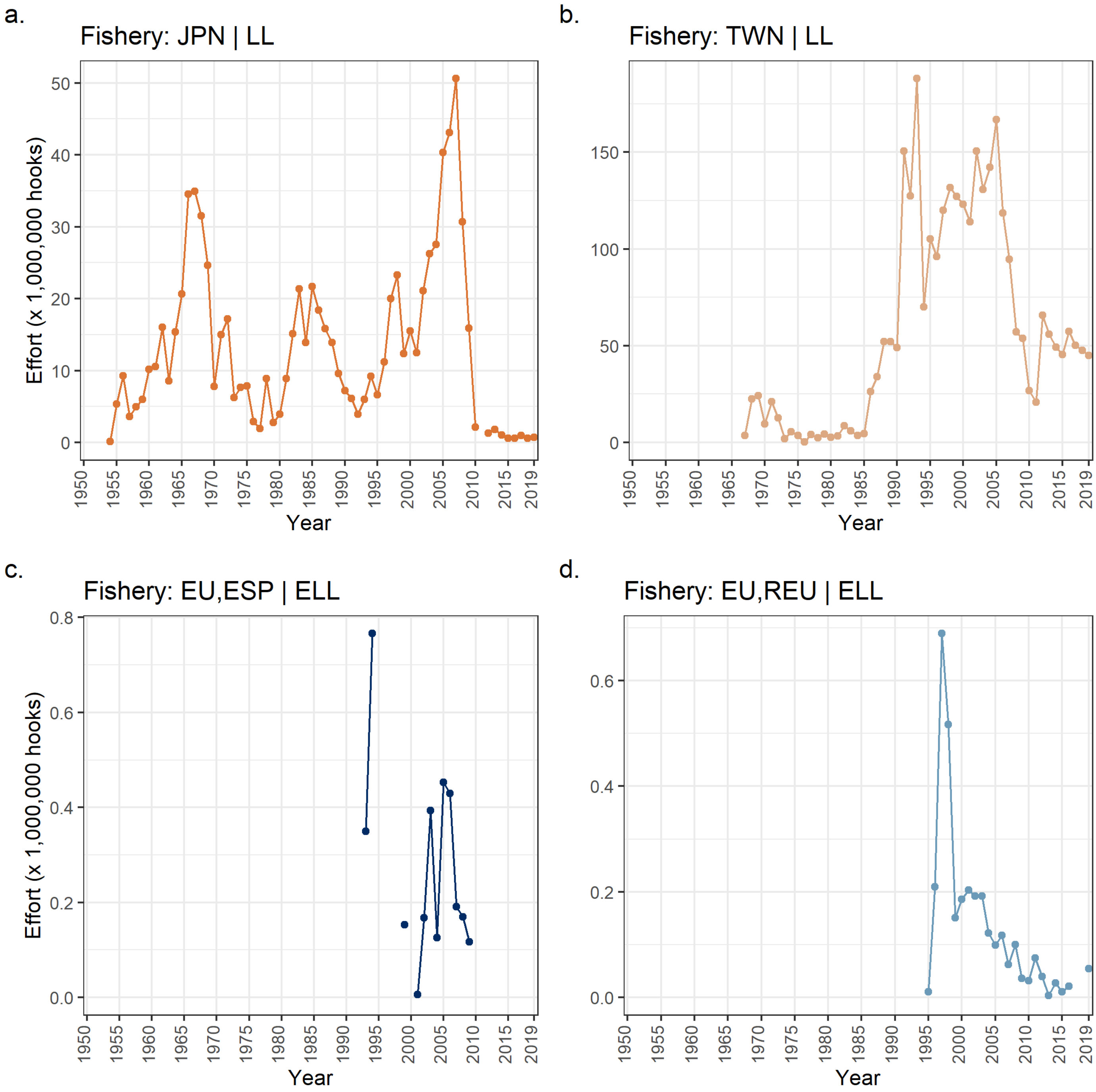

Figure 55: Total fishing effort (hooks) exerted by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based), in the North-West area used for the assessment of the Indian Ocean swordfish stock (see **Fig. 54**). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

Swordfish North-East assessment area

No data (or extremely limited data) is available for the EU,France (La Réunion-based) and EU,Spain fleets of swordfish-targeting longliners, as they rarely operate in this area.

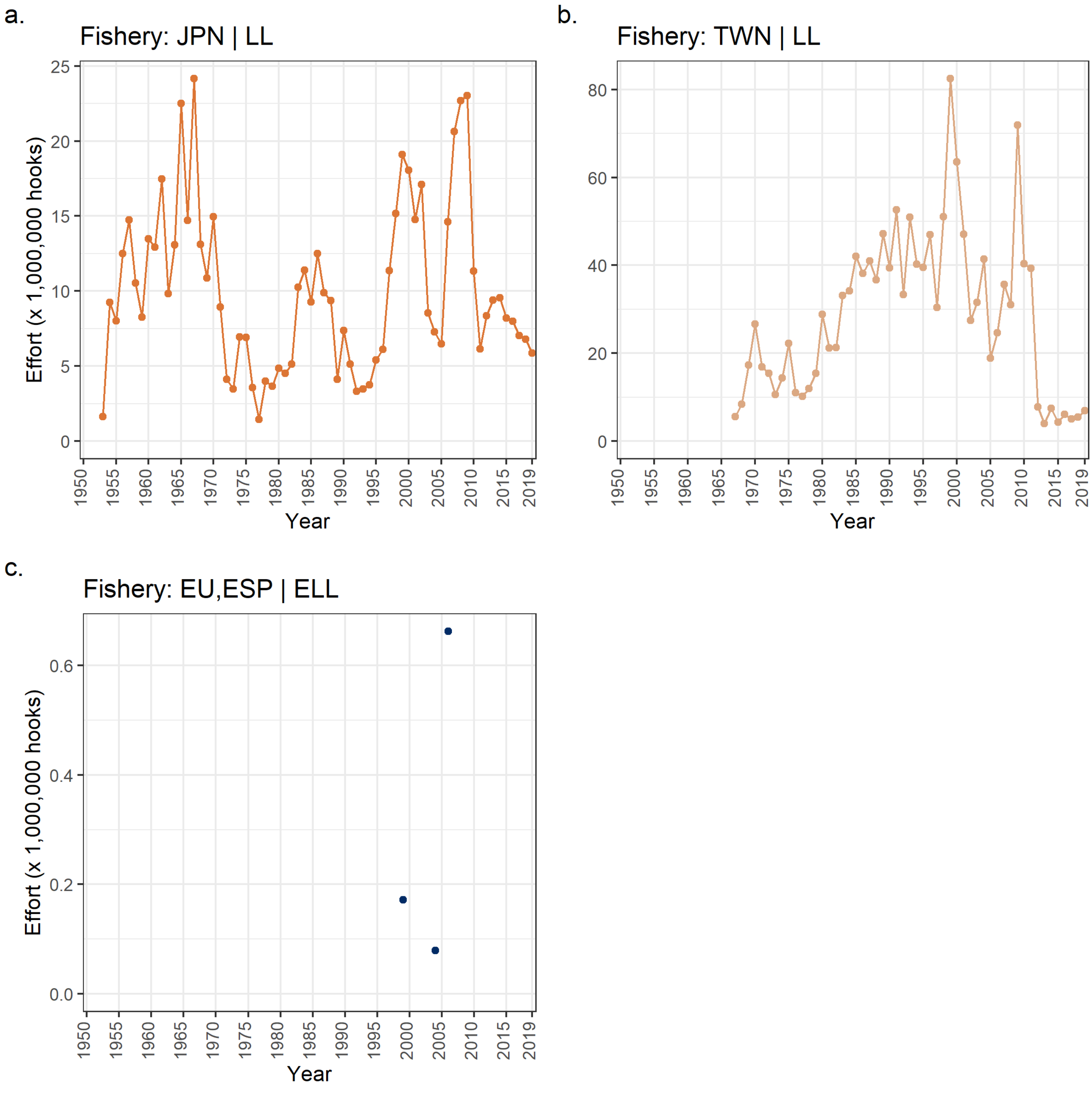

Figure 56: Total fishing effort (hooks) exerted by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based), in the North-East area used for the assessment of the Indian Ocean swordfish stock (see **Fig. 54**). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

Swordfish South-West assessment area

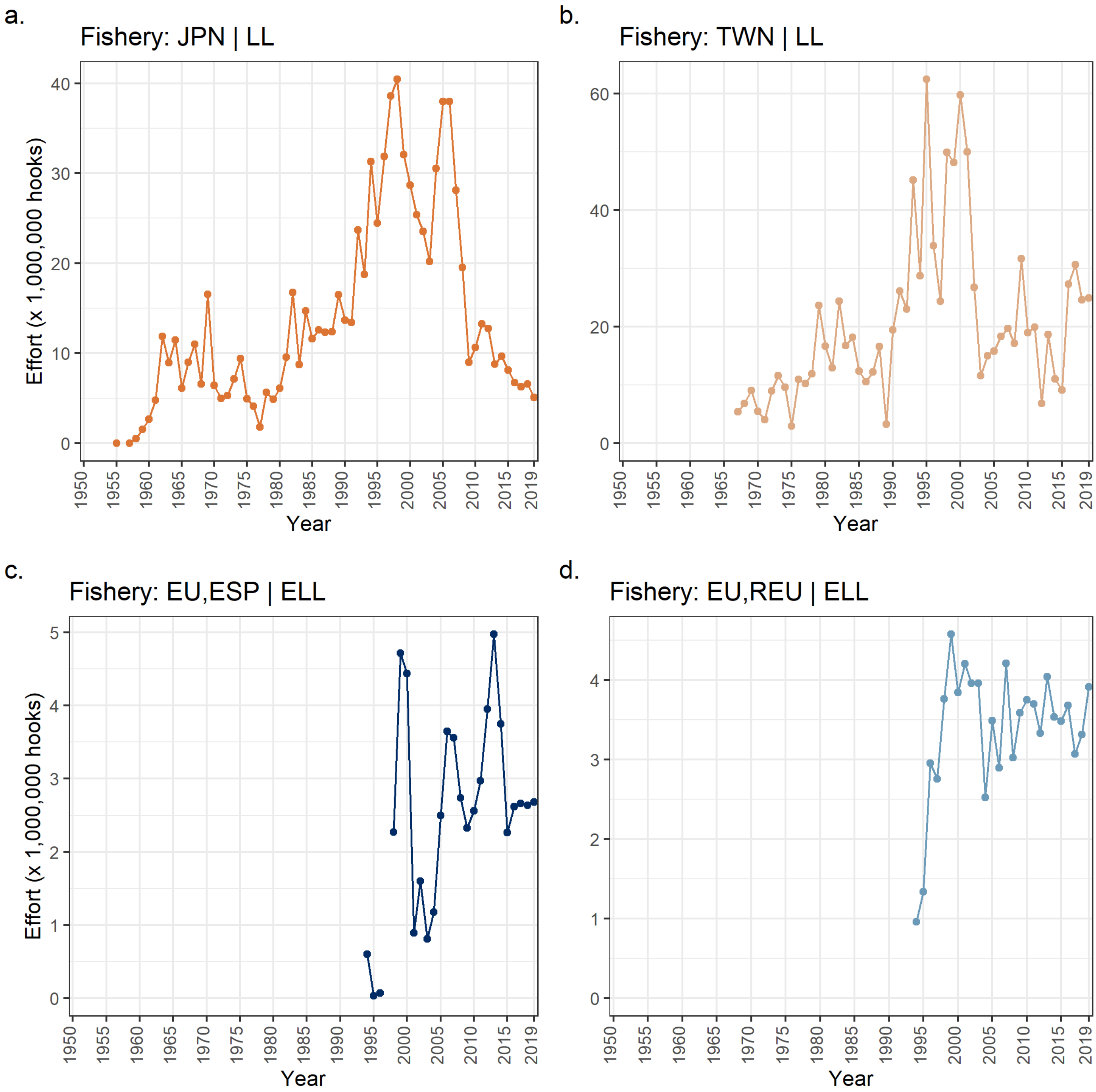

Figure 57: Total fishing effort (hooks) exerted by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based), in the South-West area used for the assessment of the Indian Ocean swordfish stock (see **Fig. 54**). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

Swordfish South-East assessment area

Figure 58: Total fishing effort (hooks) exerted by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based), in the South-East area used for the assessment of the Indian Ocean swordfish stock (see **Fig. 54**). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

Billfish hotspots

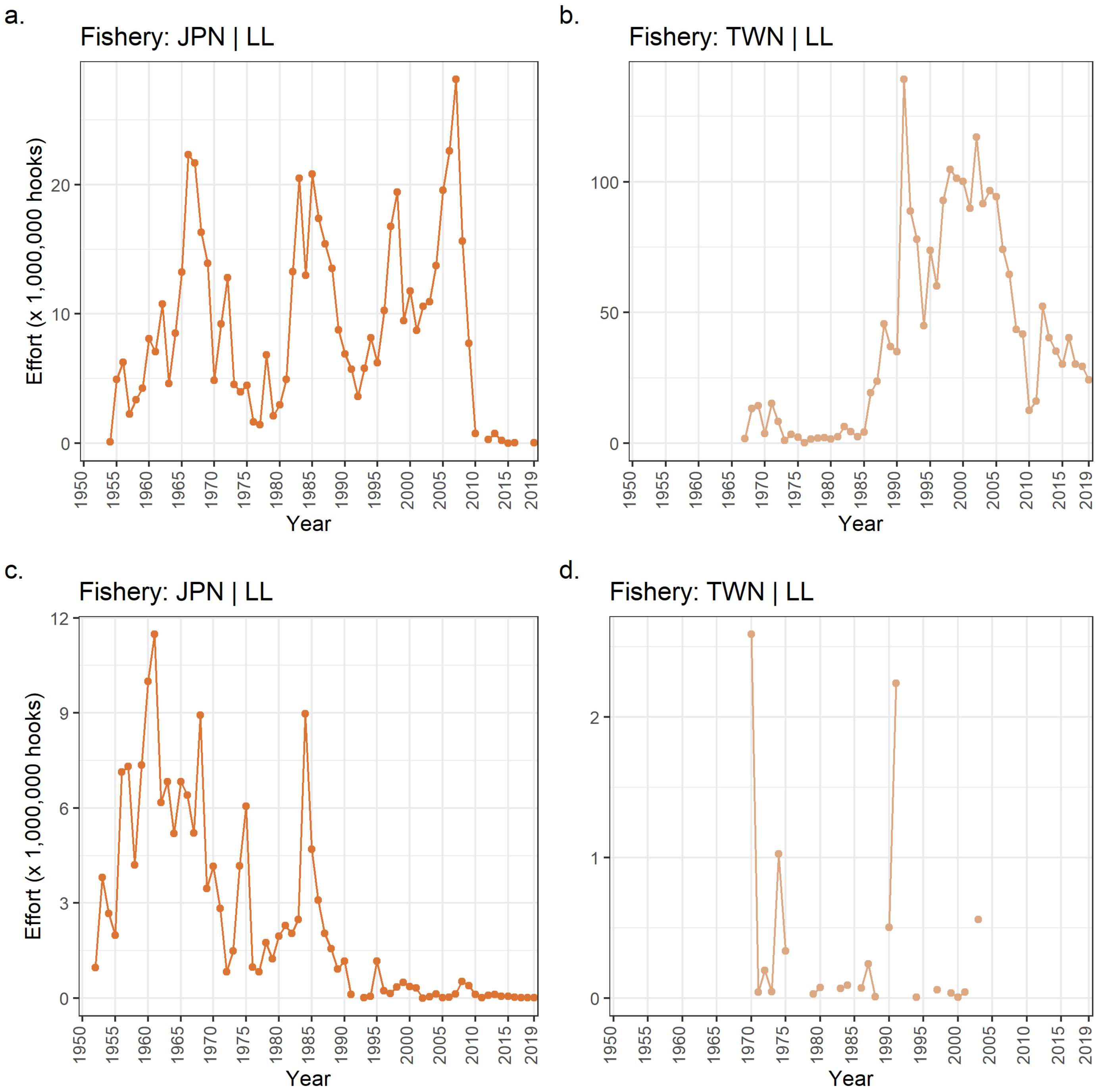

Figure 59: Total fishing effort (hooks) exerted by the longline fisheries of Japan and Taiwan,China in the somali (a, b) and australian (c, d) hotspots respectively (see **Fig. 54**). LL = drifting longline (over 1,800 hooks)

Nominal catch per unit of effort (by area and longline fleet)

Swordfish (SWO, *Xiphias gladius*)

North-West area (in numbers)

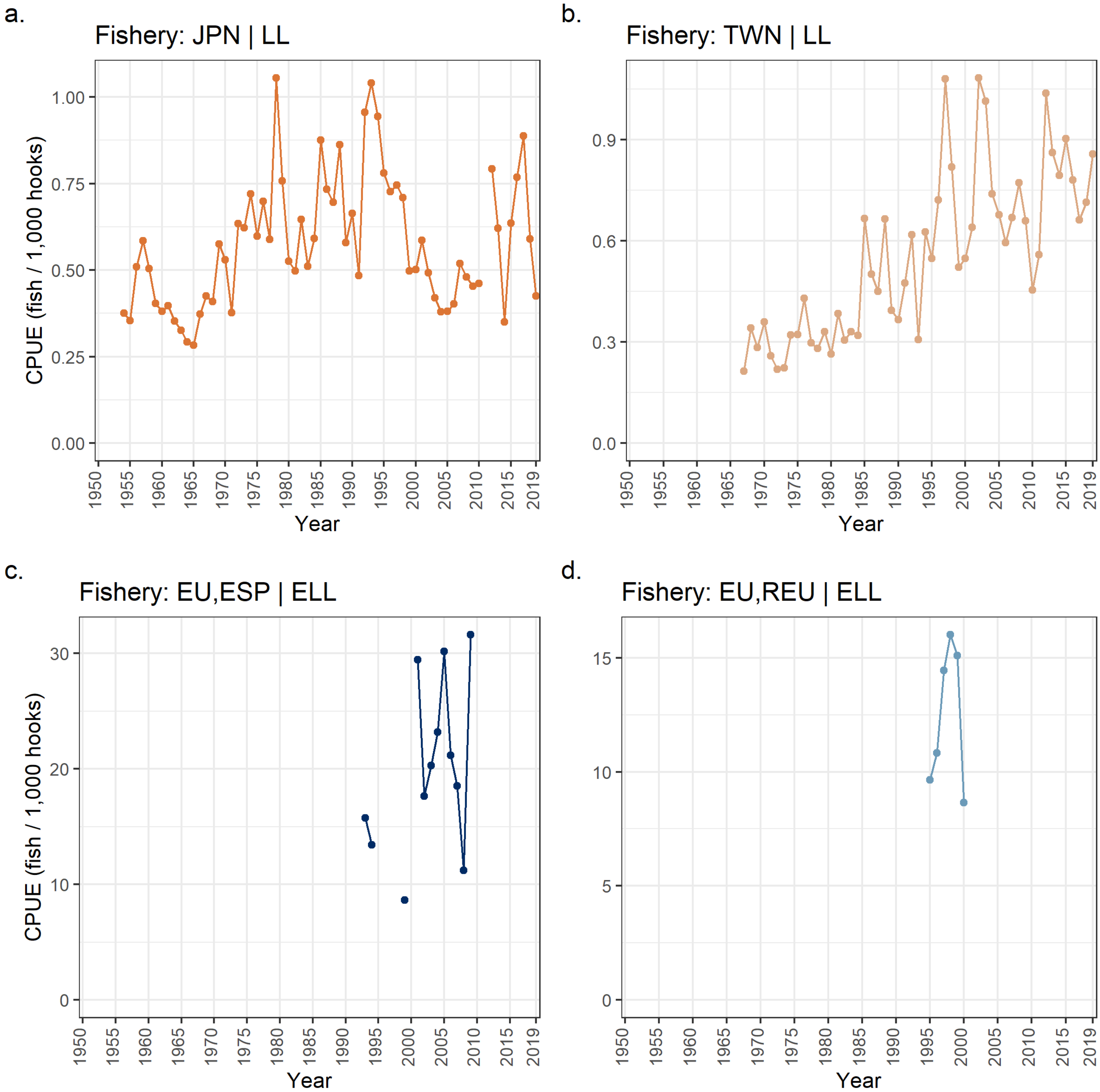

Figure 60: Nominal CPUE in numbers (number of fish / 1,000 hooks) of swordfish caught by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

North-West area (in weight)

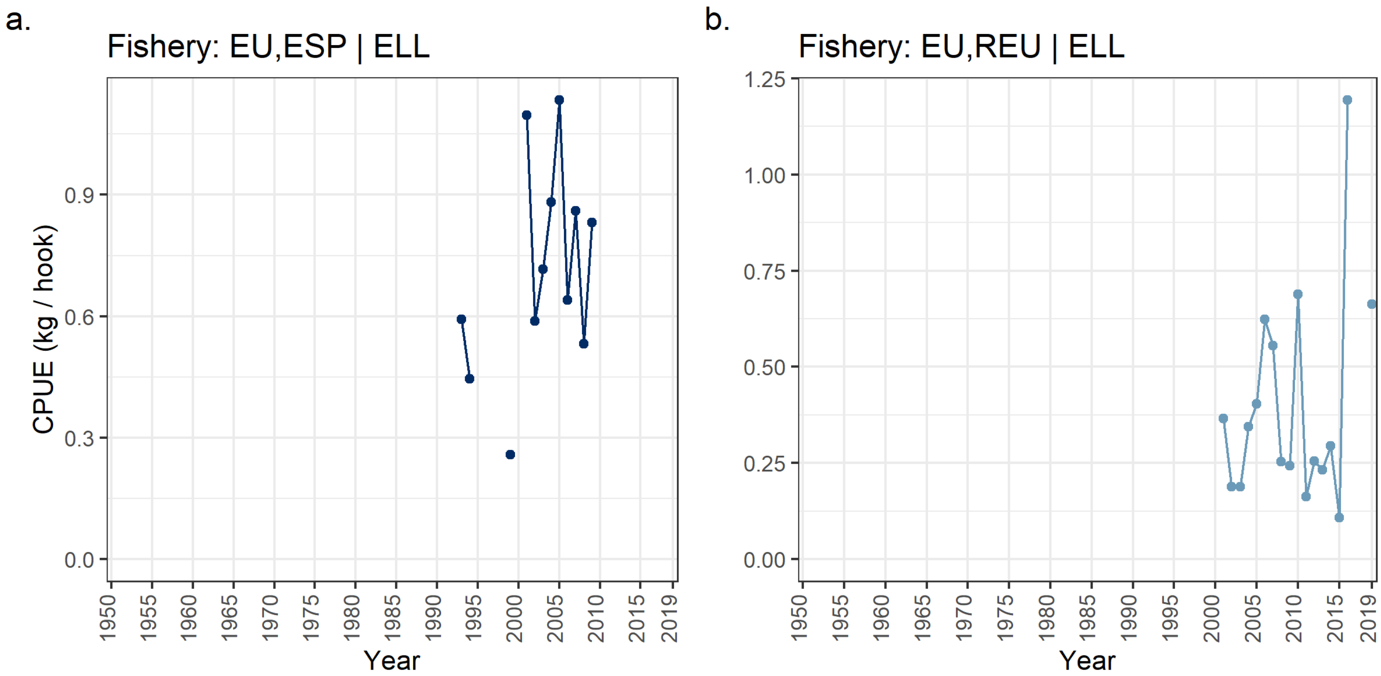

Figure 61: Nominal CPUE in weight (kg / hook) of swordfish caught by the longline fisheries of (a) EU,Spain and (b) EU,France (Réunion-based). ELL = swordfish-targeting longline

North-East area (in numbers)

No catch data (or extremely limited data) is available in *weight* for the EU,France (La Réunion-based) and EU,Spain fleets of swordfish-targeting longliners, as they rarely operate in this area.

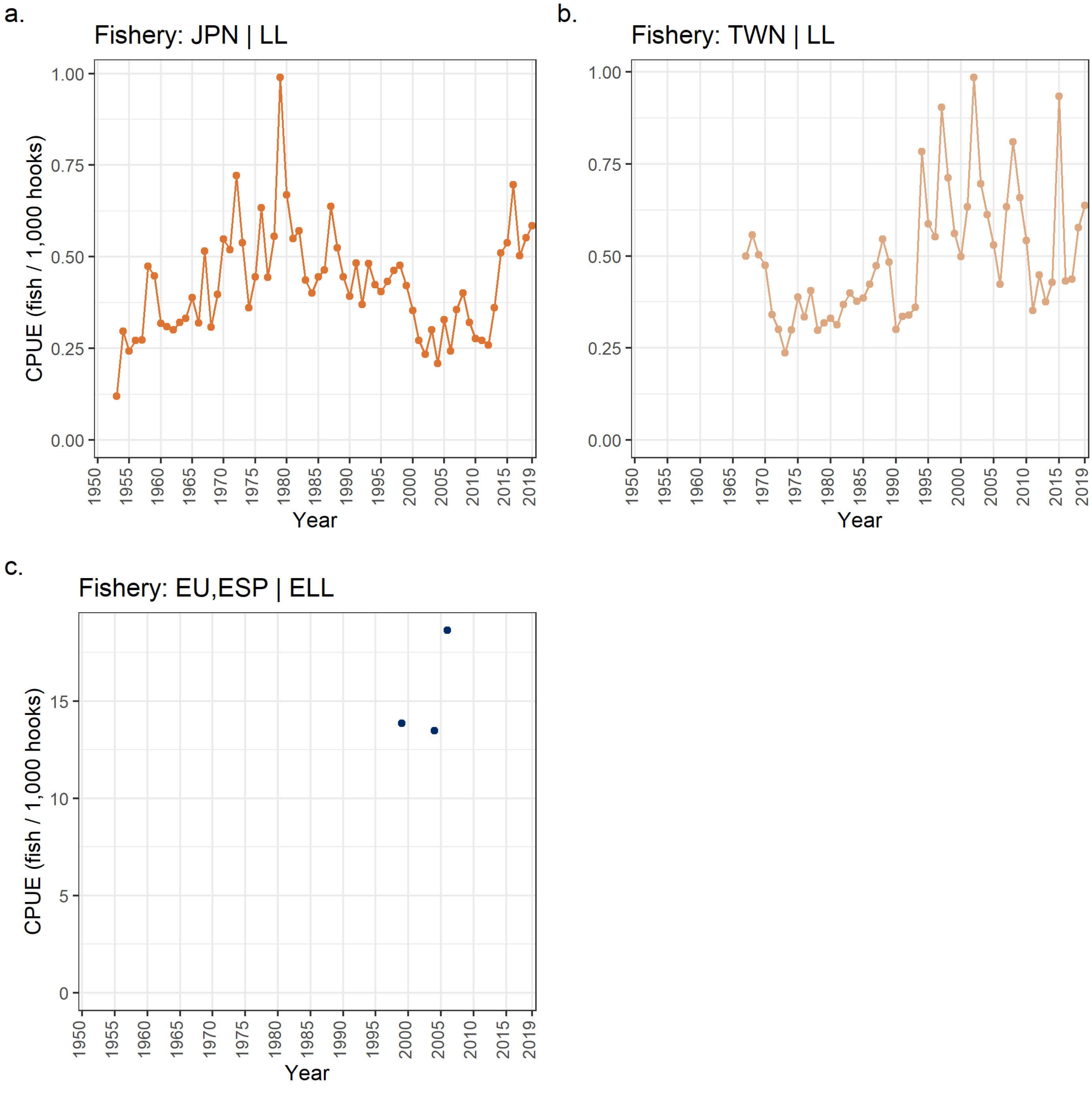

Figure 62: Nominal CPUE in numbers (number of fish / 1,000 hooks) of swordfish caught by the longline fisheries of (a) Japan, (b) Taiwan,China and (c) EU,Spain. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

South-West area (in numbers)

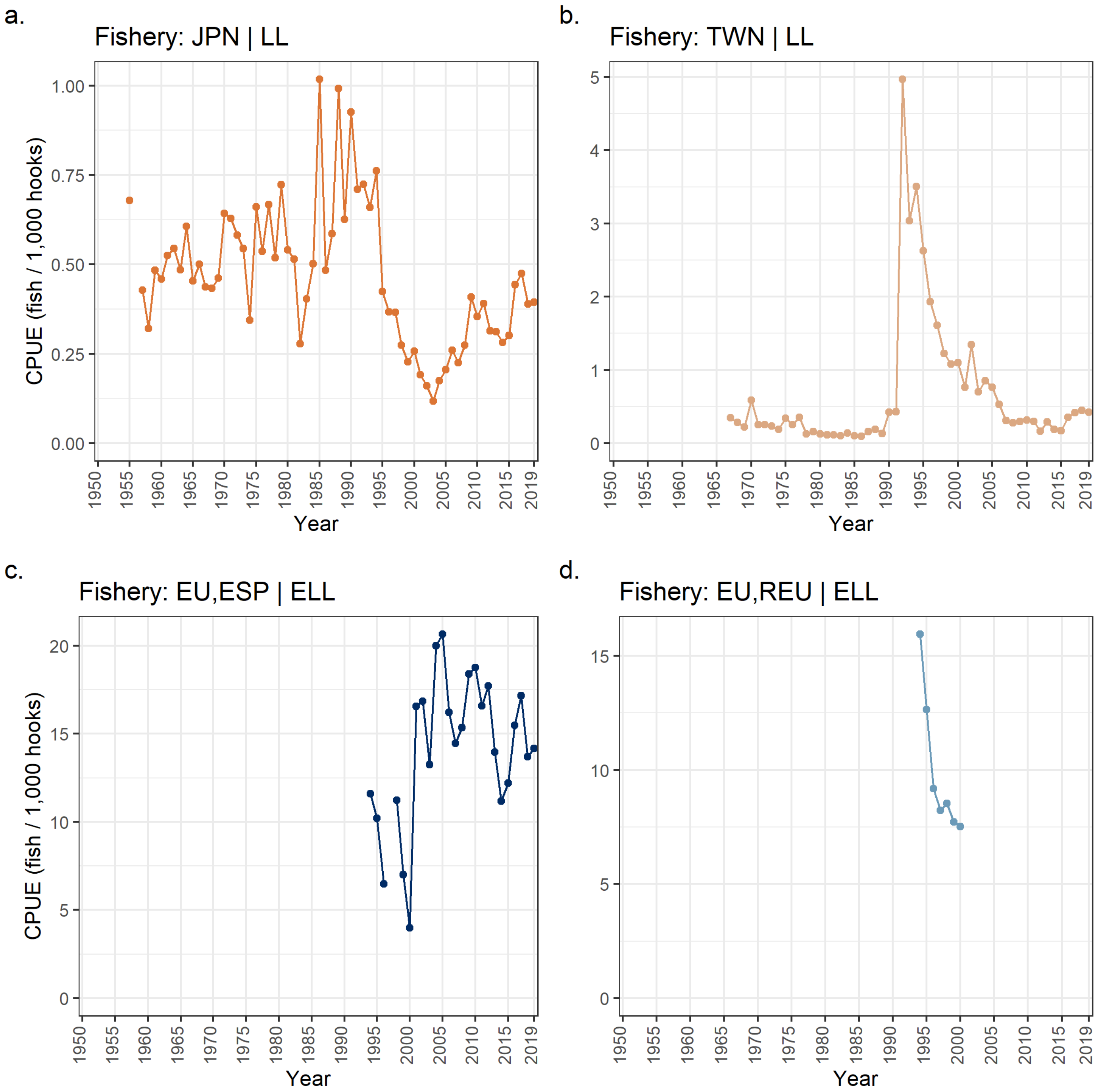

Figure 63: Nominal CPUE in numbers (number of fish / 1,000 hooks) of swordfish caught by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

South-West area (in weight)

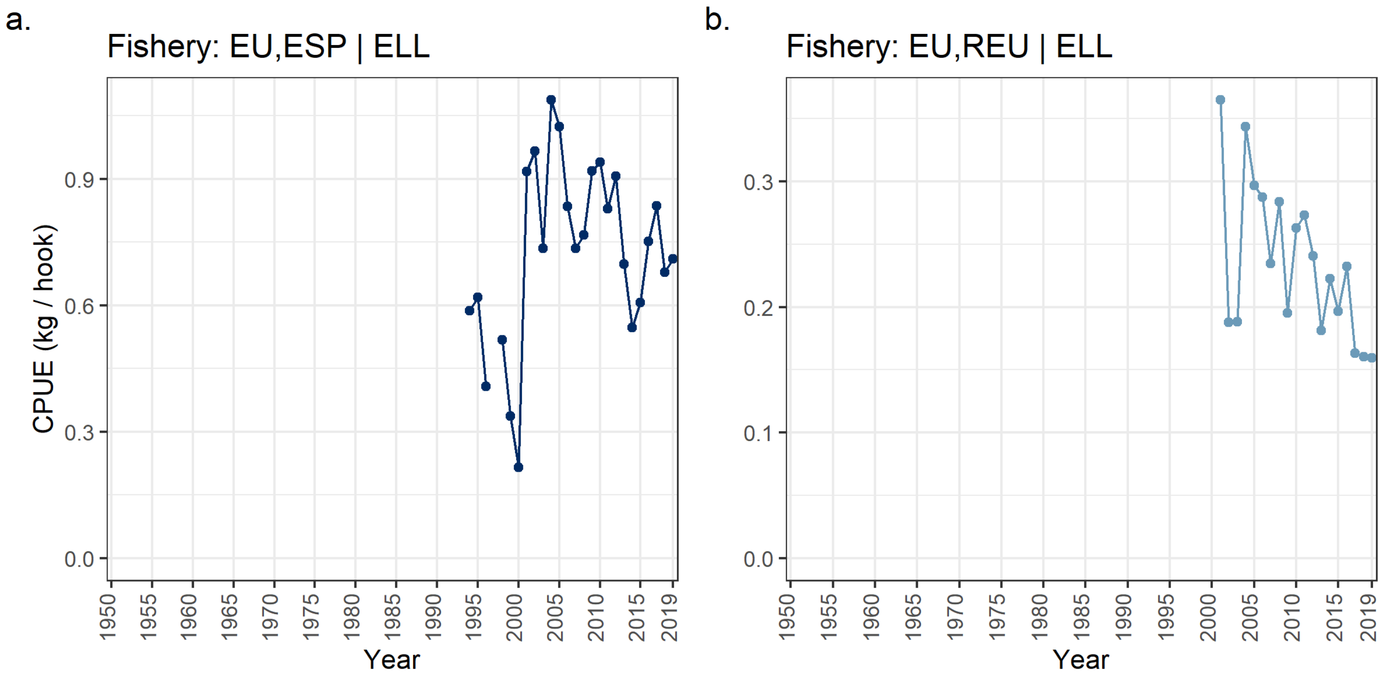

Figure 64: Nominal CPUE in weight (kg / hook) of swordfish caught by the longline fisheries of (a) EU,Spain and (b) EU,France (Réunion-based). ELL = swordfish-targeting longline

South-East area (in numbers)

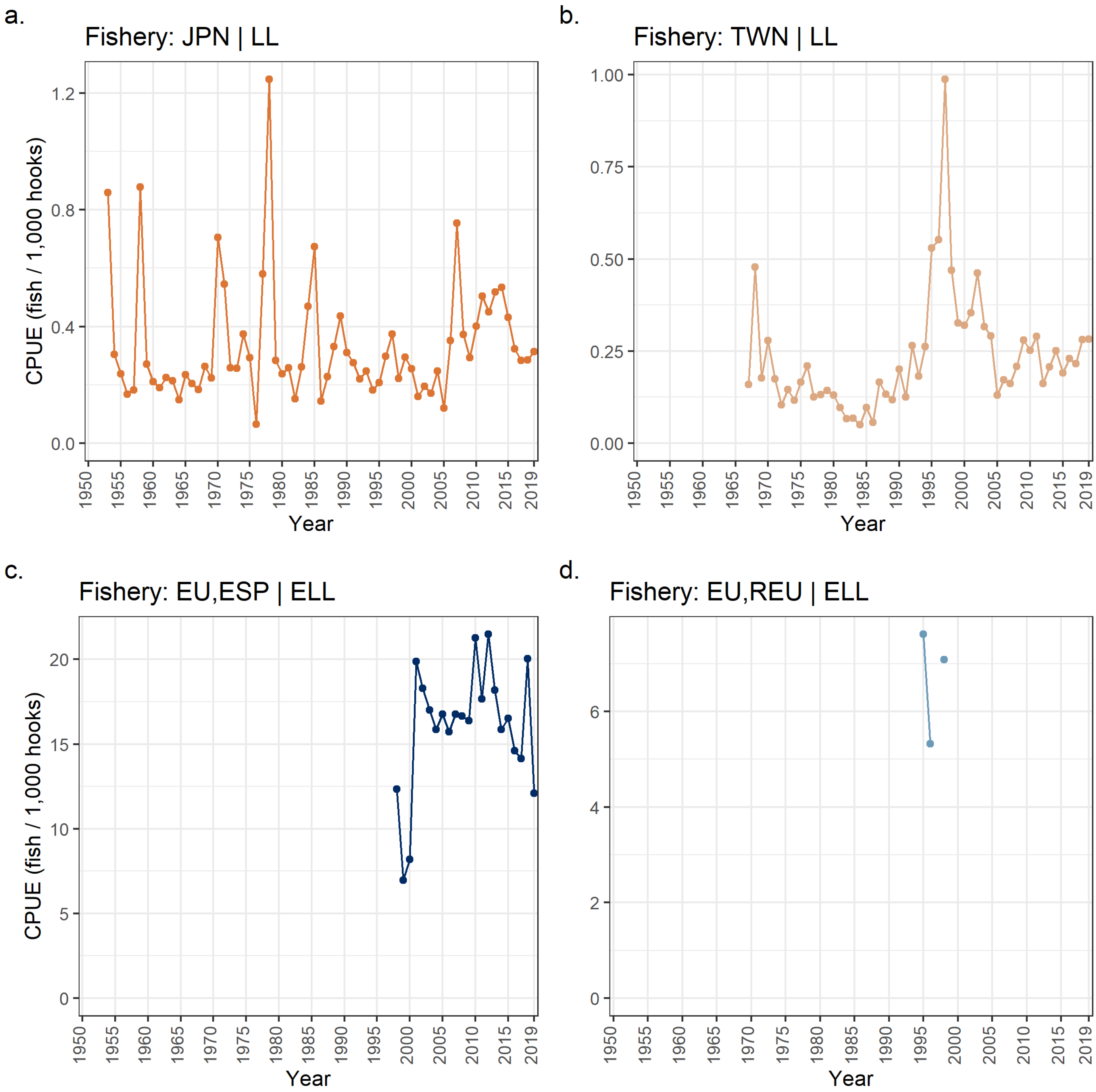

Figure 65: Nominal CPUE in numbers (number of fish / 1,000 hooks) of swordfish caught by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain and (d) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

South-East area (in weight)

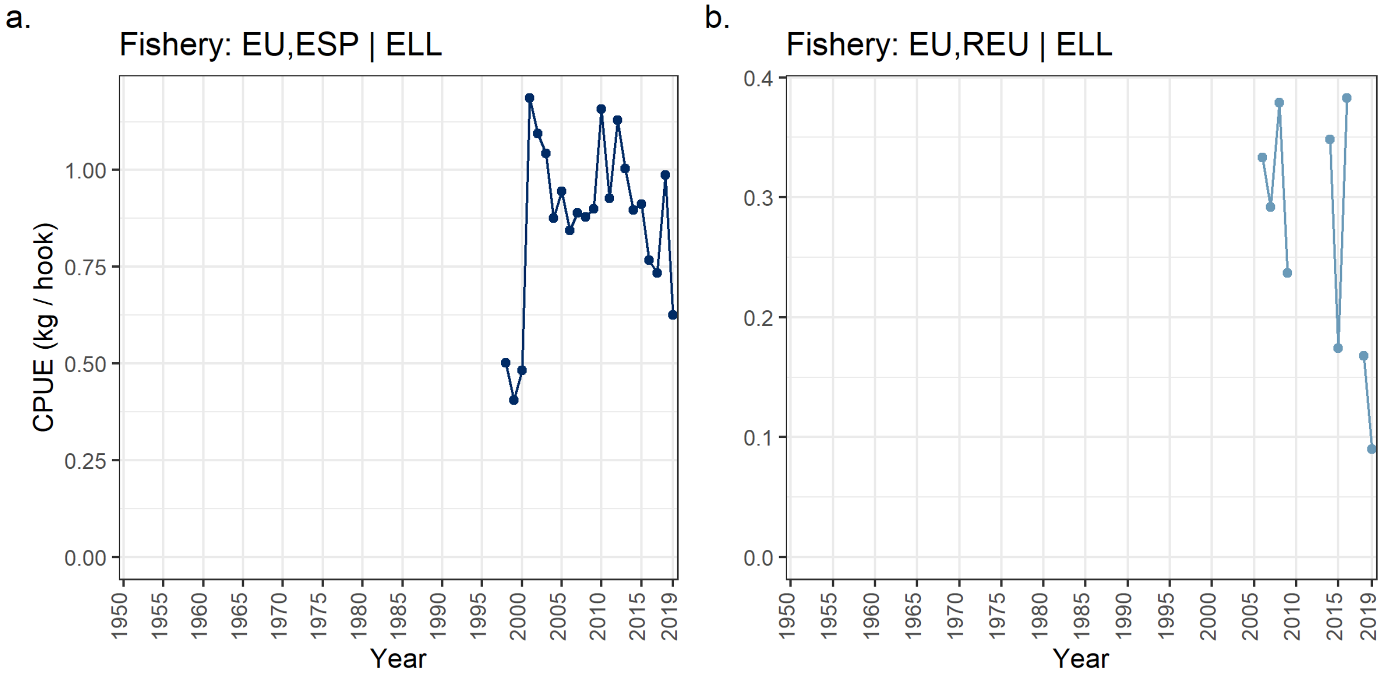

Figure 66: Nominal CPUE in weight (kg / hook) of swordfish caught by the longline fisheries of (a) EU,Spain and (b) EU,France (Réunion-based). ELL = swordfish-targeting longline

Blue marlin (BUM, *Makaira nigricans*)

Somali hotspot (in numbers)

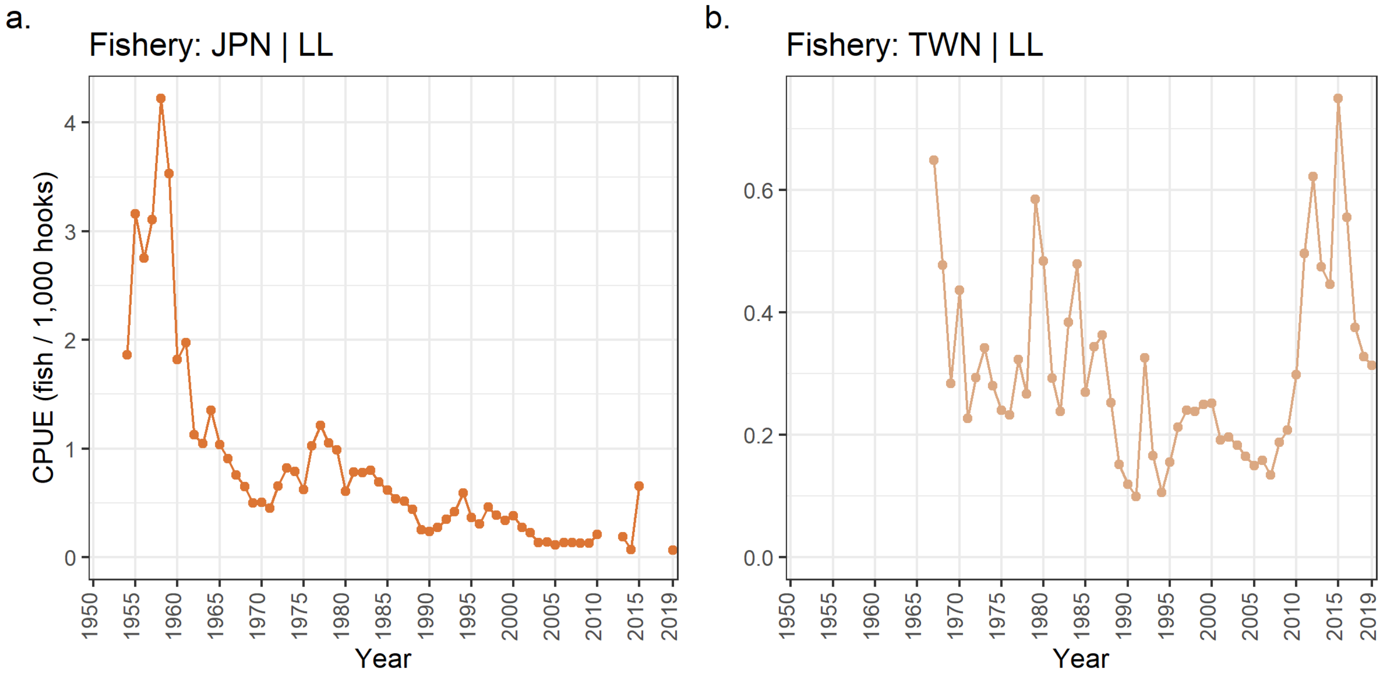

Figure 67: Nominal CPUE in numbers (number of fish / 1,000 hooks) of blue marlin caught by the longline fisheries of (a) Japan, (b) Taiwan,China. LL = drifting longline (over 1,800 hooks)

Australian hotspot (in numbers)

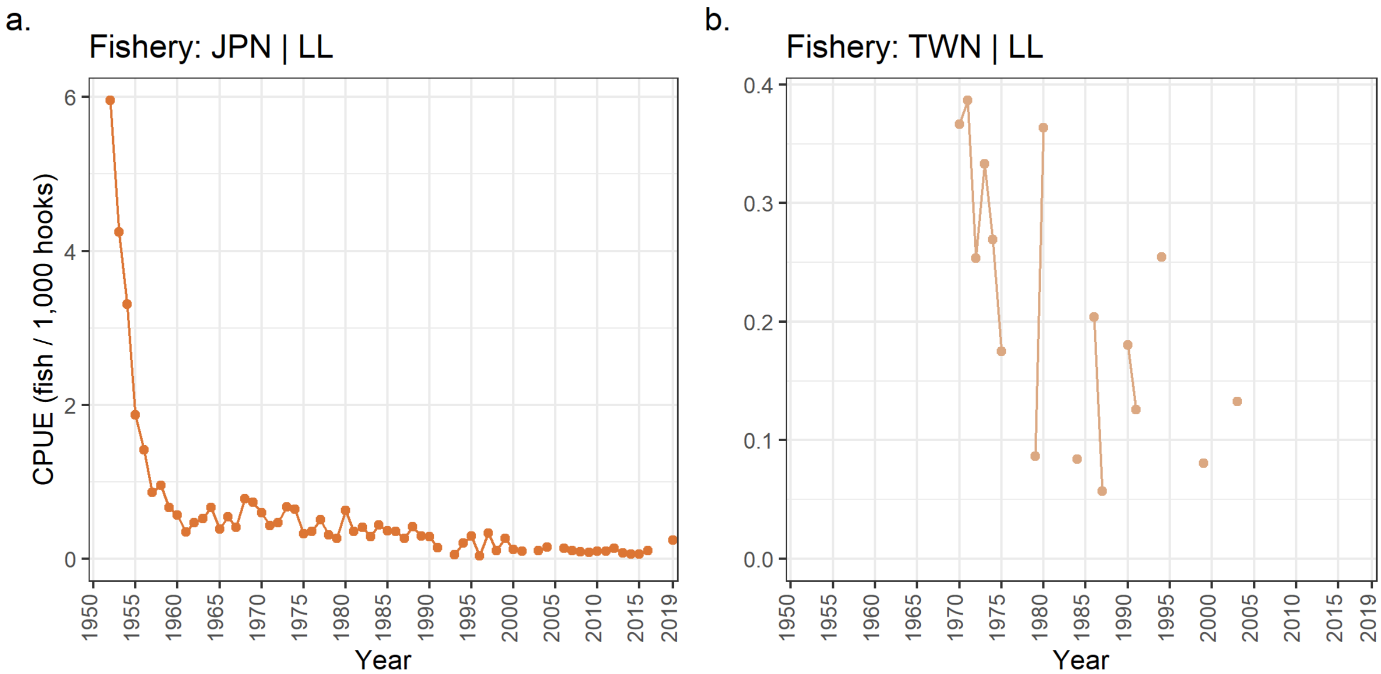

Figure 68: Nominal CPUE in numbers (number of fish / 1,000 hooks) of blue marlin caught by the longline fisheries of (a) Japan, (b) Taiwan,China. LL = drifting longline (over 1,800 hooks)

Black marlin (BLM, *Istiompax indica*)

Somali hotspot (in numbers)

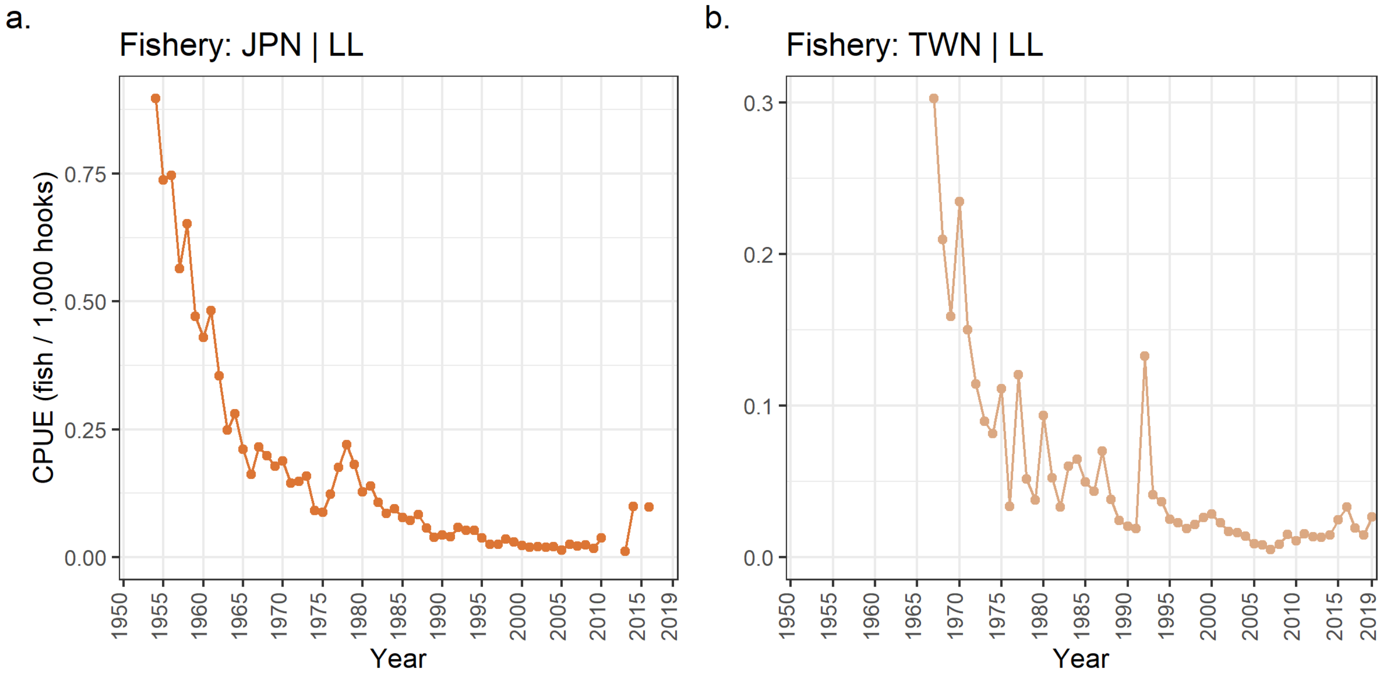

Figure 69: Nominal CPUE in numbers (number of fish / 1,000 hooks) of black marlin caught by the longline fisheries of (a) Japan, (b) Taiwan,China. LL = drifting longline (over 1,800 hooks)

Australian hotspot (in numbers)

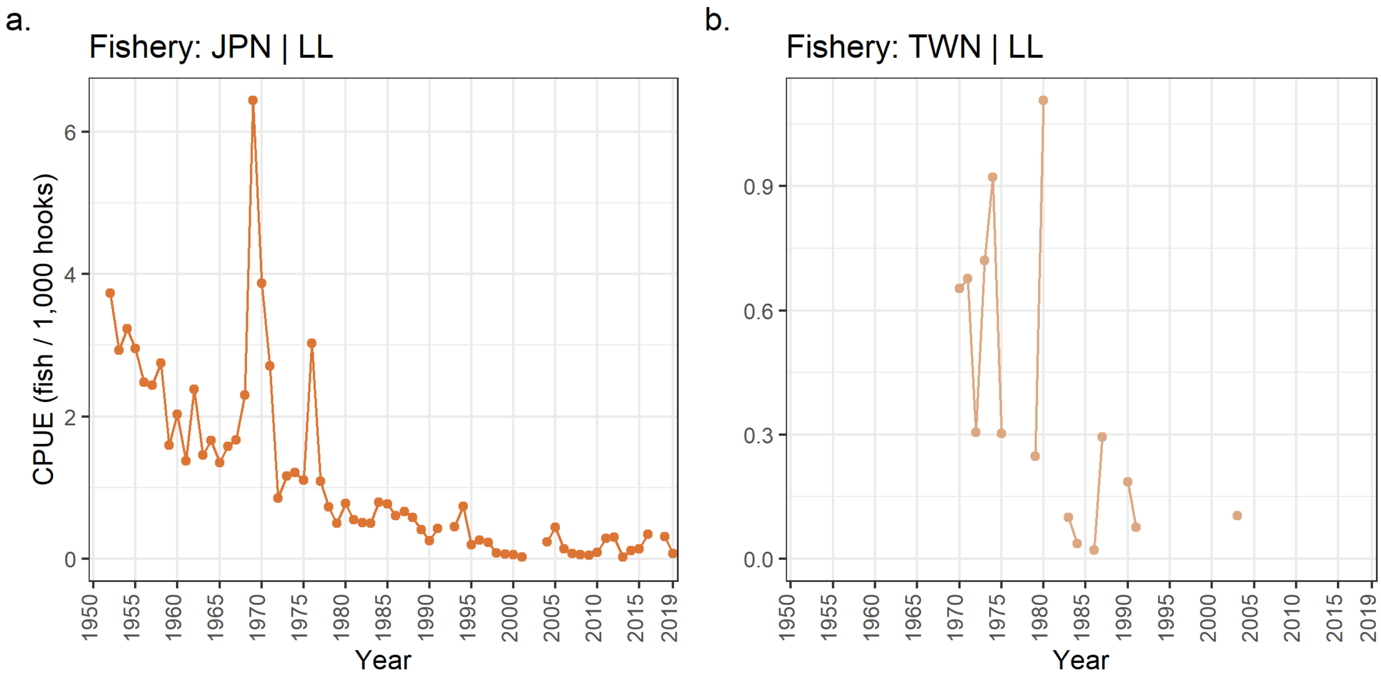

Figure 70: Nominal CPUE in numbers (number of fish / 1,000 hooks) of black marlin caught by the longline fisheries of (a) Japan, (b) Taiwan,China. LL = drifting longline (over 1,800 hooks)

Striped marlin (MLS, *Tetrapturus audax*)

Somali hotspot (in numbers)

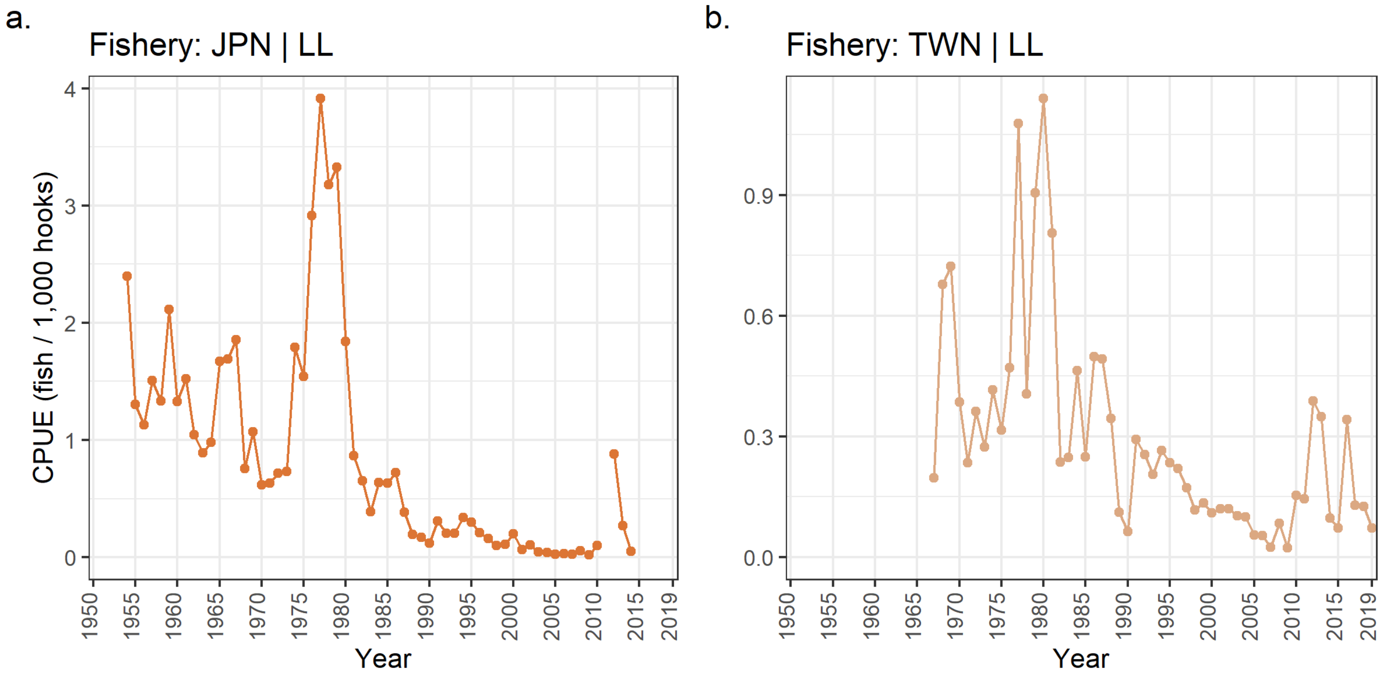

Figure 71: Nominal CPUE in numbers (number of fish / 1,000 hooks) of striped marlin caught by the longline fisheries of (a) Japan, (b) Taiwan,China. LL = drifting longline (over 1,800 hooks)

Australian hotspot (in numbers)

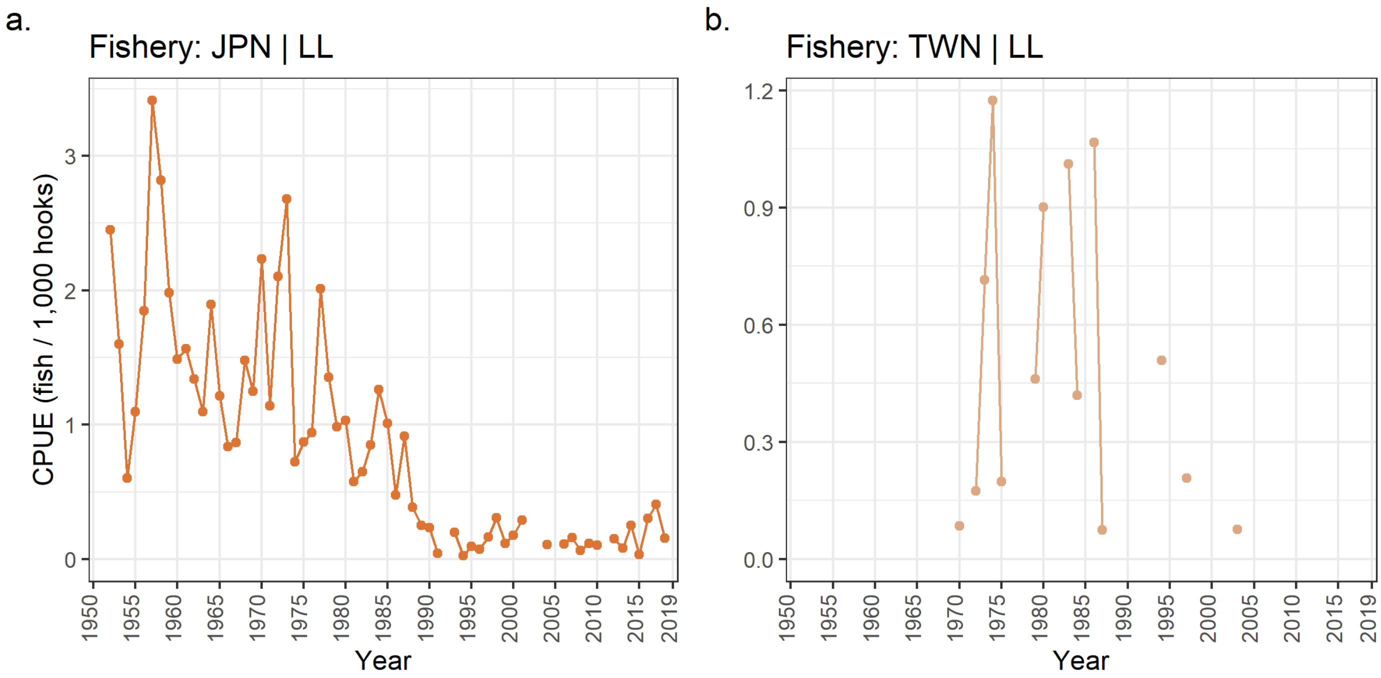

Figure 72: Nominal CPUE in numbers (number of fish / 1,000 hooks) of striped marlin caught by the longline fisheries of (a) Japan, (b) Taiwan,China. LL = drifting longline (over 1,800 hooks)

Indo-Pacific sailfish (SFA, *Istiophorus platypterus*)

Annual nominal CPUE by area (in numbers)

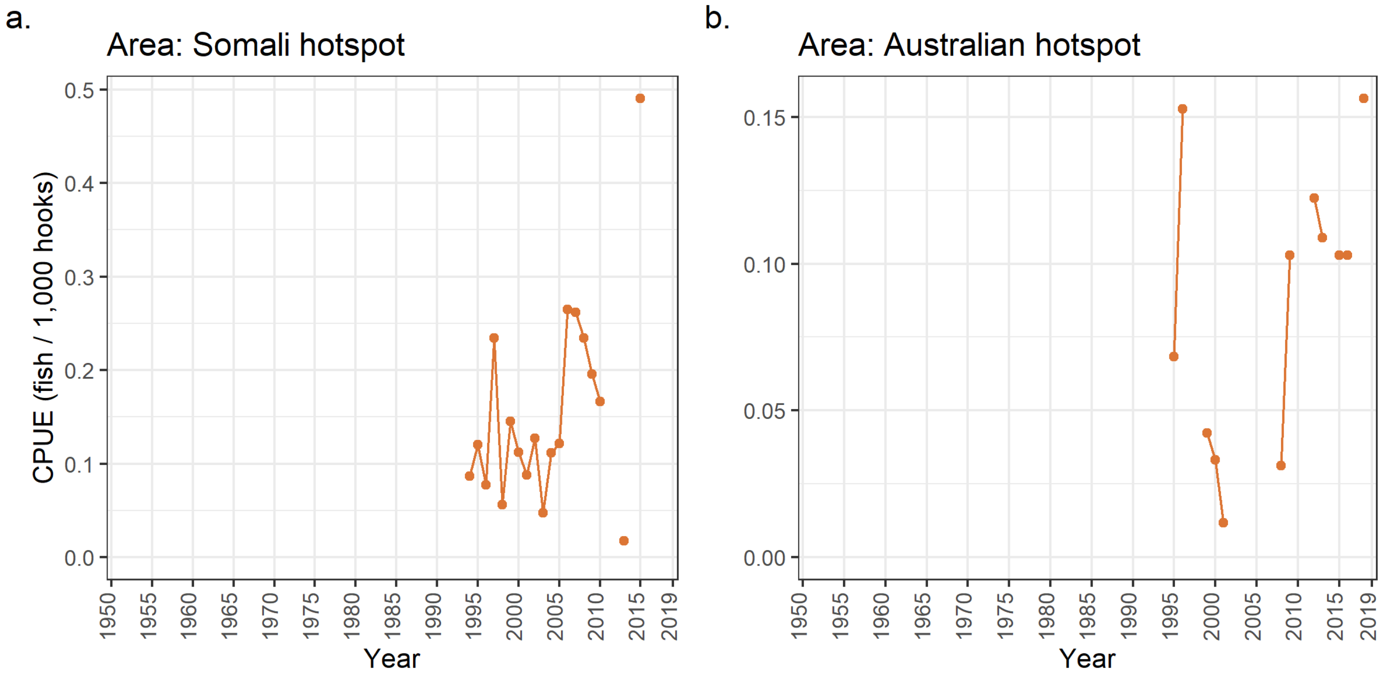

Figure 73: Nominal CPUE in numbers (number of fish / 1,000 hooks) of Indo-Pacific sailfish caught by the longline fisheries of Japan in the Somali (a) and in the Australian (b) hotspot (see **Fig. 54**). LL = drifting longline (over 1,800 hooks)

Available size-frequency data and trends in average weights

Swordfish (SWO, *Xiphias gladius*)

Size-frequency distributions

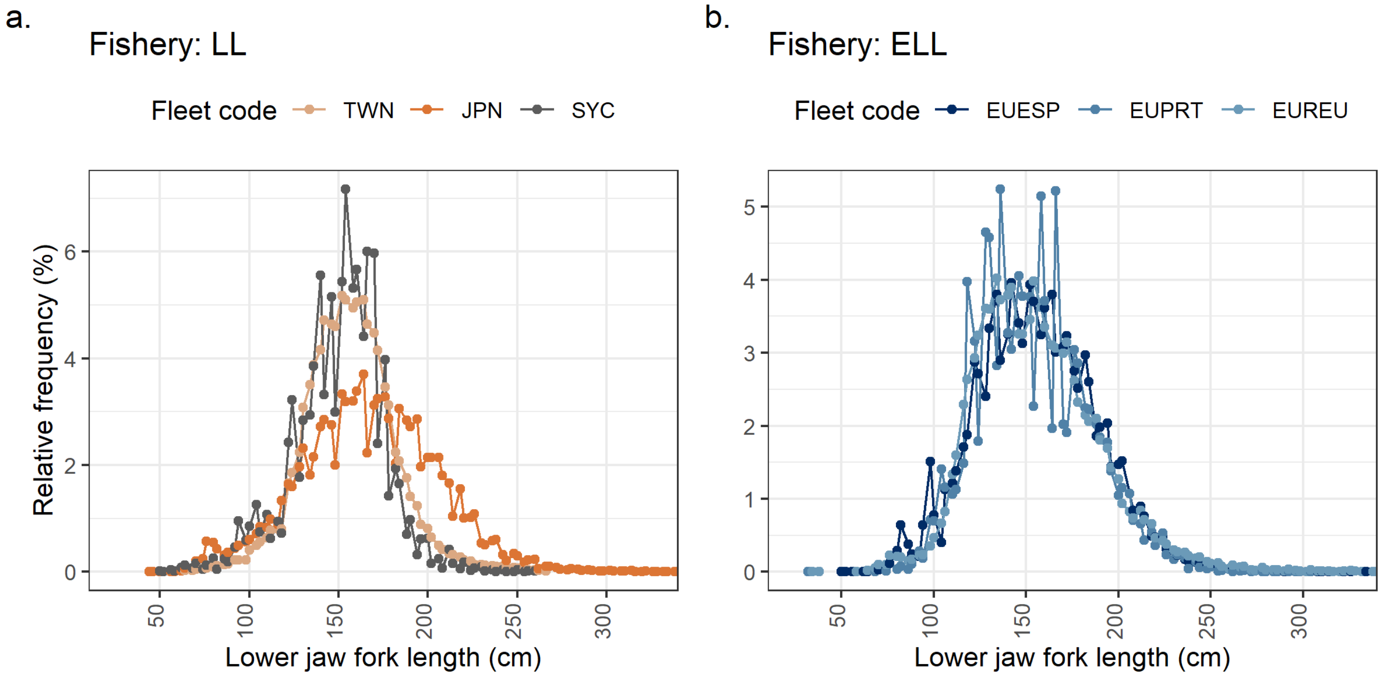

Figure 74: Relative distribution of swordfish measured lengths by fleet, as recorded by the longline fisheries of (a) Japan, Taiwan,China and Seychelles, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based). Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

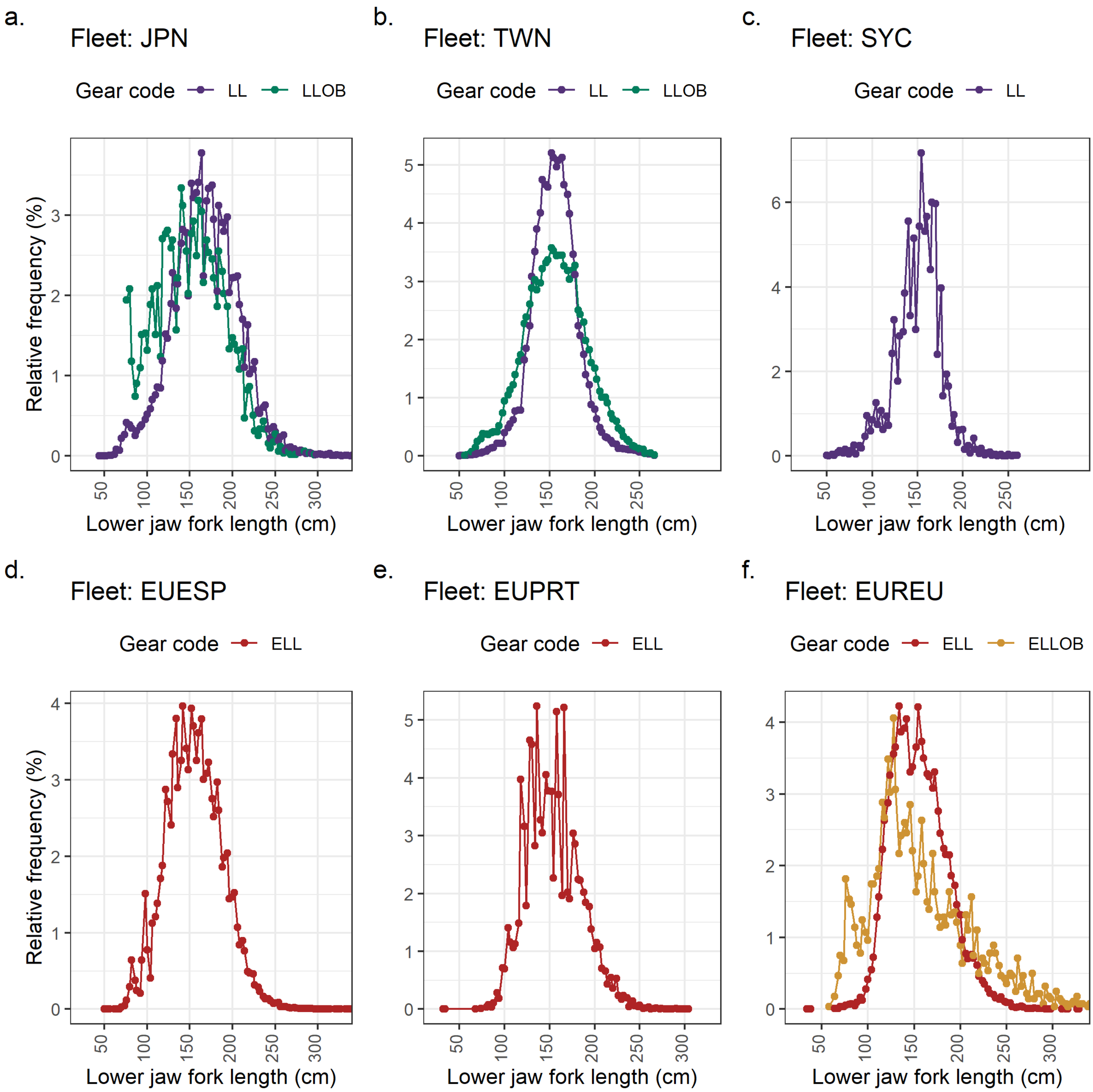

Figure 75: Relative distribution of swordfish measured lengths by fleet and source of information (logbook vs. observers), as recorded by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) Seychelles, (d) EU,Spain, (e) EU,France (Réunion-based), (f) EU,Portugal. LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

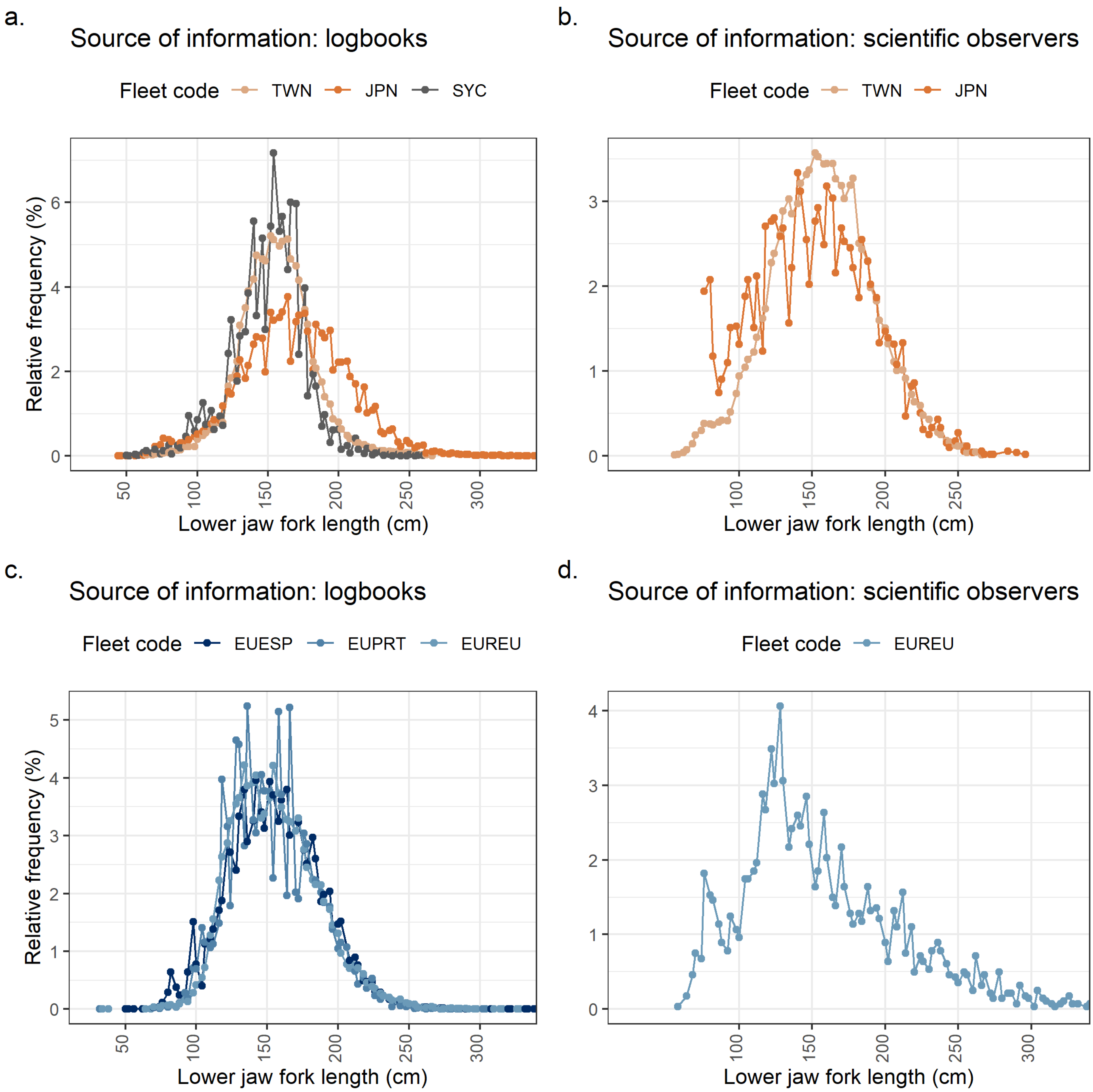

Figure 76: Relative distribution of swordfish measured lengths by source of information as recorded on logbooks (a, c) and by observers (b, c) for the longline fisheries of Japan, Taiwan,China and Seychelles, and the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based)

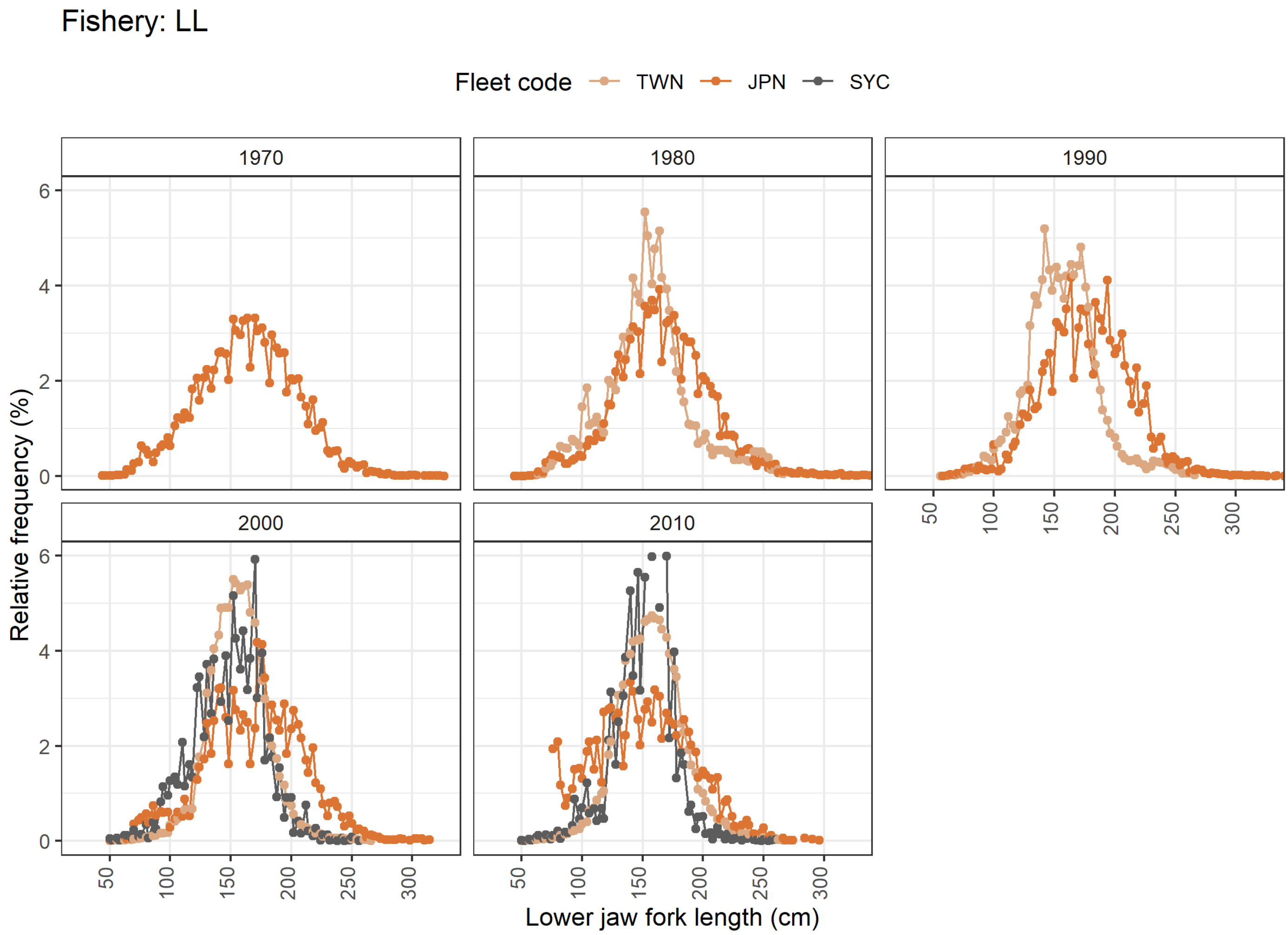

Figure 77: Relative distribution of swordfish measured lengths by fleet and decade, as recorded by the drifting longline fisheries of Japan, Taiwan,China and Seychelles. Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks)

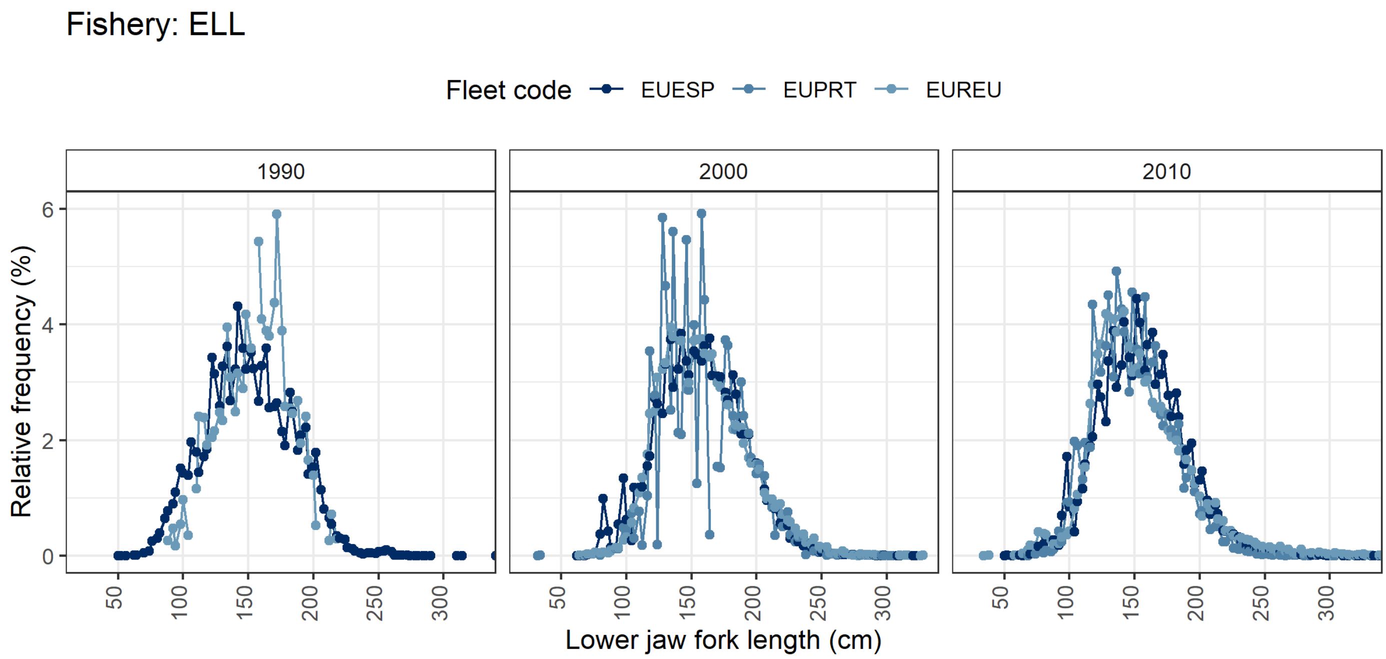

Figure 78: Relative distribution of Swordfish measured lengths by fleet and decade, as recorded by the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based). Data include information from logbooks and scientific observers. ELL = swordfish-targeting longline

Calculated average annual weights

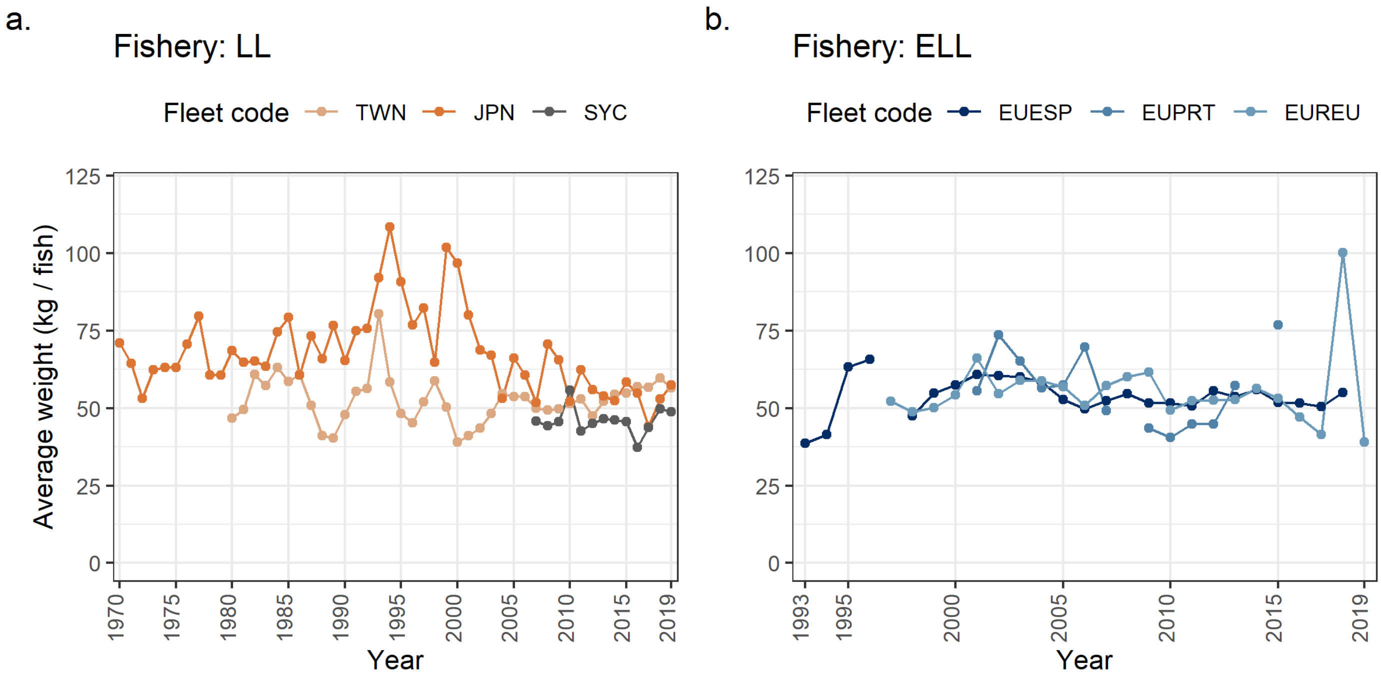

Figure 79: Annual calculated average weight of swordfish by fleet, as recorded by the longline fisheries of (a) Japan, Taiwan,China and Seychelles, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based). Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

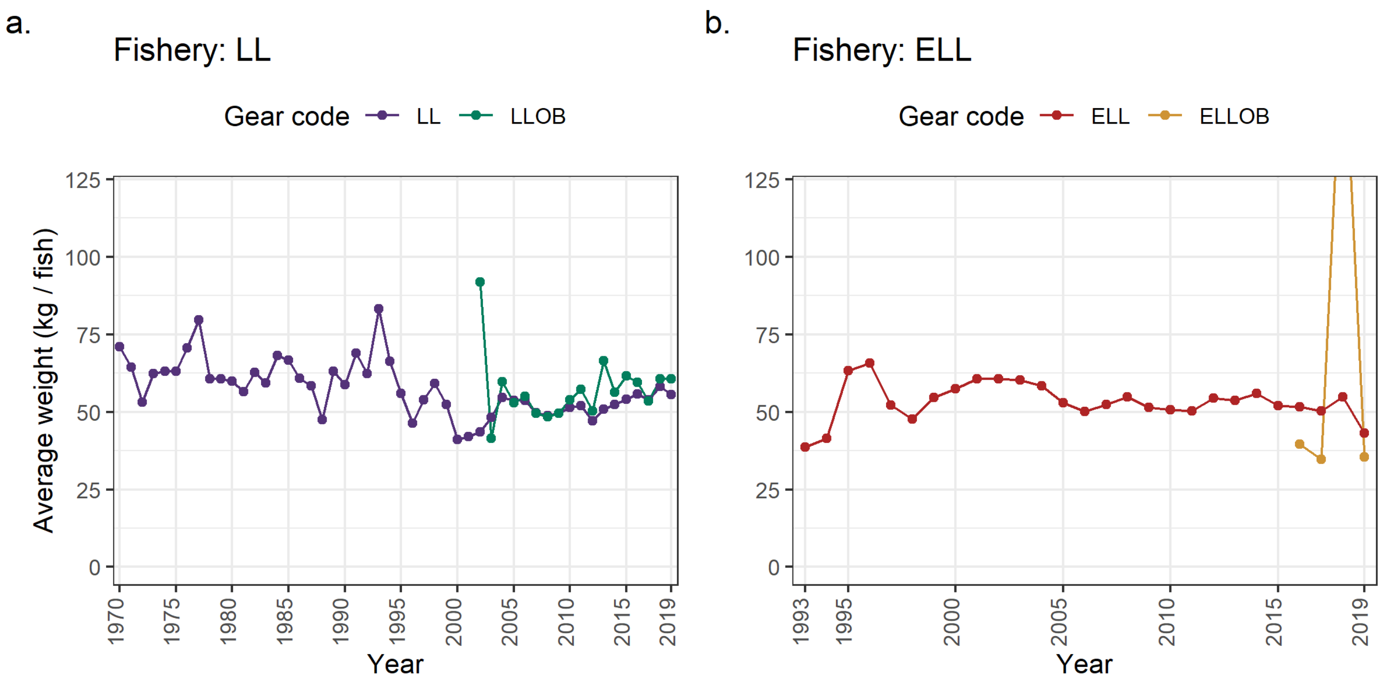

Figure 80: Annual calculated average weight of swordfish by source of information (logbook vs. observers), as recorded by (a) the drifting longline fisheries of Japan, Taiwan,China and Seychelles, and (b) the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

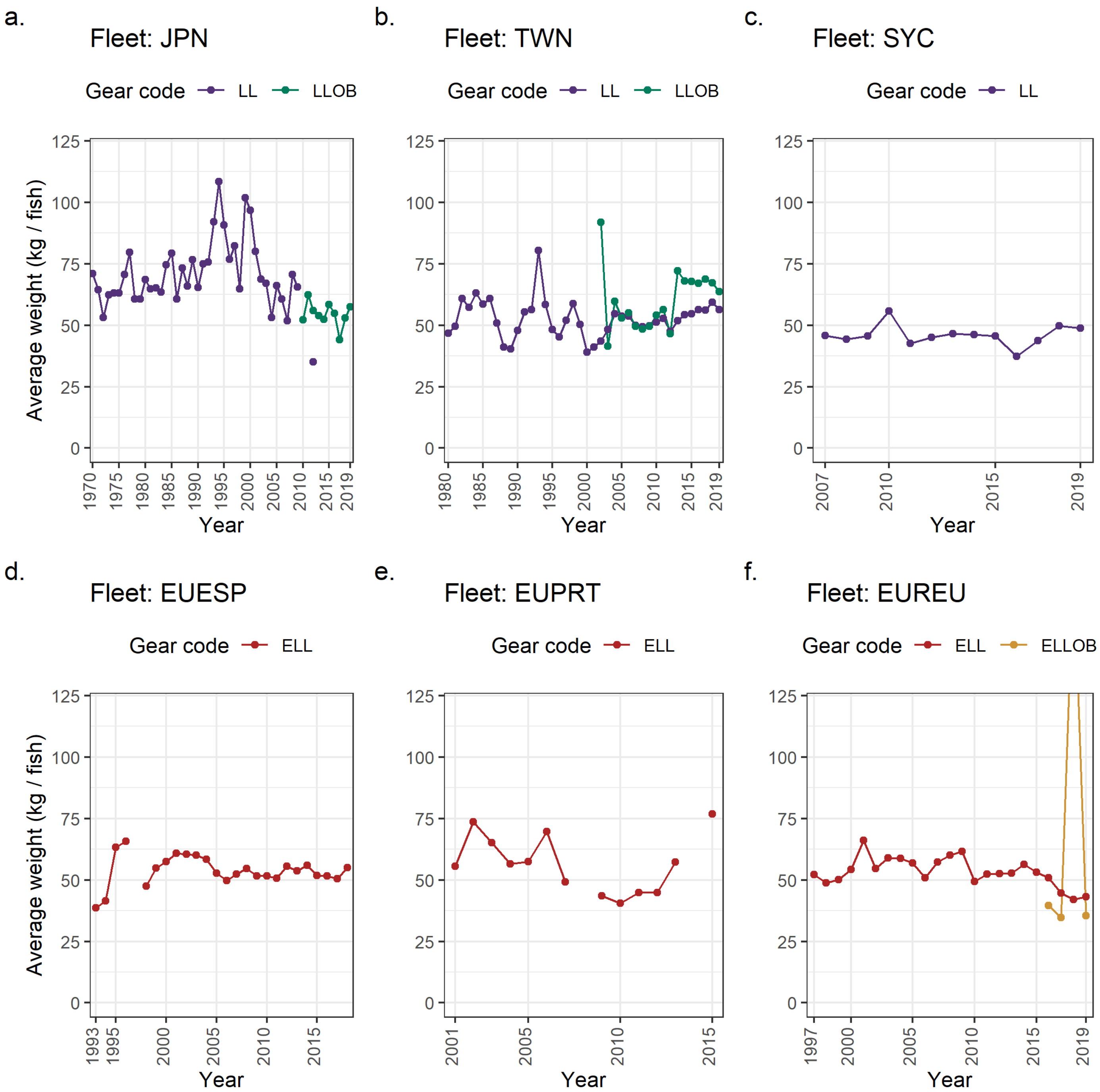

Figure 81: Annual calculated average weight of swordfish by source of information (logbook vs. observers), as recorded by the drifting longline fisheries of (a) Japan, (b) Taiwan,Chinaand (c) Seychelles, and by the swordfish-targeting longline fisheries of (d) EU,Spain, (e) EU,Portugal and (f) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

Black marlin (BLM, *Istiompax indica*)

Size-frequency distributions

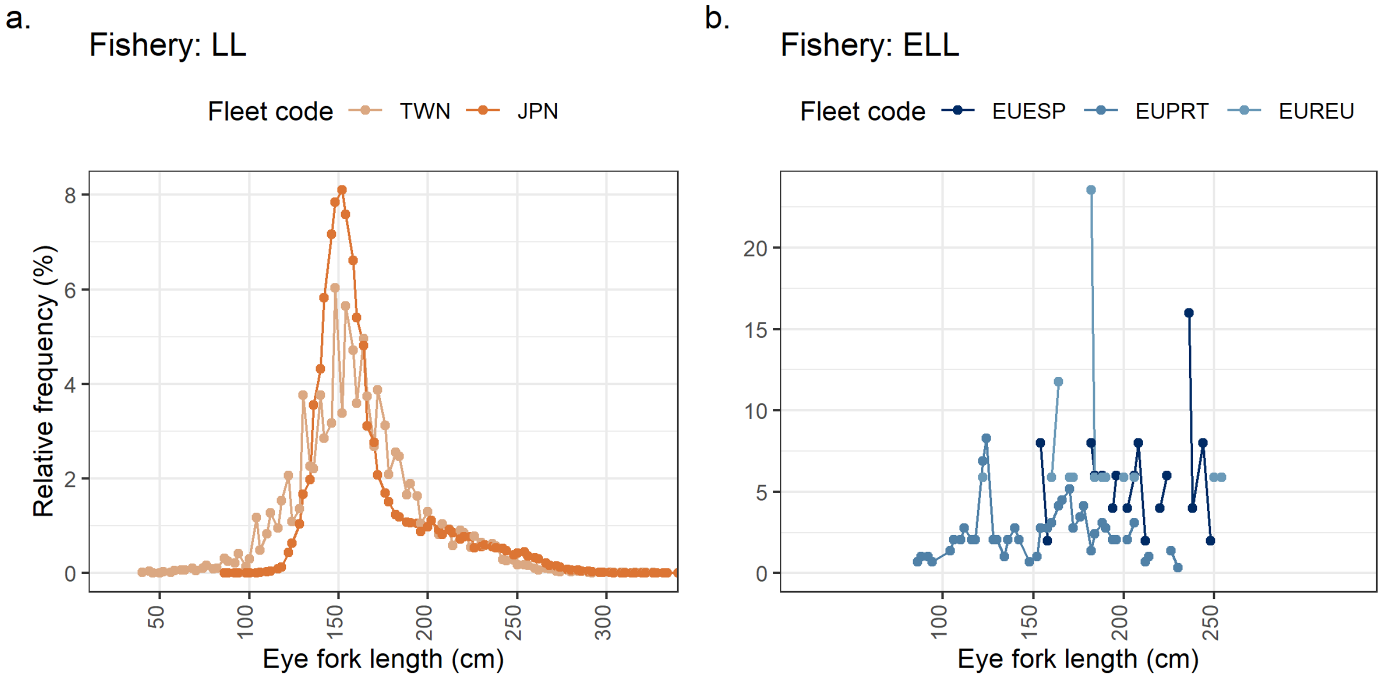

Figure 82: Relative distribution of black marlin measured lengths by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

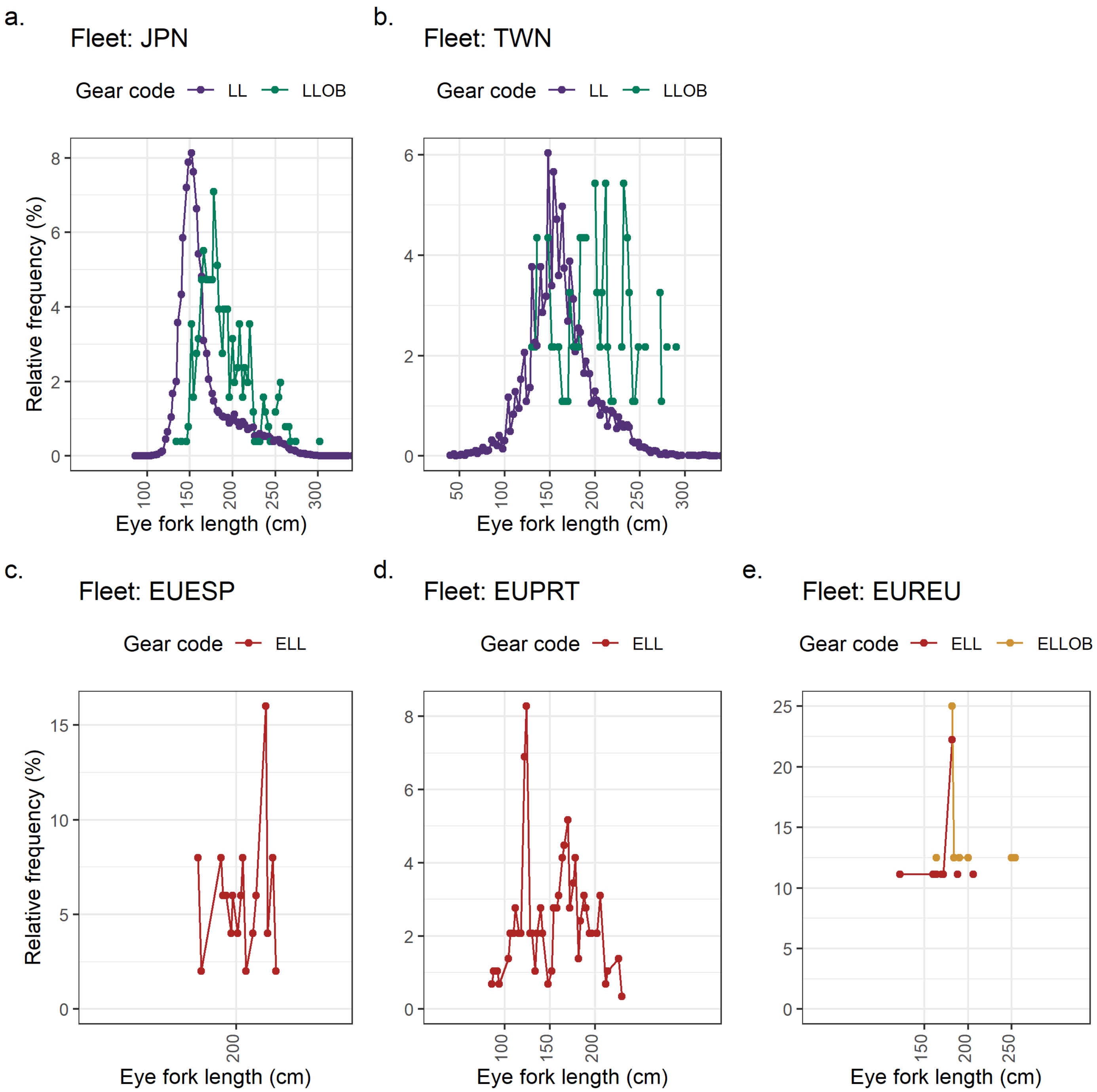

Figure 83: Relative distribution of black marlin measured lengths by fleet and source of information (logbook vs. observers), as recorded by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain, (d) EU,Portugal, (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

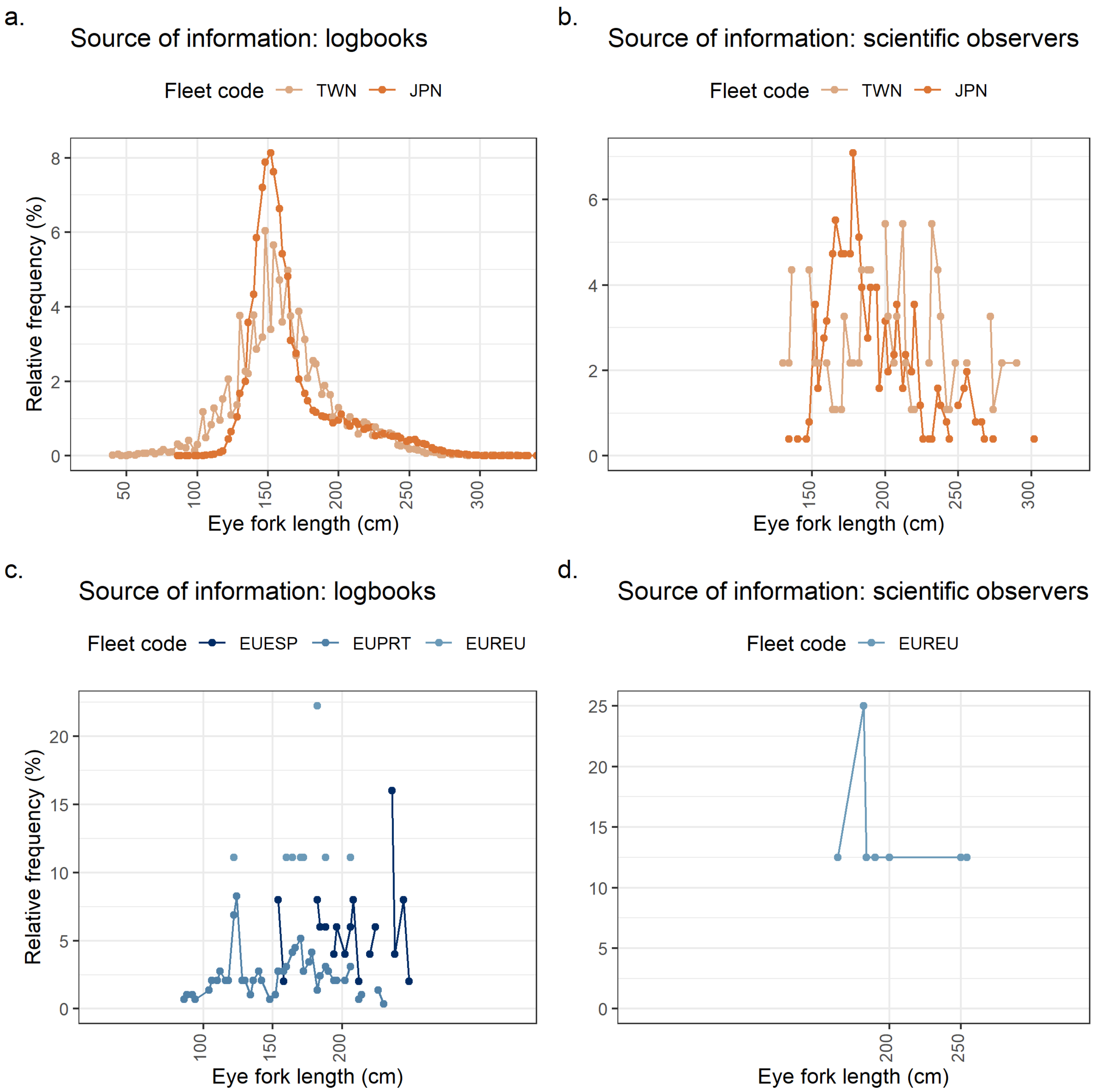

Figure 84: Relative distribution of black marlin measured lengths by source of information as recorded on logbooks (a, c) and by observers (b, c) for the longline fisheries of Japan and Taiwan,China, and the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based)

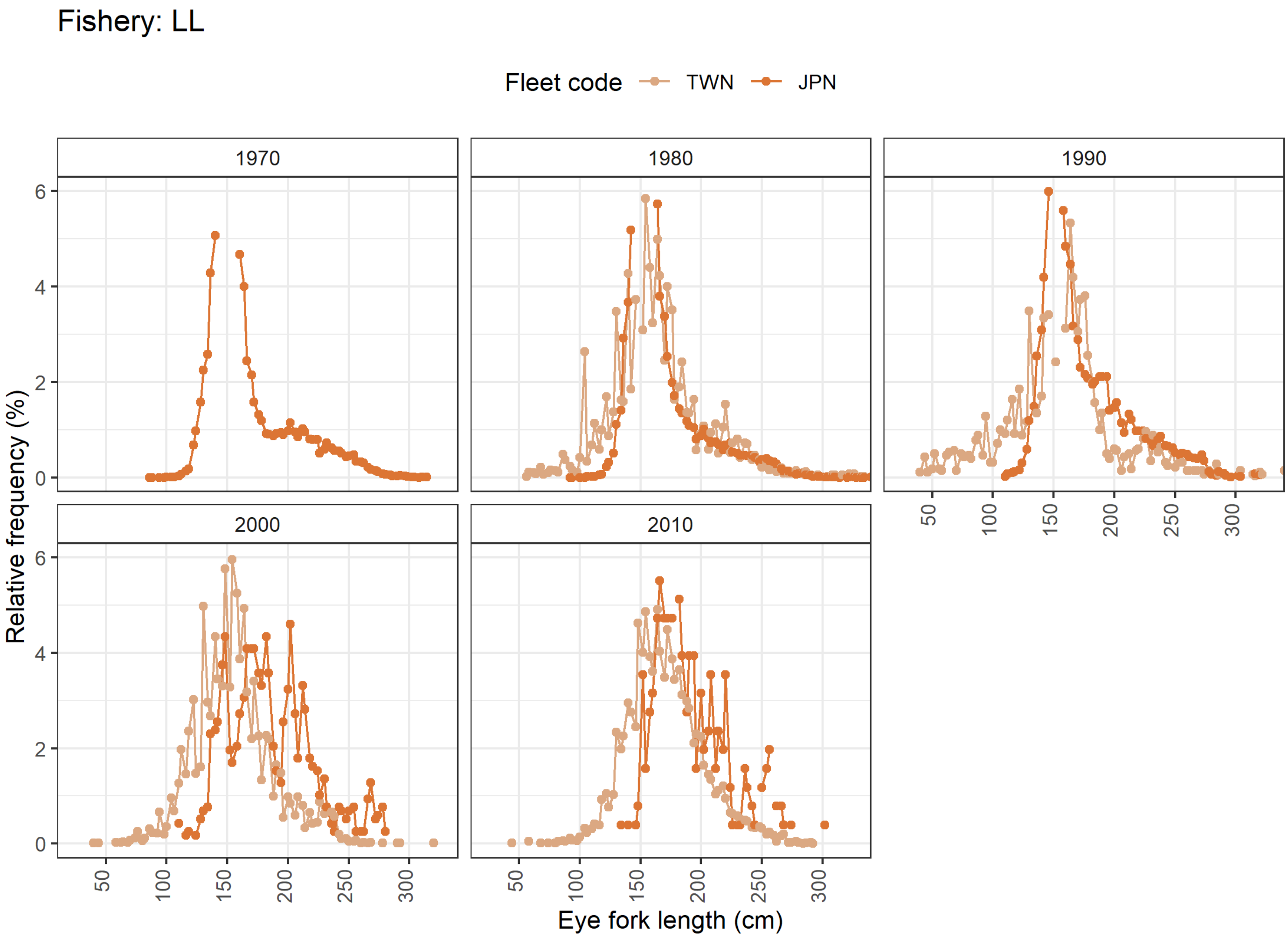

Figure 85: Relative distribution of black marlin measured lengths by fleet and decade, as recorded by the drifting longline fisheries of Japan and Taiwan,China. Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks)

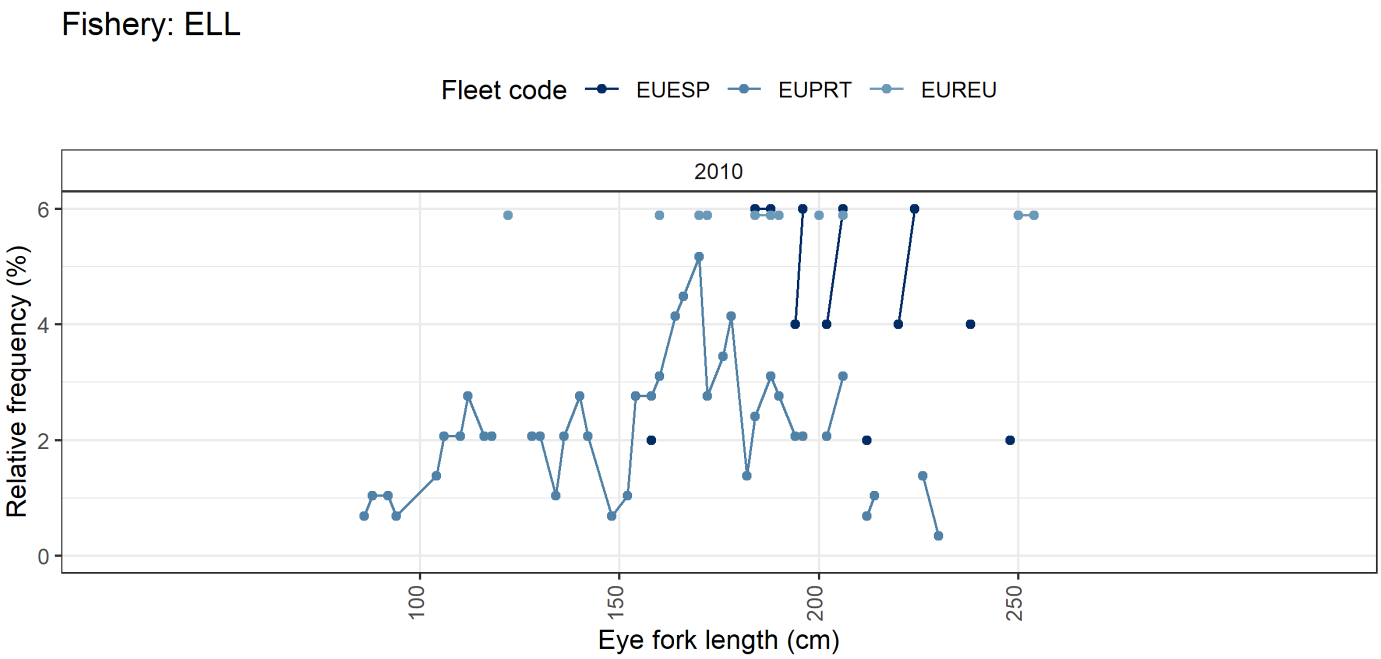

Figure 86: Relative distribution of black marlin measured lengths by fleet and decade, as recorded by the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. ELL = swordfish-targeting longline

Calculated average annual weights

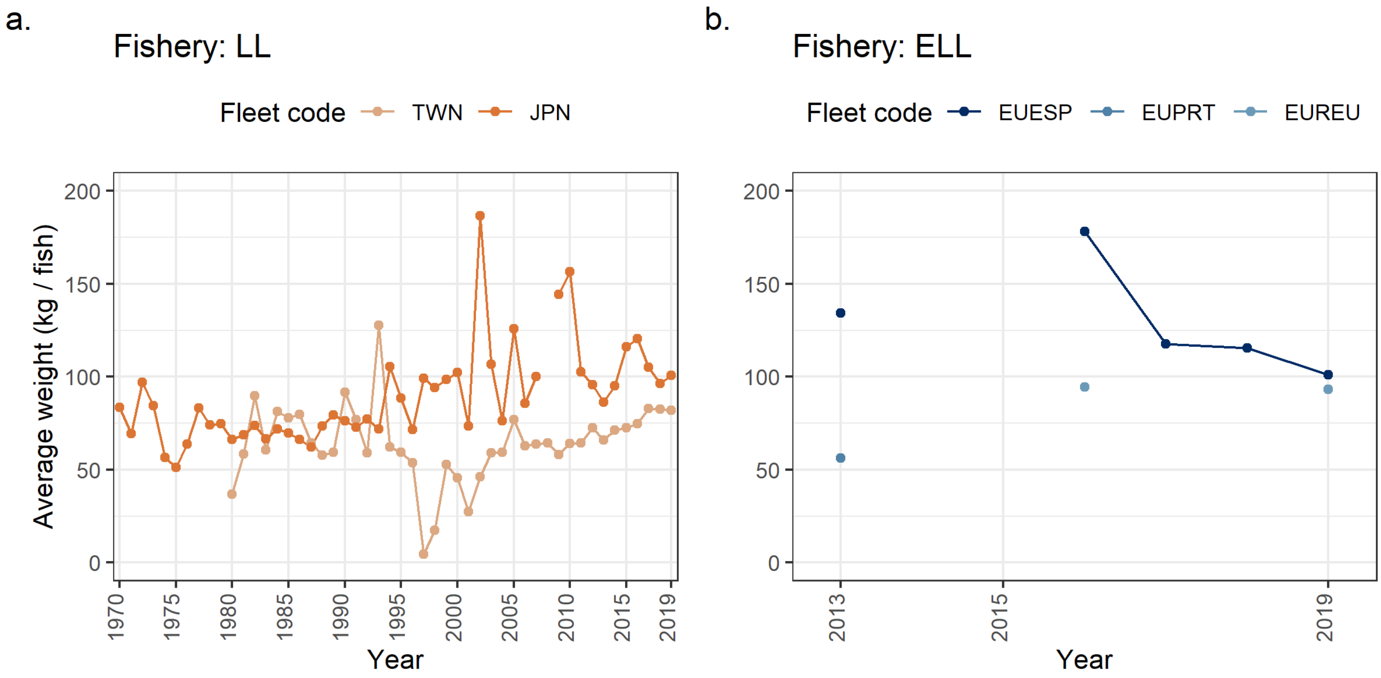

Figure 87: Annual calculated average weight of black marlins by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

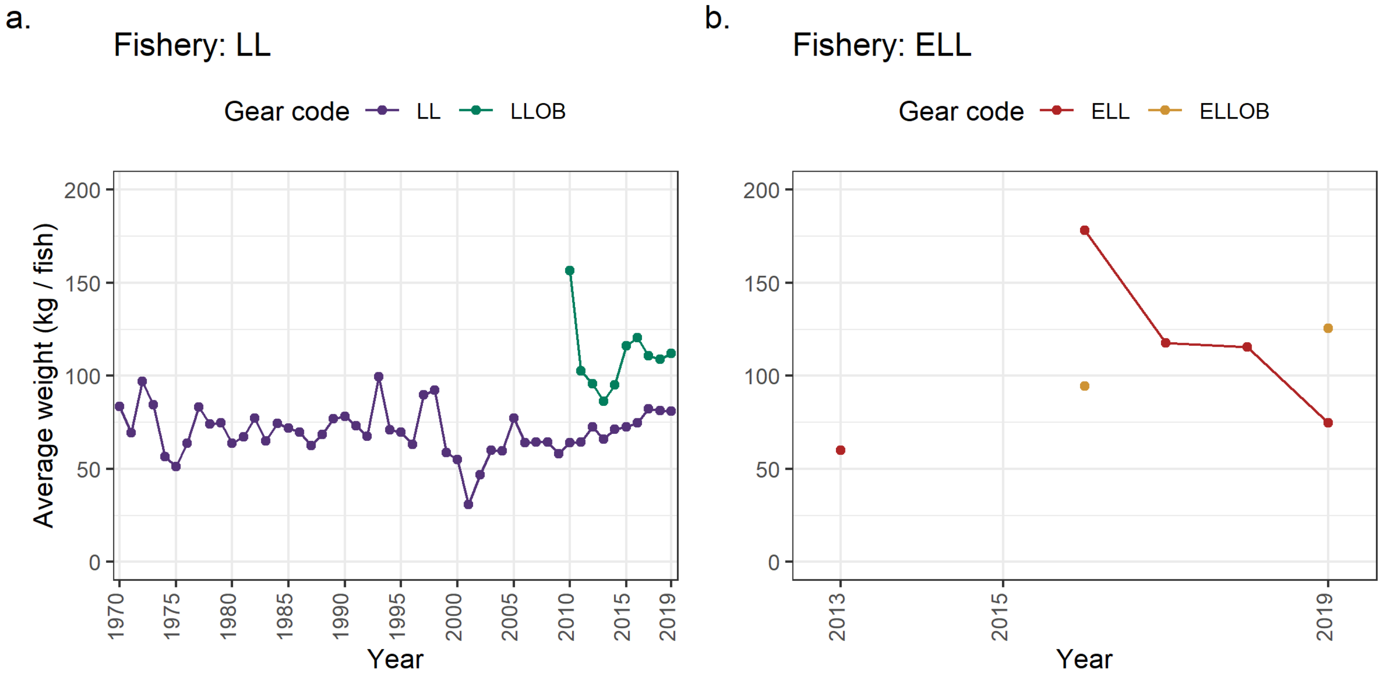

Figure 88: Annual calculated average weight of black marlins by source of information (logbook vs. observers), as recorded by (a) the drifting longline fisheries of Japan and Taiwan,China, and (b) the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

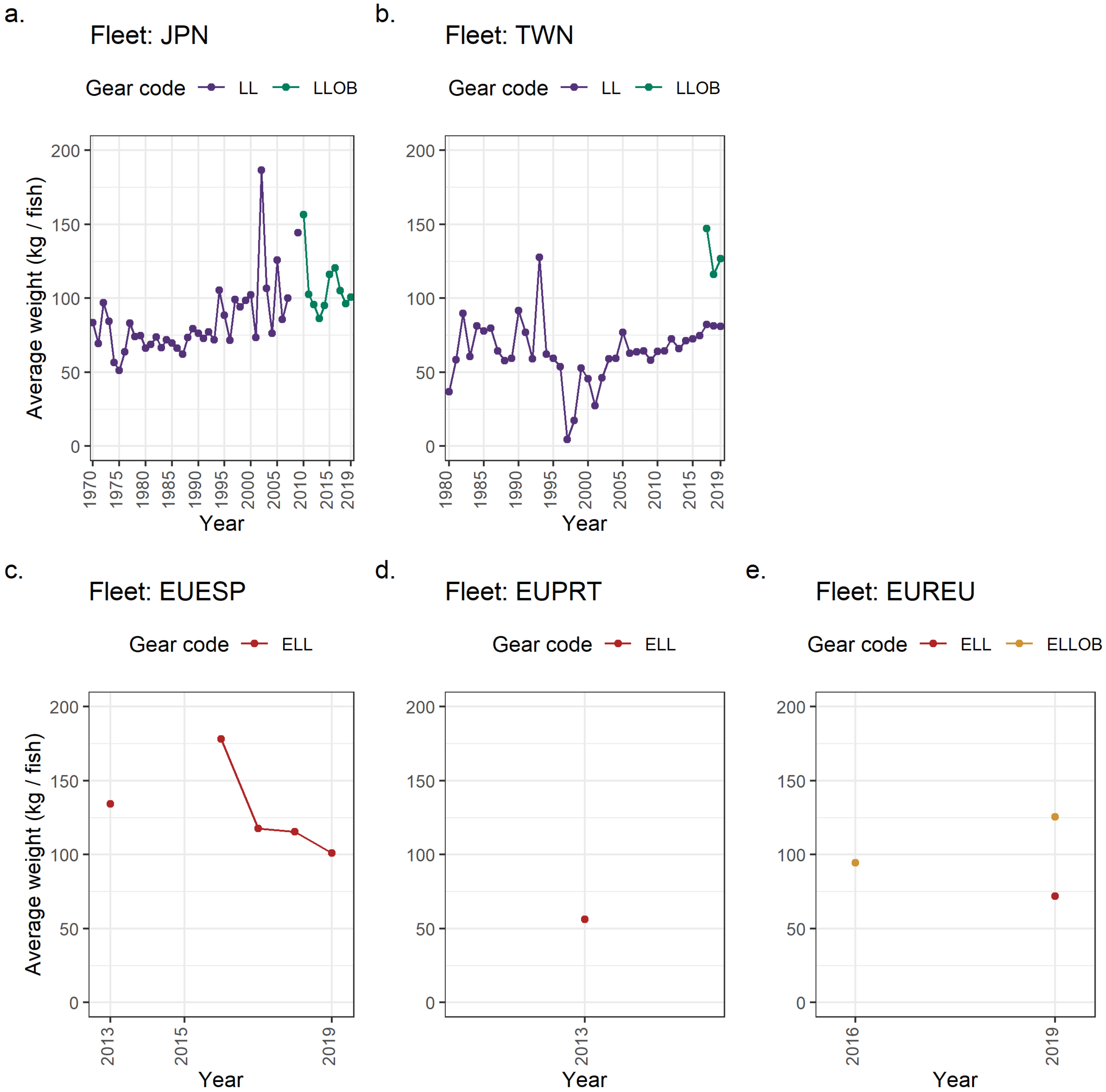

Figure 89: Annual calculated average weight of black marlins by source of information (logbook vs. observers), as recorded by the drifting longline fisheries of (a) Japan and (b) Taiwan,China, and by the swordfish-targeting longline fisheries of (c) EU,Spain, (d) EU,Portugal and (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

Blue marlin (BUM, *Makaira nigricans*)

Size-frequency distributions

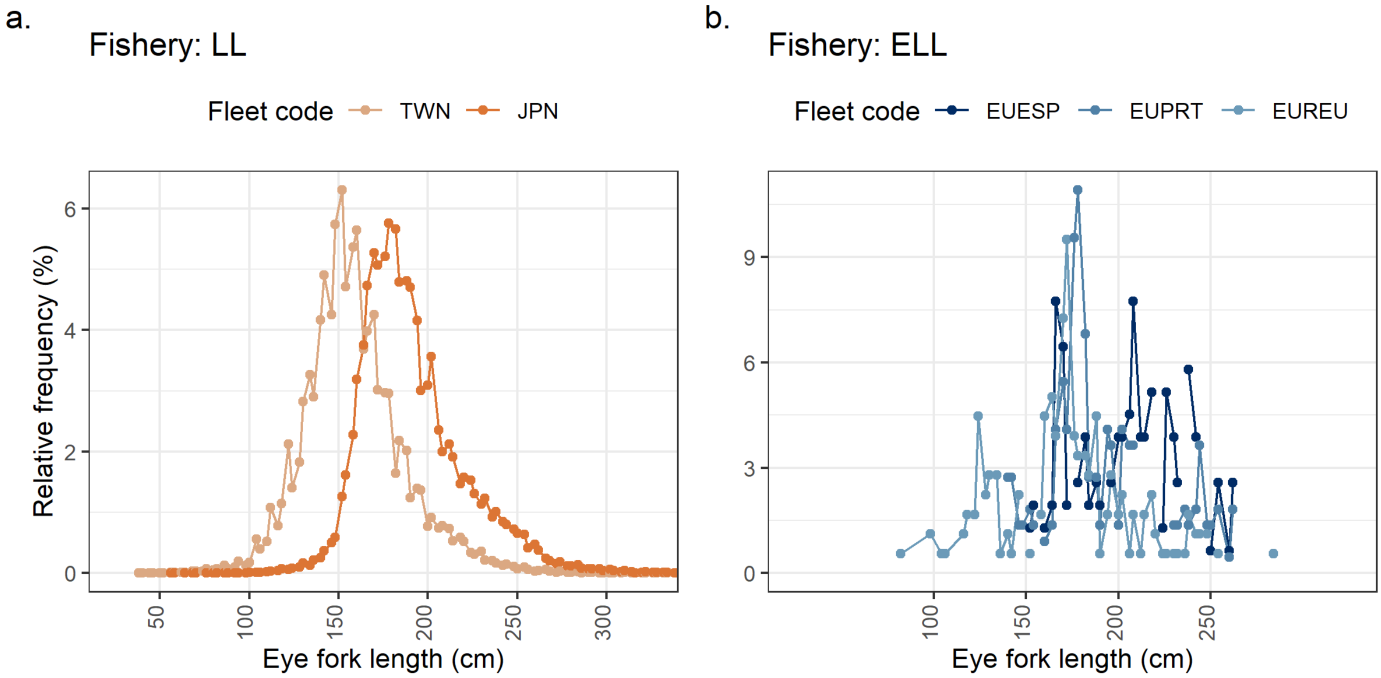

Figure 90: Relative distribution of blue marlin measured lengths by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

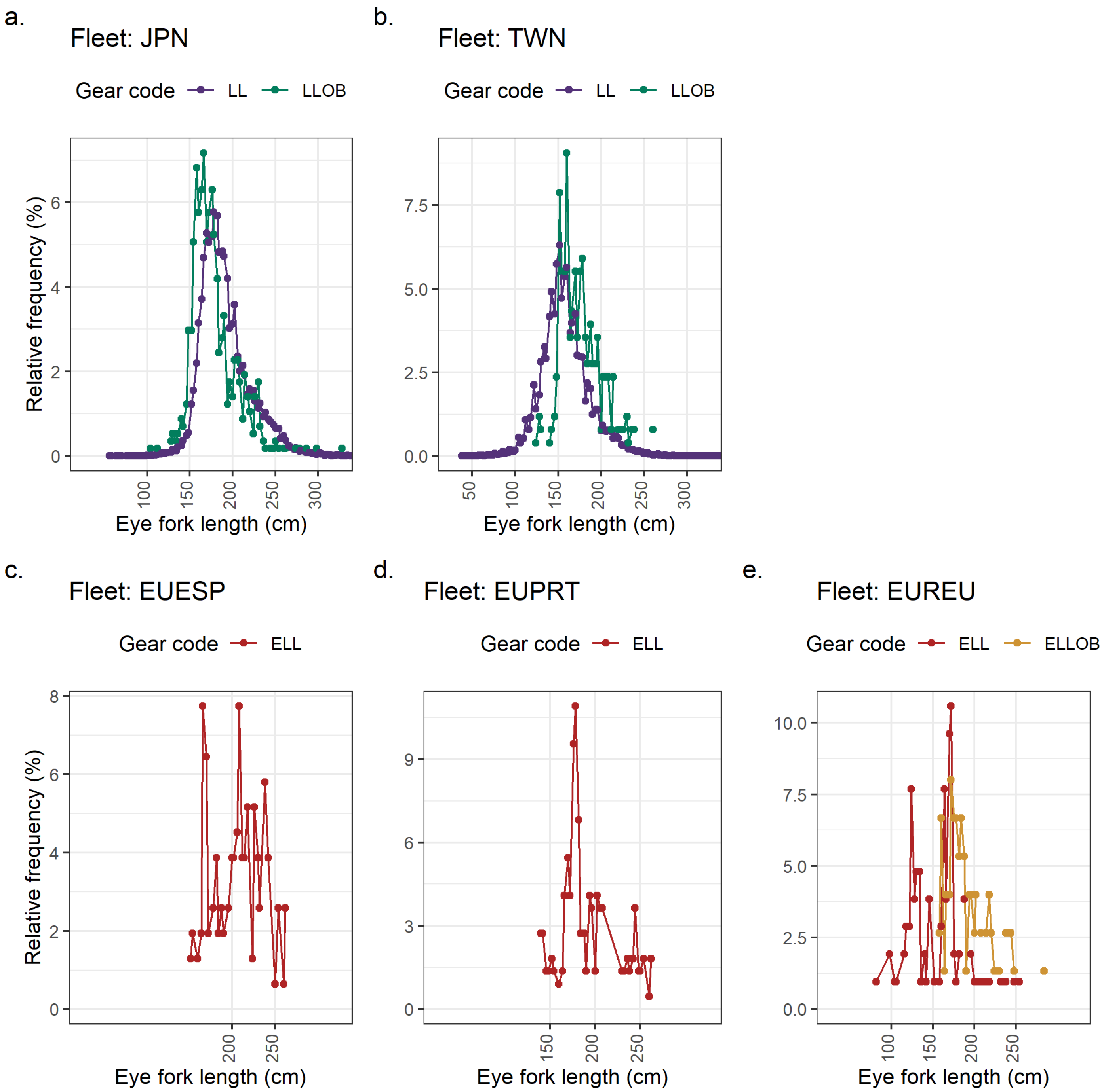

Figure 91: Relative distribution of blue marlin measured lengths by fleet and source of information (logbook vs. observers), as recorded by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain, (d) EU,Portugal, (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

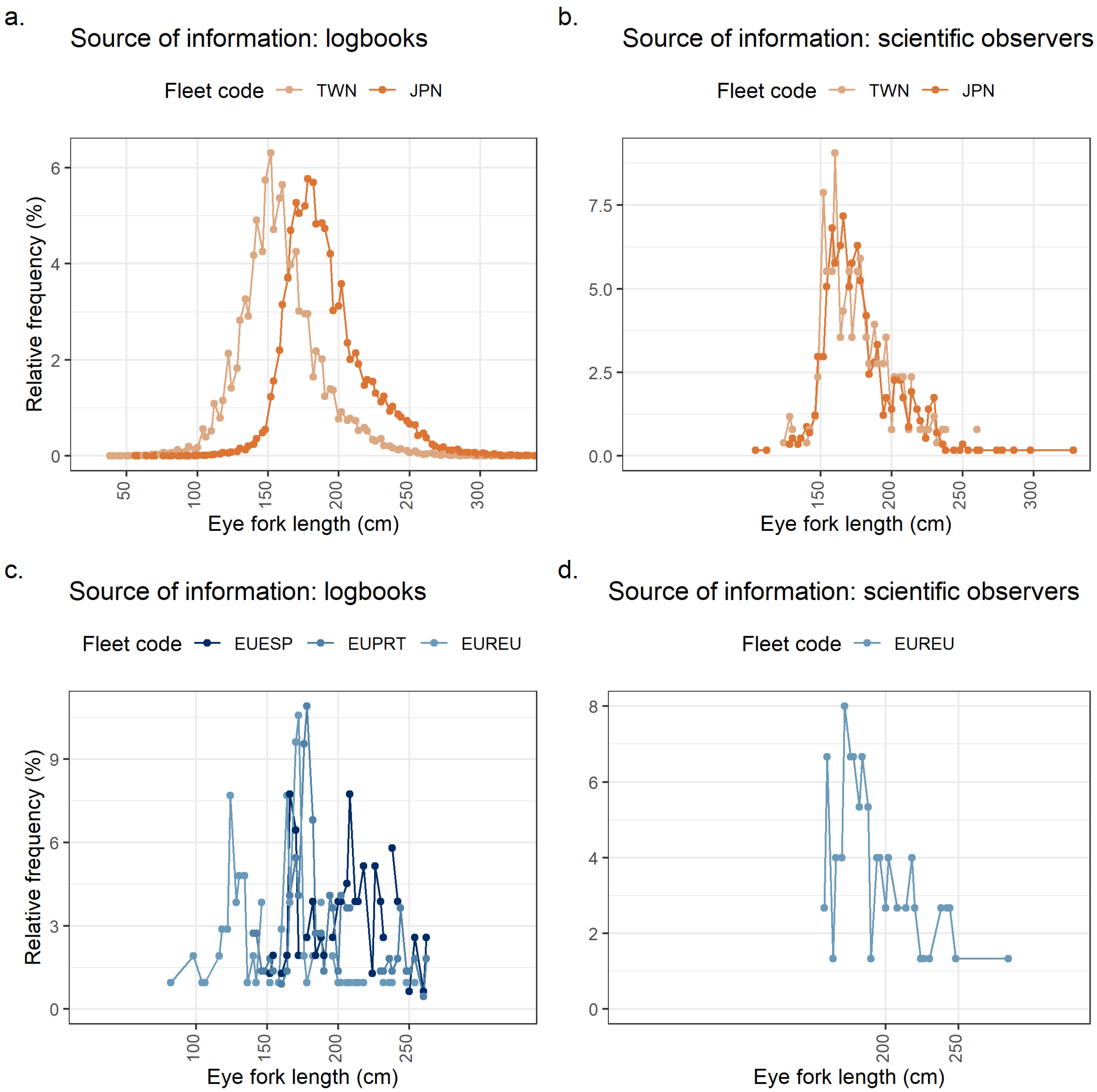

Figure 92: Relative distribution of blue marlin measured lengths by source of information as recorded on logbooks (a, c) and by observers (b, c) for the longline fisheries of Japan and Taiwan,China, and the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based)

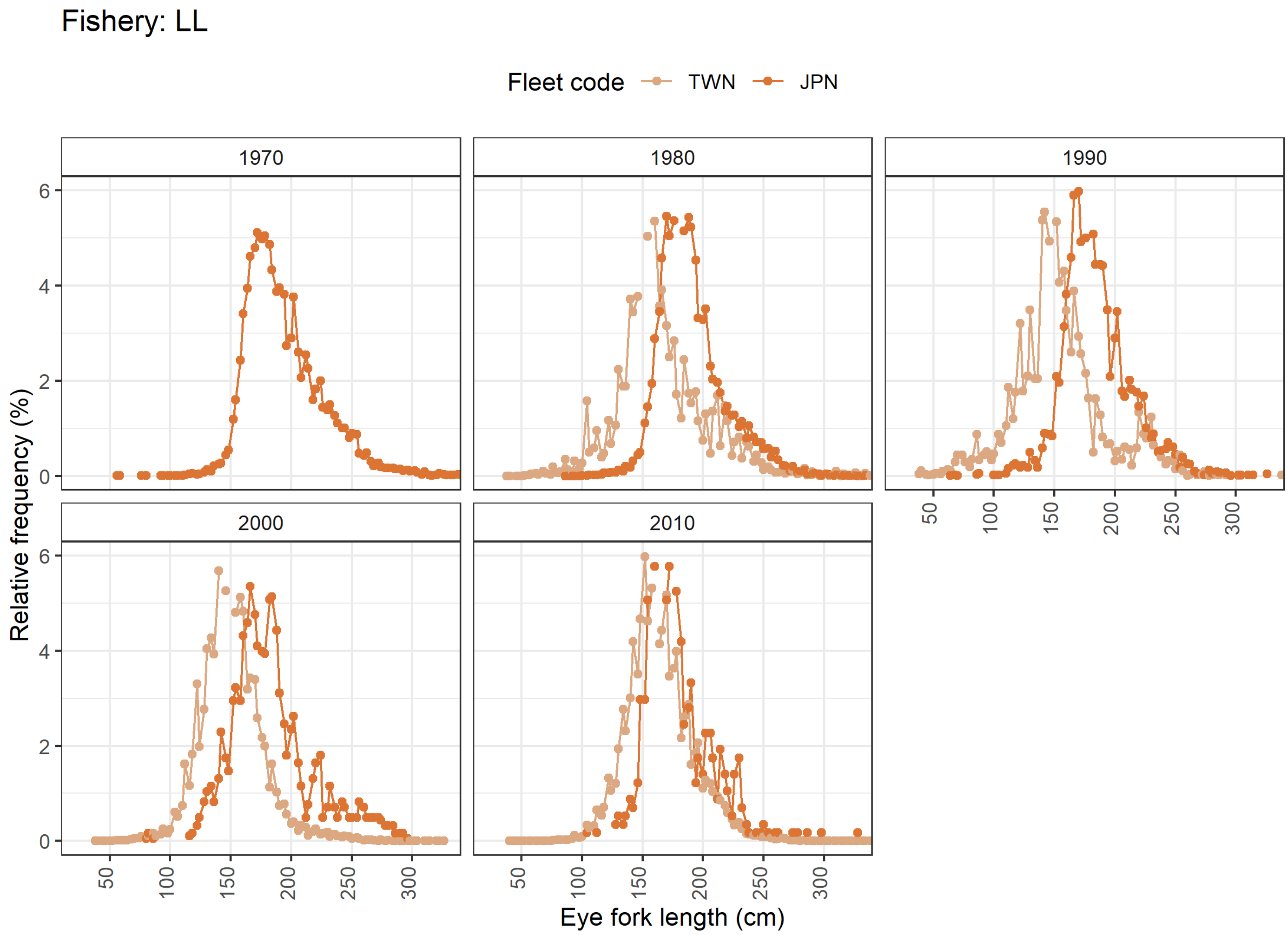

Figure 93: Relative distribution of blue marlin measured lengths by fleet and decade, as recorded by the drifting longline fisheries of Japan and Taiwan,China. Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks)

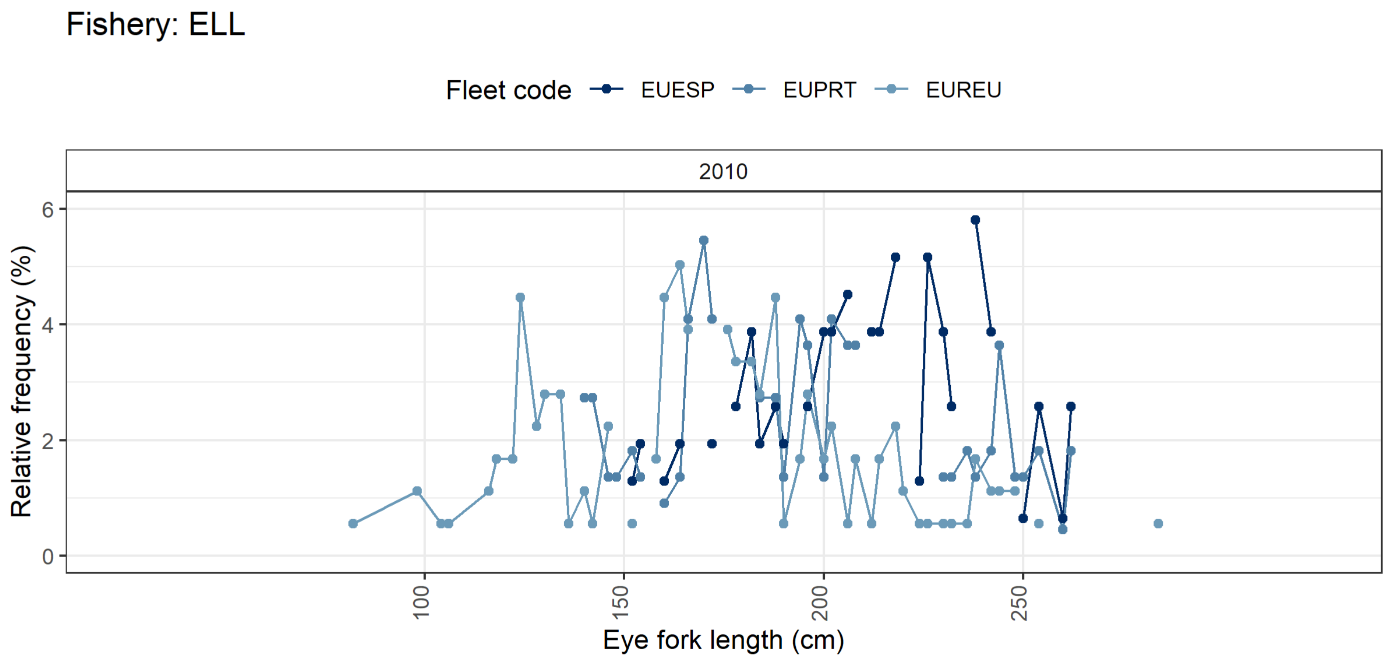

Figure 94: Relative distribution of blue marlin measured lengths by fleet and decade, as recorded by the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. ELL = swordfish-targeting longline

Calculated average annual weights

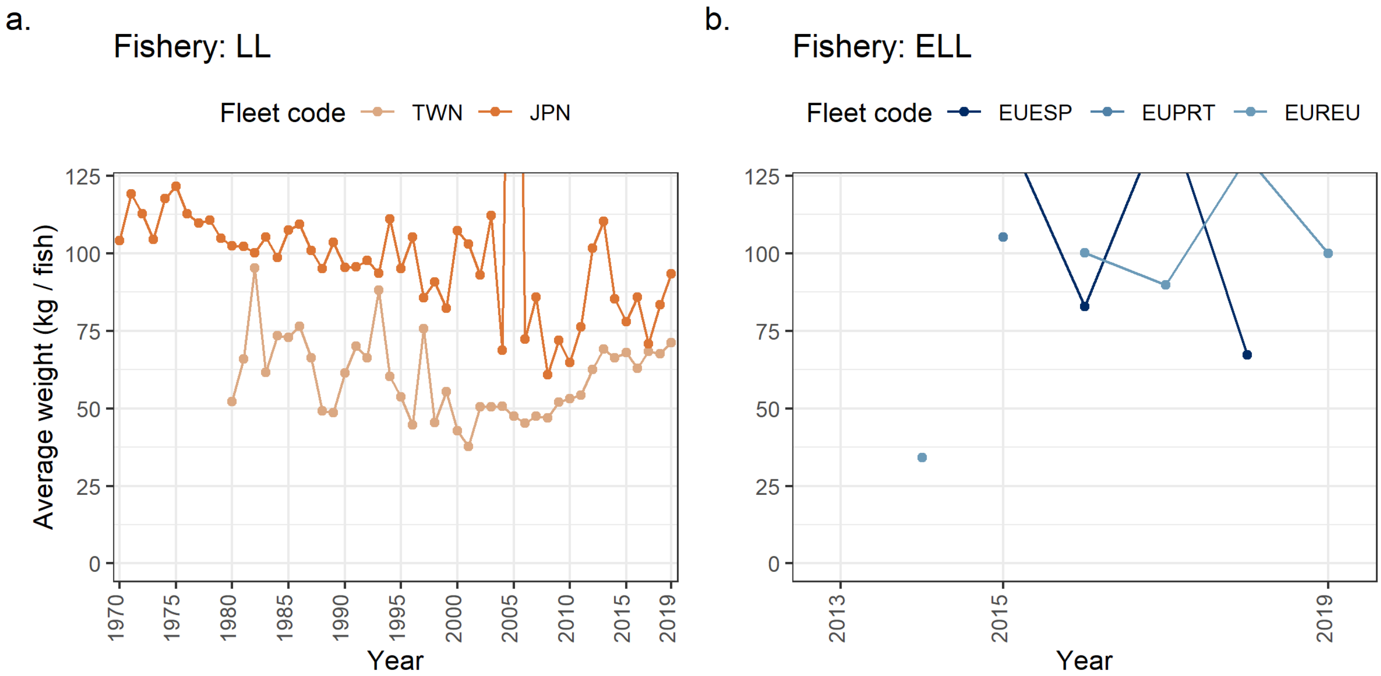

Figure 95: Annual calculated average weight of blue marlins by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

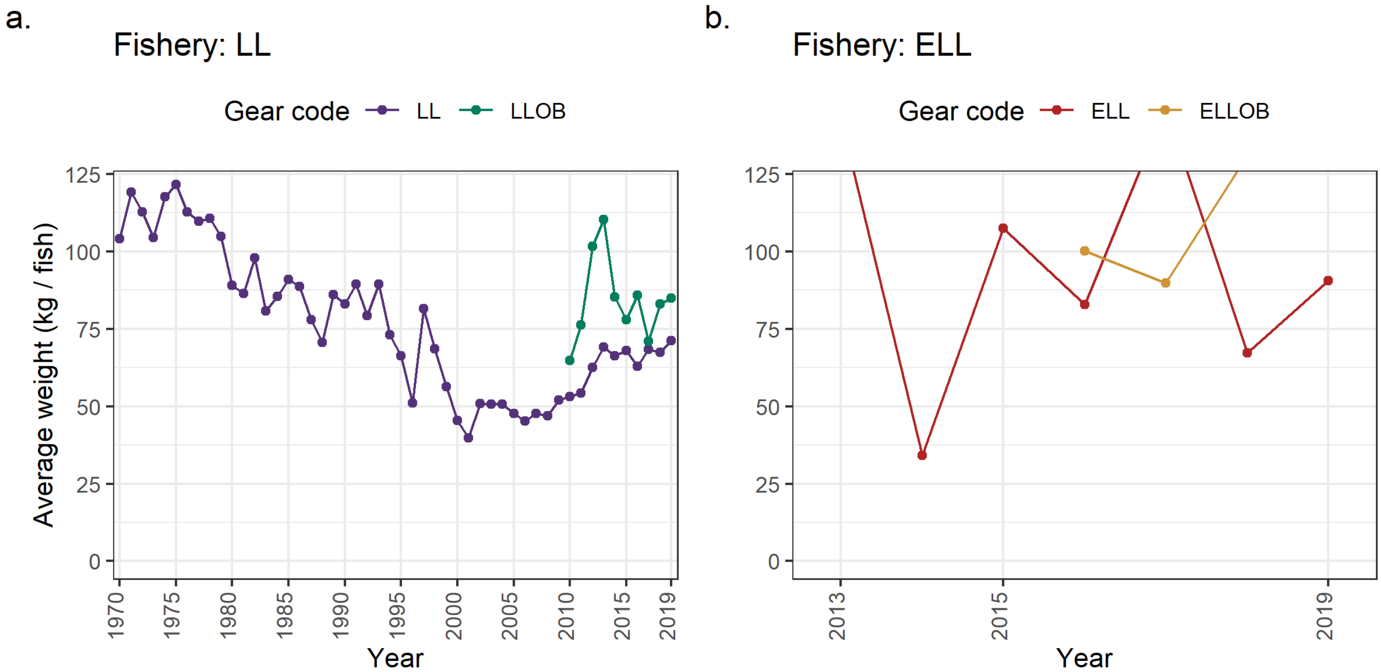

Figure 96: Annual calculated average weight of blue marlins by source of information (logbook vs. observers), as recorded by (a) the drifting longline fisheries of Japan and Taiwan,China, and (b) the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

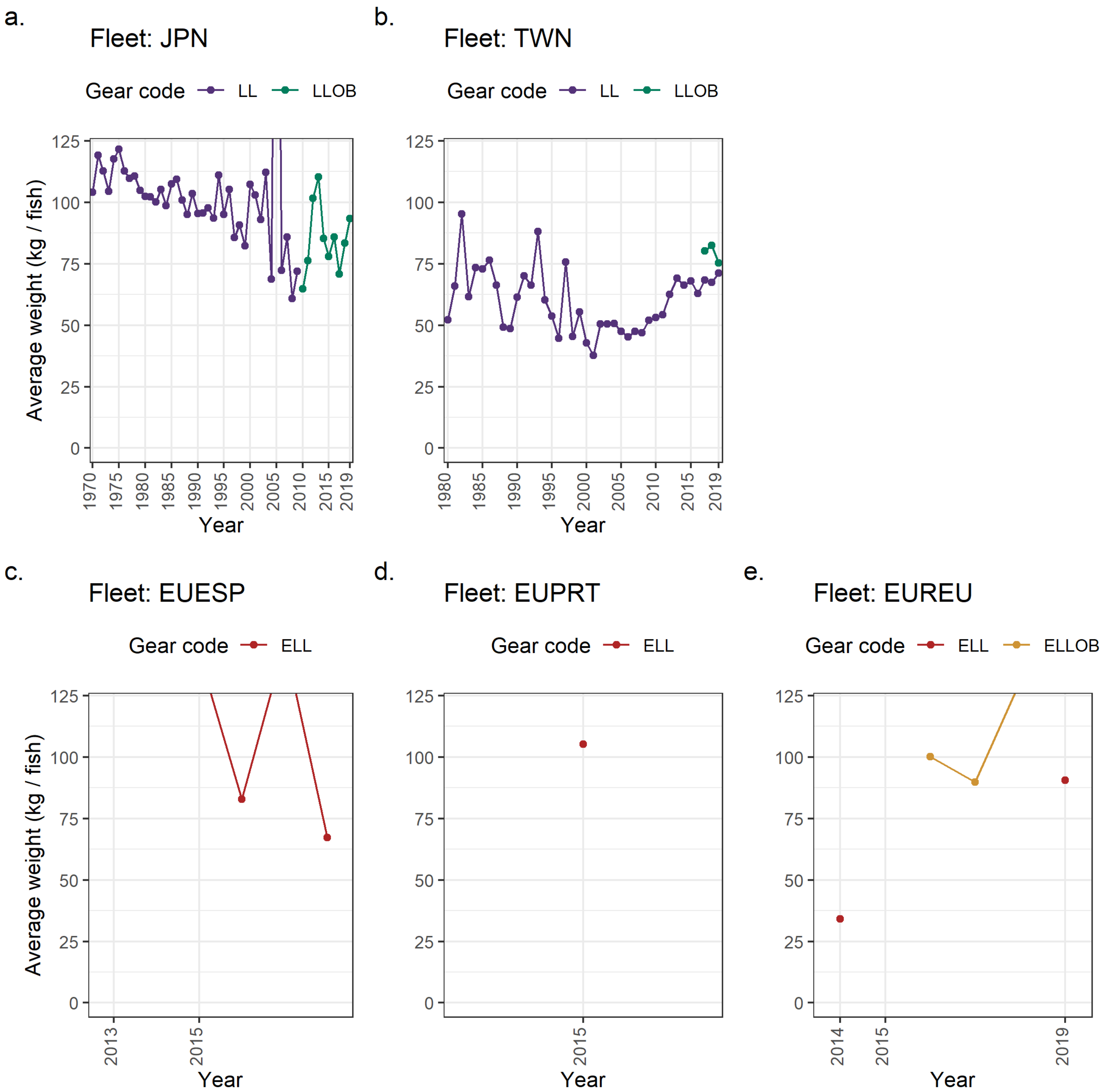

Figure 97: Annual calculated average weight of blue marlins by source of information (logbook vs. observers), as recorded by the drifting longline fisheries of (a) Japan and (b) Taiwan,China, and by the swordfish-targeting longline fisheries of (c) EU,Spain, (d) EU,Portugal and (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

Striped marlin (MLS, *Tetrapturus audax*)

Size-frequency distributions

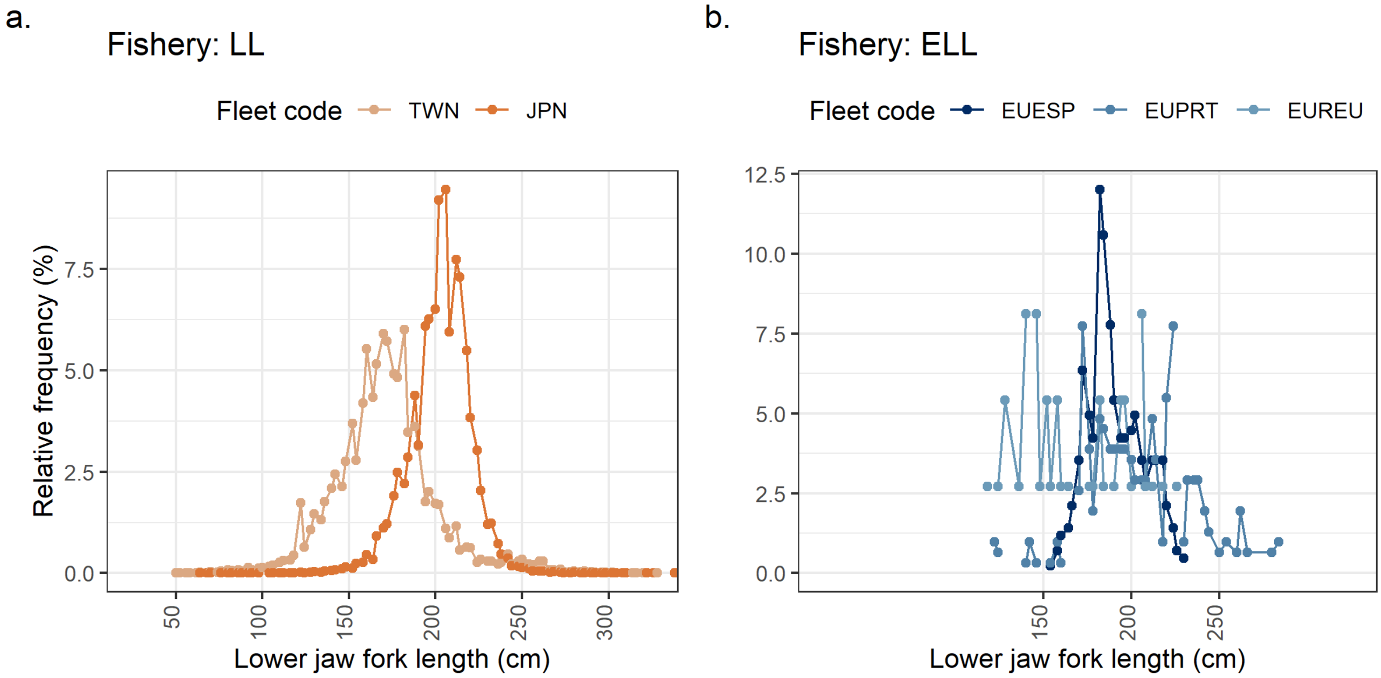

Figure 98: Relative distribution of striped marlin measured lengths by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

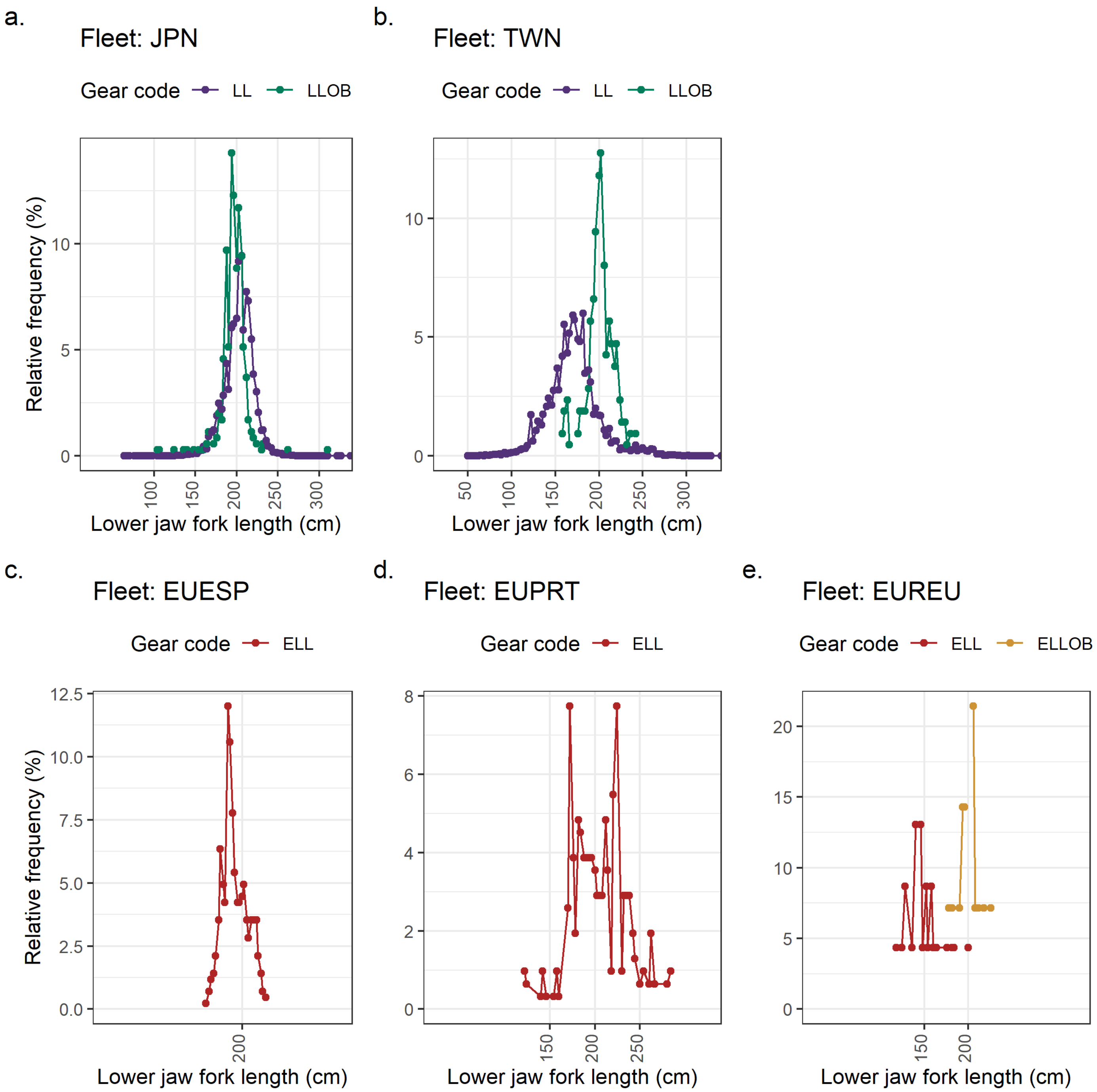

Figure 99: Relative distribution of striped marlin measured lengths by fleet and source of information (logbook vs. observers), as recorded by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain, (d) EU,Portugal, (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

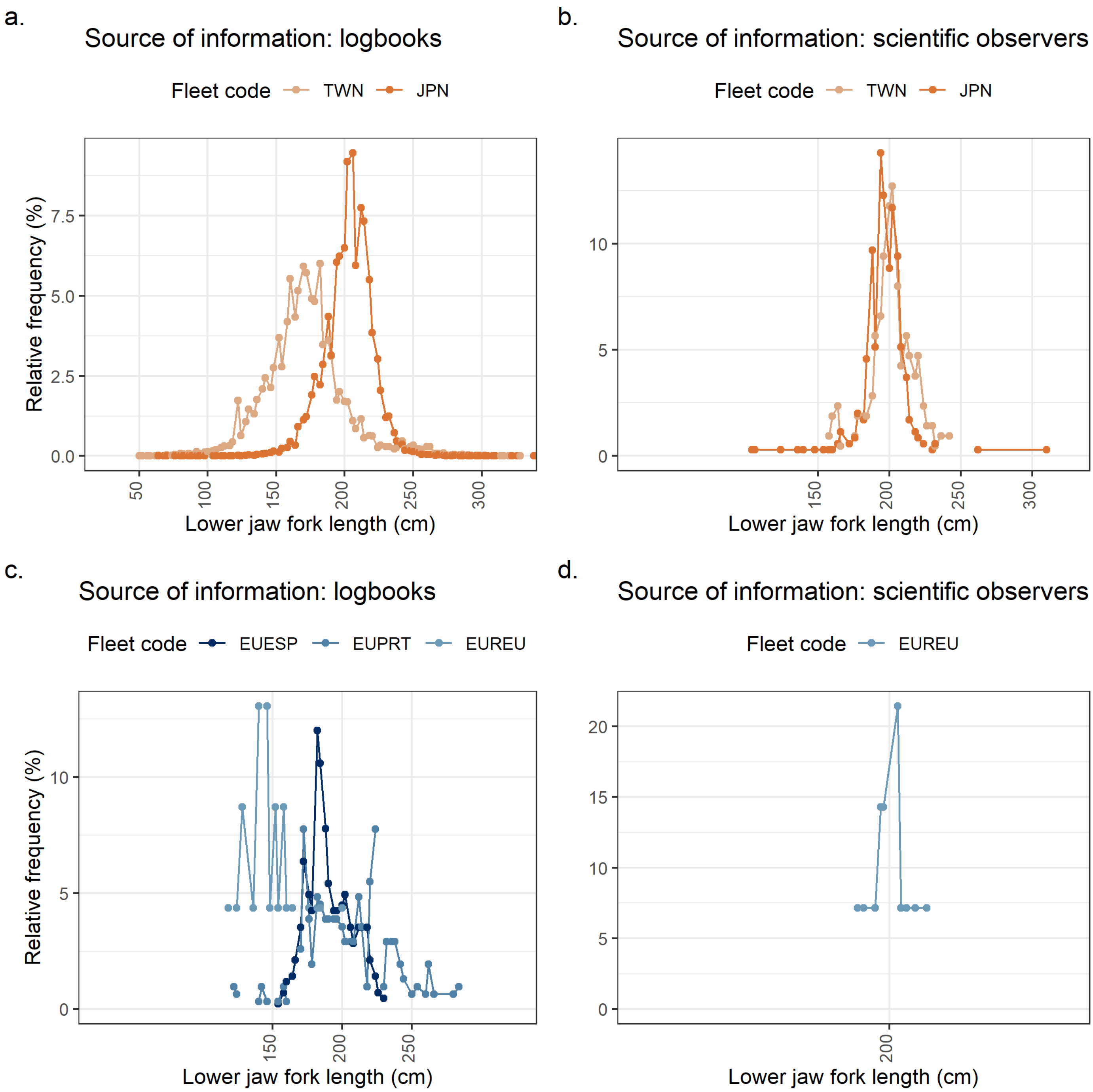

Figure 100: Relative distribution of striped marlin measured lengths by source of information as recorded on logbooks (a, c) and by observers (b, c) for the longline fisheries of Japan and Taiwan,China, and the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based)

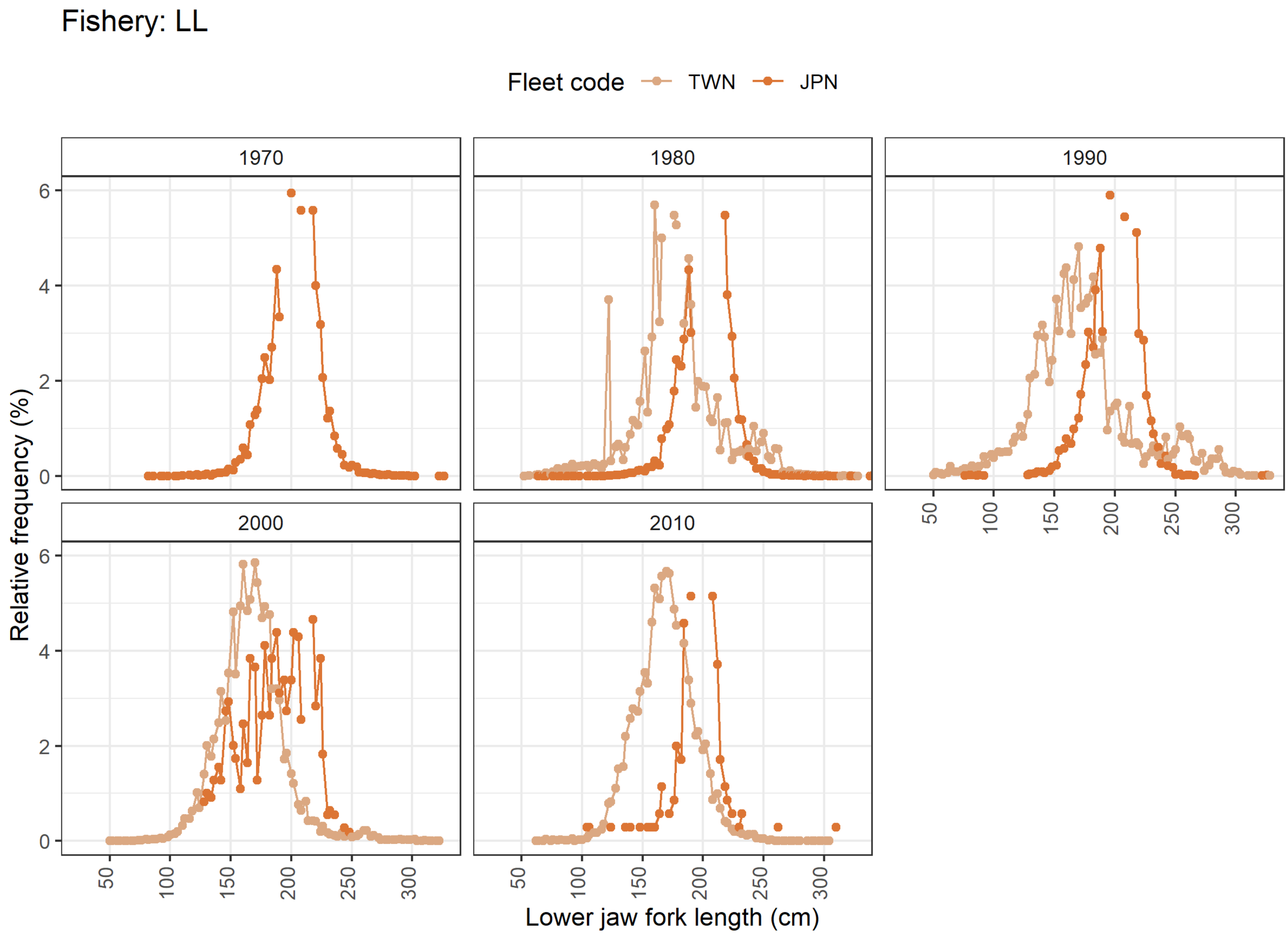

Figure 101: Relative distribution of striped marlin measured lengths by fleet and decade, as recorded by the drifting longline fisheries of Japan and Taiwan,China. Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks)

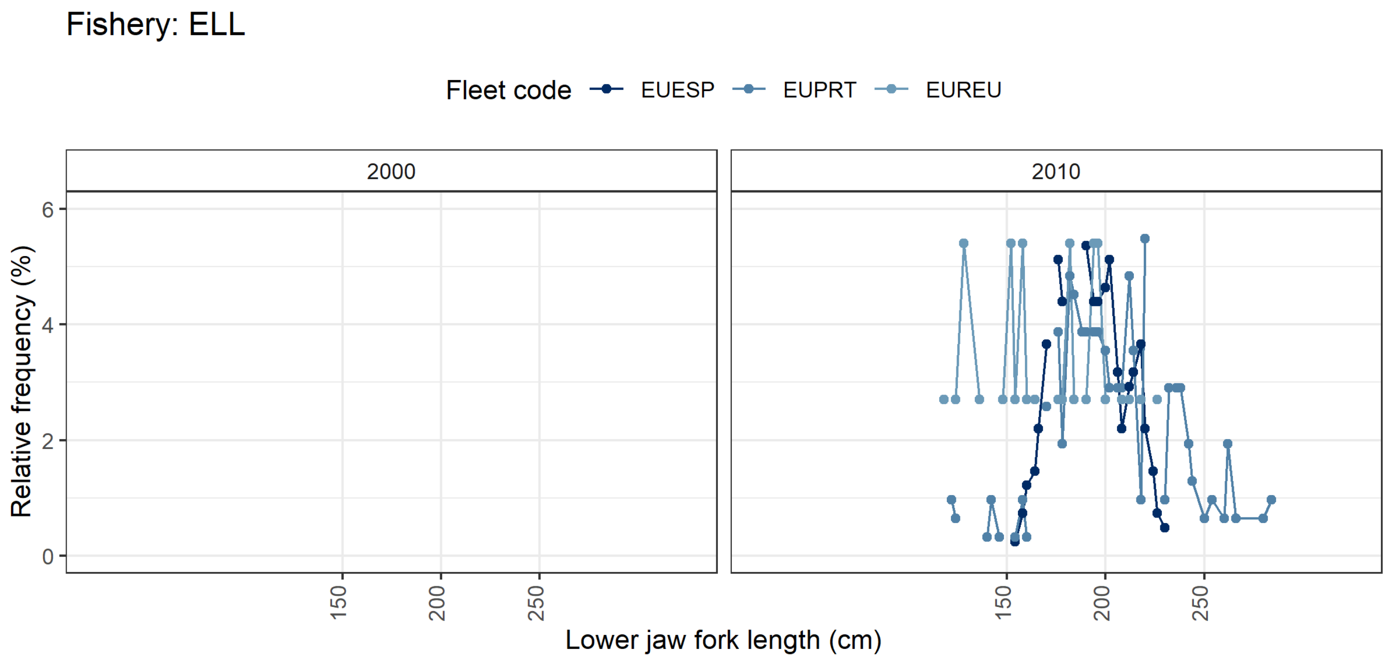

Figure 102: Relative distribution of striped marlin measured lengths by fleet and decade, as recorded by the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. ELL = swordfish-targeting longline

Calculated average annual weights

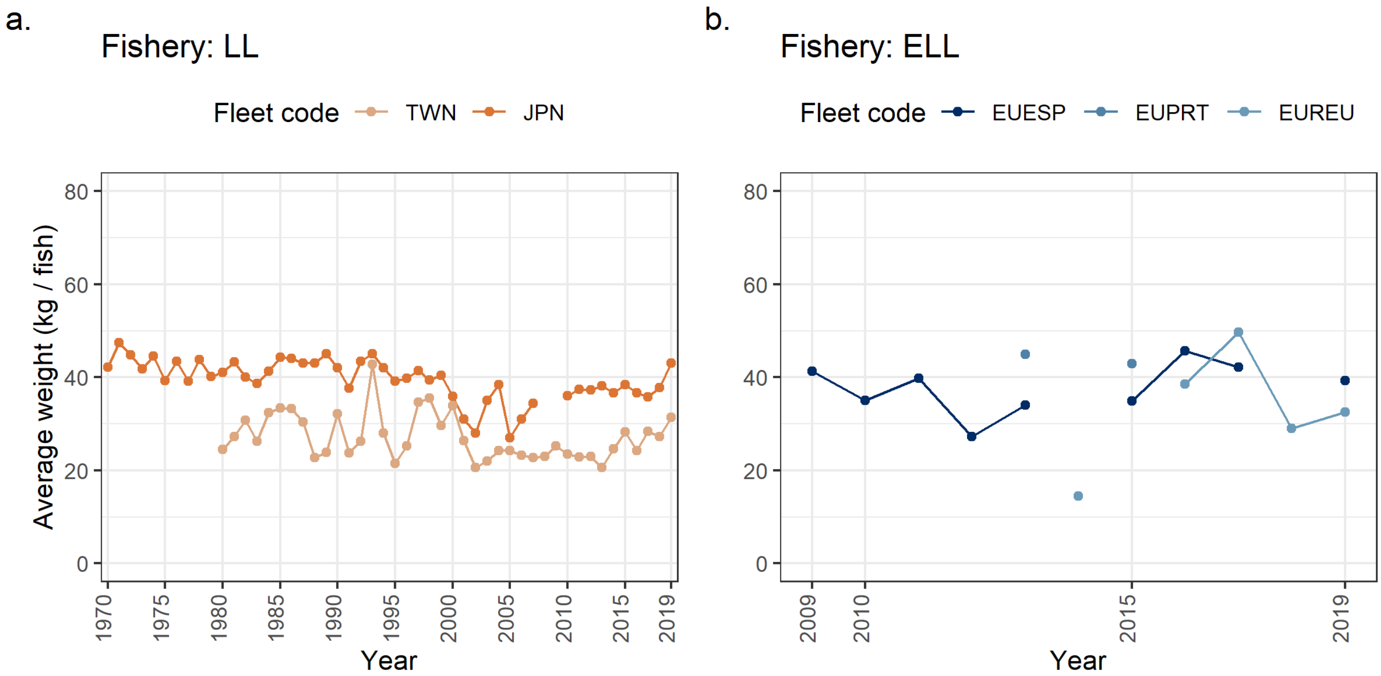

Figure 103: Annual calculated average weight of striped marlins by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

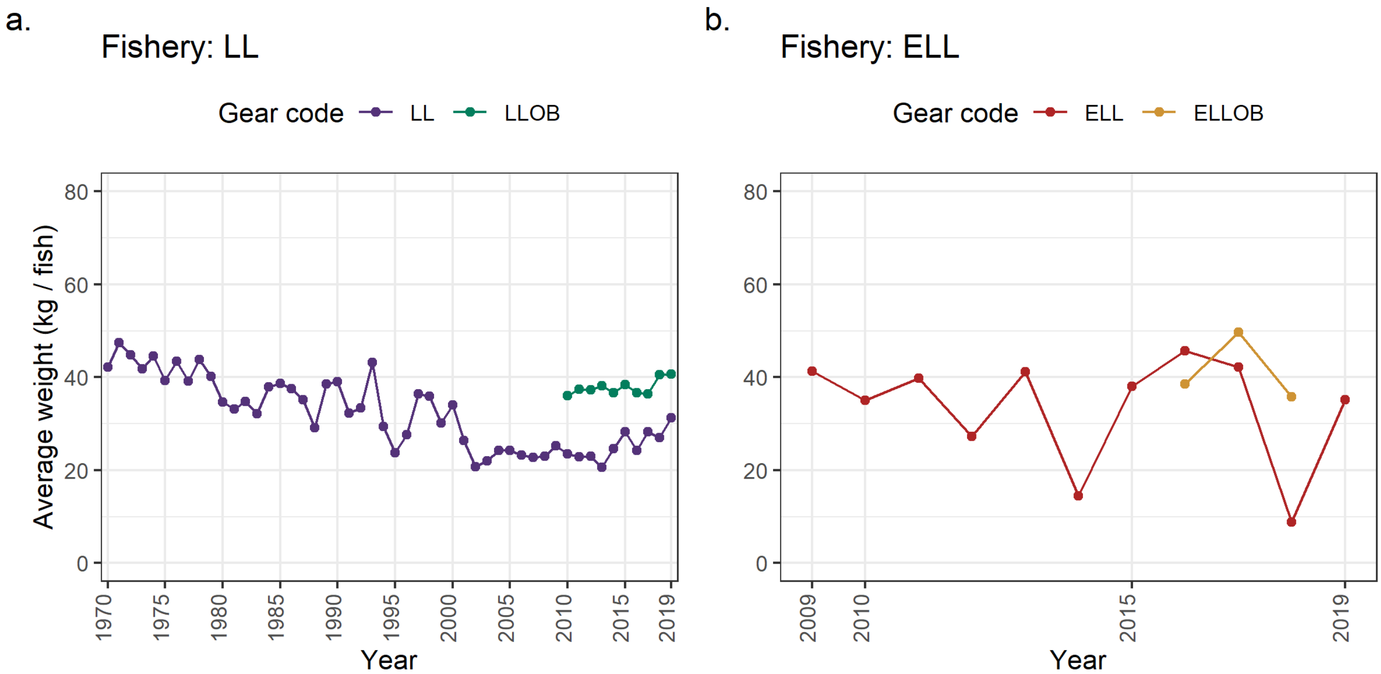

Figure 104: Annual calculated average weight of striped marlins by source of information (logbook vs. observers), as recorded by (a) the drifting longline fisheries of Japan and Taiwan,China, and (b) the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

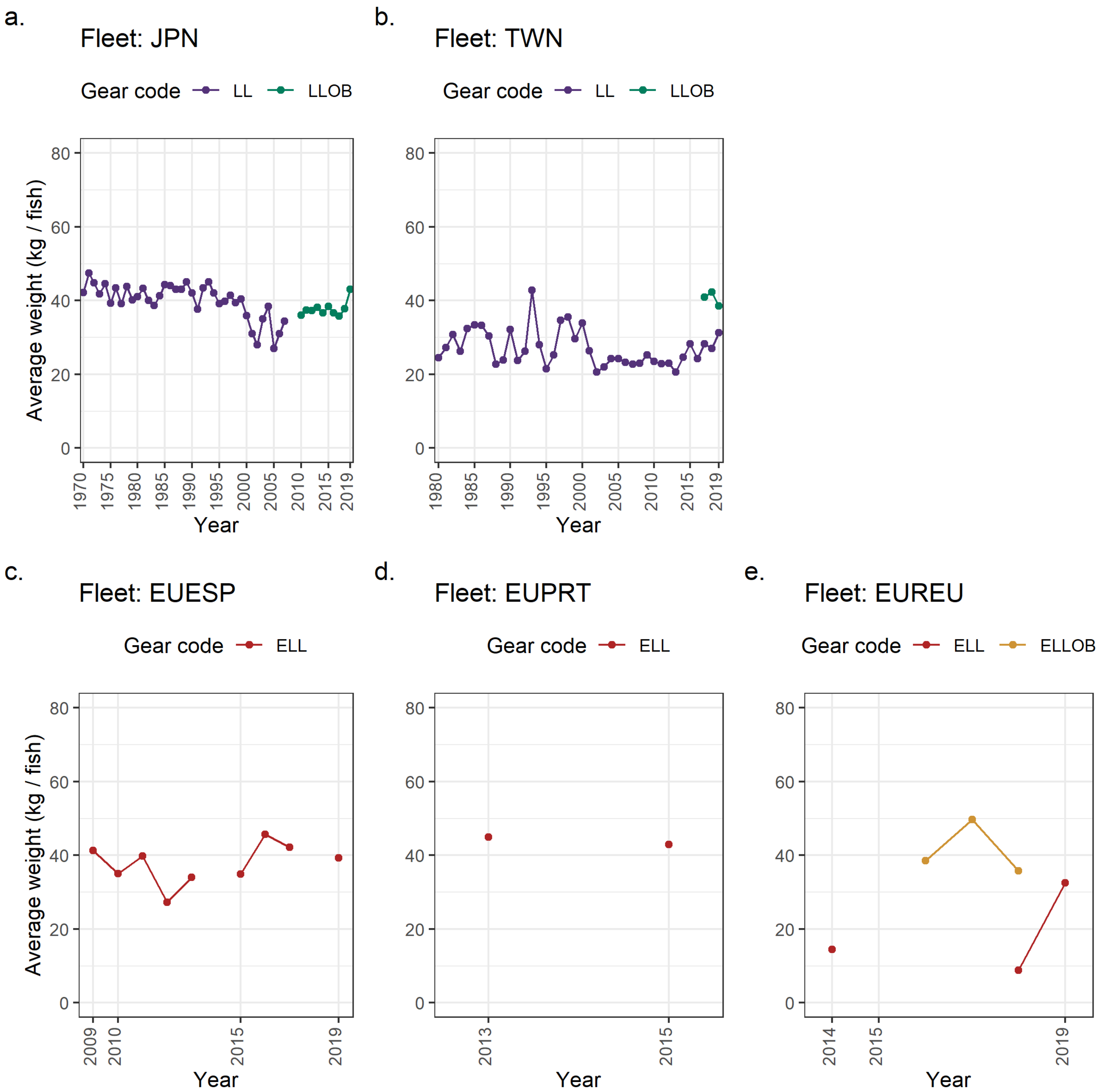

Figure 105: Annual calculated average weight of striped marlins by source of information (logbook vs. observers), as recorded by the drifting longline fisheries of (a) Japan and (b) Taiwan,China, and by the swordfish-targeting longline fisheries of (c) EU,Spain, (d) EU,Portugal and (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

Indo-Pacific sailfish (SFA, *Istiophorus platypterus*)

Size-frequency distributions

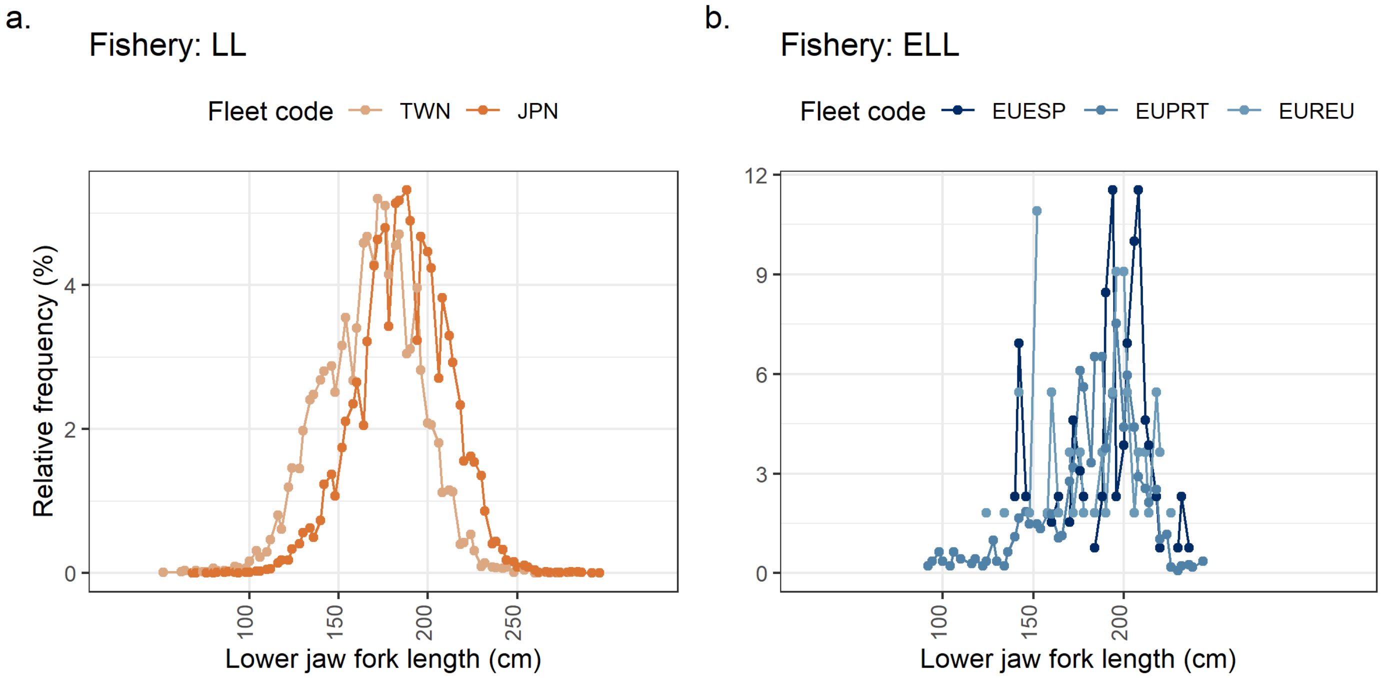

Figure 106: Relative distribution of Indo-Pacific sailfish measured lengths by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

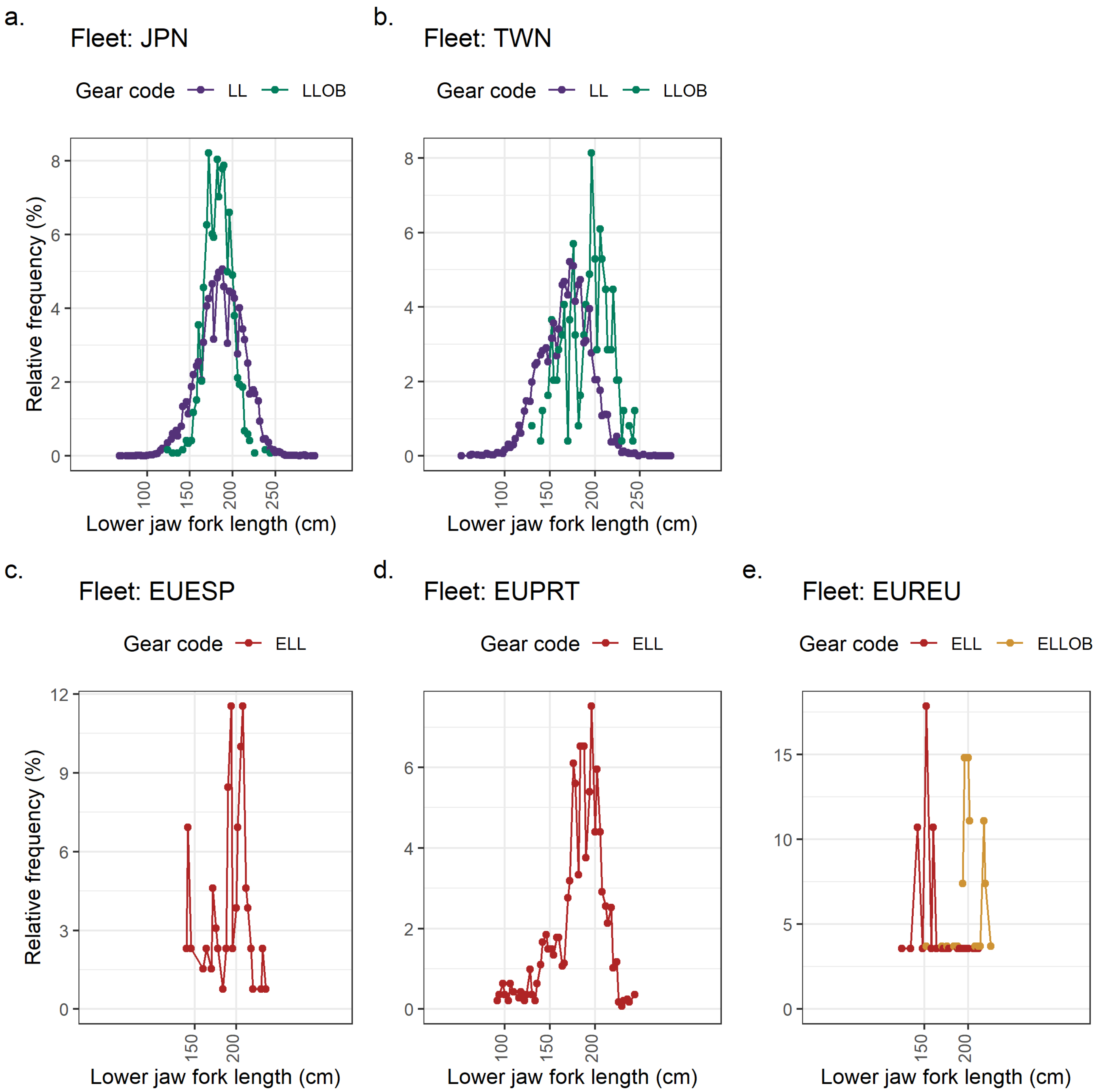

Figure 107: Relative distribution of Indo-Pacific sailfish measured lengths by fleet and source of information (logbook vs. observers), as recorded by the longline fisheries of (a) Japan, (b) Taiwan,China, (c) EU,Spain, (d) EU,Portugal, (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

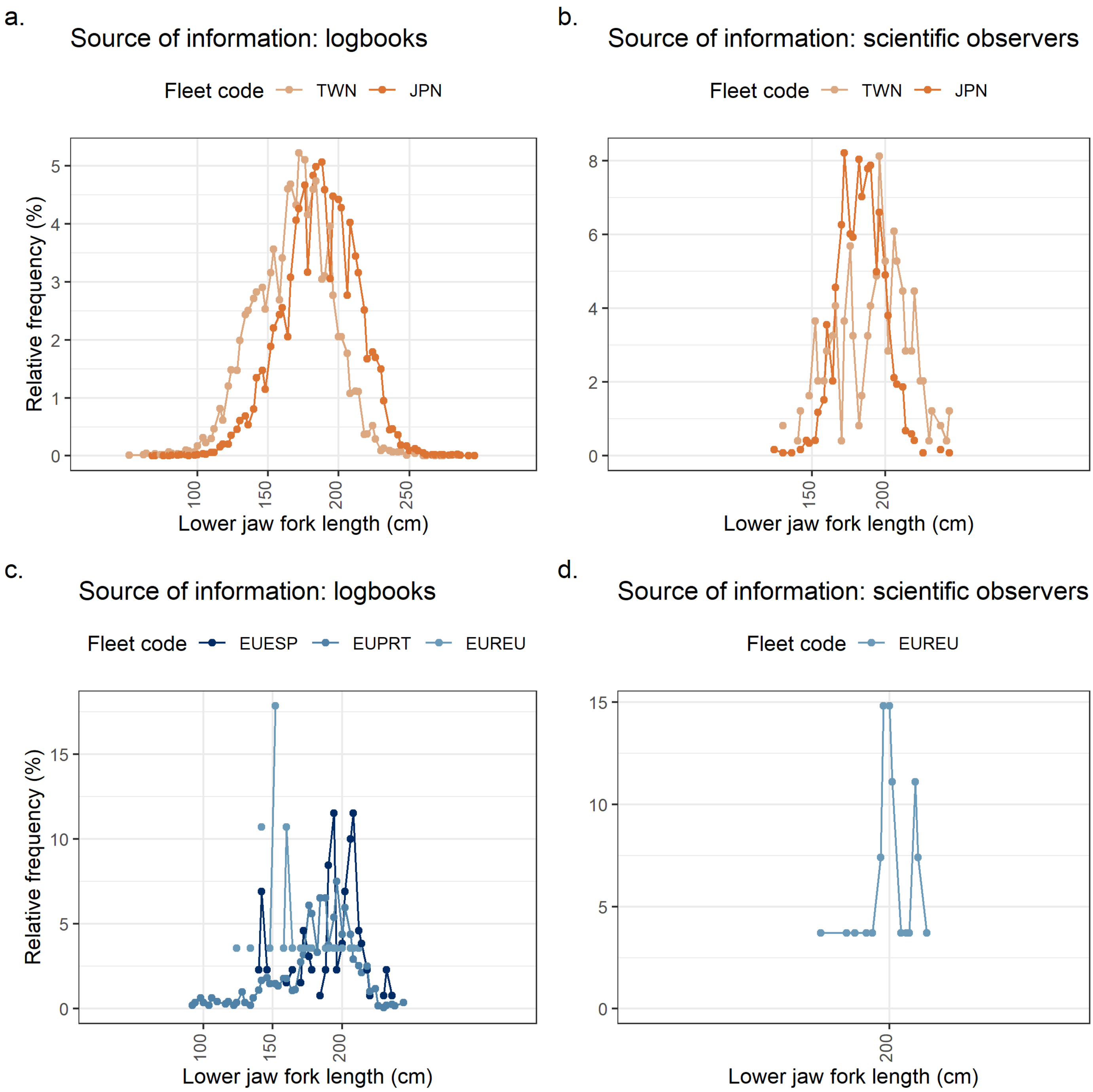

Figure 108: Relative distribution of Indo-Pacific sailfish measured lengths by source of information as recorded on logbooks (a, c) and by observers (b, c) for the longline fisheries of Japan and Taiwan,China, and the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based)

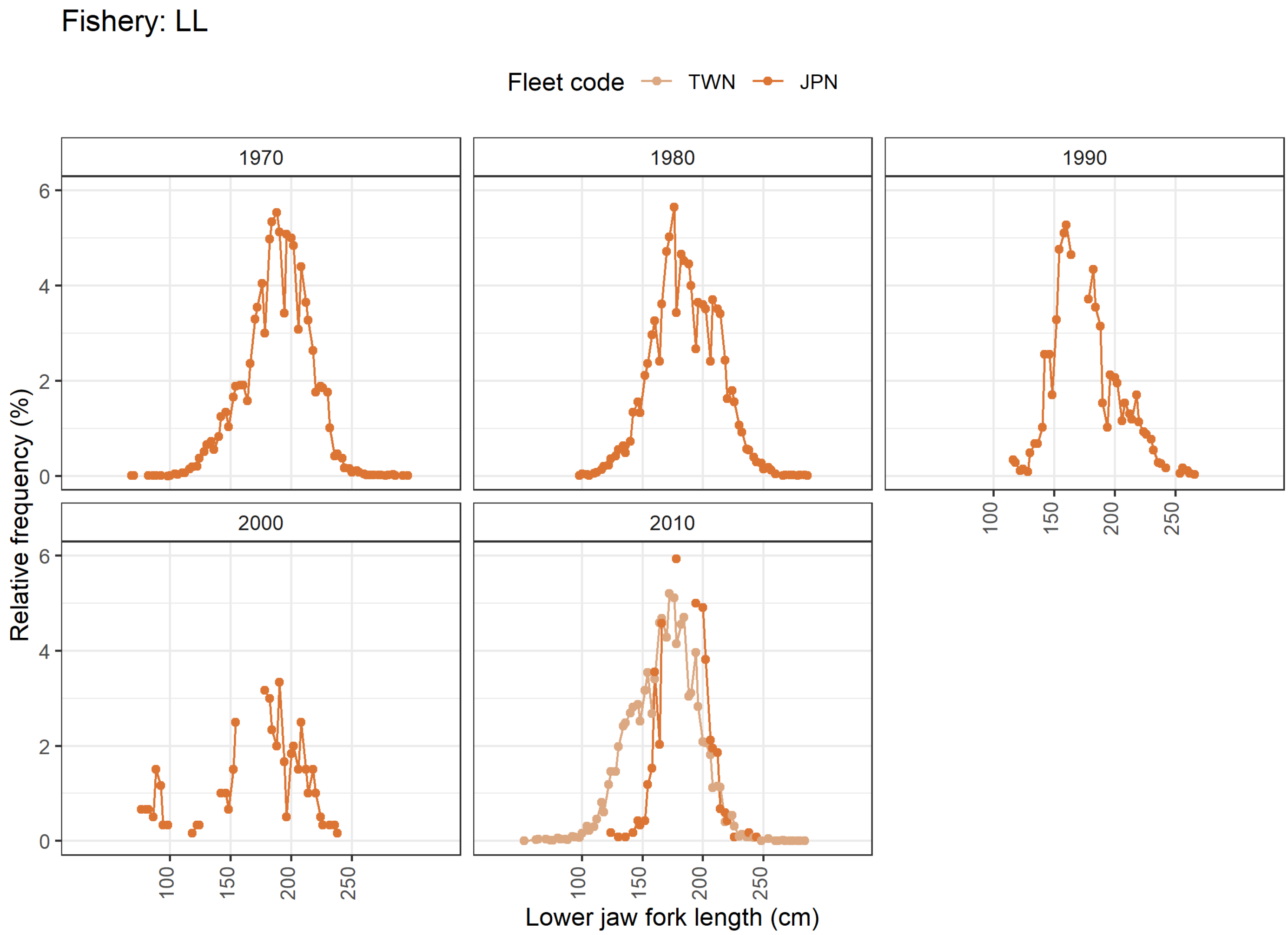

Figure 109: Relative distribution of Indo-Pacific sailfish measured lengths by fleet and decade, as recorded by the drifting longline fisheries of Japan and Taiwan,China. Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks)

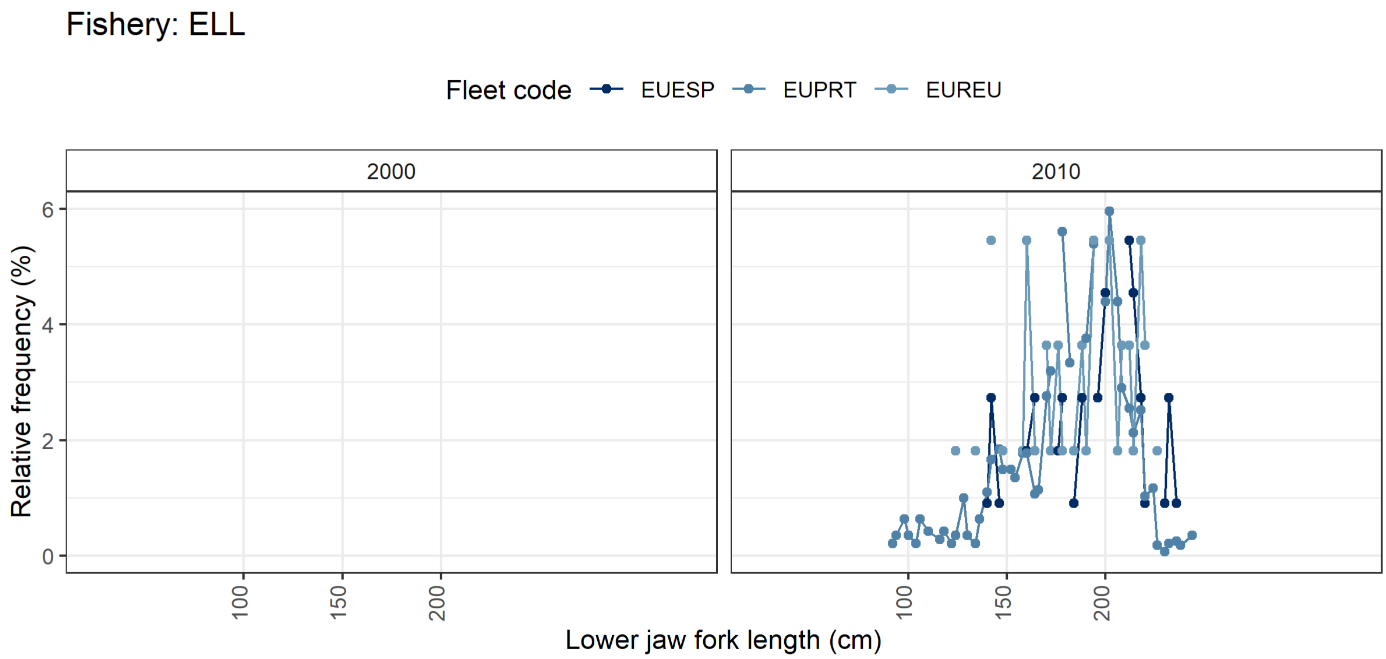

Figure 110: Relative distribution of Indo-Pacific sailfish measured lengths by fleet and decade, as recorded by the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. ELL = swordfish-targeting longline

Calculated average annual weights

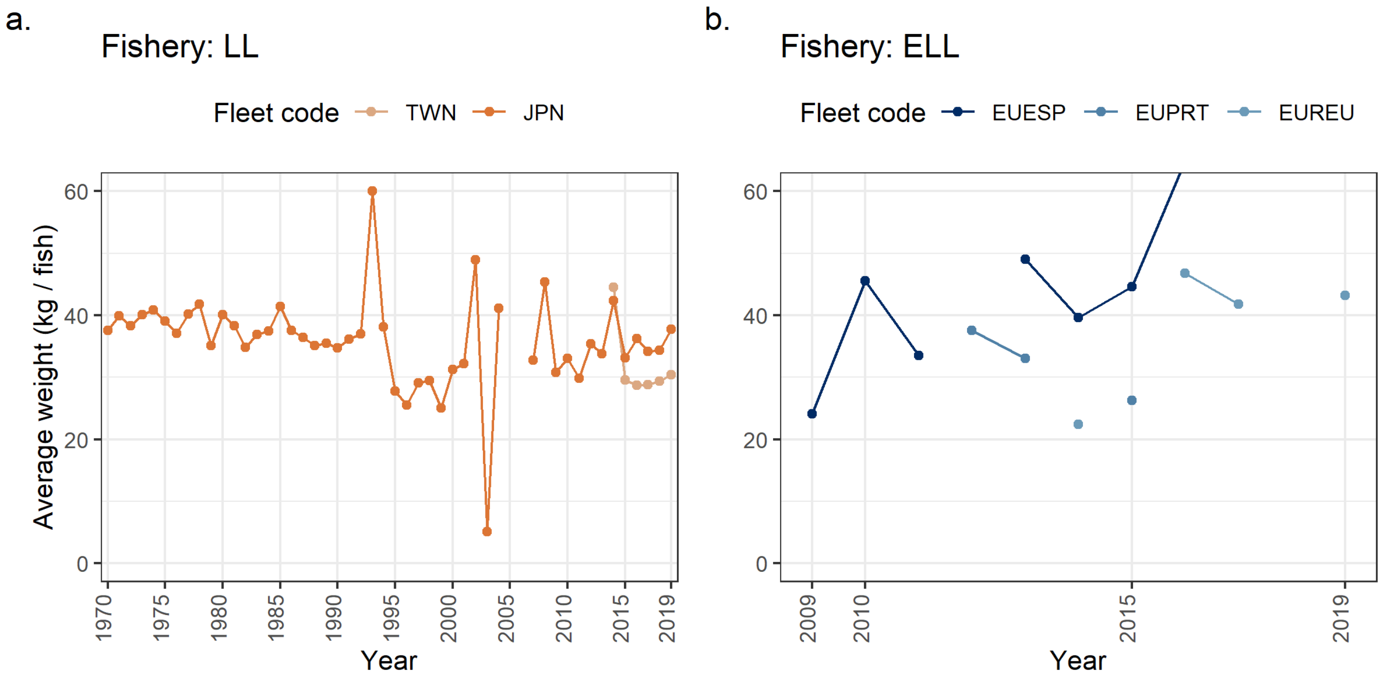

Figure 111: Annual calculated average weight of Indo-Pacific sailfish by fleet, as recorded by the longline fisheries of (a) Japan and Taiwan,China, and (b) EU,Spain, EU,Portugal and EU,France (Réunion-based) . Data include information from logbooks and scientific observers. LL = drifting longline (over 1,800 hooks), ELL = swordfish-targeting longline

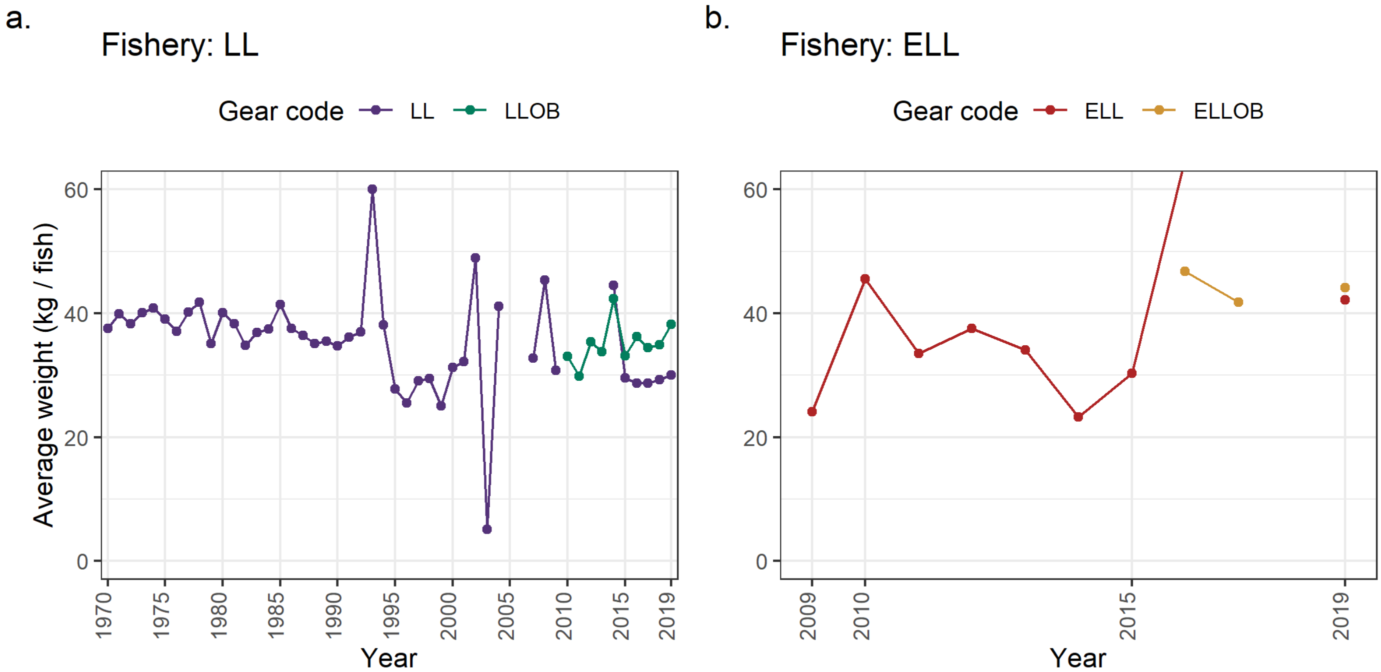

Figure 112: Annual calculated average weight of Indo-Pacific sailfish by source of information (logbook vs. observers), as recorded by (a) the drifting longline fisheries of Japan and Taiwan,China, and (b) the swordfish-targeting longline fisheries of EU,Spain, EU,Portugal and EU,France (Réunion-based) . LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

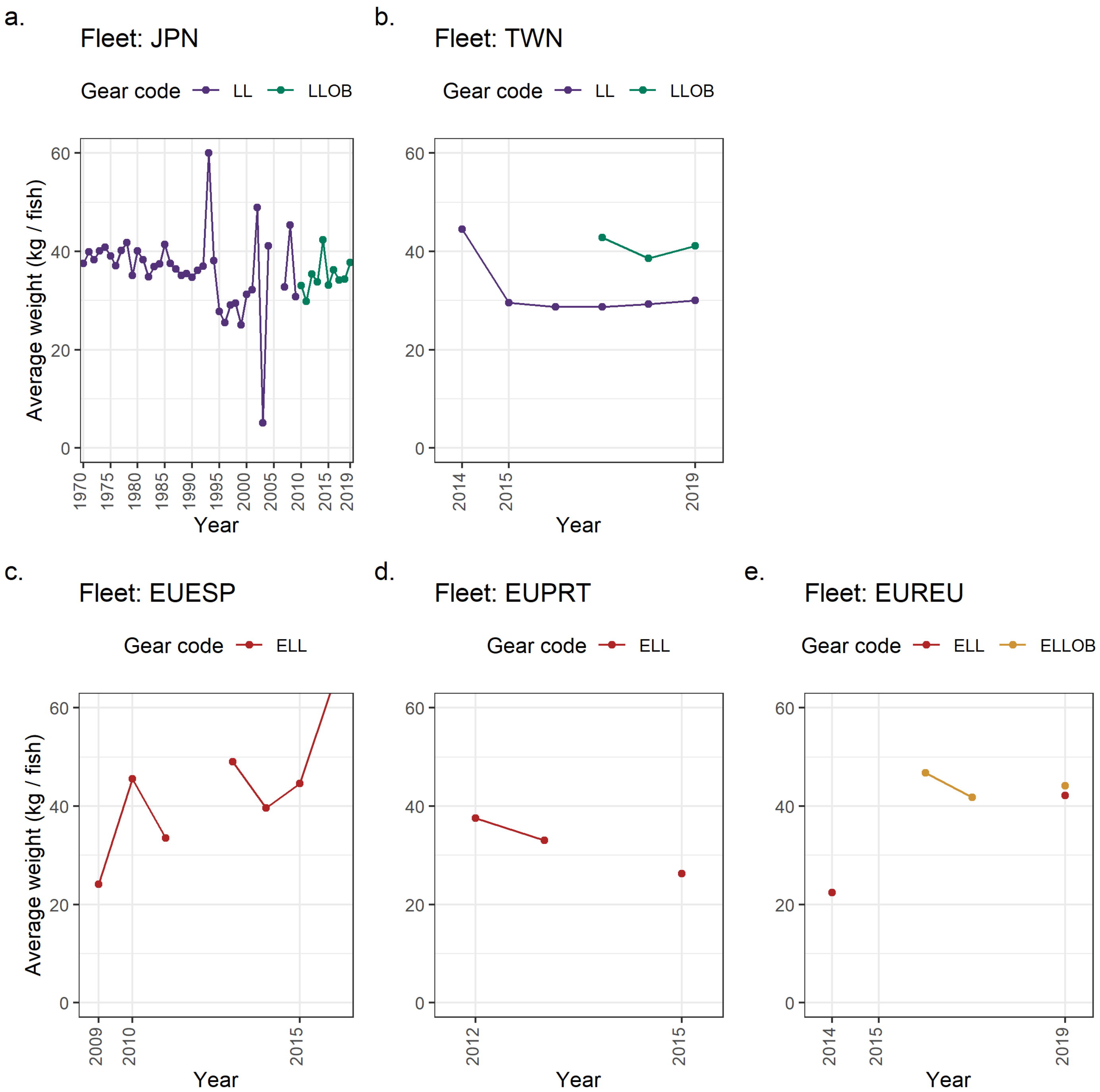

Figure 113: Annual calculated average weight of Indo-Pacific sailfish by source of information (logbook vs. observers), as recorded by the drifting longline fisheries of (a) Japan and (b) Taiwan,China, and by the swordfish-targeting longline fisheries of (c) EU,Spain, (d) EU,Portugal and (e) EU,France (Réunion-based). LL = drifting longline (over 1,800 hooks), LLOB = drifting longline (over 1,800 hooks) - data from scientific observers, ELL = swordfish-targeting longline, ELLOB = swordfish-targeting longline - data from scientific observers

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