

ANTARCTICA AND SURROUNDING ISLANDS: UPDATED CATCH RECONSTRUCTIONS FOR 2011-2018*

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Abstract

This contribution presents updated catch reconstructions for 2011-2018 for Antarctica's Large Marine Ecosystem and the Exclusive Economic Zones of Bouvet Island (Norway), Crozet Island (France), Falkland Islands (U.K.), South Georgia, South Sandwich, and South Orkney Islands (U.K.), Kerguelen Islands (France), St. Paul and Amsterdam Islands (France) and Prince Edward Island (South Africa). The major difficulties in updating the catch reconstructions for these countries were the remote nature of these areas and the data peculiarity of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) of reporting by fishing season (i.e., December of one year to November the next year) rather than standardized to calendar year. These difficulties were overcome by converting catches reported for the fishing season to calendar year, and applying literature estimates to estimate IUU fishing of commercially valuable species. Specific details on how each reconstruction was updated and carried forward are presented by island or island group.

Introduction

This contribution presents the basic methods used and assumptions made to update to 2018 the catch reconstructions initially covering the year 1950 to 2010 performed by the *Sea Around Us* and its international network of collaborators. As Antarctica itself has no Exclusive Economic Zone (EEZ), the areas covered here are the Large Marine Ecosystem (LME) around the Antarctic continent and the Exclusive Economic Zones (EEZ) around Bouvet Island (Norway), Crozet Island (France), Falkland Islands (United Kingdom), St. Paul and Amsterdam (France), South Georgia, South Sandwich and South Orkney Islands (U.K.), Kerguelen Islands (France) and Prince Edward Island (South Africa). The major difficulties in updating the catch reconstructions for these countries were the remote nature of these areas, which leads to IUU fishing and the peculiarity of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) of reporting by fishing season (i.e., December of one year to November the next year) rather than standardized to calendar year. These difficulties were overcome by converting catches reported by fishing season to calendar year and applying literature estimates to estimate IUU fishing of commercially valuable species. Specific details on how each reconstruction was updated and or carried forward are presented by island or island group.

Antarctica (Large Marine Ecosystem)

The original reconstruction of the fisheries catches of the continental margin of the Antarctic Large Marine Ecosystem was completed from 1950-2010 by Ainley and Pauly (2014, 2016). Since the original reconstruction, new data from CCAMLR have become available and used to update the reported baseline of

* Cite as: Dunstan, D., C. Brown, S.-L. Noël, V. Relano, R. White and D. Zeller. 2020. Antarctica and surrounding islands: Updated catch reconstruction for 2011 – 2018, p. 148-165. In: B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic*. Fisheries Centre Research Report 28(5).

the reconstruction to 2017, which was then carried forward using the procedure in Noël (2020) and catch data to 2018 from CCAMLR (2018).

Reported baseline data

CCAMLR reported landings from FAO sub-areas 48.1, 48.5, 48.6 (partially), 58.4.1, 58.4.2, 88.1, 88.2 and 88.3 were assumed to encompass the Antarctic shelf and slope and were included in the reconstruction for 2011-2017. Additional areas previously not included in the original reconstruction (or anywhere else in the *Sea Around Us* database) are 58.4.3a/b and 58.4.4a/b. They were incorporated for this update. All catch data in the Antarctic Large Marine Ecosystem (LME) are considered industrial and assigned to high-seas waters because the LME does not overlap with any country's EEZ. The main target species include toothfishes (*Dissostichus* spp.), Antarctic krill (*Euphausia superba*) and mackerel icefish (*Champsocephalus gunnari*). Most other species caught in this region are considered by-catch.

Illegal, unreported and unregulated catches

The CCAMLR fishery reports estimates of illegal, unreported and unregulated catch of *Dissostichus* spp. for each subarea, and these data are included as the unreported component of the reconstructed catch. However, the estimates stopped in 2011 due to uncertainties in the methodology of the CCAMLR assessment, even though IUU fishing is thought to still be occurring in some areas but remains undetected (CCAMLR 2016a). Therefore, we assumed the 2010 IUU amount was held constant for 2011-2017. According to CCAMLR (2010), discarding by-catch is prohibited south of 60° S, which contains most of the Antarctic shelf and slope; thus, no discards were assumed for this region. This is likely incorrect, and future research-intensive updates need to examine this carefully.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on CCAMLR data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

In Antarctica, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the OSPAR Commission (Marine Conservation Institute 2020) are the main organizations responsible for the protection of biological diversity. There are more than 49 MPAs around Antarctica (Marine Conservation Institute 2020), which jointly cover 2,686,567 km².

The South Orkney Islands southern shelf MPA covers 94,000 km² in the south Atlantic and was established in 2009 by the CCAMLR as the world's first high-seas MPA. In December 2017, the world's largest Marine Protected Area, the Ross Sea Region MPA, came into force, protecting 1.55 million km², of which 1.12 million km² (New Zealand Government 2016) are fully protected, i.e., no fishing is permitted. This MPA has three main zones that provide marine protection, sustainable fishing and scientific interests. This MPA, also established by the CCAMLR, shields ecologically important habitats and iconic regional species such as Weddell seals, Antarctic petrels, Ross Sea killer whales and Emperor and Adelie penguins (New Zealand Foreign Affairs and Trade 2020).

The 25 CCAMLR member countries will decide if the General Zone protection (i.e., no-take area) of the MPA continues beyond the 35-year duration of the initial agreement. CCAMLR assesses the scientific progress made every five years and evaluates the objectives every 10 years (New Zealand Foreign Affairs and Trade 2020).

Chown *et al.* (2017) provided a strategic plan to act effectively to prevent biodiversity loss by 2020 and assessed the outlook for Antarctica and the Southern Ocean as similar to the rest of the planet. The strongest opportunity to improve biodiversity protection was through the Antarctic Treaty System and expected to be effective in combination with wide support from governments, industry, and public (Chown *et al.* 2017).

During the 38th Annual Meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR-38), held in Hobart, Tasmania, from 21 October to 1 November 2019, some members expressed concerns regarding the lack of transparency by CCAMLR. “They noted that the Antarctic Treaty System and other international organizations that manage fisheries are more transparent and that their meeting documents are often freely accessible and suggested that CCAMLR consider the release of meeting documents to support transparency” (CCAMLR 2016b).

Bouvet Island (Norway)

The original catch reconstruction of Bouvet Island from 1950-2010 was done by Padilla *et al.* (2015, 2016). Since the initial reconstruction, new data from CCAMLR have become available (CCAMLR 2018) which allow updating the reconstruction to 2017 with a subsequent carry-forward to 2018 using the procedure in Noël (2020).

Reported baseline data

The reported baseline data for the catch reconstruction in the Bouvet Island EEZ was derived from CCAMLR sub-area 48.6. The Bouvet Island Exclusive Economic Zone (EEZ) covers only a small portion of sub-area 48.6; thus, the reported catch was disaggregated into catches assumed to have been taken inside and outside the EEZ using the ratio of the taxon distributions that are found in the Bouvet Island EEZ.

Illegal, unreported and unregulated catches

In a recent CCAMLR fishery report (CCAMLR 2017), there is a mention of “compelling evidence of IUU activity in Subarea 48.6” from 2013-2016. According to Sumby (2012), unreported landings of target species (*Dissostichus* spp.) are 13.6% higher than the reported landings in the Antarctic, so this percentage was applied to all reported landings (target and non-target species) for both inside and outside the Bouvet Island EEZ. Thus, we kept the previous unreported rate at 13.6%.

CCAMLR includes all discards in their reported data. Therefore, to estimate how much of the reported catch was actually discarded, a discard rate derived from Boonzaier *et al.* (2012) for Prince Edward Island (South Africa) was applied to the reported and unreported total catches of non-target taxa. The target species (*Dissostichus* spp.) was assumed to have negligible discards.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on CCAMLR data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The Norwegian government has agreed to protect the biological diversity of Bouvet Island through international agreements, i.e., the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute, 2020).

However, in 1971, even before these agreements, the island and four nautical miles of surrounding territorial waters were declared a Nature Reserve. Some species such as *Arctocephalus gazella* (fur seals) have been protected since 1935 (Huyser 2001).

The Nyrøysa platform and the northern and southern beaches of Westwindstranda were declared a site of the Ecosystem Monitoring Programme by the CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources). “[This is with the] objective of establishing a network of sites throughout the Southern Ocean for conducting long-term monitoring studies of the foraging ecology, demography and population trends of vertebrate predator populations. A draft management plan exists for Nyrøysa, but is not yet in force” (Huyser 2001).

Some of the past and present projects of the Norwegian Polar Institute in Bouvet Island are focused on monitoring and evaluating ocean currents and sea ice variability (Fram Strait project, A-TWAIN, Fimbul ice-shelf, Nansen Legacy), as well as monitoring marine environments and evaluating the status of some species (Polar Bear Monitoring, SEAPOP, CEMP, Seabird Tracking, ICE-WHALES) (Norwegian Polar Institute 2020).

“The Norwegian Polar Institute has authority delegated by the Ministry of Climate and Environment to grant permission for the use of off-road vehicles and aircraft landings, and to allow dispensation from other provisions for the purposes of research or other special activities. [...] As an active contributor to processes and discussions at national and international levels, the Norwegian Polar Institute is involved in enhancing and defining new instruments in the North and South on the basis of knowledge and general policy development” (Norwegian Polar Institute 2020).

Crozet Island (France)

Following the completion of the original catch reconstruction by Pruvost *et al.* (2015, 2016), which covered the years 1950-2012, the *Sea Around Us* updated it to 2017, then carried the data forward to 2018 using CCAMLR data (CCAMLR 2018) and the procedure of Noël (2020).

The CCAMLR statistics are reported by fishing season (i.e., December of one year to November of the next) and the original reconstruction (Pruvost 2015) followed this seasonal fishing year. In this update, the data in vol. 30 of CCAMLR’s Statistical Bulletin (CCAMLR 2018) were used to convert and update the reconstructed catches from the Crozet EEZ for 1977-2017 by calendar year (i.e., January to December; Figure 1).

Reporting baseline

All reported landings of the ridge-scaled rattail (*Macrourus carinatus*), whiteleg skate (*Amblyraja taaf*) and blue antimora (*Antimora rostrata*) were considered by-catch of the longline fishery for Patagonian toothfish (*Dossostichus eleginoides*). By-catch was considered to be 100% discarded until 2007 when the market value was high enough to retain and land bycatch taxa (Pruvost 2015). In the original reconstruction, reported discard amounts were categorized as “unreported” because the logic in the *Sea Around Us* database at the time did not allow a “reported discard.” All CCAMLR reported discards have now been changed to “reported.”

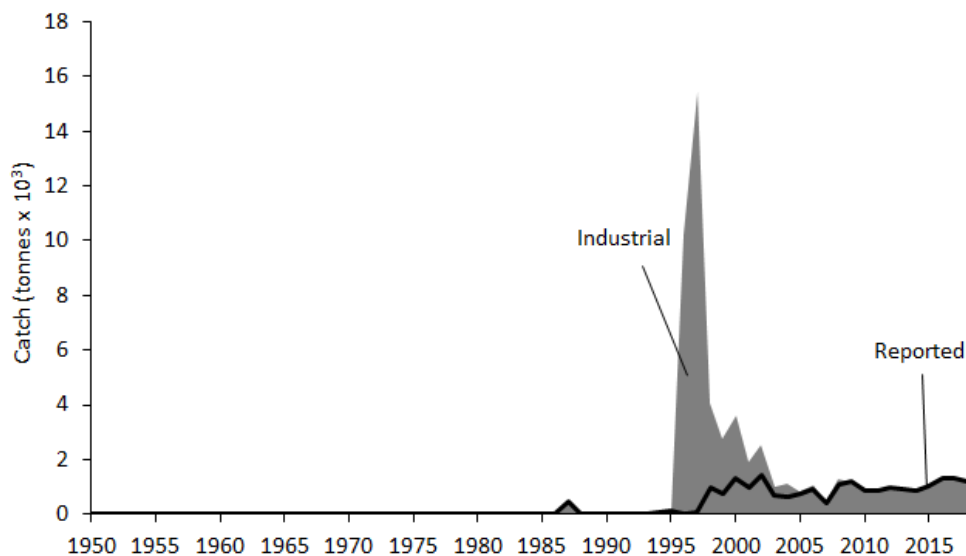


Figure 1. Reconstructed domestic (i.e., French) catch for Crozet Island's EEZ by fishing sector by calendar year (Jan-Dec), 1977-2018, for the Crozet Islands sub-area of CCAMLR/FAO Area 58.5.1.

Illegal, unreported and unregulated catches

Illegal, Unreported and Unregulated catches (IUU) of the Patagonian toothfish were estimated by CCAMLR (2018) by fishing season. These IUU catches were re-expressed in calendar years by applying the ratio of reported toothfish landings from December to the seasonal IUU catches (Table 1). The December ratio of IUU catch were reassigned to the previous year, e.g., the IUU December catch from fishing season 1990 (Dec 1989 to Nov 1990) was reassigned to calendar year 1989, etc.

Table 1. Legal reported catch and illegal, unreported and unregulated catch of Patagonian toothfish, *Dissostichus eleginoides* in the Crozet Islands EEZ (Subarea 58.6.), as reported by calendar year by CCAMLR (2019), in tonnes.

Calendar year	Reported catch (tonnes)	IUU catch (tonnes)	Total removal (tonnes)	Calendar year	Reported catch (tonnes)	IUU catch (tonnes)	Total removal (tonnes)
1983	17		17	2005	597	15	611
1987	488		488	2006	779	52	831
1988	21		21	2007	368	0	368
1994	56	0	56	2008	845	153	998
1995	115	0	115	2009	880	0	880
1996	3	7875	7878	2010	647	0	647
1997	88	11782	11870	2011	703	0	703
1998	978	2159	3136	2012	811	0	811
1999	696	1451	2147	2013	778	0	778
2000	1236	1551	2787	2014	733	0	733
2001	906	569	1475	2015	832	0	832
2002	1198	740	1938	2016	1054	0	1054
2003	475	275	751	2017	1144	0	1144
2004	498	353	851				

Under-reported bycatch and illegal by-catch of the Patagonian toothfish fishery were recalculated for bycatch species (including the ridge-scaled rattail, whiteleg skate and blue antimora) based on yearly reported and unreported toothfish landings (Table 2).

Table 2. Catch of bycatch species (ridge-scaled rattail, *Macrourus carinatus*; whiteleg skate, *Amblyraja taaf*; blue antimora, *Antimora rostrata*) taken by the longline fishery for Patagonian toothfish, *Dissostichus eleginoides* in the Crozet Islands EEZ (Subarea 58.6), as reported by calendar year by CCAMLR (2019), in tonnes.

Catch per year	Rattail	Skate	Antimora	Catch per year	Rattail	Skate	Antimora
1997	13	3	0	2008	143	46	67
1998	0	0	0	2009	187	45	75
1999	37	1	0	2010	111	56	78
2000	62	9	0	2011	93	29	23
2001	63	14	0	2012	100	77	22
2002	201	49	0	2013	69	47	18
2003	132	78	0	2014	86	38	39
2004	83	59	0	2015	106	16	70
2005	85	13	90	2016	120	33	142
2006	72	32	70	2017	111	23	59
2007	66	3	0				

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on CCAMLR data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France has agreed to protect biological diversity of the Crozet Islands through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020). The Ramsar site belongs to the *Réserve naturelle nationale des Terres australes françaises*, which includes a large variety of inland and coastal wetland types such as peatlands, marshes and lakes, rocky shores, estuaries and fjords (Ramsar sites information service 2020).

The MPA in these islands is part of the national natural reserve of the *Terres australes françaises* and one of the first and largest protected areas in the world. In this MPA, no extractive activity is allowed (TAAF 2020a). Many species of penguins are represented in these islands, such as macaroni penguins (*Eudyptes chrysolophus*; 4 million individuals), and king (*Aptenodytes patagonicus*), rockhopper (*Eudyptes chrysocome*) and gentoo (*Pygoscelis papua*) penguins (TAAF 2020b). At Crozet islands the population of macaroni penguins first increased and then stabilized in the 2000s. However, while most penguin populations breeding in the French Southern Territories increased or were stable over the past 30–60 years, the northern rockhopper penguin, king and gentoo penguins' populations of Crozet island did not exhibit the same positive trend (Barbraud *et al.* 2020).

Other sea birds present in the Crozet Islands are Giant petrels, White-chinned petrels, Small petrels, Howler albatrosses, Gray-headed albatrosses, Black-browed albatrosses, Yellow-billed albatrosses, Sooty albatross, Skuas, and Dominican gulls. Some marine mammals that can be found in these Islands are sea lions, elephant

seals and orcas, or killer whales (TAAF 2020b). “The Crozet killer whales underwent a sharp decline in the 1990s and this was partly attributed to illegal fishers using lethal means to repel whales depredating toothfish (Poncelet *et al.* 2010; Tixier *et al.* 2015, 2017). However, it is likely that the illegal over-exploitation of toothfish stocks, paired with substantial decreases of southern elephant seals, king penguins and large whales (Guinet *et al.* 1992; Clapham *et al.* 1999; Weimerskirch *et al.* 2003, 2018; Pruvost *et al.* 2015), has also contributed to the decline of this population (Tixier *et al.* 2019). Decreased toothfish availability may also have caused dietary shifts for killer whales in areas where stocks were depleted” (Tixier *et al.* 2019).

Falkland Islands (U.K.)

The original reconstruction for the Falkland Islands, performed by Palomares and Pauly (2015, 2016) for 1950-2010, was updated here to 2017 using national data from the Falkland Islands Government, then carried forward to 2018 using the procedure documented in Noël (2020) and catch data from the Falkland Islands Government for 2018.

Reported baseline data

The 2011-2013 data extension used data from the 2014 edition of the Falkland Islands Government data, while the extension to 2014 used data from the same source published in 2015 (Falkland Islands Government 2015). The group “Rajidae” and “Others” were disaggregated into more specific taxa using the same methods applied by Palomares and Pauly (2015). The “Hakes” (*Merluccius* spp.) category was originally split 80% between Argentine hake (*Merluccius hubbsi*) and 20% southern hake (*Merluccius australis*) based on an assumption in the original reconstruction. However, new information provides a more detailed species split for 1987-2017 (Arkhipkin *et al.* 2015). Catches were updated for 1987-2017 using this revised taxonomic composition.

FAO vs Falkland Islands Government data

A comparison between the Falkland Island data and the FAO data was conducted to account for any extra catch reported by FAO for U.K. fishing in the Southwest Atlantic area. FAO catch data were generally higher than the national catch data. Thus, the excess catch reported to the FAO was assigned as U.K. fishing in waters outside the Falkland Islands EEZ. In addition, FAO data from 1950-1988 were added to the original reconstruction because the Falkland Islands’ data reporting only started in 1989 (Figure 1).

Discards

Discards were not originally included in the 1950-2010 reconstruction, but have been estimated for the full time series, i.e., from 1950 to 2017, then carried forward to 2018. Laptikhovsky *et al.* (2006) estimated an average discard rate of 4.2% during their study period from 2000-2005.

From 1989-2006, discards were disaggregated to 45% longtail southern cod (*Patagonotothen ramsayi*) and 55% ‘marine fishes not identified’. However, starting in 2007, longtail southern cod became a more commercially valuable species and was likely retained. Therefore, discards from 2007-2017 were assigned 100% to ‘marine fishes not identified’.

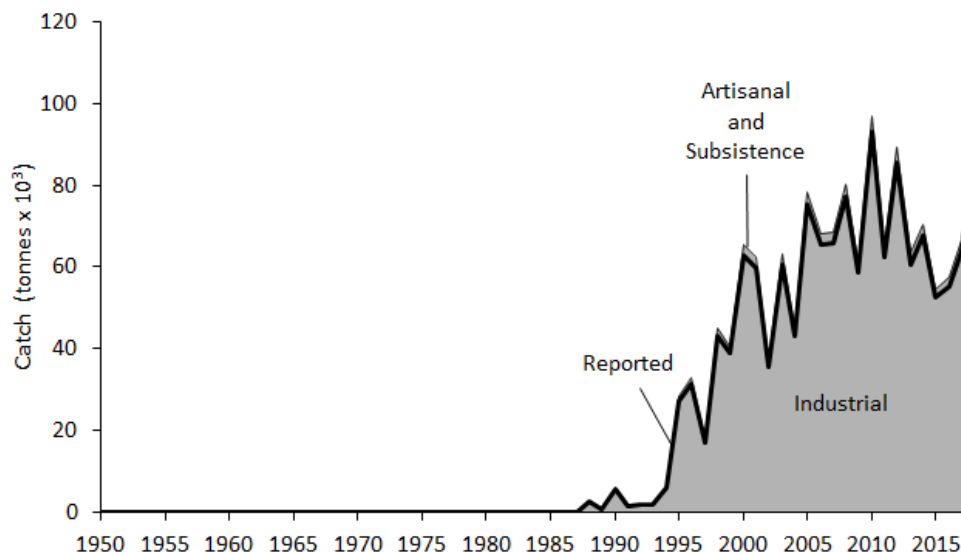


Figure 1. Reconstructed domestic catch within the Falkland Islands' EEZ by fishing sector for 1950-2018. Recreational and subsistence catches are included but are too small to be visible separately.

Artisanal and subsistence catches

The unreported landings for the 2011-2017 period continued the same trend of small (<1 tonne) artisanal catches of Patagonian blennie (*Eleginops maclovinus*) and inanga (*Galaxias maculatus*) and the subsistence catch of miscellaneous marine fish. According to Falkland Islands Government (2015), from 2007, there was no longer a fishery for the Patagonian scallop (*Zygochlamys patagonica*). All catch of this species was considered discarded bycatch for the 2007-2017 period.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on national data from the Falkland Islands Government to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The Falkland Islands have agreed to protect their biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

The Falkland Islands MPAs' extent is 52 km², which is less than 0.01% of the entire EEZ (549,974 km²; Palomares and Pauly 2015). There are very small MPAs such as the Middle Island (1.63 km²) and the Arch Island East (2.17 km²). Both were established a long time ago (1966 and 1978) and have the designation of Nature Reserve or IUCN management category Ia (UNEP-WCMC and IUCN 2020), which is the strictest management category.

Little is found in the literature about the effectiveness of these areas in protecting the biodiversity in Falkland Islands' waters. However, a study focused on megafauna found that “for wide ranging species (for instance, southern elephant seals), the overall species core use areas may be found outside of the Falkland Islands EEZ most of the year. Marine Spatial Planning (MSP) within a country's waters can improve sustainable marine management and conservation at the national level. Nonetheless, for protection of wide-ranging species to be effective, cross-nation MSP will also be required” (Augé *et al.* 2018).

Kerguelen Islands (France)

The reconstruction of marine fisheries catches in the Kerguelen Islands was completed for 1950-2010 by Palomares and Pauly (2011, 2016), updated to 2017 by the *Sea Around Us* and forward carried to 2018. As a French territory, the Kerguelen Islands' reported landings remain aggregated within France's FAO reported landings data. Therefore, reported landings for Kerguelen Islands were updated using France national data sources and the CCAMLR Statistical Bulletin (CCAMLR, 2018) for the Kerguelen Island region (CCAMLR area 58.5.1). The CCAMLR reports by fishing effort and tonnage with parameters, including fishing country and taxa.

Legal and illegal catches

In recent years, Patagonian toothfish (*Dissostichus eleginoides*) longlining by France was the only legal fishery in the Kerguelen Island region (CCAMLR, 2019). Reports included the target species Patagonian toothfish, bycatch species, such as grenadiers (*Macrourus* spp.) and rays (*Raja* spp.) and discards, e.g., blue antimora (*Antimora rostrata*).

Illegal, unreported and unregulated fishing has occurred in the area since 2006. Although no vessels have been sighted since 2014, abandoned gear has been recovered, and it was assumed foreign fishing remains present despite the absence of any illegal catch estimates since 2011.

Within the Kerguelen Islands, there are annual fishing season closures as well as catch and vessel limits (CCAMLR 2019). Due to the highly regulated nature of legal fishing in the area including strict monitoring via obligatory logbooks, observers and inspections with reports including tonnages for bycatch and discards, we continued to consider the entire catch as reported. Future research needs to more closely investigate the likely scale of illegal fishing in these waters.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on CCAMLR landing data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France has agreed to protect biological diversity of the Kerguelen Islands through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020). The Ramsar site belongs to the *Réserve naturelle nationale des Terres australes françaises*, which includes a large variety of inland and coastal wetland types such as peatlands, marshes and lakes, rocky shores, estuaries and fjords (Ramsar sites information service 2020).

The MPA in these islands is part of the national natural reserve of the *Terres australes françaises* and one of the first and largest protected areas in the world. In this MPA, no extractive activity is allowed (TAAF 2020a). The location of the Kerguelen Islands, where the cold Antarctic waters are mixed with the warmer waters of the Indian Ocean, is a place where animal populations are still abundant. Large breeding colonies of pinnipeds and penguins (king penguins, gentoo penguins, eastern rockhopper penguins, and macaroni penguins; Tixier *et al.*, 2019) can be found on the coast, and the waters are home to populations of toothfish (*Dissostichus* spp.). The marine vegetation is abundant, and it is characterized by underwater forests of *Macrocystis* or by a coastal fringe of *Durvillea antarctica* (TAAF 2020b). "The original ecosystems were, however, deeply

modified on the one hand by the overexploitation of resources (whaling and sealing throughout the 19th century, industrial fishing at the end of the 20th century) and on the other hand by voluntary or involuntary introduction exogenous animals that have acclimatized: rabbits, cats, rats, reindeer, trout, etc.” (TAAF 2020b).

Prince Edward Island (South Africa)

The original reconstruction of Prince Edward Island’s (PEI) fisheries catches from 1950–2010 was done by Boonzaier *et al.* (2012, 2016); here, it is updated to 2017, then carried forward to 2018.

Baseline data

We updated the reported landings utilizing new data from the CCAMLR Statistical Bulletin (CCAMLR 2018). Catches by South Africa from CCAMLR area 58.6 and 58.7, were allocated 100% inside the PEI Exclusive Economic Zone (EEZ). A portion of the EEZ lies just outside the CCAMLR convention area in FAO area Western Indian Ocean (area 51); thus, we added the South African catch of Patagonian toothfish (*Dissostichus eleginoides*, the main target species) reported in Western Indian Ocean (FAO area 51) as being taken within the PEI EEZ area within FAO area 51.

A marine protected area including a ‘no-take’ zone within 12 nautical miles of the Prince Edward and Marion Islands was implemented in 2013 with the primary aim of protecting biodiversity (DAFF 2014). We assumed that no illegal fishing occurred in this no-take zone (see DAFF 2014).

Catches of Patagonian toothfish

To estimate the tonnage of Patagonian toothfish caught in the Western Indian Ocean, the total CCAMLR reported catch was subtracted from the estimated total catch taken from the EEZ of Prince Edward Island as presented by the South African Department of Agriculture, Forestry and Fisheries national report for 2011 and 2012 (DAFF 2014). The catch of Patagonian toothfish in the Western Indian Ocean for 2013 and 2014 was taken from CCAMLR (2015). For 2015 and 2016, the catch of Patagonian toothfish was taken from the CCAMLR (2016) report. For 2017, the South Africa CCAMLR area 58.6 and 58.7 catches were subtracted by the total amount in the CCAMLR (2017) report. The discard taxa and proportions for CCAMLR area 58.6 and 58.7 were used to estimate the associated discards from the area 51 *D. eleginoides* fishery from 2011–2017.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on CCAMLR landing data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

South Africa has agreed to protect the biological diversity of Prince Edward Island through international agreements, i.e., the Convention on Biological Diversity (Aichi), the United Nations Convention on the Law of the Sea, the Ramsar Convention on Wetlands of International Importance, the International Coral Reef Initiative and the World Heritage Convention. The country is also a signatory to Regional Treaties and Agreements such as the Regional Seas Convention (Marine Conservation Institute 2020).

Prince Edward Island has an MPA of 181,229 km² (Marine Conservation Institute 2020), which occupies 38% of the entire EEZ (473,371 km² only Prince Edward Island; Boonzaier *et al.* 2016). This MPA has different zones: control, restricted and sanctuary. In the 4441 km² of the sanctuary zone, fishing is prohibited and the passage and anchoring of vessels is limited. In the restricted zone, controlled commercial fishing is permitted.

In the control zone, fishing for toothfish (*Dissostichus eleginoides*) is allowed with a permit (Minister of water and environmental affairs 2013).

A 38-year long study conducted on pinnipeds at Prince Edward Islands by the Marine Mammal Programme (MMP) found an increase in the southern elephant seals' (*Mirounga leonine*) population and a subsequent increase of sympatric populations of Subantarctic fur seals *Arctocephalus tropicalis* and Antarctic fur seals *A. gazella*, especially after the ban of commercial sealing (Bester *et al.* 2011).

St. Paul and Amsterdam Islands (France)

The original reconstruction of fisheries catches around the remote French sub-Antarctic volcanic islands of St. Paul and Amsterdam was originally completed by Pruvost *et al.* (2015); see also Pruvost *et al.* (2016). This reconstruction was updated to 2018 using available French and FAO data for this region.

Given that the St. Paul and Amsterdam Islands belong to the French 'Southern and Antarctic Lands' ('*Terres australes et antarctiques françaises*' or TAAF), the reported data sources from 2001 to 2010 for St. Paul and Amsterdam consisted of both French national and FAO data.

FAO data to 2018 from the TAAF were included for catches of St. Paul rock lobster (*Jasus paulensis*) and miscellaneous marine fishes. National data collected by the *Direction des pêches maritimes et de l'aquaculture*, in collaboration with the National Museum of Natural History (NMNH) in Paris, were included for catches of yellowtail amberjack (*Seriola lalandii*), trumpeters (Family Latridae), St. Paul's fingerfins and other cheilodactylids (*Nemadactylus* spp.), and others.

Due to the fluctuating numbers from national data over the years, the overall linear trend of total catches recorded in national data from 2001 to 2010 was calculated, then carried forward to 2018. These calculated totals were then disaggregated based on the 10-year average ratios of the total catch calculated for each taxon. FAO data for the French Southern Territory (TAAF) in the Western Indian Ocean (FAO area 51) were assigned to this EEZ, as in the past reconstruction.

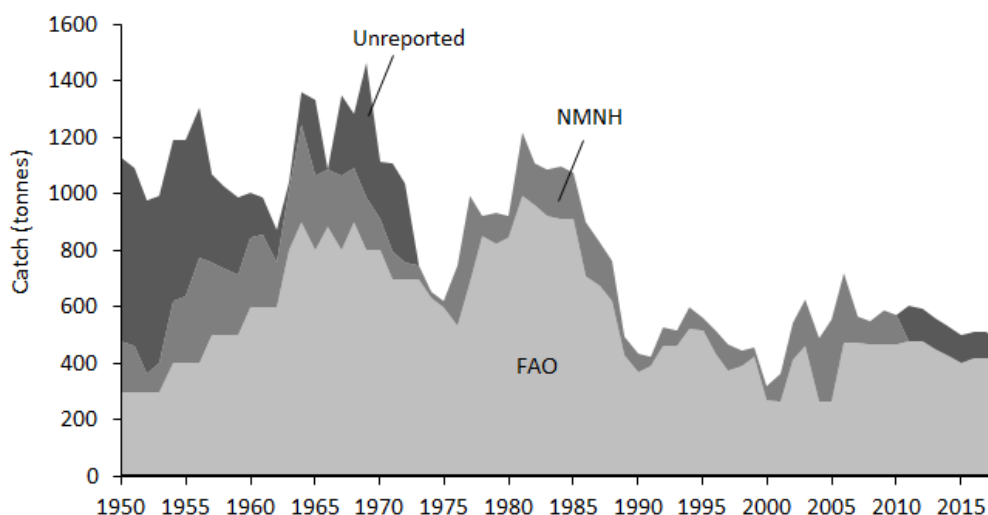


Figure 1. Catches in the St. Paul and Amsterdam EEZ for 1950-2018, by data sources, i.e., FAO and NMHN (French) data.

Marine biodiversity protection

France has agreed to protect the biological diversity of St. Paul and Amsterdam islands through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020). The Ramsar site belongs to the *Réserve naturelle nationale des terres australes françaises*, which includes a large variety of inland and coastal wetland types such as peatlands, marshes and lakes, rocky shores, estuaries and fjords (Ramsar sites information service 2020). St. Paul and Amsterdam islands also harbor ‘mIBAs’, i.e., Marine Important Bird and Biodiversity Areas (Heerah *et al.* 2019).

The MPA in these islands, part of the national natural reserves of the French Southern Territories, was one of the first and largest protected areas in the world where any industrial or commercial extractive activity is prohibited, including fishing (TAAF 2020a).

The productive waters that surround St. Paul and Amsterdam islands provide habitats and feeding and breeding grounds to benthic and pelagic fish species, seabirds, cetaceans and pinnipeds, including large population of Subantarctic fur seal (*Arctocephalus tropicalis*) (TAAF 2020b). The Amsterdam Islands stand out as the major breeding ground for Indian yellow-nosed albatross (*Thalassarche carteri*). However, from the 1980s to 2015, the colony decreased by 1.1% per year, resulting in an estimated decrease of 38.6% from 1983 to 2015. This was due to the increase of sea surface temperatures, fisheries bycatch, and mostly avian cholera (Weimerskirch 2018).

South Georgia, South Sandwich and South Orkney Islands (United Kingdom)

The original reconstructions of catches for the South Georgia, South Sandwich and South Orkney Islands were completed by Palomares and Pauly (2015, 2016a, 2016b). They were updated to 2017 here using data in CCAMLR (2018), then carried forward using the procedure in Noël (2020).

Reported baseline data

All of the CCAMLR sub-areas 48.3 and 48.4 data were allocated to the South Georgia and South Sandwich EEZs; data of sub-area 48.2 were allocated to the South Orkney ‘EEZ’. Note that the South Orkney Islands, in contrast to the South Georgia and South Sandwich Islands, do not have a formally claimed EEZ around them. Here, however, we follow Palomares and Pauly (2016b) in treating the waters up to 200 nautical miles around the South Orkney as forming their ‘EEZ’.

Correcting for an omission

Since the initial catch data reconstruction, it has come to our attention that there was some CCAMLR catch by the former USSR in area 48 (sub-area unspecified) that had not been included in the *Sea Around Us* database. A portion of this unspecified catch has been allocated to sub-areas 48.2, 48.3 and 48.4, and thus added into the reconstruction. All of the additional catch was allocated to specific CCAMLR areas by using the ratios of the existing catch with a sub-area assigned to it. FAO data for the former USSR targeting marbled rockcod (*Nototothenia rossii*) in FAO area Antarctic Atlantic in the late 1960s (before CCAMLR started recording statistics) and was not included in the *Sea Around Us* database. This catch has been added to the South Georgia EEZ because this is where CCAMLR first started to report that the former USSR fished marbled rockcod in 1970, and there are no reports of the former USSR fishing anywhere else in FAO area Atlantic Antarctic at that time.

Discards

The CCAMLR data include by-catch and discards in their total catch reports, but these are not taxonomically disaggregated. Thus, some by-catch taxa thought to be discarded, such as blue antimora (*Antimora rostrata*), grenadiers (Family Macrouridae) and rays (Order Rajiformes), have been labelled as ‘CCAMLR reported discards’.

In 2012, a large marine protected area (MPA) was declared by the U.K. around the South Georgia and South Sandwich Islands to reduce biodiversity loss (Handley *et al.* 2020). Management boundaries within the MPA allow for multiple use zones and temporal closures (Trathan *et al.* 2014). Current management measures for fisheries within the MPA were evaluated to protect top predators, though unregulated fisheries outside of the MPAs boundaries may pose a threat to the protection of these species (Handley *et al.* 2020).

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on CCAMLR landing data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The United Kingdom has agreed to protect the biological diversity of the South Georgia, South Sandwich and the South Orkney islands through the international Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Taken together, these islands protect over 80% (UNEP-WCMC and IUCN 2020a, 2020b) of the EEZ around them (i.e., 1,593,430 km²; Palomares and Pauly 2016a, 2016b).

In 1982, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) was formed and in 1993 the South Georgia and South Sandwich Islands Maritime Zone was declared (Trathan *et al.* 2014). However, the CCAMLR recognized the need to create permanent spatial protection measures only in 2005 (Trathan *et al.* 2014).

In 2009, the so-called MPA ‘South Orkney Islands Southern Shelf (SOI SS)’ was established. It was the first MPA to be designated by CCAMLR and also the first one designated entirely within internationally managed waters. Nevertheless, further designations in the Southern Ocean were slowed down due to divergent views of country members of CCAMLR and calls for additional scientific evidence. Therefore, it was not until 2012, when the Government of South Georgia and the South Sandwich Islands (GSGSSI) declared an MPA in its Maritime Zone. The Government of these islands agreed on a high-level of protection, based on scientific advice (Trathan *et al.* 2014).

Some of the pressures affecting these waters are associated with illegal, unreported and unregulated fishing, even though the instruments of the Antarctic Treaty System offer a high level of environmental protection (Trathan *et al.* 2014). For the Antarctic Treaty System and the CCAMLR, it is important to enable “scientific studies in areas where the confounding effects of climate change, marine mammal recovery and other human induced factors can be studied in the absence of fishing” (Trathan and Grant 2020).

Discussion

Recent establishment of MPAs within the territories of islands surrounding Antarctica seek to protect the unique biodiversity of these remote areas. However, the difficulty of patrolling the waters around these distant territories and challenges to enforcing fishing access by CCAMLR have resulted in illegal, unreported and unregulated fishing for commercially valuable species such as *Dissostichus eleginoides* by foreign fleets. We

have presented here our best estimates of these unreported catches based on information from CCAMLR estimates and other sources.

Acknowledgments

Funding for the work presented here was provided by the Minderoo Foundation, by the Marisla, Oak, and David and Lucille Packard Foundations, and by the Bloomberg Philanthropies through Rare.

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