SIOFA Fisheries Summary: toothfish (*Dissostichus spp., D. eleginoides, D. mawsoni*) 2025

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Prepared by the SIOFA Secretariat

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Contents

Summary of updates in this version:

- Catch and Effort data is presented for the last 10 years in the series (2014–2023) and Observer data for the last 20 years (2004-20023), previous data will remain available in older reports but is not showcased here.
- Included additional historical data, deriving from a review of the activities of the Spanish fleet in 2001–2017.
- Figures updated to be color-blind friendly, wherever possible, mostly using the Okabe-Ito color scale (Okabe & Ito 2008, “Color Universal Design (CUD): How to Make Figures and Presentations That Are Friendly to Colorblind People.” http://jfly.iam.u-tokyo.ac.jp/color/) or other high-contrast color scales.
- Toothfish Management Areas used instead of Management Units, following the exact CMM 15 nomenclature.
- Observer data on biological measurements (see Section 7.1) split into the two different species, as requested by SC9.
- A description of the toothfish historical fishing and tagging data in the SIOFA Area by CCAMLR vessels prior to SIOFA included in the corresponding section (confidential).
- Added a summary report on tag overlap statistics (see Section 7.2.1).
- Added an analysis of discards in the fishery (see Section 10.3)

1. Purpose of this document

The SIOFA Fisheries Summaries describe specific SIOFA fisheries in the SIOFA Area (Figure 1) and summarize the available information for each species, and their biology and ecology. This document is targeted at the general public and institutions and countries wanting to better understand SIOFA fisheries. It also describes SIOFA data available on SIOFA individual fisheries that could be used by scientists and consultants for scientific research.

The SIOFA Ecosystem Summary provides more detailed information on effects of SIOFA fisheries on ecosystems and species in the SIOFA Area. The SIOFA Fisheries Overview integrates these documents and describes general trends for the main fisheries in the SIOFA Area.

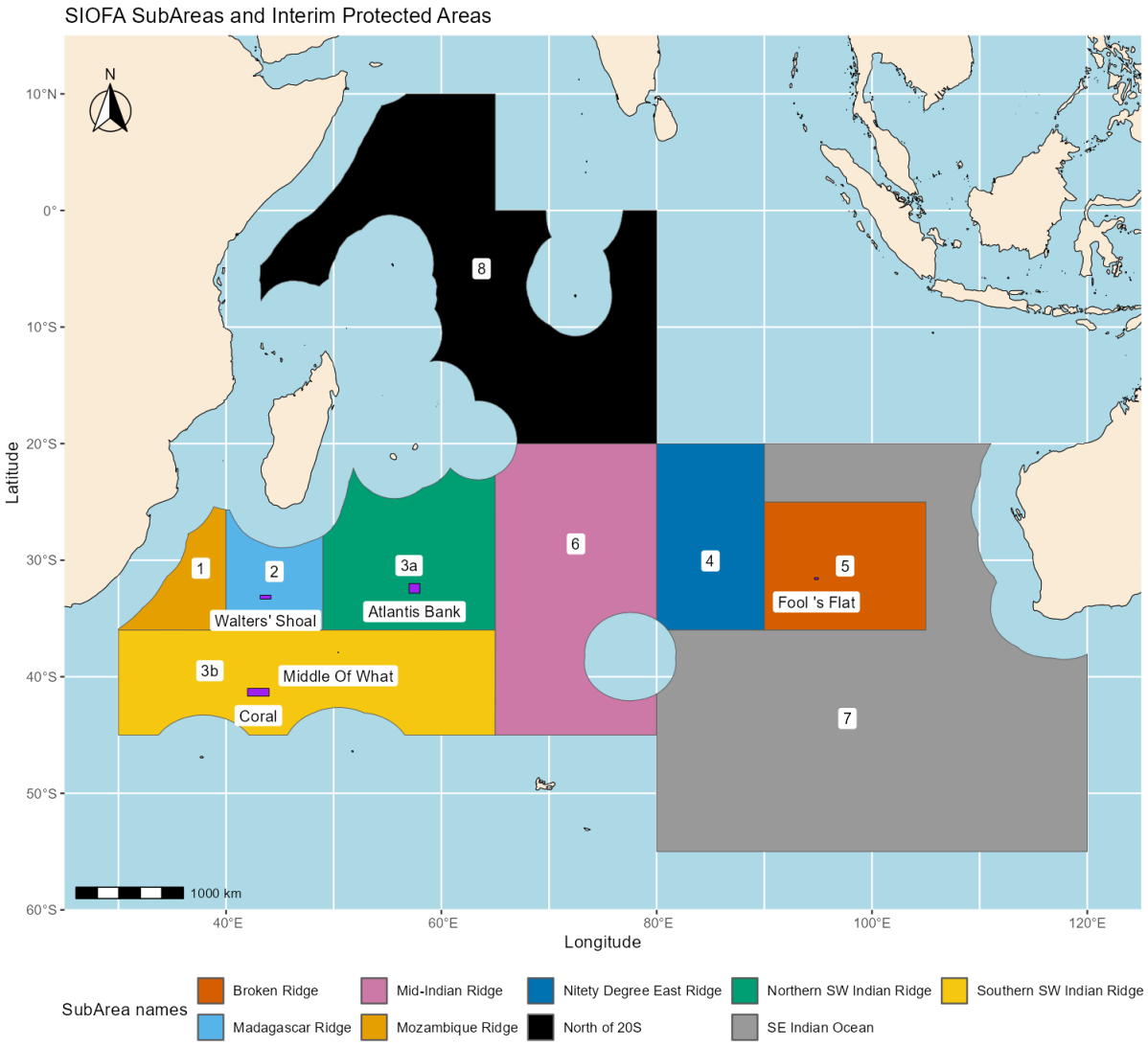

Figure 1 – The SIOFA Area and Subareas (source: SIOFA Spatial database). The Subarea numbers and colour codes are used consistently throughout this summary to identify Subareas. The map highlights SIOFA Interim Protection Areas (in magenta) as defined in CMM 01(2023) (Annex 3). All the interim protection areas have been labelled by name for easier recognition.

2. Data sources and analysis code

2.1 Data availability

There are thirteen CCPs that are members of SIOFA. The SIOFA Secretariat receives data from CCPs pertaining to their fishing activities, biological sampling, and Scientific Observer reports as per CMM 02(2023) (Data Standards). The SIOFA Secretariat acts as custodian for these data on behalf of its members. Request to release or publish these data (e.g., for scientific purposes) are regulated under CMM 03(2016) (Data Confidentiality). Data requests can be made through the SIOFA Secretariat (secretariat@siofa.org).

The main SIOFA databases are:

- AggregatedCatchEffort, which contains catch (and sometimes effort) aggregated at different spatial resolutions, varying from the whole SIOFA Area to 20' squares, from 2000 to 2019.
- HBHCatchEffort, which contains haul-by-haul catch and effort at a spatial accuracy varying from degrees to seconds, from 1998 to 2022.
- Observer, which contains Scientific Observer collected biological sampling, observer reported catches, and observed operations data, from 2012 to 2022.

The SIOFA databases are supported by other data assets such as:

- Spatial layers, which contains all the GIS spatial layers available to the Secretariat (e.g., boundaries of SIOFA Subareas, Assessment Areas). These have been collected at https://github.com/SIOFASecretariat/SIOFA_SC_Spatial_layers
- Codes, including gear and species codes etc. Some of these have been collected at https://github.com/SIOFASecretariat/FAO-unfied-codes

The main SIOFA databases have been described in the outputs of project SEC2021-05 (see SC-07-08, restricted access), where it was noted that the data was repeated (i.e., overlaps) across the first two databases. A suggestion has been made to further develop the three databases as three 'subject areas' that form part of a single SIOFA Fisheries Database in the future.

Further data (e.g., on active vessels) is available from Annual National Reports (2015–2025) that SIOFA CCPs submit to the Scientific Committee every year, which are made publicly available on the SIOFA website (https://siofa.org/meetings/groups/Scientific%20Committee%20Meeting).

2.2 Missing/incomplete/problematic data for the purposes of this report

2024 Catch, Effort and Scientific Observer data are scheduled to be submitted to the Secretariat at the end of May in 2025. Any data more recent than 2023 should be thus considered as draft, potentially incomplete and subject to further revisions, and has therefore been excluded from this report.

Inconsistencies between tows times and positions have been detected in the 2021 and 2022 data from the orange roughy fishery. Similarly, catch weights in the 2023 data from the orange roughy fishery likely contained some errors. Furthermore, small inconsistencies have been identified in the reported trap effort from 2021.

These data were included in this report, but caution should be exercised when interpreting positional data at a fine scale or catches for the most recent year.

While these reports are based on best available data, there might be other data issues that have not been detected and caution is advised when interpreting the results presented.

2.3 Data used in this report

A SIOFA database extract was delivered on 17 September 2024 and used in this report.

The information presented in this report was extracted from different sources, depending on the type of data required. To minimize the confusion that can arise from having to interpret multiple data sources, explicit references to data sources have been made in each table/figure caption in the report.

The report is intended to cover the last five years of available data (at a minimum) but note that the data used covers the 2014–2023 period (10 years of data), and that the period covered varies across the different sections as detailed below.

i. Active fleet composition (2014–2023): SIOFA HBHCatchEffort and SIOFA AggregatedCatchEffort databases
ii. Main fisheries (2000–2023): Annex 1 of CMM 17(2024).
iii. Total catches per CCP (2014–2023): SIOFA AggregatedCatchEffort database, combined with SIOFA HBHCatchEffort database.
iv. Catch, Effort (including per Subarea) and discards (2014–2023): SIOFA HBHCatchEffort database, SIOFA AggregatedCatchEffort database and spatial layers (this does not include non-fish catch, see Section 10 for definitions of target catch).
v. VMEs (2004–2023): SIOFA Observer and HBHCatchEffort databases.
vi. Fishing in Interim Protected Areas (2014–2023): SIOFA HBHCatchEffort and Spatial databases
vii. Biological sampling (2014-2023): SIOFA Observer database.
viii. Observer-reported catches (2014-2023): SIOFA Observer database.
ix. Observer coverage (2014-2023): SIOFA Observer database.

2.4 Analysis code

The code that produces all analyses presented in this report is publicly available at https://github.com/SIOFASecretariat/SIOFA_SC_Reports_code

3. Species Summary

Common name	Toothfish, Patagonian toothfish, Antarctic toothfish
Scientific name	*Dissostichus spp.* (toothfish), *Dissostichus eleginoides* (Patagonian toothfish), *Dissostichus mawsoni* (Antarctic toothfish)
Scientific synonyms	
FAO species code	TOT (toothfish), TOP (Patagonian toothfish), TOA (Antarctic toothfish)
Year of this report	2025
Assessment Areas/Management Areas	Two management areas: William's Ridge and Del Cano Rise
Assessment method	Assessment for the Del Cano Rise fishery only, based on CPUE by seabed area analogy and the Chapman mark-recapture estimation
Most recent assessment	2025
Year of next assessment	2026
Harvest strategy	SIOFA has adopted Management Objectives and Performance Indicators for defined toothfish management areas (MoP11 Report, Annex O). These include maintaining the stock or a suitable proxy or fluctuating around (i.e., with a 50% probability) 50% B_0., and ensuring that the stock is above a limit reference point (LRP) 20% B_0 with a 90% probability A management strategy evaluation (MSE) should initially evaluate alternative sensitivity choices of 50-60-70% probability of being at or above a TRP of 40-50-60% B_0 for toothfish (MoP11 report, paragraph 148). A harvest strategy to achieve these objectives has not been defined yet.
Summary of current stock status	Uncertain, pending updated assessment utilising improved data collection.

This report describes the Patagonian toothfish fisheries in the SIOFA Area and available biological parameters for Patagonian toothfish (TOP, *Dissostichus eleginoides*). Note that data also include species reported as *Dissostichus spp*., because Antarctic toothfish (TOA, *Dissostichus mawsoni*) may also occurs in the SIOFA area at low levels, but this is thought to be quite rare (the first reported capture of *D. mawsoni* in the SIOFA area was in 2019, but more captures were reported up to 2022).

Management advice for this species is given in the Report of the Scientific Committee of SIOFA and management decisions are summarised in the Report of the Meeting of Parties of SIOFA.

Fisheries for Patagonian toothfish in the SIOFA Area are managed under CMM 01(2024) (Interim Management of Bottom Fishing) and CMM 15(2024) (Management of Demersal Stocks). A comprehensive harvest strategy for Patagonian toothfish stocks has not yet been determined, but the MoP adopted management objectives and performance indicators for toothfish (MoP11 report, Annex O), including some sensitivity choices for the Management Strategy Evaluation.

A preliminary assessment of Patagonian toothfish in the Del Cano Rise fishery is described in Sarralde et al. (2020), using a depletion analysis and standardised CPUE trends. Outputs were highly uncertain, but it is possible that the stock has been reduced to levels lower than the biomass target. The authors of this assessment highlight the need for improved data collection to inform more precise estimates

of stock status. Separately, Ziegler and Miller (2022) provided a fishery characterisation of the Williams Ridge fishery but considered that data were too poor to estimate the biomass in the area. Catches from the Williams Ridge area are incorporated into the integrated stock assessment for the adjacent Heard Island and McDonald Islands Fishery in CCAMLR area 58.5.2.

In 2024, the EU and France on behalf of its Overseas Territories presented a toothfish assessment for the Del Cano Rise and South Indian Ridge areas, based on CPUE by seabed area analogy trend analysis (restricted paper SC-09-35). The SC requested that similar assessments be provided by the SIOFA Secretariat on an annual basis, going forward.

4. Biological Summary

Patagonian toothfish is a large, long-lived, relatively late-maturing demersal notothenioid fish often found at depths greater than 1000 m. Patagonian toothfish are present in subantarctic and Southern Ocean waters all the way around the Antarctic continent, but mainly at subantarctic latitudes, as they are largely replaced by the closely related Antarctic toothfish (D *mawsoni*) at higher latitudes.

Adult *D. elegenioides* generally inhabit continental slopes or underwater topographic features at depths of 1000-2000 m, to a maximum recorded depth of 3850 m. They spawn in deep water (approximately 1000 m) during the austral summer, producing pelagic eggs and larvae. Larvae become demersal at around 10 cm length and 1 year old and inhabit shallower waters (<300 m) until age 6-7, after which they undertake a gradual ontogenetic migration to progressively deeper waters. Sexual maturity occurs around 70-95 cm length and age 6-9 years; the maximum recorded size and age exceeds 2 m and 50 years (Collins et al. 2010).

As juveniles Patagonian toothfish are primarily piscivorous; as adults they become generalist predators and scavengers of the full range of available prey, mainly demersal fish, squid and crustaceans. Toothfish are in turn preyed upon by colossal squid, elephant seals, and sperm whales. Predation by killer whales has also been reported but this is more commonly in association with learned depredation behaviour whereby killer whales remove toothfish from longlines during hauling (Earl et al. 2021).

There is now some evidence of large-scale geographic migration by adult Patagonian toothfish. In the past, a range of studies using genetics, biochemistry, parasitology, suggested a high degree of site fidelity without much mixing of stocks between adjacent populations (Collins et al. 2010). However, tag recaptures within SIOFA highlighted east to west movements, against prevailing currents.

5. Description of the fishery

Patagonian toothfish (TOP, *Dissostichus eleginoides*) is the dominant species of toothfish caught in the SIOFA area. Antarctic toothfish (TOA, *Dissostichus mawsoni*) were reported caught in the SIOFA area for the first time in 2021. Toothfish are primarily targeted using demersal longlines and to a much lesser extent using traps.

Most toothfish fisheries operate within the area managed by CCAMLR (the Convention for the Conservation of Antarctic Marine Living Resources). Juvenile toothfish were first caught as bycatch in shallow subantarctic trawl fisheries, but target toothfish fisheries developed rapidly in the 1990s following the development of deep-water longlining. There followed a period of over-exploitation of many toothfish stocks from the combined effects of legitimate target and IUU toothfish fishing. These problems have largely been addressed due to effective governance in the CCAMLR Area, but some stocks may still be depleted and IUU fishing remains a threat in some locations where monitoring and enforcement are difficult (Collins et al. 2010).

5.1 Fleet and gear

Toothfish are targeted primarily using demersal longlines and to a much lesser extent using traps. Toothfish target fisheries in the SIOFA area reflect largely exploratory fishing activities in the margins of managed stocks in adjacent CCAMLR areas, beginning in 2003. Fishing effort has been highly variable since that time, pursued intermittently by different countries, including Australia, the EU (Spain), France (Overseas Territories), Japan, and Korea. Since 2017 most toothfish target fishing has been by Spanish and French vessels in subarea 3b (Sarralde et al. 2020), and by Australian vessels in subarea 7.

In the 2019-2023 period, participation in the toothfish fishery has involved on average 3.2 vessels per year.

5.2 Fishing areas

Patagonian toothfish fisheries in the SIOFA area are subject to catch limits within two defined Management Areasin the extreme southern (subantarctic) portions of subareas 3b and 7 (Figure 2). The western unit in subarea 3b is called the Del Cano Rise fishery; the eastern unit in subarea 7 is called the Williams Ridge fishery (Figure 3). Note however that, in recent years, a substantial portion of the toothfish catch is taken from outside these management areas (Figure 3).

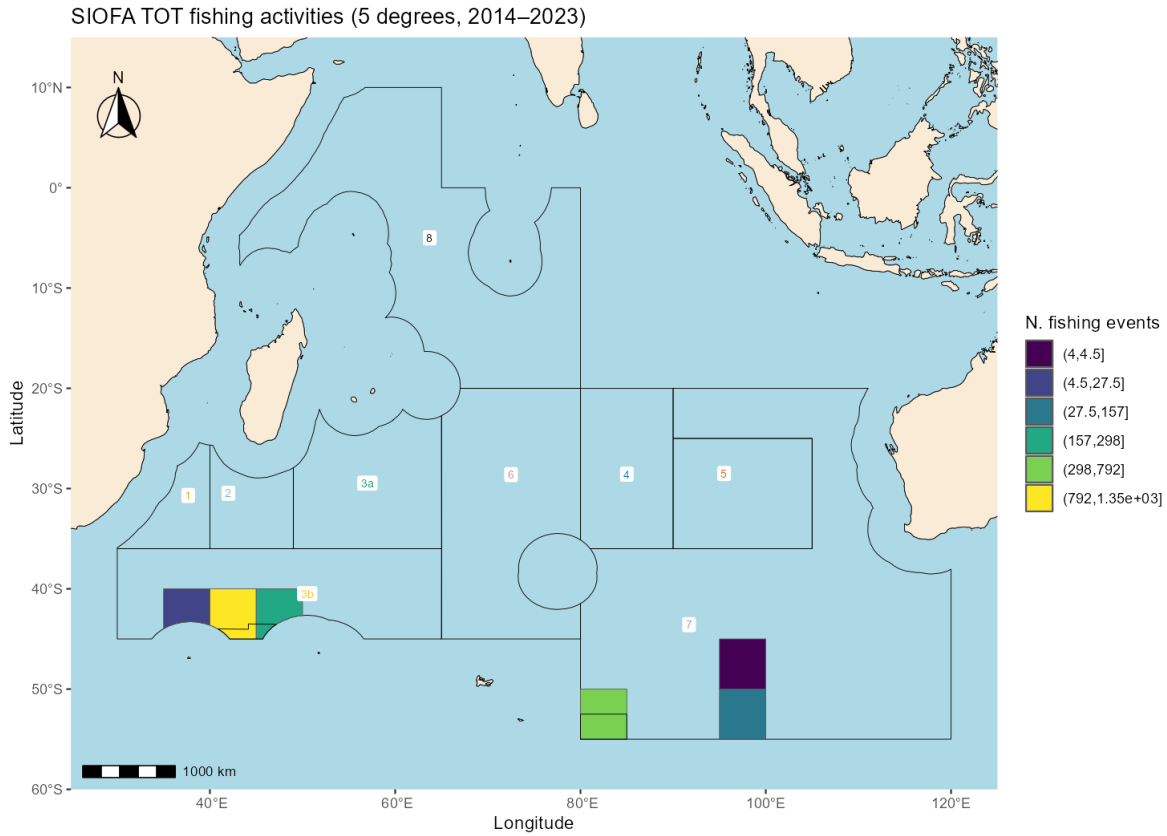

Figure 2 – Spatial distribution of fishing events that caught toothfish in the SIOFA Area, derived from haul-by-haul level fishing data, aggregated at a 5x5 degrees resolution (source: SIOFA HBHCatchEffort databases 2014–2023). This map represents all fishing events that caught any TOP, irrespective of declared target species. Black lines represent the boundaries of SIOFA subareas and of toothfish management areas.

5.3 Assessment Areas

Two management areas are defined (in CMM 15(2024), paragraphs 13 and 50) for Patagonian toothfish in the SIOFA Area (Figure 3): the Del Cano Rise fishery in the southwest portion of the SIOFA Area (subarea 3b) and the William's Ridge (WR) fishery in the southeast portion of the SIOFA area (subarea 7). Note that not all catch of toothfish in the SIOFA area is taken inside these two management areas. Note also that both of these areas are adjacent to managed toothfish fisheries in the CCAMLR Area (CCAMLR Subareas 58.7 and 58.6, Divisions 58.5.1, 58.5.2, 58.4.3b and 58.4.1), and with fisheries inside the South African and French EEZs (in the case of the Del Cano Rise) or the Australian EEZ (in the case of Williams Ridge). The proximity of these other fisheries has prompted discussion of the need for data exchange between SIOFA and CCAMLR (see Ziegler and Miller 2021, CCAMLR and SIOFA SC Chairs 2022).

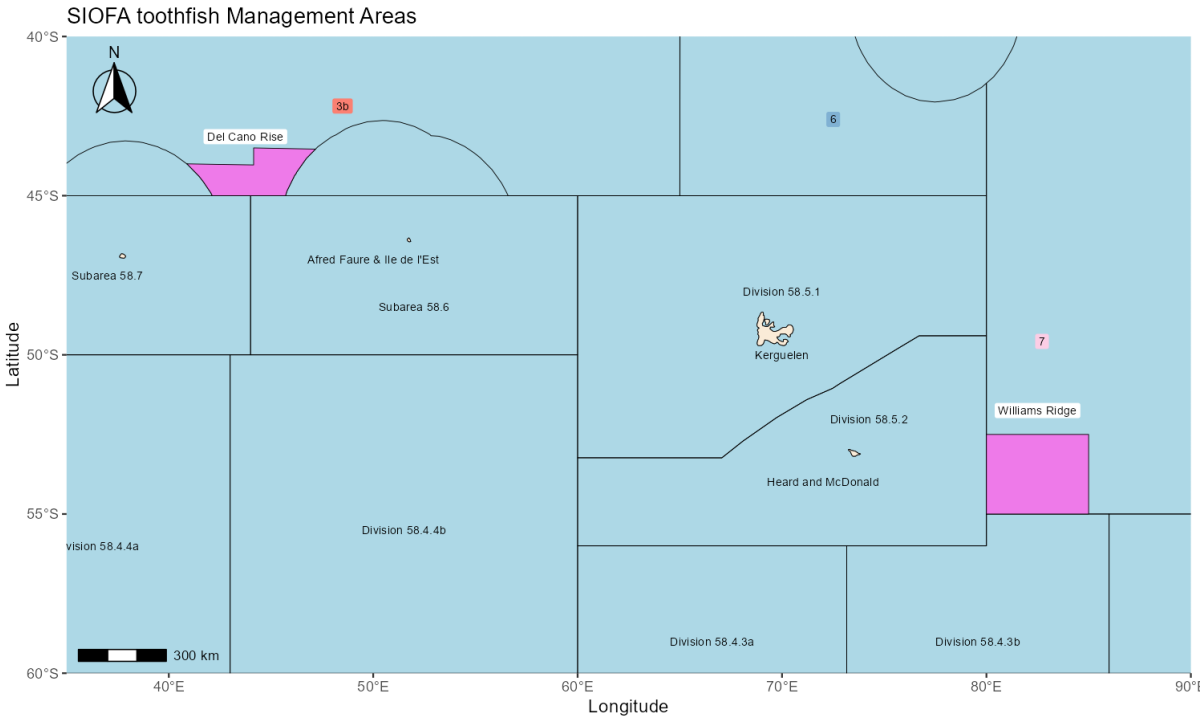

Figure 3 – Map of SIOFA Management Areas (in magenta) for toothfish as defined in CMM 15(2024) (source: SIOFA Spatial layers) and adjacent CCAMLR Subareas and Divisions. Labels indicate names of each management unit.

5.4 Catch and effort

Note that fishing effort and catches reported in this section represent total catch of toothfish (both Patagonian and Antarctic, where this occurs), irrespective of whether each particular fishing event had been targeting toothfish or not, but excluding fishing effort where the catch of toothfish was zero. Furthermore, the CPUE data aggregate data from both management areas and from outside of the management areas. In this context CPUE as depicted here cannot be considered a reliable index of abundance. In contrast the stock assessment analyses described by Sarralde et al. (2020) used CPUE standardisation and restricted the use of data to a single management unit (Del Cano Rise) in an attempt to derive an index of abundance.

Catches of toothfish have been highly variable over time but are decreasing in recent years since a peak in 2019. This pattern of reported catches closely mirrors the pattern for total effort, (Figure 4a), such that CPUE is relatively stable (Figure 5). Toothfish are mostly caught in two distinct management areas in the southern portions of the SIOFA area, in subareas 7 and 3b (Figure 4b) but some catch also occurs outside these areas. Since 2020, most catches occurred in Southern Indian Ridge, just outside of the Del Cano Rise management unit, in subarea 3b.

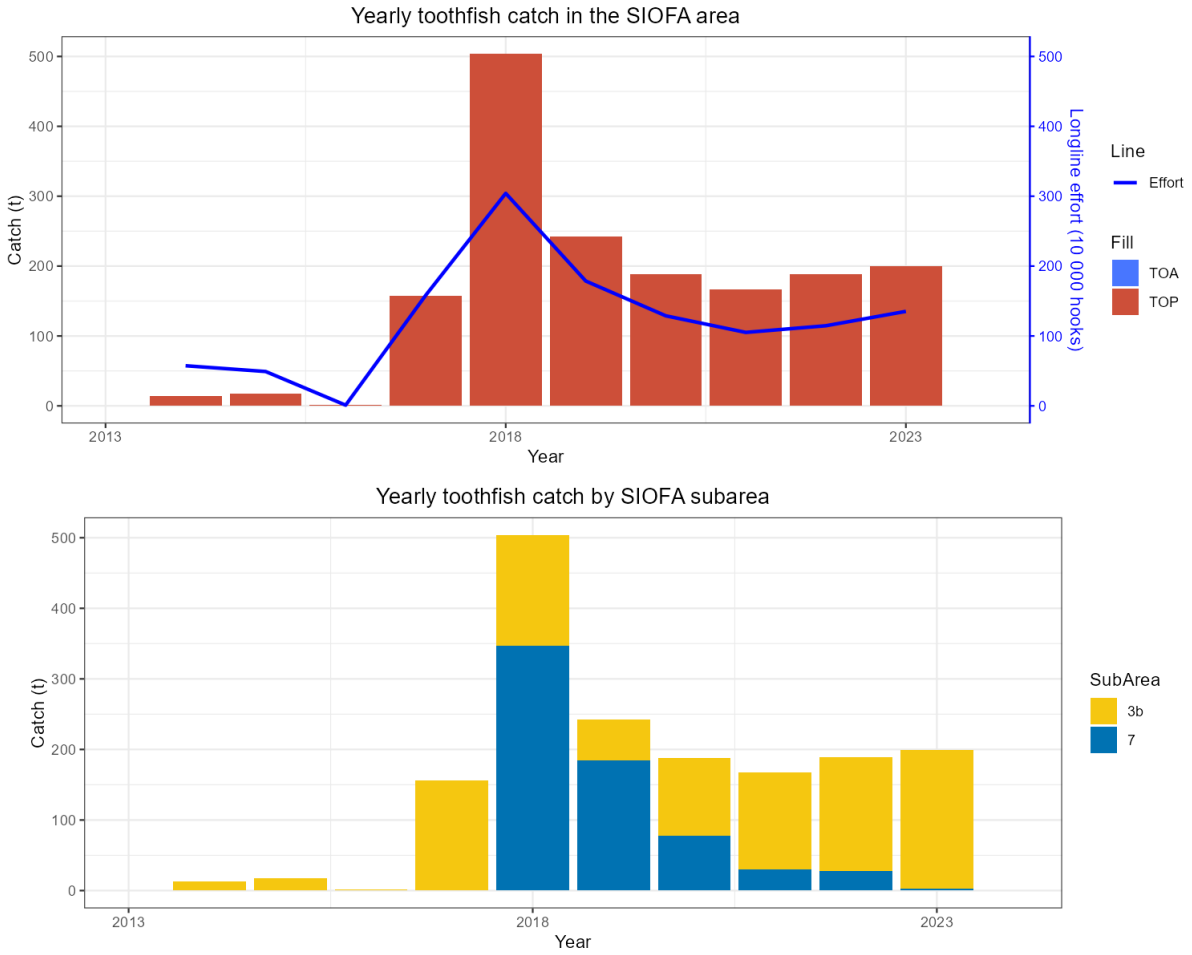

Figure 4a and b — Yearly catch of toothfish (tonnes) and effort (10 thousand hooks) in the SIOFA area (upper panel, a) and in different SIOFA subareas (lower panel, b) (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023). Note that the subareas are larger than the toothfish management areas and some catch comes from outside these areas.

Unstandardised catches per units of effort (CPUEs) have risen historically but are stable since around 2017.

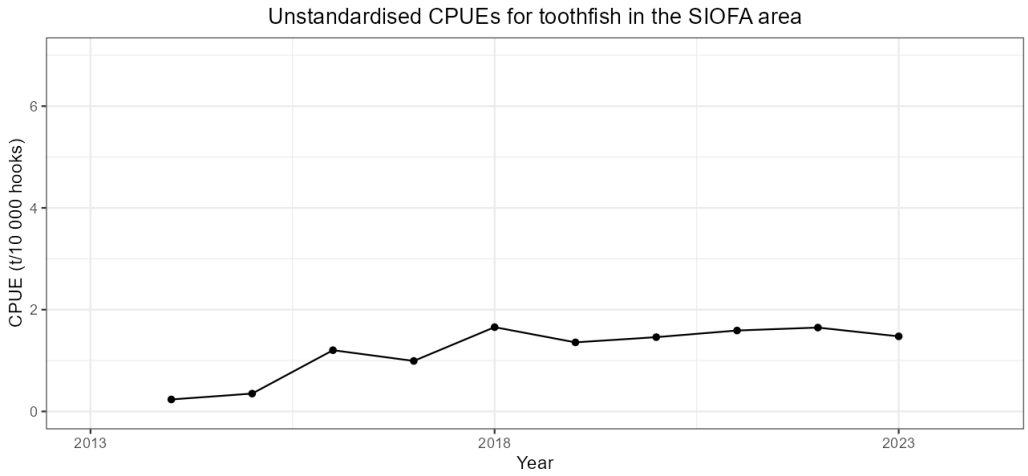

Figure 5 – Unstandardised catch per unit effort (CPUEs) of Patagonian toothfish in the SIOFA area (tonnes/10 000 hooks) (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023).

In the Del Cano Rise fishery area, Sarralde et al. (2020) summarise historical catches as shown in Figure 6.

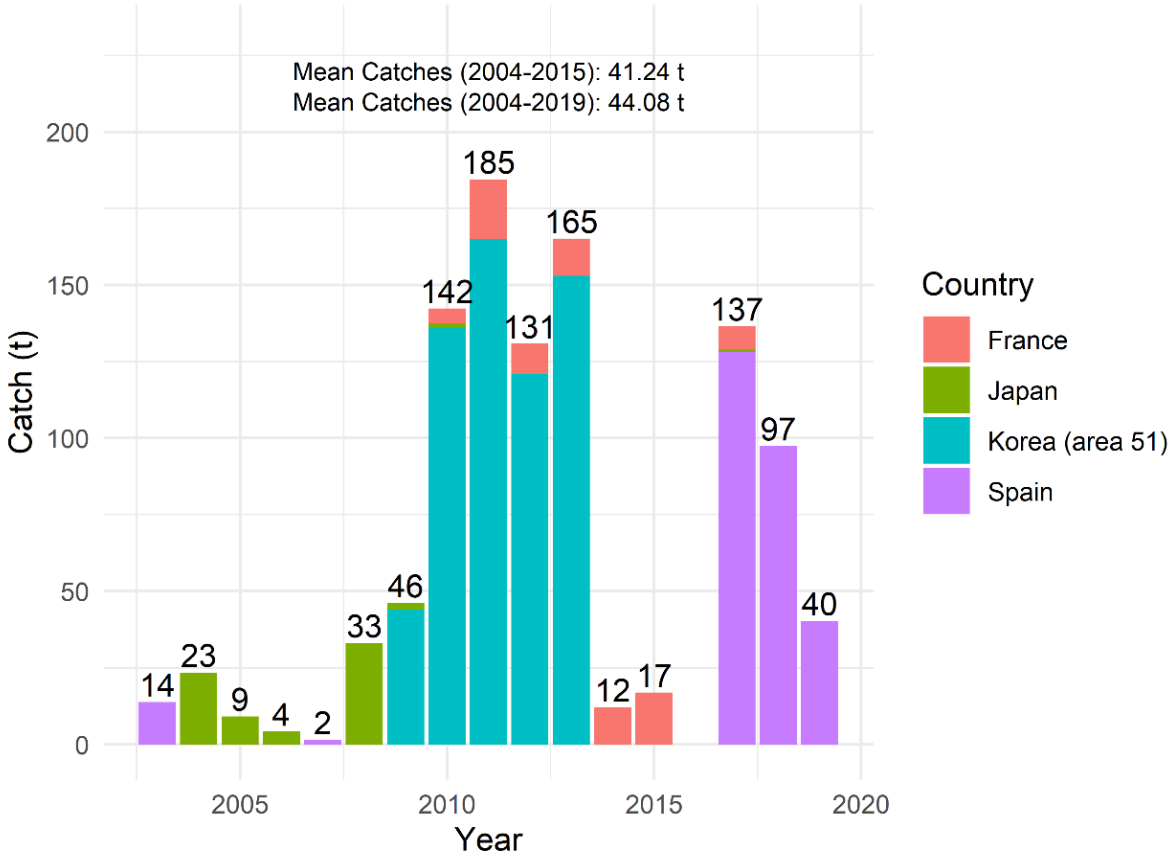

Figure 6 – Catches of toothfish in the Del Cano SIOFA area from 2003 - 2019 (from Sarralde et al. 2020).

Annual catches in the Williams Ridge fishery were summarised by Ziegler and Miller (2022) are reported in Table 1.

Table 1 – Fishing season, toothfish catch limits, and reported catch in the Williams Ridge fishery as reported by Ziegler and Miller (2022), including number of hauls, number of active fishing vessels, and deployed fishing gear type.

Season [a]	Catch limit (tonnes) [b]	Reported catches (t) in MoP-07-15	Reported catches (t)	Reported catches (t) excl. record 251	Number of hauls	Number of Longline Vessels	Fishing gear
2018		339	339	339	93	1	Spanish line
2019		127	127	127	102	1	Autoline
2020	140	59 [c]	75	75	50	2	Autoline
2021	140		43	37	47	3	Autoline
2022 [d]	140		29	29	23	1	Autoline

[a] Fishing seasons from 1 December - 30 November of the following year as specified in CMM 15(2024). 2017/18 is denoted as 2018, 2018/19 as 2019 and so on.

[b] Catch limits have been in place since the 2020 season.

[c] Catches from December to February only.

[d] These data were published while the season was ongoing so may be incomplete.

Toothfish catch and bycatch are further investigated in Section 10.

5.5 Catch limits

CMM 15(2024) (Management of Demersal Stocks) specifies a catch limit of 44 tonnes for the Del Cano Rise fishery, and other requirements for vessels operating in this area (see CMM 15(2024) paragraphs 13-30).

CMM 15(2024) specifies a catch limit of 140 tonnes for the Williams Ridge fishery. This catch limit is subject to additional spatial restrictions to address the risk of localised depletion and ensure representative data collection, and additional requirements regarding toothfish tagging rates and biological data collection. See CMM 15(2024) paragraphs 31-50.

Catch limits have not been defined for other areas where toothfish fisheries take place within the SIOFA Area.

5.6 Illegal Unreported and Unregulated (IUU) catch

No claims of Illegal Unreported and Unregulated (IUU) catches of Patagonian toothfish have been reported to SIOFA.

5.7 Other sources of fishing mortality

Some unaccounted mortality is known to occur arising from whale depredation, whereby killer whales and/or sperm whales remove fish from longlines during hauling (Earl et al, 2021, Gasco et al. 2021, Gasco et al. 2020). Using an analysis of spatial depredation rates and comparisons of observed catch rates in the presence and in absence of both whale species, Gasco et al. (2020) estimated that in the Del Cano Rise fishery, 8% of total toothfish catches were removed by either killer whales or sperm whales.

The same authors noted that depredation is a learned behaviour that is acquired by different groups of whales, especially as individual depredating whales move between areas, and that depredation behaviour appeared to be in its early stages of development among whales in the SIOFA area. They recommended implementation of mitigation measures by toothfish fishery vessels to prevent the development of a serious depredation problem in SIOFA toothfish fisheries. They also warned that the estimation of total removals by depredation may be expected to vary significantly between locations and may change rapidly in time. Gasco et al. (2021) proposed data collection protocols for demersal longline fisheries to document the extent of whale interactions and inform more accurate estimation of unaccounted mortality. These protocols were endorsed by the Scientific Committee in 2021 (SC6 paragraph 116).

6. Stock assessment and status

There are two defined toothfish management areas within the SIOFA convention area, both of which are adjacent to and potentially contiguous with toothfish populations in the CCAMLR area. The Del Cano Rise fishery in SIOFA subarea 3b is near the Crozet Islands (CCAMLR Division 58.6) and the Prince Edward and Marion Islands (CCAMLR Division 58.6 and 58.7). The William's Ridge fishery in SIOFA subarea 7 is adjacent to the Heard Island and McDonald Islands (CCAMLR Division 58.5.2).

In SIOFA a preliminary assessment was delivered for the Del Cano Rise population only (Sarralde et al. 2020). CPUE and cumulative catch were used for a depletion analysis and two data-poor stock assessment models were applied. A Catch-MSY stock reduction analysis method that use informative priors for some demographic parameters and a State-Space Surplus Production Model (JABBA) that links the standardised CPUE to the biomass level were used. The depletion analysis estimated the initial biomass by the end of 2017 at 470 t (with a standard error of 104 t). The fraction of the biomass estimated to have been captured by the vessels was large over this period (274 t), representing more than 55% of the estimated initial biomass. The authors of the analysis comment that it is not currently clear what the natural repletion rate of toothfish biomass in this region would be (Sarralde et al., 2020). Results for the CMSY and JABBA models in the Del Cano Rise area estimated that the median size of the pristine biomass ranged 300 - 800 t depending on the assumptions made concerning what proportion of reported catches in the earlier 2009-2013 period came from this area (Sarralde et al. 2020). The authors concluded that: 1) these preliminary data-poor population model results confirm a decrease of biomass following the initial period of higher exploitation (2009 – 2013), after which the stock has not (yet) returned to its level prior to exploitation, 2) Some models also infer a toothfish biomass decrease following the second phase of higher exploitation (2017-2019), suggesting that had this level of fishing pressure been maintained over a longer time period, the stock would likely have decreased beyond the point of replenishing itself, and 3) these approaches are in an early stage of development at this time, and require more development and further data in order to estimate sustainable catch limits reliably (Sarralde et al., 2020).

In 2024, J. Selles, R., Sarralde and F. Massiot-Granier presented a paper to SC9 (SC-09-35) detailing their work on a biomass estimation for the Del Cano Rise and the South Indian Ridge areas, using two methods: the CPUE by seabed area analogy and the Chapman mark-recapture estimation. There were insufficient recaptures to apply the Chapman mark-recapture estimation, and thus only PUE by seabed area analogy results were provided in the paper. The authors estimated the biomass in Del Cano Rise management area as 1 699 tonnes and the biomass in the South Indian Ridge proposed management area as 3 511 tonnes. Based on this work, the SC made a recommendation on the catch limit for the Del Cano Rise management area, which was endorsed by MoP11. SC also reiterated their recommendation to create a South Indian Ridge management area, including a specific catch limit, but MoP11 did not endorse this recommendation at that stage.

No assessment is available for the Williams Ridge fishery in subarea 7. Ziegler and Miller (2022) characterised fishery trends for this fishery in the context of adjacent CCAMLR toothfish management areas. They concluded that data are currently insufficient to inform a full stock assessment, but noted declining catch rates since fishing restarted in this area in 2018 in part due to the introduced catch and effort limits (CMM-2019/15), and recommended that current management measures remain in place. Catches from the Williams Ridge fishery are incorporated into the stock assessment at Heard Island and McDonald Islands that are presented to CCAMLR.

In 2024 and 2025, scientific advice on catch limits in the Del Cano Rise, and the proposed South Indian Ridge, was determined using the trend analysis method (CCAMLR FSA-WG) and is described in paper SC-10-23.

There is no or characterisation available for toothfish in areas outside of these two defined management areas.

6.1 Harvest strategy and reference points

SIOFA has adopted complementary arrangements for *D. eleginoides* between SIOFA and CCAMLR (para 126 of SC6 Report). Accordingly, SIOFA adopted the following biomass reference points also used by CCAMLR: Target = $0.5*B_0$, and Limit = $0.2*B_0$

Harvest strategies to achieve these reference points have not been decided upon within SIOFA.

Brandão et al. (2022) considered harvest strategies for toothfish based on changes in CPUE trend, but noted a preliminary stock assessment has only been completed for the Del Cano Rise fishery (Sarralde et al. 2020). They further noted that the data for this stock exhibit increasing trends for both catch and CPUE, which is not compatible with harvest strategy approaches that assume that CPUE is a useful index of abundance.

Separately, for a range of species including toothfish, Butterworth et al. (2021) discussed the relative merits and drawbacks of adopting either i) a harvest strategy based on a constant catch consistent with recent 'status quo' catch levels; or ii) a simple harvest strategy based on an estimate of B_{msy} and thus F_{msy}, or iii) a constant fisheries mortality (F) consistent with recent 'status quo' F values. Butterworth et al. (2021) note that approach i) generates stable TACs but may result in some foregone catch levels in the short term because current biomass is thought to be substantially higher than B_{msy}. They note that approach ii) is likely to result in higher inter-annual TAC variability (relative to approach iii), reflecting uncertainty regarding B_o.

Both Sarralde et al. (2020) and Butterworth et al. (2021) recommend that improved data collection is required to inform more reliable stock assessments for toothfish in the SIOFA area.

7. Data collection

Catch and effort fishery data are collected under CMM 02(2023) and were submitted by the CCPs listed in Table 2.

Table 2 – Toothfish catch and effort data submitted by different SIOFA CCPs, by year (source: SIOFA AggregatedCatchEffort and HBHCatchEffort database 2014–2023). HBH= haul-by-haul level data; AGG= aggregated data at different levels.

Toothfish catch and effort data submitted by different SIOFA CCPs		
Year	**Country**	**Database**
2014	FR-OT	HBH
2015	FR-OT	HBH
2016	ESP	HBH
2017	ESP	HBH
2017	FR-OT	HBH
2017	JPN	AGG
2018	ESP	HBH
2019	ESP	HBH
2019	FR-OT	HBH
2020	AUS	HBH
2020	ESP	HBH
2020	FR-OT	HBH
2021	AUS	HBH
2021	ESP	HBH
2021	FR-OT	HBH
2022	AUS	HBH
2022	ESP	HBH
2022	FR-OT	HBH
2023	AUS	HBH
2023	ESP	HBH
2023	FR-OT	HBH

Scientific Observer biological data (i.e., measures and biological samples of toothfish) are collected as a requirement of CMM 02(2023), and were submitted by the CCPs listed in Table 3.

Table 3 – Toothfish Scientific Observer biological data collected by different SIOFA CCPs, by year (source: SIOFA Observer database 2004–2023).

Toothfish observer data submitted by different SIOFA CCPs	
Year	**Country**
2017	FR-OT
2017	JPN
2018	ESP
2019	ESP
2019	FR-OT
2020	AUS
2020	ESP
2020	FR-OT
2021	AUS
2021	ESP
2021	FR-OT
2022	AUS
2022	ESP
2022	FR-OT
2023	AUS
2023	ESP
2023	FR-OT

7.1 Biological data summaries

Scientific observer data are collected as a requirement of CMM 02(2023) and CMM 15(2024), submitted by different CCPs participating in the fishery. In the Williams Ridge fishery, CMM 15(2024) (para 31) requires that representative data and samples of length, weight, sex, maturity stage, gonad weight, and otoliths hall be collected. There are no comparable data collection requirements for toothfish fisheries operating in areas outside the Williams Ridge management unit.

A summary of Patagonian and Antarctic toothfish biological data collected by Scientific Observers, and counts of records by year for selected data fields, are shown in Table 4 and Table 5, respectively.

Table 4 – Patagonian toothfish biological data collection by Scientific Observers, by year. Numbers of records per year are summarised for the following: length, weight, otoliths collected, sex determination, gonad maturity stage, gonad weight, and stomachs sampled (source: SIOFA Observer database 2014–2023).

Patagonian toothfish observer data measurements							
Year	**Length (n)**	**Weight (n)**	**Otoliths collected (n)**	**Sex (n)**	**Maturity (n)**	**Gonad weight (n)**	**Stomachs sampled (n)**
2017	792	478	478	704	0	478	0
2018	254	254	19	254	254	0	0
2019	4 954	4 603	962	4 902	4 766	0	0
2020	5 552	5 307	962	5 430	5 422	0	0
2021	3 291	3 099	1 982	3 137	3 104	0	0
2022	4 378	3 820	1 252	4 198	4 124	7	0
2023	5 389	5 380	652	5 390	5 373	0	0
Total	24 610	22 941	6 307	24 015	23 043	485	0

Table 5 – Antarctic toothfish biological data collection by Scientific Observers, by year. Numbers of records per year are summarised for the following: length, weight, otoliths collected, sex determination, gonad maturity stage, gonad weight, and stomachs sampled (source: SIOFA Observer database 2014–2023).

Antarctic toothfish observer data measurements							
Year	**Length (n)**	**Weight (n)**	**Otoliths collected (n)**	**Sex (n)**	**Maturity (n)**	**Gonad weight (n)**	**Stomachs sampled (n)**
2019	1	1	1	1	1	0	0
2020	12	12	12	12	12	0	0
2021	17	17	14	17	17	0	0
2022	7	7	1	3	3	0	0
Total	37	37	28	33	33	0	0

7.2 Tag data

In 2021 the SIOFA Scientific Committee endorsed the recommendations of a SIOFA/CCAMLR joint workshop regarding exchange of toothfish data, to standardise the process of data exchange between SIOFA and CCAMLR (as described in Annex A and Annex B of CCAMLR and SIOFA SC Chairs (2022)). The Scientific Committee also endorsed the adoption of toothfish tagging methods consistent with toothfish tagging protocols in CCAMLR (as described by the SIOFA Secretariat, 2022).

In 2024, the SIOFA SC tasked the Secretariat to retrieve historical tagging data that might have been available at the CCAMLR Secretariat from fishing activities in the SIOFA Area prior to the establishment of SIOFA. The SIOFA Data Officer retrieved from Uruguay 60 tag records from the vessel 'Banzare',

which conducted fishing activities in the SIOFA Area in 2009, and included these in the SIOFA Observer database. The Data Officer was also able to retrieve catch and effort data from 10 fisheries operations conducted by Ukraine in 2004, and these data were included in the SIOFA CatchEffort database.

The data for the 264 tagged fish which were released between April 2008 to June 2008 by the 'Banzare' were reported to CCAMLR and included in the tag linking algorithm, resulting in one additional linked recapture reported here.

Japan also flagged that they might have some data from the operations of the 'Shinsei Maru No. 3' in 2010 and 2013. These data are not available to SIOFA and thus not included in this analysis.

Two Spanish vessels fished in the SIOFA management area in 2017 and 2018. These vessels recovered eleven tagged Patagonian toothfish (*Dissostichus eleginoides*) in 2017 and 2018, but the release data from one of these toothfish are missing. The time elapsed between the release and recapture was between 3 and 10 years and all fish were small at release (between 75-93 cm). The maximum growth in weight was 5 kg and 26 cm in length. Specimens recaptured travelled (straight line distance) from 6 to ~1800 km, with 6 of 10 individuals showing a long-distance movement (exceeding 1000 km). This information was provided to CCAMLR by Sarralde and Barreiro (2018).

Table 6 summarizes the number of toothfish tagged and released in the SIOFA Area to date, as available in the SIOFA database after the most recent data exchange with CCAMLR. Table 7 summarizes recaptures in the SIOFA Area to date. Most recaptures in the SIOFA Area were of fish originally released in the CCAMLR Area, but 14 individuals were released in the SIOFA Area (Table 7). In 2023, three individuals released in the SIOFA Area were recaptured in the CCAMLR Area (one at a considerable distance from the release point, in CCAMLR Subarea 88.2) and another individual released in the Williams Ridge toothfish management area was recaptured in CCAMLR division 58.5.1 in 2024.

Table 6 – Summary of Patagonian toothfish tag releases in the SIOFA Area, by Subarea and year (source: SIOFA Observer database/CCAMLR database 2009-2023).

Patagonian toothfish tag releases in the SIOFA Area (2009-2023)			
Year	**SIOFA Subarea 7**	**SIOFA Subarea 3b**	**Total**
2009	0	60	60
2020	175	0	175
2021	150	687	837
2022	149	774	923
2023	15	1 043	1 058
Total	489	2 564	3 053

Table 7 – Summary of Patagonian toothfish tag recaptures in the SIOFA Area, by Subarea (source: SIOFA Observer database/CCAMLR database 2019-2023). Numbers of recaptured tags originating from the CCAMLR areas are provided in separate columns.

Patagonian toothfish tag recaptures in the SIOFA Area (2019-2023)				
Year	All recaptures in SIOFA Subarea 3b	All recaptures in SIOFA Subarea 7	CCAMLR tags recaptured in SIOFA Subarea 3b	CCAMLR tags recaptured in SIOFA Subarea 7
2019	0	1	0	1
2020	2	1	2	1
2021	5	3	3	3
2022	5	5	1	4
2023	9	2	3	1
Totals	21	12	9	10

Toothfish recapture data were shared with CCAMLR to collect more detailed information on release/recapture locations and fish condition (last update 25/09/2024).

[this section is not included in the public version of the manuscript, due to confidentiality limitations set out in CMM 03(2016)]

7.2.1 Tag overlap statistics

In 2024, SC9 tasked the SIOFA Secretariat with adding "*tagging rate required and achieved and the tag overlap statistics achieved, where possible*" to this summary (SC9 report, paragraph 222) but was not specific on the extent of this addition. In this Section, the Secretariat provided a basic summary of the tag overlap principles and a summary report of tag overlap estimates.

CMM 15(2024) article 26 requires *".. vessels to tag and release Dissostichus spp. specimens at a rate of at least 5 fish per tonne green weight caught. A minimum overlap statistic of at least 60% shall apply for tag release, once 30 or more Dissostichus spp. specimens have been caught.".*

Furthermore, please note that SIOFA CMM 15 is not specific on the basis for the tag overlap calculation (e.g. per trip/per fishing season/per calendar year). The Secretariat adopted a consistent approach with CCAMLR when calculating the tag overlap statistic, and thus this summary presents information on the tag overlap calculated on a "per trip" basis.

The calculation of the tag overlap statistic (θ) uses the formula in footnote 3 of CM 41-01, Annex C:

$$\theta = \left(1 - \frac{\sum_{i=1}^{n} \left| P_t - P_c \right|}{2}\right) \times 100$$

where Pt is the proportion of all fish tagged in length bin i

Pc is the proportion of all fish caught (i.e. the sum of all fish caught and either landed or tagged and released)

for lengths aggregated in 10cm length bins

and Pt is derived from the measured lengths reported in the C2 Tagging Worksheet

Pc is derived from the measured lengths reported in the observer Biological Sampling worksheet, and the C2 Tagging worksheet, and the total number of fish caught and reported in the C2 Haul Catch worksheet. The measured length-frequency distribution of fish caught in each haul is scaled to the total number of fish caught in that haul, and the scaled length-frequency distributions are summed across all completed hauls.

SIOFA tag overlap statistics were calculated using the CCAMLR tool (https://github.com/CCAMLR-Science/CCAMLRTOOLS) first published in 2023. The CCAMLR routine calculates tag overlap statistics (both summaries and plots) based on season and area.

Please note that trips in SIOFA are considerably longer than those in CCAMLR, which created the need to modify the data inputs to match the trips.

Table 9 summarises the tag overlap statistic for Patagonian toothfish per vessel trip and assessment area, using all data available. Vessel names are anonymised to provide a measure of confidentiality. Data is presented only for trips executed after October 2019 onwards, as tag overlap requirements first came into force in that period (CMM 2019/15).

Table 8– Summary of tag overlap statistic for Patagonian toothfish by Year/CCP (source: SIOFA CatchEffort and Observer databases 2014-2023), using all data available. Vessel names are anonymised to provide a measure of confidentiality. Yellow highlights cells with problematic tag rates.

Summary of tag overlap statistics in SIOFA fisheries (2019-2023) for Patagonian toothfish					
Trip/Season	SIOFA SubArea	Vessel	CCP	Tag rate	Tag overlap
2019	3b	Vessel 1	EU	0.0	100.00
2019	7	Vessel 1	EU	0.0	100.00
2020	7	Vessel 5	AUS	0.0	100.00
2020	3b	Vessel 1	EU	0.0	71.30
2020	7	Vessel 1	EU	2.5	71.30
2020	3b	Vessel 4	FR-OT	0.0	100.00
2020	3b	Vessel 3	FR-OT	0.0	100.00
2021/22	3b	Vessel 1	EU	5.0	77.36
2021	7	Vessel 6	AUS	0.0	100.00
2021	7	Vessel 7	AUS	5.2	91.05
2021	3b	Vessel 1	EU	5.2	66.46
2021	7	Vessel 1	EU	4.0	66.46
2021	3b	Vessel 3	FR-OT	6.2	75.08
2022/23	3b	Vessel 1	EU	5.1	53.69
2022	3b	Vessel 3	FR-OT	5.4	89.76
2022	7	Vessel 8	AUS	5.5	94.19
2023	7	Vessel 5	AUS	4.5	73.06
2023	3b	Vessel 3	FR-OT	8.6	82.67

All the instances of tag overlap = 100% and tag rate = 0 in Table 9 are caused by a lack of tag release data (e.g. for French vessels trips prior to 2022). This data gap in the Secretariat Observer database likely originated from the lack of a clear submission form for this type of data prior to 2022. The SC might want to consider filling this data gap in the future, as CCPs indicated that the data are available at the national level.

No tag overlap statistic was calculated for TOA, because the number of caught individuals never exceeded 30 individuals per vessel/trip/season (see CMM 15(2024) article 26).

8. Summaries of abundance indices and other observational data

8.1 Scaled length frequencies

Scaled length frequency data are not available for toothfish at this time.

Raw catch length-frequencies for the Williams Ridge fishery only are presented by Ziegler and Miller (2022, Figure 8).

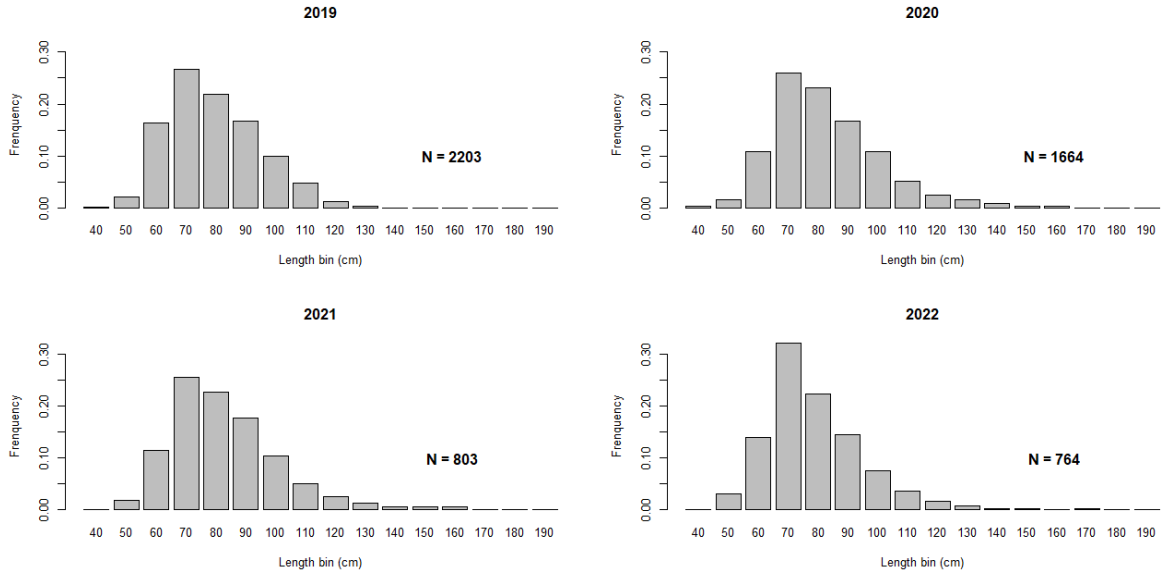

Figure 7 – Catch length-frequencies in the Williams Ridge fishery area, based on raw data for the 2019 -2022 seasons. N is the number of sampled fish. Source: Ziegler and Miller (2022).

Raw catch length-frequencies were also presented by the EU (Spain) within paper SC-08-INFO-17-Rev1, for both the Del Cano and the South West Indian Ridge areas in the 2017–2022 period (Figure 9 and Figure 10, respectively).

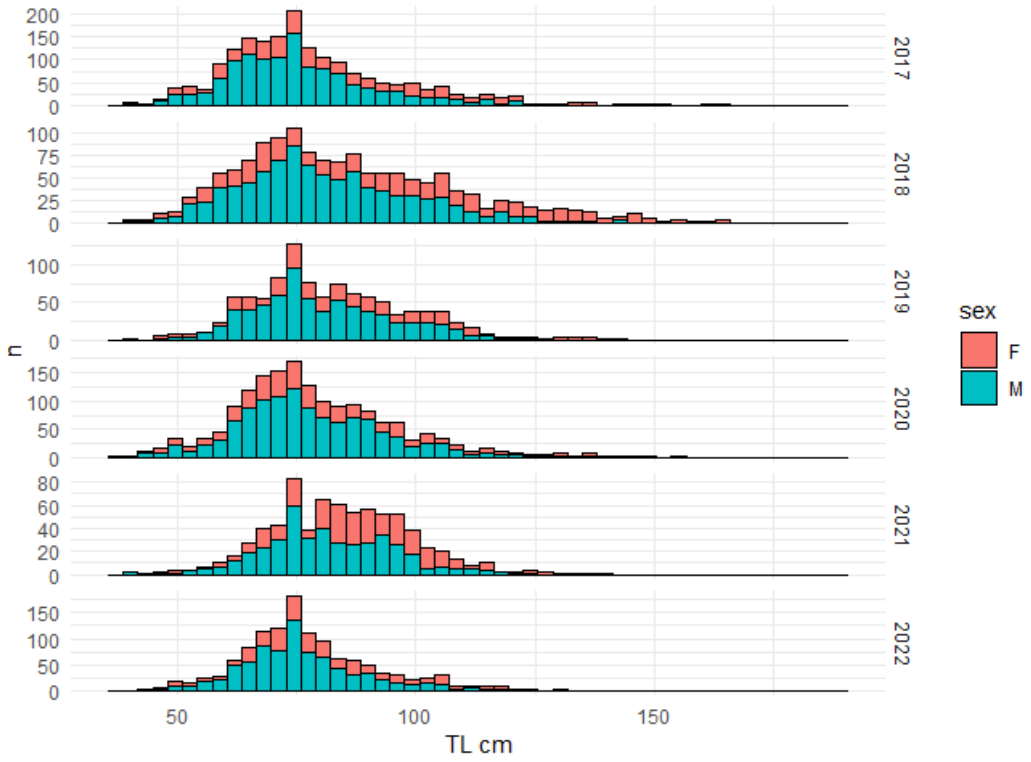

Figure 8 – Catch length-frequencies by sex from 2017 to 2022 for the 3-b Del Cano area. n is the number of sampled TOP. Source: paper SC-08-INFO-17-Rev1.

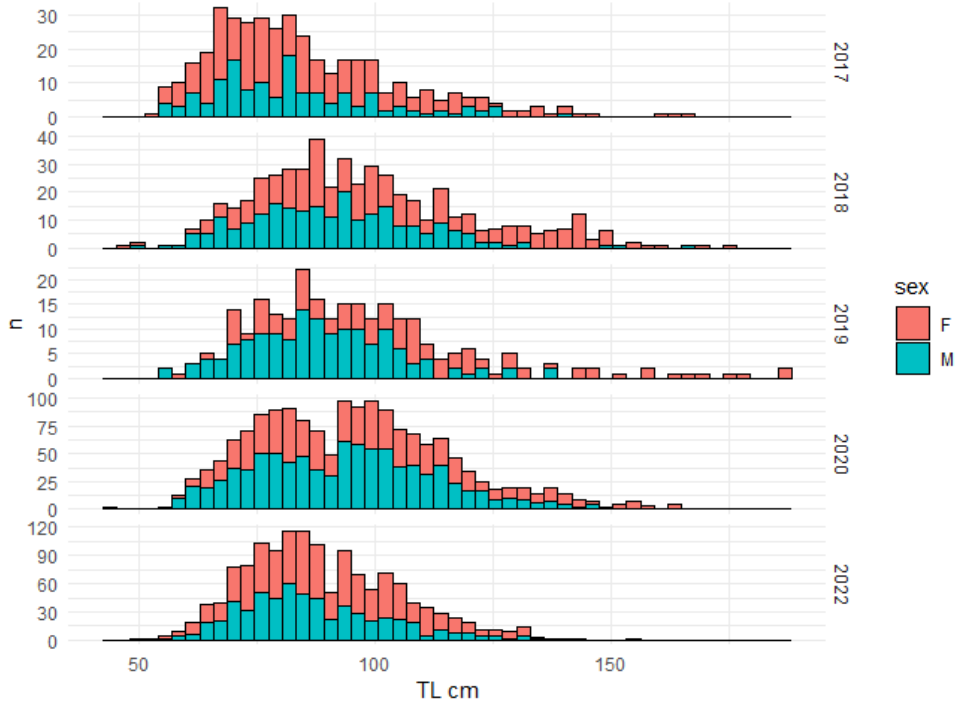

Figure 9 – Catch length-frequencies by sex from 2017 to 2022 for the 3-b South West Indian Ridge area. n is the number of sampled TOP. Source: paper SC-08-INFO-17-Rev1.

Raw catch length-frequencies were also presented by France OT within paper SC-08-INFO-17-Rev1, for the Del Cano area in the 2014–2022 period (Figure 11).

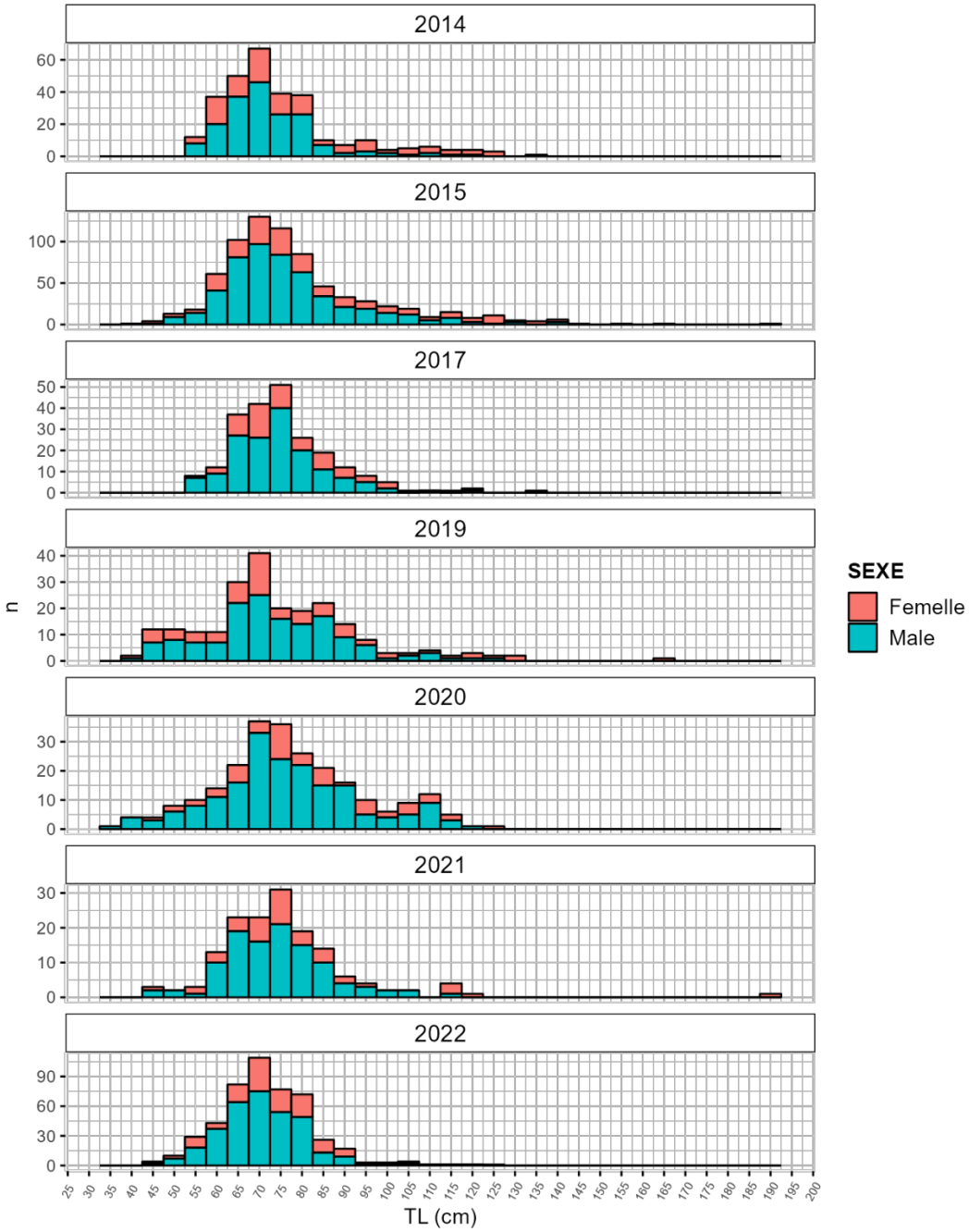

Figure 10 – Catch length-frequencies for the 2014 to 2022 seasons for the 3-b Del Cano area. N is the number of sampled TOP. Source: paper SC-08-INFO-17-Rev1.

8.2 Scaled age frequencies

Scaled age frequency data are not available for toothfish at this time.

8.3 CPUE indices

Sarralde et al. (2020) produced standardised CPUE trends for the Del Cano Rise fishery, but noted that these were unlikely to produce a useful index of abundance due to limitations in the quality of the catch-effort data. In particular, the data from one CCP was not included, and from the remaining CCPs, only part of the catches taken from within the Del Cano Rise area was able to be included, because

the data had not been recorded with sufficient spatio-temporal specificity. The authors recommended, and the SC endorsed, adoption of improved data collection protocols.

In the Williams Ridge fishery, Ziegler and Miller (2022) reported generally declining catches since 2018 but noted that standardised CPUEs were uncertain due to the confounding effects of variable spatial and temporal fishing effort patterns.

8.4 Acoustic biomass indices

It is considered infeasible to utilise acoustic survey methods to assess toothfish in the SIOFA area.

8.5 Trawl survey indices

No trawl surveys have been undertaken for toothfish in the SIOFA Area.

8.6 Tag based abundance estimates

SIOFA requires tagging by CCP vessels targeting toothfish in the SIOFA area (CMM 15(2024)) and collects toothfish tagging data, including via regular data exchange with CCAMLR, where tagging has been ongoing for a longer time, in toothfish fisheries adjacent to the SIOFA toothfish management areas (SIOFA SC Chair and CCAMLR SC Chair, 2022; SERAWG-04-INFO-04). Tag release and return data are summarised in Section 7.2 above; these tag returns are not sufficient to inform an estimate of abundance in SIOFA toothfish fisheries at this time.

9. Biological parameters

Biological parameters have not been estimated for toothfish from data collected specifically from SIOFA fisheries. Butterworth et al. (2021) proposed M = 0.15, L_∞ = 134 cm, a_{50} = 6-9 y, and maximum age = 50 based on data from Patagonian toothfish sampled elsewhere (Table 10).

Table 9 – Proposed biological parameters for toothfish, based on toothfish sampled elsewhere.

Relationship	Parameter (units)	Area	Value			References
			Both	Male	Female	
Natural mortality	M (y^{-1})	all	0.15			Butterworth et al. (2021)
Von Bertalanffy growth coefficient	t_0 (y)					
	k (y^{-1})		0.1			Butterworth et al. (2021)
	L_∞ (cm)		134			Butterworth et al. (2021)
Length-weight	c.v. a ($t.cm^{-1}$) b					
Maturity	a_{50} ($\pm a_{to95}$)		6-9			Butterworth et al. (2021)
Stock recruitment relationship						
Stock recruitment steepness	h					
Recruitment variability	σ_R					
Ageing error type	Normal					
Ageing error parameters	c.v.					

9.1 Natural mortality

Natural mortality has not been estimated specifically for toothfish in the SIOFA Area.

Butterworth et al. (2021) propose a value of M = .15 for toothfish in the SIOFA area.

9.2 Growth parameters

Growth parameters have not been estimated specifically for toothfish in the SIOFA Area.

Butterworth et al. (2021) propose the following biological growth parameters for toothfish (Table 11).

Table 10 – Growth parameters for toothfish in the SIOFA Area proposed by Butterworth et al. (2021).

Parameter	**Combined sex**
L-inf	134 cm
kappa	0.1
Average age at maturity	6-9
Maximum age	50

9.3 Length/age relationship

No length-age relationship is available for toothfish sampled specifically in the SIOFA area.

Von Bertalanffy growth parameters for based on review of toothfish parameters derived elsewhere are shown above in Tables 4 and 5 (from Butterworth et al. 2021).

9.4 Maturity and spawning

No maturity analysis is available derived from toothfish sampled specifically in the SIOFA area.

9.5 Stock recruitment relationship

The stock-recruitment relationship for toothfish has not yet been investigated in the SIOFA area.

9.6 Tag parameters

SIOFA does require tagging for toothfish, with measures complementary to CCAMLR. See Section 7.2 for a summary of tagging data.

10. Catch/bycatch/discards and ecosystem impacts

Bycatch commonly refers to the capture of all fish species that were not intended as a target in a given fishing event.

Bycatch was defined by the SIOFA SC as "*Fishery resources that are not target nor targeted typically in the taxonomic classes Chondrichthyes and Actinopterygii and infraphylum Agnatha and class Cephalopoda and Crustacea, that are part of the catch which is not the target*" (paragraph 207c of the SC8 report).

The ratio of catch and bycatch in the toothfish fisheries suffers from a lack of reported target species for fishing events that caught toothfish in 2013, and 2016–2020. Hence, it was not possible to determine catch/bycatch ratios in these events based on declared targets.

As a practical mean of estimating the catch/bycatch ratio in fishing events where targets were not declared, the Workshop on the development of ecosystem and fisheries summaries (WS2022-SUM1) suggested using a catch threshold whereby hauls in which at least a certain percentage of the catch was toothfish, to be designated as toothfish target hauls. This section uses a 20% target catch threshold (a typical average threshold for declared events).

10.1 Toothfish target catch /bycatch

Target catch/bycatch is depicted in Figure 12. Note that the 20% catch threshold rule to define toothfish target hauls was applied only to fishing effort for which targets were not declared, and that the ratios might not be strictly comparable to the data where targets were declared in this figure. Future work should consider harmonizing this time series.

The species identity of these bycatches in toothfish target hauls is shown in Figure 13.

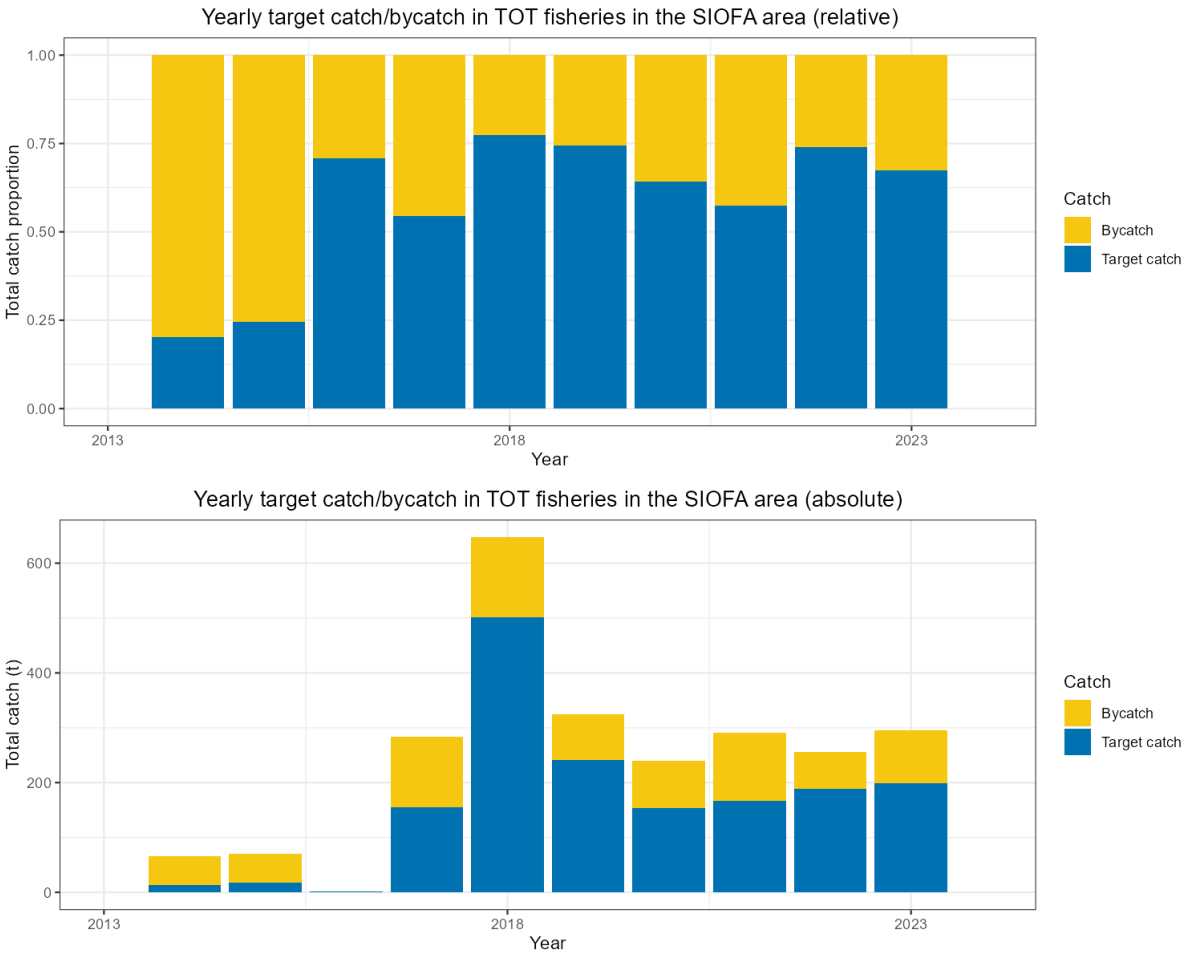

Figure 11a and b – Total catch of toothfish and other bycatch species in SIOFA fisheries that targeted toothfish, shown as relative values (upper panel, a) and absolute values (lower panel, b) (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023). Catches reported without location information are not included.

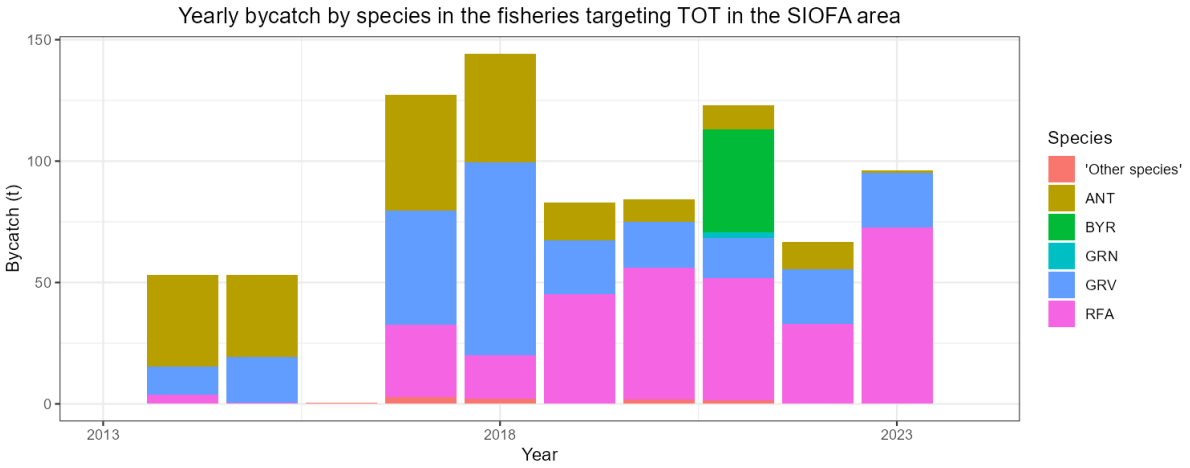

Figure 12– Yearly catch weights of bycatch species in fisheries targeting toothfish in the SIOFA area, by species (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023). Species are identified by their 3-letter FAO code.

Sharks is used in this report as a broad term to include all Chondrichthyans (see Appendix B of the Overview of SIOFA Fisheries for a full list of taxa), unless otherwise specified.

Catches of sharks in the toothfish fishery were not rare. The most bycaught shark species by weight was Whiteleg skate (RFA, *Amblyraja taaf*), with significant catches of Kerguelen sandpaper skate (BYR, *Bathyraja irrasa*) in 2021 (Figure 14).

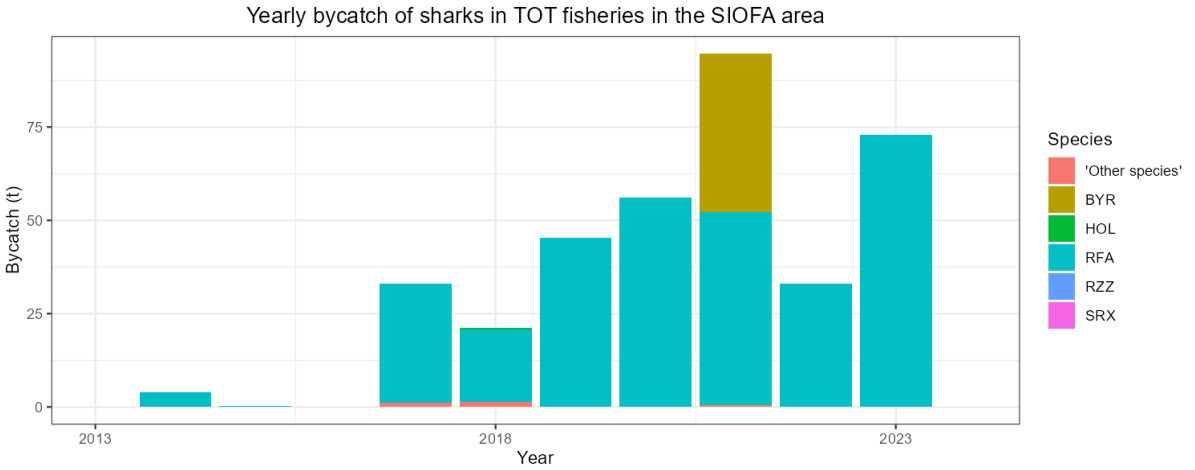

Figure 13 – Reported bycatch of shark species in fisheries targeting toothfish (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023).

10.2 Target catch/bycatch by SIOFA Subarea

Relative catches and bycatches in fisheries targeting toothfish in the SIOFA Area are represented in Figure 15. Note that toothfish catches in Subarea 3b have been reported in further detail within paper SC-10-23 Data limited fisheries biomass estimates: trend analysis for SIOFA toothfish (restricted paper).

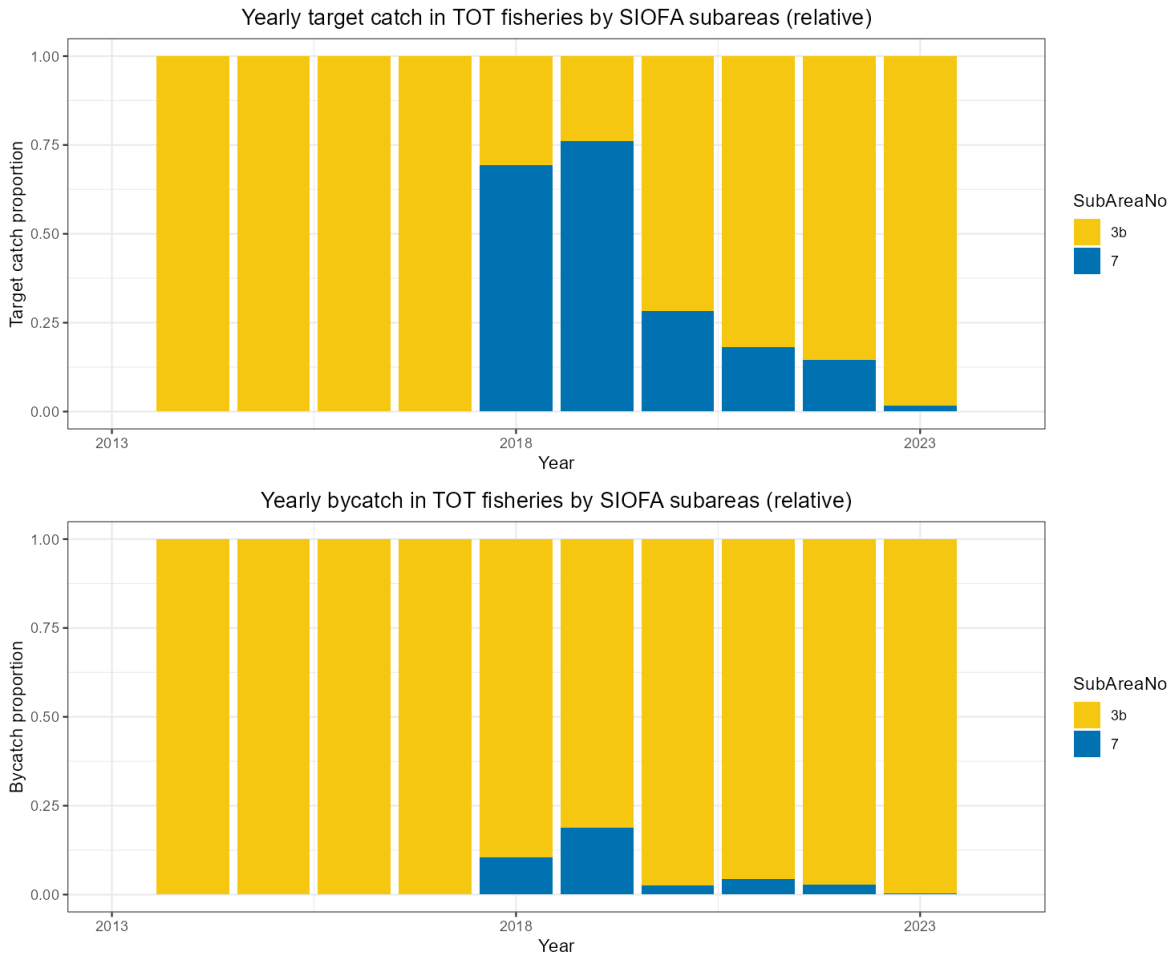

Figure 14a and b – Distribution of target catch (a) and bycatch (b) in fisheries targeting toothfish in different SIOFA Subareas (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023). Catches reported without location information are not included.

10.3 Discards

A specific field is included in SIOFA CatchEffort databases to indicate the fate of the catch, including retained, discarded and "other" categories.

Discard rates of fisheries targeting toothfish in the SIOFA Area are presented in Figure 16.

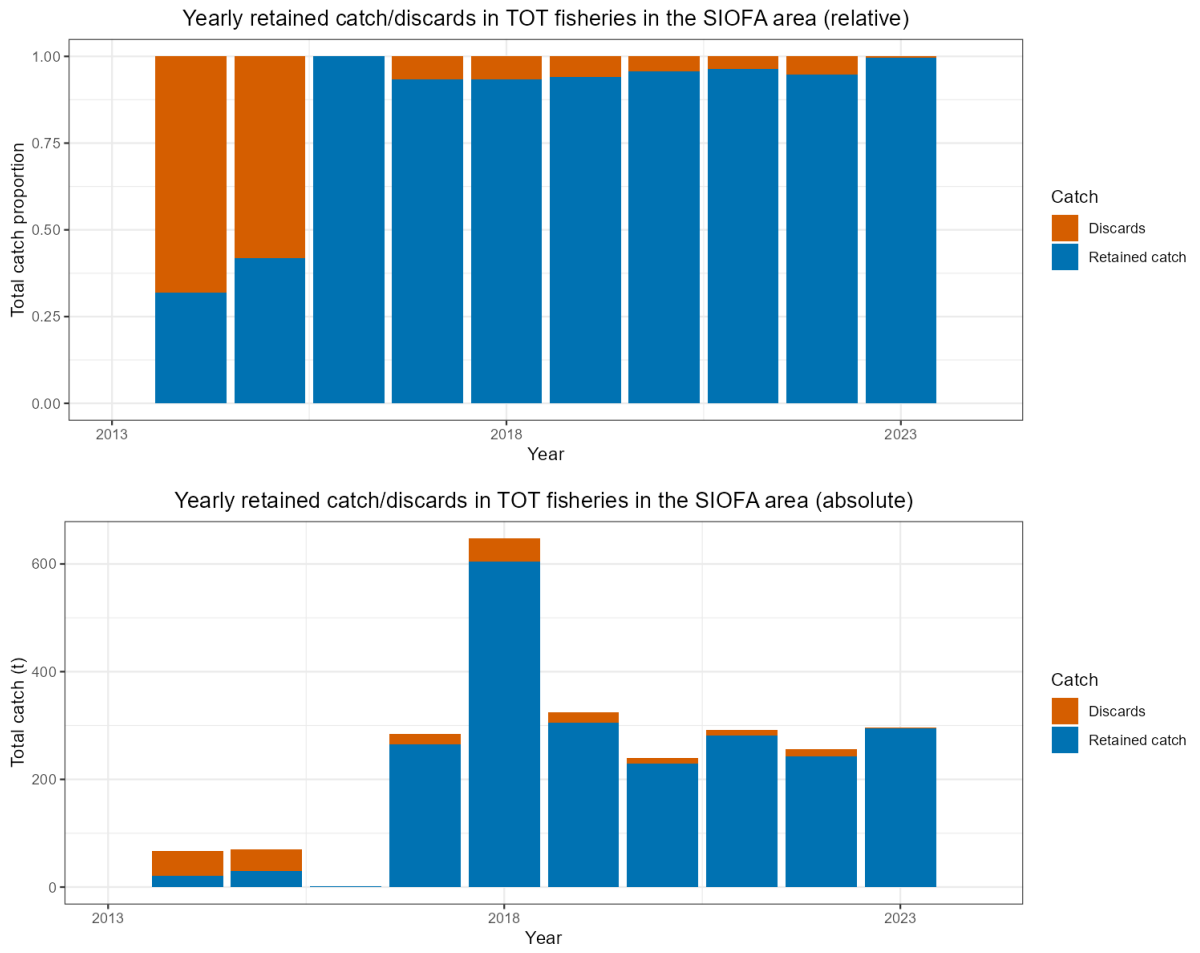

Figure 15a and b – Total retained and discarded catch in SIOFA fisheries that targeted toothfish, shown as relative values (upper panel, a) and absolute values (lower panel, b) (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023). Catches reported without location information are not included.

Discards composition by species in fisheries targeting toothfish in the SIOFA Area is represented in Figure 17. Some of the most represented species in discards are the blue antimora (*Antimora rostrata*, ANT) and grenadiers nei (*Macrourus spp,* GRV).

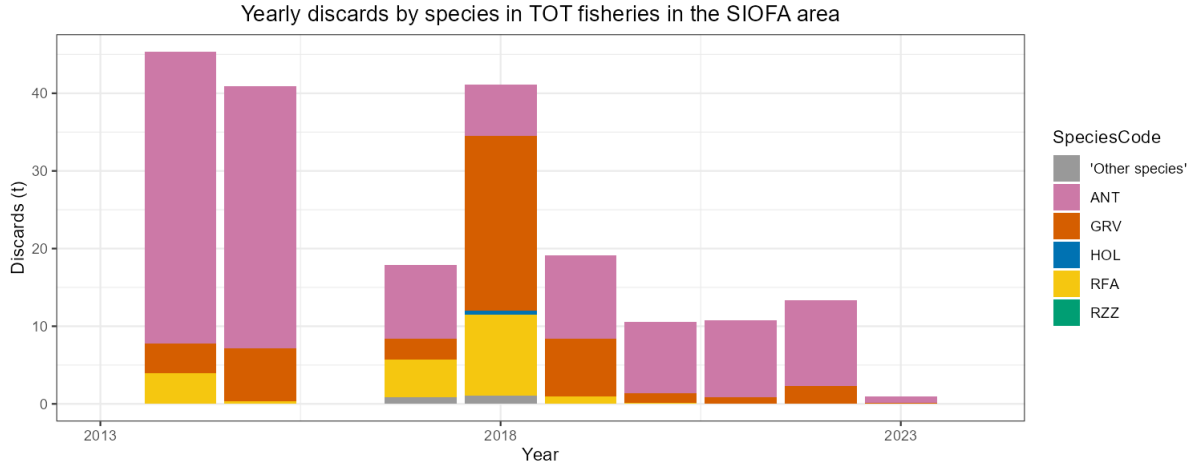

Figure 16 – Reported discards of fish species in fisheries targeting toothfish (source: SIOFA AggregatedCatchEffort and HBHCatchEffort databases 2014–2023). Only the top five species (by weight) are fully represented, while the other species have been grouped in a single category.

10.4 Target catch/bycatch in management areas

The Del Cano Rise and Williams Ridge management areas are formally defined in CMM 15(2024).

The majority of toothfish catches come from the Del Cano Rise management area, in SIOFA Subarea 3b. A smaller proportion of toothfish catches are reported from the Williams Ridge management area, in Subarea 7 (Figure 18).

[this figure is not included in the public version of the manuscript, due to confidentiality limitations set out in CMM 03(2016)]

10.5 Incidental catch of VME taxa and other invertebrates

SIOFA Scientific Observers recorded the incidental catch of VME indicator taxa in fishing operations targeting toothfish starting in 2017. While early years saw no incidental captures, these have been much more important in recent years (> 100 kg in 2020 and 2022, Figure 19). While cumulative annual weights can be high, typical weights for single fishing operations are relatively small. A wide diversity of VME indicator taxa can be observed in incidental catches.

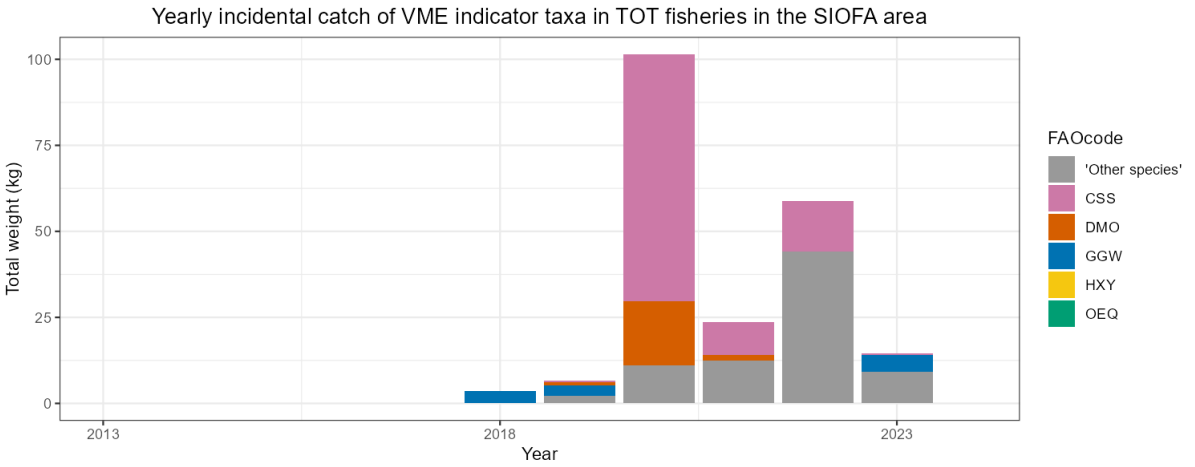

Figure 17 – Yearly incidental catch of VME indicator taxa in fisheries targeting TOP within the SIOFA Area, by taxa group (source: SIOFA Observer and HBHCatchEffort databases 2003–2022). Only the top five species (by weight) are fully represented, while the other species have been grouped in a single category. Taxa are indicated by their 3-letter FAO code (see Appendix C of the SIOFA Ecosystem Summary). A figure with the full list of taxa is included

11. Interactions with seabirds, mammals, turtles, sharks and other species of concern

Only incidental captures of seabirds, marine mammals, turtles, and sharks considered to be at high risk and/or concern are reported in the SIOFA Scientific Observer database, and the following sections have drawn from this database to explore the number and locations of these interactions.

Incidental captures of other species (e.g., of sharks) are also recorded in the SIOFA CatchEffort database but are not reported here (see Section 10.1 instead).

Figure 20 shows the reported locations of incidental captures (Figure 20a) and observations (Figure 20b) of seabirds, mammals, and sharks considered to be at high risk and/or concern (i.e., included in SIOFA CMM 12) captured in fishing operations targeting toothfish in the SIOFA Area, as recorded by Scientific Observers.

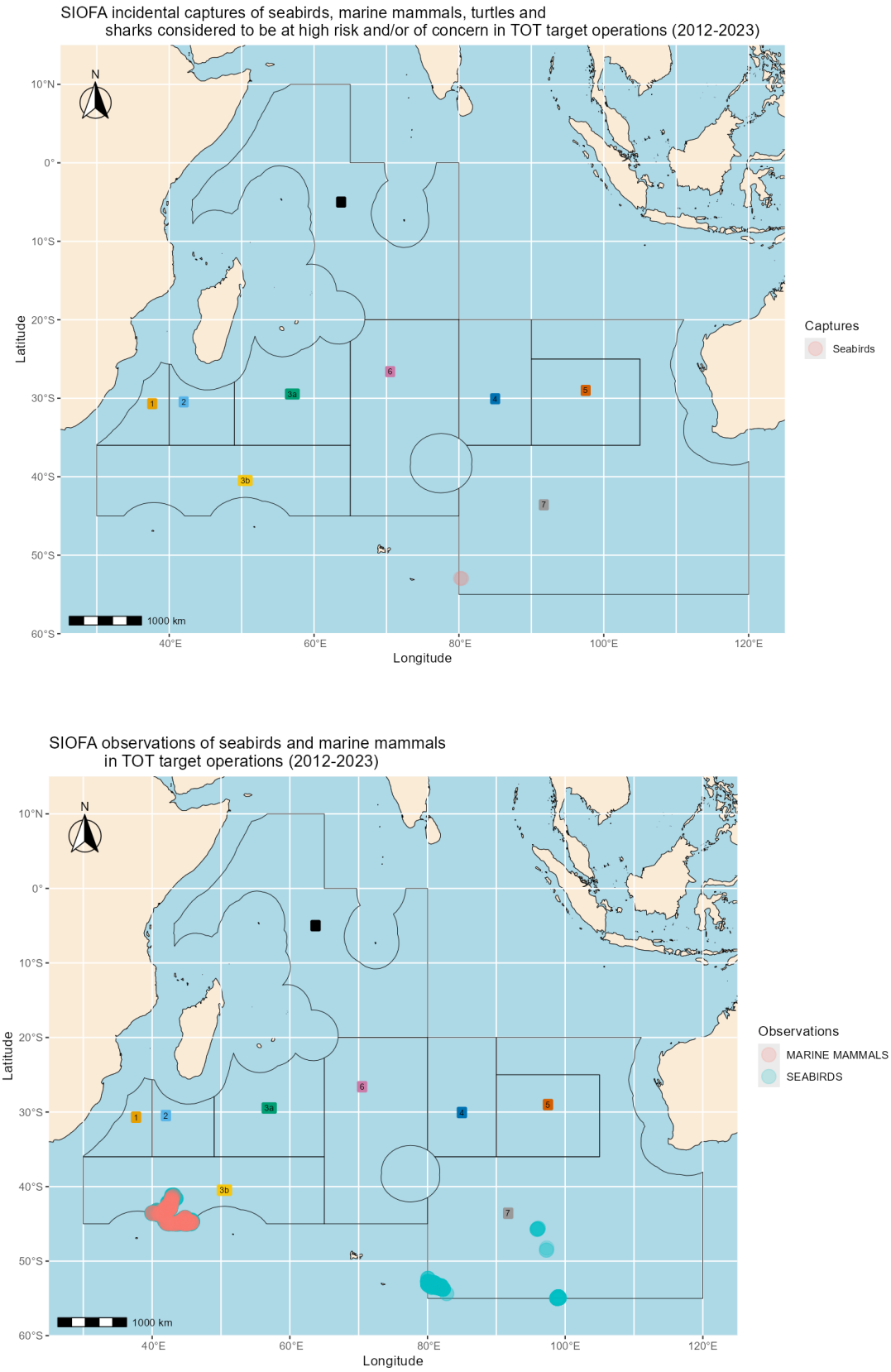

Figure 18a and b – Reported locations of incidental captures (a, upper) and observations (b, lower) of seabirds, cetaceans, and sharks considered to be "at high risk" and/or "of concern", as defined in Annex 1 of CMM 12(2024), captured in fishing operations targeting toothfish in the SIOFA Area, as recorded by SIOFA Scientific Observers (source: SIOFA Observer database 2004–2023).

11.1 Seabirds interactions

Provisions for the mitigation of accidental capture of seabirds in toothfish fisheries are in CMM 13(2022) (Conservation and Management Measure on mitigation of seabirds bycatch in demersal longlines and other demersal fishing gears fisheries(Mitigation of Seabirds Bycatch)).

11.1.1 Captures

A single incidental capture event was reported by SIOFA Scientific Observers in toothfish fisheries: in 2019, 2 individuals of Antarctic giant petrel (*Macronectes giganteus*) were captured and released in SIOFA Subarea 7. No information is available on status at release.

11.1.2 Observations

The presence of several different seabirds was recorded by Scientific Observers around fishing operations that targeted toothfish in the SIOFA Area (Table 12).

Table 11 – Number of seabirds observed around fishing operations that targeted toothfish between 2019 and 2022 (source: SIOFA Observer database 2004–2023).

Year	Common name	Scientific name	Fishing gear	Abundance
2019	Antarctic giant petrel	*Macronectes giganteus*	Set longlines	7025
2019	Black-browed albatross	*Thalassarche melanophris*	Set longlines	1140
2019	Cape petrel	*Daption capense*	Set longlines	3403
2019	Hall's giant petrel	*Macronectes halli*	Set longlines	1155
2019	Prions nei	*Pachyptila spp*	Set longlines	3
2019	*Seabirds nei*		Set longlines	542
2019	Southern royal albatross	*Diomedea epomophora*	Set longlines	1
2019	Wandering albatross	*Diomedea exulans*	Set longlines	192
2019	White-chinned petrel	*Procellaria aequinoctialis*	Set longlines	1650
2019	Wilson's storm petrel	*Oceanites oceanicus*	Set longlines	8
2020	Albatrosses nei	*Diomedeidae*	Set longlines	11
2020	Antarctic giant petrel	*Macronectes giganteus*	Set longlines	3952
2020	Atlant. yellow-nosed albatross	*Thalassarche chlororhynchos*	Set longlines	2
2020	Black-bellied storm petrel	*Fregetta tropica*	Set longlines	269
2020	Black-browed albatross	*Thalassarche melanophris*	Set longlines	4615
2020	Brown skua	*Stercorarius antarcticus*	Set longlines	1
2020	Cape petrel	*Daption capense*	Set longlines	879
2020	Giant petrels nei	*Macronectes spp*	Set longlines	365
2020	Great shearwater	*Puffinus gravis*	Set longlines	1
2020	Grey petrel	*Procellaria cinerea*	Set longlines	13
2020	Grey-headed albatross	*Thalassarche chrysostoma*	Set longlines	1
2020	Hall's giant petrel	*Macronectes halli*	Set longlines	4063
2020	Indian yellow-nosed albatross	*Thalassarche carteri*	Set longlines	69
2020	Light-mantled sooty albatross	*Phoebetria palpebrata*	Set longlines	6
2020	Prions nei	*Pachyptila spp*	Set longlines	149
2020	*Seabirds nei*		Set longlines	167
2020	Shy albatross	*Thalassarche cauta*	Set longlines	414
2020	Sooty albatross	*Phoebetria fusca*	Set longlines	2
2020	Southern fulmar	*Fulmarus glacialoides*	Set longlines	3
2020	Wandering albatross	*Diomedea exulans*	Set longlines	8196

Year	Common name	Scientific name	Fishing gear	Abundance
2020	White-chinned petrel	*Procellaria aequinoctialis*	Set longlines	17252
2020	Wilson's storm petrel	*Oceanites oceanicus*	Set longlines	100
2021	Albatrosses nei	*Diomedeidae*	Set longlines	10
2021	Amsterdam Island albatross	*Diomedea amsterdamensis*	Set longlines	2
2021	Antarctic giant petrel	*Macronectes giganteus*	Set longlines	5655
2021	Black-browed albatross	*Thalassarche melanophris*	Set longlines	5476
2021	Blue petrel	*Halobaena caerulea*	Set longlines	16
2021	Cape petrel	*Daption capense*	Set longlines	125
2021	Giant petrels nei	*Macronectes spp*	Set longlines	176
2021	Grey-headed albatross	*Thalassarche chrysostoma*	Set longlines	2
2021	Hall's giant petrel	*Macronectes halli*	Set longlines	2350
2021	Indian yellow-nosed albatross	*Thalassarche carteri*	Set longlines	2850
2021	Light-mantled sooty albatross	*Phoebetria palpebrata*	Set longlines	3
2021	*Seabirds nei*		Set longlines	32
2021	Southern royal albatross	*Diomedea epomophora*	Set longlines	1608
2021	Wandering albatross	*Diomedea exulans*	Set longlines	14393
2021	White-chinned petrel	*Procellaria aequinoctialis*	Set longlines	18386
2022	Antarctic giant petrel	*Macronectes giganteus*	Set longlines	20675
2022	Atlant. yellow-nosed albatross	*Thalassarche chlororhynchos*	Set longlines	1
2022	Black-browed albatross	*Thalassarche melanophris*	Demersal longlines	261
2022	Black-browed albatross	*Thalassarche melanophris*	Set longlines	2601
2022	Cape petrel	*Daption capense*	Demersal longlines	199
2022	Cape petrel	*Daption capense*	Set longlines	633
2022	Giant petrels nei	*Macronectes spp*	Demersal longlines	374
2022	Giant petrels nei	*Macronectes spp*	Set longlines	155
2022	Grey petrel	*Procellaria cinerea*	Set longlines	1
2022	Grey-headed albatross	*Thalassarche chrysostoma*	Demersal longlines	3
2022	Hall's giant petrel	*Macronectes halli*	Set longlines	382
2022	Indian yellow-nosed albatross	*Thalassarche carteri*	Set longlines	1551
2022	Light-mantled sooty albatross	*Phoebetria palpebrata*	Demersal longlines	23
2022	Prions nei	*Pachyptila spp*	Demersal longlines	79
2022	Prions nei	*Pachyptila spp*	Set longlines	77
2022	*Seabirds nei*		Demersal longlines	8
2022	*Seabirds nei*		Set longlines	184
2022	Shy albatross	*Thalassarche cauta*	Set longlines	1046
2022	Southern fulmar	*Fulmarus glacialoides*	Demersal longlines	13
2022	Southern royal albatross	*Diomedea epomophora*	Set longlines	582
2022	Wandering albatross	*Diomedea exulans*	Demersal longlines	112
2022	Wandering albatross	*Diomedea exulans*	Set longlines	17040
2022	White-chinned petrel	*Procellaria aequinoctialis*	Demersal longlines	485
2022	White-chinned petrel	*Procellaria aequinoctialis*	Set longlines	24876
2023	Amsterdam Island albatross	*Diomedea amsterdamensis*	Set longlines	26
2023	Antarctic giant petrel	*Macronectes giganteus*	Set longlines	31940
2023	Black-browed albatross	*Thalassarche melanophris*	Set longlines	2162
2023	Cape petrel	*Daption capense*	Set longlines	2285
2023	Giant petrels nei	*Macronectes spp*	Set longlines	38
2023	Indian yellow-nosed albatross	*Thalassarche carteri*	Set longlines	4127
2023	*Seabirds nei*		Set longlines	25

Year	Common name	Scientific name	Fishing gear	Abundance
2023	Shy albatross	*Thalassarche cauta*	Set longlines	2507
2023	Sooty albatross	*Phoebetria fusca*	Set longlines	2
2023	Wandering albatross	*Diomedea exulans*	Set longlines	38762
2023	White-chinned petrel	*Procellaria aequinoctialis*	Set longlines	56415

11.2 Marine mammals interactions

Gasco et al. (2020) estimated whale depredation in SIOFA toothfish fisheries using photo-identification data of killer whales and sperm whales in the southern Indian Ocean and comparing catch rates in the presence and absence of whale depredation, based on French observer data from the Crozet Islands and Spanish observer data on del Cano Rise in the SIOFA area. Of the 37 individual killer whales identified from the del Cano Rise fishery, 26 of these have also been observed interacting with longline vessels in the Crozet and/or Kerguelen Islands (a photo ID catalog of killer whales in this region is described in Tixier et al. 2021). Based on the available data from the period 2009–2019, depredation rates on longlines targeting *D. eleginoides* in the del Cano Rise in the SIOFA area were estimated to be 8% of total toothfish catch.

Gasco et al. (2020) note that depredation is a learned behaviour that is acquired by different groups of whales, especially as individual depredating whales move between areas, and that depredation behaviour appeared to be in its early stages of development among whales in the SIOFA area. The Scientific Committee has endorsed the implementation of mitigation measures by toothfish fishery vessels to prevent the development of a serious depredation problem in SIOFA toothfish fisheries (CMM 15(2024), paragraphs 47-48), and data collection protocols for demersal longline fisheries to document the extent of whale interactions and inform more accurate estimation of unaccounted mortality (SC6 paragraph 116).

11.2.1 Captures

No incidental captures of mammals were recorded in toothfish fisheries.

11.2.2 Observations

Observations of several cetaceans, both odontocetes and mysticetes, were recorded by SIOFA Scientific Observers around fishing operations that targeted toothfish (Table 13).

Table 12 – Number of mammals observed around fishing operations that targeted toothfish (source: SIOFA Observer database 2004–2023).

Observations of marine mammals in SIOFA toothfish fisheries				
Year	**Common name**	**Scientific name**	**Fishing gear**	**Maximum abundance**
2021	Antarctic minke whale	*Balaenoptera bonaerensis*	Set longlines	3
2021	False killer whale	*Pseudorca crassidens*	Set longlines	10
2021	Killer whale	*Orcinus orca*	Set longlines	205
2021	Sperm whale	*Physeter macrocephalus*	Set longlines	41
2022	Long-finned pilot whale	*Globicephala melas*	Set longlines	30
2022	Marine mammals nei	-	Set longlines	2
2022	Sperm whale	*Physeter macrocephalus*	Set longlines	59
2023	False killer whale	*Pseudorca crassidens*	Set longlines	120
2023	Humpback whale	*Megaptera novaeangliae*	Set longlines	1
2023	Killer whale	*Orcinus orca*	Set longlines	149
2023	Sperm whale	*Physeter macrocephalus*	Demersal longlines	1
2023	Sperm whale	*Physeter macrocephalus*	Set longlines	118

11.3 Turtles interactions

No turtles captures or observations have been recorded in toothfish fisheries by SIOFA Scientific Observers.

11.4 Shark captures of species considered to be at high risk and/or of concern

No captures of deep-sea shark taxa considered to be at “high risk” and/or “of concern” , as listed in Annex 1 of SIOFA CMM 12(2024) (Conservation and Management Measure for Sharks (Sharks)) were reported in the SIOFA Observer database for fisheries that targeted toothfish between 2017 and 2023.

12. Effects of the fishery on the ecosystem

The effects of this fishery on the ecosystems have not yet been investigated.

13. References

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14. Appendix A – Data included in figures

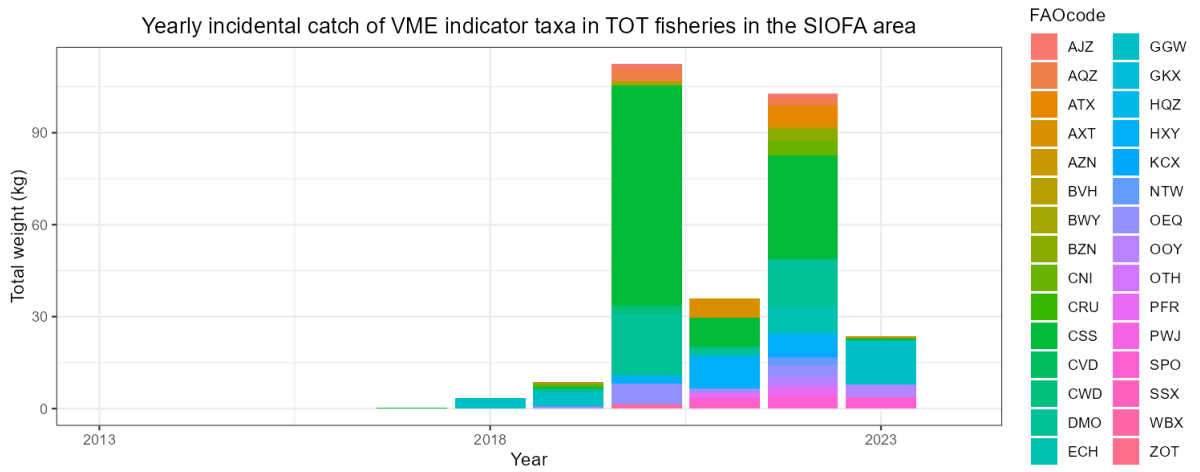

Figure 19 – Yearly incidental catch of VME indicator taxa in fisheries targeting TOP within the SIOFA Area, by taxa group (source: SIOFA Observer and HBHCatchEffort databases 2003–2022). Taxa are indicated by their 3-letter FAO code (see Appendix C of the SIOFA Ecosystem Summary).