# Validating IOTC candidate ecoregions through a comparative analysis of main tuna and tuna-like species and fishing fleets

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## Abstract

Implementing an EAFM requires identifying a spatial framework where ecosystems can be characterized, monitored, and reported. Within the IOTC convention area, a spatial framework of nine candidate ecoregions has been developed to support ecosystem-based planning and research, as well as the development of ecosystem-based advice products to complement single-species fisheries management advice. Building on previous ecoregion delineation efforts, this study validates the nine candidate ecoregions by evaluating their ability to demarcate areas with distinct communities of tuna and tuna-like species, as well as unique fisheries and fleets. Using IOTC and CCSBT fishery statistics datasets, we characterize core fleets, their gears, and catch composition within each ecoregion, and analyze the differences among ecoregions to assess their ecological and fisheries uniqueness to serve as a spatial framework for supporting ecosystem-based planning, research, and advice products. The findings reveal unique fleet compositions in each ecoregion, with regional fleets dominating, except in the ACE, where across-regions fleets prevail. The catch composition of the fleets also varies significantly across ecoregions, with neritic tunas and Spanish mackerels being more prominent in coastal tropical ecoregions, tropical oceanic species like skipjack and yellowfin tunas being prevalent in tropical oceanic ecoregions, while temperate oceanic species such as southern bluefin tuna and swordfish dominate in higher latitude ecoregions. While our findings highlight the unique ecological and fishery characteristics of each ecoregion, we also recommend refinements and boundary adjustments, including treating coastal areas adjacent to continental landmasses as distinct ecoregions, extending ecoregion boundaries to align with Exclusive Economic Zones (EEZs), and reclassifying areas like the northern region of the ACE and Indonesian Throughflow to improve ecological and fleets representation within each ecoregion.

## 1. Introduction

All tuna Regional Fisheries Management Organizations (RFMOs) have started to discuss how to operationalize an Ecosystem Approach to Fisheries Management (EAFM) according to internationally agreed standards (Juan-Jorda et al., 2018). EAFM emerged in response to the limitations of traditional fisheries management, which often focused narrowly on single species and has failed to consider the broader ecosystem context (Link, 2010). The EAFM is a spatially-explicit approach to the integrated management of fisheries that incorporates ecosystem knowledge and uncertainties, considers multiple external influences, and accounts for diverse societal objectives and their trade-offs (FAO, 2003; Garcia et al., 2003). It strives to account for the connectivity between species, their habitats, physical environments, and their connection with humans and fishing communities (Fogarty, 2014; Rice et al., 2011).

The implementation of EAFM in tuna RFMOs has been slow due to the challenges of operationalizing an EAFM in the context of international fisheries (Juan-Jorda et al., 2018). Although most tuna RFMOs have endorsed the EAFM in their convention mandates or Scientific Committee Strategic Science Work Plans, there is a need to improve the scientific base knowledge to support its operationalization. Additionally, all tuna RFMOs have yet to adopt an EAFM implementation roadmap, which is highly recommended for setting goals for ecosystem-based planning and research and developing advice products to complement the more traditional fisheries management advice.

A crucial step in advancing the implementation of the EAFM is the identification of spatial units or spatial frameworks, such as ecoregions, that are both ecologically meaningful and practical for supporting ecosystem-based research and the development of advice products (Staples et al., 2014). In recent years, the Indian Ocean Tuna Commission (IOTC) Working Party on Ecosystems and Bycatch (WPEB) has been developing a process to advance the identification of ecologically meaningful regions (ecoregions) to be used as a spatial framework for guiding EAFM implementation in the IOTC convention area (Figure 1, Table 1) (Juan Jorda et al., 2020). These ecoregions have the potential to be used as spatial frameworks to support the development of ecosystem-based research and advise products (e.g., regional indicator-based ecosystem cards, ecosystem models, integrated ecosystem assessments, ecosystem-fisheries overviews, etc.) to complement existing fisheries management advice for informing EAFM implementation in IOTC (ICES, 2020; Rice et al., 2011; Zador et al., 2016).

The delineation of ecoregions involves a multiple-step consultative process, each phase supported by a series of activities and informed decisions (Loveland & Merchant, 2004; Mackey et al., 2008). Between 2019 and 2022, two IOTC ecoregion workshops were held to develop a general framework for guiding the entire ecoregion delineation process. These workshops included discussions on the purpose and applications of ecoregions, the establishment of pre-defined criteria for guiding the regionalization, and conducting the spatial analysis to drive a proposal of draft ecoregions, which were subsequently refined by expert knowledge (Juan-Jorda et al., 2022; Juan-Jorda et al., 2019). The pre-defined criteria for guiding the regionalization included three main guiding factors: (1) the main oceanographic patterns and biogeography of the pelagic ecosystem in the Indian Ocean; (2) the spatial distributions of major IOTC species (Table 2) along with the ecological communities they form; and (3) the spatial patterns of the main

IOTC fisheries (Table 3), their core fishing grounds, and the fisheries complex they form. These three thematic factors collectively (oceanography, species communities, and fishing grounds of major fisheries) guided the ecoregion delineation in IOTC (Figure 1). Consequently, the resultant ecoregions are characterized, in principle, by distinct oceanographic characteristics, core species, and core fisheries.

During the second IOTC Ecoregion workshop in 2022, nine candidate ecoregions were identified and refined within the IOTC convention area (Figure 1, Juan-Jorda et al., 2022). In line with the ecoregion guiding framework, the IOTC candidate ecoregions should be considered a working hypothesis to be tested, validated, and refined, if needed, before they are used for resource planning, research, and management. Therefore, the IOTC WPEB endorsed the candidate ecoregion and recommended the development of pilot studies and example products to test their usefulness and feasibility as a spatial framework to support ecosystem-based planning and research products in IOTC (IOTC WPEB18, 2022).

Two approaches are generally used for testing and validating ecoregions (Bailey, 1983; Loveland & Merchant, 2004). One approach consists of statistically evaluating the hypothesis underlying the regionalization and the expected qualities of the resultant ecoregions (Table 4). This approach is chosen when the aim is to quantitatively evaluate and verify the results of the ecoregion mapping. A second approach for validating and verifying the ecoregion maps contends that the ultimate test of the utility of ecoregions as tools for resource planning, research, assessment, and provision of advice may be the extent to which they meet the end user needs (Bailey, 1983; Bryce & Clarke, 1996; Loveland & Merchant, 2004). Therefore, it consists of developing pilot products (e.g. Ecosystem-Fisheries Overviews, regional EcoCards, etc.) to test how the ecoregions support or affect the intended uses of the ecoregions.

Building on the first approach to ecoregion validation, the objective of this study is to assess the hypothesis underlying the regionalization of the IOTC candidate ecoregions and their expected qualities and attributes (expected qualities listed in Table 4) to quantitatively assess and validate the ecoregion mapping outputs (Figure 1). Specifically, we identify and characterize the main fleets operating in IOTC, delineating their main fishing gears and catch composition across each IOTC candidate ecoregion. Then, we evaluate the degree of similarity and dissimilarity among the IOTC candidate ecoregions. This comparative analysis seeks to validate the underlying regionalization and the expected qualities and attributes of the IOTC candidate ecoregions while also providing recommendations for potential refinements and boundary adjustments.

It is important to note that this validation approach of evaluating statistically the hypothesis underlying the regionalization and the resultant ecoregion mapping is known to be challenging. This is because the ecoregion maps are a synthesis and a compromise of many components of thematic factors underlying the criteria, and they are the result of a process of generalization to reduce complexity to a manageable spatial framework for a particular purpose. In addition, the boundaries of the ecoregions are often considered gradients rather than sharp edges or “true” boundaries, which are considered transition zones. These characteristics do not lend ecoregion maps and their boundaries to easy verification using conventional statistical measures (Bailey, 1983; Loveland & Merchant, 2004). Therefore, it is advisable that when attempting to quantitatively evaluate the IOTC candidate ecoregions to acknowledge (1) that the ecoregions are a compromise of three underlying thematic factors and (2) that the homogeneity that distinguishes an ecoregion from another is most manifested at the core of the region, while distinguishable characteristics are less clear at the periphery (the regional edges).

## 2. Methods

### 2.1 Data sources

We used two IOTC datasets and one CCSBT dataset (Table 5) to identify, map, and describe the most important fleets operating in each ecoregion (i.e., the core fleets) and characterize their main fishing gears and catch composition across each IOTC candidate ecoregion. The IOTC Nominal Catch dataset provides comprehensive information on the Nominal Catch for all species by year, IOTC area, fishery, fleet, and vessel flag, including species targeted and non-targeted (considered bycatch) by fleet. From the 1950s until 2022, the IOTC Nominal Catch dataset aggregates the annual catches in live weight of all tuna and tuna-like species and other species caught by tuna and tuna-like fisheries by year and IOTC statistical area. The IOTC Raised Catch dataset is the best scientific estimate of the raised Nominal Catch data, which contains georeferenced ($5^{o}$ x $5^{o}$) live weight data. This dataset covers explicitly the five main tuna and billfish species managed by IOTC (albacore tuna -*Thunnus alalunga*, bigeye tuna - *Thunnus obesus*, skipjack tuna - *Katsuwonus pelamis*, yellowfin tuna -*Thunnus albacares*, and swordfish - *Xiphias gladius*, Table 2, Figure 2). The IOTC Nominal Catch dataset is available on the IOTC website, whereas the IOTC Raised Catch dataset is available through request to IOTC's secretariat. The primary distinction between the Nominal Catch dataset and the Raised Catch dataset is whether the catches are georeferenced and the taxonomic completeness in the catch composition (Table 5). One additional dataset utilized to complete this analysis was the catch data from the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). The CCSBT catch dataset provides information on the catch by weight of southern bluefin tuna by year, month, gear, ocean, and 5-degree grid. CCSBT is the only tuna RFMO managing one tuna species, the southern bluefin tuna - *Thunnus maccoyii*.

### 2.2 Comparative analysis across IOTC candidate ecoregions

We qualitatively evaluate the degree of similarity and dissimilarity in terms of fleet composition and their catches across the IOTC candidate ecoregions.

#### *2.2.1 Identification of core fleets in each ecoregion*

We used the IOTC and CCSBT datasets (Table 5) to identify, map, and describe the most important fleets operating in each ecoregion (i.e. the core fleets). The IOTC Raised Catch dataset contains six gear groups and 132 fleets (fleet defined as the combination of GearGroup and FleetCode) reporting catches between 1950 and 2022 in the whole IOTC convention area. We examined the catches over the last 13 years (2010-2022) to provide a snapshot of the main fleets currently operating in the ecoregions. The identification of core fleets for each ecoregion relied on a comprehensive and iterative methodology, incorporating a series of ranking and sequential filtering steps. These filters were designed to encapsulate the broad spectrum of fleets that could be deemed representative of a particular ecoregion's dynamics. Core fleets were defined as distinct combinations of flag States and fishing gear types (Table 3), meeting stringent criteria related to their catch volume, operational range, and activity intensity within an ecoregion. This methodological approach was consistently applied to identify core fleets within the nine ecoregions.

The initial step to identify core fleets involved identifying the total count of unique fleets from the IOTC Raised Catch dataset (Somali Current Ecoregion (SCE) = 56 fleets, North Central Coastal Province Ecoregion (NCCPE) = 32 fleets, Northeast Coastal Province Ecoregion (NECPE) = 26 fleets, Maldives Ecoregion (ME) = 30 fleets, Indian Ocean Monsoon Gyre Ecoregion (IOMGE) = 64 fleets, Indian Ocean Gyre Ecoregion (IOGE) = 48 fleets, Agulhas Current Ecoregion (ACE) = 34 fleets, Leeuwin Current Ecoregion (LCE) = 14 fleets, and Southern Ocean Ecoregion (SOE) = 40 fleets) that reported catches (between 2010-2022) in each ecoregion. Subsequently, a range of metrics and indicators were computed for each fleet to determine which fleets qualify as core fleets within each ecoregion. The initial indicators examined for each fleet using the Raised Catch dataset included:

- Indicator 1: The number of years with reported catches over the past 13 years for each fleet.
- Indicator 2: Presence of catch reporting in at least three out of the last six years for each fleet.
- Indicator 3: Percentage of the total catch of each fleet within the ecoregion relative to the total catch across the IOTC convention area for each fleet.
- Indicator 4: Percentage of the total fishing ground of each fleet within the ecoregion relative to the entire fishing ground across the IOTC area, measured in the number of pixels (5°x 5° degree squares) with reported catches.
- Indicator 5: Percentage of total catch of each fleet relative to the total catch of all fleets within an ecoregion.
- Indicator 6: Percentage of the fishing ground of each fleet relative to the ecoregion area, also measured in pixels (5°x 5° degree squares) with reported catches.

We applied three sequential filters to determine which fleets qualify as core fleets within each ecoregion (Figure 3). The first filter applied to the fleets within each ecoregion was temporal, utilizing the frequency of data reporting as a proxy for fleet activity. Fleets reporting data for at least three of the past six years (2016-2022) were retained, while the others were excluded. A second and third filter was applied to identify core fleets that are representative of only one ecoregion (termed regional fleet) and identify core fleets that can be representative of multiple ecoregions (termed across-regions fleets). The second filter consisted of two criteria aimed at identifying fleets with strong ties to the ecoregion (regional fleets), even if their catch volumes were comparatively lower. To pass this filter, a fleet had to demonstrate that at least 55% of its catch originated from within the ecoregion, or that at least 55% of its fishing activity occurred within its boundaries. For the remaining fleets, the third filter was applied, with two criteria, to identify if the fleet had a significant presence in the ecoregion in terms of catches and fishing activity (across-regions fleet). These across-region fleets had to capture in the ecoregion at least 1% of the total catch volume within the ecoregion over the past 13 years or conduct fishing operations across at least 40% of the area of the ecoregion.

### *2.2.2 Characterization of catch and gear composition in each ecoregion*

Building upon the core fleets identified for each ecoregion, we conducted an analysis to characterize historical catches within each ecoregion, disaggregating them by major target taxa and gear groups. This analysis involved utilizing both the IOTC Nominal Catch dataset and the IOTC Raised Catch dataset (with the SBT georeferenced catches included), as the allocation of catch to a fleet depended on the spatial extent of their catches and fishing grounds within ecoregions. The IOTC Nominal Catch dataset offers a broad taxonomic coverage, encompassing reported nominal catches for tuna and tuna-like species and other species caught in IOTC fisheries by each fleet. However, these reported catches lack georeferencing at a spatial resolution, enabling automatic assignment to specific ecoregions. Conversely, the IOTC Raised Catch dataset contains nominal catch data only for the five major commercial species, with georeferencing ($5^o$x $5^o$) facilitating direct assignment to ecoregions. Thus, catch data for each fleet were sourced from either the IOTC Nominal Catch dataset or the Raised Catch dataset, depending on the spatial distribution of catches and fishing grounds within the ecoregions. IOTC Nominal Catch data was attributed to a fleet when the majority of the catch and extension of fishing grounds occurred within the area of an ecoregion. Alternatively, the IOTC Raised Catch data was attributed to a fleet if its catches and fishing grounds spanned both inside and outside ecoregion areas, with only catches of the fleet within the ecoregion considered in such cases. This analysis offers a comprehensive overview of the species caught by the main core fleets in an ecoregion, along with their catch trends over time.

## 3. Results

### 3.1 Core fleet composition across IOTC candidate ecoregions

Each IOTC ecoregion exhibits a unique composition of core fleets, characterized by varying proportions of regional and across-regions fleets, which underscores the uniqueness of each ecoregion (Figures 4 and 5). In all the ecoregions, with the exception of the ACE, regional fleets dominate both in catch volume and fishing grounds, with the majority of their activities confined within the boundaries of each ecoregion (Figure 4, Table 6). Conversely, the ACE is the most different, distinguished by a significant presence of across-regions fleets (six out of seven core fleets), with only one regional fleet operating there (South Africa longline) (Figure 5G). This contrasts with other ecoregions where across-regions fleets represent a smaller proportion of the total fleet activity (e.g. SCE, IOMGE, and IOGE) or are not present at all. The NCCPE, ME, and SOE are entirely represented by regional fleets (Figure 5 B, D, and I).

The SCE has the larger number of core fleets (28 fleets, Figure 5A), followed by the two oceanic ecoregions: the IOMGE (11 fleets, Figure 5E) and IOGE (12 fleets, Figure 5F). The smaller coastal ecoregions (NCCPE, NECPE, ME, and LCE) have the smallest number of core fleets (ranging from three to five core fleets) (Figure 5 B, C, D, and G). The SOE also has a relatively small number of core fleets (seven), some of which span the entire area of the region and others confined to the southern Australian coast (Figure 5 I). The majority of core fleets (66 fleets) operate exclusively within a single ecoregion, indicating that their primary fishing activities and catch volumes are concentrated within that specific region (Figure 4). However, a subset of fleets (8 fleets) are classified as core fleets in two ecoregions, and three fleets are identified as core fleets across three ecoregions. This distribution reflects the predominantly localized operations of most fleets (the regional fleets), contrasted with the broader geographic range of the other core fleets (the across-regions fleets), particularly in oceanic regions where these across-regions fleets have a more extensive operational range and can be representative of multiple ecoregions.

The core fleets characteristic of each ecoregion typically catch or target species that are more localized to the ecoregion, highlighting the strong link between fleet operations and the ecological characteristics of each ecoregion, with tropical species dominating in equatorial coastal and oceanic areas, and temperate species being more prevalent in higher-latitude regions (Figure 6). The tropical coastal and oceanic ecoregions (SCE, NCCPE, NECPE, ME, IOMGE) are more dominated by fleets targeting (catching in more volume) skipjack and yellowfin tunas, along with other more neritic tropical species. The presence of fleets targeting neritic species such as kawakawa and narrow-barred Spanish mackerel is evident, especially in coastal ecoregions of SCE, NCCPE, and NECPE.

Conversely, more temperate coastal and oceanic ecoregions (IOGE, ACE, LCE, and SOE)  are characterized by fleets targeting more temperate species like southern bluefin tuna, swordfish, and albacore tuna. Therefore, there is a noticeable shift in species composition towards cooler-water species in these higher-latitude ecoregions. Furthermore, we observe that some species, such as yellowfin and skipjack, are common target species across multiple regions, indicating the broad distribution of these species in the Indian Ocean, while other species, such as southern bluefin tuna and swordfish, are primarily targeted in specific ecoregions (IOGE, ACE), highlighting the ecological and operational specialization of fleets in the different regions.

### 3.2 Catch composition of core fleets across IOTC candidate ecoregions

The large contribution of regional fleets to the overall catches within each ecoregion allows for a more detailed characterization of temporal catch patterns and species composition by the core fleets within each ecoregion (Figure 7). This is because the catch composition for the regional fleets is sourced from the IOTC Nominal Catch dataset, providing enhanced taxonomic resolution and enabling a more detailed characterization of temporal catch patterns by the core fleets within each ecoregion. In contrast, the catch data for across-regions fleets are derived from the IOTC Raised Catch dataset, which has the advantage that the catch is georeferenced to specific ecoregions but comes with reduced taxonomic resolution.

The specific composition of catches and temporal patterns of the catch differ significantly between ecoregions, with some ecoregions showing the dominance of certain species like skipjack tuna (e.g. ME), while others exhibit a broader mix of species (e.g. SCE) (Figure 8):

- The SCE is dominated by yellowfin and skipjack tuna, with significant contributions from neritic small tunas and seerfishes (frigate Tuna and Indo-Pacific king mackerel). There have also been small catches of various shark species, especially in recent years.
- The NCCPE is mostly dominated by neritic small tunas and seerfishes (e.g. frigate tuna and Indo-Pacific king mackerel), followed by yellowfin tuna catches, with an increase of reported shark catches in recent years.

- The NECPE is dominated by skipjack and yellowfin tuna, with significant contributions from neritic small tunas and seerfishes (frigate tuna and Indo-Pacific king mackerel).
- The historical catches in the ME ecoregion are predominantly skipjack and yellowfin tunas.
- In more oceanic ecoregions, the more tropical IOMGE is dominated by catches of the three tropical tunas (skipjack, yellowfin, and bigeye tunas), while the more subtropical-temperate IOGE is dominated by a mix of tropical tunas and larger proportion of catches of albacore tuna, swordfish, and blue shark.
- The ACE is dominated by a mix of tropical tunas and a larger proportion of catches of albacore, swordfish, blue shark, and some southern bluefin tuna.
- The SOE and LCE are dominated by catches of southern bluefin tuna, especially in early periods.

The composition of fishing gears also varies across different ecoregions (Figure 9):

- In the SCE, gillnets dominate the catch, followed by line and purse seine fisheries, with a gradual increase in line and purse seine fisheries from the 1980s to 2022.
- Similar to the SCE, in the NCCPE, gillnets dominate the catch, followed by line and purse seine fisheries.
- In the NECPE, the purse seine dominates the catches, followed by other gears and line fisheries.
- In contrast, the ME is dominated by baitboat catches, reflecting a unique gear composition in this region.
- The IOMGE is dominated largely by purse seine catches and, to a lesser extent, longline, gillnet, and line fisheries, while the IOGE is characterized by a significant presence of longlines, alongside contributions from lines and gillnets, particularly in the more recent years.
- Longlines are the dominant gear in the ACE, while in the LCE, other gears predominated in the early years, currently dominating longline fisheries.
- Last, in the SOE, longlines mainly contributed to the catches in the early years, while line fisheries do in more recent years.

## 4. Discussion

This comparative analysis seeks to validate the regionalization framework by assessing the expected qualities and attributes of the nine IOTC candidate ecoregions. The main attributes under evaluation are (1) whether ecoregions demarcate areas with distinct communities of tuna and tuna-like species (targeted IOTC species) and (2) whether ecoregions demarcate areas where unique fisheries and fleets operate, targeting similar IOTC species, including both artisanal and commercial fisheries. After analyzing the degree of similarity and dissimilarity in the fleet, fisheries, and their catch composition among ecoregions, the analysis revealed that each IOTC ecoregion has a unique composition of core fleets, with regional fleets dominating in most ecoregions, except for the ACE, where across-regions fleets are more prominent. Catch compositions also vary significantly across ecoregions, with tropical species like skipjack and yellowfin tuna being prevalent in equatorial regions, while temperate species such as southern bluefin tuna and swordfish dominate in higher latitude ecoregions. Additionally, fishing gear usage patterns differ between ecoregions, reflecting the distinct cultural, ecological and operational characteristics of each area. Firstly, we address the challenges encountered in characterizing core fleets and historical catch patterns across the nine ecoregions using IOTC fishery statistical datasets. Later, we recommend potential refinements and adjustments for the IOTC candidate ecoregions.

Challenges in characterizing core fleets at the ecoregion level primarily stem from the coarse spatial resolution of the IOTC Raised Catch dataset, which is based on 5x5 degree grids. This resolution is often too broad for accurately assigning catches to smaller or narrower ecoregions, particularly those demarcated by continental shelves (ME, NCCPE, and NECPE). To address this, one approach could be to assume that all catches within the Exclusive Economic Zones (EEZs) of countries adjacent to these ecoregions are allocated to the corresponding ecoregion. Alternatively, extending the boundaries of ecoregions to align with national EEZs could provide a more accurate reflection of the fishing activities of fleets operating in more coastal waters. Another challenge arises from the potential misallocation of fleets (that are primarily oceanic) to coastal ecoregions due to the large grid size of the catch datasets, as some fleets may appear in coastal areas where they are not authorized to fish, such as Indian fleets within the Maldives EEZ or Indonesian fleets within the Australian EEZ. This issue could be mitigated by incorporating expert knowledge to verify whether these fleets are permitted to operate within the EEZs of other countries.

Characterizing historical catches and species composition of core fleets within each ecoregion also presents challenges, particularly regarding the accuracy and completeness of taxonomic reporting within each ecoregion. The quality and completeness of the catch data differs across ecoregions depending on whether it is sourced from the IOTC Nominal Catch dataset or the IOTC Raised Catch dataset. Ecoregions where regional fleets contribute significantly to overall catches (e.g. NCCPE, ME, SOE) benefit from better characterization of temporal catch patterns, as the Nominal Catch dataset provides higher taxonomic resolution. In contrast, in ecoregions where across-regions fleets are more predominant (e.g. IOGE and ACE) their catches are derived from the IOTC Raised Catch dataset, which offers georeferenced information but with reduced taxonomic resolution and completeness. To improve the spatial characterization of the historical catches within the IOTC convention area, the IOTC should continue to encourage the submission of spatially disaggregated catch data at the highest possible resolution and enhance the IOTC Raised Catch dataset by including a broader range of species and refining estimates for fleets that do not report georeferenced catches.

We present the following recommendations to guide future refinements of the IOTC candidate ecoregions within the Indian Ocean. These refinements are critical for enhancing the ecological representation of both coastal and oceanic ecoregions, with a particular focus on improving the differentiation between tropical and temperate marine ecosystems that are associated with IOTC species and fisheries. Refining ecoregions is essential for supporting the implementation of the EAFM, as it facilitates more accurate ecosystem-based planning, research, and the development of advisory products that are tailored to the unique ecological characteristics of each region.

- **Treatment of coastal areas as distinct ecoregions.** Currently, certain coastal areas adjacent to continental landmasses bordering the Indian Ocean are part of oceanic ecoregions rather than being designated as coastal ecoregions. Specifically, coastal areas of southern Indonesia, northern Australia, and southern Australia are included within an oceanic ecoregion (IOGE), despite their proximity to continental landmasses and having regional coastal fleets targeting tuna and tuna-like species. To improve the ecological and fisheries representation in IOTC ecoregions, it is recommended that all coastal continental areas in the Indian Ocean be delineated as coastal ecoregions, either as unique ecoregions or as subregions within a hierarchical regionalization framework. This approach would more accurately reflect the activities of coastal fleets operating in nearshore environments, targeting species such as neritic tunas and seerfishes, and differentiate them from fleets primarily operating in oceanic regions targeting pelagic tuna and tuna-like species.

- **Extension of coastal ecoregion boundaries to include the Exclusive Economic zones.** Coastal ecoregions defined primarily by their continental shelves, such as the NCCPE, the NECPE and ME, could be extended to encompass their entire Exclusive Economic Zones (EEZs). The current narrow delineations of these ecoregions do not adequately represent and fully capture the extent of the fishing grounds utilized by coastal fleets targeting IOTC species. Additionally, the low spatial resolution of IOTC fishery datasets (5x5 degree grids) complicates the accurate assignment of catches to these narrowly defined ecoregions. Expanding these ecoregions to align with EEZ boundaries would improve the precision of mapping fleet activities of coastal fisheries and species distributions of neritic species, thereby enhancing the ecological and operational representation within these regions.

- **Reclassification of the Northern ACE:** The northern area of the ACE is characterized by higher catches of tropical tunas, primarily by purse seine fleets. This region's ecological and fisheries characteristics align more closely with the SCE or the IOMGE. To improve the accuracy of regional classifications, it is recommended that this area be re-evaluated for potential inclusion within one of these adjacent ecoregions, which more accurately reflect the region's species composition, fisheries dynamics, and underlying oceanographic conditions.

- **Reevaluation of the Indonesian Throughflow:** The eastern coastal region of the IOGE, encompassing the Indonesian Throughflow, is characterized by a catch composition dominated by tropical tuna and tuna-like species, predominantly harvested by Indonesian fleets. Considering the ecological and fisheries characteristics of this area, it may be more accurately classified as part of the Indian Ocean Monsoon Gyre or Northern Coastal Province ecoregions. Such reclassification would better align this region with similar areas in terms of species composition, fisheries operations, and oceanographic features.

## 5. Conclusions

This comparative analysis seeks to validate the regionalization framework by assessing the expected qualities and attributes of the nine IOTC candidate ecoregions, and provides recommendations for potential refinements and adjustments. The study highlights the necessity of refining the ecoregions to better capture the ecological and fisheries dynamics of IOTC fisheries of both coastal and oceanic ecosystems, as well as the distinction between tropical and temperate systems of tuna and tuna-like communities within the Indian Ocean. By addressing the challenges associated with identifying core fleets and characterizing their historical catches at the ecoregion level, we can improve the delineations of ecoregions to ensure they are characterized by relatively homogeneous ecosystems, intended to serve as analytical units to support ecosystem planning, incentivize ecosystem research, and the development of advice products for the integrated management of fisheries resources in IOTC. The recommended adjustments, namely (i) delineating coastal areas as distinct ecoregions, (ii) aligning coastal ecoregion boundaries with EEZs, and (iii) reclassifying specific regions, such as Northern ACE and the Indonesian Throughflow**,** are critical steps toward enhancing the utility of ecoregions for ecosystem-based planning in IOTC. These efforts will ultimately contribute to more sustainable and informed fisheries management advice in IOTC, ensuring that management advice is better aligned with the unique ecological and fisheries characteristics of each region.

## 6. References

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## 7. Main Figures

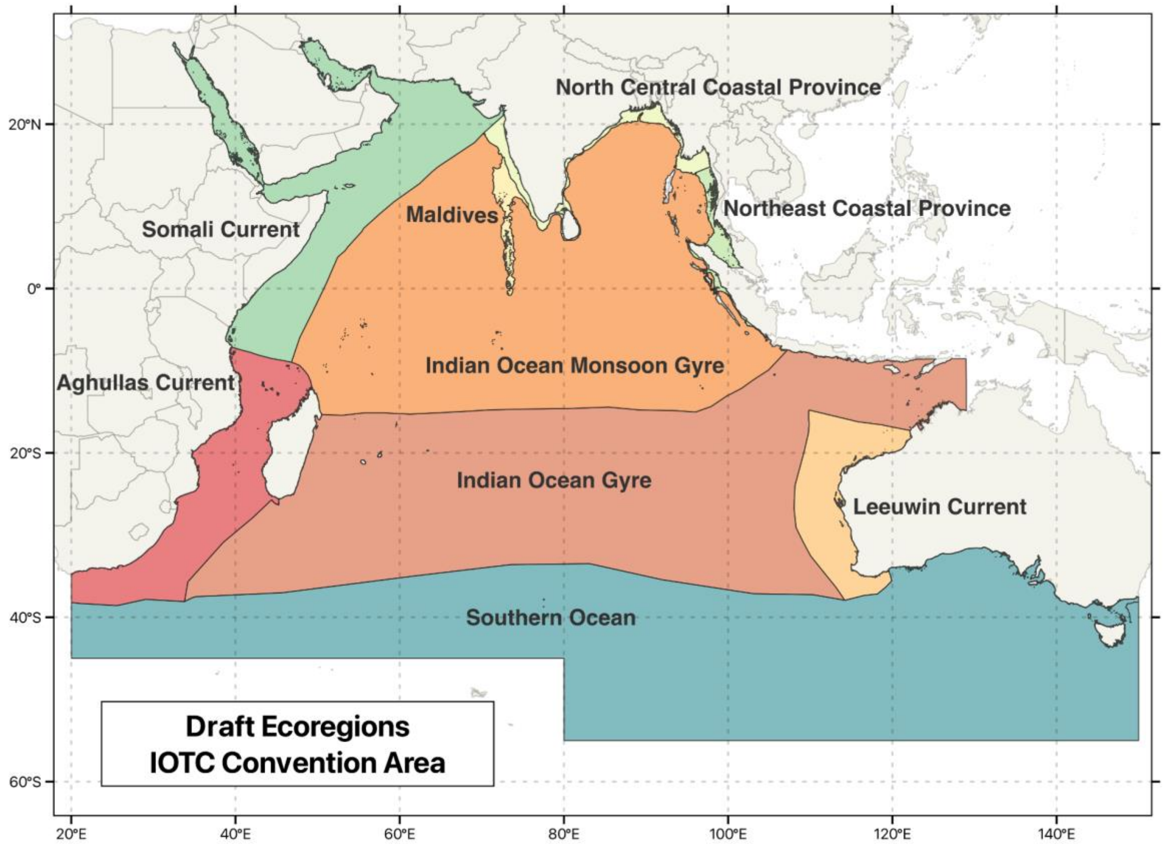



Figure 1 - Candidate ecoregions within the IOTC convention area refined during the second IOTC ecoregion workshop (Juan-Jorda et al., 2022).

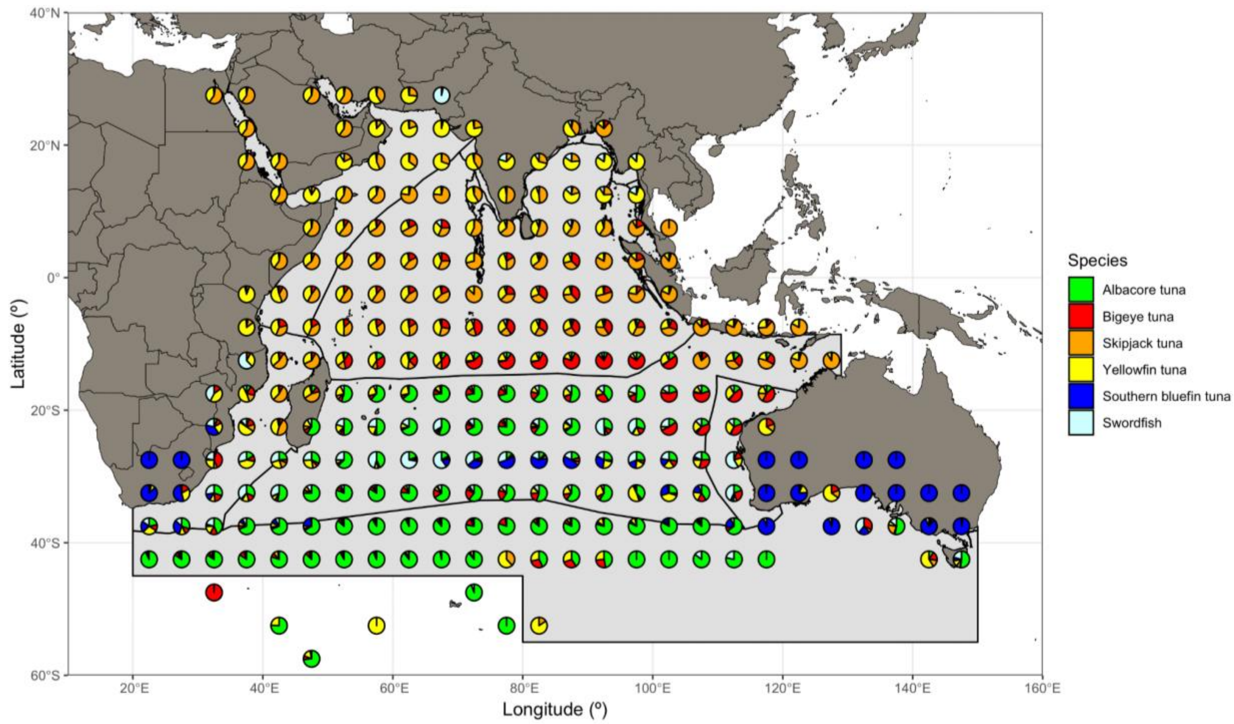



Figure 2 - Average catch composition (between 2010 - 2022) for the main IOTC species (six tuna and tuna-like species) across the 132 fleets operating in the IOTC convention area

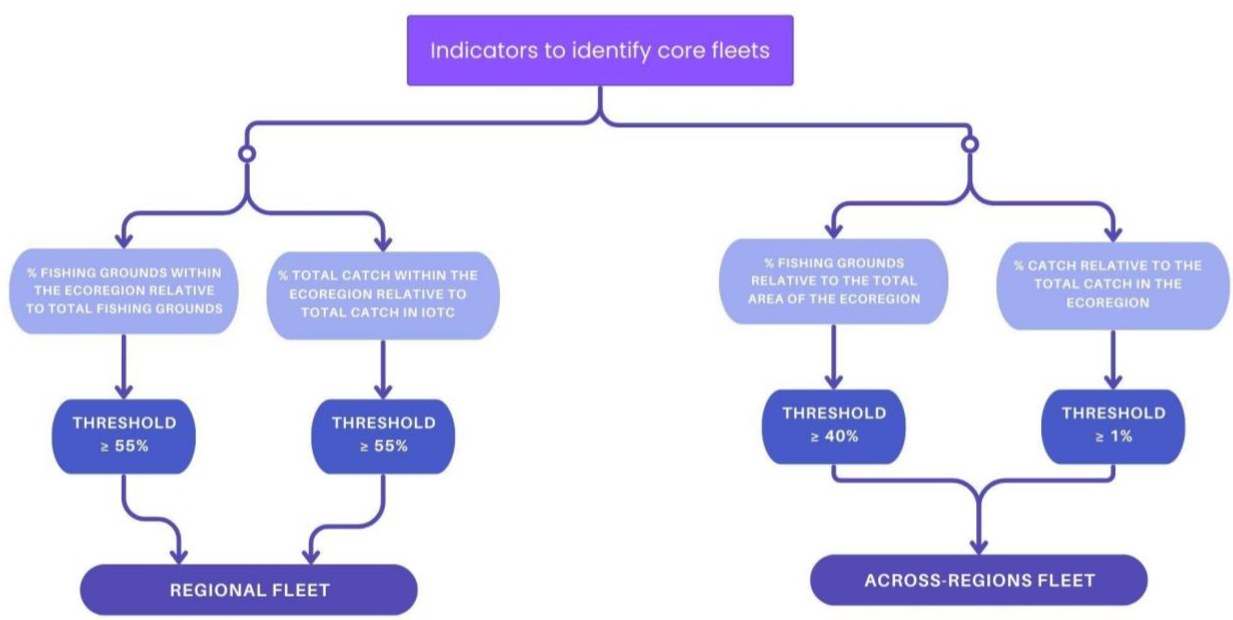



Figure 3 - Criteria and Indicators to identify core fleets within each ecoregion

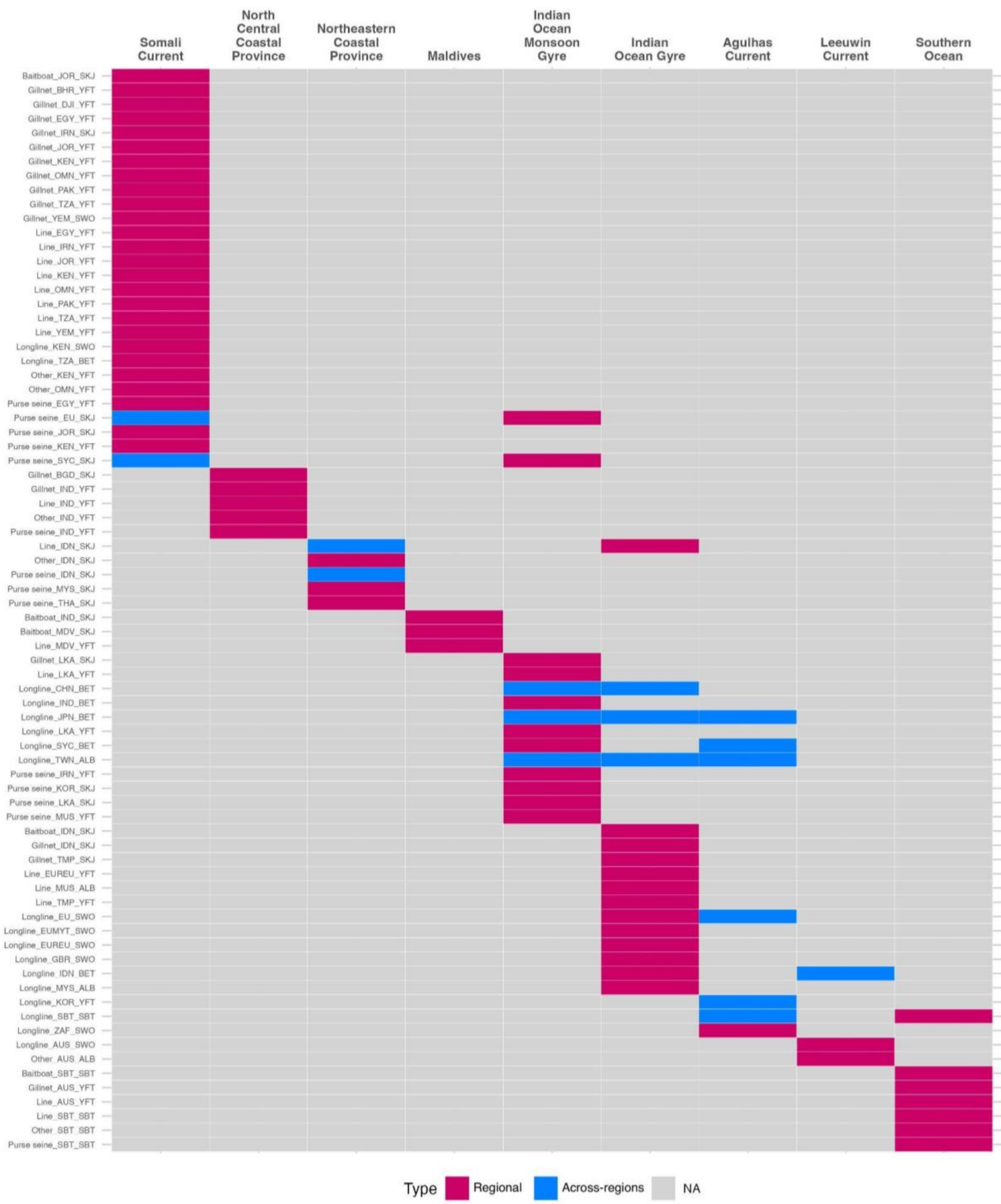
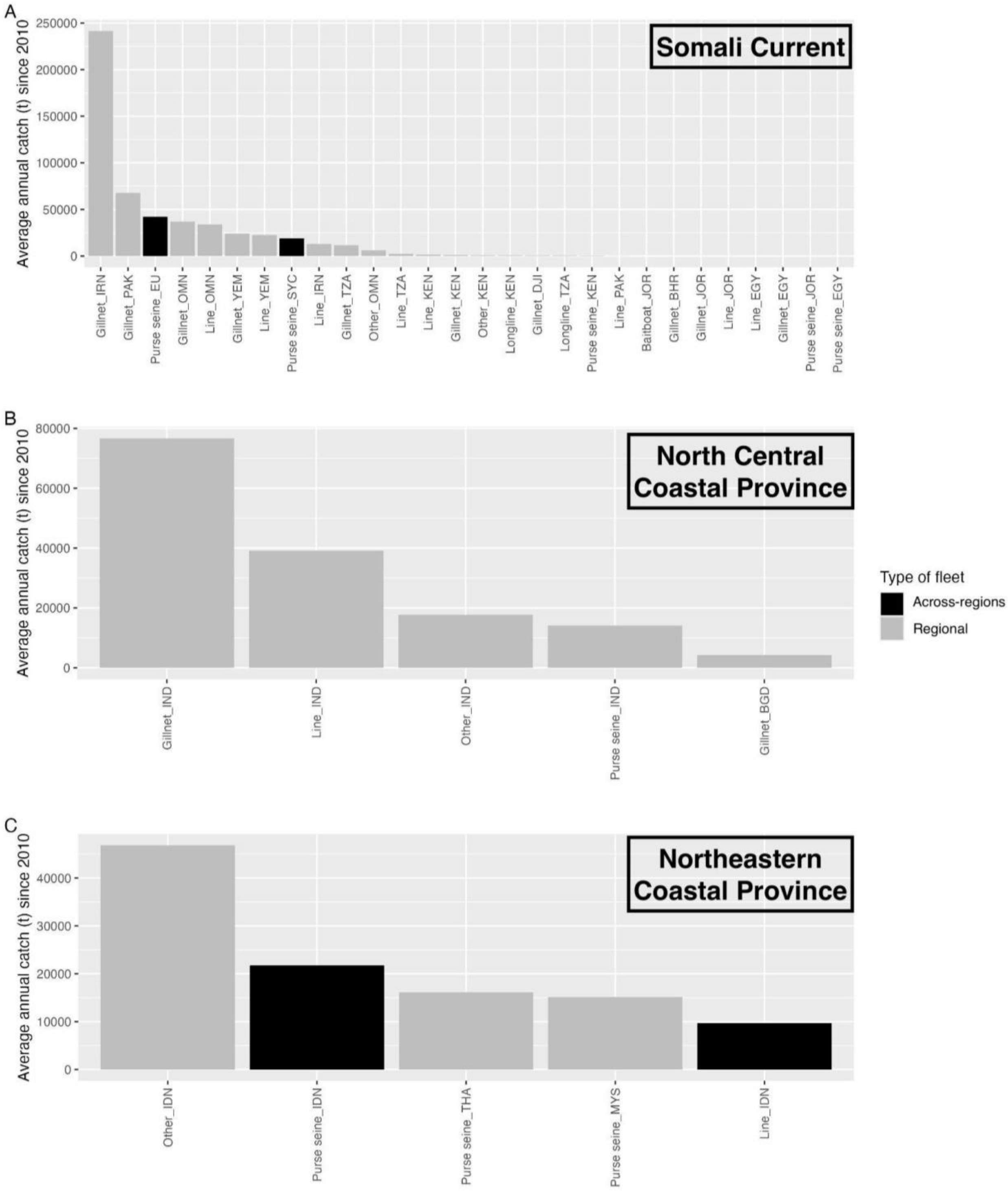
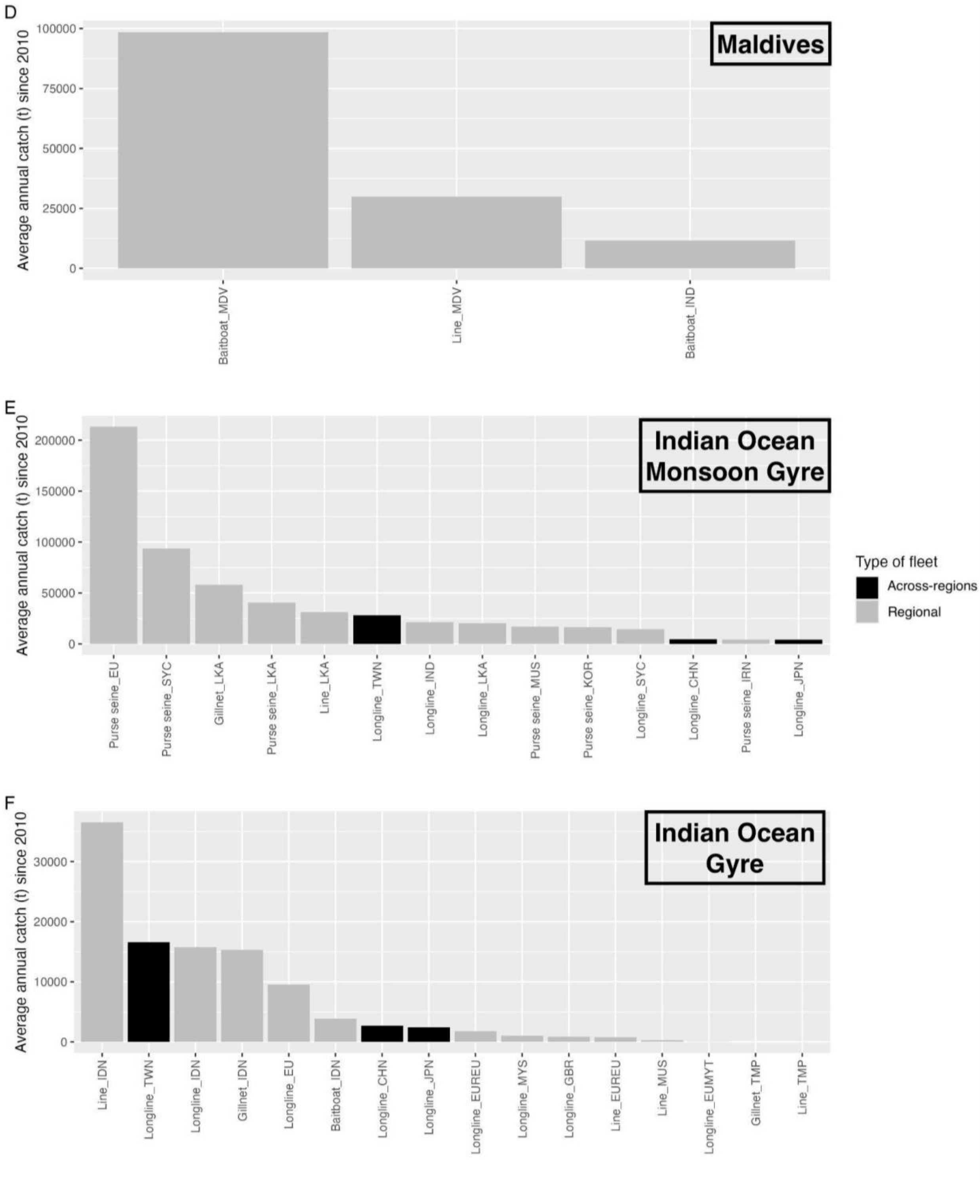



Figure 4 - Comparative analysis of fleet composition across IOTC candidate ecoregions, categorized by fleet type (regional and across-regions fleets). The x-axis lists the different ecoregions ordered from more coastal tropical ecoregions to tropical oceanic ecoregions, to temperate coastal and oceanic ecoregions. The y-axis list specific fleets (with fishing gear and flag state) and have been ranked based on their primary target species (most caught species) following this order (skipjack tuna, yellowfin tuna, bigeye tuna, albacore, swordfish, southern bluefin tuna).


A
Somali Current
Average annual catch (t) since 2010
250000
200000
150000
100000
50000
0
Gillnet_IRN
Gillnet_PAK
Purse seine_EU
Gillnet_OMN
Line_OMN
Gillnet_YEM
Line_YEM
Purse seine_SYC
Line_IRN
Gillnet_TZA
Other_OMN
Line_TZA
Line_KEN
Gillnet_KEN
Other_KEN
Longline_KEN
Gillnet_DJI
Longline_TZA
Purse seine_KEN
Line_PAK
Baitboat_JOR
Gillnet_BHR
Gillnet_JOR
Line_JOR
Line_EGY
Gillnet_EGY
Purse seine_JOR
Purse seine_EGY
B
North Central Coastal Province
Average annual catch (t) since 2010
80000
60000
40000
20000
0
Gillnet_IND
Line_IND
Other_IND
Purse seine_IND
Gillnet_BGD
Type of fleet
Across-regions
Regional
C
Northeastern Coastal Province
Average annual catch (t) since 2010
40000
30000
20000
10000
0
Other_IDN
Purse seine_IDN
Purse seine_THA
Purse seine_MYS
Line_IDN


D
Maldives
Average annual catch (t) since 2010
100000
75000
50000
25000
0
Baitboat_MDV
Line_MDV
Baitboat_IND
E
Indian Ocean Monsoon Gyre
Average annual catch (t) since 2010
200000
150000
100000
50000
0
Purse seine_EU
Purse seine_SYC
Gillnet_LKA
Purse seine_LKA
Line_LKA
Longline_TWN
Longline_IND
Longline_LKA
Purse seine_MUS
Purse seine_KOR
Longline_SYC
Longline_CHN
Purse seine_IRN
Longline_JPN
Type of fleet
Across-regions
Regional
F
Indian Ocean Gyre
Average annual catch (t) since 2010
30000
20000
10000
0
Line_IDN
Longline_TWN
Longline_IDN
Gillnet_IDN
Longline_EU
Baitboat_IDN
Longline_CHN
Longline_JPN
Longline_EUREU
Longline_MYS
Longline_GBR
Line_EUREU
Line_MUS
Longline_EUMYT
Gillnet_TMP
Line_TMP

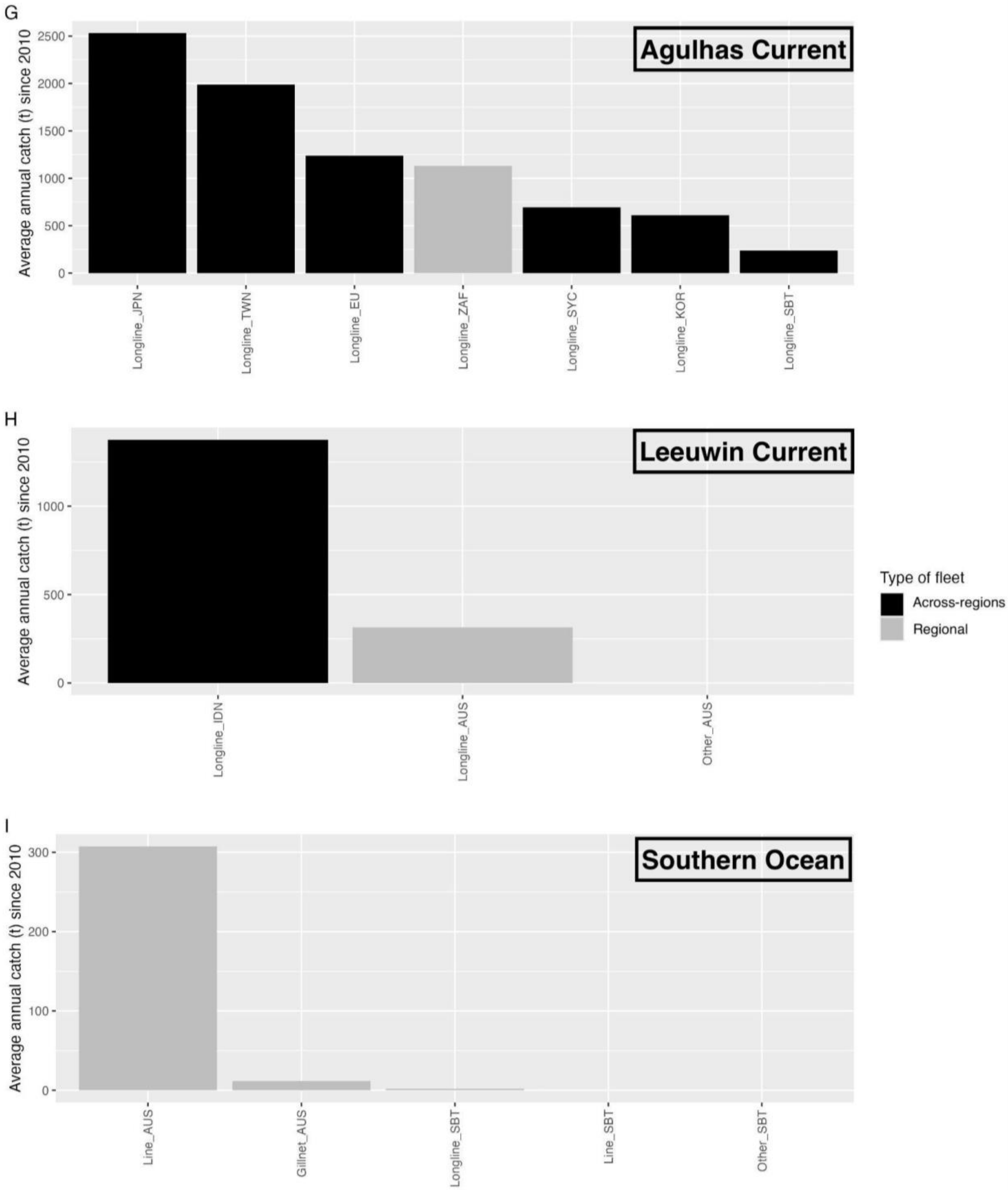



Figure 5 - Core fleets identified in each of the IOTC candidate ecoregions. (A) SCE, (B) NCCPE, (C ) NECPE, (D) ME, (E) IOMGE, (F) IOGE , (G) ACE, (H) LCE, (I) SOE

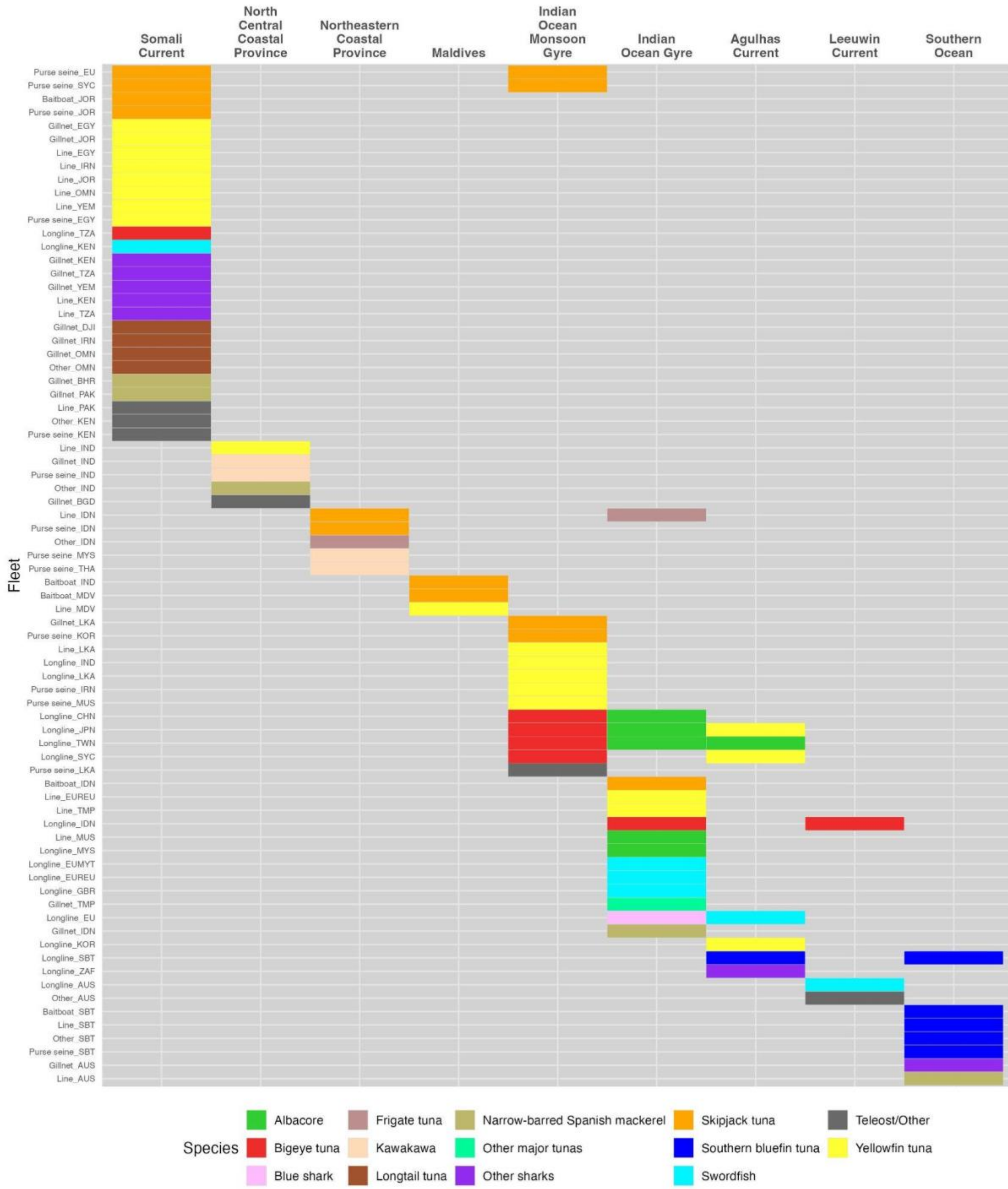



Figure 6 - Comparative analysis of fleet composition across IOTC candidate ecoregions, categorized by primary species target in each fleet (in terms of volume of catches). The x-axis lists the different ecoregions ordered from more coastal tropical ecoregions to tropical oceanic ecoregions, to temperate coastal and oceanic ecoregions. The y-axis lists specific fleets (with fishing gear and flag state) and has been ranked based on their primary target species (most caught species) following this order (skipjack tuna, yellowfin tuna, bigeye tuna, albacore, swordfish, southern bluefin tuna).

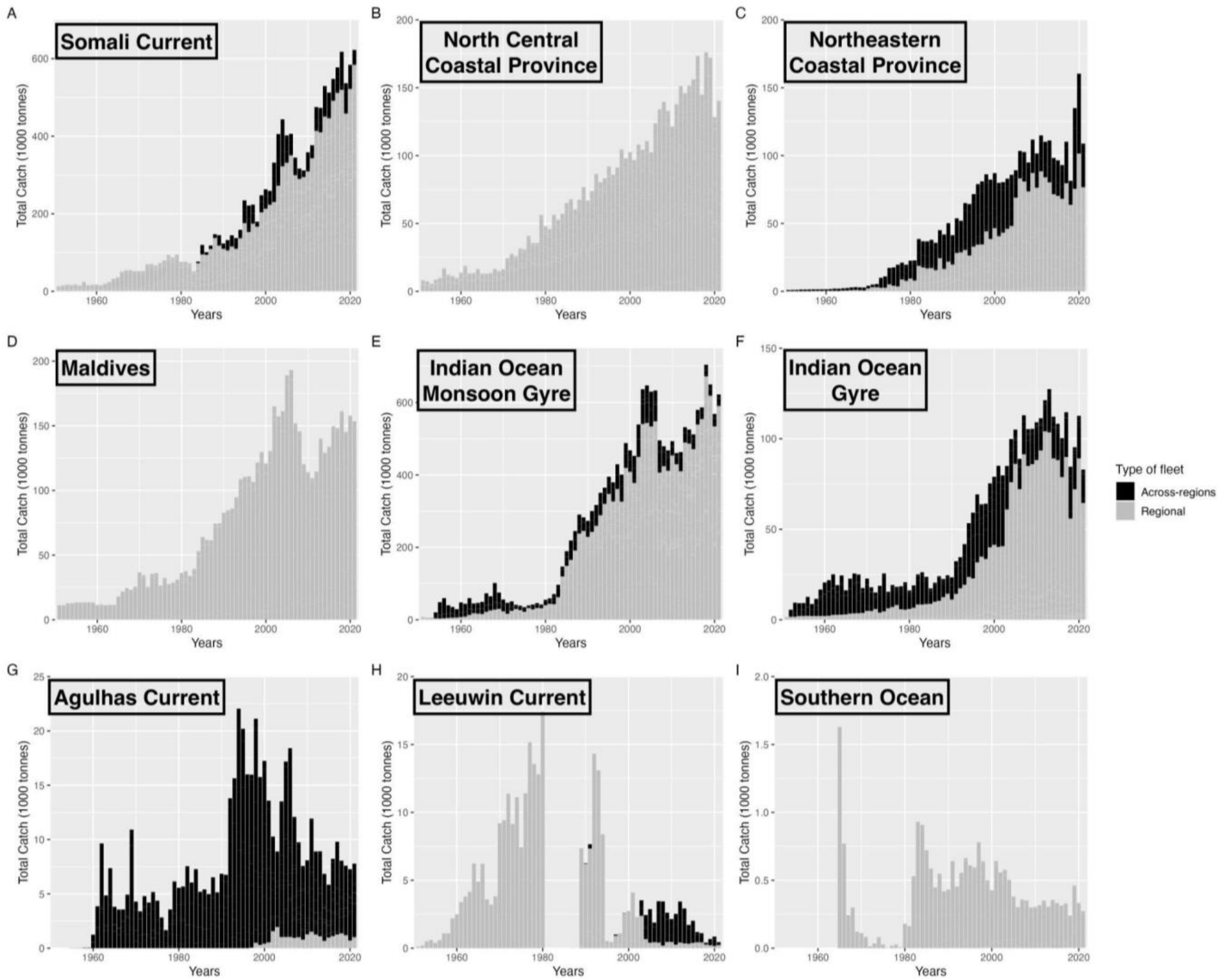



Figure 7 - Historical catches in each IOTC candidate ecoregion between 1950 and 2022 disaggregated by source of data. Catches are sourced from the core fleets identified in each ecoregion.

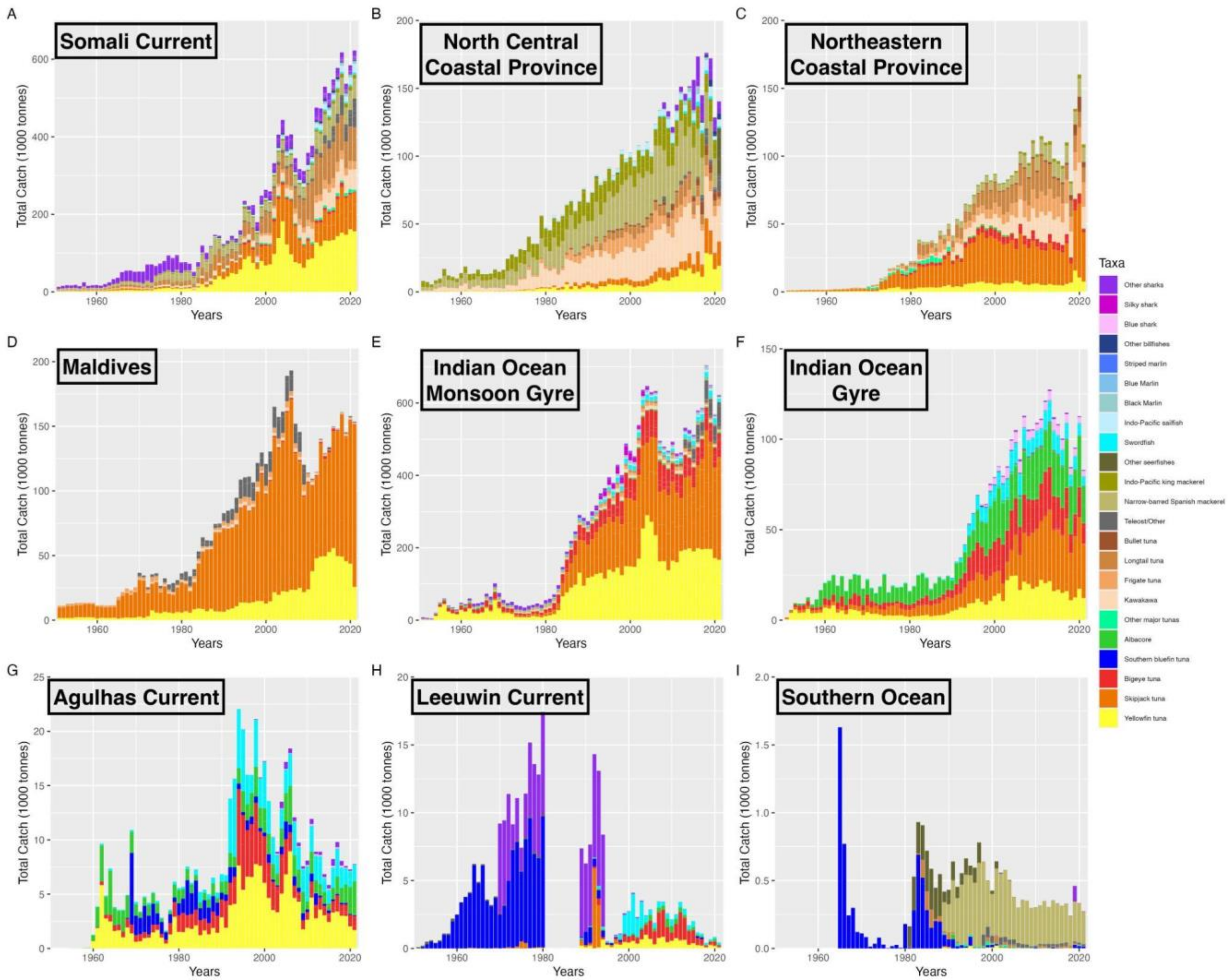



Figure 8 - Historical catches in each IOTC candidate ecoregion between 1950 and 2022 disaggregated by taxa groups. Catches are sourced from the core fleets identified in each ecoregion.

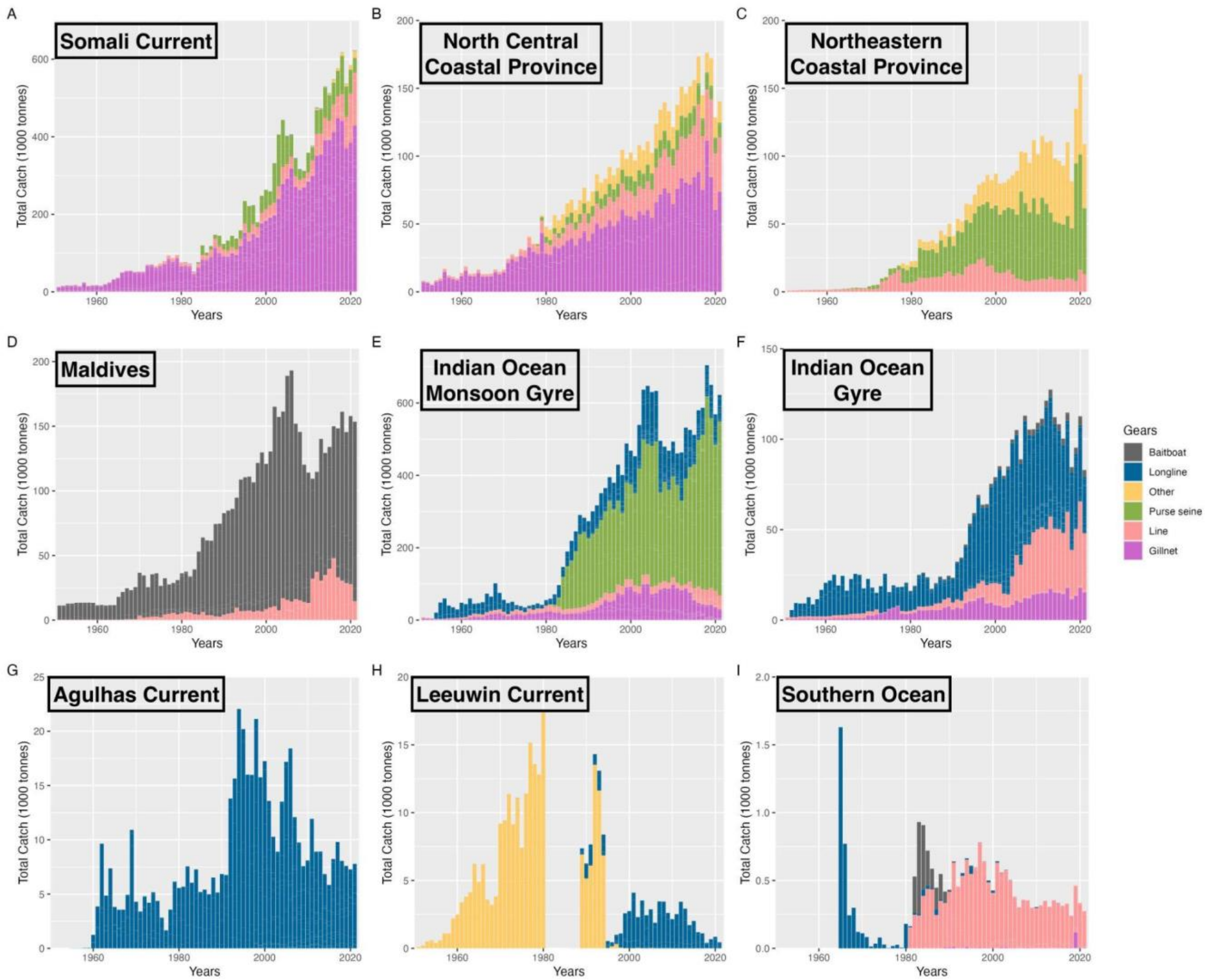



Figure 9. Historical catches in each IOTC candidate ecoregion between 1950 and 2022 disaggregated by type of fishing gear. Catches are sourced from the core fleets identified in each ecoregion.

## 8. Main Tables

Table 1. IOTC candidate ecoregion (full names and acronyms).

| **Ecoregion name** | **Acronym** |
|---|---|
| Somali Current Ecoregion | **SCE** |
| Maldives Ecoregion | **ME** |
| North Central Coastal Province Ecoregion | **NCCPE** |
| Northeast Coastal Province Ecoregion | **NECPE** |
| Indian Ocean Monsoon Gyre Ecoregion | **IOMGE** |
| Agulhas Current Ecoregion | **ACE** |
| Indian Ocean Gyre Ecoregion | **IOGE** |
| Leeuwin Current Ecoregion | **LCE** |
| Southern Ocean Ecoregion | **SOE** |

Table 2. IOTC major tuna and tuna-like species. *These are the five major species covered in the georeferenced Raised Catch dataset (see Table 5).

| Taxa group | Common name | Acronym | Latin name | Climate |
|---|---|---|---|---|
| *Billfishes* | Black marlin | **BLM** | *Istiompax indica* | Subtropical |
| | Blue marlin | **BUM** | *Makaira nigricans* | Subtropical |
| | Striped marlin | **MLS** | *Kajikia audax* | Subtropical |
| | *Swordfish | **SWO** | *Xiphias gladius* | Subtropical |
| | Indo-Pacific sailfish | **SFA** | *Istiophorus platypterus* | Subtropical |
| *Neritic tunas* | Bullet tuna | **BLT** | *Auxis rochel* | Subtropical |
| | Frigate tuna | **FRI** | *Auxis thazard* | Subtropical |
| | Kawakawa | **KAW** | *Euthynnus affinis* | Subtropical |
| | Longtail tuna | **LOT** | *Thunnus tonggol* | Subtropical |
| | Indo-Pacific king mackerel | **GUT** | *Scomberomorus guttatus* | Subtropical |
| | Narrow-barred Spanish mackerel | **COM** | *Scomberomorus commerson* | Subtropical |
| *Temperate tunas* | *Albacore | **ALB** | *Thunnus alalunga* | Temperate |
| | Southern bluefin tuna | **SBT** | *Thunnus maccoyii* | Temperate |
| *Tropical tunas* | *Bigeye tuna | **BET** | *Thunnus obesus* | Tropical |
| | *Skipjack | **SKJ** | *Katsuwonus pelamis* | Tropical |
| | *Yellowfin tuna | **YFT** | *Thunnus albacares* | Tropical |

Table 3. Main fisheries gear groups operating in the IOTC convention area

| **Main gears** | **Acronym** |
|---|---|
| Baitboat | **BB** |
| Gillnet | **GL** |
| Line | **LI** |
| Longline | **LL** |
| Other gear | **OT** |
| Purse seine | **PS** |

Table 4- Core criteria establishing the main thematic factors used to guide the ecoregion delineation and the expected qualities of the ecoregion based on the chosen criteria.

| **Core thematic factors** | **Expected qualities of the ecoregions** |
|---|---|
| The oceanography and biogeography of the water column:<br><br>Rationale: Understanding the major oceanographic and biogeographic aspects of the water column offers valuable insights into the spatial distribution of marine species and ecological processes. Integrating knowledge of both the physical and biological aspects of the water column, particularly those related to lower trophic levels, into an ecological delineation helps identify ecologically meaningful units based on shared oceanographic characteristics. | •The boundaries of proposed ecoregions appropriately delineate areas with clear oceanographic and biogeographic justifications and are characterized by distinct oceanographic and biogeographic features.<br>•Ecoregions characterized by similar oceanographic and biogeographic features are likely to exhibit comparable ecological communities and ecosystem processes, making them suitable units for informing EAFM implementation.<br>•It should be feasible to establish connections between ecosystem planning and ecosystem research, as well as the development of ecosystem assessments and advice products to support the delivery of integrated fisheries management advice. |
| The core distribution of main IOTC targeted species:<br><br>Rationale: Understanding the distribution of the main IOTC species (main targeted species) and species communities they form is crucial for characterizing the composition and structure of ecosystems within ecoregions. By identifying and characterizing species communities, insights into the ecological context of each ecoregion can be gained, including species interactions, trophic relationships, and ecosystem dynamics. | •The proposed ecoregions demarcate areas with a distinct community of tuna and tuna-like species (targeted IOTC species), thus, an ecoregion is likely to exhibit relatively homogenous ecological communities and ecosystem processes.<br><br>•Incorporating information on species communities into ecoregion delineation supports integrated science and management approaches that consider the broader ecological context of fisheries management. |

| | |
|---|---|
| The spatial dynamics and core fishing grounds of main IOTC fisheries:<br><br>Rationale: Identifying the primary fishing grounds of major IOTC fisheries, along with areas where a set of fisheries are targeting similar IOTC species, enables the development of region-wide products (e.g., bycatch assessments, ecosystem assessments). Additionally, fisheries activities can have cascading effects on marine ecosystems. Therefore, delineating ecoregions based on the spatial patterns of major fisheries facilitates the assessment of ecosystem-wide impacts and cumulative effects of multiple fisheries, supporting mixed fisheries and multi-species advice. | •The proposed ecoregions demarcate areas where a unique set of fisheries operate, targeting similar IOTC species, including both artisanal and commercial fisheries.<br>•The proposed ecoregions are characterized by a distinct set of IOTC fisheries targeting similar IOTC species.<br>•Since an ecoregion will encompass an area where multiple fisheries operate, leading to spatial overlap in fishing activities, it should allow for coordinated efforts to connect ecosystem planning and research, as well as the development of bycatch and ecosystem assessments to effectively provide integrated advice and support integrated management (e.g. mixed fisheries scenarios, cumulative impacts of fisheries). |

Table 5. IOTC and CCSBT fishery statistics datasets used in the analyses.

| Name | Description | Advantages | Disadvantages |
|---|---|---|---|
| *Nominal Catch dataset* | Nominal Catches by year (1950 to 2022), IOTC area, fleet, fishery, gear, and species, including bycatch species. | Better taxonomic resolution and completeness. 214 different taxa reported. Publicly available. | Catch data not georeferenced. |
| *Raised Catch dataset* | Estimated raised georeferenced catches (weight and number) for main species by year (1950 to 2022), quarter, 5x5 degree grid, fleet, fishery, and species. | Catch data georeferenced. | Poor taxonomic completeness since catch only available for five tuna and tuna-like species. Only available through request. |
| *CCSBT catch dataset* | Estimated georeferenced catches (weight) for SBT by year (1965 to 2022), month, gear, ocean, and 5x5 degree grid. | Catch data georeferenced. Publicly available. | Difficulties integrating the dataset with IOTC data. |

Table 6. Average indicator values describing the attributes of regional fleets and across-regions fleets in each ecoregion.

| | | Core fleets | | | | Regional fleets | | Long-distance fleets | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | % total catch within the Ecoregion relative to total catch in IOTC | % fishing ground within the ecoregion relative to total fishing ground | % catch relative to the total catch in the ecoregion | % fishing grounds relative to the total area of the ecoregion |
| **Ecoregion** | **Reporting fleets since 2010** | **Total** | **Regional** | **Long-distance** | **% Catch from the core fleets within the ecoregion** | **Average** | **Average** | **Average** | **Average** |
| **Somali Current** | 55 | 28 | 26 | 2 | 95 | 96,05 | 90 | 13,76 | 39,06 |
| **North Central Coastal Province** | 31 | 5 | 5 | - | 54 | 70 | 59,53 | - | - |
| **Northeast Coastal Province** | 25 | 5 | 3 | 2 | 99 | 64,93 | 24,48 | 39,65 | 57,14 |
| **Maldives** | 29 | 3 | 3 | - | 96 | 98,13 | 39,22 | - | - |
| **Indian Ocean Monsoon Gyre** | 63 | 14 | 11 | 3 | 87 | 81,51 | 35 | 2,74 | 89,28 |
| **Indian Ocean Gyre** | 47 | 15 | 12 | 3 | 70 | 88,61 | 73,61 | 5,12 | 80,73 |
| **Agulhas Current** | 33 | 7 | 1 | 6 | 69 | 98,1 | 52,63 | 11,46 | 81,95 |
| **Leeuwin Current** | 13 | 3 | 2 | 1 | 58 | 95,6 | 60,72 | 49 | 50 |
| **Southern Ocean** | 39 | 7 | 7 | - | 46 | 84,5 | 78,31 | - | - |

## Annex 1 - Supplement material figures

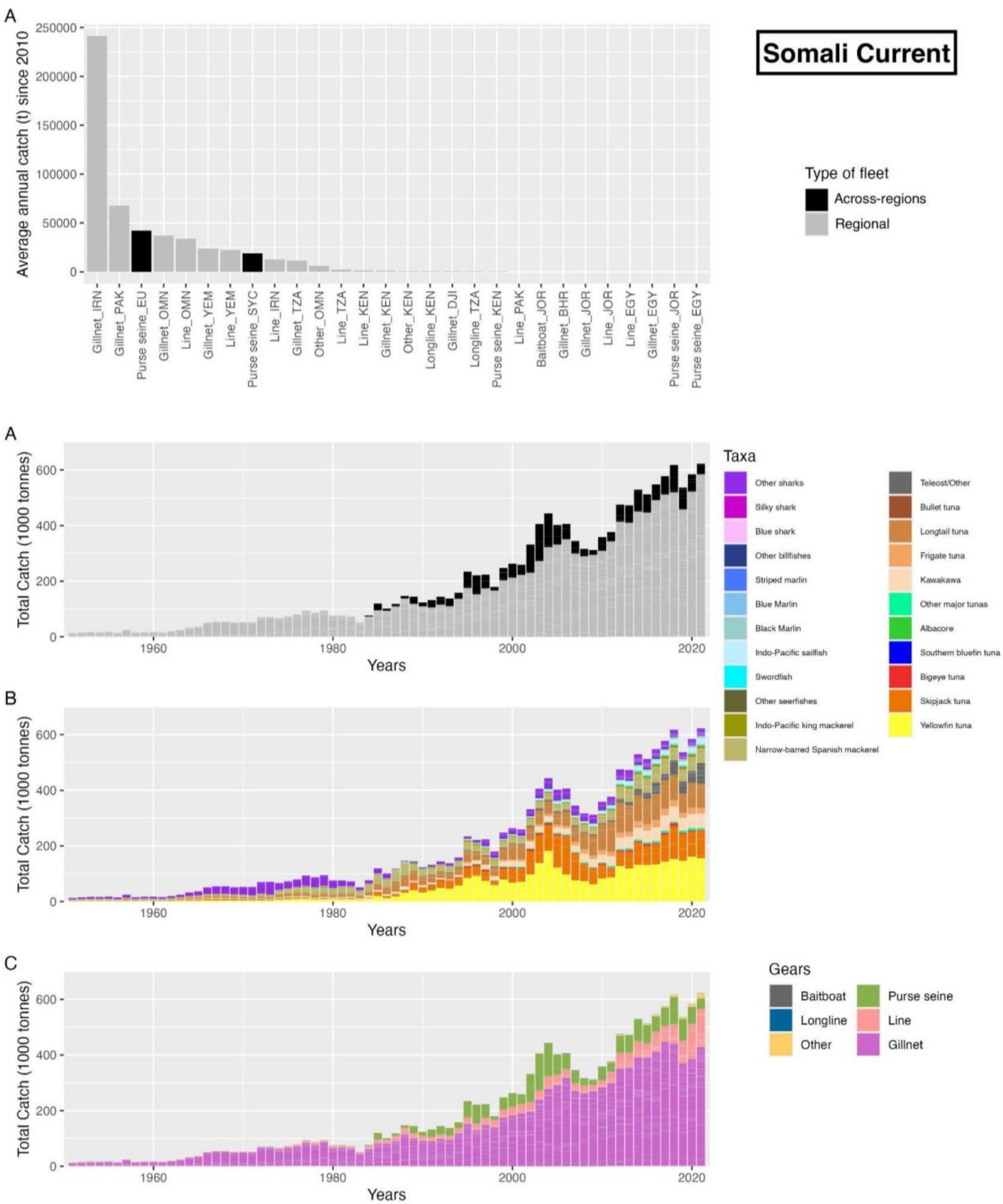



Figure SM1 - Core fleets and historical catches in the SCE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

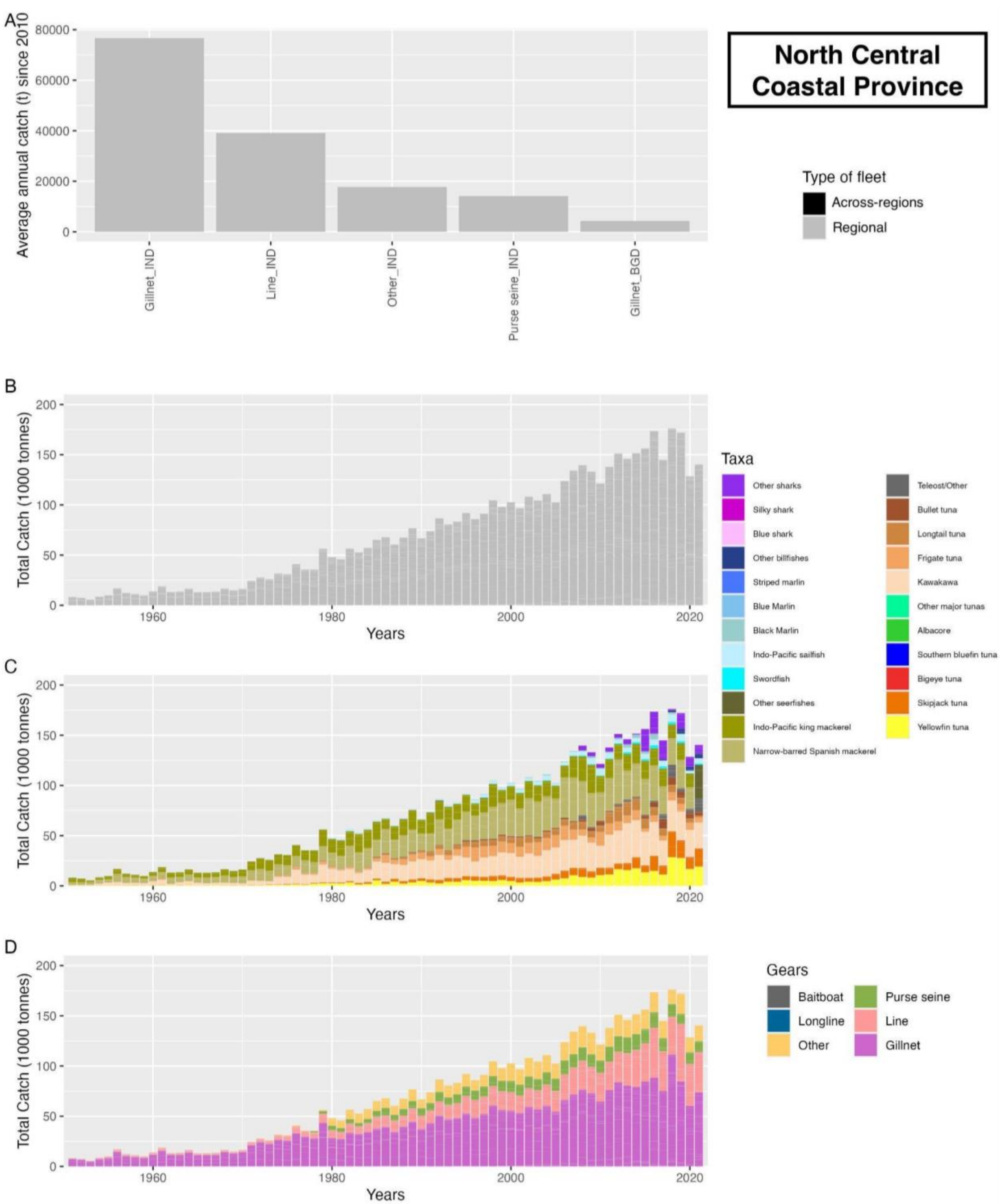



Figure SM2 - Core fleets and historical catches in the NCCPE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

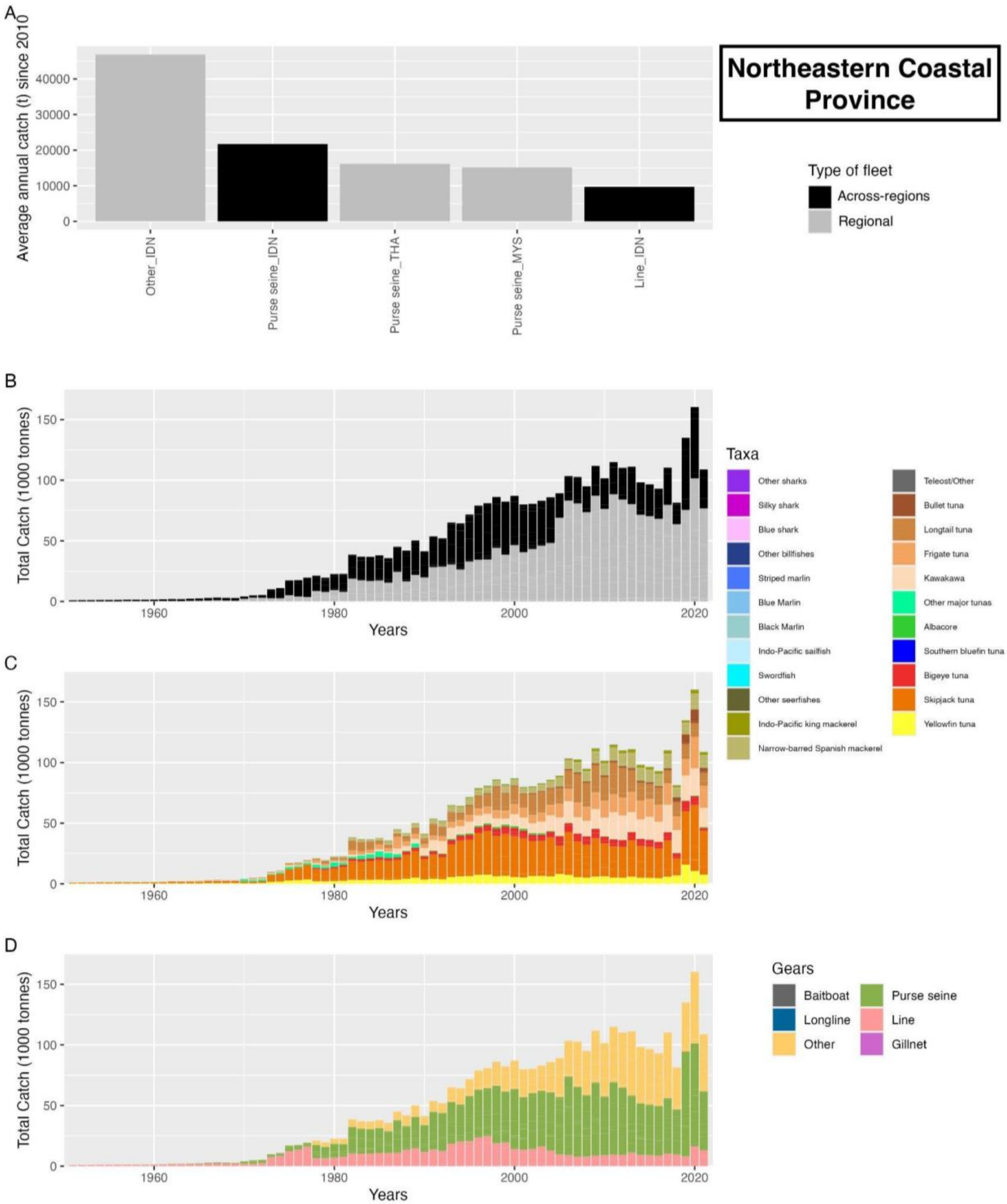



Figure SM3 - Core fleets and historical catches in the NECPE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

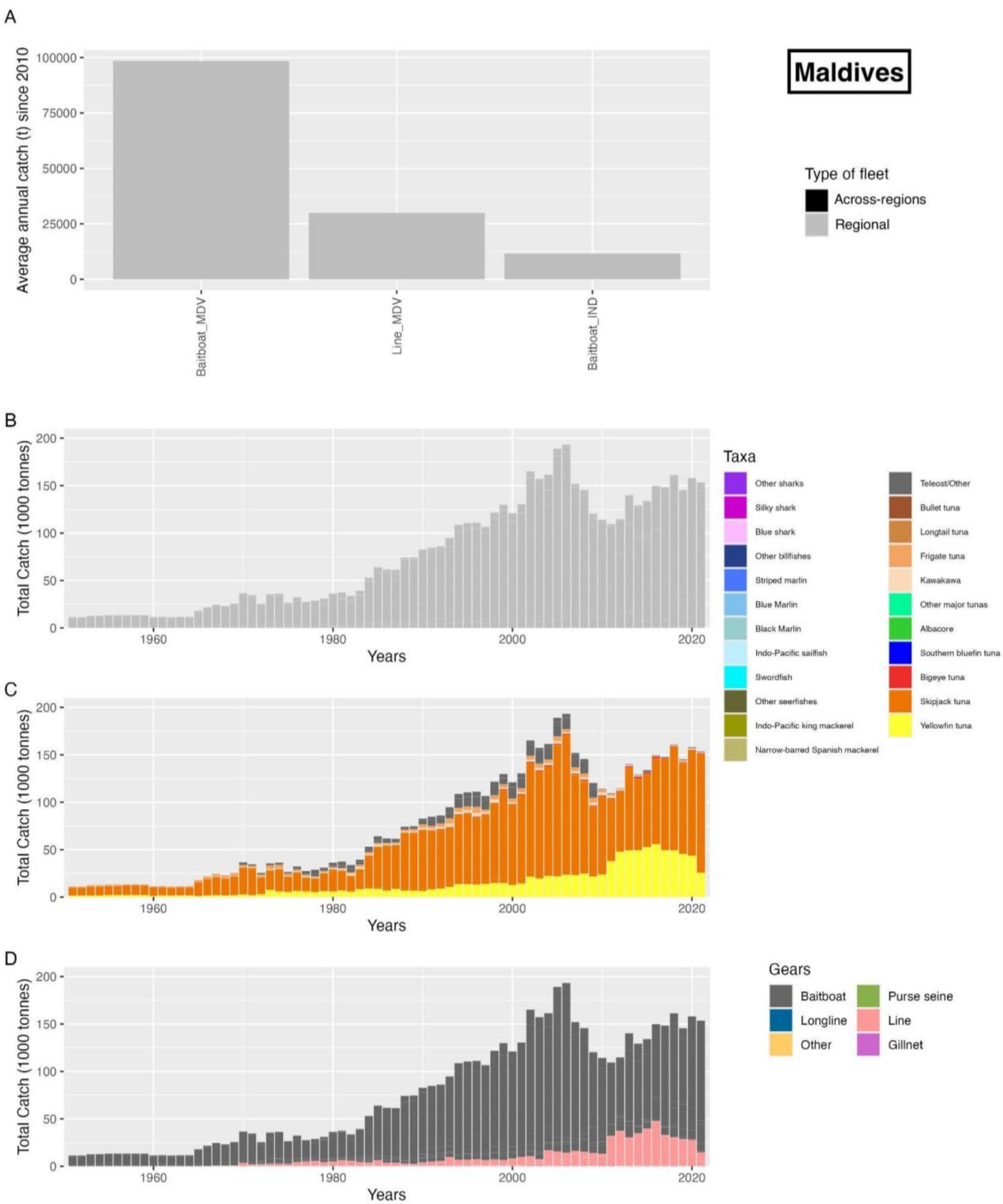



Figure SM4 - Core fleets and historical catches in the ME. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

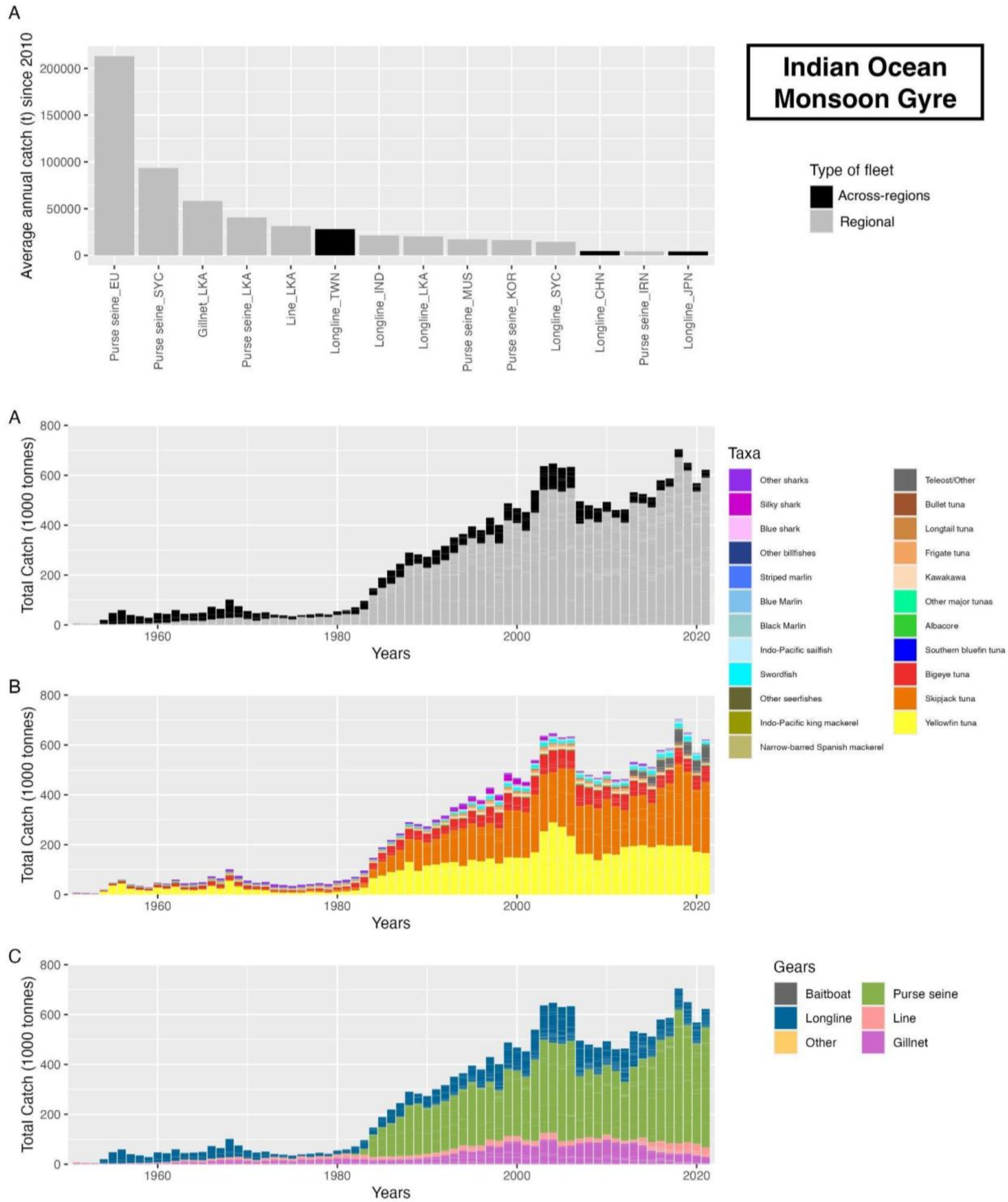



Figure SM5 - Core fleets and historical catches in the IOMGE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

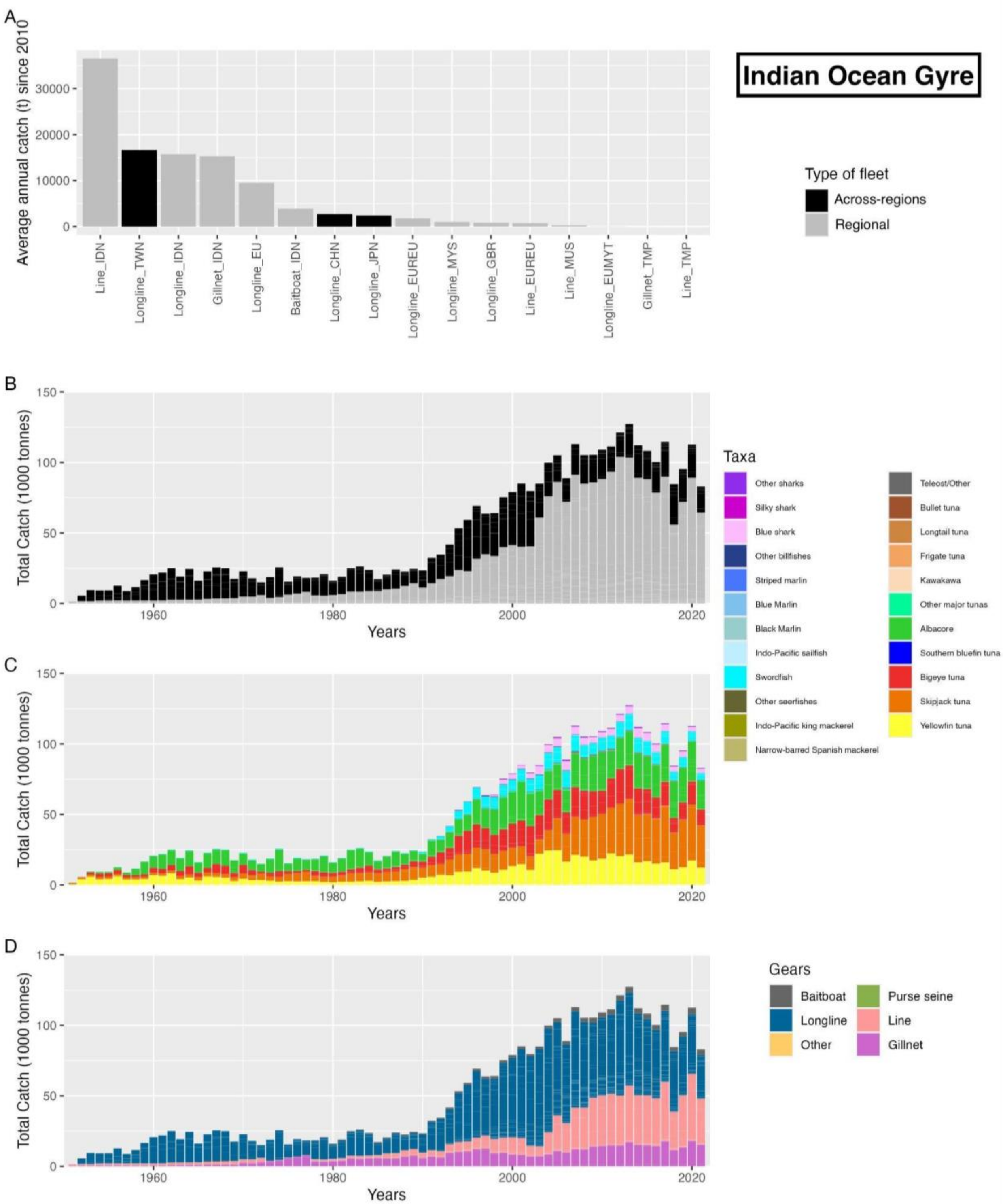



Figure SM6 - Core fleets and historical catches in the IOGE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

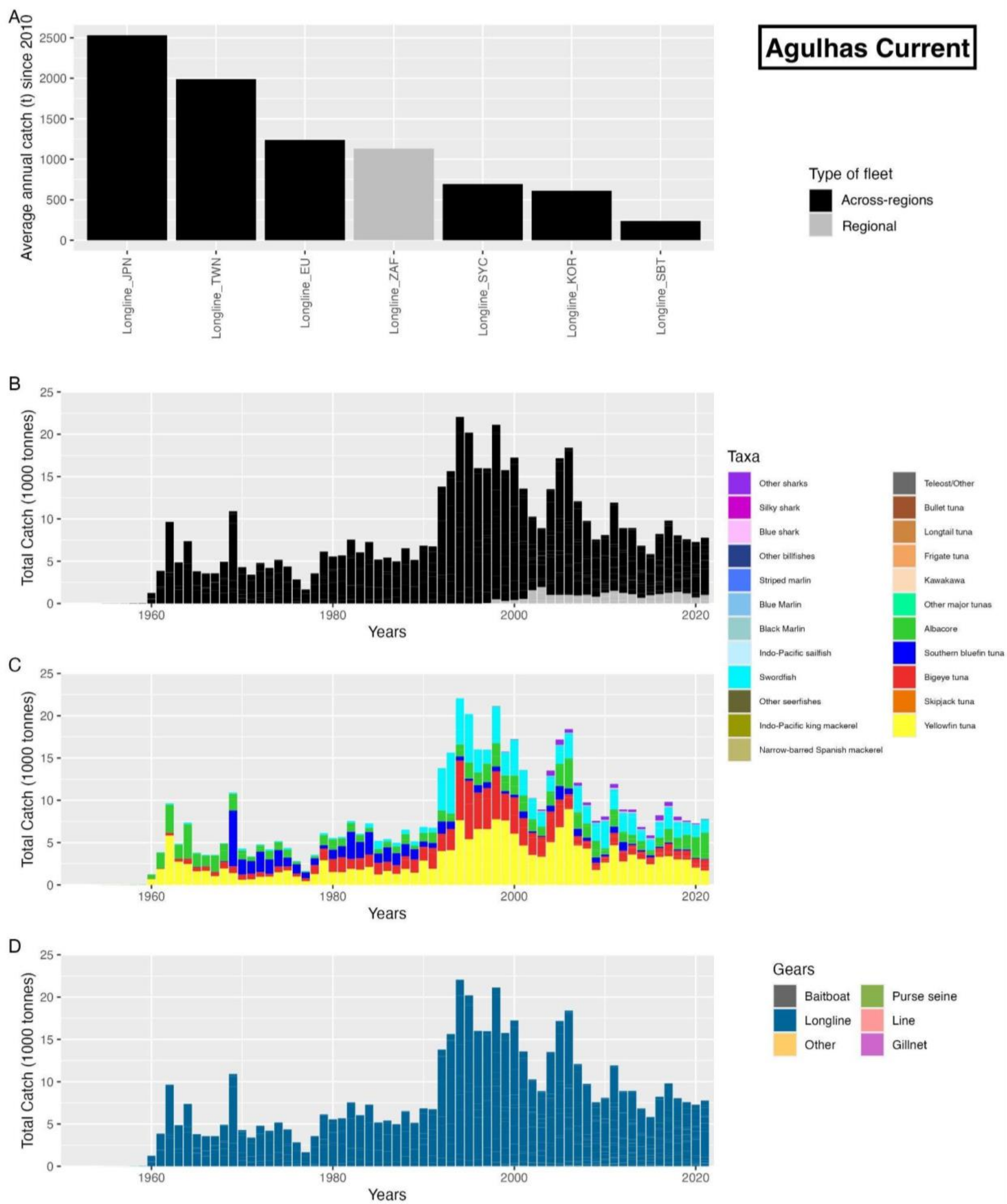



Figure SM7 - Core fleets and historical catches in the ACE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

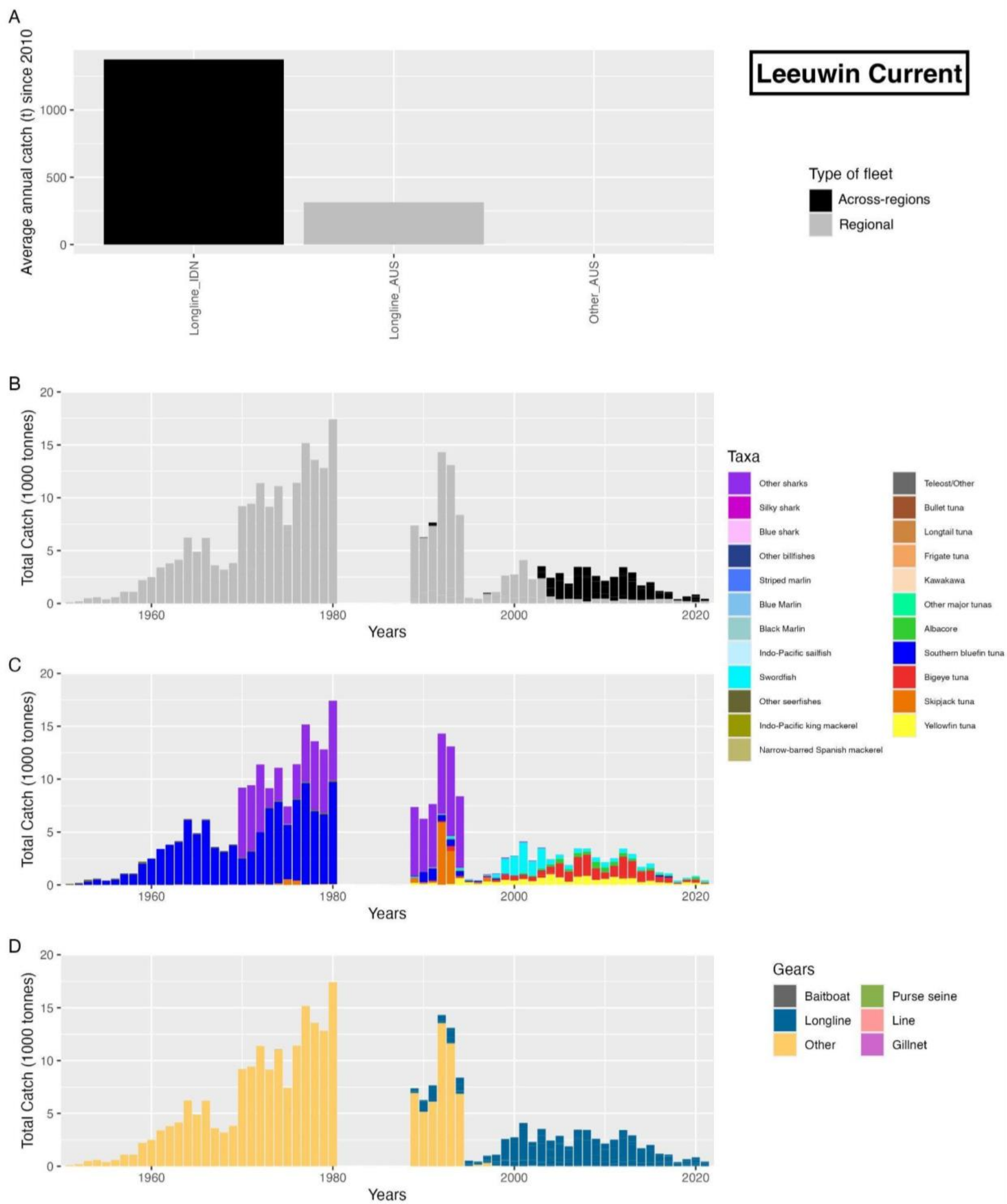



Figure SM8 - Core fleets and historical catches in the LCE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears.

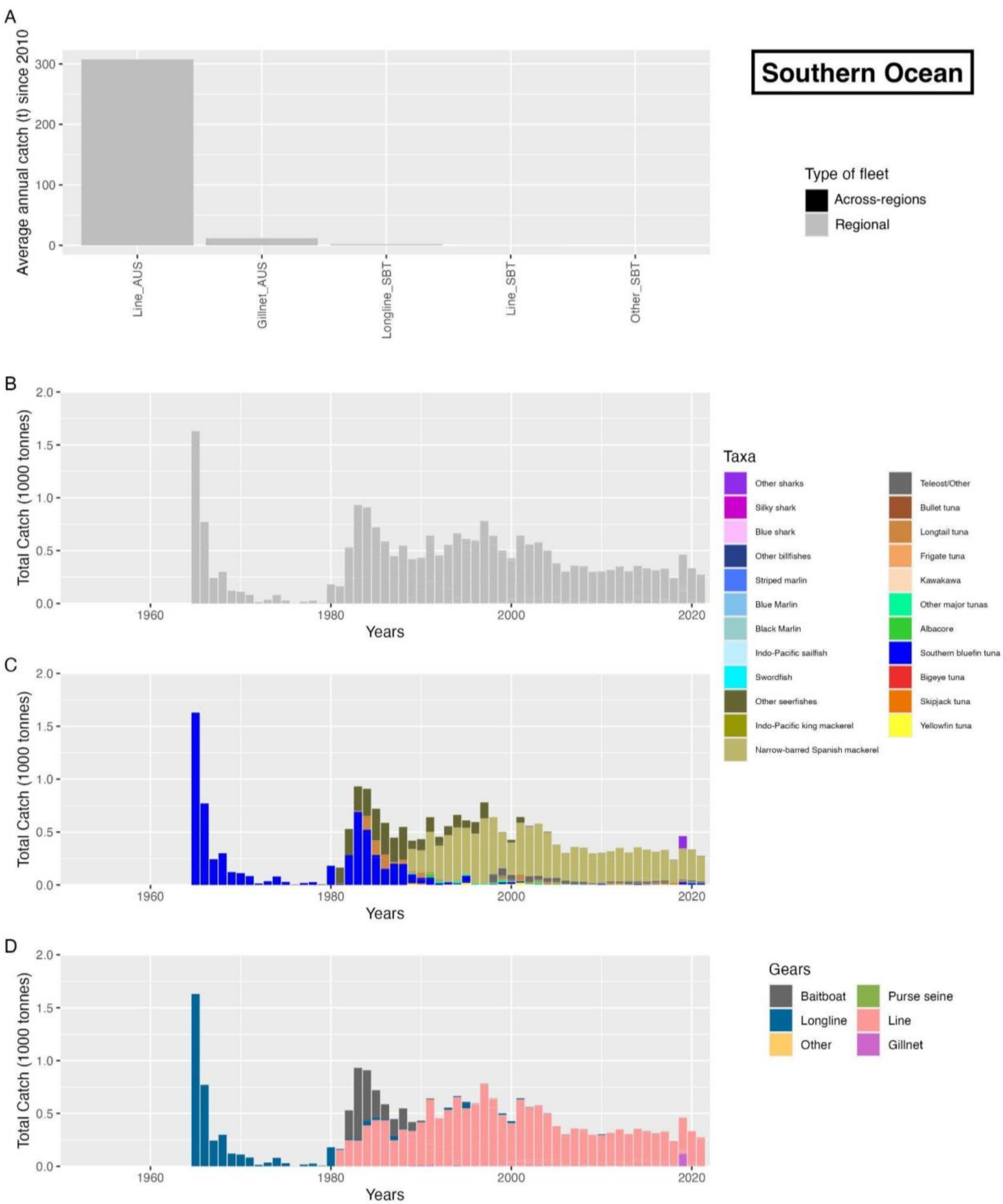



Figure SM9 - Core fleets and historical catches in the SOE. (A) core fleets (B) historical catches disaggregated by source of data, (C) historical catches disaggregated by major taxa, and (D) historical catches disaggregated by major gears

## Annex 2 - Supplement material tables

Table SM1 - SCE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within SCE relative to total catch in IOTC | %fishing grounds within SCE relative to total fishing grounds | % catch relative to the total catch in SCE | % fishing grounds in SCE relative to the total SCE area | Type of fleet |
| **Baitboat_JOR** | 13 | 7 | 100 | 100 | 0,0094 | 6,25 | Regional |
| **Gillnet_BHR** | 11 | 7 | 100 | 100 | 0,0006 | 6,25 | Regional |
| **Gillnet_DJI** | 13 | 7 | 100 | 100 | 0,0229 | 3,12 | Regional |
| **Gillnet_EGY** | 6 | 5 | 100 | 100 | 0,001 | 6,25 | Regional |
| **Gillnet_IRN** | 13 | 7 | 91 | 88 | 32,7102 | 68,75 | Regional |
| **Gillnet_JOR** | 13 | 7 | 100 | 100 | 0,0048 | 6,25 | Regional |
| **Gillnet_KEN** | 13 | 7 | 100 | 100 | 0,1739 | 6,25 | Regional |
| **Gillnet_OMN** | 13 | 7 | 90,6 | 85,71 | 3,1965 | 18,75 | Regional |
| **Gillnet_PAK** | 13 | 7 | 100 | 100 | 7,6049 | 12,5 | Regional |
| **Gillnet_TZA** | 13 | 7 | 100 | 100 | 1,6556 | 12,5 | Regional |
| **Gillnet_YEM** | 13 | 7 | 100 | 100 | 0,9633 | 6,25 | Regional |
| **Line_EGY** | 6 | 5 | 100 | 100 | 0,0016 | 6,25 | Regional |
| **Line_IRN** | 13 | 7 | 97,4 | 88 | 2,6787 | 68,75 | Regional |
| **Line_JOR** | 13 | 7 | 100 | 100 | 0,0041 | 6,25 | Regional |
| **Line_KEN** | 13 | 7 | 100 | 100 | 0,2887 | 9,38 | Regional |
| **Line_OMN** | 13 | 7 | 79,8 | 83,33 | 7,4148 | 15,62 | Regional |
| **Line_PAK** | 3 | 3 | 100 | 100 | 0,0018 | 12,5 | Regional |
| **Line_TZA** | 13 | 7 | 100 | 100 | 0,0362 | 12,5 | Regional |
| **Line_YEM** | 13 | 7 | 100 | 100 | 10,6279 | 6,25 | Regional |
| **Longline_KEN** | 6 | 5 | 86,6 | 4,08 | 0,0985 | 6,25 | Regional |
| **Longline_TZA** | 11 | 5 | 62,4 | 7,19 | 0,105 | 31,25 | Regional |
| **Other_KEN** | 4 | 4 | 100 | 100 | 0 | 6,25 | Regional |
| **Other_OMN** | 9 | 5 | 93,5 | 85,71 | 0,0213 | 18,75 | Regional |
| **Purse seine_EGY** | 3 | 3 | | 100 | 0 | 6,25 | Regional |
| **Purse seine_EU** | 13 | 7 | 19,6 | 20 | 19,004 | 40,62 | Across-regions |
| **Purse seine_JOR** | 7 | 7 | 100 | 100 | 0 | 6,25 | Regional |
| **Purse seine_KEN** | 4 | 4 | 100 | 100 | 0,0117 | 6,25 | Regional |
| **Purse seine_SYC** | 13 | 7 | 20,2 | 20,34 | 8,5242 | 37,5 | Across-regions |

Table SM2 - NCCPE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within NCCPE relative to total catch in IOTC | %fishing grounds within NCCPE relative to total fishing grounds | % catch relative to the total catch in NCCPE | % fishing grounds in NECPE relative to the total NCCPE area | Type of fleet |
| Gillnet_BGD | 3 | 3 | 100 | 100 | 1,3408 | 20 | Regional |
| Gillnet_IND | 13 | 7 | 59 | 23,08 | 10,7546 | 60 | Regional |
| Line_IND | 13 | 7 | 71,3 | 60 | 39,3052 | 60 | Regional |
| Other_IND | 13 | 7 | 53,4 | 54,55 | 2,1457 | 60 | Regional |
| Purse seine_IND | 13 | 7 | 66,3 | 60 | 0,1563 | 60 | Regional |

Table SM3 - NECPE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within NECPE relative to total catch in IOTC | %fishing grounds within NECPE relative to total fishing grounds | % catch relative to the total catch in NECPE | % fishing grounds in NECPE relative to the total NECPE area | Type of fleet |
| Line_IDN | 13 | 7 | 19,7 | 10 | 24,4393 | 57,14 | Across-regions |
| Other_IDN | 13 | 7 | 66,9 | 41,67 | 17,7192 | 71,43 | Regional |
| Purse seine_IDN | 13 | 7 | 31,4 | 15,38 | 54,8636 | 57,14 | Across-regions |
| Purse seine_MYS | 12 | 6 | 56,8 | 23,08 | 0,0782 | 42,86 | Regional |
| Purse seine_THA | 3 | 3 | 71,1 | 2,7 | 1,7319 | 14,29 | Regional |

Table SM4 - ME core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| **Fleet name** | **Years with reported catch since 2010** | **Years with reported catch since 2016** | **% total catch within ME relative to total catch in IOTC** | **%fishing grounds within ME relative to total fishing grounds** | **% catch relative to the total catch in ME** | **% fishing grounds in ME relative to the total ME area** | **Type of fleet** |
| **Baitboat_IND** | 13 | 7 | 100 | 66,67 | 7,7413 | 50 | Regional |
| **Baitboat_MDV** | 13 | 7 | 99,1 | 33,33 | 68,0743 | 75 | Regional |
| **Line_MDV** | 13 | 7 | 95,3 | 17,65 | 19,8664 | 75 | Regional |

Table SM5 - IOMGE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| **Fleet name** | **Years with reported catch since 2010** | **Years with reported catch since 2016** | **% total catch within IOMGE relative to total catch in IOTC** | **%fishing grounds within IOMGE relative to total fishing grounds** | **% catch relative to the total catch in IOMGE** | **% fishing grounds in IOMGE relative to the total IOMGE area** | **Type of fleet** |
| **Gillnet_LKA** | 13 | 7 | 75,2 | 37 | 7,6716 | 66,07 | Regional |
| **Line_LKA** | 13 | 7 | 90,2 | 9 | 4,9907 | 16,07 | Regional |
| **Longline_CHN** | 13 | 7 | 48,5 | 48 | 1,0204 | 85,71 | Across-regions |
| **Longline_IND** | 12 | 6 | 86,3 | 52 | 0,2335 | 92,86 | Regional |
| **Longline_JPN** | 13 | 7 | 41,6 | 48 | 0,9399 | 85,71 | Across-regions |
| **Longline_LKA** | 13 | 7 | 72,2 | 39 | 2,3818 | 69,64 | Regional |
| **Longline_SYC** | 13 | 7 | 72,8 | 48 | 1,7886 | 85,71 | Regional |
| **Longline_TWN** | 13 | 7 | 52,1 | 54 | 6,2671 | 96,43 | Across-regions |
| **Purse seine_EU** | 13 | 7 | 80 | 38 | 38,3522 | 67,86 | Regional |
| **Purse seine_IRN** | 12 | 6 | 73,7 | 31 | 0,5044 | 55,36 | Regional |
| **Purse seine_KOR** | 11 | 7 | 85,3 | 37 | 2,6402 | 66,07 | Regional |
| **Purse seine_LKA** | 10 | 7 | 95,6 | 28 | 1,5432 | 50 | Regional |
| **Purse seine_MUS** | 10 | 7 | 86,8 | 29 | 2,5217 | 51,79 | Regional |
| **Purse seine_SYC** | 13 | 7 | 78,5 | 37 | 16,3397 | 66,07 | Regional |

Table SM6 - IOGE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within IOGE relative to total catch in IOTC | %fishing grounds within IOGE relative to total fishing grounds | % catch relative to the total catch in IOGE | % fishing grounds in IOGE relative to the total IOGE area | Type of fleet |
| Baitboat_IDN | 13 | 7 | 100 | 100 | 2,6492 | 6,25 | Regional |
| Gillnet_IDN | 13 | 7 | 98,6 | 23,53 | 10,8185 | 6,25 | Regional |
| Gillnet_TMP | 12 | 6 | 100 | 100 | 0,0014 | 1,56 | Regional |
| Line_EUREU | 13 | 7 | 100 | 100 | 0,3441 | 6,25 | Regional |
| Line_IDN | 13 | 7 | 74,2 | 55 | 25,8193 | 34,38 | Regional |
| Line_MUS | 13 | 7 | 100 | 100 | 0,1865 | 6,25 | Regional |
| Line_TMP | 12 | 6 | 100 | 100 | 0,002 | 1,56 | Regional |
| Longline_CHN | 13 | 7 | 28,5 | 31,62 | 1,9016 | 67,19 | Across-regions |
| Longline_EU | 13 | 7 | 70,2 | 56,1 | 2,2277 | 71,88 | Regional |
| Longline_EUMYT | 9 | 3 | 62,5 | 62,5 | 0,0171 | 15,62 | Regional |
| Longline_EUREU | 13 | 7 | 91 | 44,83 | 1,0074 | 20,31 | Regional |
| Longline_GBR | 11 | 5 | 89,7 | 87,8 | 0,265 | 56,25 | Regional |
| Longline_IDN | 13 | 7 | 77,1 | 53,57 | 11,1374 | 46,88 | Regional |
| Longline_JPN | 13 | 7 | 24,8 | 34,21 | 1,7725 | 81,25 | Across-regions |
| Longline_TWN | 13 | 7 | 30,6 | 33,9 | 11,6803 | 93,75 | Across-regions |

Table SM7 - ACE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within ACE relative to total catch in IOTC | %fishing grounds within ACE relative to total fishing grounds | % catch relative to the total catch in ACE | % fishing grounds in ACE relative to the total ACE area | Type of fleet |
| Longline_EU | 13 | 7 | 27,6 | 10,98 | 11,7389 | 75 | Across-regions |
| Longline_JPN | 13 | 7 | 25 | 7,89 | 24,0017 | 100 | Across-regions |
| Longline_KOR | 12 | 6 | 31,9 | 11,58 | 5,3444 | 91,67 | Across-regions |
| Longline_SBT | 13 | 7 | 7,4 | 9,68 | 2,2659 | 75 | Across-regions |
| Longline_SYC | 13 | 7 | 6,3 | 6,82 | 6,5779 | 75 | Across-regions |
| Longline_TWN | 13 | 7 | 3,7 | 5,08 | 18,8486 | 75 | Across-regions |
| Longline_ZAF | 13 | 7 | 98,1 | 52,63 | 6,3292 | 83,33 | Regional |

Table SM8 - LCE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | Type of fleet |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within LCE relative to total catch in IOTC | %fishing grounds within LCE relative to total fishing grounds | % catch relative to the total catch in LCE | % fishing grounds in LCE relative to the total LCE area | |
| Longline_AUS | 13 | 7 | 91,2 | 21,43 | 9,3863 | 75 | Regional |
| Longline_IDN | 13 | 7 | 6,7 | 7,14 | 49,0136 | 50 | Across-regions |
| Other_AUS | 3 | 3 | 100 | 100 | 0,0011 | 25 | Regional |

Table SM8 - SOE core fleets

| | Temporal filter | | Indicators to identify regional fleets | | Indicators to identify across-regions fleets | | Type of fleet |
|---|---|---|---|---|---|---|---|
| Fleet name | Years with reported catch since 2010 | Years with reported catch since 2016 | % total catch within SOE relative to total catch in IOTC | %fishing grounds within SOE relative to total fishing grounds | % catch relative to the total catch in SOE | % fishing grounds in SOE relative to the total SOE area | |
| Baitboat_SBT | 9 | 7 | 100 | 100 | 0,0143 | 4,44 | Regional |
| Gillnet_AUS | 12 | 6 | 71,4 | 71,43 | 0,0028 | 11,11 | Regional |
| Line_AUS | 13 | 7 | 55,8 | 58,33 | 0,0067 | 7,78 | Regional |
| Line_SBT | 9 | 7 | 99,2 | 90 | 0,0211 | 10 | Regional |
| Longline_SBT | 13 | 7 | 65,1 | 48,39 | 14,4659 | 50 | Regional |
| Other_SBT | 7 | 7 | 100 | 80 | 0,0124 | 4,44 | Regional |
| Purse seine_SBT | 13 | 7 | 100 | 100 | 31,9323 | 4,44 | Regional |