REVIEW OF THE STATISTICAL DATA AND FISHERY TRENDS FOR TROPICAL TUNAS

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Purpose

To provide the Working Party on Tropical Tunas (WPTT) with a review of the status of the information available on tropical tunas in the databases at the IOTC Secretariat as of **September 2020**, as well as a range of fishery indicators, including catch and effort trends for fisheries catching tropical tunas in the IOTC area of competence. It covers data on nominal catches (retained and discards), catch-and-effort, size-frequency and other data, including release and recapture (tagging).

Background

Prior to each WPTT meeting the IOTC Secretariat develops a series of tables, figures, and maps that highlight historical and emerging trends in the fisheries data held by the IOTC Secretariat. This information is used during each WPTT meeting to inform discussions around stock status and in developing advice to the Scientific Committee.

This document summarises the standing of a range of information received for the tropical tuna species under the IOTC Mandate (**Table 1**), in accordance with IOTC Resolution 15/02 *Mandatory statistical requirements for IOTC Members and Cooperating Non-Contracting Parties (CPCs)*[2], for the period 1950–2019.

The document also provides summaries of any important reviews to series of historical catches for tropical tunas and a range of fishery indicators, including catch and effort trends, for fisheries catching tropical tunas in the IOTC area of competence.

The report is split into the following sections:

- **Section 1**: Overview of data for tropical tuna species in the Indian Ocean.
- **Section 2**: Data issues related to the statistics reported to the IOTC for tropical tuna species.
- **Section 3**: Status of fisheries statistics for each tropical tuna species, including:
  - Fisheries and main catch trends
  - Data availability and related data quality issues
  - Tagging data
- **Appendix I**: IOTC standard length and weight equations for tropical tunas, average weights by species
- **Appendix II**: Review of effort trends by types of fisheries.

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[2] Supersedes IOTC Resolutions 98/01, 05/01 and 08/01

Major data categories covered by the report

Nominal catches

Total annual retained catches (in live weight) and discards (in live weight and number) estimated per fleet, IOTC area, gear and year. If these data are not reported by a CPC, the Secretariat estimates its total catch from a range of sources that include: partial catch and effort data, data in the FAO FishStat database, catches estimated by the IOTC from data collected through port sampling, data published through web pages or other means; data reported by parties on the activity of vessels under their flag (IOTC Resolution 10/08; IOTC Resolution 12/05) or other flags (IOTC Resolution 14/05; IOTC Resolution 05/03); data on imports of bigeye tuna from vessels under the flag concerned (IOTC Resolution 01/06) and data on imports of tropical tunas from canning factories collaborating with the *International Seafood Sustainability Foundation*[3].

Catch-and-effort data

Refers to fine-scale data, usually from logbooks, reported in aggregated format and stratified per fleet, year, gear, type of school, month, grid, and species. Information on the use of fish aggregating devices (FADs) and activity of vessels that assist industrial purse seiners to locate tuna schools (supply vessels) is also collected.

Length-frequency data

Individual body lengths of IOTC species stratified per fleet, year, gear, type of school, month, and area.

Tagging data

Release and recovery data gathered in the framework of the Indian Ocean Tuna Tagging Programme (IOTTP), which encompass data gathered during the Regional Tuna Tagging Project – Indian Ocean (RTTP-IO) and data gathered during a series of small-scale tuna tagging projects in Maldives, India, Mayotte, Indonesia and by other institutions, e.g., the Southeast Asian Fisheries Development Center (SEAFDEC) and the National Research Institute of Far Seas Fisheries (NRIFSF), with the support of IOTC. In 2012, the data from past projects implemented in Maldives in the '90s were added to the tagging database at the Secretariat, and as of October 2020 this database contains 218, 239 releases and 34,347 recoveries of tropical tunas.

TABLE 1. Tropical tuna species under the IOTC mandate

IOTC code	English name	Scientific name
BET	Bigeye tuna	*Thunnus obesus*
SKJ	Skipjack tuna	*Katsuwonus pelamis*
YFT	Yellowfin tuna	*Thunnus albacares*

[3] Data currently under processing: ISSF-affiliated canneries provide the Secretariat with quarterly summary of catch imports by vessel, trip, species and commercial category.

Section 1: Overview of data for tropical tuna species in the Indian Ocean

Fisheries and catch trends (2015-2019) for tropical tuna species

Main species

Tropical tuna species account for roughly two thirds of total catches of IOTC species in recent years. Skipjack tuna, in particular, accounts for almost 50% of total catches of tropical tunas, followed by yellowfin tuna (41.6%), while catches of bigeye tuna account for the remaining 8.7% (**Fig. 1c-d**).

Main fisheries

Purse seine accounts for 44% of total catches of tropical tunas, with important catches also reported by handline, coastal longline and trolling (18%), gillnet (18%), pole-and-line (11%), and longline (7%) with catches occurring in both coastal waters and the high seas (**Fig. 2a-b**).

Tropical tunas are the target species of many industrial and artisanal fisheries throughout the Indian Ocean, although they are also a bycatch of fisheries targeting other tunas, small pelagic species, or other non-tuna species.

Main fleets

Tropical tunas are caught by both coastal countries in the Indian Ocean and distant water fishing nations (**Fig. 2c**).

In recent years the coastal and industrial fisheries of five countries (Indonesia, Maldives, Sri Lanka, I.R. Iran and India) have accounted for almost 50% of the total catches of tropical tuna species in the Indian Ocean, while the industrial purse seiners and longliners flagged by EU,Spain, Seychelles and EU,France contributed a further 34% to total catches for these species.

Retained catch trends

Total catches of tropical tunas steadily increased from the ‘50s to reach a maximum of more than 1.2 million MT in 2005, accounting for 70% of the total catch of all species under the IOTC mandate in that year (**Fig. 1a-b**). The catches then decreased to around 809,000 MT in 2011 in relation to the piracy threat before re-increasing to more than 1.1 million MT in 2018. In 2019, the catches of tropical tunas have been estimated at 1,047,653 MT, almost to the same levels as the previous year, reaching 60% of catches of all IOTC species combined.

The importance of tropical tunas to the total catches of IOTC species in the Indian Ocean has changed over the years, in particular following the arrival of industrial purse seine fleets targeting tropical tunas in the early ’80s (**Fig. 1a-b**). With the onset of piracy in the late ’00s, the activities of fleets operating in the Northwest Indian Ocean have been displaced or reduced – particularly the Asian distant-water longline fleets – leading to a relative decline in the proportion of catches from tropical tunas that went down to around 55% of total catches of all IOTC species during 2008-2019, compared to around 65 % during the pre-piracy period (1996-2007). Other factors such as the concurrent development of gillnet fisheries catching neritic tunas and billfish species might explain the decline in the contribution of tropical tunas to catches of all IOTC species observed in the last decade.

Economic markets

The majority of catches of tropical tuna species are sold to international markets, including the sashimi market in Japan (large specimens of yellowfin tuna and bigeye tuna in fresh or deep-frozen condition), and canning factories in the Indian Ocean region or abroad (skipjack tuna and, to a lesser extent, yellowfin tuna and bigeye tuna). A component of the catches of tropical tunas, in particular skipjack tuna caught by some coastal countries in the region, is sold in local markets or retained by the fishermen for direct consumption.

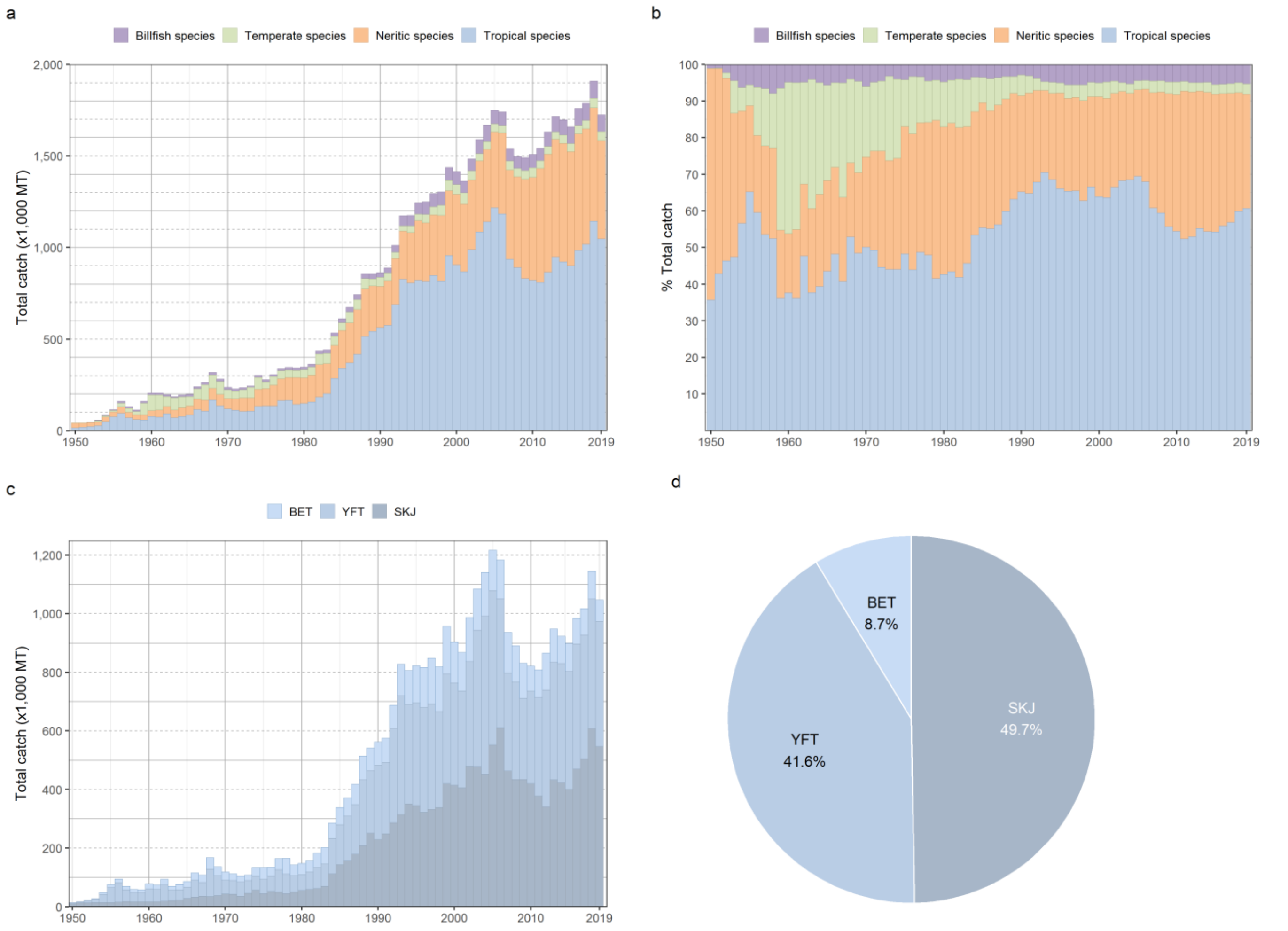

Fig. 1. Top: contribution of tropical tunas to the total catches of IOTC species in the Indian Ocean over the period 1950-2019. (a) Annual nominal catches (MT) by group of species; (b) Percentage of the annual nominal catches by group of species. **Bottom**: Contribution of each tropical tuna species to the total combined catches of tropical tunas; (c) Annual nominal catches by species in MT, 1950-2019; (d) Percentage of the average annual catch by species, 2015-2019

TABLE 2. Best scientific estimates of the annual nominal catches (MT) of all tropical tunas by fishery for the period 1950–2019. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). 'Purse seine' includes industrial purse seiners only, while 'Other' includes all remaining fishing gears not explicitly listed

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Baitboat	12,138	17,516	30,604	50,250	90,250	126,640	98,379	84,047	85,049	117,409	102,414	100,574	109,503	118,062	132,333	116,698
Gillnet	3,900	10,918	19,178	27,156	83,143	172,011	165,751	149,800	168,997	174,285	187,309	173,989	170,498	199,555	209,535	172,499
Line	4,257	8,314	19,066	35,695	68,750	95,407	111,565	138,637	168,568	174,557	188,137	163,325	199,404	170,339	184,299	192,191
Longline	28,673	63,595	60,901	84,678	208,361	202,441	104,821	106,815	149,158	122,690	88,778	86,748	75,261	67,992	65,875	67,238
Purse Seine	0	32	1,405	115,923	317,309	399,348	328,453	317,427	281,335	345,463	343,553	363,187	418,061	451,203	542,176	487,651
Other gears	184	466	828	2,522	4,725	8,860	12,242	12,253	12,395	13,646	12,989	12,156	12,016	11,023	10,035	11,376
Total	**49,152**	**100,841**	**131,982**	**316,224**	**772,538**	**1,004,707**	**821,211**	**808,979**	**865,502**	**948,050**	**923,180**	**899,979**	**984,743**	**1,018,174**	**1,144,253**	**1,047,653**

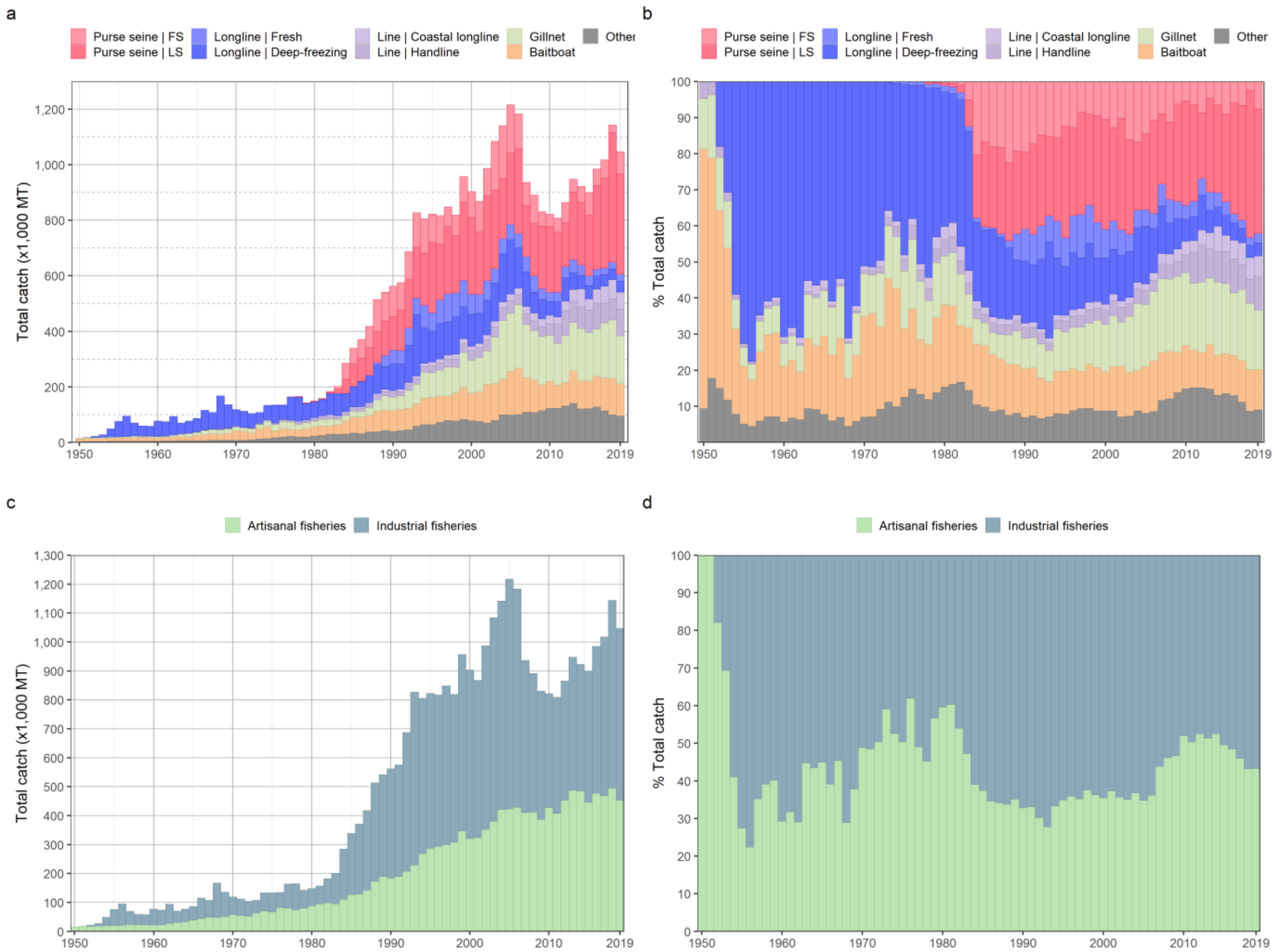

Fig. 2. Annual time series of bigeye tuna during 1950-2019 (a) cumulative nominal catches (MT) by gear; (b) percentage share of all tropical tuna catches by gear; (c) cumulative nominal catches (MT) by fishery type and (d) percentage share by fishery

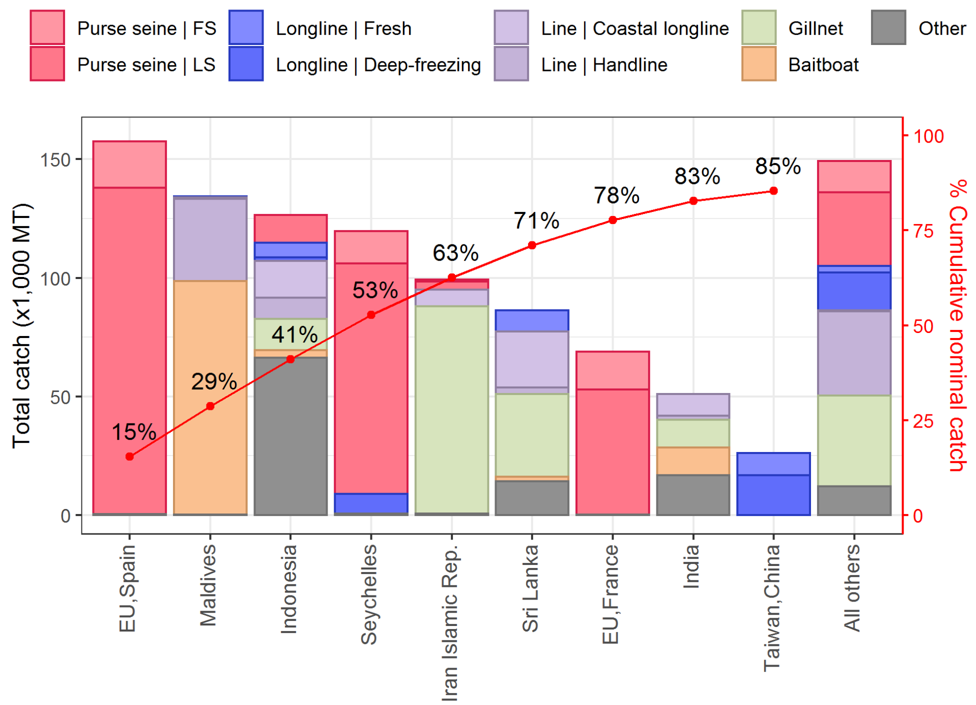

Fig. 3. Average nominal catches (MT) of tropical tunas over the period 2015–2019, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned

Section 2: summary of data issues related to the statistics of tropical tuna species reported to the IOTC

The following section provides a summary of the main issues, by type of dataset, that the IOTC Secretariat considers to negatively affect the quality of tropical tuna statistics available at the IOTC for the consideration of the WPTT.

Nominal (retained) catches

- EU (purse seiners): changes introduced in the statistical methodologies used by one component of the EU purse-seine fleet to estimate species composition for 2018, resulted in figures largely contrasting with other segments of the same fleet: this specific issue was discussed during the 21st Session of the WPTT and – while no revision to the catch figures has been officially provided by EU – the WPTT21 agreed on using revised catch levels for stock assessment and management purposes. To date, no official revision for the species composition of catches reported by the EU purse-seine fishery in 2018 was received by the IOTC Secretariat and the species composition for 2019 seems to have returned to levels comparable with what was available prior to 2018.
- Taiwan,China (longline): inconsistencies have been noted between catches of bigeye tuna originating from the Indian Ocean by the Taiwanese longline fleet – as reported by the nominal catches compared to the Bigeye Statistical Document – as a result of possible misreporting of catches between the Atlantic and Indian Oceans. Between 2001-2004, the Bigeye Statistical Document has recorded higher catches of Indian Ocean bigeye tuna compared to nominal catches – even after the official nominal catches were revised upwards by around 3,000 – 6,000 MT per year. While current bigeye nominal catches in the IOTC database are closer to those reported to the Bigeye Statistical Document, discrepancies still remain, and the issue has still not been fully resolved.
- Sri Lanka (gillnet-longline): although Sri Lanka has reported catches of bigeye tuna for its gillnet/longline fishery, catches are considered to be too low, possibly due to the mislabelling of catches of bigeye tuna as yellowfin tuna.
- I.R. Iran (drifting gillnet): in 2013 I.R. Iran reported catches of bigeye tuna for its drifting gillnet fishery for the first time (i.e., data for year 2012). Until then the IOTC Secretariat estimated I.R. Iran catches of bigeye tuna by assuming various levels of activity of vessels using driftnets on the high seas, depending on the year, and catch ratios between bigeye tuna and yellowfin tuna recorded for industrial purse seiners on free-swimming tuna schools in the northwest Indian Ocean. Catches of bigeye tuna have been eventually provided by I.R. Iran for the period 2005 – 2011 at around 700 MT per year, however these estimates remain uncertain.
- Pakistan (drifting gillnet): revised catch series for the gillnet fishery of Pakistan (from 1987 to 2018) have been officially endorsed in December 2019 following the WPDCS15 and eventually the 22nd session of the Scientific Committee, and are now included in the IOTC database. These revised catch series introduce sensible changes to the total yearly captures of both skipjack tuna and yellowfin tuna: catch volumes of the former are now around 2,165 MT less (on a yearly average), while for the latter an average yearly increase of 6,224 MT is recorded. Still, the revised catch series continue reporting zero catches of bigeye tuna, which is partially contrasting with information from comparable gillnet fisheries operating in similar areas: for this reason, the IOTC Secretariat is still liaising with the Ministry of Fisheries and WWF Pakistan to understand, and resolve, this potential inconsistency.
- Coastal fisheries of Indonesia, Madagascar, Sri Lanka[4] (other than gillnet/longline) and Yemen: the catches of tropical tunas for these fisheries have been estimated by the IOTC Secretariat in recent years (for Sri Lanka, until 2014) – although the quality of the estimates is thought to be very poor due to the lack of information available about the fisheries operating in these countries. Currently IOTC estimates are based on FAO data, however the quality of catches remains highly uncertain and a more substantial review of catches is still required.
- Indonesia (longline): has not reported catches for longliners under their flag that are not based in their ports.
- Comoros (coastal fisheries): in 2011 and 2012 the IOTC Secretariat and OFCF provided support to the strengthening of data collection for the fisheries of Comoros, including a Census of fishing boats and the implementation of sampling to monitor the catches unloaded by the fisheries in selected location along the coast. The IOTC Secretariat and the *Centre National de ressources Halieutiques* of Comoros derived estimates of catch using the data collected and the new catches estimated are at around half the values reported in the past by Comoros

[4] In 2012-13 the Ministry of Fisheries and Aquatic Resources Development of Sri Lanka received support from IOTC, the OFCF and BOBLME to strengthen its data collection and processing system, which lead to improvements in the estimate of catch for the coastal fisheries of Sri Lanka for 2012 and subsequent years

(around 5,000 MT per year instead of 9,000 MT). The IOTC Secretariat revised estimates of catch for the period 1995 – 2010 using the new estimates.

Discards (all fisheries)

The total amount of tropical tunas discarded at sea remains unknown for most fisheries and time periods prior to 2013 (i.e., prior to the introduction of IOTC Resolution 13/11, superseded by IOTC Resolutions 15/06 and 17/04[5]) despite the obligation to report these data as per IOTC Resolution 15/02. Discards of tropical tunas are thought to be significant during some earlier periods of industrial purse seine fisheries using fish aggregating devices (FADs) and may also be high due to depredation of catches of longline fisheries, by sharks or marine mammals, in tropical areas.

The practice of *high grading* in longline fisheries (with a particular focus on yellowfin tuna following the implementation of catch limits in 2017[6]) has been raised and discussed at the sixth *IOTC CPUE Workshop on Longline Fisheries*[7]. Such practice might only concern a component of the Taiwanese longline fishery operating in the South of the Indian Ocean while discarding of tropical tunas is generally considered negligible by experts from other longline fisheries (e.g. Japan, Korea, Seychelles) as there is a market for small-sized tunas. Further analysis of the datasets collected through the Regional Observer Scheme (ROS), which have been growing in number over the years[8], might be helpful to provide information on discards of tropical tunas in order to better estimate the effects they may have on (i) fisheries selectivity, (ii) magnitude of the catch, and (iii) CPUE time series.

Catch-and-effort and CPUE series

For a number of fisheries important for catches of tropical tuna, catch-and-effort remains either unavailable, incomplete (i.e., missing catches by species, gear, or fleet), or only partially reported according to the standards of IOTC Resolution 15/02, and therefore of limited value in deriving indices of abundance:

- EU (purse seine): as in the case of nominal catches, the changes in statistical methodologies used to estimate species composition from one component of the EU purse seine fleet introduced a range of statistical artifacts in the catch-and-effort data submitted for 2018. A proposal for re-estimating the species composition of time-area catches for the fleet using proxy data (from the same and comparable fleets) was discussed at the WPDCS15 in 2019, although no official revision was received or produced by the IOTC Secretariat to date. The artifact identified in 2018 is not found in the C-E data reported by the EU in 2019 and the overall species composition of reported C-E data for the fleet seems to be more closely in line with 2017 and previous years.
- I.R. Iran (coastal and offshore fisheries): I.R. Iran ranks fifth highest in terms of total catches of tropical tunas in 2019 (mostly accounted for by drifting gillnets), however - until recently - catch-and-effort data have not been reported according to IOTC standards, in particular for vessels operating in offshore waters. Following an IOTC Data Compliance mission in November 2017, I.R. Iran began to submit catch-and-effort data in accordance with the reporting requirements of IOTC Resolution 15/02, and this led to measurable improvements to the data available for the Iranian fisheries in the IOTC database for 2007 and following years.
- Sri Lanka (gillnet-longline): until 2014 Sri Lanka did not report catch-and-effort data as per the IOTC standards, including separate catch-and-effort data for gillnet-longline and catch-and-effort data for those vessels that operate outside its EEZ. For this reason, time-area catches prior to 2014 are considered to be uncertain.
- Indonesia (longline): several IOTC-OFCF missions were conducted from November 2015 onwards to assist Indonesia with reporting of catch-and-effort, size frequency data and Regional Observer data collected on-board longline vessels. In 2019 (i.e. data for 2018) catch-and-effort data from logbooks covering around 5% of fishing operations for the longline and coastal purse-seine fleets of Indonesia (as well as for some other coastal fisheries) were received by the IOTC Secretariat for the first time as a consequence of the successful implementation of the *One Data* initiative that aims at strengthening data collection processes and coordination at regional and national levels.

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[5] IOTC Resolution 17/04 *On a ban on discards of bigeye tuna, skipjack tuna, yellowfin tuna, and non-targeted species caught by purse seine vessels in the IOTC area of competence*

[6] IOTC Resolution. 16/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock*, superseded by IOTC Resolutions. 17/01, 18/01 and 19/01

[7] https://iotc.org/fr/documents/WPTT/21/INF01

[8] https://www.iotc.org/documents/WPEB/16/08-ROS

- Pakistan (drifting gillnet): no catch-and-effort reported for the gillnet fishery, in particular for vessels that operate outside the EEZ of Pakistan. WWF-Pakistan has been implementing a crew-based data collection programme for over four years, which includes information on total enumeration of catches and fishing location (for sampled vessels), and could be used to estimate catch-and-effort for Pakistan gillnet vessels in the absence of a national logbook program. The IOTC Secretariat is currently liaising with WWF-Pakistan to evaluate the quality of the data collected and see whether these could be used for other purposes besides cross-verifying the revised catch series provided in recent years.
- India (longline): catches and catch-and-effort data have been reported for its commercial longline fishery for activities inside of the EEZ of India. However, India has not reported catches of tropical tunas or other species for longline vessels under its flag operating offshore.

Size data (all fisheries)

- EU (purse seine)**:** potential discrepancies identified in the size-frequency data provided by EU,ESP and EU,FRA in 2018 and 2019. In particular, the average weight of sampled yellowfin tuna caught in free schools by EU,ESP in 2019 is the lowest recorded in the last 5 years (29.34 Kg/fish vs. an average of 40.43 Kg/fish for 2015-2018). EU,ESP also provided *unraised* size-frequency data in 2018, which show a possible bias towards larger specimens of sampled yellowfin tuna, yielding an average weight of 9.34 Kg/fish vs. an average of 5.89 Kg/fish for 2019 and 2015-2017). A similar tendency by EU,ESP to sample larger fish in 2018 has also been detected for bigeye and skipjack, tuna.

  In the case of EU,FRA the situation is somehow complementary, as EU,FRA reported *unraised* size frequency data in 2019 which yield the highest average weight for all three sampled tropical tuna species in recent years (18.48 Kg/fish for yellowfin tuna, 9.92 Kg/fish for bigeye tuna and 3.97 Kg/fish for skipjack tuna). This situation raises important questions about the representativeness of the raw samples reported by the two components of the EU purse seine fleet in 2018 and 2019, which are particularly important in light of the usage of these size-frequency samples in the assessments of the stocks of all species concerned.
- Japan and Taiwan,China (longline): in 2010, the IOTC Scientific Committee identified several issues concerning the size frequency statistics available for longline fisheries of Japan and Taiwan,China, which remain unresolved.

  Until 2016 the number of specimens sampled for length on-board Japan-flagged longliners remained below the minimum of one-fish-per-metric-ton of catch recommended by the IOTC – although since 2010 size data are being recorded by scientific observers and also provided by Japan as part of the IOTC Regional Observer Scheme data submissions.

  For several years the IOTC Scientific Committee has expressed concern about the poor coverage of length frequency samples for a number of major longline fleets, such as those from Japan, Indonesia, and India, and the potential negative impact this could have on stock assessments.

  In addition, inconsistencies have been noted between the average weights of tropical tunas derived from catch-and-effort and size frequency datasets, particularly for the Taiwanese longline fleet, when comparing data for the same area and time-period[9].

  In early 2019 an IOTC consultant was hired to review IOTC's longline size frequency data which, among other tasks, included visits to the national fisheries institutions of the key fleets collecting longline size data. The work is now finalized and its report will be presented at the IOTC Working Parties and Scientific Committee in late 2020.
- I.R. Iran and Pakistan (gillnet): although both countries have reported size frequency data for their gillnet fisheries in the past (Pakistan) and in recent years (I.R. Iran), these have not been fully reported according to requirements, and the number of samples is often below the minimum sample size recommended by the IOTC.
- Sri Lanka (gillnet-longline): although Sri Lanka has reported length frequency data for tropical tunas in recent years (but no data for gillnet and coastal longliners and ringnetters in 2018), the very strong similarity between the annual size histograms of skipjack tuna caught with gillnet and ringnet suggests the data have been duplicated from one year to the other and raises questions regarding the data collection system in place in Sri-Lanka.
- Indonesia (longline): size frequency data have been reported for its fresh-tuna longline fishery in previous years (e.g. 2002-2003), however samples cannot be fully broken down by fishing area (i.e., 5°x5° grid) and they refer

[9] https://www.iotc.org/documents/review-length-frequency-data-taiwanchina-distant-water-longline-fleet

exclusively to longliners based in ports in this country. In 2019 and 2020. size-frequency data in agreement with the requirements of IOTC Resolution 15/02 were received by the IOTC Secretariat for the first time for both the coastal and fresh-tuna longline fleets of Indonesia.

- To date, these countries **have not reported size frequency data for their fisheries**:
  - Longline (commercial): India, Oman and the Philippines;
  - Coastal fisheries: India and Yemen (Indonesia has recently reported data for some of their coastal fisheries in 2018 and 2019).

Biological data (all tropical tuna species)

- Surface and longline fisheries (in particular Taiwan,China, Indonesia, Japan, and China):

  The IOTC database does not contain enough data to allow for the estimation of statistically robust length-weight keys or non-standard size to standard length keys for tropical tuna species, due to the general lack of biological data available from the Indian Ocean.

  An alternative source of such biological information would be the Regional Observer Scheme (ROS) database, which collates data – including size and weight measurements – recorded by scientific observers and reported to the IOTC Secretariat (in detailed form) as part of the ROS data exchange workflow.

  A first attempt at using ROS data to estimate length-weight relationships for albacore tuna was made during the WPTmT 2019: a similar approach could be considered for tropical tuna species in the future, once the extent of the information within the ROS database is deemed adequate for the purpose.

  A summary of the current biological length-weight equations and availability of alternative sources are documented in Appendix II for the consideration of the WPTT, following the recommendation of the WPDCS.

Section 3: status of fisheries statistics for tropical tunas

BET - Bigeye tuna (*Thunnus obesus*)

Fisheries and main catch trends (2015-2019)

Main fishing gears

Industrial fisheries accounted for the majority of catches of bigeye tuna during 2015–2019, with about 40% of the total catch taken by deep-freezing and fresh longline and about 34% by purse seine (**Table 3; Fig. 5**). Catches of bigeye tuna by coastal fisheries were dominated by coastal longline (10%) and coastal purse seine (6%), and a mix of other gears composed of liftnet, coastal gillnet, trolling, and handline.

In recent years catches by gillnet fisheries have been increasing, due to major changes for some fleets (e.g., Sri Lanka and I.R. Iran); notably increases in boat size, developments in fishing techniques and fishing grounds, with vessels using deeper gillnets on the high seas in areas important for bigeye tuna targeted by other fisheries. Gillnet fisheries represented 35% of the catches of the 'Other' gear group during 2015-2019 (**Table 2**).

Main fleets (and primary gear associated with catches)

Percentage of total catches (2015–19): the four main fleets catching bigeye tuna are Indonesia (fresh / coastal longline, coastal purse seine): 23%; EU,Spain (purse seine): 16%; Taiwan,China (longline): 16%; Seychelles (longline and purse seine): 13% (**Fig. 5**).

Main fishing areas

- **Primary**: Western Indian Ocean, in waters off Somalia;
- **Secondary**: Eastern Indian Ocean.

In contrast to yellowfin tuna and skipjack tuna, where the majority of catches are taken in the western Indian Ocean, bigeye tuna is also exploited in the eastern Indian Ocean, particularly since the late '90s due to increased activity of small longliners fishing tuna to be marketed fresh (e.g., Indonesia). However, in recent years (2011 and following) catches of bigeye tuna in the eastern Indian Ocean have shown a decreasing trend, as some vessels have moved South to target albacore.

Retained catch trends

Total catches of bigeye tuna in the Indian Ocean increased steadily from the '70s, from around 20,000 MT in the '70s, to over 150,000 MT by the late '90s, going through the development of the industrial longline fisheries and arrival of European purse seiners in the '80s. Since 2007 catches of bigeye tuna by longliners have been relatively low, less than half of the catch levels recorded before the onset of piracy in the northwest Indian Ocean (e.g., ≈50,000 MT).

- Longline fisheries: bigeye tunas have been caught by industrial longline fleets since the early '50s, but before 1970 only represented incidental catches. After 1970, the introduction of fishing practices that improved catches of bigeye tuna, and the emergence of a sashimi market, resulted in bigeye tuna becoming a primary target species for the industrial longline fleets. Large bigeye tunas (averaging just above 40 kg) are primarily caught by longliners, in particular deep-freezing ones.

  Since the late '80s, Taiwan,China has been the major longline fleet targeting bigeye tuna in the Indian Ocean, accounting for more than 40% of the total longline catch in the Indian Ocean in recent years (**Fig. 5**).

  Between 2007 and 2011 catches have fallen sharply, largely due to the decline in the number of Taiwanese longline vessels active in the north-west Indian Ocean in response to the threat of piracy. Current catches (totalling at around 73,000 MT) still remain far lower than the levels recorded from the late '90s through the mid '00s (**Table 3** and **Fig. 5**).

- Purse seine fisheries: since the late '70s, bigeye tuna has been caught by purse seine vessels fishing on tunas aggregated on floating objects and, to a lesser extent, associated with free swimming schools of yellowfin tuna (**Fig. 5a**). Purse seiners under the flags of EU countries and Seychelles account for the majority of purse seine catches of bigeye tuna in the Indian Ocean (**Fig. 6**) – mainly small juvenile bigeye (averaging around 5 kg) compared to longliners which catch much larger sized fish (40-60 kg) (**Fig. A3**). Development of a proper industrial purse seine fleet for Indonesia in 2018 resulted in significant catches of bigeye tuna being reported for the first time (around 5,000 MT). The catch reported by Indonesia for this fleet component however declined to less than 600 MT in 2019.

While the activities of purse seiners were also affected by piracy in the northwest Indian Ocean during 2008-2011, the decline in catches of tropical tunas has not been as marked as for longline fleets. The main reason is the presence of security personnel onboard purse seine vessels of the EU and Seychelles, which has made it possible for vessels under these flags to continue operating in the northwest Indian Ocean.

Total catches of bigeye tuna for the purse seine fishery were relatively stable at around 20,000 – 30,000 MT for all fleets until 2017: catches reported in 2018 showed a major increase of around 50% compared to previous year (45,000 MT in total) with over 66% of purse seine catches being reported by EU,Spain and Seychelles. This increase can potentially be explained by the revisions introduced in the species composition estimation by one component of the EU purse seine fleet and is still subject to further discussion and analysis. In 2019, the total purse seine catches of bigeye were back to levels similar to what was observed in 2016-2017, with a total catch of 26,000 MT, of which more than 70% was taken on associated schools.

Discard levels

Discard levels are thought to be low, although estimates of discards are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries and the Seychelles for the period 2003–2017. The existence of the practice of high-grading (discarding of small fish) in some longline fisheries has been raised as a potential issue for the accuracy of Catch Per Unit Effort (CPUE) time series but it is not considered to be a big issue for bigeye tuna as there is a market for small-sized fish.

Catch series

No major change has occurred in the nominal catch series of bigeye tuna since the WPTT meeting in 2019. The revised Pakistan gillnet catches from 1987 onwards (incorporated in the IOTC database in December 2019) do not include reports of bigeye tuna catches at all, introducing a total reduction in bigeye tuna catches of 3,925 MT (123 MT / year) in the years concerned (1987-2018) when compared to the data available at the WPTT21 (**Fig. 4**).

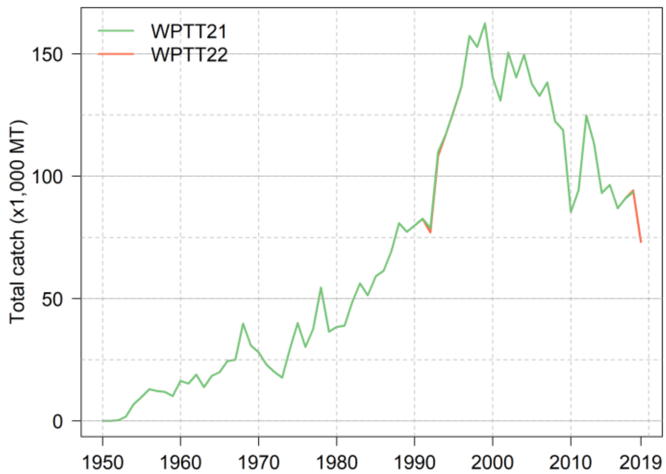


Fig. 4. Comparison of annual time series of total catches (MT) of Indian Ocean bigeye tuna available at the 21st (WPTT21, 2019) and 22nd (WPTT22, 2020) sessions of the IOTC Working Party on Tropical Tunas

TABLE 3. Best scientific estimates of the annual nominal catches (MT) of bigeye tuna by fishery for the period 1950–2019. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). 'Purse seine' includes industrial purse seiners only and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Purse seine | FS	0	0	0	2340	4824	6196	3,792	6,222	7,180	4,659	5,000	9,633	2,489	10,242	3,634	7,078
Purse seine | LS	0	0	0	4852	18315	20273	18,486	16,386	10,434	22,809	14,882	15,547	19,330	19,456	42,965	18,934
Longline | Fresh	0	0	218	3066	26282	23490	9,782	12,031	16,816	16,725	13,650	12,401	7,658	8,892	7,147	6,874
Longline | Deep-freezing	6488	21861	30413	42972	61577	70308	31,199	34,206	65,015	44,320	33,768	32,153	29,706	25,300	18,705	19,315
Line | Coastal longline	33	287	548	2204	4111	5786	7,662	7,676	7,087	8,949	9,578	9,897	9,392	9,581	6,849	6,415
Line | Handline	9	8	110	181	162	226	1,096	1,742	2,308	151	836	1,648	1,282	552	331	1,591
Other	58	114	430	2502	4759	9908	13,352	16,111	15,920	15,580	15,345	15,118	16,993	16,840	14,610	12,957
Total	**6588**	**22270**	**31719**	**58117**	**120030**	**136187**	**85,369**	**94,374**	**124,760**	**113,193**	**93,059**	**96,397**	**86,850**	**90,863**	**94,241**	**73,164**

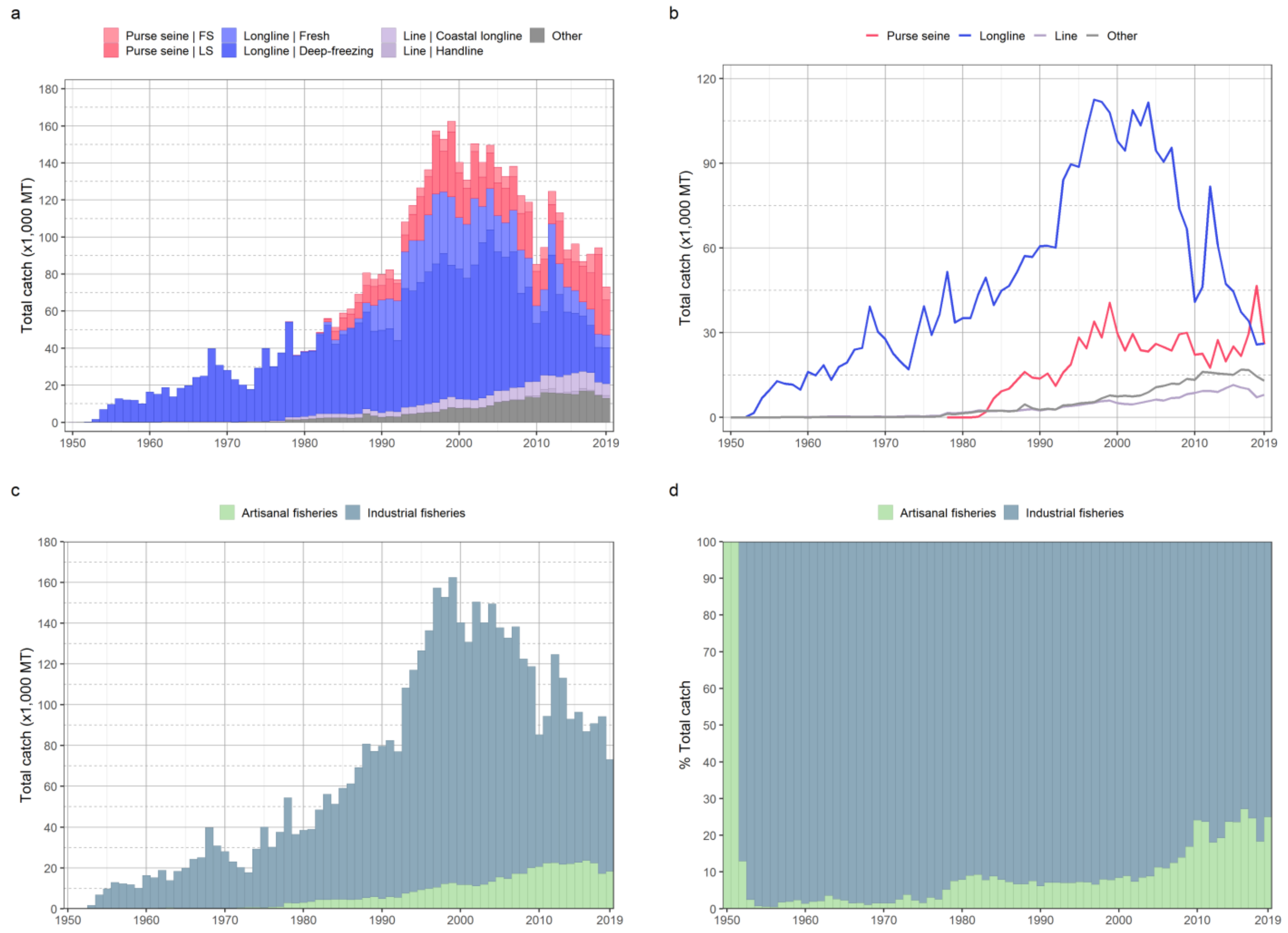


Fig. 5. Annual (1950–2019) time series of bigeye tuna (a) cumulative nominal catches (MT) by gear; (b) individual nominal catches (MT) by gear group; (c) cumulative nominal catches (MT) by fishery type and (d) percentage share by fishery type. Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

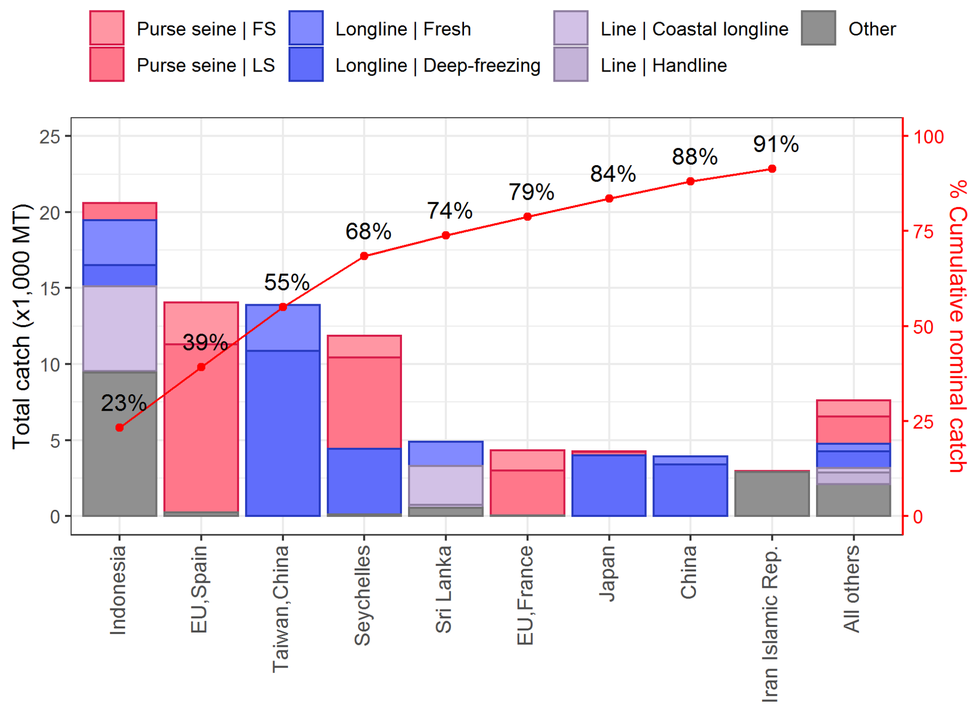


Fig. 6. Average nominal catches (MT) of bigeye tuna over the period 2015–2019, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned. Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

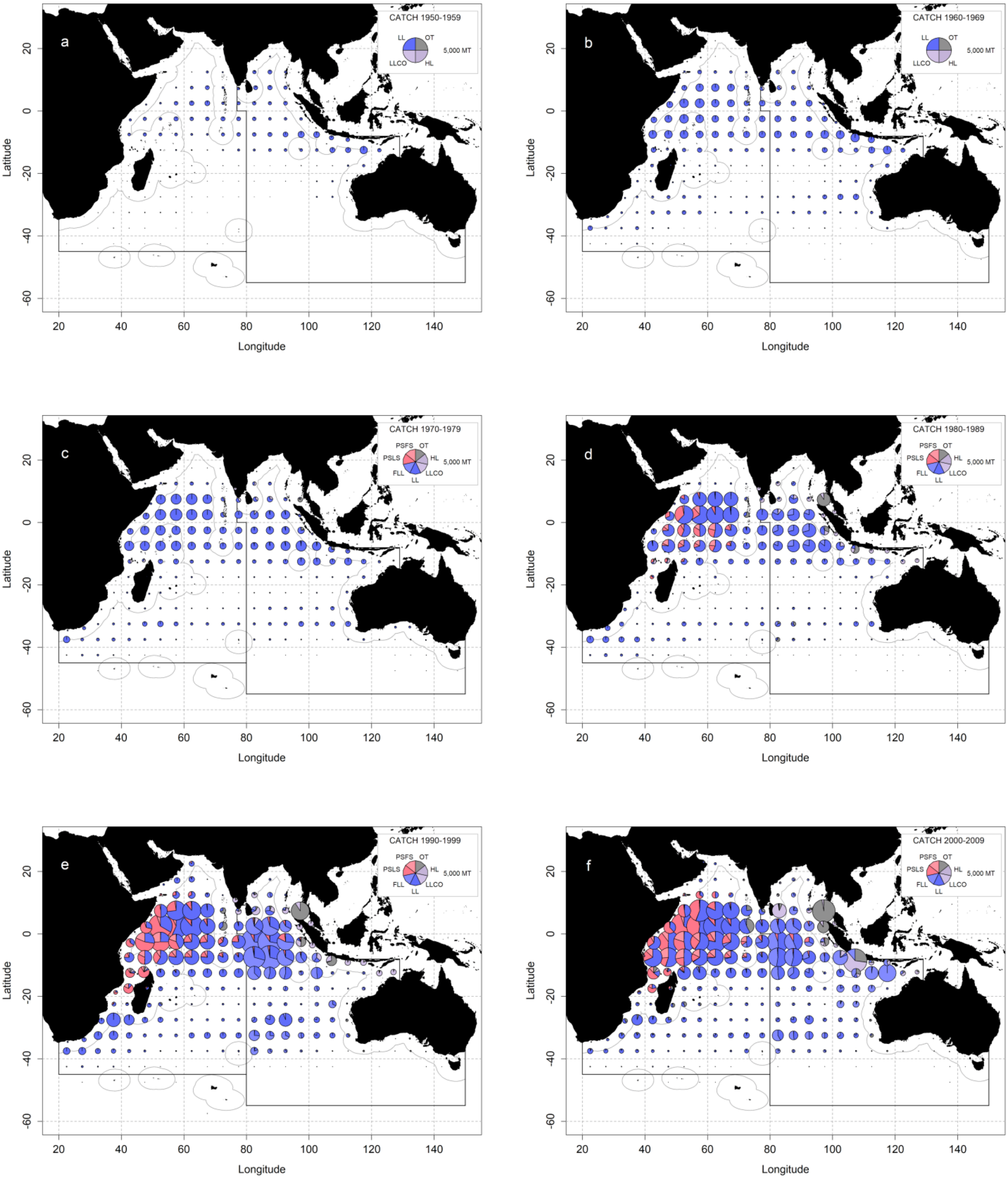


Fig. 7. Estimated average annual time-area catches (MT) of bigeye tuna for the period **1950–2009** by decade and type of gear. Black solid lines represent the IOTC areas. **PSLS** = purse seine (log/FAD school); **PSFS** = purse seine (free school); **FLL** = longline (fresh); **LL** = longline (deep-freezing); ***HL** = line (coastal longline, handline); **OT** = all remaining gears

Note that the catches of fleets for which the flag countries do not record detailed time-area data to the IOTC are reported using the estimated areas from the CAS data set. This is particularly true for the driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and longline and coastal fisheries of Indonesia (OT)

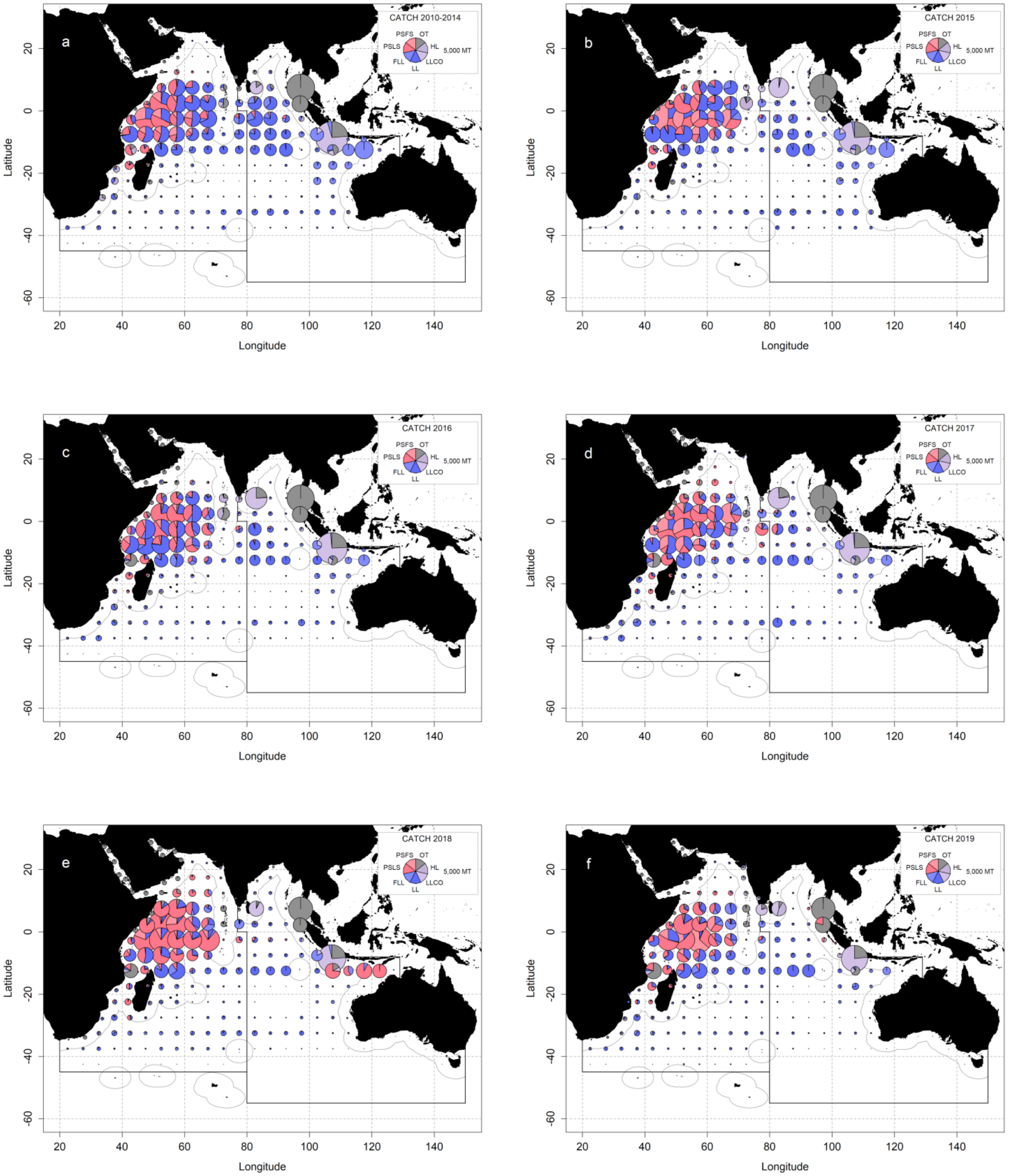


Fig. 8. Estimated average annual time-area catches (MT) of bigeye tuna for the period **2015–2019** by type of gear and for **2015–19**, by year and type of gear. Black solid lines represent the IOTC areas. **PSLS** = purse seine (log/FAD school); **PSFS** = purse seine (free school); **FLL** = longline (fresh); **LL** = longline (deep-freezing); **HL** = line (coastal longline, handline); **OT** = all remaining gears

Data availability and related data quality issues

Retained catches

- Data are considered to be relatively reliable for the main industrial fleets targeting bigeye tuna, with a relatively low proportion of catches estimated, or adjusted, by the IOTC Secretariat (**Fig. 9a**).
- Catches of bigeye tuna in the industrial purse seine fishery are estimated from large numbers of size samples collected at unloading and a data processing procedure that relies on large, fixed time-area strata which date back to the ‘90s and are currently being assessed and revised.
- Catches are less certain for the following fisheries/fleets:
  - Non-reporting industrial purse seiners and longliners (NEI) and other industrial fisheries (e.g. longliners of India);
  - Some artisanal fisheries, including: until 2012, pole-and-line fishery of Maldives, drifting gillnet fisheries of I.R. Iran and Pakistan; until 2014, gillnet-longline fishery of Sri Lanka; artisanal fisheries of Indonesia, Comoros (before 2011) and Madagascar.

Catch-per-unit-effort (CPUE) trends

- Availability: standardized CPUE series are available for the major industrial longline fisheries (i.e., Japan, Rep. of Korea, Taiwan,China) and industrial purse seine fisheries (EU, Seychelles, Mauritius) but these latter are generally not considered as reliable proxies of tuna abundance due to the difficulties associated with the definition of fishing effort in purse seine fisheries.

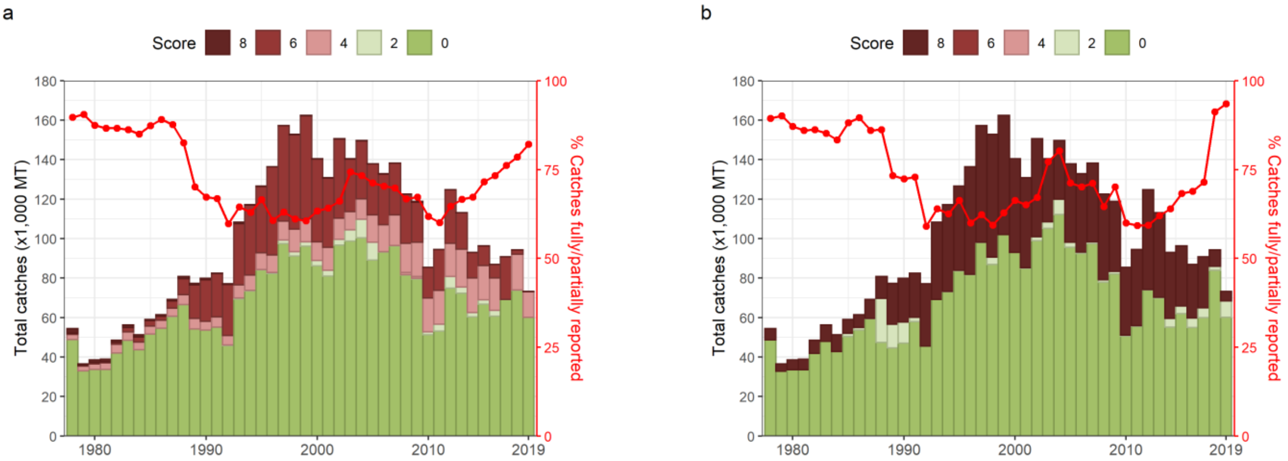
  For most other fisheries, catch-and-effort are either not available (**Fig. 9b**), or are considered to be of poor quality – especially since the early ’90s and for the following fisheries/fleets:

  - NEI purse seine and longliners: no data available;
  - Fresh-tuna longline fisheries: no data are available for the fresh-tuna longline fishery of Indonesia, while data for the fresh-tuna longline fishery of Taiwan,China have only been available since 2006;
  - Other industrial fisheries: uncertain data from significant fleets of industrial purse seiners from I.R. Iran, and longliners from India, Malaysia, Oman, and Philippines; improvements in reporting of time-area catches for Indonesian purse seiners were noted in 2018-2019 but the coverage of the geo-referenced data remains low;
  - Artisanal/coastal fisheries: incomplete or missing data for the driftnet fisheries of I.R. Iran (before 2007) and Pakistan, and the gillnet-longline fishery of Sri Lanka, especially in recent years.

Fish size or age trends (e.g., by length, weight, sex and/or maturity)

- Average fish weight: Can be assessed for several industrial fisheries although they are incomplete (**Fig. 9c**) or of poor quality for most fisheries before the mid ’80s and for some fleets in recent years (e.g. Japan and Taiwan,China longline). In 2018-2019, as a consequence of a decrease in catches from longline fleets and a corresponding relevant increase in catches from industrial purse seine fleets (fishing on log-schools), the estimated average weight of caught individuals decreased sensibly to an all-time low of less than 4.5 Kg / fish (Indian Ocean wide, all gears) as opposed to about 10 Kg / fish estimated during 2013-2017 (**Fig. A3**).
- Catch-at-Size (Age) table: Data are available, but the estimates are more uncertain for some years and some fisheries due to:
  - Lack of size data available from industrial longliners before the mid ’60s, from the early ’70s up to the mid80s and in recent years (Japan and Taiwan,China), with some inconsistencies between observer and crew-based samples as well as with average weights derived from logbooks when catches are reported in both numbers and weights.
  - Lack of size data available for some industrial fleets (NEI, India, Indonesia, I.R. Iran, Sri Lanka).

Data quality (by dataset)



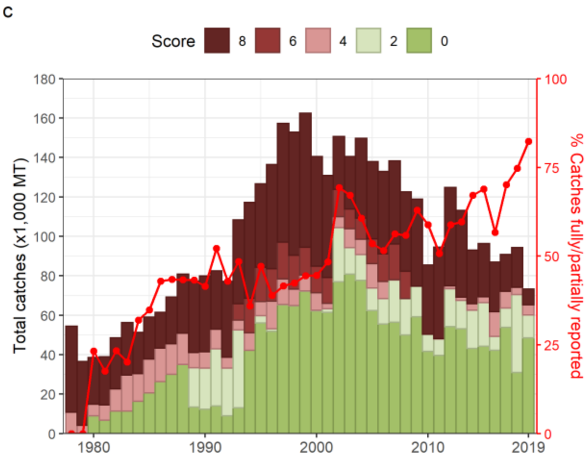


Fig. 9. Annual nominal catches (MT) of bigeye tuna estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2019) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data

Each IOTC dataset is assessed against IOTC reporting standards, where:

- *Score 0 indicates the amount of nominal catch associated with each dataset that is fully reported according to IOTC standards;*
- *Scores 2–6 refer to the amount of nominal catch associated with each dataset that is partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document;*
- *Score 8 refers to the amount of nominal catch associated with catch-and-effort or size frequency data that is not available.*

Key to IOTC Scoring system

Nominal Catch	By species	By gear
Fully available	0	0
Partially available (part of the catch not reported by species/gear)*	2	2
Fully estimated (by the IOTC Secretariat)	4	4

*Catch assigned by species/gear by the IOTC Secretariat; or 15% or more of the catches remain under aggregates of species

Catch-and-Effort	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 30% of total catch covered through logbooks)	2	
Not available at all	8	

Size frequency data	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 1 fish measured by metric ton of catch)	2	
Not available at all	8	

Key to colour coding

Total score is 0 (or average score is 0-1)
Total score is 2 (or average score is 1-3)
Total score is 4 (or average score is 3-5)
Total score is 6 (or average score is 5-7)
Total score is 8 (or average score is 7-8)

Tagging data

- A total of 35,948 bigeye tuna (representing 16.5% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP), of which about 96% were tagged during the main Regional Tuna

Tagging Project-Indian Ocean (RTTP-IO) and released off the coast of Tanzania in the western Indian Ocean, between May 2005 and September 2007 (**Fig. 10**). The remaining were tagged during small-scale projects, and by other institutions with the support of the IOTC Secretariat, in the Maldives, Indian, and in the southwest and the eastern Indian Ocean.

- To date, 5,781 specimens (16% of releases for this species) have been recovered and reported to the IOTC Secretariat. These tags were mainly reported from the purse seine fleets operating in the Indian Ocean (91%), while 5% were recovered from longline vessels.

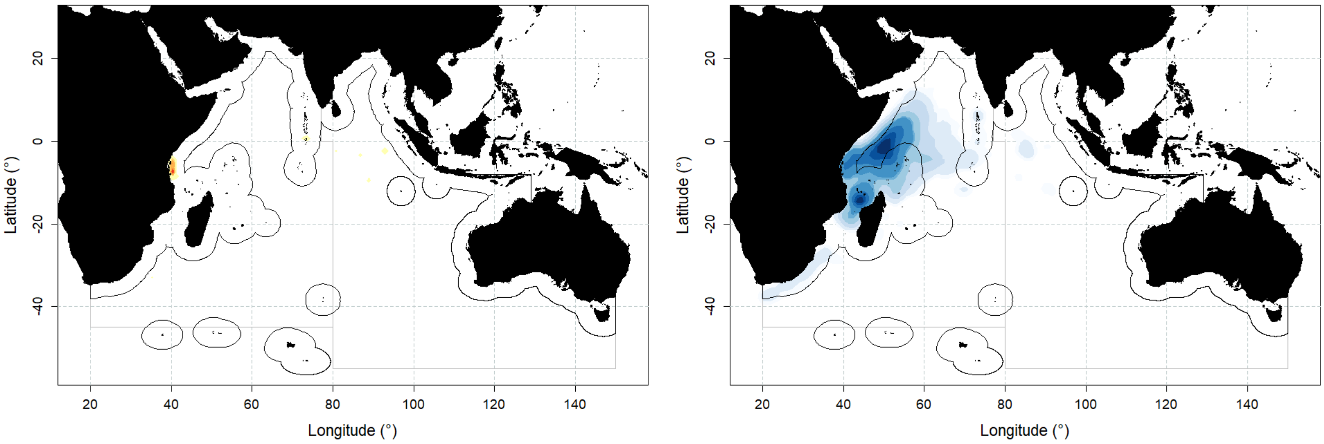


Fig. 10. Density distribution of (left panel) releases and (right panel) recoveries of bigeye tuna tagged during the during the Maldivian and Indian Ocean Tuna Tagging programmes

SKJ - Skipjack tuna (*Katsuwonus pelamis*)

Fisheries and main catch trends (2015–19)

Main fishing gears

Skipjack tuna are mostly caught by industrial purse seine (44%) while pole-and-line and gillnet have the same level of contribution (19%) (**Table 4**; **Fig. 12**).

Main fleets (and primary gear associated with catches)

The five main fleets catching skipjack tuna are EU,Spain (purse seine): 19%; Maldives (pole-and-line): 16%; Indonesia (coastal purse seine, troll line, gillnet): 16%; Seychelles (purse seine): 13% and I.R. Iran (gillnet): 9% (**Fig. 13**).

Main fishing areas

- **Primary**: Western Indian Ocean, in waters off Somalia and north of the Mozambique Channel and in the Maldives;
- **Secondary**: Waters off Sri Lanka, western Australia, and Indonesia.

Retained catch trends

- Purse seine fisheries: the increase in catches of skipjack tuna in the last 40 years has largely been driven by the arrival of purse seiners in the early '80s, and the development of the fishery in association with FADs since the early to mid '90s. Following the major decrease in purse seine effort related to the piracy threat during 2008-2012, the catches of skipjack tuna have steadily increased to exceed 300,000 MT in 2018, with more than 95% caught on schools associated with drifting FADs and logs (**Table 4**; **Fig. 12**).

  In 2019, the purse seine catches of skipjack tuna were larger than 280,000 MT, with more than 12% of the catches coming from free schools (34,668 MT) while the mean annual percentage contribution of free schools to the skipjack purse seine catch was around 5% during 2010-2016 and less than 3% during 2017-2018.

- Pole-and-line fisheries: the Maldivian pole-and-line fishery, which represents the main pole-and-line fishery of the Indian Ocean, effectively increased its fishing effort with the mechanisation of its fleet since 1974, including an increase in boat size and power, as well as the use of anchored FADs since 1981. Skipjack tuna represents around 80% of the total catch of Maldives, where catches of skipjack tuna increased regularly between 1980 and 2006 – from around 20,000 MT to over 130,000 MT.

  Catches of skipjack tuna reported by Maldivian pole-and-liners then declined to as low as 55,000 MT in 2012, i.e. less than half the catches taken in 2006 - although the reasons for the decline remain unclear. One explanation may be improvements in the data collection with the introduction of logbooks and more accurate, albeit lower, estimates of skipjack landed; while the introduction of handlines and a shift in targeting from skipjack tuna to yellowfin tuna may also be a contributing factor. Catches of skipjack tuna with pole-and-line increased to reach 100,000 MT in 2018, with most of these catches (over 80%) being caught by larger vessels with overall length above 24m. In 2019, the catches reported for the fishery were close to 90,000 MT.

- Gillnet fisheries: several fisheries using gillnets have reported large catches of skipjack tuna in the Indian Ocean, including the gillnet/longline fishery of Sri Lanka, driftnet fisheries of I.R. Iran and Pakistan, and gillnet fisheries of Indonesia. In recent years gillnet catches have represented about 20% of the total catches of skipjack tuna in the Indian Ocean (**Table 4**; **Fig. 12**). Although it is known that vessels from I.R. Iran and Sri Lanka have been using gillnets on the high seas in recent years, reaching as far as the Mozambique Channel, the activities of these fleets are not fully understood, as vessels may use a mix of gillnet and longline fishing gears and time-area catch-and-effort series have been made available for those fleets only in recent years.

Discard levels

Discard levels are thought to be low, although estimates of discards are unknown for most fisheries, except for the industrial purse seine fishery for 2003-2017. Discards may also occur in the driftnet fishery of I.R. Iran, as this species has no commercial value in this country.

Catch series

No major change has occurred in the nominal catch series of skipjack tuna since the WPTT meeting in 2019. The revised Pakistan gillnet catches from 1987 onwards (incorporated into the IOTC database in December 2019) introduced a total reduction in skipjack tuna catches of 69,277 MT (2,165 MT / year) in the years concerned (1987-2018) when compared to the data available at the WPTT21 (**Fig. 11**).

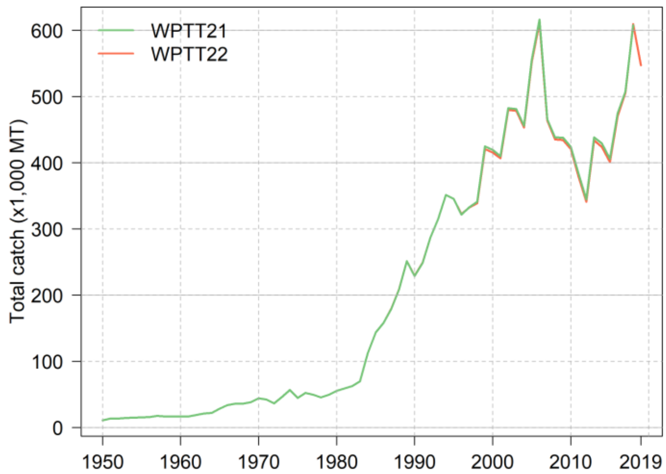


Fig. 11. Comparison of annual time series of total catches (MT) of Indian Ocean skipjack tuna available at the 21st (WPTT21, 2019) and 22nd (WPTT22, 2020) sessions of the IOTC Working Party on Tropical Tunas

TABLE 4. Best scientific estimates of the annual nominal catches (MT) of skipjack tuna by fishery for the period 1950–2019. Colour codes (yellow = lower, green = higher) describe the intensity of captures by fishery across decades (left) and years (right). 'Purse seine' includes industrial purse seiners only and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Purse seine | FS	0	0	41	15,252	30,776	25,672	8,774	9,000	2,984	5,742	7,228	7,800	6,888	6,170	6,235	34,268
Purse seine | LS	0	0	125	34,457	124,043	163,801	144,097	123,056	80,989	119,864	122,490	123,994	182,735	208,876	301,570	247,687
Baitboat	10,007	15,148	24,684	41,705	76,903	109,571	83,506	69,404	68,821	93,010	81,568	82,748	96,268	99,423	111,867	97,516
Gillnet	2,310	6,775	11,173	14,524	43,159	111,700	98,919	87,724	92,570	105,673	102,900	87,419	82,796	99,663	111,983	88,941
Other	2,697	4,943	10,894	24,183	44,250	62,238	85,399	89,266	95,566	109,547	109,873	98,712	101,499	91,354	77,524	78,837
Total	**15,014**	**26,866**	**46,917**	**130,121**	**319,131**	**472,982**	**420,695**	**378,450**	**340,930**	**433,836**	**424,059**	**400,673**	**470,186**	**505,486**	**609,179**	**547,249**

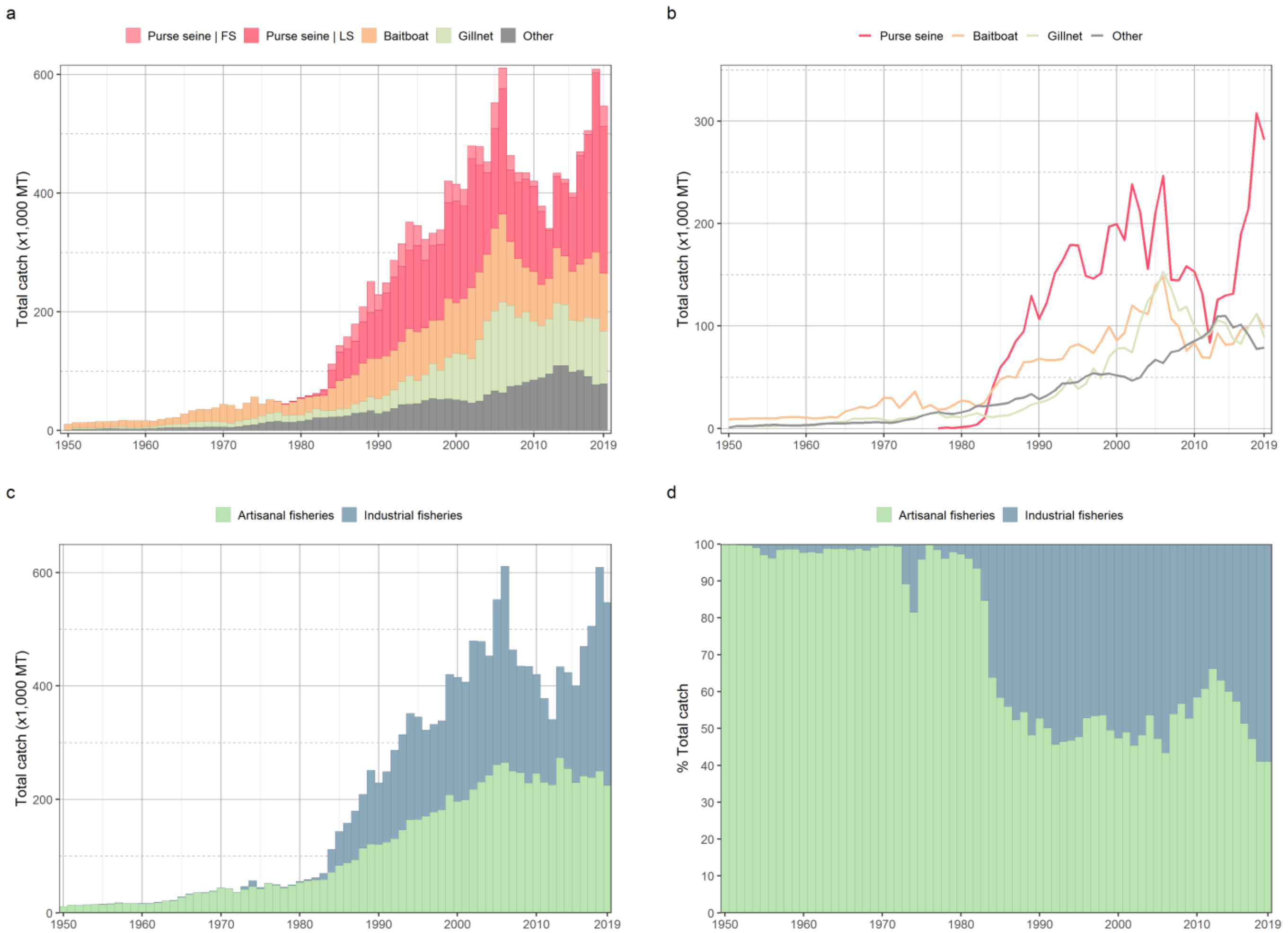


Fig. 12. Annual time series of skipjack tuna during 1950-2019 (a) cumulative nominal catches (MT) by gear; (b) individual nominal catches (MT) by gear group for skipjack tuna; (c) cumulative nominal catches (MT) by fishery type and (d) percentage share by fishery type. Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

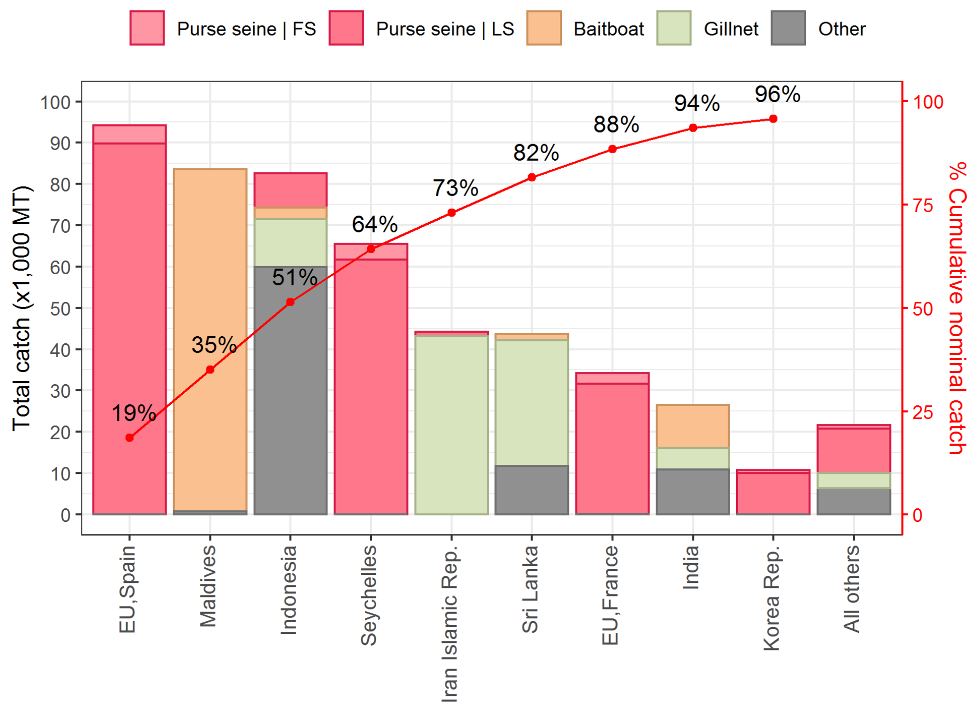


Fig. 13. Average nominal catches (MT) of skipjack tuna over the period 2015–2019, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned. Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

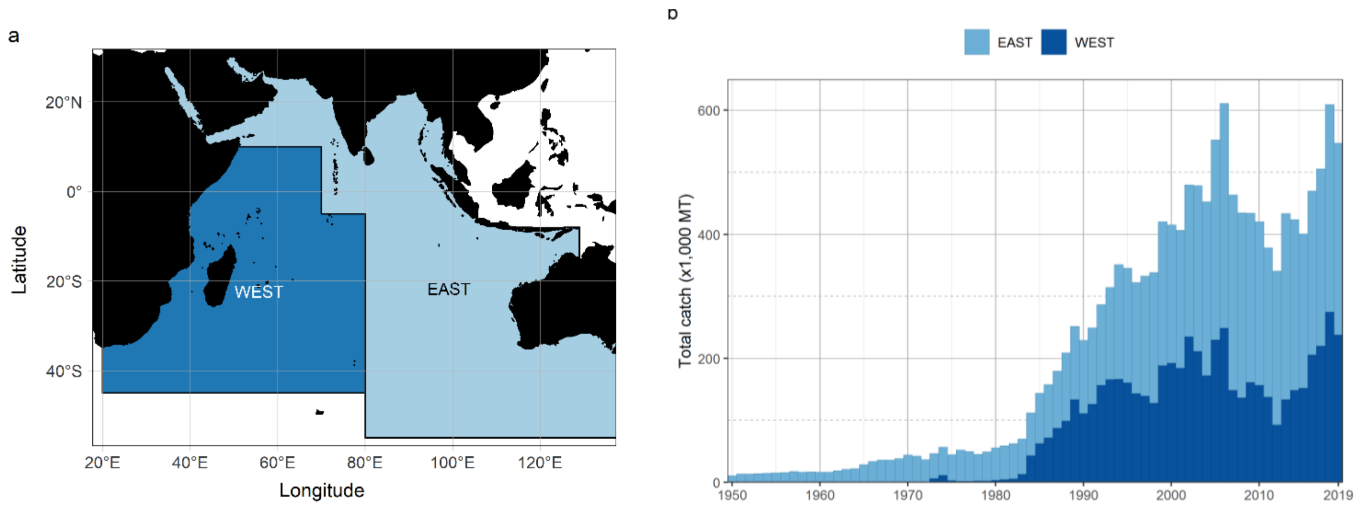


Fig. 14. (a) Map of areas used for some configuration of the assessment model of skipjack tuna in 2020 (see Document IOTC-2020-WPTT-22(AS)-10) and (b) annual time series of nominal catches (MT) of skipjack tuna for each assessment area

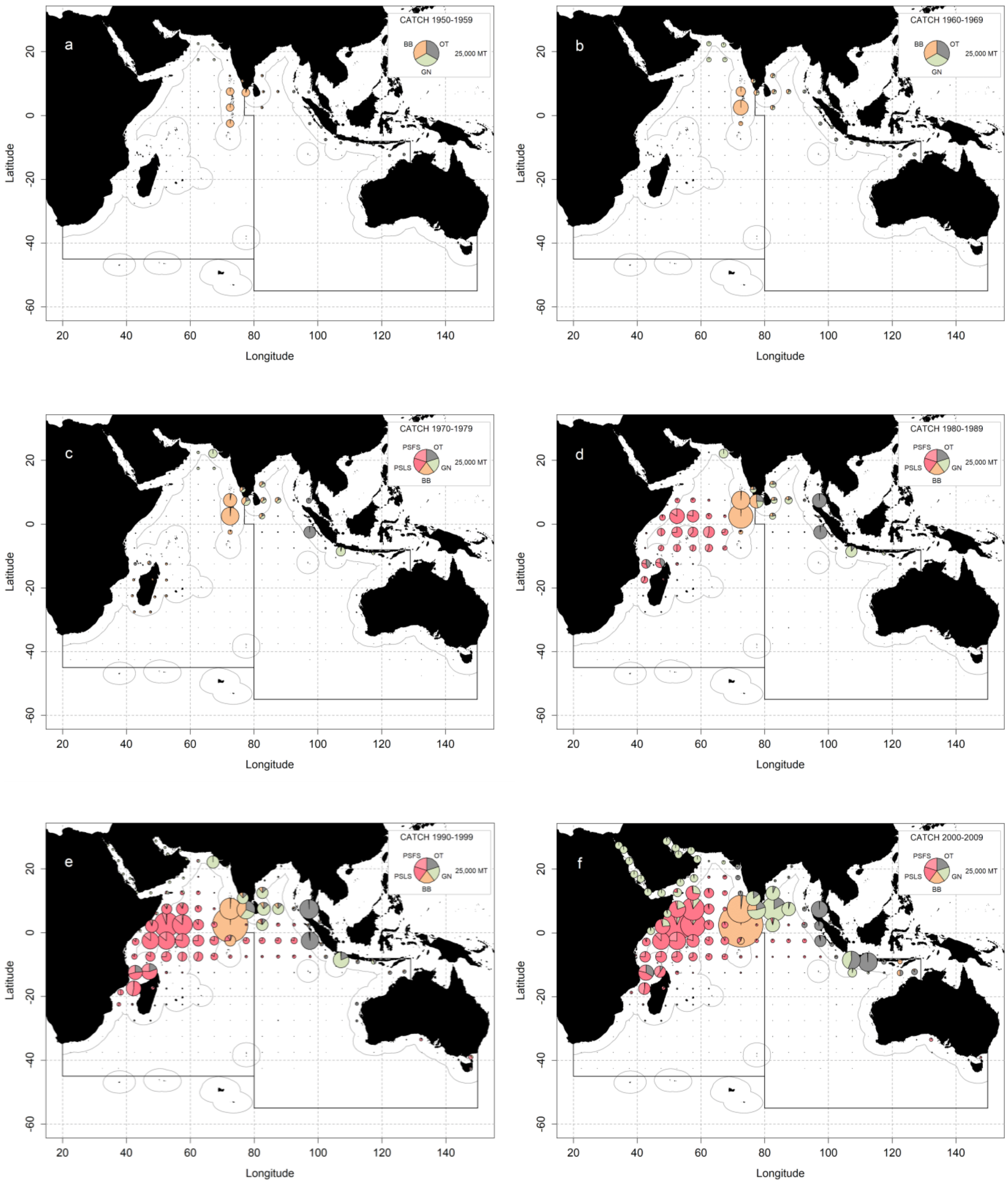


Fig. 15. Estimated average annual time-area catches (MT) of skipjack tuna for the period **1950–2009** by decade and type of gear. Black solid lines represent the IOTC areas. **PSLS** = purse seine (log/FAD school); **PSFS** = purse seine (free school); **GN** = gillnet; **BB** = baitboat / pole-and-line; **OT** = all remaining gears

Note that the catches of fleets for which the flag countries do not record detailed time-area data to the IOTC are reported using the estimated areas from the CAS data set. This is particularly true for the driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and longline and coastal fisheries of Indonesia (OT)

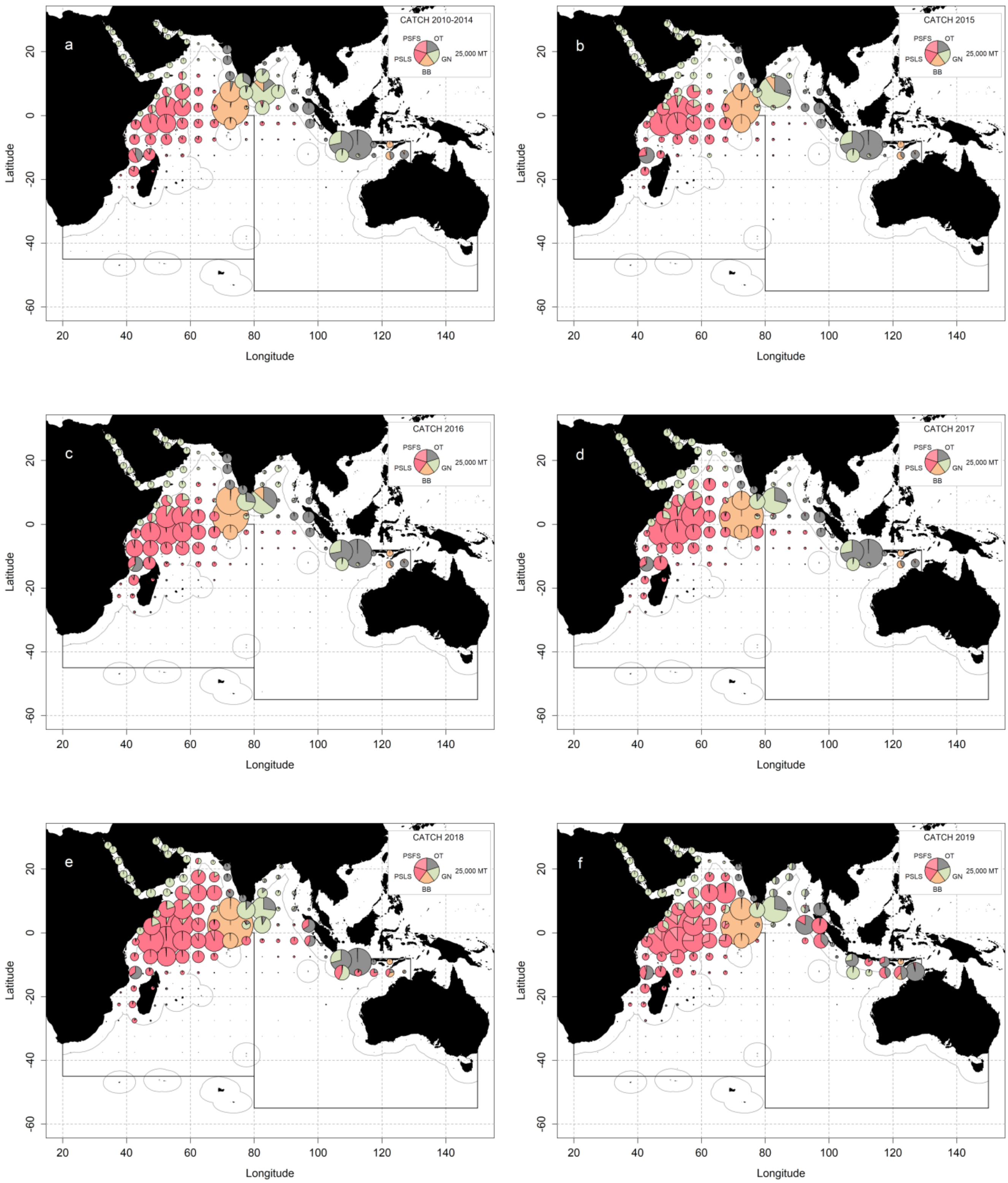


Fig. 16. Estimated average annual time-area catches (total combined in tonnes) of bigeye tuna for the period **2010–2014** by type of gear and for **2015–19**, by year and type of gear. Black solid lines represent the IOTC areas. **PSLS** = purse seine (log/FAD school); **PSFS** = purse seine (free school); **GN** = gillnet; **BB** = baitboat / pole-and-line; **OT** = all remaining gears

Data availability and related data quality issues

Retained catches

- Retained catches are considered to be generally well known for the major industrial fleets, with a low proportion of catches estimated, or adjusted, by the IOTC Secretariat (**Fig. 17a**). Catches are less certain for many artisanal fisheries for several reasons, including:
  - catches not fully reported by species;
  - uncertainty in the catches from some significant fleets including the Sri Lankan coastal fisheries, and coastal fisheries of Comoros and Madagascar.

Catch-per-unit-effort (CPUE) trends

- <u>Catch-and-effort series</u> are available for the various industrial and artisanal fisheries (e.g., Maldives pole-and-line fishery, EU,France purse seine).

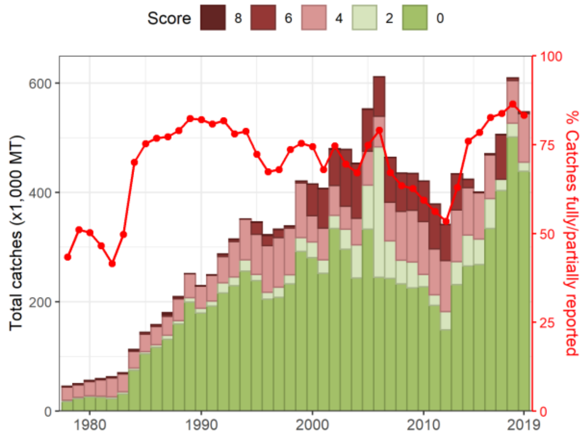
  However, for several other important fisheries catch-and-effort are either not available, or are considered to be of poor quality (**Fig. 17b**), notably:
  - insufficient data available for the gillnet fisheries of I.R. Iran (before 2007) and Pakistan;
  - poor quality effort data for the gillnet-longline fishery of Sri Lanka. In previous years catch-and-effort has not been reported fully by area, or disaggregated by gear (i.e., gillnet-longline) according to the IOTC reporting standards – however, since 2014 detailed information by EEZ area (for coastal fisheries) and grid area (for offshore fisheries) and gear started being submitted to the IOTC Secretariat;
  - no catch-and-effort data are available for important coastal fisheries using hand and/or troll lines, in particular Indonesia, India, and Madagascar. Time-area catches for handline and troll line fisheries of Indonesia were received in 2018 for the first time, and again in 2019, although with very low levels of coverage.

Fish size or age trends (e.g., by length, weight, sex and/or maturity)

- <u>Average fish weight</u>: Trends in average weights cannot be assessed before the mid ’80s and are also incomplete for most artisanal fisheries, namely hand lines, troll lines and many gillnet fisheries (e.g., Indonesia) (**Fig. 17c and A7**).
- <u>Catch-at-Size (Age) table</u>: Available but the estimates are uncertain for some years and fisheries due to:
  - general lack of size data before the mid ’80s, for all fleets/fisheries;
  - lack of size data available for some artisanal fisheries, notably most hand lines and troll line fisheries (e.g., Madagascar), many gillnet (e.g., Indonesia, Sri Lanka) and small purse seine fisheries – although Indonesia reported good size information for its small purse seine fishery in 2019. It is noteworthy that size data reported by Sri Lanka for its coastal and offshore gillnet fisheries in 2017 and 2019 were found to be identical to the data reported for 2016.

Data quality (by dataset)

a



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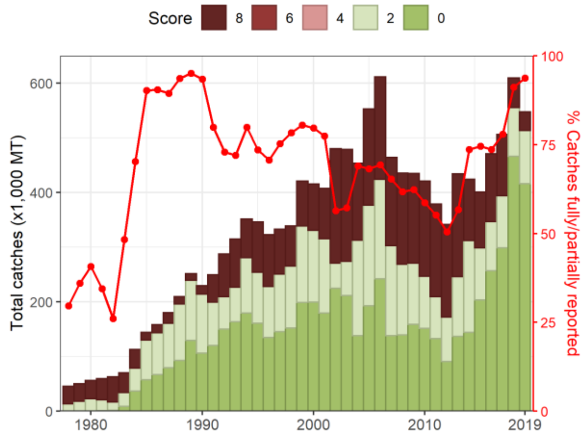

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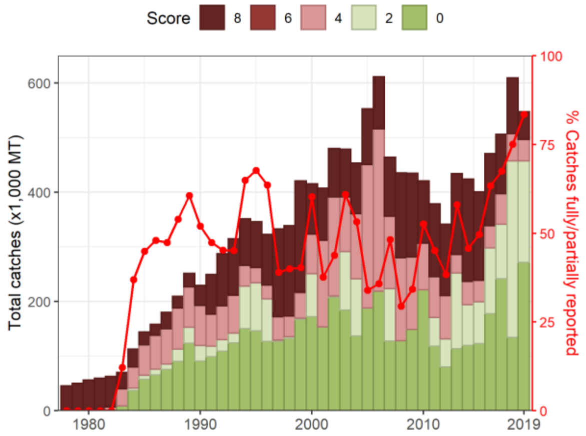


Fig. 17. Annual nominal catches (MT) of skipjack tuna estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2019) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data

Each IOTC dataset is assessed against IOTC reporting standards, where:

- *Score 0 indicates the amount of nominal catch associated with each dataset that is fully reported according to IOTC standards;*
- *Scores 2–6 refers to the amount of nominal catch associated with each dataset that is partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document;*
- *Score 8 refers to the amount of nominal catch associated with catch-and-effort or size frequency data that is not available.*

Key to IOTC Scoring system

Nominal Catch	By species	By gear
Fully available	0	0
Partially available (part of the catch not reported by species/gear)*	2	2
Fully estimated (by the IOTC Secretariat)	4	4

*Catch assigned by species/gear by the IOTC Secretariat; or 15% or more of the catches remain under aggregates of species

Catch-and-Effort	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 30% of total catch covered through logbooks)	2	
Not available at all	8	

Size frequency data	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 1 fish measured by metric ton of catch)	2	
Not available at all	8	

Key to colour coding

	Total score is 0 (or average score is 0-1)
	Total score is 2 (or average score is 1-3)
	Total score is 4 (or average score is 3-5)
	Total score is 6 (or average score is 5-7)
	Total score is 8 (or average score is 7-8)

Tagging data

- A total of 101,353 skipjack tunas (representing 46% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP), of which ≈77% (n = 78,324) were released during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) around Seychelles, in the Mozambique Channel and off the coast of Tanzania, between May 2005 and September 2007 (**Fig. 18**). The remaining fish (n = 23,029) were tagged during small-scale tagging projects, and by other institutions with the support of IOTC around the Maldives, India, and in the southwest and the eastern Indian Ocean. The past tagging projects conducted in the Maldives in the ‘90s added 14,506 tagged skipjack tunas to the database.
- To date, 17,835 specimens (12.8% of releases for this species), have been recovered and reported to the IOTC Secretariat: 1,960 as part of the historical tagging projects in the Maldives and 15,875 throughout the IOTTP. Around 70% of the recoveries were from the purse seine fleets operating from the Seychelles, and around 29% by the pole-and-line vessels mainly operating from the Maldives.

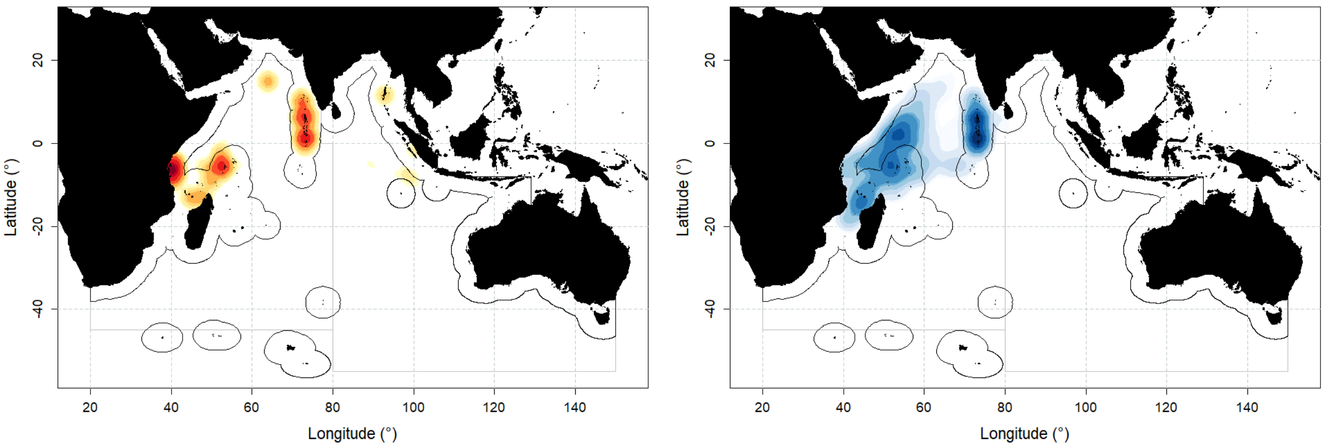


Fig. 18. Density distribution of (left panel) releases and (right panel) recoveries of skipjack tuna tagged during the during the Maldivian and Indian Ocean Tuna Tagging programmes

YFT - yellowfin tuna (*Thunnus albacares*)

Fisheries and main catch trends (2015-2019)

Main fishing gears

In recent years catches have been evenly split between industrial and artisanal fisheries, with a mean annual catch of about 210,000 MT for each component during 2015-2019. Purse seiners (free and associated schools) and longline fisheries still account for around 40% of total catches, while catches from artisanal gears – namely handline, gillnet, and pole-and-line – have steadily increased since the '80s (**Table 5**; **Fig. 20**).

Contrary to other oceans, the artisanal fishery component of yellowfin catches in the Indian Ocean is substantial, accounting for catches of around 200,000 MT per annum since 2012. Moreover, the percentage of yellowfin catches from artisanal fisheries has increased from around 30% in 2000 to nearly 50% of the total catch of yellowfin in the same period.

Main fleets (and primary gear associated with catches)

<u>Percentage of total catches (2015–19):</u> the five main fleets catching yellowfin tuna, described by similar catch levels for the three first ones, are I.R. Iran (gillnet): 12%; Maldives (handline, pole-and-line): 12%; EU-Spain (purse seine): 12%; Seychelles (purse seine): 8%; Sri Lanka (gillnet, coastal longliners): 8% (**Fig. 21**).

Main fishing areas

- **Primary**: Western Indian Ocean, around Seychelles and waters off Somalia, and Mozambique;
- **Secondary**: Maldives and along the coasts of India and Sri-Lanka.

Retained catch trends

Catches of yellowfin tuna remained stable between the mid '50s and the early '80s, ranging from between 30,000 MT and 70,000 MT, with longliners and gillnetters as the main fisheries. Catches increased rapidly in the early '80s with the arrival of the purse seiners and increased activity of longliners and other fleets, reaching over 400,000 MT by 1993.

Exceptionally high catches were recorded between 2003 and 2006 – with the highest catches ever recorded in 2004 at over 525,000 MT – while catches of bigeye tuna which are generally associated with the same fishing grounds as yellowfin tuna remained at average levels.

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

Since 2012, catches have increased from 400,000 MT to around 420,000 MT in recent years, although the catches of 440,00 MT reported for 2018 might be under-estimated to some extent in relation to the change in data processing methodology by EU,Spain for its purse seine fleet for that year (see section on data quality issues).

- <u>Purse seine fishery</u>: although some Japanese purse seiners have fished in the Indian Ocean since 1977, the purse seine fishery developed rapidly with the arrival of European vessels between 1982 and 1984. Since then, there has been an increasing number of yellowfin tuna caught, with a larger proportion of the catches consisting of adult fish, as opposed to catches of bigeye tuna, which are mostly composed of juvenile fish.

  The purse seine fishery is characterized by the use of two different fishing modes: the fishery on floating objects (FADs) catches large numbers of small yellowfin tuna in association with skipjack tuna and juvenile bigeye tuna, compared to the fishery on free swimming schools, which catches larger yellowfin tuna on multi-specific or mono-specific sets.

  As for other tropical tuna species (bigeye in particular), industrial purse seine catches of yellowfin tuna on free-school have shown a steady decline in recent years, reaching an all-time low of around 18,000 MT in 2018 as opposed to an average of 45,000 MT recorded for the previous ten years. In 2019, the catches of large yellowfin tuna on free schools re-increased to almost 40,000 MT.

- <u>Longline fishery</u>: the longline fishery started in the early '50s and expanded rapidly throughout the Indian Ocean. The longline fishery targets several tuna species in different parts of the Indian Ocean, with yellowfin tuna and bigeye tuna being the main target species in tropical waters. The longline fishery can be subdivided into a deep-freezing longline component (i.e., large scale deep-freezing longliners operating on the high seas from Japan, Korea and Taiwan,China) and a fresh-tuna longline component (i.e., small to medium scale fresh tuna longliners from Indonesia and Taiwan,China).

Discard levels

Discard levels are thought to be low, although estimates of discards are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–17.

Catch series

Some changes have occurred in the nominal catch series of yellowfin tuna since the WPTT meeting in 2019 although they have not modified the general pattern of the time series. The revised Pakistan gillnet catches from 1987 onwards (incorporated in the IOTC database in December 2019) introduced a total increase in yellowfin tuna catches of 209,441 MT (6,545 MT / year) in the years concerned (1987-2018) when compared to the data available at the WPTT21 (**Fig. 19**).

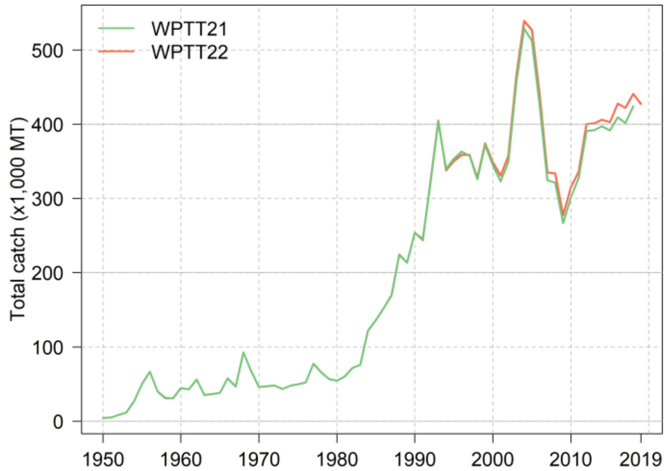


Fig. 19. Comparison of annual time series of total catches (MT) of Indian Ocean yellowfin tuna available at the 21st (WPTT21, 2019) and 22nd (WPTT22, 2020) sessions of the IOTC Working Party on Tropical Tunas

TABLE 5. Best scientific estimates of the annual nominal catches (MT) of yellowfin tuna by fishery for the period 1950–2019. Colour codes (yellow = lower, green = higher) describe the intensity of captures by gear group across decades (left) and years (right). Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Purse seine | FS	0	0	18	31,552	64,938	89,204	32,135	36,453	64,593	34,459	47,426	63,963	49,460	50,700	17,944	38,588
Purse seine | LS	0	0	17	17,597	56,278	61,890	73,383	76,659	66,166	101,898	86,417	78,395	99,268	94,479	121,699	94,111
Longline | Fresh	0	0	615	4,286	47,612	34,150	23,240	22,709	17,808	28,981	23,763	21,987	16,749	13,915	16,506	19,235
Longline | Deep-freezing	21,990	41,352	29,589	33,770	66,039	56,661	17,859	19,812	18,847	15,014	14,518	16,601	17,731	16,476	19,366	18,856
Line | Coastal longline	168	1,262	1,771	3,489	6,161	11,107	15,470	11,255	15,167	13,245	34,072	20,866	30,484	40,560	52,555	44,312
Line | Handline	621	641	2,948	7,861	19,803	34,368	33,397	58,071	78,568	70,018	71,490	73,907	86,025	65,557	72,959	89,656
Gillnet	1,575	4,118	7,928	12,034	39,199	58,819	64,529	58,074	72,912	65,326	80,484	82,650	82,967	94,515	92,437	80,268
Baitboat	2,111	2,318	5,810	8,295	12,803	16,072	14,105	14,009	15,512	24,055	20,542	17,642	12,391	18,370	20,030	18,551
Other	1,084	2,014	4,647	9,101	20,546	33,268	41,030	39,112	50,239	48,027	27,349	26,902	32,631	27,253	27,338	23,662
Total	27,549	51,705	53,343	127,985	333,379	395,539	315,148	336,154	399,812	401,023	406,061	402,913	427,706	421,825	440,834	427,239

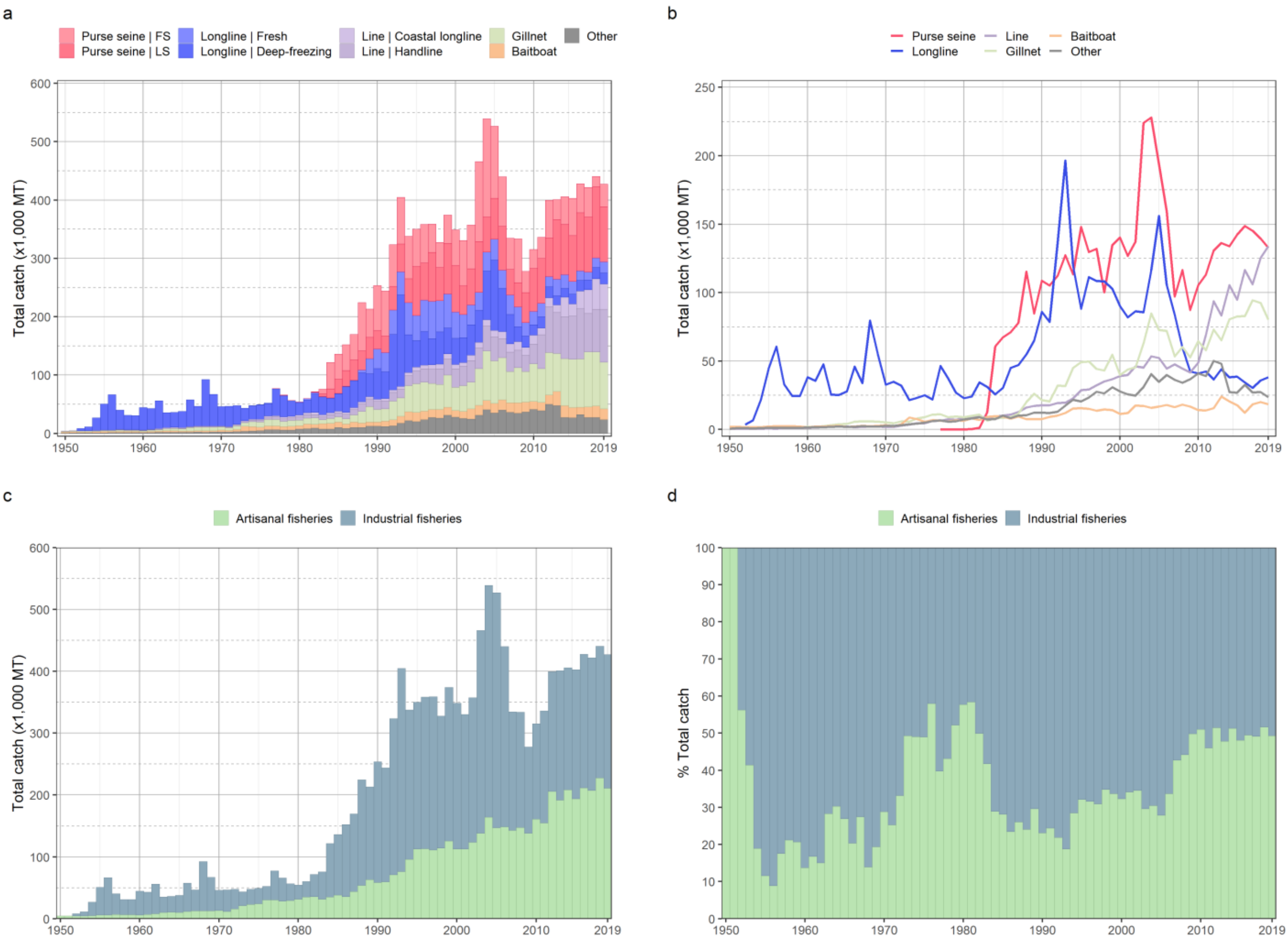


Fig. 20. Annual (1950–2019) time series of yellowfin tuna (a) cumulative nominal catches (MT) by gear; (b) individual nominal catches (MT) by gear group; (c) cumulative nominal catches (MT) by fishery type and (d) percentage share by fishery type. Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

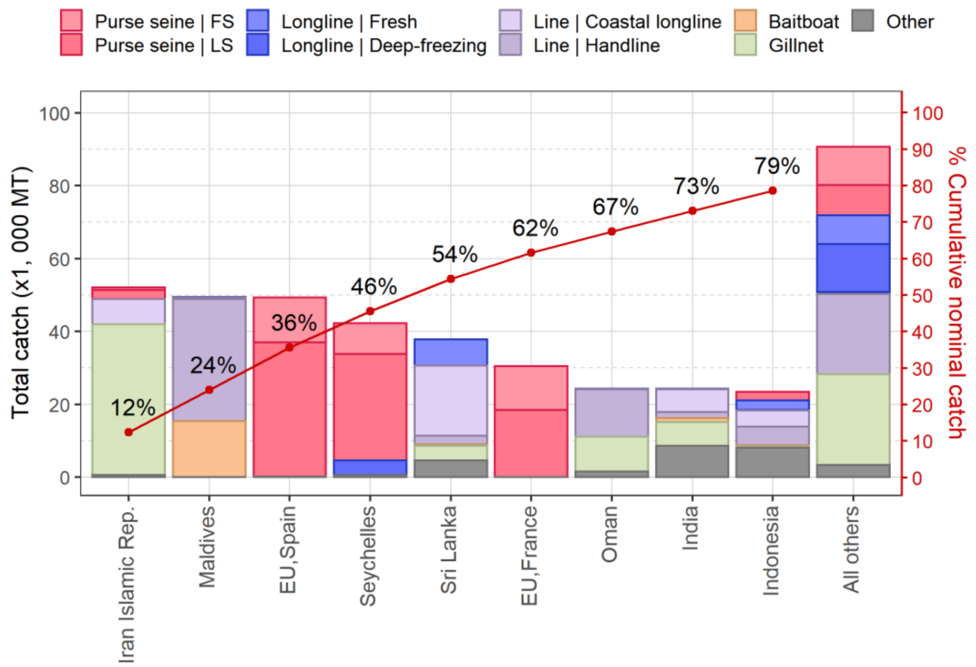


Fig. 21. Average nominal catches (MT) of yellowfin tuna over the period 2015–2019, by gear group and CPC ordered according to the importance of catches. The red solid line indicates the cumulative percentage of the total combined catches of the species for the CPCs concerned. Purse seine includes industrial purse seiners and 'Other' includes all remaining fishing gears. LS = drifting log or FAD-associated school and FS = free-swimming school

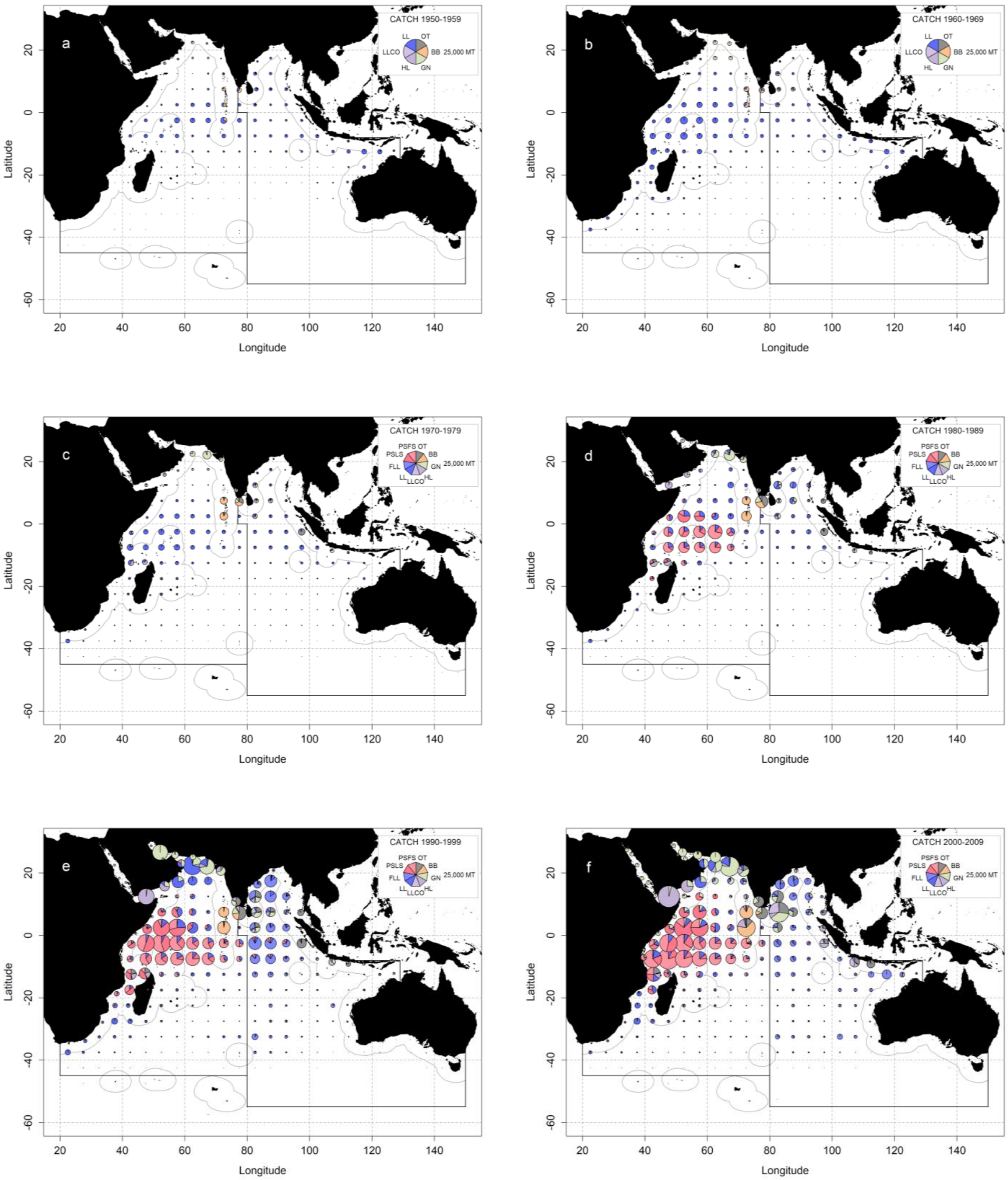


Fig. 22. Estimated average annual time-area catches (MT) of yellowfin tuna for the period **1950**–**2009** by decade and type of gear. Black solid lines represent the IOTC areas. **PSLS** = purse seine (log/FAD school); **PSFS** = purse seine (free school); **FLL** = longline (fresh); **LL** = longline (deep-freezing); **HL** = line (coastal longline, handline); **GN** = gillnet, **BB** = baitboat / pole-and-line; **OT** = all remaining gears

Note that the catches of fleets for which the flag countries do not record detailed time-area data to the IOTC are reported using the estimated areas from the CAS data set. This is particularly true for the driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and longline and coastal fisheries of Indonesia (OT)

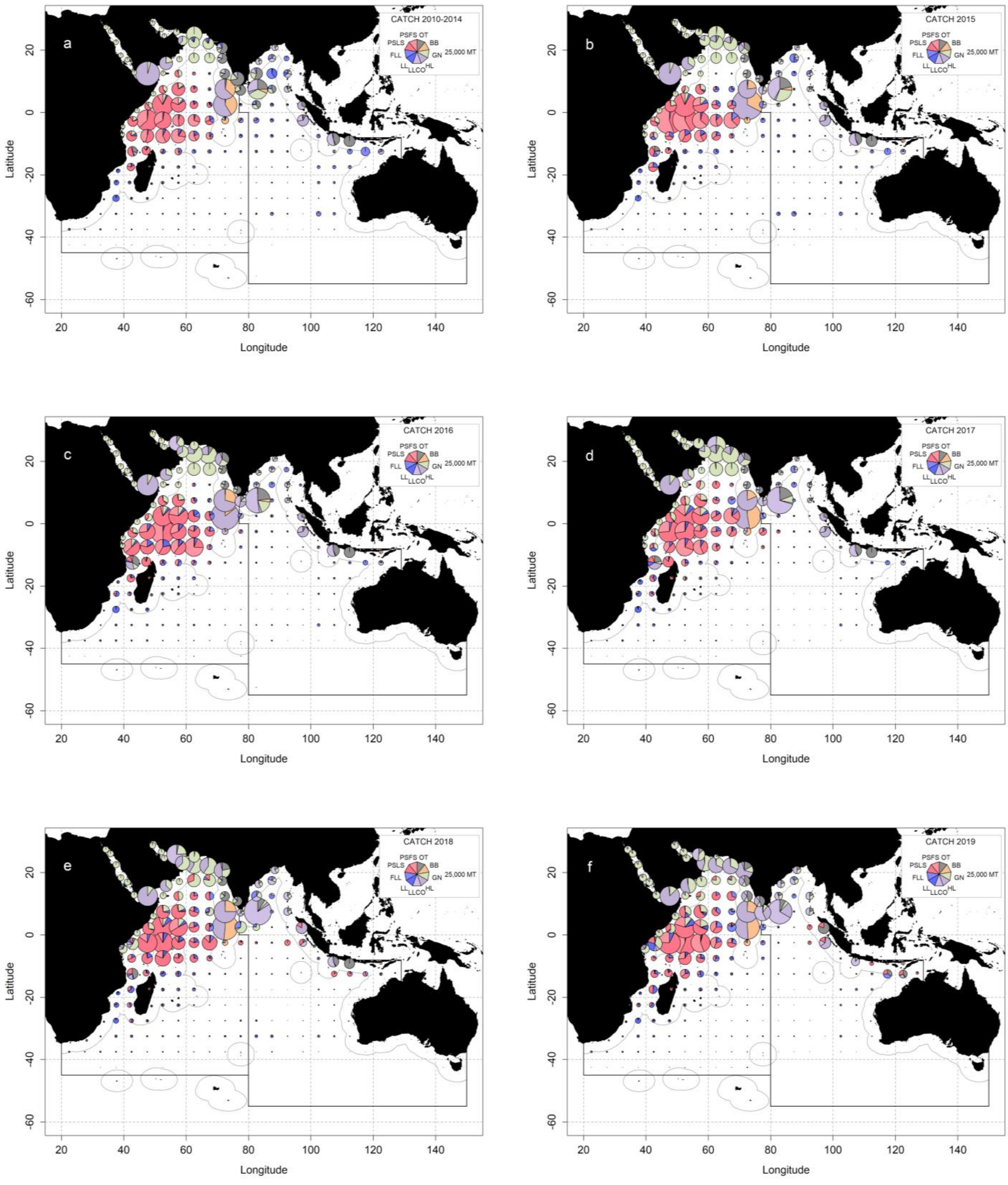


Fig. 23. Estimated average annual time-area catches (total combined in tonnes) of yellowfin tuna for the period **2010**–**2014** by type of gear and for **2015**–**19**, by year and type of gear. Black solid lines represent the IOTC areas. **PSLS** = purse seine (log/FAD school); **PSFS** = purse seine (free school); **FLL** = longline (fresh); **LL** = longline (deep-freezing); **HL** = line (coastal longline, handline); **GN** = gillnet; **BB** = baitboat / pole-and-line; **OT** = all remaining gears

Data availability and related data quality issues

Retained catches

- Data are considered to be generally well known for the major industrial fisheries, with a relatively low proportion of catches estimated, or adjusted, by the IOTC Secretariat (**Fig. 24a**).
  - The new methodology used by EU,Spain for the processing of purse seine fisheries data for 2018 resulted in a 17% reduction in the reported catch of yellowfin tuna between 2017 and 2018 when the catches of skipjack and bigeye tunas increased by 58% and 112%, respectively. The percentage of yellowfin tuna caught on associated schools reported by EU,Spain for that year was 21.8%, while it varied between 32% and 43% during 2012-2016 (i.e. prior to IOTC Resolution 16/01). Between 2018 and 2019, the percentage of bigeye tuna in the Spanish purse seine catch caught on associated schools decreased from 12.8% to 6.5% but the percentage of yellowfin tuna (23%) was still much lower than observed in the Seychelles (29.1%) and EU,France (33.5%) purse seine fisheries. Notwithstanding the request from the last WPTT, no information has yet been provided by EU,Spain on the rationale behind the exceptional species composition reported for 2018 and the methodology used for processing the data for both 2018 and 2019. Therefore, the original data set for 2018 is still within the IOTC database.
- Catches are less certain for the following fisheries/fleets:
  - many coastal fisheries, notably those from Indonesia, Sri Lanka, Yemen, and Madagascar;
  - gillnet fishery of Pakistan;
  - non-reporting industrial purse seiners and longliners (NEI), and longliners of India.

Catch-per-unit-effort (CPUE) trends

- <u>Availability</u>: Catch-and-effort series are available for the major industrial and artisanal fisheries (e.g., Japan longline, Taiwan,China) (**Fig. 24b**).

  However, for other important fisheries catch-and-effort are either not available, or are considered to be of poor quality for the following reasons:
  - data for the fresh-tuna longline fishery of Taiwan,China are only available since 2006 and partial data for the fresh-tuna longline fishery of Indonesia are available only for 2018;
  - insufficient data for the gillnet fisheries of I.R. Iran (before 2007) and Pakistan;
  - poor quality effort data for the significant gillnet-longline fishery of Sri Lanka (until 2014);
  - no data are available from important coastal fisheries using hand and/or troll lines, in particular Oman, Yemen, Madagascar, and Indonesia (until 2018).

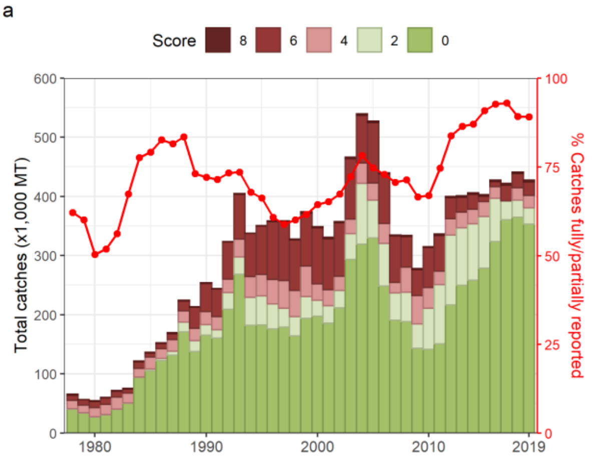
Fish size or age trends (e.g., by length, weight, sex and/or maturity)

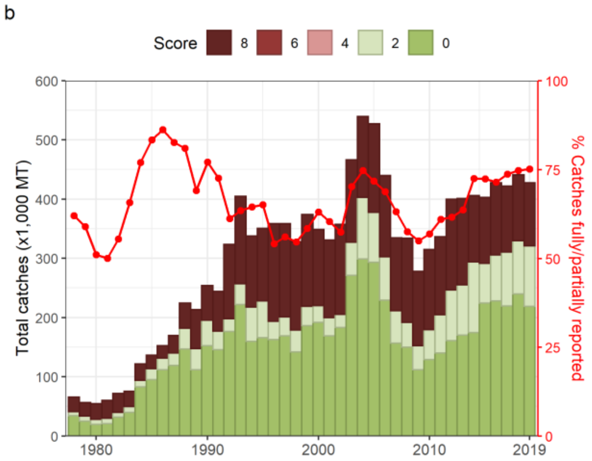
- <u>Average fish weight</u>: trends in average weight can be assessed for several industrial fisheries but they are very incomplete or of poor quality for some fisheries, namely hand lines (Yemen, Comoros, Madagascar), troll lines (Indonesia) and many gillnet fisheries (**Fig. 24c**).
  - Purse seine vessels typically take fish ranging from 40 to 140 cm fork length (FL), while smaller fish are more common in catches taken north of the equator (**Fig. A9**);
  - Longline gear mainly catches large fish, from 80 to 160 cm FL, although smaller fish in the size range 60 cm – 100 cm (FL) have been taken by longliners from Taiwan,China since 1989 in the Arabian Sea (**Fig. A10**).

- <u>Catch-at-Size (Age) table</u>: data are available, although the estimates are more uncertain in some years and fisheries due to:
  - size data not being available from important fisheries, notably Yemen, Pakistan, Sri Lanka and Indonesia (lines and gillnets) and Comoros and Madagascar (lines). Data from the artisanal fisheries of Oman (mainly handlines) is known to be available for some years (until 2016) but has not been officially submitted to the IOTC Secretariat;
  - the paucity of size data available from industrial longliners from the late ’60s up to the mid ’80s, and in recent years (Japan and Taiwan,China), with some inconsistencies between observer and crew-based samples as well as with average weights derived from logbooks when catches are reported in both numbers and weights;

- the paucity of catch by area data available for some industrial fleets (NEI fleets, I.R. Iran, India, Indonesia, Malaysia).

Data quality (by dataset)





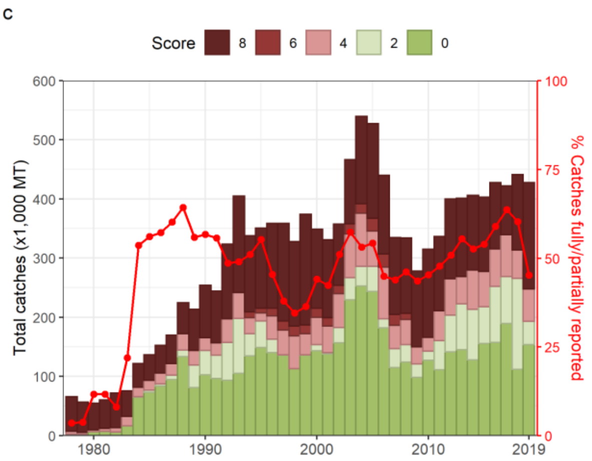


Fig. 24. Annual nominal catches (MT) of yellowfin tuna estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (red line with circles) for all fisheries (1978–2019) for (a) Nominal Catch; (b) Catch-Effort and (c) Size-Frequency data.

Each IOTC dataset is assessed against IOTC reporting standards, where:

- *Score 0 indicates the amount of nominal catch associated with each dataset that is fully reported according to IOTC standards;*
- *Scores 2–6 refers to the amount of nominal catch associated with each dataset that is partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document;*
- *Score 8 refers to the amount of nominal catch associated with catch-and-effort or size frequency data that is not available.*

Key to IOTC Scoring system

Nominal Catch	By species	By gear
Fully available	0	0
Partially available (part of the catch not reported by species/gear)*	2	2
Fully estimated (by the IOTC Secretariat)	4	4

*Catch assigned by species/gear by the IOTC Secretariat; or 15% or more of the catches remain under aggregates of species

Catch-and-Effort	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 30% of total catch covered through logbooks)	2	
Not available at all	8	

Size frequency data	Time-period	Area
Available according to standards	0	0
Not available according to standards	2	2
Low coverage (less than 1 fish measured by metric ton of catch)	2	
Not available at all	8	

Key to colour coding

	Total score is 0 (or average score is 0-1)
	Total score is 2 (or average score is 1-3)
	Total score is 4 (or average score is 3-5)
	Total score is 6 (or average score is 5-7)
	Total score is 8 (or average score is 7-8)

Tagging data

- A total of 66,428 yellowfin tuna (representing 30% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP) and tagging projects conducted in the Maldives in the '90s. Most of the specimens (82%) were tagged during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and released around Seychelles, in the Mozambique Channel, along the coast of Oman and off the coast of Tanzania, between May 2005 and September 2007 (**Fig. 25**). The remaining specimens were tagged during small-scale tagging projects, and by other institutions with the support of IOTC Secretariat, in Maldives, India, and in the southwest and the eastern Indian Ocean.
- To date, around 10,731 specimens (16.1% of releases for this species), have been recovered and reported to the IOTC Secretariat. More than 86% (n = 9,292) of these recoveries were made by the purse seine fleets operating in the Indian Ocean, while around 9% (n = 894) were made by pole-and-line and less than 1% (n = 98) by longline vessels.

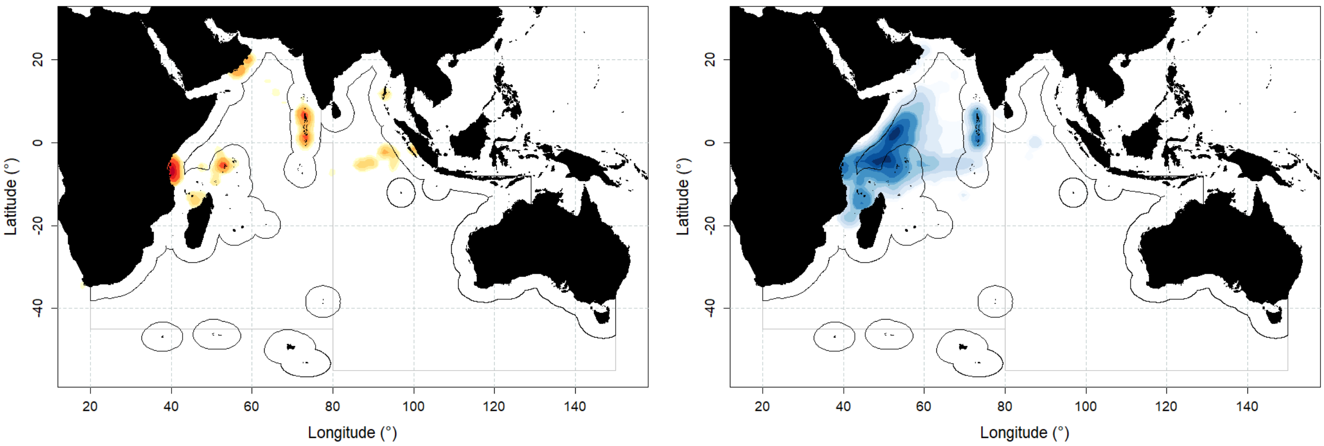


Fig. 25. Density distribution of (left panel) releases and (right panel) recoveries of yellowfin tuna tagged during the during the Maldivian and Indian Ocean Tuna Tagging programmes

Appendix I: IOTC standard length and weight equations for tropical tunas, average weights by species

Table A1. Current IOTC equations to convert from non-standard measurements into standard length (fork length), by species

Species: yellowfin tuna				***Standard length: Tip of snout to fork of tail***				
Measurement type	*Equation*	*Parameters*	*Samp. size*	*Size*	*Variance*	*Covariance ab*	*Mean residual*	*Gradient*
Weight gilled and gutted[A]	a*W^b	a= 44.28699 b= 0.3008591	2,361	Min:14 Max:71	a=0.00752476509 b=2.86244E-07	-4.626246E-05	4.095958	a=3.033852 b=495.6385
Length to the base of the 1st dorsal fin[B]	a*L^ b	a=2.0759 b=1.1513	7,036	Min: 29 Max: 164				
Species: Bigeye tuna				***Standard length: Tip of snout to fork of tail***				
Measurement type	*Equation*	*Parameters*	*Samp. size*	*Size*	*Variance*	*Covariance ab*	*Mean residual*	*Gradient*
Weight gilled and gutted[A]	a*W^ b	a= 42.2186 b= 0.3012349	316	Min:12 Max:107	a=0.0321755341 b=1.299934E-06	-0.0002034041	3.98137	a=3.03806 b=473.1455
Length to the base of the 1st dorsal fin[C]	$\frac{(L+a)^2}{(b)^2}$	a=21.45108 b=5.28756	2,858	Min:13 Max:48				

Sources:

A: Data from Penang Sampling Programme (1992-93)

B: Data from the Indian Ocean (Marsac, F. et al in IOTC-2006-WPTT-09)

C: Data from the Atlantic Ocean, Champagnat et Pianet (1974) (ibid. B)

Table A2. Current IOTC equations used to convert from standard length into round weight, per species

Species	*Gear type/s*	*From type measurement – To type measurement*	*Equation*	*Parameters*	*Samp. size*	*Length*
Yellowfin tuna	Purse seine Pole and Line Gillnet	Fork length – Round Weight(kg)[A]	RND=a*L^b	a=0.00002459 b= 2.96670	25,386	n/a
	Longline Line Other Gears	Fork length(cm) – Gilled and gutted weight(kg)[B] Gilled and gutted weight(kg) - Round Weight(kg)[C]	GGT=a*L^b RND=GGT*1.13	a= 0.0000094007 b= 3.126843987	15,133	Min:72 Max:177
Bigeye tuna	Purse seine Pole and Line Gillnet Trolling	Fork length(cm) – Round Weight(kg)[A]	RND=a*L^b	a=0.00002217 b= 3.01211	2,156	n/a
	Longline Line Other Gears	Fork length(cm) – Gilled and gutted weight(kg)[B] Gilled and gutted weight(kg) - Round Weight(kg)[C]	GGT=a*L^b RND=GGT*1.13	a= 0.0000159207 b= 3.0415414023	12,047	Min:70 Max:187
Skipjack tuna	All gears	Fork length(cm) – Round Weight(kg)[A]	RND=a*L^b	a=0.00000497 b= 3.39292	1,762	n/a

Sources:

A: Length-weight relationships for tropical tunas caught with purse seine in the Indian Ocean: Update and lessons learned (Chassot, E. et al in IOTC-2016-WPDSC12-INF05)

B: Multilateral catch monitoring Benoa (2002-04)

C: ICCAT Field Manual (Appendix 4: Population parameters for key ICCAT species. Product Conversion Factors)

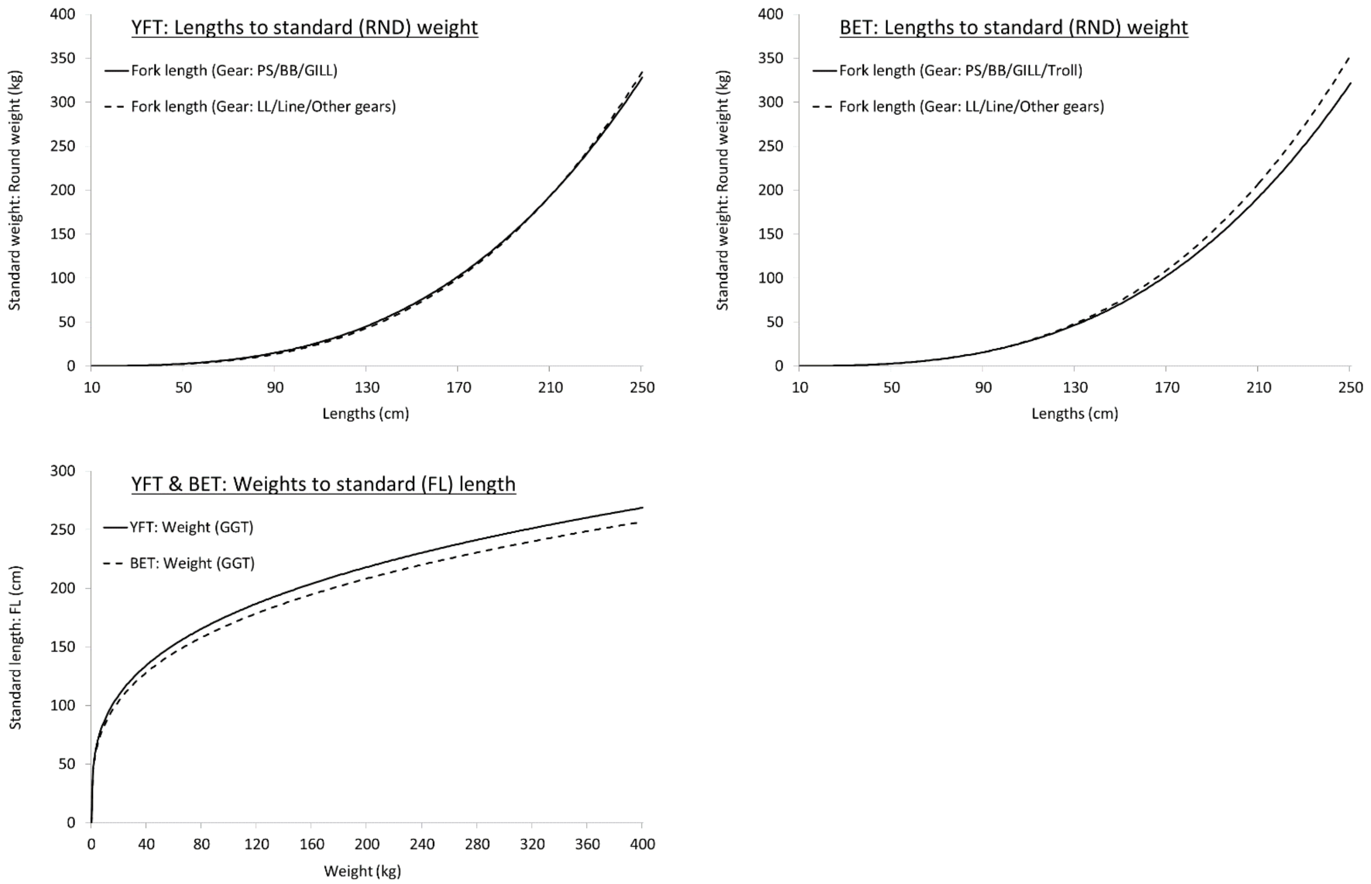


Fig. A1: Charts showing standard length and weight conversion equations for tropical tuna species

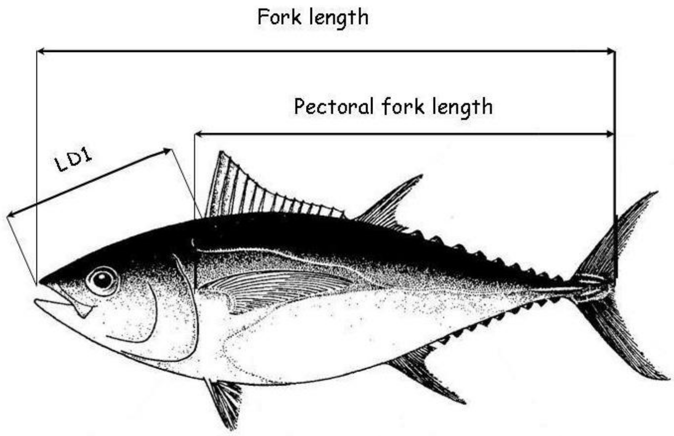


Fig A2. Types of measurements used for tuna

Average weights

BET - Bigeye tuna

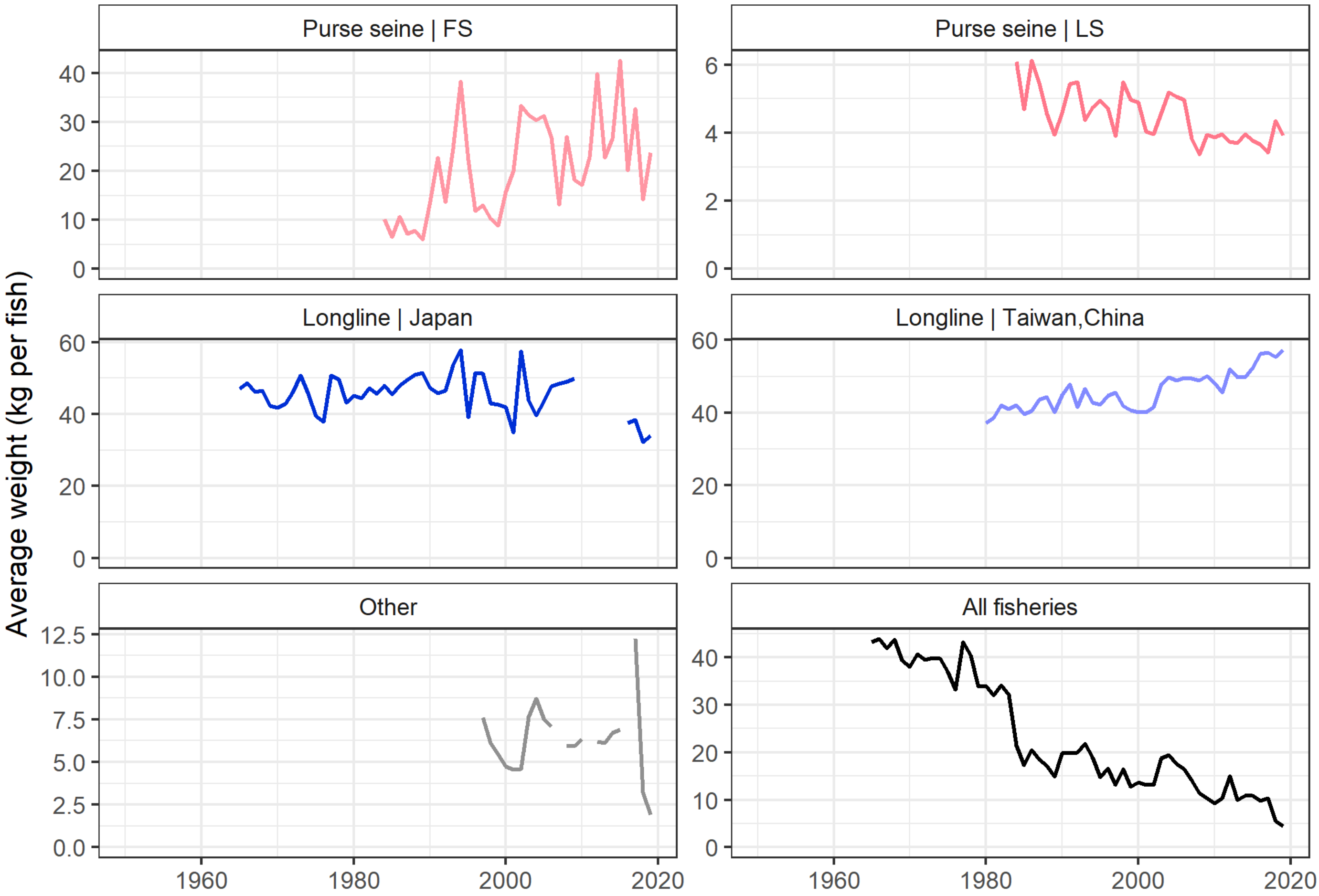


Fig A3. Annual time series of estimated average weight (kg) of bigeye tuna caught with (top left panel) purse seine on free schools (FS), (top right panel) log/FAD-associated schools (LS), (middle left panel) longline from Japan and assimilated[10], (middle right panel) longline from Taiwan,China and assimilated[11], (bottom left panel) gears from all remaining fisheries, (bottom right panel) all gears from Indian Ocean fisheries. Source: estimated raised catches in weight and number (1950-2019). Data are only shown for those years for which the original size samples cover strata with reported catches by year and fishery higher than 50 MT

[10] Japan, Rep. of Korea, and Thailand

[11] Taiwan,China and all other longline fleets not flagged by Japan, Rep. of Korea, and Thailand

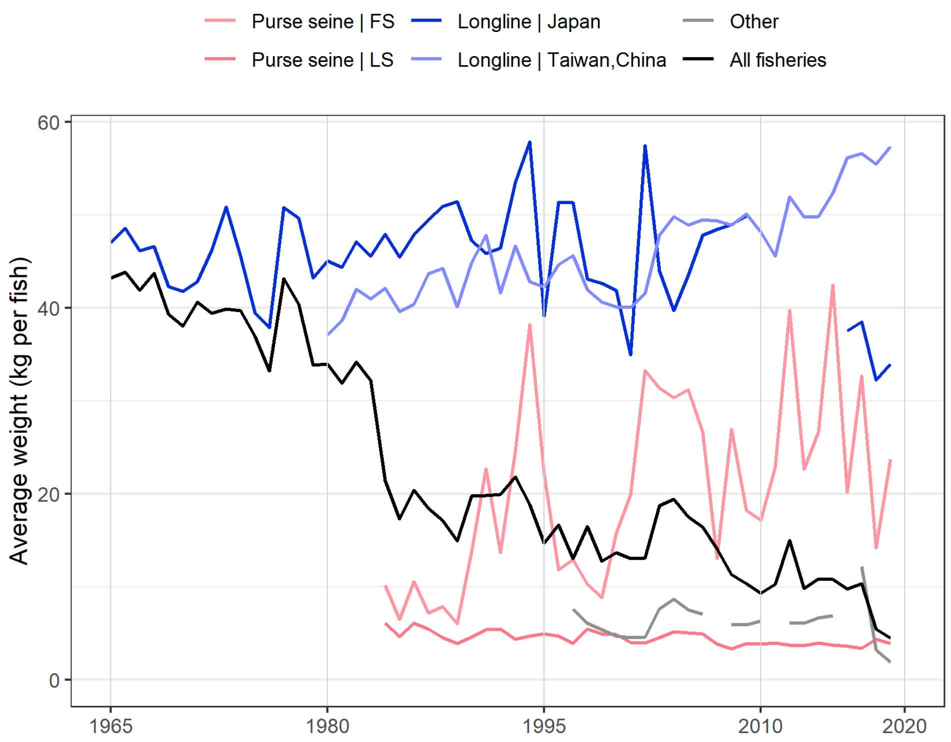


Fig A4. Comparison of annual time series of estimated average weight (kg) of bigeye tuna caught by the major fleets with different fishing gears and for all fisheries combined. Source: estimated raised catches in weight and number (1965-2019). Data are only shown for those years for which the original size samples cover strata with reported catches by year and fishery higher than 50 MT

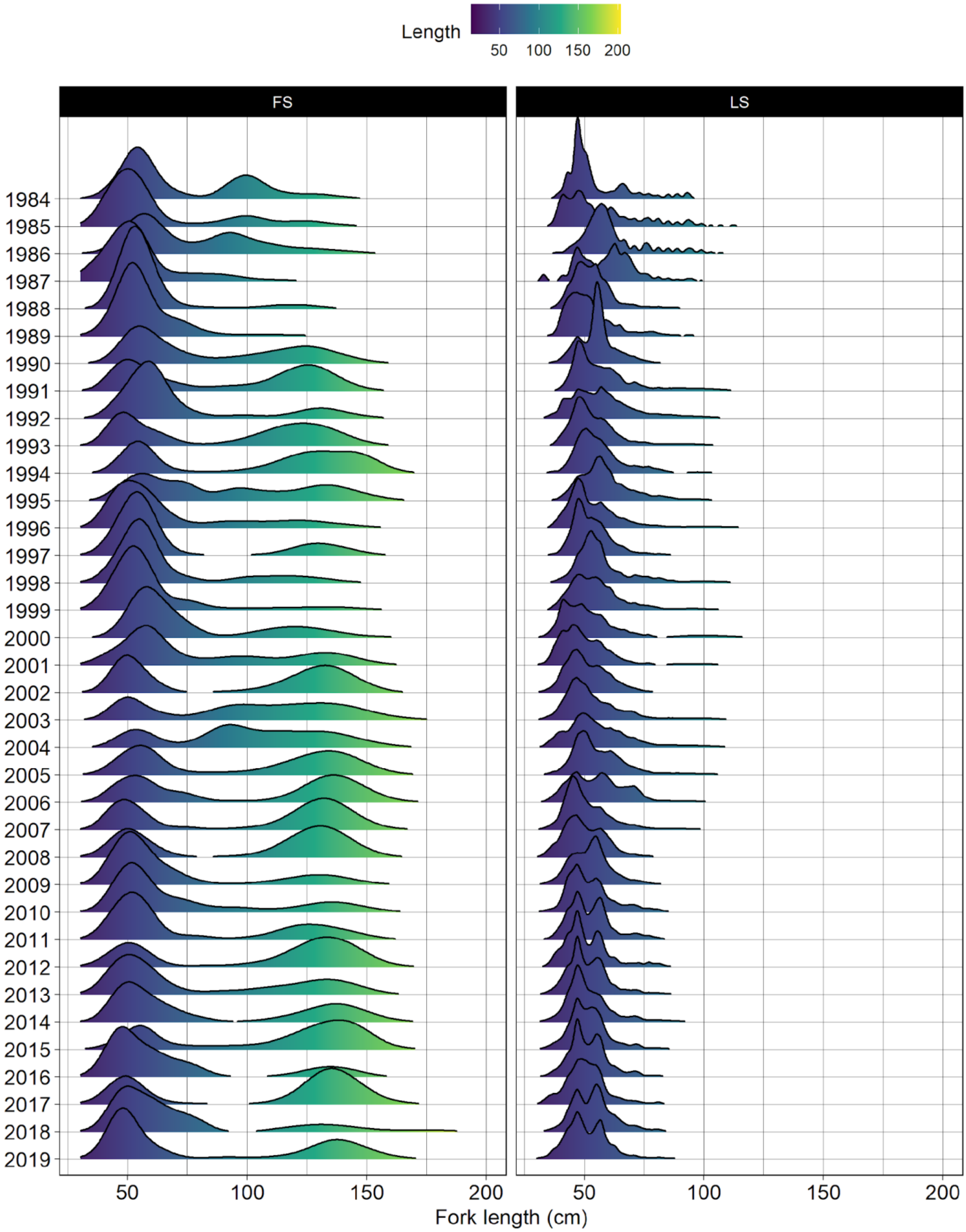


Fig. A5. Length frequency distributions (by 2 cm length class) of bigeye tuna caught with industrial purse seine on (left) free schools (FS) and (right) on log/FAD-associated schools (LS) during 1984-2019

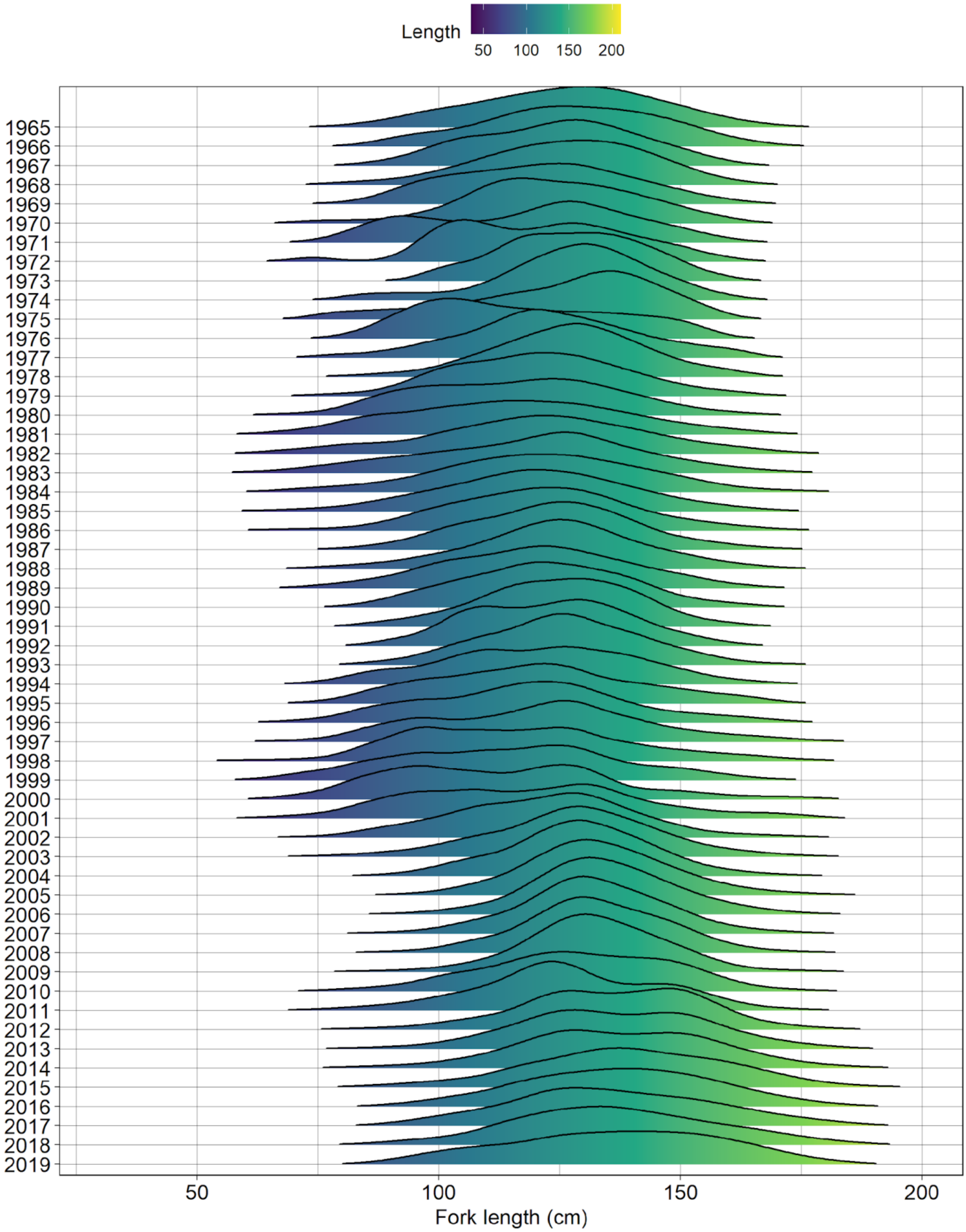


Fig. A6. Length frequency distributions (by 2 cm length class) of bigeye tuna caught with deep-freezing longline during 1965-2019

SKJ - Skipjack tuna

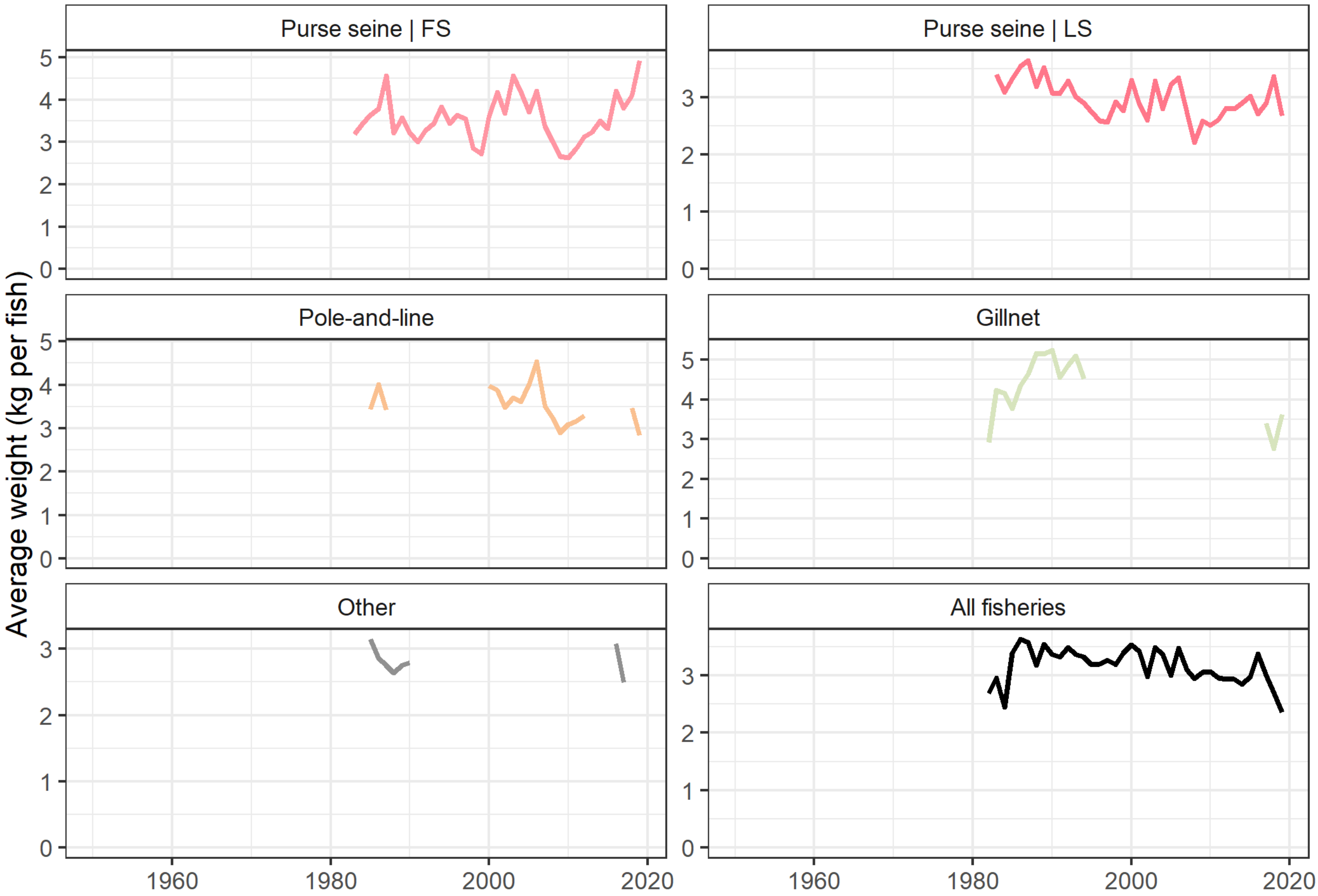


Fig. A7. Annual time series of estimated average weight (kg) of skipjack tuna caught with (top left panel) purse seine on free schools (FS), (top right panel) log/FAD-associated schools (LS), (middle left panel) pole-and-line from Maldives and India, (middle right panel)gillnet from Sri Lanka, (bottom left panel) gears from all remaining fisheries, (bottom right panel) all gears from Indian Ocean fisheries. Source: estimated raised catches in weight and number (1950-2019). Data are only shown for those years for which the original size samples cover strata with reported catches by year and fishery higher than 50 MT

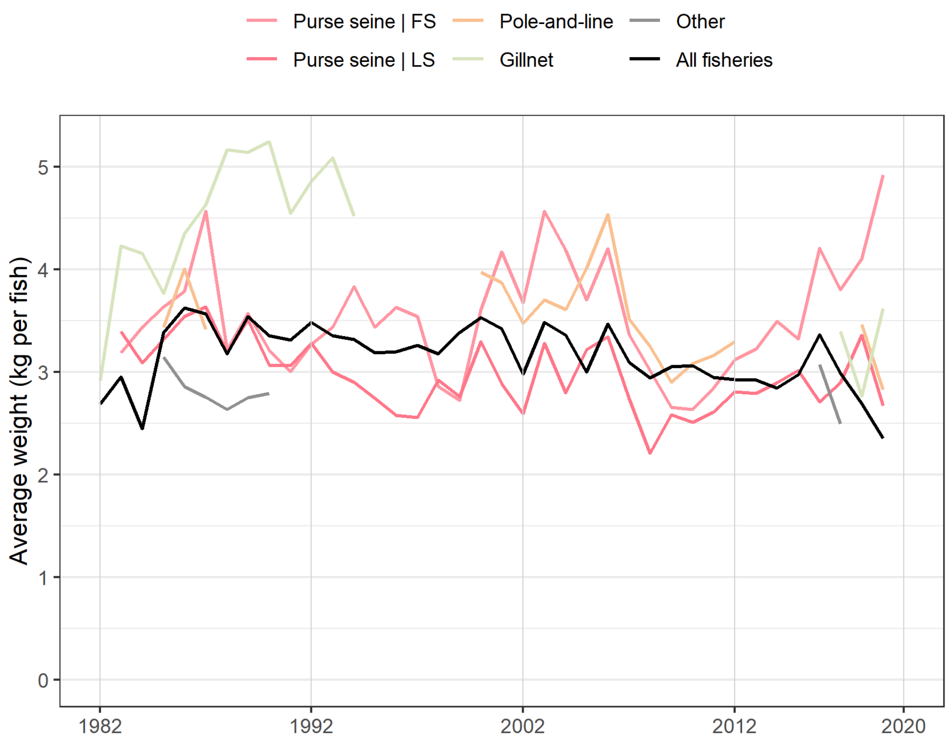


Fig. A8. Comparison of annual time series of estimated average weight (kg) of skipjack tuna caught by the major fleets with different fishing gears and for all fisheries combined. Source: estimated raised catches in weight and number (1965-2019). Data are only shown for those years for which the original size samples cover strata with reported catches by year and fishery higher than 50 MT

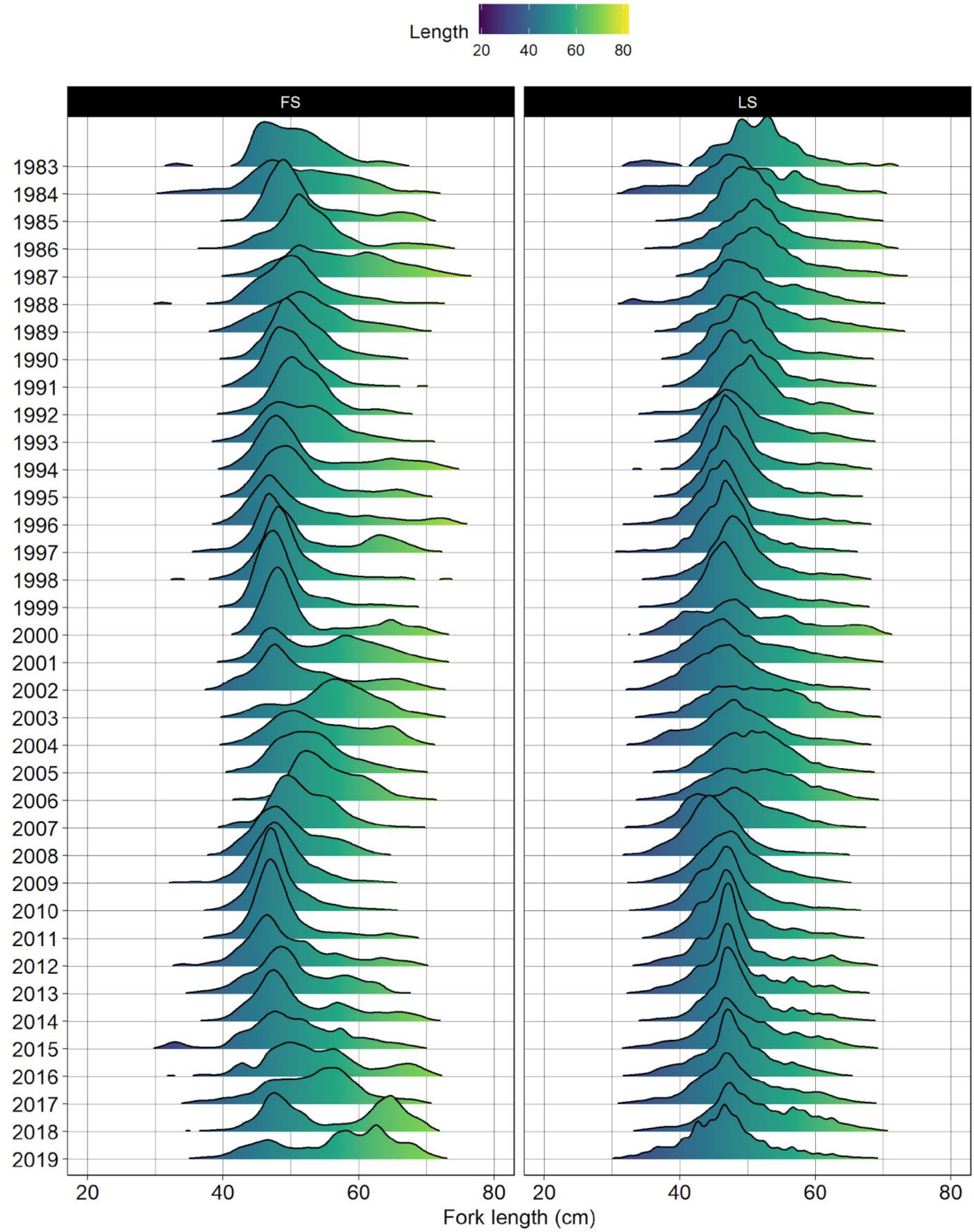


Fig. A9. Length frequency distributions (by 1 cm length class) of skipjack tuna caught with industrial purse seine on (left) free schools (FS) and (right) on log/FAD-associated schools (LS) during 1983-2019

YFT - Yellowfin tuna

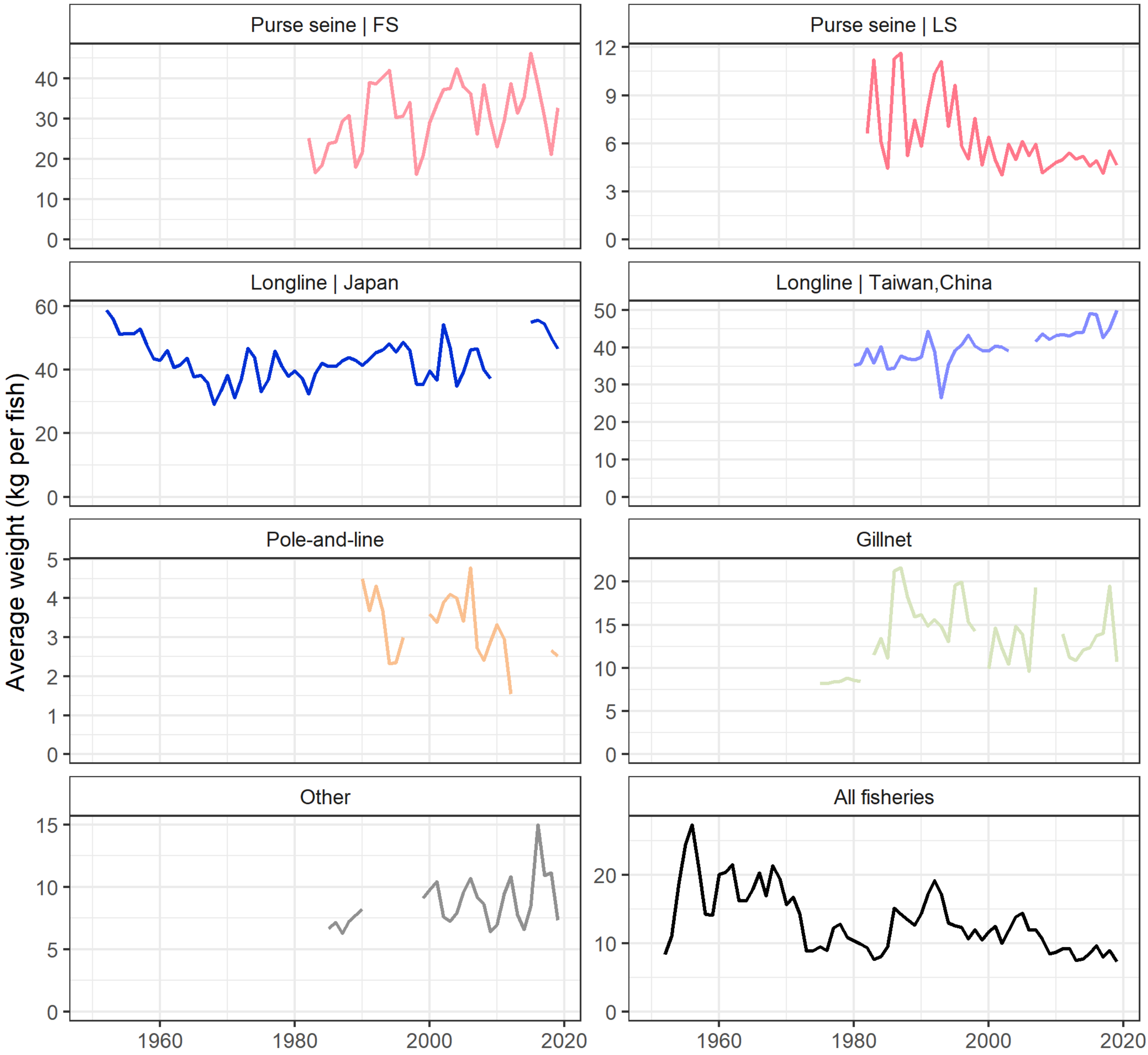


Fig. A10. Annual time series of estimated average weight (kg) of yellowfin tuna caught with (top left panel) purse seine on free schools (FS), (top right panel) log/FAD-associated schools (LS), (upper middle left panel) longline from Japan and assimilated[12], (upper middle right panel) longline from Taiwan,China and assimilated[13], (lower middle left panel) pole-and-line from Maldives and India, (lower middle right panel) gillnet from Sri Lanka, I.R. Iran, and other countries, (bottom left panel) gears from all remaining fisheries, (bottom right panel) all gears from Indian Ocean fisheries. Source: estimated raised catches in weight and number (1950-2019). Data are only shown for those years for which the original size samples cover strata with reported catches by year and fishery higher than 50 MT

[12] Japan, Rep. of Korea, and Thailand

[13] Taiwan,China and all other longline fleets not flagged by Japan, Rep. of Korea, and Thailand

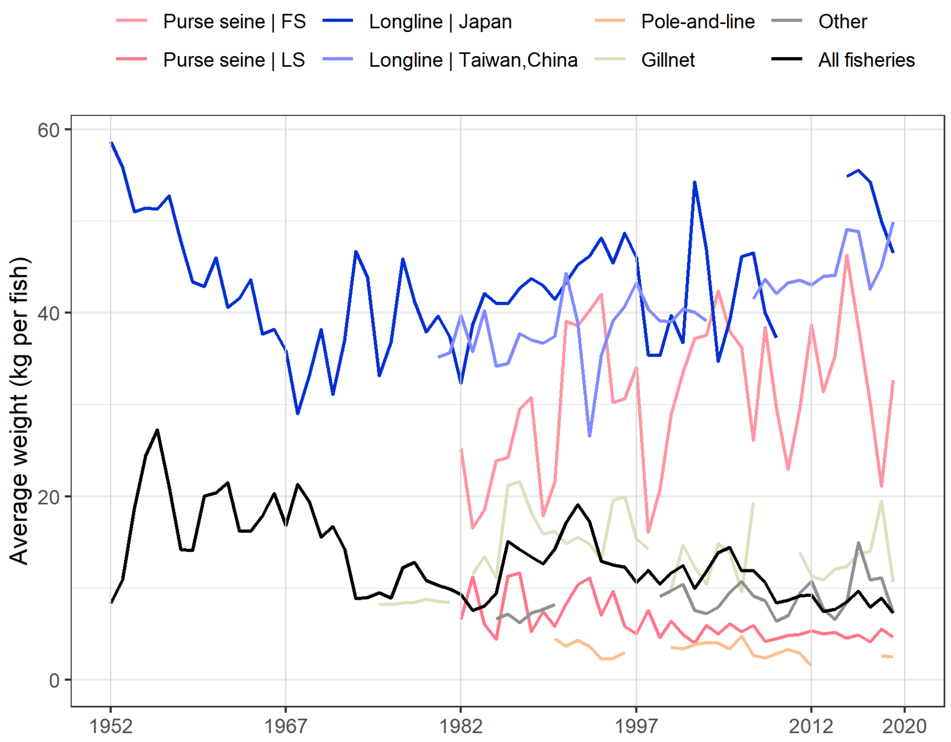


Fig. A11. Comparison of annual time series of estimated average weight (kg) of yellowfin tuna caught by the major fleets with different fishing gears and for all fisheries combined. Source: estimated raised catches in weight and number (1965-2019). Data are only shown for those years for which the original size samples cover strata with reported catches by year and fishery higher than 50 MT

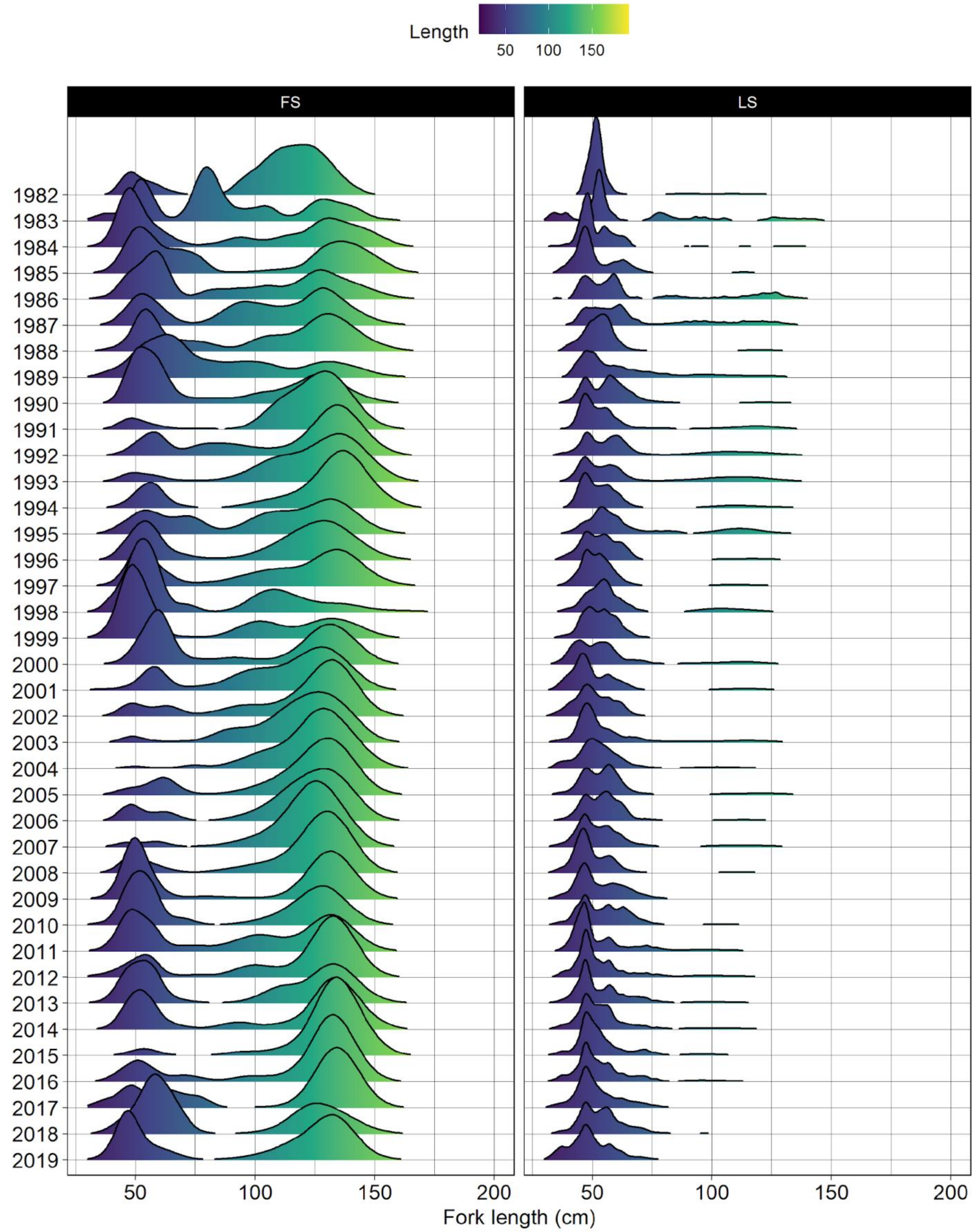


Fig. A12. Length frequency distributions (by 2 cm length class) of yellowfin tuna caught with industrial purse seine on free schools (FS) and (right) on log/FAD-associated school (LS) during 1982-2019

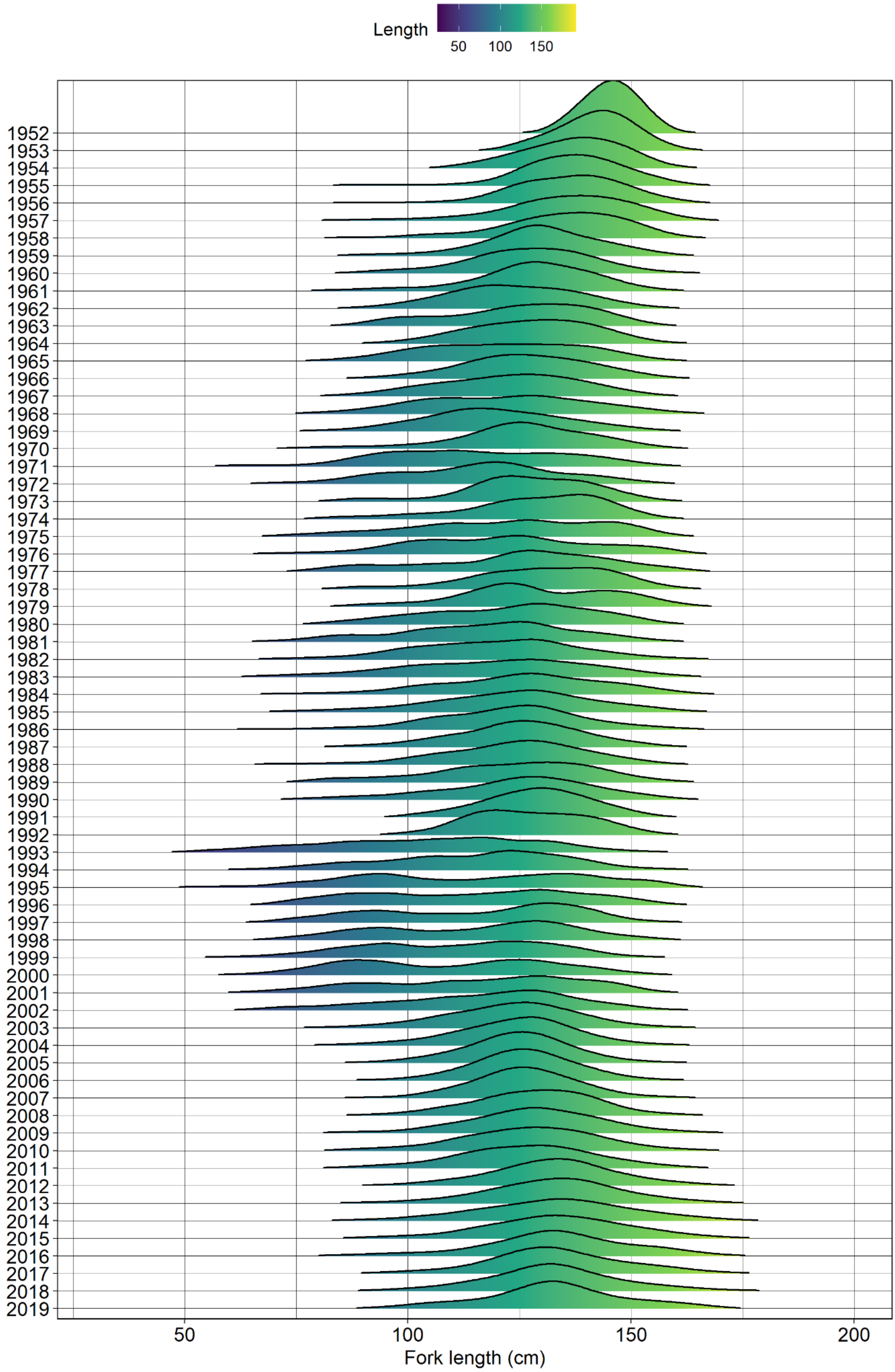


Fig. A13. Length frequency distributions (by 2 cm length class) of yellowfin tuna caught with deep-freezing longline during 1952-2019

Appendix II - effort trends for tropical tuna fisheries

Longline fisheries

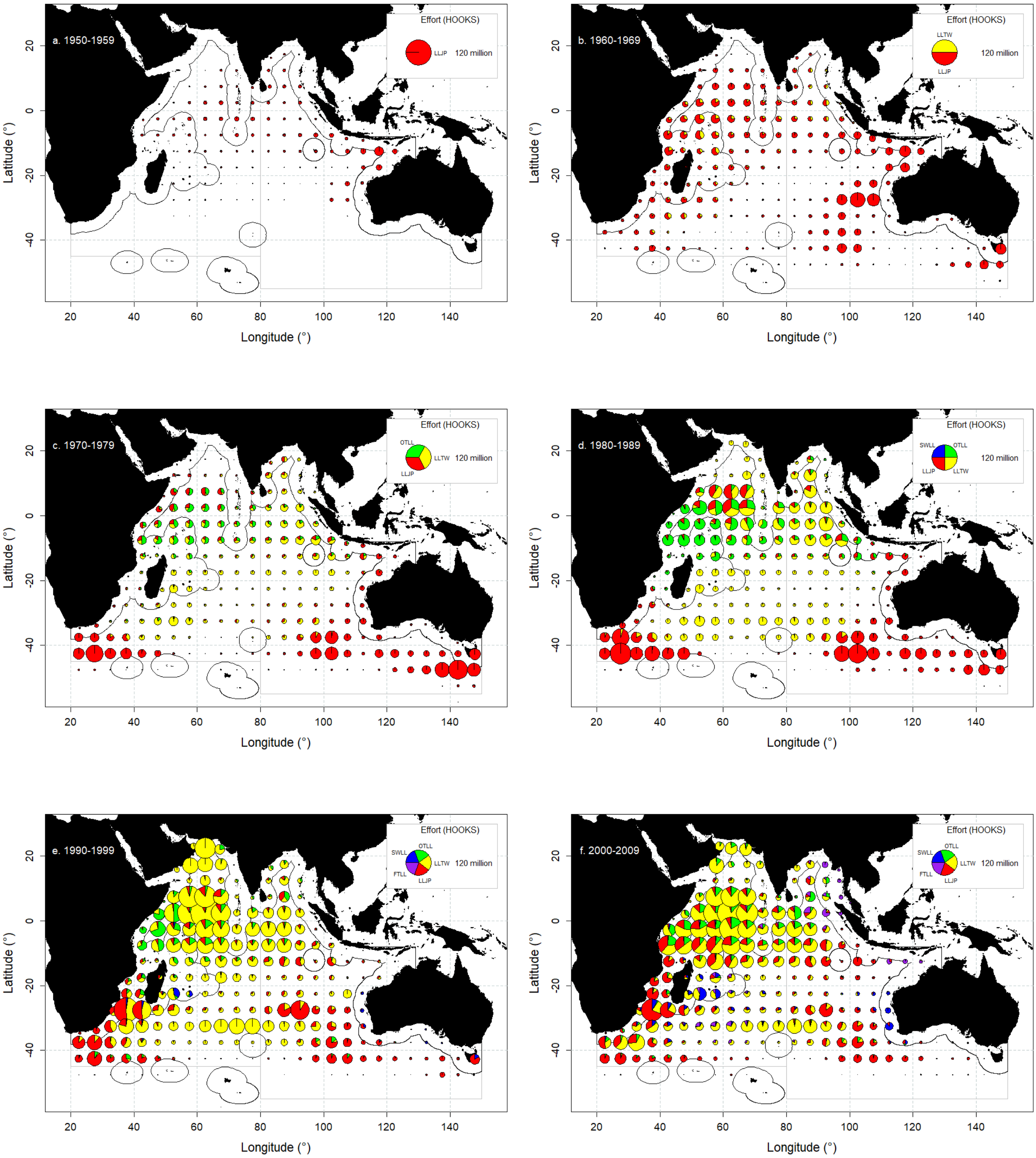


Fig. A14. Effort exerted by industrial longline fleets in the Indian Ocean, in millions (M) of hooks set, by decade (**1950-2009**) and main fleet: deep-freezing longliners from Japan (**LLJP**; red), deep-freezing longliners from Taiwan,China (**LLTW**; yellow), swordfish longliners from Australia, EU, Mauritius, Seychelles and other fleets (**SWLL**; blue), fresh-tuna longliners from China, Taiwan,China and other fleets (**FTLL**; purple), and longliners from other fleets includes Belize, China, Philippines, Seychelles, South Africa, South Korea and various other fleets (**OTLL**; green)

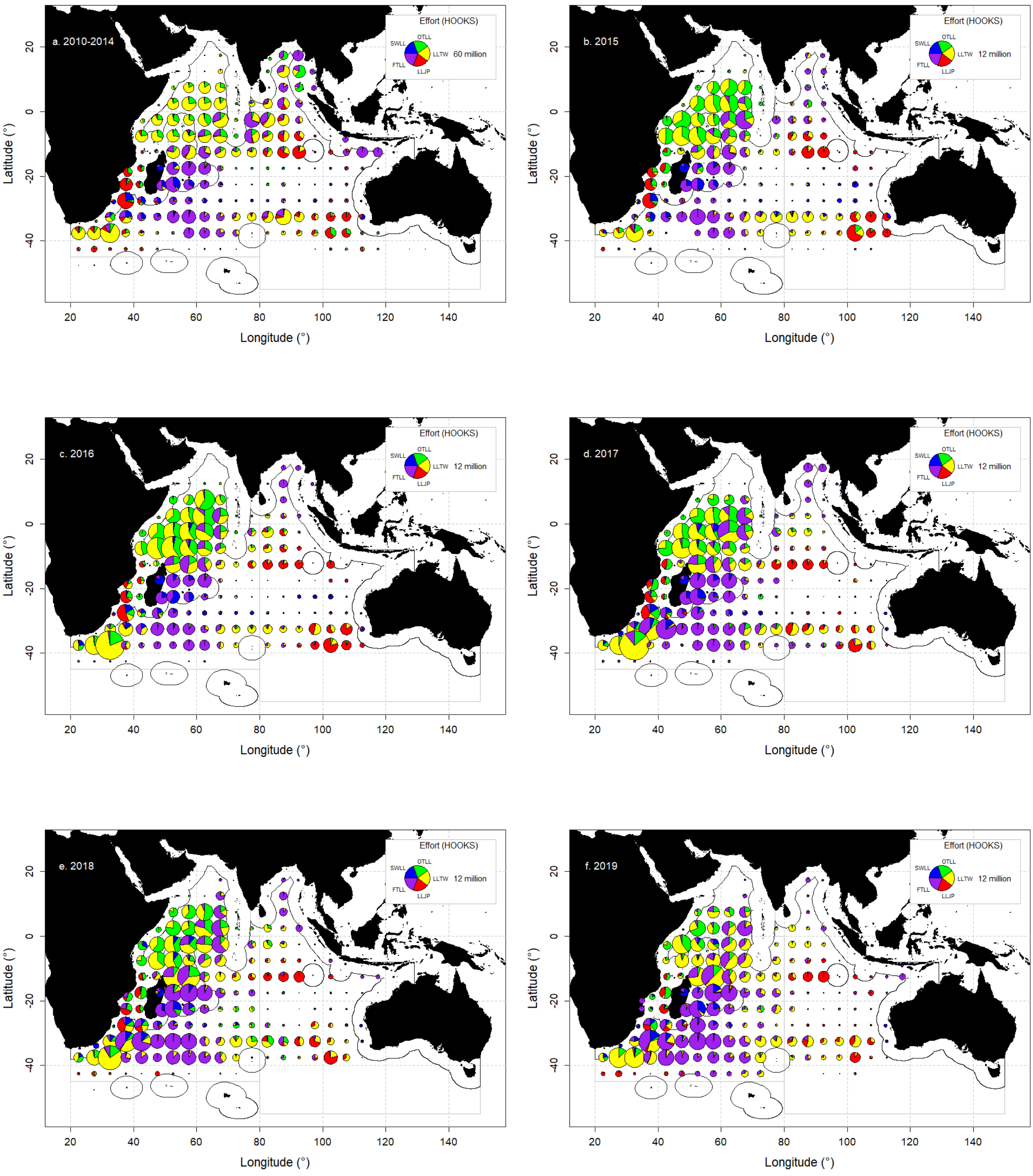


Fig. A15. Effort exerted by industrial longline fleets in the Indian Ocean, in millions (M) of hooks set, and main fleet for **2010-2014**, and **2015-2019**: deep-freezing longliners from Japan (**LLJP**; red), deep-freezing longliners from Taiwan,China (**LLTW**; yellow), swordfish longliners from Australia, EU, Mauritius, Seychelles and other fleets (**SWLL**; blue), fresh-tuna longliners from China, Taiwan,China and other fleets (**FTLL**; purple), and longliners from other fleets includes Belize, China, Philippines, Seychelles, South Africa, South Korea and various other fleets (**OTLL**; green)

Purse seine fisheries

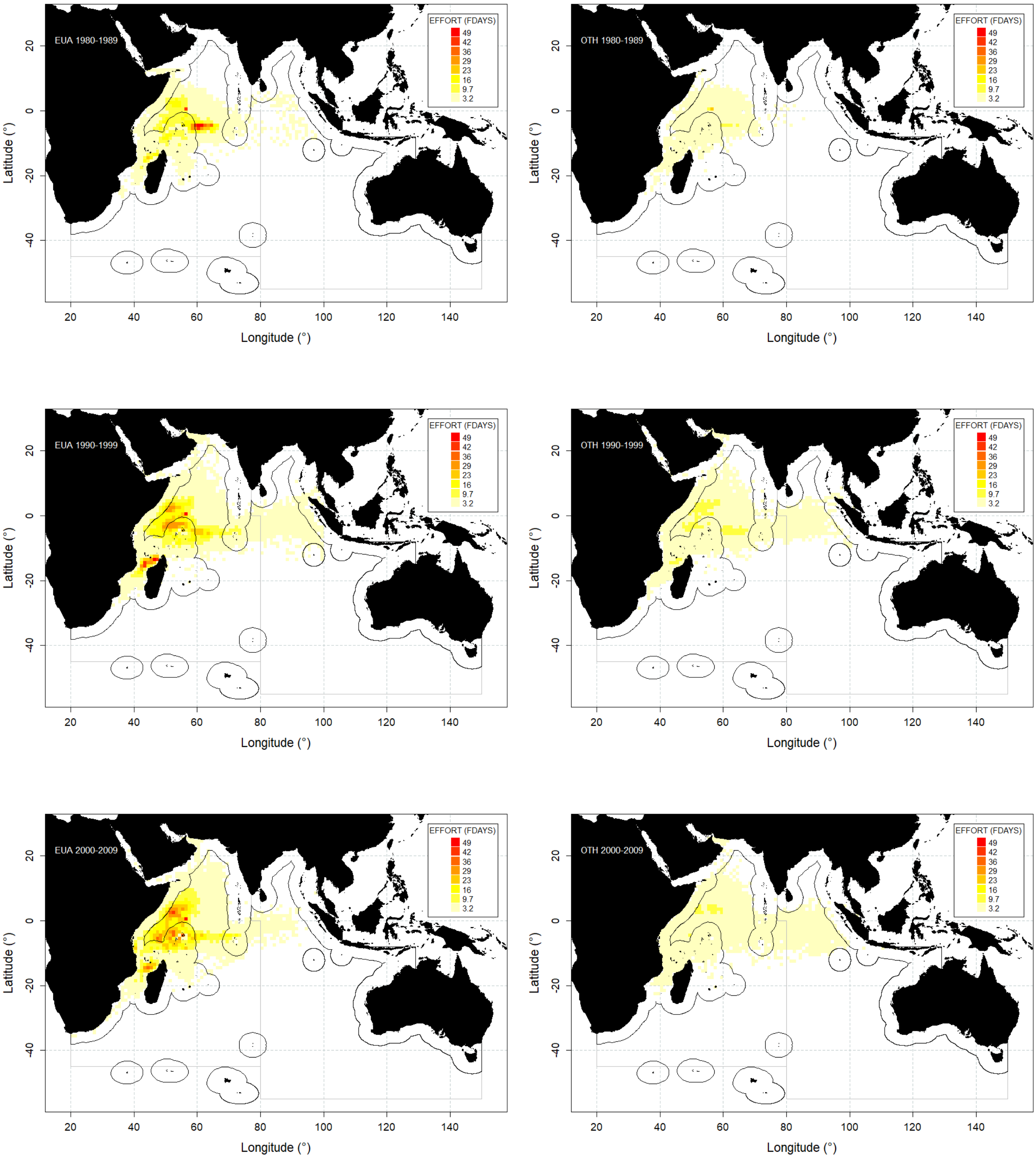


Fig. A16. Mean annual effort (fishing days; FDAYS) exerted by industrial purse seine fleets in the Indian Ocean by decade (1980-2009) and main fleet: (left panels; EUA) industrial purse seiners monitored by the EU and Seychelles and operating under flags of EU countries, Seychelles and other flags and (right panels; OTH) industrial purse seiners from other fleets, including Japan, Mauritius and purse seiners of Soviet origin and excluding effort data for purse seiners of I.R. Iran and Thailand, and days-at-sea recorded for Australia

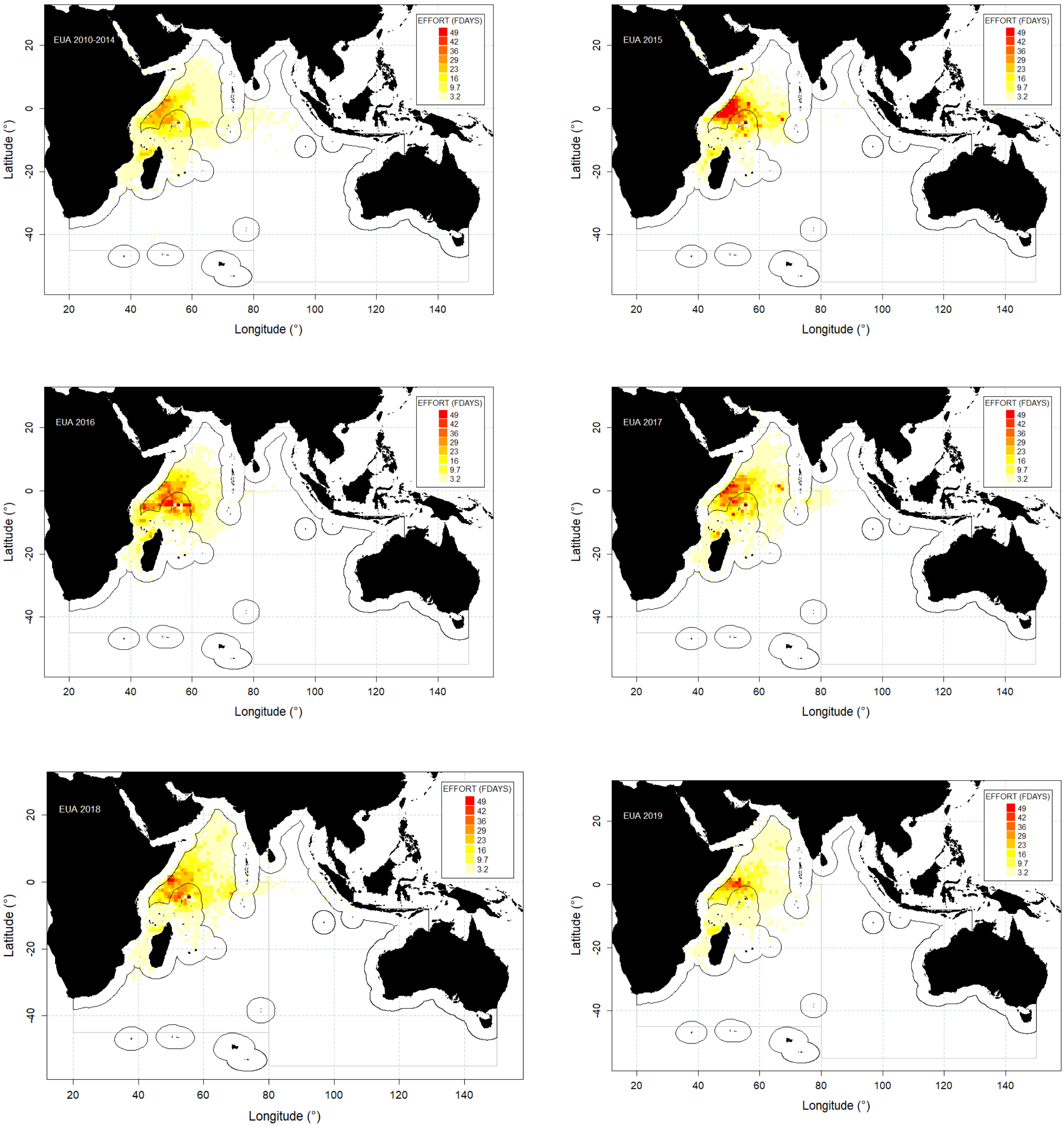


Fig. A17. Mean annual effort (fishing days; FDAYS) exerted by industrial purse seiners monitored by the EU and Seychelles and operating under flags of EU countries, Seychelles and other flags (EUA) in the Indian Ocean during 2010-14 and 2015-19