OVERVIEW OF INDIAN OCEAN ALBACORE FISHERIES, 1950-2023

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Highlights

- The Indian Ocean (IO) represents ~15% of the global catch of albacore (*Tunnus alalunga*)
- Annual catches of IO albacore have steadily increased since the 1950s to reach ~40,000 t in recent years
- Industrial longline fisheries contribute to the bulk of albacore catch in the IO
- Longline fisheries are dominated by Taiwan,China, followed by China, Japan, Malaysia, and Seychelles
- Longline catches are distributed all over the IO with high concentrations in the southwest in recent years
- Catches from artisanal fisheries have increased over time, reaching about 20% of all albacore catch in 2023
- Overall levels of albacore discards are considered to be small or negligible in most fisheries
- Information available on fishing grounds and size composition is considered to be of good quality
- Size data show that smaller fish are found at high latitudes while larger individuals occur in tropical areas
- Albacore average weight in the catch has decreased from >20 kg in the 1950s to ~15 kg in the late 1990s

Keywords: albacore, canning, Indian Ocean, longline fisheries

Introduction

The overarching objective of this paper is to provide participants at the Data Preparatory meeting of the 9th Session of the IOTC Working Party on Temperate Tunas (WPTmT09(DP)) with a summary of the main information available for albacore at the IOTC Secretariat that covers the period 1950-2023.

Materials

The analysis in the paper relies on data submitted annually to the IOTC Secretariat by Contracting Parties and Cooperating Non-Contracting Parties (CPCs) in accordance with IOTC Conservation and Management Measures (CMMs). These datasets undergo revisions throughout the year, reflecting ongoing improvements in reporting accuracy and completeness. To enhance transparency and compliance with reporting standards, the IOTC Secretariat has increased the visibility of IOTC Reporting guidelines and IOTC forms on the IOTC website. While adherence to the IOTC Reporting Guidelines is not mandatory, the use of IOTC forms is strongly recommended for submitting data to the Secretariat. These guidelines and forms facilitate effective data curation and management, ensuring that the information used for analysis is robust and reliable for assessing the status and trends of Indian Ocean albacore fisheries.

Retained Catch Data

The reporting of retained catches of species in the Indian Ocean, as mandated by IOTC Res. 15/02, requires that these catches be expressed in live weight equivalent and reported annually. This reporting encompasses several key aspects: the major fishing area within the Indian Ocean, the specific fleet involved, and the type of gear used. The preferred method for submission using IOTC Form 1RC.

Changes in retained catches can occur due to several reasons:

1. **Updates**: Preliminary data for longline fisheries are initially submitted by June 30th each year, with updates received by December 30th of the same year.

2. **Revisions by CPCs**: Contracting Parties and Cooperating Non-Contracting Parties may revise historical data due to corrections of errors, inclusion of missing data, changes in data processing methodologies, etc.

3. **Estimation Process Changes**: The Secretariat may adjust catch estimations based on improved methods or assumptions, such as the selection of proxy fleets or updated morphometric relationships. These adjustments require endorsement by the IOTC Scientific Committee.

These measures ensure that the reported data on retained catches are accurate, comprehensive, and reflective of the ongoing efforts to manage and conserve Indian Ocean fisheries resources effectively.

Discard Data

The IOTC adheres to the FAO's definition of discards, as detailed in previous reports (Alverson et al. 1994; Kelleher 2005). This definition encompasses all non-retained catch, whether individuals are released alive or discarded dead. According to IOTC Resolution 15/02, estimates of total annual discard levels in terms of live weight or number must be reported to the Secretariat. These reports should specify the Indian Ocean major area, species, and type of fishery involved.

To facilitate this reporting, the IOTC has developed IOTC Form 1DI specifically for reporting discards. The data submitted via Form 1DI should be extrapolated at the source to provide comprehensive estimates of total discard levels for the year. This extrapolation should encompass details such as the type of gear used, the fleet involved,

the specific Indian Ocean major area, and the species discarded. Notably, these reports should also include data on discards of non-fish species like turtles, cetaceans, and seabirds, ensuring a comprehensive overview of the impacts of fishing activities on marine biodiversity within the Indian Ocean region.

Discard data reported to the IOTC Secretariat via IOTC Form 1DI are often insufficient, not comprehensive, and do not consistently meet essential reporting standards. As a result, the most reliable and detailed information regarding discards typically originates from the IOTC Regional Observer Scheme (ROS; IOTC Res. 22/04). This scheme focuses on collecting precise details, including the specific spatial and temporal locations of fishing activities and interactions, as well as the fate of observed individuals, encompassing both target and bycatch species in industrial fisheries.

In addition to gaps in reporting, studies in the literature suggest that advancements in gear technology have played a significant role in reducing incidental catch and discards in tuna fishing operations (Taiwo 2013). These technological improvements aim to minimize the unintended capture of non-target species, thereby potentially decreasing overall discard rates observed in fisheries managed by the IOTC.

Geo-Referenced Catch and Effort Data

Catch and effort data within the IOTC framework are detailed and stratified across various parameters, as specified by IOTC Res. 15/02. Typically sourced from logbooks, these data are aggregated and reported annually, delineated by year, month, grid area, fleet, gear type, school type, and species targeted.

Geo-referenced catch information is particularly emphasized, either in live-weight equivalent or fish numbers, and is reported to the IOTC Secretariat. To streamline this reporting process, the recommended IOTC Form 3CE has been designed. This form facilitates the submission of geo-referenced catch and effort data, capturing details such as the activities of support vessels that assist large-scale purse seiners.

Furthermore, specific information related to the use of drifting floating objects and anchored fish aggregating devices is reported separately. This data is submitted using IOTC Forms 3DA and 3AA respectively. These forms ensure that comprehensive information on fishing activities, including associated vessels and gear technologies, is available for effective management and conservation efforts within the Indian Ocean region.

Geo-Referenced Size-Frequency Data

The size composition of catches is derived from datasets that include individual body lengths or weights collected both at sea and during the unloading of fishing vessels. To standardize reporting and ensure comprehensive data collection, the IOTC has developed the IOTC Form 4SF. This form includes all necessary fields for complete reporting of size-frequency data, stratified by fleet, year, gear type, school type, month, grid area, and species, as stipulated by IOTC Res. 15/02.

While most size data reported via Form 4SF pertain to retained catches, CPCs also have the option to use the same form to report size data for discarded individuals. This flexibility allows for a more thorough understanding of the size distribution across different species and fishing activities.

Additionally, onboard observer programs under the ROS play a crucial role in collecting supplementary size data, including measurements of individuals discarded at sea. This data is reported to the IOTC Secretariat, contributing to broader insights into fisheries dynamics and supporting management strategies aimed at sustainable resource utilization in the Indian Ocean.

Socio-Economic Data

The collection and reporting of socio-economic information from fisheries in the Indian Ocean under the IOTC framework face significant challenges and limitations. While the IOTC Form 7PR focuses on collecting price data

for all IOTC species, including albacore, reporting by CPCs is voluntary. This voluntary reporting has resulted in sparse data availability at the Secretariat, with notable exceptions such as time series of monthly prices reported by Oman since 2015 and Malaysia since 2018.

Since 2021, a collaboration has been developed between the Secretariat and the Fisheries Development Division of the Pacific Islands Forum Fisheries Agency (FFA) to provide data on crude oil prices and import prices for the principal market species (Ruaia et al. 2020) (Appendix III).

To address the current gaps in socio-economic data, the IOTC convened the first session of the Working Party on Socio-Economics (WPSE) in 2024, with the aim of defining clearer requirements for collecting and analysing socio-economic data related to tuna fisheries in the region (see IOTC-2024-WPSE01-R).

Regional Observer Scheme

Resolution 24/04 *"On a Regional Observer Scheme"* (ROS) makes provision for the development and implementation of national observer programmes among the IOTC CPCs starting from July 2010 with the overarching objective of collecting *"(…) verified catch data and other scientific data related to the fisheries for tuna and tuna-like species in the IOTC area of competence"*. As part of the ROS *"(…) each CPC shall ensure that all fishing vessels of 24 meters length overall and above and under 24 meters, if they operate outside the exclusive economic zone (EEZ) of the flag CPC and in the IOTC area of competence, comply with the minimum observer coverage of 5% as defined by the number of operations/sets"*. Observer data collected under the ROS encompass various aspects crucial for fisheries management:

1. **Fishing Activities and Positions**: Detailed information on fishing operations and vessel locations.
2. **Catch Estimates and Composition**: Identification of catch composition, monitoring of discards, bycatch species, and size-frequency distribution.
3. **Gear Information**: Specifications such as gear type, mesh size, and any attachments used by the vessel.
4. **Logbook Cross-checking**: Verification of logbook entries, including species composition, quantities, live and processed weights, and fishing locations.

Despite challenges such as variability in coverage and data completeness across different fisheries and time periods, the ROS has accumulated information from 1,764 commercial fishing trips (1013 from purse seine vessels and 751 from longline vessels of various types) between 2005 and 2022. This data primarily originates from fleets representing Japan, EU,France, and Sri Lanka for longline fisheries, and from fleets including EU,Spain, Japan, Korea, Mauritius, and Seychelles for purse seine fisheries. A comprehensive description of the status, coverage, and data collected as part of the ROS is provided in IOTC Secretariat (2022a). A full description of the ROS data requirements for each fishing gear is provided in IOTC-2024-SC27-INF06_Rev1.

Morphometric Data

Some length-length and length-weight morphometric relationships have been developed in the Indian Ocean (**Table 1**). The current reference relationship between fork length and round weight was derived from samples collected from gillnet fisheries in the early 1990s (Hsu 1999). No length-length relationship is currently considered in the IOTC processing procedure. In 2022, some preliminary analysis of the variability in the length-weight relationship of albacore was conducted Based on a large dataset of morphometric data shared by several CPCs (IOTC Secretariat et al. 2022).

Tab. 1. IOTC reference length-weight power relationships for Indian Ocean albacore. FL = upper-jaw fork length (cm); FD = first dorsal length (cm); RD = round weight (kg)

Code	Species	Source	Target	Equation	a	b	Min length	Max length	Reference
ALB	Albacore	FL	RD	RD = a*FL^b	1.3718e-05	3.0973	46.0	118	Penney (1994)
ALB	Albacore	FL	RD	RD = a*FL^b	3.5050e-05	2.8570	45.0	120	Huang et al. (1991)
ALB	Albacore	FL	RD	RD = a*FL^b	5.6907e-05	2.7514	46.2	112	Hsu (1999)
ALB	Albacore	FL	RD	RD = a*FL^b	8.0000e-05	2.7271	83.0	106	Setyadji et al. (2012)
ALB	Albacore	FL	RD	RD = a*FL^b	3.2537e-06	3.4240	67.0	118	Dhurmeea et al. (2016)
ALB	Albacore	FL	PF	PF =a*FL+b	7.0160e-01	0.6174	67.0	118	Dhurmeea et al. (2016)
ALB	Albacore	FL	FD	FD = a*FL+b	2.6780e-01	5.4938	83.0	116	Dhurmeea et al. (2016)

Methods

The release of the latest versions of the curated IOTC datasets for albacore in the public-domain, as per the confidentiality rules set in IOTC Res. 12/02, is done following some processing data steps which are briefly summarised below.

Data Processing

The data processing procedures at the IOTC Secretariat involve several systematic steps to ensure the quality and accuracy of reported datasets. Here's an overview of these procedures:

1. **Data Quality Review**: Initially, the Secretariat conducts a standard review of the quality and completeness of datasets submitted by Contracting Parties and Cooperating Non-Contracting Parties (CPCs). Historically, this review was solely performed by the Secretariat, but recent improvements have introduced validator tools for each dataset. These tools encourage CPCs to validate their data before submission, thereby minimizing errors and ensuring compliance with mandatory IOTC standards. Despite CPC validations, the Secretariat continues to validate datasets independently to ensure readiness for further processing.

2. **Processing Steps for Scientific Estimates**: Once validated, a series of processing steps are applied to derive scientific estimates of retained catches for the 16 species under IOTC management. Key processing rules include:

    a. **Data Imputation**: In cases where catches are not reported by a CPC for a specific year, data may be imputed using various sources such as partial catch and effort data, the FAO FishStat database, or data on imports from processing factories collaborating with organizations like the International Seafood Sustainability Foundation.

    b. **Re-estimation**: For fisheries with known data quality issues, re-estimation of species and/or gear composition may occur. This process utilizes data from other years or areas, or employs proxy fleets assumed to have similar catch compositions, e.g., Moreno et al. (2012) and IOTC Secretariat (2018).

c. **Disaggregation**: If catches are reported in aggregate form, a disaggregation process breaks down these aggregates by species and gear (IOTC Secretariat 2016). This involves using data from strata where species and gears are reported separately, and applying spatial-temporal substitution schemes when necessary.

These methodologies are evolving, with a gradual reduction in re-estimation practices due to improvements such as increased number of CPCs reporting of disaggregated data, availability of secondary data sources from national portals, and technical assistance provided to CPCs facing data challenges.

A total of 3 species aggregates including albacore have been used by some CPCs for reporting retained catches between 1950 and 2023 (**Table 2**).

Tab. 2. Species groups including albacore used for reporting annual retained catch data to the IOTC Secretariat

Species code	Species name	ALB
TUN	Tunas nei	✓
TUS	True tunas nei	✓
TUX	Tuna-like fishes nei	✓

A total of 6 gear aggregates have been used by some CPCs for reporting retained catches of albacore between 1950 and 2023 (**Table 3**).

Tab. 3. List of gear aggregates with their component gear codes that have been used to report some catches of albacore

Aggr. code	Gear aggregate	Category	BB	GILL	HAND	LIFT	LL	LLCO	PS	PSS	RR	SPOR	TRAW	TROL
BBPS	Baitboat and purse seine	Baitboat	✓						✓					
GIHT	Gillnet and hand line and troll line	Gillnet		✓	✓									✓
HATR	Hand line and Troll line	Trolling			✓									✓
HOOK	Hook and line	Trolling			✓			✓						✓
RRBB	Rod and reel and pole and line	Baitboat	✓								✓			
UNCL	Unclassified	Other	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Details on the results of the estimation process used to derive the 2023 best scientific estimates for 2023 including the changes in time series of retained catches relative to the previous Working Party on Temperate Tunas are provided in Appendix III and Appendix IV, respectively.

Third, and applying to all 16 IOTC species plus the most common shark species defined in the appendices of IOTC Resolution 15/01, filtering and conversions are applied to the size-frequency data to harmonize their format and structure and remove data which are non-compliant with IOTC standards, e.g., when measurements are provided with size bins exceeding the maximum width considered meaningful for the species (IOTC Secretariat 2020). The standard length measurements considered at IOTC are eye-fork length (EFL; straight distance from the orbit of the eye to the fork of the tail) for black and blue marlins, and fork length (FL; straight distance from the tip of the lower jaw to the fork of the tail) for all other species subject to mandatory size measurements (IOTC Secretariat 2020). All size samples collected using other types of measurements are converted into FL and EFL by using the IOTC

equations, considering size range and intervals that may vary with species. If no IOTC-endorsed equations exist to convert from a given length measurement for a species to the standard FL and EFL measurements, the original size data are not disseminated but kept within the IOTC databases for future reference.

Data Quality

A scoring system has been designed to assess the reporting quality of retained catch, catch and effort, and size-frequency data submitted to the Secretariat for all IOTC species. The determination of the score varies according to each type of dataset and aims to account for reporting coverage and compliance with IOTC reporting standards (**Table 4**). Overall, the lower the score, the better the quality. It is to note that the quality scoring does not account for sources of uncertainty affecting the data such as issues in sampling and processing as well as under- or misreporting.

The IOTC Secretariat has implemented a scoring system to evaluate the reporting quality of retained catch, catch and effort, and size-frequency data submitted by Contracting Parties and Cooperating Non-Contracting Parties (CPCs) to the Secretariat. This scoring system is designed to assess the extent to which data submissions adhere to IOTC reporting standards (**Table 4**). Overall, the scoring system plays a crucial role in ensuring that the data used for scientific assessments and management decisions within the IOTC are reliable and consistent across member states.

Tab. 4. Key to IOTC quality scoring system

Data set	Criterion	By species	By gear
Retained catches	Fully available	0	0
	Partially available	2	2
	Fully estimated	4	4
Catches and efforts	Available according to standards	0	0
	Not available according to standards	2	2
	Low coverage (<30% logbooks)	2	
	Not available	8	
Size frequencies	Available according to standards	0	0
	Not available according to standards	2	2
	Low coverage (<1 fish per tonne caught)	2	
	Not available	8	

Annual Retained Catches

Historical Trends (1950-2023)

Annual Retained catch levels of albacore have increased from approximately 4,000 t in the 1950s to around 41,000 t in the 2020s (**Fig. 1**). Industrial fisheries operating in areas beyond national jurisdiction (ABNJ) have accounted for most of the catch since the development of large-scale longline fisheries in the early to mid-1950s. In recent

years, catches from artisanal fisheries have increased, reaching approximately 20% of total albacore catches in 2023.

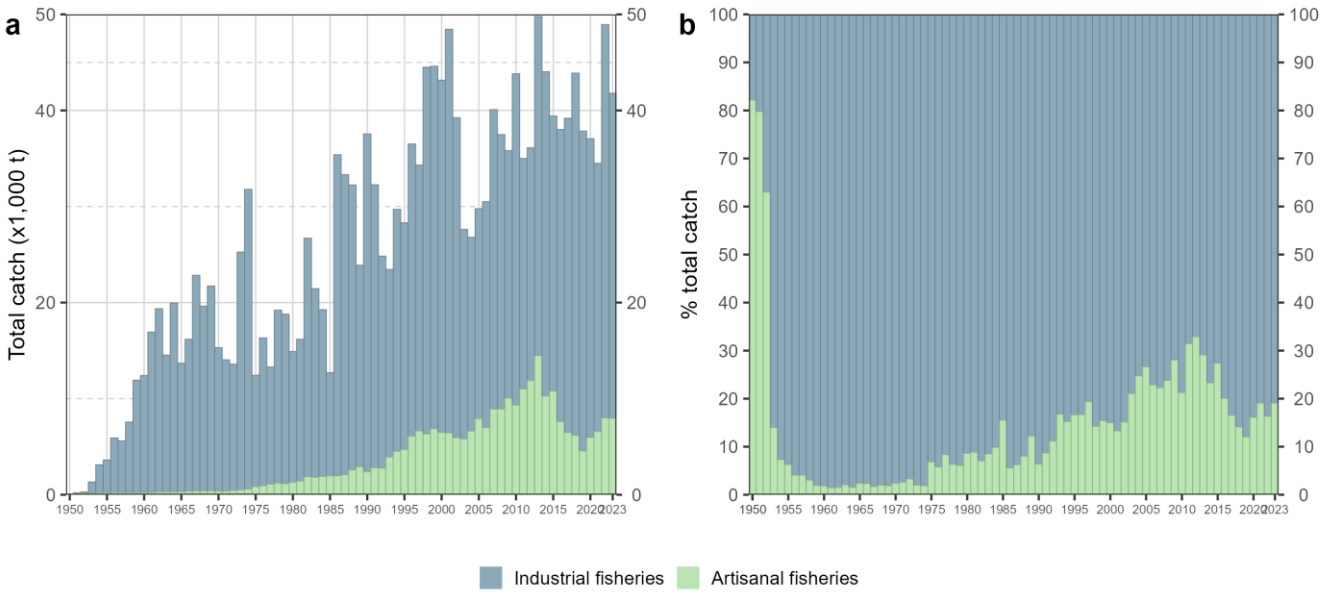

Fig. 1. Annual time series of cumulative retained absolute (a) and relative (b) catches (metric tonnes; t) of albacore by type of fishery for the period 1950-2023

Over the past seven decades, albacore has been primarily caught by large-scale longline fisheries, except for between 1986 and 1991, when a large-mesh driftnet fishery, operating mainly in ABNJ, accounted for a substantial share of the total catches (**Fig. 2**). Following a significant increase in catches throughout the 1990s, from approximately 8,000 t in 1990 to 37,000 t in 2001, the deep-freezing longline fishery experienced a substantial decline, reducing catches to around 8,000 t in 2007. Since then, catch levels have fluctuated at approximately 13,000 t. Meanwhile, a fresh longline fishery rapidly developed during the 2000s, reaching annual catches of around 20,000 t over the past decade (**Table 5** and **Fig. 2**).

Tab. 5. Best scientific estimates of average annual retained catches (metric tonnes; t) of albacore by decade and fishery for the period 1950-2019. The background intensity colour of each cell is directly proportional to the catch level

Fishery	1950s	1960s	1970s	1980s	1990s	2000s	2010s
Purse seine | Other	22	36	83	417	2,207	1,729	1,308
Longline | Other	0	0	0	18	219	1,060	560
Longline | Fresh	45	76	173	522	1,522	8,184	20,713
Longline | Deep-freezing	3,717	17,317	17,069	14,986	21,662	18,215	9,550
Line | Coastal longline	99	167	379	1,026	2,411	3,759	4,722
Line | Trolling	53	89	205	534	1,271	2,012	2,183
Line | Handline	17	29	68	151	375	621	1,295
Baitboat	0	1	2	48	14	16	33
Gillnet	5	8	18	5,873	3,851	182	148
Other	3	5	12	31	74	115	200
Total	3,962	17,728	18,008	23,607	33,606	35,893	40,712

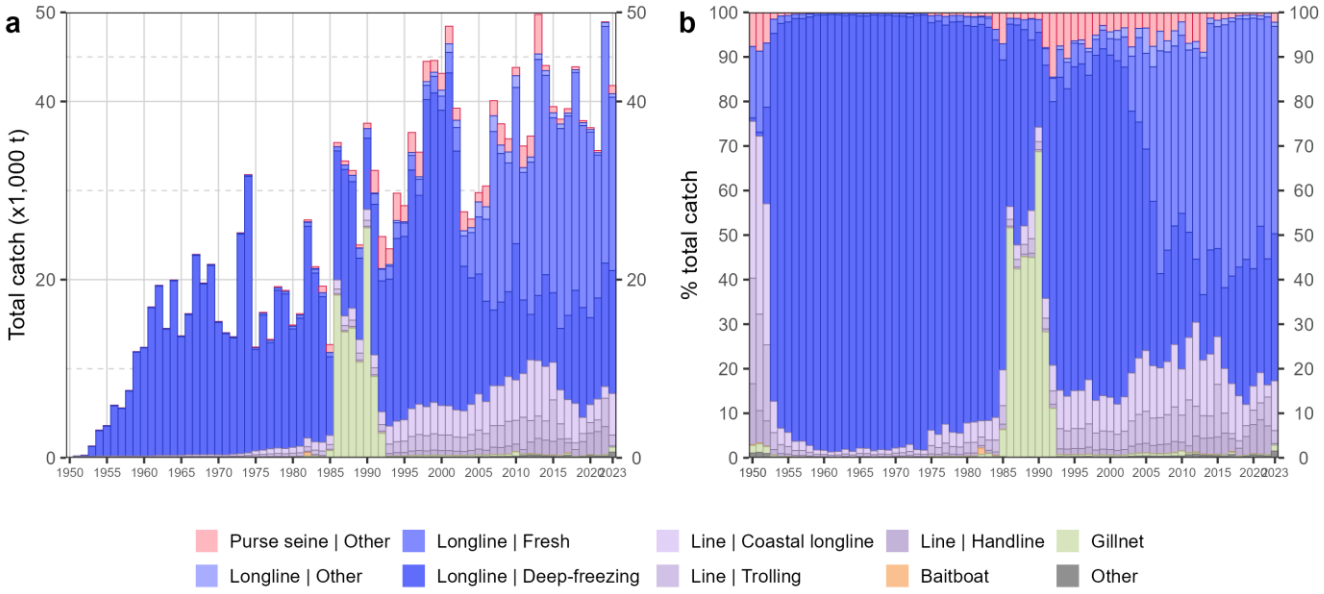

Fig. 2. Annual time series of cumulative retained absolute (a) and relative (b) catches (metric tonnes; t) of albacore by fishery for the period 1950-2023

Available retained catch data for albacore indicate the predominance of the fresh longline fishery over the past decade, contributing on average more than 50% of total annual catches (**Table 6**). Catches from this fishery have shown a slight increase, rising from approximately 14,000 t in 2011 to around 19,000 t in 2023. Meanwhile, catches from the deep-freezing longline have increased from a low of approximately 6,900 t in 2016 to around 14,000 t in 2023 (**Table 6**).

Tab. 6. Best scientific estimates of annual retained catches (metric tonnes; t) of albacore by fishery for the period 2014-2023. The background intensity colour of each cell is directly proportional to the catch level

Fishery	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Purse seine | Other	577	700	546	499	325	242	204	250	74	928
Longline | Other	536	565	517	315	314	324	282	273	434	382
Longline | Fresh	22,378	19,637	22,440	22,385	24,451	20,429	20,843	16,038	26,579	19,462
Longline | Deep-freezing	10,299	7,806	6,897	9,468	12,695	12,328	9,763	11,348	13,861	13,805
Line | Coastal longline	6,109	4,221	3,809	4,385	4,428	1,802	2,009	2,340	1,315	4,661
Line | Trolling	2,166	4,649	1,706	453	737	919	1,197	1,309	3,171	1,212
Line | Handline	1,648	1,533	1,842	1,137	775	1,591	2,402	2,663	3,137	155
Baitboat	46	40	16	69	7	16	28	16	5	0
Gillnet	56	88	114	199	94	78	83	88	146	552
Other	222	184	131	279	61	123	245	175	216	631
Total	44,036	39,422	38,017	39,190	43,887	37,852	37,056	34,499	48,938	41,787

Main Fishery Features (2019-2023)

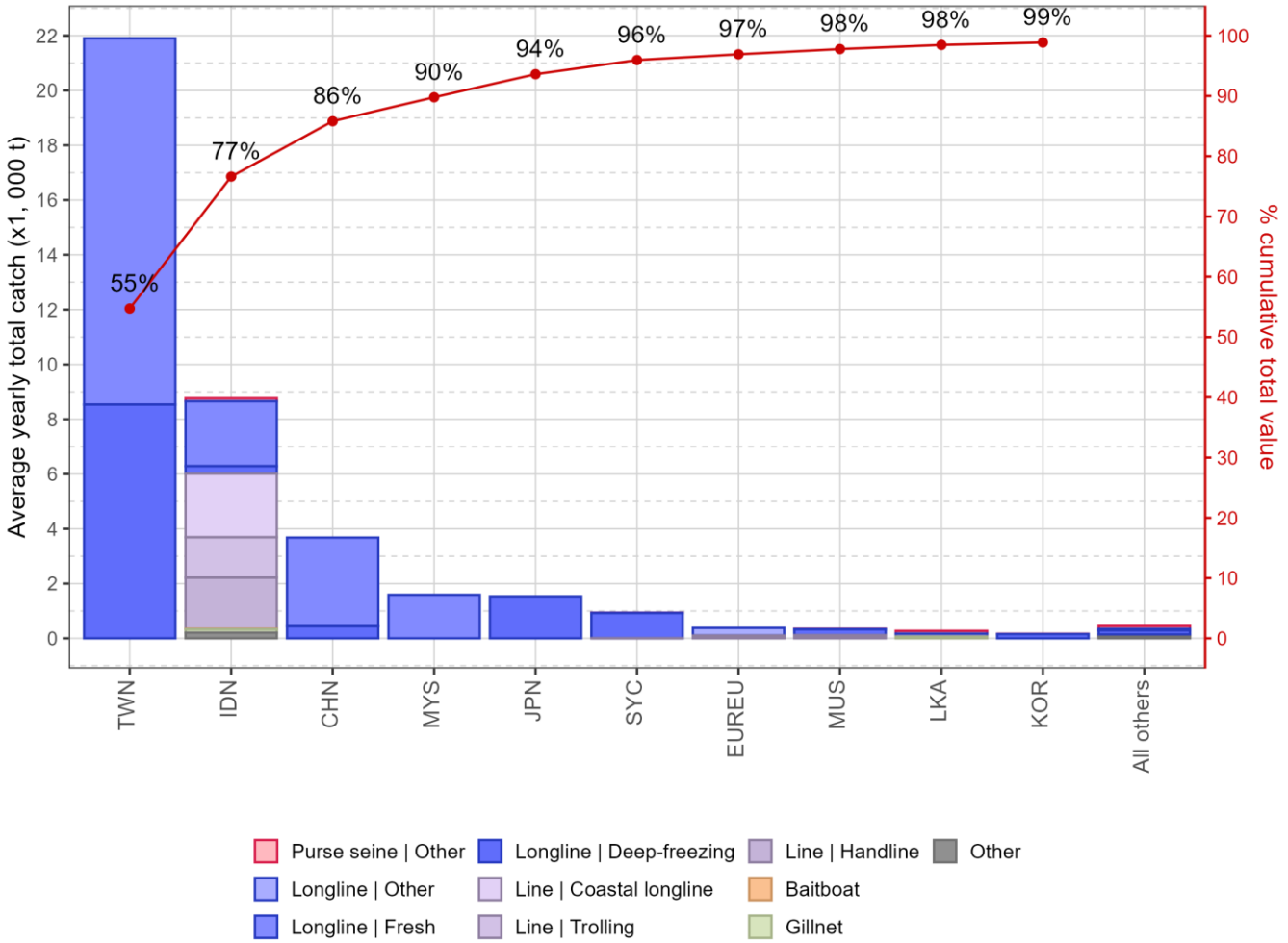

Fig. 3. Mean annual catches (metric tonnes; t) of albacore by fleet and fishery for the period 2019-2023, with indication of cumulative catches by fleet

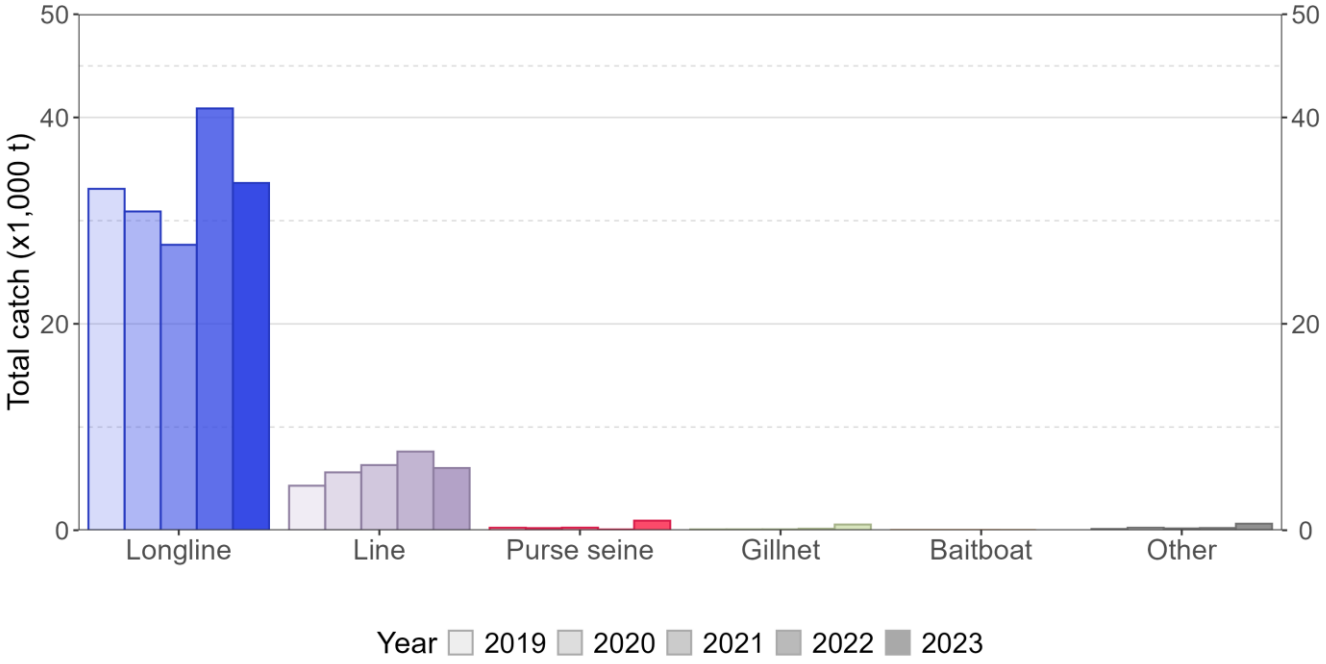

Fig. 4. Annual catch (metric tonnes; t) trends of albacore by fishery group for the period 2019-2023

Tab. 7. Mean annual catches (metric tonnes; t) of albacore by fishery for the period 2019-2023

Fishery	Fishery code	Catch	Percentage
Longline | Fresh	LLF	20,670	51.6
Longline | Deep-freezing	LLD	12,221	30.5
Line | Coastal longline	LIC	2,425	6.1
Line | Handline	LIH	1,990	5.0
Line | Trolling	LIT	1,561	3.9
Purse seine | Other	PSOT	339	0.8
Longline | Other	LLO	339	0.8
Other	OT	278	0.7
Gillnet	GN	189	0.5
Baitboat	BB	13	0.0

Uncertainties in Annual Retained Catch Data

In 2023, approximately 84% of the retained catch was estimated to have been fully reported to the Secretariat, with the remainder requiring partial or full estimation. Some of these catches were repeated from 2022 for CPCs that did not report data to the Secretariat (Appendix I). Furthermore, a temporary re-estimation of the coastal fisheries of Indonesia was performed.

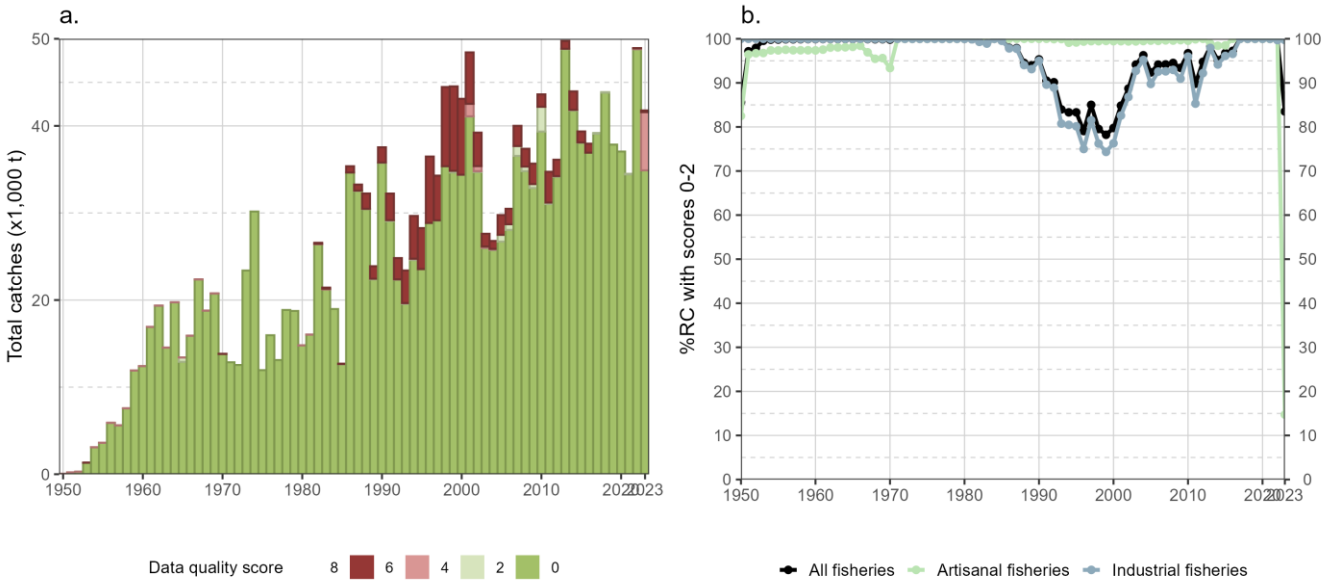

Fig. 5. Annual time series of (a) cumulative retained catches (metric tonnes; t) estimated by quality score and (b) contribution (percentage; %) of retained catches fully or partially reported to the IOTC Secretariat to all retained caches of albacore for all fisheries and by type of fishery, for the period 1950-2023

Several key issues need to be noted when considering the historical time series of retained catches of albacore:

- Catches of albacore from longliners operating under flags of non-reporting countries (e.g., Belize, Honduras, Indonesia, Malaysia) have been estimated by the Secretariat between 1985 and 2016 based on some strong assumptions regarding vessel numbers and annual catch rates (Herrera 2002a, 2002b). While estimates of non-reported catches were moderately high during the 1990s and early 2000s, reaching nearly 10,000 t in 1999, they have declined significantly since the mid-2000s. In recent years, these catches have been considered negligible due to the reduced practice of reflagging, the implementation of port State measures, and improved monitoring of vessel activities and data reporting by the relevant CPCs, such as Malaysia.

- In the past, the Secretariat re-estimated catches of albacore from the longline fisheries of the Philippines (1999-2010), India (2004-2011), and Oman (2017-2018), as reported data appeared to be incomplete. These re-estimations were based on: i) inconsistencies between reported bigeye tuna catches and those monitored through the IOTC Statistical Document Programme in the case of the Philippines; ii) the number of vessels recorded in the Record of Authorized vessels (RAV) and the Active List of Vessels (AVL) for India, and (iii) the lack of detailed catch reporting by species for Oman.

- Catches of albacore from Indonesian fisheries have recently been fully re-estimated to better reflect improved data collected through logbook and landing monitoring systems in Indonesia (Indonesia 2024). Data are considered to be the best scientific estimates but should be considered with caution, particularly prior to the 2010s when logbooks were not systematically implemented in Indonesian fisheries. It is important to note that the re-estimation methodology was not applied to 2023 and some work is ongoing to establish the best approach for that year.

- The catches of albacore estimated for the fresh-tuna longline fishery of Taiwan,China are only available from 2001 onward: prior to 2001, catches for the Taiwanese fleet remain relatively uncertain.

Discard levels

The total amount of albacore discarded at sea remains unknown for most fisheries and time periods despite the obligation to report these data as per IOTC Res. 15/02. Information from the literature indicates that discard levels

of albacore are generally low in longline fisheries, mostly because of the high market value fetched by the species (Huang and Liu 2010; Wang et al. 2021). Discarding by longliners mainly happens when the fish is damaged or shows signs of depredation by whales and sharks (e.g., Munoz-Lechuga et al. 2016). Almost no information on discarding of albacore is available for coastal line fisheries, although the phenomenon is supposed to be negligible.

Information available in the ROS regional database for longline fisheries covers the period NA-NA and only a fraction of the Indian Ocean fishing grounds, as data are limited to vessels flagged by EU,France, Japan, and Sri Lanka. Levels of discarding appear to be low but this should be considered with caution due to the current low level of ROS data coverage. The size range of albacore discarded at sea in the longline fisheries of EU,France and Japan is similar to the size of the fish retained and does not show any individual smaller than <60 cm fork length (**Fig. 6**).

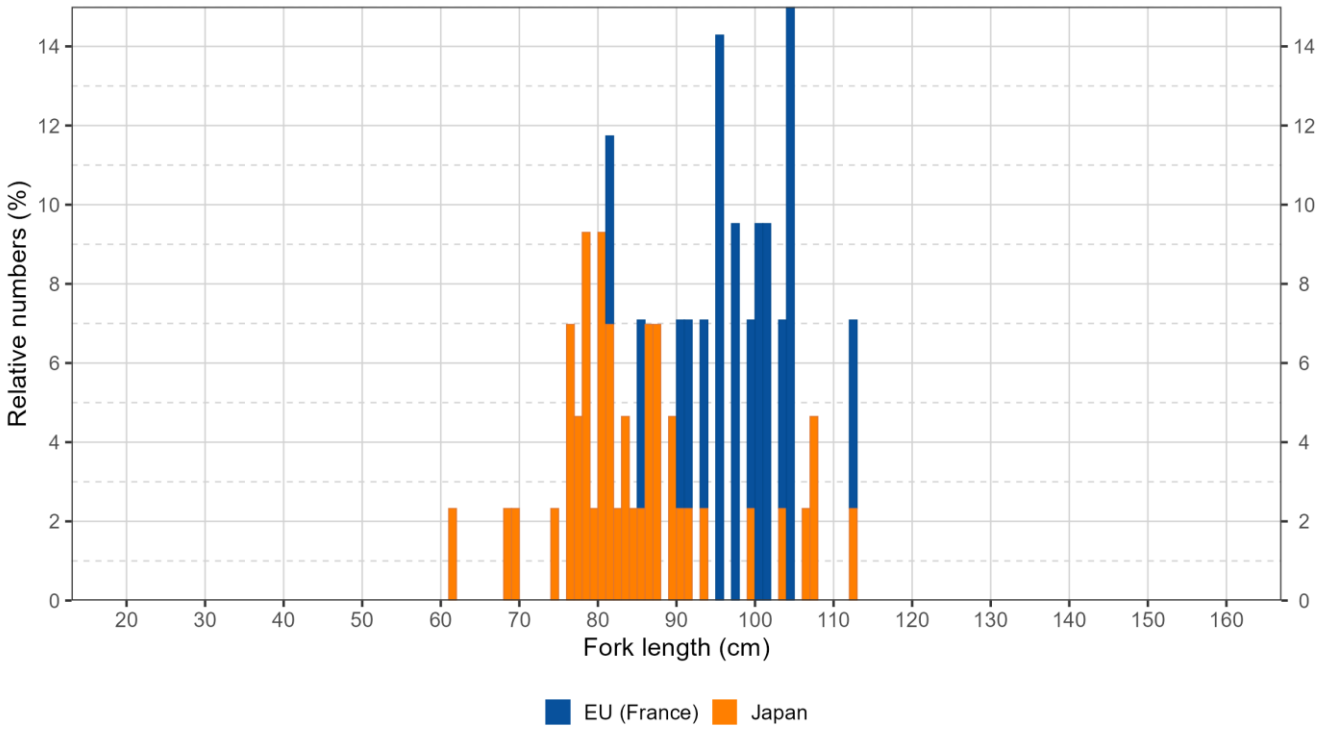

Fig. 6. Distribution of fork lengths (cm) of albacore discarded at sea in the longline fisheries of Japan and EU,France as available in the ROS regional database

Geo-referenced catch data

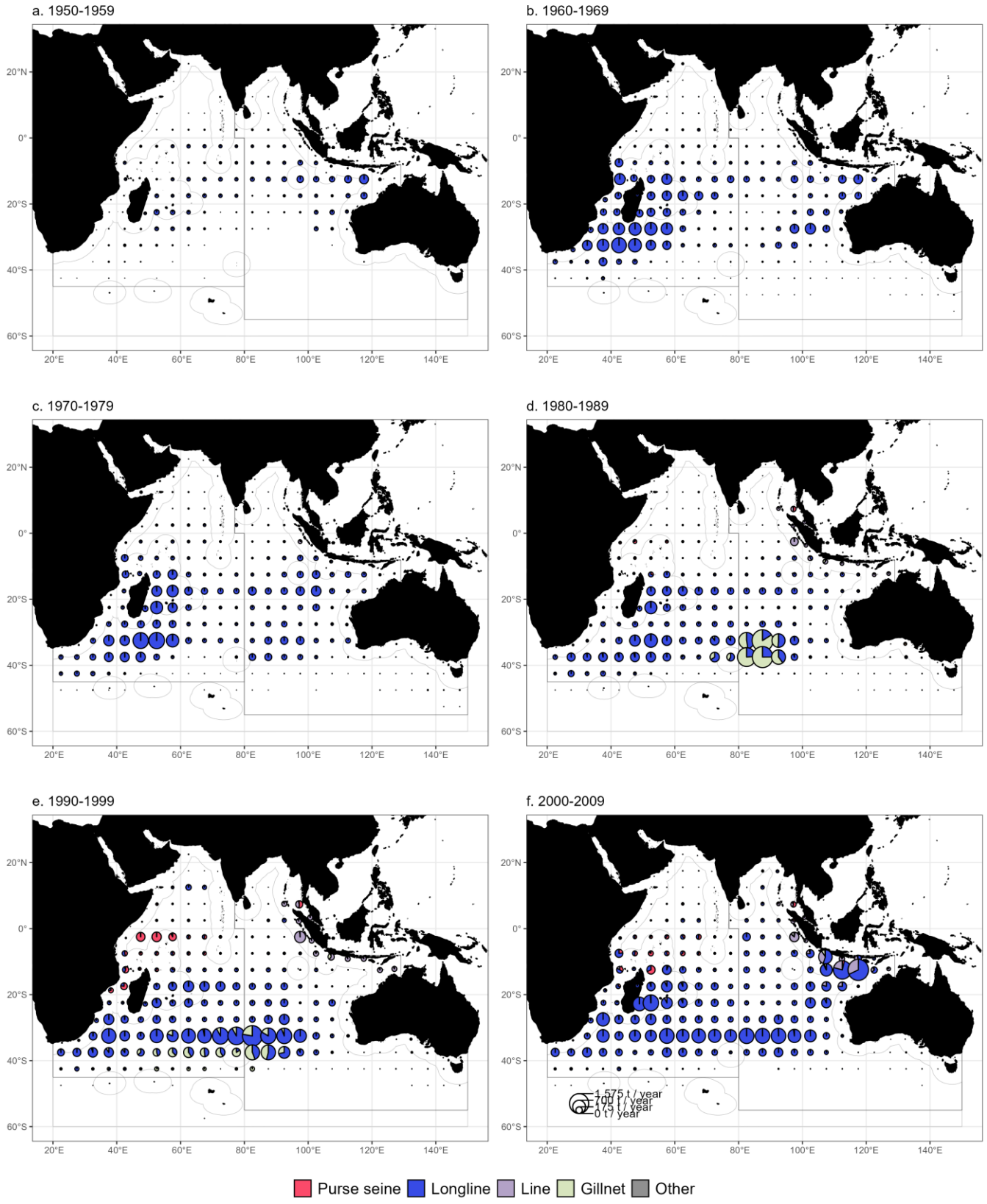

Fig. 7. Mean annual time-area catches (in weight) of albacore raised to the annual retained catches for the last decade (2010-2019) and for each year during the recent period (2016-2020). Source: raised time-area catches dataset (1950-2020)

During the past decade (2010-2019), hotspots of albacore catches appeared to have emerged in the fishing grounds east of Mozambique (including their adjacent high seas), in the southeastern waters of Indonesia, and in the high seas south of 25°S in the southwestern Indian Ocean (**Fig. Error! Reference source not found.**). This latter area now represents the main fishing grounds of albacore in the Indian Ocean, with most of the catch in recent years coming from longline fisheries operating between 40-80°E and 10-40°S.

Uncertainties in Geo-Referenced Catch and Effort data

The reporting quality of catch and effort data for albacore is the highest among IOTC species, due to the predominance of industrial fisheries monitored through logbooks since the 1950s. In recent years, the high percentage of annual retained catches with quality scores between 0 and 2 has indicated that both the quantity and reporting quality of available catch and effort data for albacore are high. In 2023, approximately 87% of the retained catch was estimated to have corresponding spatial information on catch and effort fully reported by IOTC standards (**Fig. 8**).

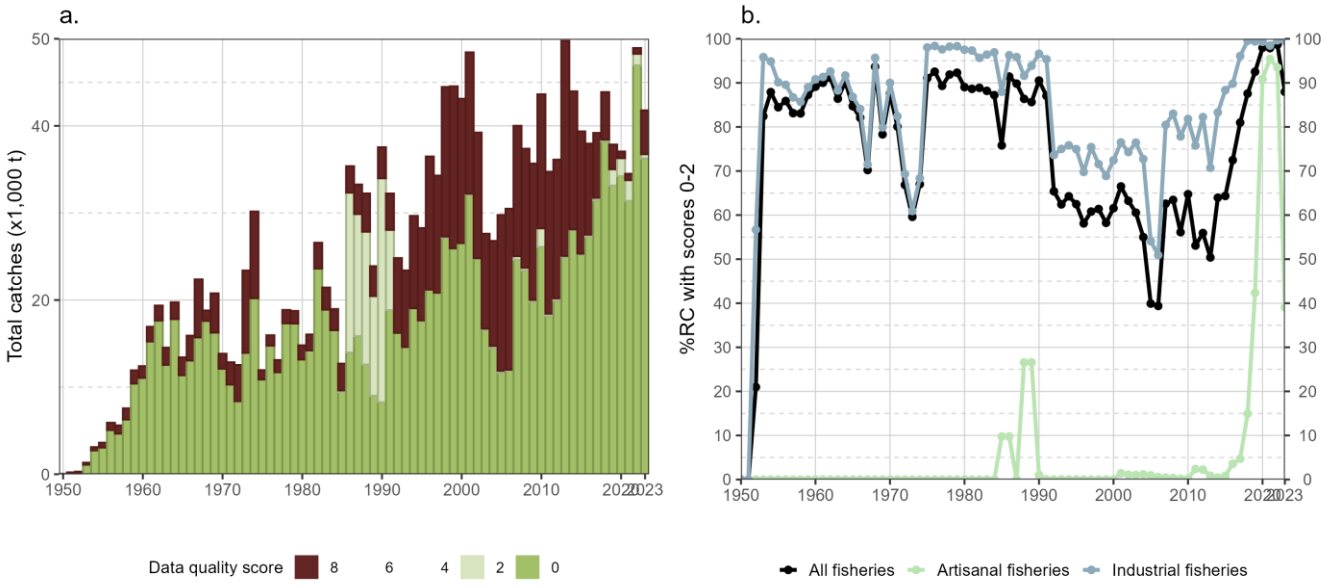

Fig. 8. Annual time series of (a) cumulative retained catches (metric tonnes; t) estimated by quality score and (b) contribution (percentage; %)of retained catches with corresponding geo-referenced catch and effort data reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 to all retained caches of albacore for all fisheries and by type of fishery, for the period 1950-2023

The following uncertainties in catch and effort data for albacore should be noted:

- Little information on catch and effort was reported for the industrial longline fishery of Indonesia prior to the implementation of the national “One Data Initiative” in 2017. The sampling coverage has much increased over the recent years and reached around 77% in 2023.
- Catch and effort data for the fresh-tuna longline fishery from Taiwan,China are only available since 2007, compared to nominal catches from 2001. Estimates of total catches, and time-area catches, prior to these periods therefore remain highly uncertain.
- Although some catch and effort data are available for the longline fisheries of India, Malaysia, Oman, and the Philippines, they are usually incomplete and fall short of the IOTC data reporting standards.

Size composition of the catch

Temporal patterns and trends in estimated average weights

Average weights of Indian Ocean albacore were derived from the geo-referenced catches by fleet, gear, fishing mode, year, month, and grid raised to the annual retained catch (IOTC Secretariat 2022b). Considering the limitations in the original datasets and the assumptions required by the estimation process (e.g., use of proxy fleets), the estimated average weights should be considered with caution. This is particularly true for most coastal fisheries considering the paucity or absence of their original size data which cause the estimates of average weights to be based on strong assumptions. As such, we only show here the time series of average weights for industrial longline and purse seine fisheries which represent between 80% and 100% of the annual total catch of albacore since the mid-1950s.

Due to their contribution to the total catch, deep-freezing and fresh longline fisheries drive the temporal patterns of average weight in the catch of Indian Ocean albacore since the 1950s (**Fig. 9**). Overall, average weight of albacore in the catch of the main fisheries targeting albacore showed a decreasing trend between 1952 and 1997, before increasing to more than 20 kg in 2009 and showing a decreasing trend thereafter, reaching 19.1 kg in 2020.

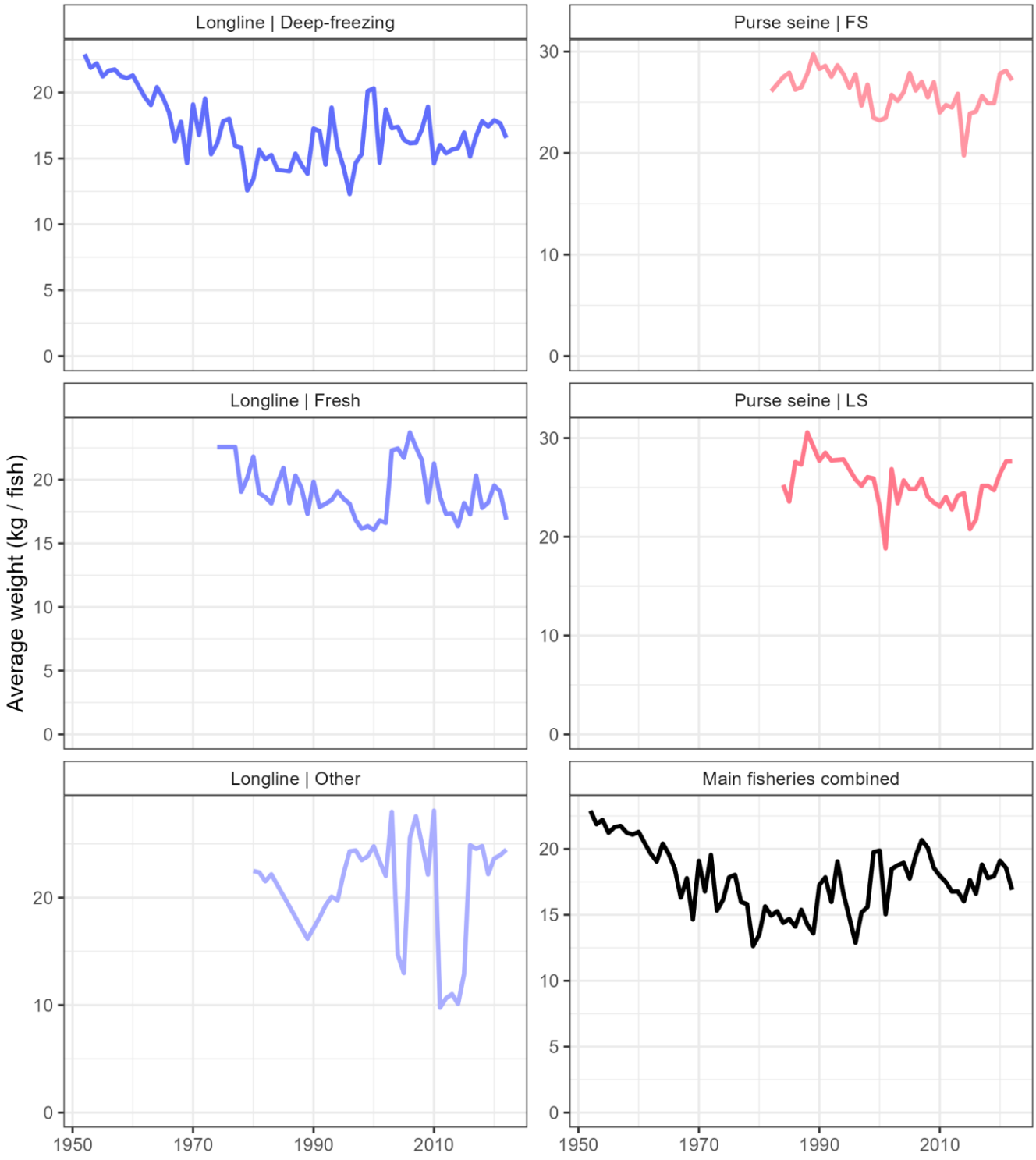

Fig. 9. Annual time series of estimated average weight (kg/fish) of albacore for the fisheries described by a good coverage of size data. Longline | Other includes swordfish and shark-targeted longlines; FS = Free-swmming schools; LS = schools associated with floating objects

Spatial distribution of estimated average weights

The distribution of estimates weights of albacore over the last decades shows a strong spatial pattern in the sizes of fish caught in the Indian Ocean (**Fig. 10**). Larger albacores are found in tropical waters, while their smaller counterparts occur in temperate waters in the southern Indian Ocean. Although albacores are caught at different

sizes according to the fishing gear (IOTC Secretariat 2022b), the distribution of the average weight of albacore caught with longlines confirms this pattern with a clear distinction between juveniles occurring south of 25°S (average weights of 10-15 kg) and adult albacore larger than 20-25 kg distributed along the equatorial area, this pattern being consistent across decades (IOTC Secretariat 2022b).

The recent annual distribution of average weights of albacore appears to be very consistent across the years, with fish less than 15 kg located in the southern Indian Ocean, along the coasts of Indonesia, and in the Bay of Bengal (**Fig. 11**). The larger individuals (>25 kg) are found in the catches located in the tropical area, in particular in the western Indian Ocean with a predominance in the Gulf of Oman and off the coasts of Somalia, except for 2019 (**Fig. 11**).

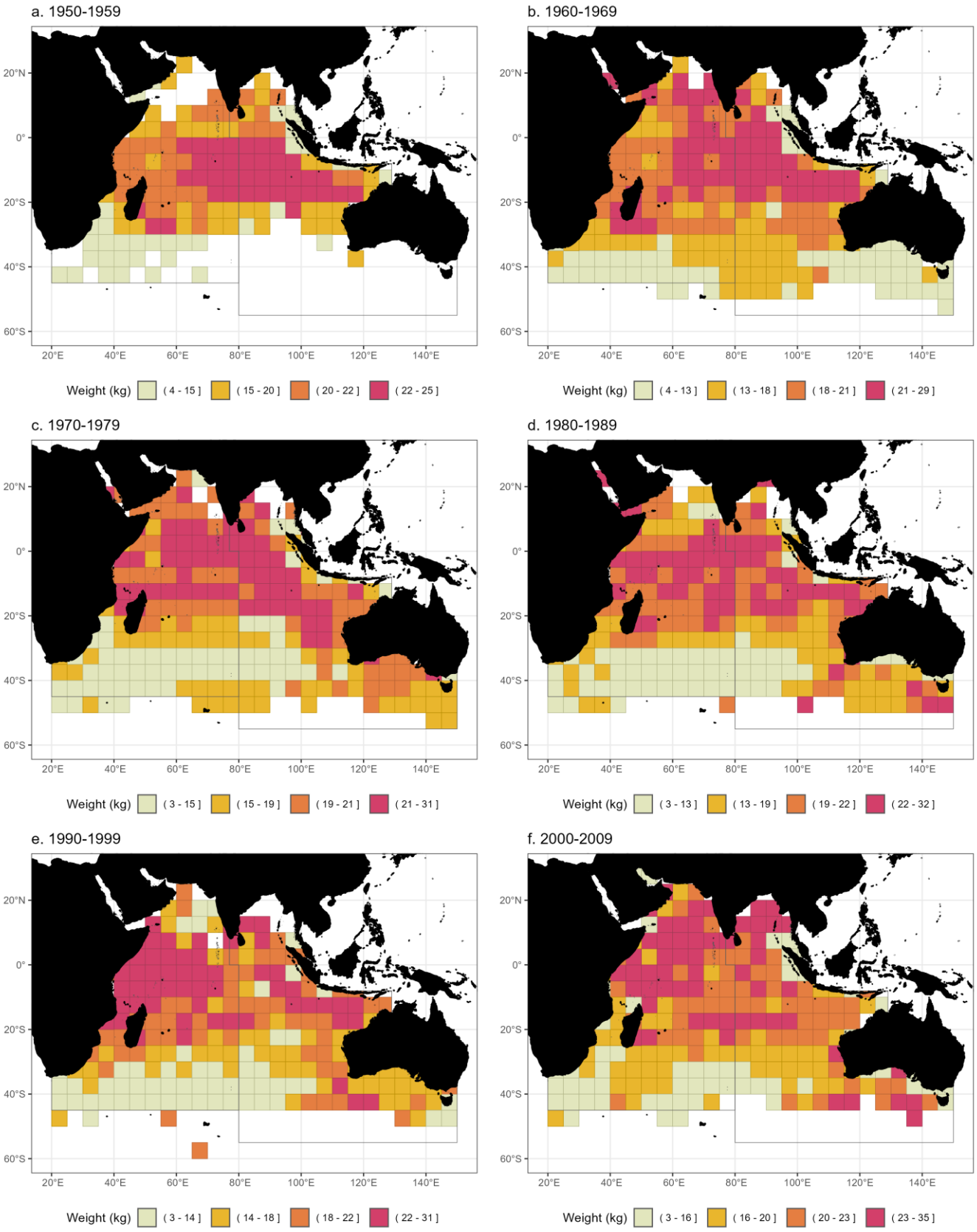

Fig. 10. Estimated average weight (kg / fish) in the catch of Indian Ocean albacore by decade and 5x5 grid, all fisheries combined, 1950-2009

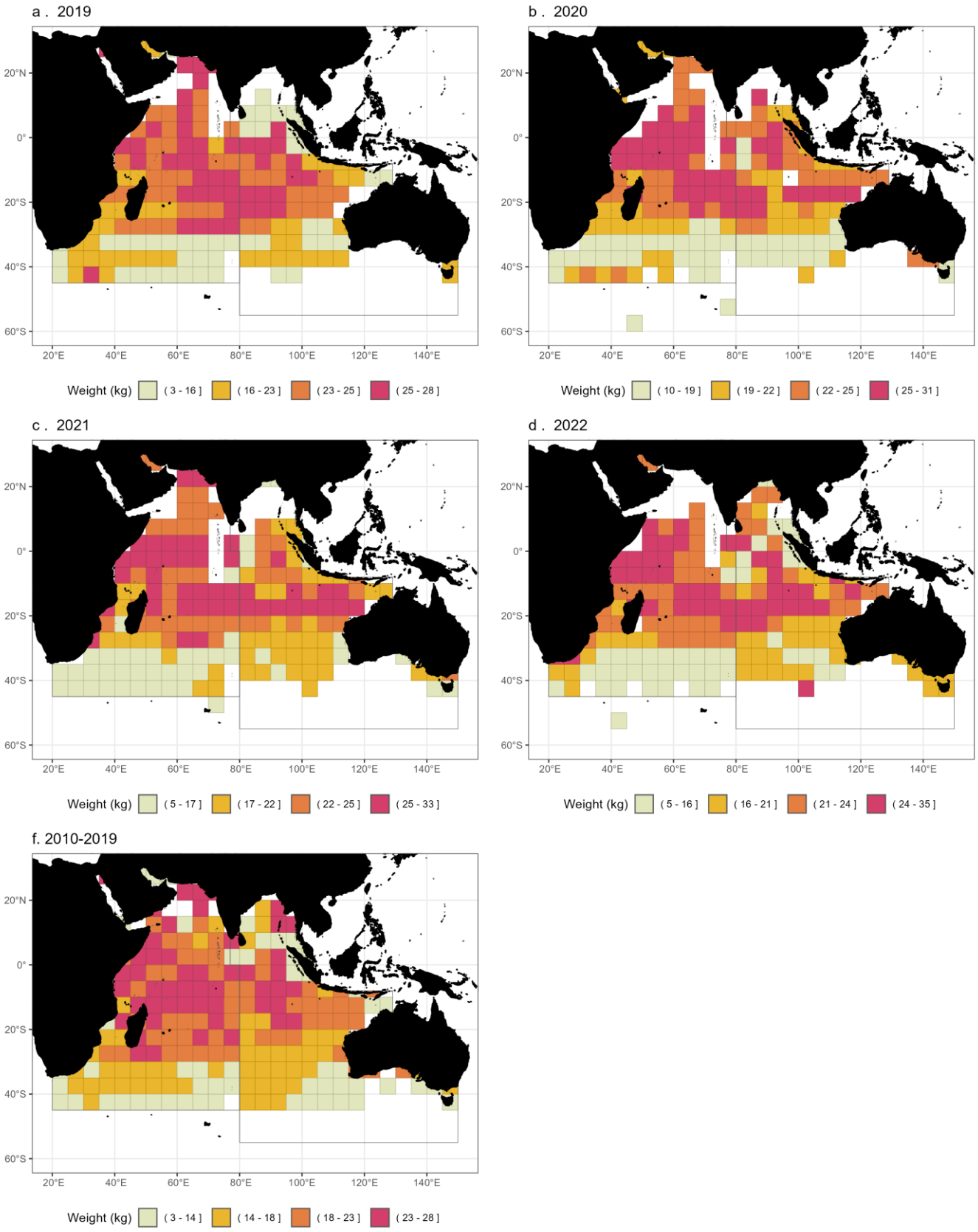

Fig. 11. Estimated average weight (kg / fish) in the catch of Indian Ocean albacore by 5x5 grid and year during 2019-2022 and for the decade 2010-2019, all fisheries combined

Uncertainties in Geo-Referenced Size-Frequency Data

The reporting quality in size-frequency data for albacore shows some large variability over time and an increasing trend since the late 2000s. In recent years, the high percentage of annual retained catches of quality scores between 0-2 showed that the amount and reporting quality of the size-frequency data available for albacore were good. In 2023, approximately 62% of the retained catch was estimated to have size-frequency data fully reported by IOTC standards (**Fig. 12**).

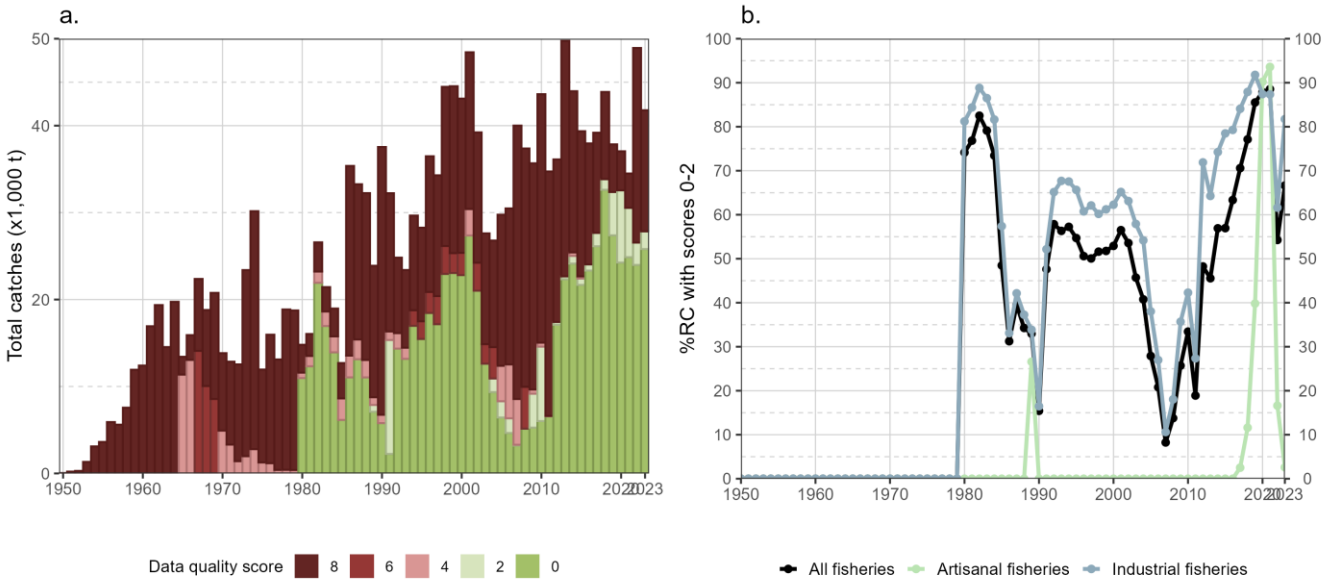

Fig. 12. Annual time series of (a) cumulative retained catches (metric tonnes; t) estimated by quality score and (b) contribution (percentage; %) of retained catches with corresponding geo-referenced size-frequency data reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 to all retained caches of albacore for all fisheries and by type of fishery, for the period 1950-2023

The following points of uncertainty in the size-frequency data of albacore should be noted:

- Although some size data are available for the large-mesh size driftnet fishery of Taiwan,China that operated over the period 1982–92, the sampling coverage was low and well below the sampling target of 1 fish per metric tonne for all years of activity of the fishery.
- Size-frequency data for the fresh-tuna longline fishery of Indonesia have been reported for a limited number of years, during the mid-2000s. However samples, where available, cannot be fully disaggregated by month and fishing area (5x5 grid) and refer mostly to the component of the catch that was unloaded fresh. For this reason, the quality of the samples in the IOTC database is considered low.
- A large data set of size samples is available for the deep-freezing longline fishery of Taiwan,China since 1980. However, the length distributions of albacore available from 2003 have been found to be different when compared to earlier years (Geehan and Hoyle 2013). In addition, since 2003 higher average weights derived from length data have also been reported, compared to average weights from catch and effort (for the same time-periods and areas), which suggests changes in the sampling protocols of specimens measured for lengths – particularly the proportion of smaller sized fish (Hoyle et al. 2021). Size data collected by observers since 2002 are considered to be of better quality and have been given preference over the size data collected by the crews since the early 2000s.
- The number of size samples available for the Japanese deep-freezing longline fleet has shown large fluctuations over the years following a large decline in the late 1980s and was well below the sampling target between 1994 and 1996.

- No size data have been reported to the Secretariat for the longline fisheries of India (2004-2011), Oman (2014-2020), and Philippines (1998-2014) while Malaysia (2005-2020) only started reporting data in 2018.

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Appendix I: Best scientific estimates for 2023

The preparation of the best scientific estimates of retained catches of albacore for 2023 required some processing performed by the Secretariat in agreement with the re-estimation procedures endorsed by the IOTC Scientific Committee (see section Data processing).

First, catches for the IOTC CPCs and non-members which have not reported annual retained catches of albacore to the Secretariat for the year 2023 were repeated from the previous year 2022. The amount of catch estimated in 2023 was small overall, including the small coastal handline and trolling line fishery of Mauritius (around 100 t) and large-scale longline fishery of Oman (around 100 t). Catches for Mauritius were broken down by gear as the original catches were reported for a gear code (HATR) that combines handline and trolling line gears.

Second, in absence of clear guidance for estimating the catches of Indonesian coastal fisheries for 2023 following the endorsement of a new estimation approach for the period 1950-2022 (Indonesia 2024), the historical estimation process was temporarily performed for 2023. In brief, a fixed proportion of the annual total catch derived from catch composition samples collected during 2003-2011 is used to estimate the annual nominal catch of each species by fishing gear (Moreno et al. 2012).

Appendix III: Monthly time series of crude oil prices and import prices, 2000-2023

Crude oil price

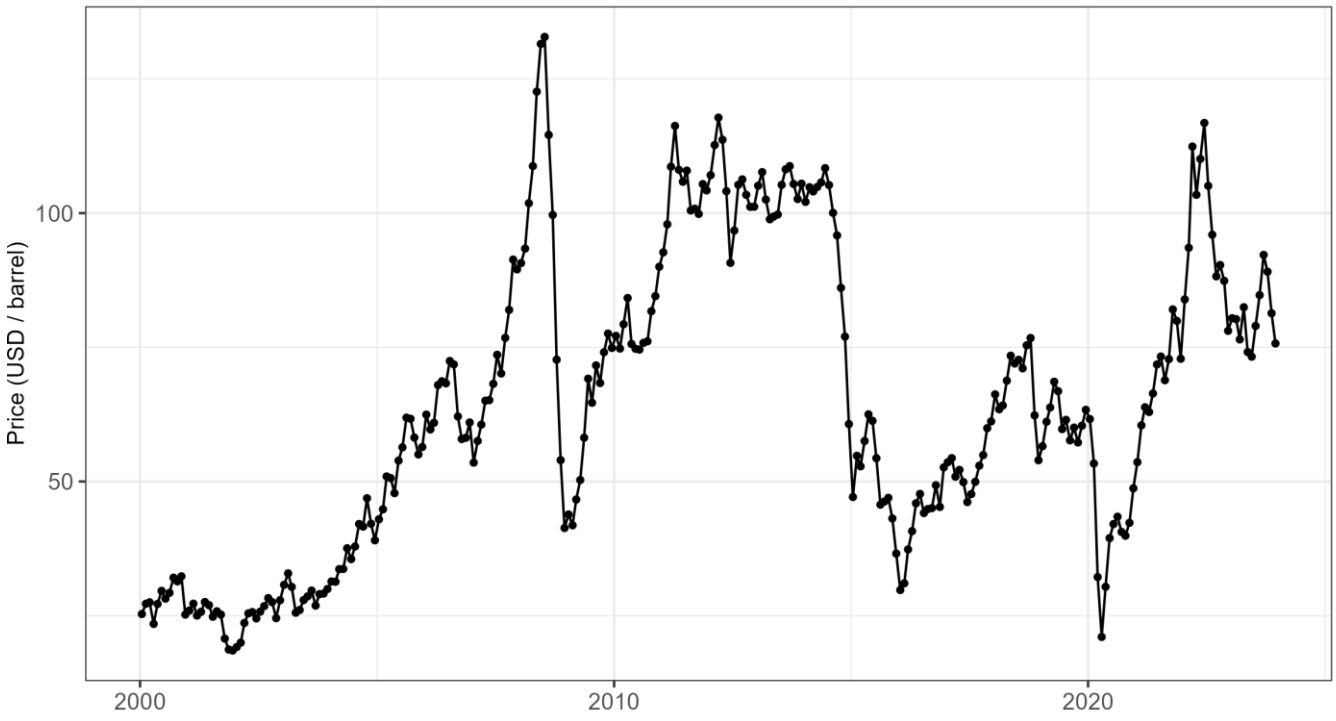

Fig. 13. Monthly time series of crude oil spot price (USD/barrel) during the period 2000-2023 (compiled by the FFA Fisheries Development Division)

Import prices for albacore

Fig. 14. Monthly time series of import prices (USD/kg) for canning-grade frozen (Thailand) and sashimi-grade fresh albacore (USA) during the period 2000-2023 (compiled by the FFA Fisheries Development Division)