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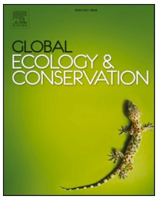

Original research article

Recent IUCN Red List assessments of two species of icefish (Channichthyidae) reveal concerns about the Red List process and opportunities for improvement

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ABSTRACT

Two species of Southern Ocean icefish (Channichthyidae) were recently assessed using the International Union for Conservation of Nature (IUCN) Red List criteria, with the South Georgia icefish (*Pseudochaenichthys georgianus*) categorised as Endangered and the Scotia Sea icefish (*Chaenocephalus aceratus*) categorised as Vulnerable. Both species are distributed in the Area 48 in the Southern Ocean, notably around South Georgia, the South Orkney Islands and the northern Antarctic Peninsula. These fish were subject to exploitation (mostly as bycatch) in the 1970s and early 1980s and continue to be taken as bycatch in small quantities in the Antarctic krill fishery. The primary basis for the Red List designations was that stocks remain depleted from historic over-exploitation. However, the assessments did not take account of a contemporary 36-year time series of data from regular scientific trawl surveys in South Georgia waters and sporadic surveys around the South Orkneys and Antarctic Peninsula. A review of data available from the Commission for the Conservation of Antarctic Marine Living Resources and other sources, suggests that the assessments may not be sufficiently supported and warrant re-examination. Our evaluation, using the available data and considering the Red List criteria, suggests that a categorisation of Least Concern may be appropriate for both species. Furthermore, we draw insights from the icefish species assessments to evaluate the IUCN Red List process and make recommendations for improvement. These include the need for a coordinated approach, including prioritisation of species, consultation with appropriate expert groups, enhanced rigour in the delivery of the process, and greater capacity building.

1. Introduction

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (hereafter Red List) was established in 1964 to assess species conservation status using standardised Categories and Criteria. While the core criteria have remained the same since 2001 (Version 3.1, IUCN 2001), the accompanying guidelines, have been regularly updated to reflect advances in science and methodology (IUCN, 2024). The Red List provides information regarding species' status, trends and threats to guide conservation planning, inform policy and international conventions and direct resource allocation, including to scientific research (Betts et al., 2020). Red List assessments inform multilateral agreements (e.g. Convention on Biological Diversity, CITES), site designations (e.g. Important Bird and Biodiversity Areas (Donald et al., 2019)) and fisheries sustainability evaluations, such as Marine Stewardship Council (MSC) certifications (MSC, 2024). Species can be classified as Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern or Data Deficient. Species listed as threatened (i.e. Critically Endangered, Endangered or Vulnerable) often receive enhanced conservation measures to support their recovery (Simkins et al., 2025). Whilst the Red List has helped improve the conservation status of many species (Rodrigues et al., 2006; Betts et al., 2020), it has been criticised for geographic and taxonomic biases (Bachman et al., 2019), reliance on outdated assessment information and overemphasis on vertebrates and charismatic species (Palacio et al., 2023).

Most assessments are conducted by members of the IUCN Species Survival Commission (SSC), appointed Red List Authorities (RLAs), Red List Partners, or specialists working on IUCN-led assessment projects (IUCN, 2016). However, assessments can also be carried out by individuals who have sufficient knowledge of a species (IUCN, 2016; see also www.iucnredlist.org/assessment/process). The Red List is centrally managed by the Red List Unit (RLU), part of the IUCN Secretariat. All assessments must be submitted through the RLU, which carries out checks on the application of the Red List criteria and the quality of the supporting information before publishing them (IUCN, 2016). If an RLA exists, assessments should be reviewed by the RLA prior to submission, otherwise the RLU coordinates an independent review (IUCN, 2024).

Early Red List assessments relied on expert opinion, prompting concerns about subjectivity and leading to more data-driven and objective criteria (Rodrigues et al., 2006; Mace et al., 2008). However, expert judgement remains important and sometimes contentious (Palacio et al., 2023). Criteria are based on population size, rate of decline, geographic range, and threat levels. Assessments should draw on data across species' distributions, including published and grey literature and other reliable sources of information. Despite available rules and guidelines (IUCN, 2016, 2024) implementation is not always consistent (Bachman et al., 2019).

Assessments often start with a species list, from which species can be prioritised (Bachman et al., 2019). There may be an initial pre-assessment, during which available data are gathered and reviewed, followed by the assessment itself when data are analysed and Red List metrics produced (IUCN, 2016). Marine fish are commonly evaluated using the rate of change in abundance, considering factors including overfishing and habitat loss. Debate surrounds the relevance of Red List assessments for marine fish, primarily due to the distinction between fisheries management biological thresholds and those used to indicate extinction risk (Rice and Legace, 2007; Millar and Dickey-Collas, 2018). While declines below a fishery reference point may indicate reduced productivity, this does not necessarily equate to a species being at risk of extinction, and may be reversible through management interventions, such as adjusting catch limits (Davies and Baum, 2012). Nonetheless, when carefully applied, the Red List criteria are reasonably compatible with fisheries science (Davies and Baum, 2012; Millar and Dickey-Collas, 2018). Momentum for assessing marine fish species continues to grow (Miqueleiz et al., 2022; Loiseau et al., 2024), with 28,866 (78%) of marine and freshwater fish now evaluated (IUCN Summary Statistics).

The icefish family Channichthyidae Gill 1861 is unique amongst vertebrates in lacking haemoglobin. There are 11 genera and up to 25 species of icefish (Kock, 2005; www.fishbase.se; Eastman and Eakin, 2021), all restricted to the Southern Hemisphere, and all but one (pike icefish, *Champsocephalus esox*), only found south of the Antarctic Polar Front. All species are demersal or semi-pelagic, inhabiting depths from shallow coastal areas to ~ 1000 m. Many species are nest builders, including *Chaenocephalus aceratus* (Detrich et al., 2005) and *Neopagetopsis ionah*, whose extensive nesting areas were recently discovered in the Weddell Sea (Purser et al., 2021).

In 2024, two species of icefish were assessed against the Red List criteria (Williams, 2024a; b; see Table 1). The Scotia Sea icefish (*Chaenocephalus aceratus* (Lonnberg, 1906)) was categorised as Vulnerable under Red List Criteria A2[18] (sub-criteria b,c,d,e), whilst the South Georgia icefish (*Pseudochaenichthys georgianus* Norman 1937) was listed as Endangered under the same criteria (Table 1). For a species to be considered Endangered under Criteria A2 the population must have declined by > 50% in three generations, with generation length being the average age of parents of the current cohort. For Vulnerable the population must have been reduced by > 30% in three generations. Both species are listed under the sub-criteria b, c, d & e, which mean the designation is based on (b) an abundance index; (c) a decline in area of occupancy, extent of occurrence or habitat quality; (d) actual or potential exploitation; and (e) effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites. The pike icefish has also been assessed as Vulnerable (Buratti et al., 2020).

Both the Scotia Sea icefish and the South Georgia icefish reside entirely within the area of competence of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), which manages Southern Ocean fisheries (Constable et al., 2000). Whilst both are caught as bycatch in trawl fisheries, directed fishing has been prohibited since 1990 under CCAMLR's legally binding Conservation Measures (CMs). CCAMLR holds much of the relevant data, including data from fisheries and regular scientific trawl surveys, yet these data were not considered during the species' assessments (CCAMLR, 2024b).

Here we review the available data for both species, evaluate whether their current IUCN Red Listing categories are appropriate and also consider how the Red List process can be improved through better, use of available data and expert consultation.

2. Methods

Data on distribution of both icefish species were collated from published works (e.g. Gon and Heemstra, 1990), the CCAMLR Statistical Bulletin, and CCAMLR working group papers (which are indexed on the CCAMLR website: www.ccamlr.org and available on request). Catch history was derived from the CCAMLR Statistical Bulletin (CCAMLR, 2024a), but consideration was also given to catches by the Soviet Union in the period 1977–1988, that were not attributed to species (Agnew and Kock, 1990). The catch data included bycatch in the mackerel icefish (*Champsocephalus gunnari*) and Antarctic krill (*Euphausia superba*) fisheries in FAO Area 48 (SW Atlantic sector of the Southern Ocean).

For the South Georgia region (Subarea 48.3), we reviewed data from early surveys conducted on German research vessels (1976, 1978, 1985; Kock 1985; Kock, 1986),from Polish commercial fishing vessels (Slosarczyk et al., 1984; Mucha and Slosarczyk, 1987; Sosinski and Szlakowski, 1992) and from a Spanish survey in late 1986 (Balguerias, 1989) (Supplementary Table 1). Details of the early German surveys are limited, and the Spanish survey used semi-pelagic gear, which probably had lower catchability for demersal species. The early estimates from Polish commercial fishing were exclusively from the fishing grounds (NE of South Georgia) during commercial operations and are not directly comparable with research surveys. Since 1987 fishery-independent research surveys have been routinely conducted around South Georgia by the US (1987, 1988), Poland / United Kingdom (UK) (1989) and since 1990 by the UK (Supplementary Table 1), with data submitted to CCAMLR and available for our analyses. These surveys covered the South Georgia and Shag Rocks continental shelves over depths of 50–350 m (e.g. Hollyman et al., 2021). The first three surveys were conducted on a Polish trawler (FV *Professor Siedlecki*), but since 1990 surveys were conducted on UK registered fishing or research vessels, with a standard bottom trawl (FP-120) (Belchier et al., 2015). Each survey consisted of between 38 and 105 30-minute (bottom contact) trawls, fished with a horizontal net opening of 18–20 m and vertical opening of 4–5 m. Recent surveys (since 2008) each conducted more than 70 trawls. Most surveys were conducted during the austral summer, but surveys in 2008 and 2021 were in April / May and those in 1997 and 2007 were in August / September. Biomass of each species was estimated using a bottom depth (75–250 & 250–350 m) and area stratified (five strata) estimate of density, based on swept area of the trawls and seafloor areas in each stratum, bootstrapped to generate confidence intervals (Hollyman et al., 2021). These estimates differ slightly from early estimates (Slosarczyk et al., 1984; Reid et al., 2007) as depth strata boundaries have been revised and estimates of seafloor area in each stratum have been refined (Fretwell et al., 2009) as has the methodology used to calculate mean and confidence intervals of biomass estimates. In addition, a deeper survey was undertaken in 2003 (Gregory et al., 2017) and a small number of deeper trawls conducted on other surveys, providing data on the maximum depth for the icefish species. Additional surveys were conducted by the Soviet Union (1990), Russia (2002) and Argentina (1994, 1997, 2014, 2022) (see Supplementary Table 1), but methods differed, biomass of the two species were not always estimated and, given the consistent nature of the UK surveys, are not considered further here.

Around the South Orkney Islands (Subarea 48.2), trawl surveys were conducted on a more sporadic basis during the austral summer (Supplementary Table 1), with 5 surveys conducted using a stratified approach similar to that used for the South Georgia surveys (Supplementary Table 1; Jones et al., 2000; Jones and Kock, 2009). In each case, trawls had a planned bottom contact time of 30 mins. Biomass estimates and confidence intervals were computed per stratum using seafloor area. German surveys on commercial fishing

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[18] A2 is when a population reduction has been observed, estimated, inferred or suspected in the past, where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible. See IUCN (2024) for definition of Categories A-E.

Table 1
Summary of the current IUCN Red List assessments for *Chaenocephalus aceratus* (Williams, 2024a) and *Pseudochaenichthys georgianus* (Williams, 2024b).

	Chaenocephalus aceratus	*Pseudochaenichthys georgianus*
Category	Vulnerable	Endangered
Criteria	A2 b,c,d,e	A2 b,c,d,e
Assumed generation time	15–17 years	8.5 years
Rationale	Inferred that the species has undergone a 40% decline over the past three generations (40–45 years; 1978 – 2023).	Inferred that the species has undergone a > 50% decline over the past three generations (25 years; 1998–2023).
b: Index of abundance	Relies on 40% decline estimated by Kock (1991) and lack of recovery since (used data only to 2006). Current population trend **decreasing**.	Biomass estimates from mid-1980s imply a 75% decline from pre-exploitation stock levels. Current population trend **decreasing**.
c: Decline in area of occupancy	No evidence, but considered vulnerable to warming	
d: Actual or potential exploitation	No directed exploitation (since 1990), but small bycatch in Antarctic krill (*Euphausia superba*) and mackerel icefish (*Champsocephalus gunnari*) fisheries	
e: Effects of introduced taxa, competitors etc	No evidence provided	
Primary sources of information	Kock and Kellermann (1991); Reid et al. (2007); Riginella et al. (2016); Novillo et al. (2019)	Sosinski and Szlakowski (1992), Clarke et al. (2008), Traczyk and Meyer-Rochow (2019)

vessels (1976 & 1978) were non-random (Kock and Jones, 2005) and are poorly documented and hence not considered here.

Surveys around the South Shetland Islands (Subarea 48.1) have not been of a consistent design, with many surveys focussed on just the Elephant Island region, whilst others have included the rest of the archipelago (Supplementary Table 1). The early surveys (1981–2002; nine surveys) were summarised in Kock and Jones (2005), with subsequent surveys in 2003 (Jones et al., 2003), 2006 (Jones and Kock, 2006), 2012 (Kock and Jones, 2012) and 2018 (Arana et al., 2020). These surveys were conducted in a similar manner to surveys undertaken around South Georgia and South Orkney Islands (Supplementary Table 1), but Kock (1998) noted that estimates of seafloor area in survey strata have been improved and, in the case of the Elephant Island area, reduced by 25–40% meaning that biomass estimates were subsequently reduced. Two earlier German surveys of Elephant Island (1976 and 1978; Supplementary Table 1) were non-random, with small numbers of trawls (Kock, 1998) and not used for biomass estimates.

During each survey the total weight of each species was obtained. Biological data were collected for abundant species, including *C. aceratus* and *P. georgianus*. Samples of *C. aceratus* and *P. georgianus* were randomly selected from catches and were measured (Total Length (TL), nearest cm below), and weighed (to nearest 10 g), with sex and maturity determined using a standard maturity scale (Kock and Kellermann, 1991). To estimate length at sexual maturity, total length versus proportion of fish in maturity stages 3–5 for each sex were fitted to a logistic equation:

$$p = \frac{1}{1 + e^{-(\alpha + \beta \mathrm{TL})}}$$

where p = estimated proportion of males and females in maturity stages 3–5; TL=total length and α, ß are coefficients (Kock and Jones, 2005). Kock and Jones (2005) distinguished between length at first maturity (using stages 2–5, L_{50}) and length at first spawning (L_{m50}).

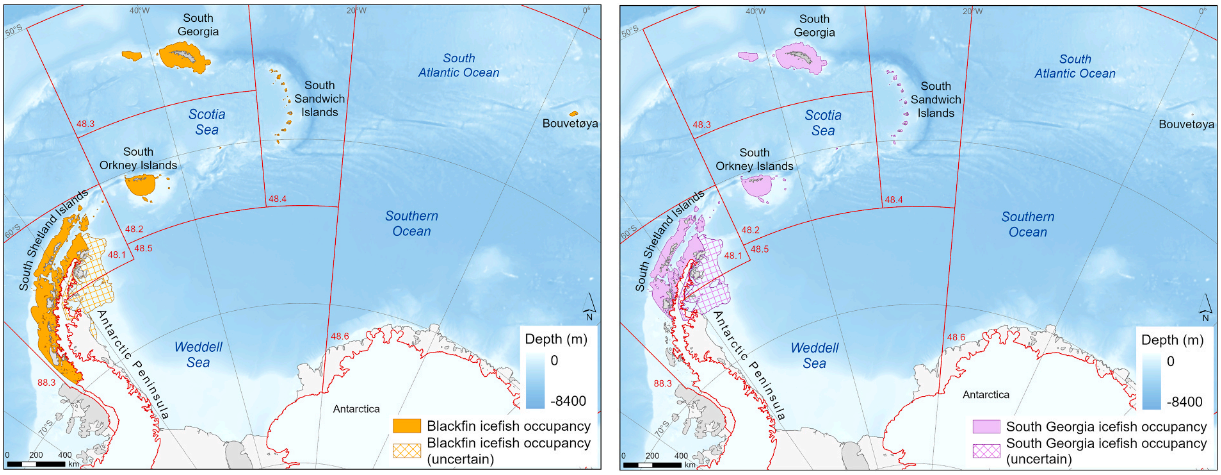

Fig. 1. Distribution of Scotia Sea icefish (*Chaenocephalus aceratus*) (left) and South Georgia icefish (*Pseudochaenichthys georgianus*) (right), based on sources listed in the text.

Here we have considered stages 3–5 (length at first spawning) but reported length at first maturity when length at first spawning was not available. This information was extracted from a range of publications and CCAMLR papers.

We searched for peer reviewed publications using the Web of Science (23/05/2025) to find key life history information that is required for the Red List process and then undertook a backward search based on citations in these papers to find additional papers. The search terms included each of the two species names and any synonym along with one of following terms to extract biologically relevant information: fecund*, larv*, matur*, reprod*, hatch*, grow* and spawn*. Additional biological information and survey reports were obtained from CCAMLR Working Group papers (available on request from CCAMLR Secretariat and authors).

3. Results

3.1. Scotia Sea icefish

3.1.1. Distribution

The Scotia Sea icefish (*C. aceratus*) was first described by Lönnberg (1906) from a specimen caught in Cumberland Bay, South Georgia. The species is distributed around the Scotia Arc islands, the northern Antarctic Peninsula and Bouvet Island (Fig. 1), with high abundance around South Georgia (Reid et al., 2007), the South Orkney Islands (Jones et al., 2000), South Shetland Islands (La Mesa et al., 2004) and Elephant Island (Kock and Jones, 2012) and lower abundance around the northern tip of the Antarctic Peninsula (Kock and Jones, 2012). Few records exist near Joinville and D'Urville islands (Kock et al., 2004), and some records from commercial fishing in that area may be misidentifications (Kock et al., 2003). There are limited data on the eastern (Weddell Sea) Antarctic Peninsula region and distribution here is uncertain. The species is occasionally caught on the Shag Rocks shelf, northwest of South Georgia, where seafloor temperatures are slightly warmer (Reid et al., 2007). Across its range, the bathymetric distribution spans shallow water to 700 m, but records from deeper than 350 m are rare (Gregory et al., 2017). Small catches of *C. aceratus* reported (CCAMLR, 2024a) from longlines in the Ross Sea region (Subarea 88.1) and East Antarctica (Divisions 58.4.1 and 58.4.2) were likely misidentifications of other icefish species. Populations are assumed to be connected through larval transport (Papetti et al., 2009). The South Georgia surveys (1987–2025) provide no evidence of bathymetric or geographic shifts in distribution. Based on the range, we estimate the adult habitat is approximately 215,000 km^2.

3.1.2. Exploitation

Commercial fishing around South Georgia began in the 1969/70, targeting marbled rockcod (*Notothenia rossii*) and later mackerel icefish and yellow-finned rock-cod (*Patagonotothen guntheri)* (Kock, 1992). Most of the catches until 1989/90 were by Soviet Union vessels, with Polish, East German and Bulgarian vessels also fishing from 1976/77 (Kock, 1992). During the early years some *C. aceratus* were taken as bycatch but were not targeted. Species composition in the early years of fishing is uncertain, because bycatch was only reported from the 1976/77 season onwards by Poland and East Germany, but remained unreported or incomplete by Soviet Union vessels (Agnew and Kock, 1990; Kock, 2005). *C. aceratus* (and *P. georgianus*) were targeted in 1977/78, when the stock of *C. gunnari* had declined following heavy fishing during the previous season (Kock, 1991; Kock, 2005).

Agnew and Kock (1990) used Polish catch composition to reconstruct Soviet catches of *C. aceratus* around South Georgia and developed a population model that estimated that the stock of *C. aceratus* had decreased from 18,000 to 6000 tonnes between 1976/77 and 1988/89. The CCAMLR Statistical Bulletin records catches since 1977 and, although reported catches of *C. aceratus* were primarily taken near South Georgia, the maximum catch of around 4000 tonnes in 1979 was split between South Georgia, the South Orkney Islands and the Antarctic Peninsula region (Fig. 2). CCAMLR prohibited targeted fishing for *C. aceratus* in 1990 (Conservation Measure

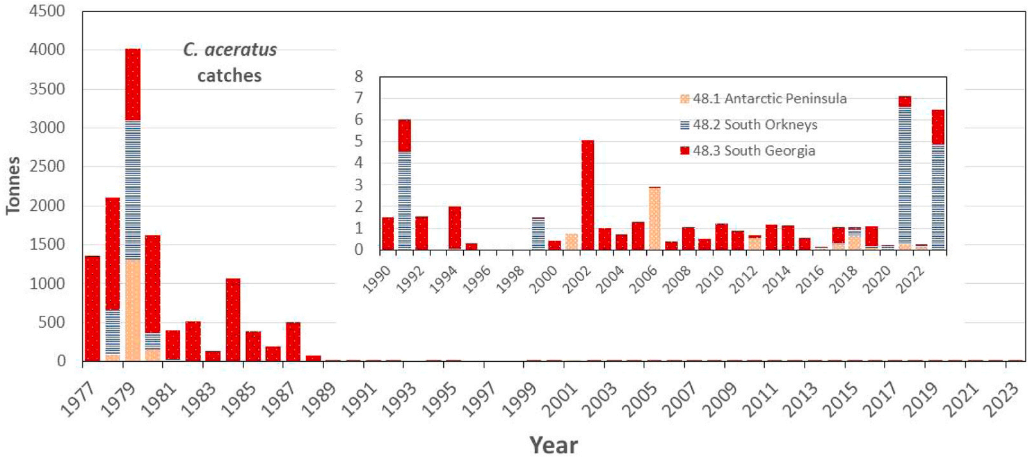

Fig. 2. Catches of Scotia Sea icefish (*Chaenocephalus aceratus*) from 1977 to 2023 (data from CCAMLR Statistical Bulletin). Inset from 1990 to 2023 shows bycatch in fisheries for mackerel icefish and Antarctic krill.

(CM) 27/IX and CM 22/IX), and that prohibition remains. Bycatch limits in South Georgia fisheries were established in 1995 (CM 33–01). Since 1990 (Fig. 2, inset) bycatch (< 8 tonnes per annum) has been taken in fisheries targeting Antarctic krill and mackerel icefish, with notable catches near the South Orkney Islands in 2021 and 2023. By-catch in the mackerel icefish fishery is exclusively adult fish, but larval, juvenile and adult fish are taken in the krill fishery (CCAMLR, 2025). Extrapolations from observer data indicate slightly higher bycatch in some years (CCAMLR, 2025), but less than 30 tonnes per annum.

Exploitation around Elephant Island occurred principally in 1978/79 and 1979/80 (Kock, 1998) and although this reduced biomass and size of fish, Kock and Jones (2005) reported recovery by the late-1980s.

3.1.3. Biomass estimates

The first biomass estimate of *C. aceratus* at South Georgia emanated from a German survey in 1976, estimating the stock at 18,719 tonnes, with a similar survey in 1978 producing a similar estimate (Kock, et al., 1985). Kompowski (1990) and Sosinski and Szlakowski (1992) summarised biomass estimates of *C. aceratus* at South Georgia for the period 1975–1988 (see also Slosarczyk et al., 1984; Mucha and Slosarczyk, 1987), based on swept area methods from a combination of German research and Polish commercial and research fishing, but primarily from fishing grounds (Fig. 3). Estimates ranged from 18,719 tonnes in 1975/76 (pre-exploitation) to 4047 in 1978/79. The estimate of 18,576 tonnes from the end of the exploitation period in 1987 (Mucha and Slosarczyk, 1987) was similar to the 1976 estimate. Fluctuations were attributed to both exploitation and variable year class strength. Slosarczyk et al. (1984) estimated a biomass of 23,400 tonnes in 1984, towards the end of the main exploitation period, but this estimate was based on limited commercial fishing and was excluded from subsequent Polish reviews (Kompowski, 1990; Sosinski and Szlakowski, 1992).

Since 1985 fishery-independent surveys have been undertaken regularly (Supplementary Table 1) and continue to show fluctuations in biomass (Fig. 3). The Spanish survey in 1986/87 used a semi-pelagic trawl, and the estimate of biomass (2659 tonnes) is likely to be an underestimate due to reduced catchability of *C. aceratus* with such gear. The next lowest value was estimated from a winter survey in 2008 (3084 tonnes) and the highest (23,923 tonnes) in January- February 2025, although this was after the Red List assessment. Both the 2023 and 2025 surveys estimated biomass considerably higher than the long-term mean (Fig. 3). Whilst most surveys were conducted during summer, the 1997, 2007, 2008 and 2021 surveys were conducted during autumn / winter, when *C. aceratus* are spawning, which may have influenced catches. James et al. (2026) noted that winter catches of mature fish were dominated by females and postulated that males may be outside the survey area, possibly at nesting locations.

Biomass estimates were derived from five surveys (1985, 1991, 1999, 2009 and 2018) around the South Orkney Islands shelf (Kock, 1986; Jones et al., 2000; Kock and Jones, 2005; Jones and Kock, 2009; Arana et al., 2020). Here we rely on Kock and Jones (2005) for the early surveys, as they used consistent updated seafloor areas. Kock (1986) derived biomass estimates from 1975/76 and 1977/78, but these were non-random (Kock and Jones, 2005) and not included here. Estimates ranged from 5175 (1985) to 16,031 tonnes (1991), with the most recent survey (January 2018) estimating the biomass at 6716 tonnes, albeit that survey only conducted 21 trawls in the area (Arana et al., 2020).

Twelve random trawl surveys were conducted around Elephant Island and the South Shetland Islands from 1981 to 2018, but designs were inconsistent, with seven surveys conducted exclusively around Elephant Island (Kock, 1998; Kock and Jones, 2005; Kock and Jones, 2012; Arana et al., 2020) (Fig. 3; Supplementary Table 1). Early German surveys around Elephant Island (1976–1996) were reviewed by Kock (1998) with biomass estimates ranging from 768 tonnes (1985) to 7619 (1986). The first two surveys conducted in the area (1976, 1978; Kock et al. 1985) were not random and not considered here. Five surveys (1998–2012) included Elephant Island and the rest of the South Shetland Islands, with biomass ranging from 2209 to 4581 tonnes, with the most recent comprehensive survey (2012) estimating a biomass of 3122 tonnes (Kock and Jones, 2012). A more recent (2018) survey only included 15 trawls around Elephant Island, estimating biomass of 453 tonnes (Arana et al., 2020). A 2006 survey of the northern Antarctic Peninsula and Joinville Island (Jones and Kock, 2006) caught insufficient *C. aceratus* to estimate biomass.

3.1.4. Life history

C. aceratus spawns in winter at South Georgia, as evidenced by maturity data from multiple trawl surveys and peaks in larval abundance (Reid et al., 2007; Belchier and Lawson, 2013; James et al., 2026). Further south, spawning is reported between March and June (Kock and Jones, 2005). Lisovenko (1988) suggested *C. aceratus* migrate inshore in autumn for spawning in coastal waters around South Georgia. Like many icefish species, *C. aceratus* are known to build nests and provide parental care. Nesting sites have only been identified at Bouvet Island (Detrich et al., 2005), but are likely in shallow coastal areas, with males providing parental care. Egg incubation takes around 4 months (La Mesa et al., 2020), hatching at approximately 11 mm TL (La Mesa et al., 2020). Larvae occur in South Georgia inshore waters between August and February (Belchier and Lawson, 2013). Off the South Shetlands larvae were estimated to have hatched between July and December based on assumed daily ring counts of otoliths (La Mesa and Ashford, 2008). Length frequency analysis from multiple summer surveys at South Georgia shows discrete size classes, which almost certainly represent age classes (Kock, 1986; Reid et al., 2007; James et al., 2026). Putative age classes 1 + (7–21 cm), 2 + (22–28 cm) and 3 + (29–35 cm) were clearly distinguished in the length-frequency data, with ages 4–6 identified by length-frequency analysis (James et al., 2026). Maximum longevity is somewhat uncertain. Whilst length-frequency data from South Georgia indicate longevity of more than 6 years (Reid et al., 2007; James et al., 2026) and possibly as much as 15 years (Reid et al., 2007), studies using annuli in otoliths have estimated longevity of 15–17 years (Table 2). There is, however, uncertainty about otolith-based estimates due to the lack of validation (La Mesa and Eastman, 2023) and inconsistency with length-frequency data (Reid et al., 2007). At South Georgia males reach maturity (Lm_{50}) at a smaller size (440–480 mm TL) than females (510–591 mm TL) (Table 2), which length-frequency data indicate is 4 years old in males and 5 in females.

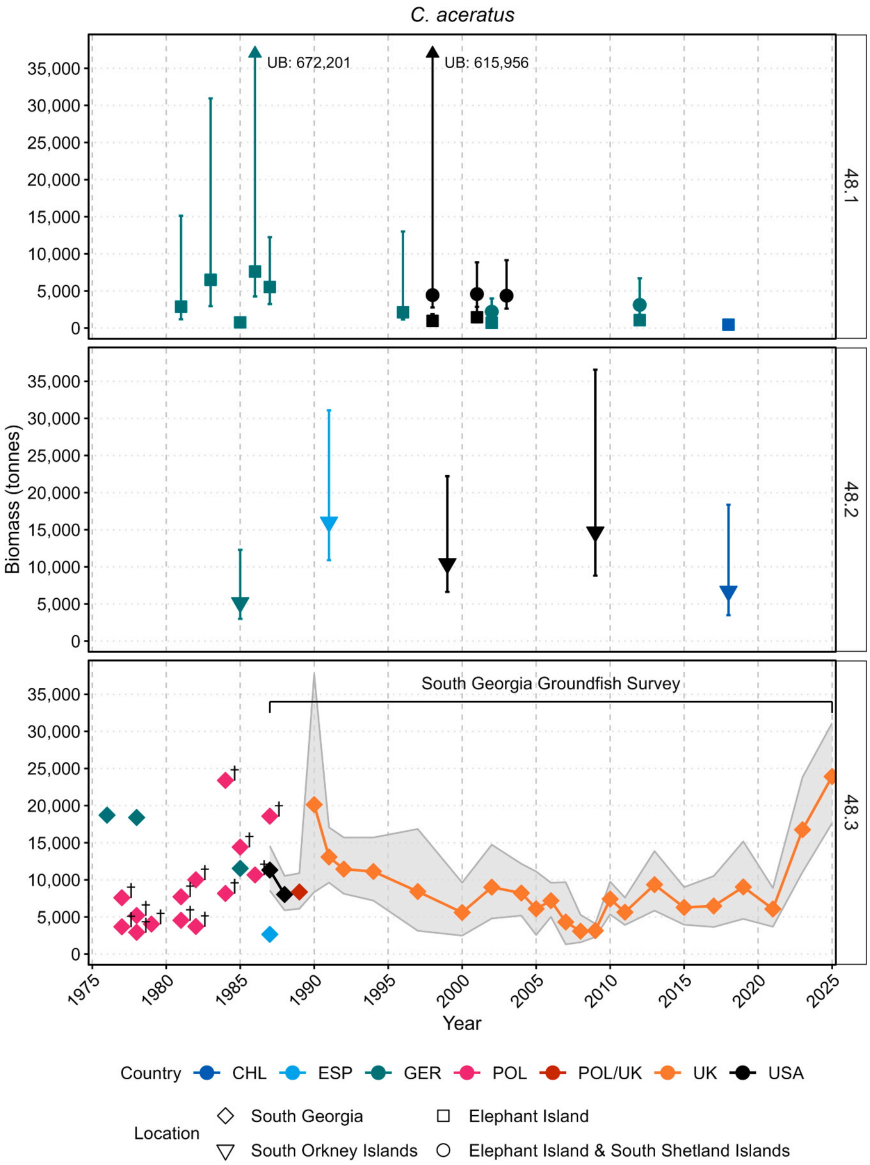

Fig. 3. Biomass estimates and 95% confidence intervals for Scotia Sea icefish (*C. aceratus*) from surveys in the South Shetland Islands (Subarea 48.1; upper), South Orkneys (Subarea 48.2; middle) and South Georgia and Shag Rocks (Subarea 48.3; lower) shelves. For the South Georgia Groundfish survey series the grey band represents the 95% confidence intervals. Biomass estimates pre-1985 are uncertain due to survey design and use of commercial fishing data.† = estimates based on commercial fishing. UB = upper bound of confidence limit. CHL = Chile; ESP = Spain; GER = Germany; POL = Poland.

3.2. *South Georgia icefish*

3.2.1. *Distribution*

The South Georgia icefish (*P. georgianus*) was described from a specimen taken at South Georgia (Norman, 1937). The distribution is similar to that of *C. aceratus*, extending from the South Shetland Islands to the South Orkney Islands and islands in the Scotia Sea, including South Georgia, Shag Rocks (low abundance; Clarke et al. 2008) and the South Sandwich Islands (Fig. 1). The South Georgia icefish is rare or absent on the Antarctic Peninsula / Joinville Island area (Kock and Jones, 2006, 2012), not abundant around the South Shetland Islands (Kock, 1998) and occurrence on the Weddell Sea coast of the Antarctic Peninsula is uncertain. *P. georgianus* is generally restricted to depths < 500 m, with the greatest density at 150–250 m depth around South Georgia (Clarke et al., 2008). It is not known from Bouvet Island and bycatch records for this species in the CCAMLR statistics (CCAMLR, 2024a) in Area 58 (Indian Ocean Sector) and 88 (Ross Sea region; also Granata et al. 2002) are likely to be misidentifications. Connectivity between populations in the different archipelagos is likely due to larval transport (Papetti et al., 2009), but extensive adult movements are unlikely and

Table 2
Life history parameters for the Scotia Sea icefish (*Chaenocephalus aceratus*).

Location	Max size (mm)	Longevity (years)	Size at 50% maturity L_{m50} (mm)	Age at first spawning (years)	Comments	Source
South Georgia	♂: 610 ♀: 760	15	♂: 440 ♀: 520	♂: 4 ♀: 5	Data from 1986 to 2006	Reid et al. (2007)
	♂: 670 ♀: 730	Not reported	♂: 484 ♀: 591	4–6	Large sample size from 30 years of surveys	James et al. (2026)
	♂: 570 ♀: 670	♂: 15 ♀: 17	Not reported	Not reported	Very small sample size (52); aged by putative otolith annuli	Olsen (1955)
	720	12	Not reported	Not reported	1985–1988	Kompowski (1990)
	720	14	Not reported	Not reported	1989–1992	Kompowski (1994)
	670	Not reported	♂: 434 ♀: 440	Not reported	1985 survey	Kock (1986)
	Not reported	Not reported	♂: 460 ♀: 474	Not reported		Kock, 1981 (in Kock, 1986)
Elephant Island	700	Not reported	♂: 446 ♀: 572	Not reported	March 1998	Jones et al. (1998)
	Not reported	Not reported	♂: 411 ♀: 456	Not reported	Nov 1983 & Feb 1985	Kock (1986)
	Not reported	Not reported	♂: 386 ♀: 451	Not reported		Kock, 1981 (in Kock, 1986)
	680	♂: 9 ♀: 12	Not reported	Not reported	1983/84–1987/88	Kompowski (1990)
	Not reported	Not reported	♂: 446 ♀: 572	Not reported	Surveys from 1985 to 2005	Kock and Jones (2005)
South Shetland Islands	715	Not reported	♂: 469 ♀: 583	Not reported	March 1998	Jones et al. (1998); Kock et al. (2000)
	♂: 540 ♀: 670	♂: 15 ♀: 17	♂: 387^{*1} ♀: 451^{*1}	♂: 9 ♀: 10	Age based on putative annuli in otoliths	La Mesa et al. (2004)
	685	17	♂: 454 ♀: 577	♀: 13	Age based on putative annuli in otoliths	Riginella et al. (2016)
	Not reported	Not reported	♂: 469 ♀: 583	Not reported	Surveys from 1985 to 1998	Kock and Jones (2005); Kock et al. (2000)
King George Island	650	10	Not reported	Not reported	1986/87 and 1987/88	Kompowski (1990)
South Orkney Islands	705	Not reported	♂: 440 ♀: 576	Not reported	Surveys from 1985 to 1998	Kock and Jones (2005); Kock et al. (2000)
	660	17	♂: 439 ♀: 571	♀: 14	Age based on putative annuli in otoliths	Riginella et al. (2016)

CCAMLR manages each area discretely. The South Georgia surveys showed no changes in bathymetric or geographic distribution. Based on its distribution (Fig. 1), we estimate the adult habitat area to be 155,000 km^2 (excluding the uncertain area on the Weddell Sea side of the Antarctic Peninsula).

3.2.2. *Exploitation*

As with *C. aceratus*, *P. georgianus* was a regular bycatch species during the early years of fishing around South Georgia. Large catches by Polish vessels in 1976/77 and 1977/78, when 15,000 tonnes were caught over two seasons (Fig. 4; Slosarczyk et al., 1984), suggest that *P. georgianus* may have been targeted (Agnew and Kock, 1990).

Whilst Polish and East German vessels generally reported bycatch to species-level, Soviet Union catches were not all attributed to species, hence Agnew and Kock (1990) attempted to reconstruct Soviet Union catches in the South Georgia region (Subarea 48.3) and estimated catches for the period 1976/77–1988/89. The highest reconstructed catch was 21,220 tonnes in 1977/78, with 10,815 tonnes in 1976/77, but these estimates should be treated with caution.

CCAMLR prohibited targeted fishing for *P. georgianus* in 1990 (CM 27/IX and CM 22/IX) and set by-catch limits for fisheries in South Georgia in 1995 (CM 33–01). Since 1990 (Fig. 4, inset), by-catch ($<$ 40 tonnes) has come from krill and mackerel icefish fisheries, with notable catches near South Georgia and the South Orkney Islands in 2004 and 2005 (Fig. 4). In the last decade, by-catch has primarily been in the krill fishery in Subarea 48.2 (CCAMLR, 2025), with catches of less than 5 tonnes per annum since 2008. By-catch in the mackerel icefish fishery is exclusively adult fish, but larval, juveniles and adult fish are taken in the krill fishery (CCAMLR, 2025).

3.2.3. *Biomass estimates*

The first biomass estimates of *P. georgianus* around South Georgia came from German surveys in 1976 (36,401 tonnes) and 1978 (31,057 tonnes) (Kock, 1985). Between 1976/77 and 1986/87 swept area biomass estimates from Polish commercial fishing operations ranged from 4192 tonnes (1979) to 70,000 tonnes (1984) (Slosarczyk et al., 1984; Sosinski and Szlakowski, 1992). The 70,000 tonne estimate for 1983/84 (Slosarczyk et al., 1984) seems anomalously high, particularly as it came towards the end of the main period of exploitation, and it was not recorded in subsequent reviews of Polish estimates (Sosinski and Szlakowski, 1992). These

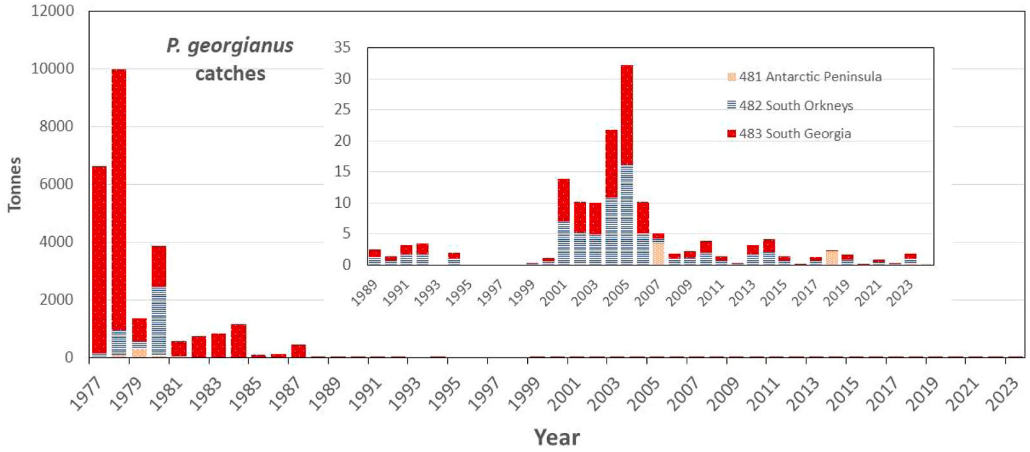

Fig. 4. Catches of South Georgia icefish (*Pseudochaenichthys georgianus*) from 1977 to 2023 (data from CCAMLR Statistical Bulletin). Inset highlights catches from 1989 to 2023 which were bycatch in Antarctic krill and mackerel icefish (48.3 only) fisheries.

estimates, focused on fishing grounds to the NE of South Georgia, and hence did not provide an accurate representation of the stock, particularly if density estimates were extrapolated to areas not surveyed.

Since 1985 fishery-independent research surveys have been routinely conducted on the South Georgia and Shag Rocks shelves (Fig. 5; Supplementary Table 2) and have shown a cyclical pattern with no long-term trend. The lowest estimate (2010 tonnes) came from the Spanish survey in 1986/87, that survey used a semi-pelagic trawl (Balguerias, 1989). The next lowest estimates came from the winter survey in April 2008 (2913 tonnes), with estimates of less than 5000 tonnes from summer surveys in 2000, 2005 and 2011 (Fig. 5). The highest estimate came from the most recent survey in early 2025 (31,753 tonnes; Fig. 5), albeit after the Red List assessment for the species. Evidence suggests *P. georgianus* (particularly males) may move to shallow water (< 150 m), to spawn in winter (James et al., 2026), hence biomass estimates may be lower at that time of year, as the surveys largely cover depths 75 – 350 m. Kock (1986) also noted that demersal trawl surveys may underestimate biomass due to regular vertical migration reducing catchability.

Five surveys (1985, 1991, 1999, 2009 and 2018) around the South Orkney Islands (Jones et al., 2000; Kock and Jones, 2005; Arana et al., 2020; Supplementary Table 1) estimated biomass from 4739 (1985) to 18,847 tonnes (1991), with the most recent survey (January 2018) estimating the biomass at 10,610 tonnes,[19] but that survey only conducted 21 trawls in the area (Arana et al., 2020).

Twelve random trawl surveys were conducted around Elephant Island and the South Shetland Islands (1981–2018), but were inconsistent in their design, with seven surveys exclusively around Elephant Island (Kock, 1998; Kock and Jones, 2005; Kock and Jones, 2012; Arana et al., 2020) (Fig. 5; Supplementary Table 1). Early German surveys around Elephant Island (1976–1996), reviewed by Kock (1998) had small catches of *P. georgianus* and biomass was not estimated. Five surveys (1998–2012) included Elephant Island and the rest of the South Shetland Islands, three of which estimated biomass in the range 691 (1998) to 1330 (2002) tonnes (Kock and Jones, 2005), but surveys in 2003 and 2012 caught insufficient numbers to estimate biomass (Kock and Jones, 2012). The most recent (2018) survey only included 15 trawls around Elephant Island, but did not catch any *P. georgianus* (Arana et al., 2020). A 2006 survey of the northern Antarctic Peninsula and Joinville Island (Jones and Kock, 2006) did not catch any *P. georgianus*.

3.2.4. Life history

Evidence from surveys at South Georgia (Clarke et al., 2008; James et al., 2026) and peaks in larval abundance (Belchier and Lawson, 2013) indicate that *P. georgianus* spawn during late autumn / winter in a single discrete period, but may be later further south (Traczyk and Meyer-Rochow, 2019). Eggs are demersal and nesting may occur in a similar manner to other icefish species (La Mesa et al., 2020). Eggs hatch after 4–5 months at 15 mm TL (La Mesa et al., 2020) and larvae occur inshore at South Georgia from June to January (Belchier and Lawson, 2013; James et al., 2026).

Length-frequency data from South Georgia surveys show four distinct cohorts, with the largest (420–590 mm TL), including mature individuals (Clarke et al., 2008; James et al., 2026), indicating rapid growth until maturity and longevity of 6 years, consistent with Traczyk and Meyer-Rochow (2019). Maximum size was reported as 590 mm in females and 560 mm TL in males (Table 3),[20] which Clarke et al. (2008) considered to be around 6 years old based on von Bertalanffy parameters derived from length-frequency analysis. Early unvalidated otolith studies suggested longevity of 13 years or more (Olsen, 1955; Mucha, 1980; Chojnacki and Palczewski, 1981), indicating little or no increase in length once maturity is reached. However Mucha (1980) noted the difficulty in distinguishing annual rings in *P. georgianus* otoliths and that estimated ages may be subject to error. Whilst older length classes may be difficult to distinguish in length-frequency data the size (putative age) classes remain discrete in *P. georgianus* at South Georgia (Clarke et al.,

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[19] Note that the biomass estimate (1061 tonnes) reported in Arana et al. (2020) is erroneous and the correct figure is in CCAMLR WG-SAM-18/25

[20] A fish of 600 mm was not sexed

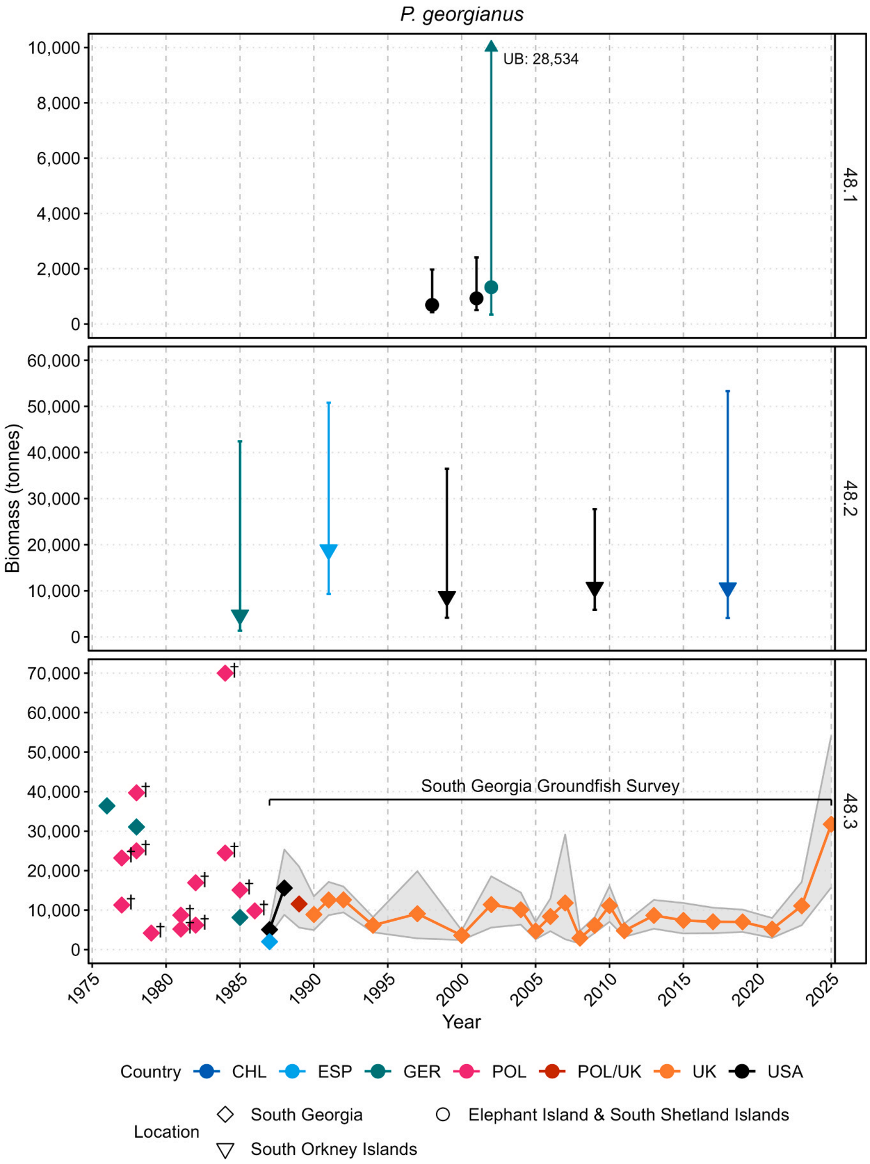

Fig. 5. Biomass estimates and 95% confidence intervals (where reported) for the South Georgia icefish (*P. georgianus*) from surveys in the South Shetland Islands (Subarea 48.1; upper), South Orkneys (Subarea 48.2; middle) and South Georgia and Shag Rocks (Subarea 48.3; lower) shelves. For the South Georgia Groundfish survey series the grey band represents the 95% confidence intervals. Biomass estimates pre-1985 are uncertain due to survey design and use of commercial fishing data.† = estimates based on commercial fishing. UB = upper bound of confidence limit. CHL = Chile; ESP = Spain; GER = Germany; POL = Poland.

2008; James et al., 2026). Furthermore, Traczyk et al. (2021) used a range of methods to age *P. georgianus* from otoliths and concluded that the species does not live much more than 6 years, consistent with length-frequency data. If South Georgia icefish undertake parental care in a manner similar to other icefish, there is likely to be high post-spawning mortality, particularly in whichever sex undertakes the guarding of eggs. Traczyk and Meyer-Rochow (2019) suggested a four-year biomass cycle at South Georgia, linked to sea surface temperatures and strengths of age-classes.

4. Discussion

The IUCN Red List is widely used by policymakers, conservation practitioners, researchers and funding bodies to prioritise conservation actions, inform legislation and international agreements, guide funding allocation and track progress toward biodiversity targets (Rodrigues et al., 2006; Simkins et al., 2025). It is also used in business decision making (Bennun et al., 2018) and in fisheries sustainability assessments (MSC, 2024). Given that they carry greater authority and influence than individual scientific publications, it

Table 3

Life history parameters for the South Georgia icefish (*Pseudochaenichthys georgianus*). ^{*1}Estimated age of the largest fish caught in the surveys, based on von Bertalanffy growth parameters. ^{*2} L_{max} reported in the paper.

Location	Max size (mm)	Longevity (years)	Size at 50% maturity L_{m50}	Age at L50	Comments	Source
South Georgia	♂: 550 ♀: 590	6^{*1}	♂: 465 mm ♀: 475 mm	♂: 4 ♀: 4	Surveys from 1987 to 2006	Clarke et al. (2008)
	♂: 560 ♀: 590	Not estimated	♂: 468 mm ♀: 480 mm	~3–4	Surveys from 1987 to 2023	James et al. (2026)
	510	13	405–455 mm	~5–6	1977/78, putative annuli in otoliths	Chojnacki and Palczewski (1981)
	560	7	Not estimated	Not estimated	Ageing using a variety of methods	Traczyk et al. (2021)
South Georgia, South Orkneys & South Shetland	600^{*2}	6	1976: 510 1992: 450	3–4	Data from 1976 to 2009; "disappearance of larger icefish since 1977".	Traczyk and Meyer-Rochow (2019)
South Shetland Islands	555	Not estimated	Not estimated	Not estimated	March 1998	Kock et al., (2000)
South Orkney Islands	535	Not estimated	♂: 451 ♀: 456	Not estimated	1999	Kock et al. (2000); Kock and Jones (2005)

is critical that the Red List assessments utilise the full body of available information, including expert knowledge, with clear justification, sources of uncertainty and flag any data quality concerns (Rodrigues et al., 2006; IUCN, 2016).

The recent Red List assessments of the South Georgia icefish and Scotia Sea icefish (Williams, 2024 a, b) fell short of the requisite high standards. Neither considered data from recent (last 15 years) demersal fish surveys at South Georgia, where both species remain abundant. Nor was CCAMLR consulted, despite holding highly relevant survey data and reports (CCAMLR, 2024b). If CCAMLR had been consulted, recent survey and other data would have been made available and different Red List categories would likely have resulted.

Certification bodies, such as the MSC, use the Red List to identify threatened species that could be impacted by fishing. Any species listed as threatened on the Red List are assigned Endangered, Threatened and Protected (ETP) status within the MSC Fisheries Standard (MSC, 2024), requiring greater precaution, including evidence of effective management measures to reduce impacts on ETP species (MSC, 2024). Accurate Red List assessments are therefore essential to identify risks without unfairly penalising well-managed fisheries.

4.1. *Evaluating the existing IUCN Red List assessment of P. georgianus*

Listing *P. georgianus* as Endangered is difficult to justify. The assessment invoked criteria A2 b,c,d,e (IUCN version 3.1), based on assumptions of a generation time of 8.5 years,[21] and a > 50% decline in the last three generations (1998–2023). Williams (2014b) assumed an age at first reproduction of 4, a longevity of 13 years and $z = 0.5$, giving the generation time of 8.5 years. However, recent studies suggest a longevity of 7 or 8 years, with first reproduction at 4, giving a generation time of six years (using a conservative $z = 0.5$). Thus three generations equates to 18 years, rather than the 25 years assumed in the assessment (Williams, 2024b). Furthermore, there is no evidence to support a greater than 50% decline in biomass in the last 18 or 25 years. The evaluation that the stock was reduced by 75% in the late 1970s is uncertain and appears to be based on a rough post-hoc evaluation of which species were caught by the Soviet Union fleet (Agnew and Kock, 1990), and early biomass estimates from commercial fishing at South Georgia (1976–1984), more than 40 years ago. Furthermore, the IUCN guidelines (Version 3.1, Section 5.5) note that depleted stocks may not qualify under criteria A2 if the declines occurred more than three generations ago.

The 36-yr South Georgia survey series (six generations) shows variability, but no evidence of a systematic decline. Although the most recent high estimate of biomass on the South Georgia shelf (2025) was not available at the time of the assessment, the estimate from 2023 (Hollyman et al., 2023) was well above the long-term average. Furthermore, although recent data are limited, there is no evidence of substantial declines in abundance from other areas. Thus, the assertion in the Red List assessment (Williams, 2024b) that the current population trend is decreasing is not supported. The assertion that the species is still taken as bycatch in "large amounts" in fishing activity that "target smaller icefish species" is uncorroborated and incorrect. In terms of area of occupancy (A2(c)), whilst there is a potential risk of climate-induced changes, there is no evidence of a contraction of habitat or change in distribution during the surveys at South Georgia (Clarke et al., 2008; James et al., 2026) and insufficient data to evaluate this in other areas. There is no current directed exploitation (A2 (d)), although larval and juvenile *P. georgianus* are taken as bycatch in the Antarctic krill fishery, particularly in the South Orkney Islands region (CCAMLR, 2025). The Red List assessment provided no evidence of threats from effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites (A2 e), and we found no evidence in the literature for such threats.

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[21] Red List guidelines indicate that generation time should be age at first reproduction + z (length of reproductive period); where z is between 0 and 1 and usually < 0.5.

4.2. *Evaluating the existing IUCN Red List assessment of C. aceratus*

The listing of *C. aceratus* as Vulnerable (Williams, 2024a) is similarly questionable. As with *P. georgianus*, the assessment was based on criteria A2 b,c,d,e and assumed an age of first reproduction of 10–14 years (La Mesa et al., 2004; Riginella et al., 2016) based on counts of unvalidated annuli in otoliths, and a longevity of at least 20 years, incorrectly inferred from Kock and Kellerman (1991), giving a generation time of 15–17 years.

Data from South Georgia clearly shows 50% maturity at around 5 years (Reid et al., 2007; James et al., 2026), with longevity greater than 6 years, but uncertain. It is possible that *C. aceratus* live as long as 17 years at high latitudes, but increased mortality associated with parental care is likely to impact longevity. A longevity of around 15 years seems a reasonable, if probably high estimate that, combined with a z value of 0.5 (also conservative), gives a generation time of 10 years and an evaluation period of 30 years (1993–2023).

Given the lack of contemporary data considered, the assertion that the current population trend is decreasing is not supported. With an assumed long generation time, the assessment drew on estimates of decline during the brief period of exploitation (late 1970s) (Agnew and Kock, 1990) to underpin the Vulnerable designation. The South Georgia survey series has shown fluctuating biomass (3084 - 23,923 tonnes), with the last two surveys estimating the highest biomass since the early 1990s. Data are limited for other parts of the range, but there is no evidence of a population decline from any available surveys over the last 30 years. The reference to a 35, 000 tonne catch limit for mackerel icefish is 40 years out of date and irrelevant to *C. aceratus,* which has a bycatch limit of 2200 tonnes (since 1995). CCAMLR has set catch limits for *C. gunnari* in Subarea 48.3 (South Georgia) of less than 7000 tonnes (mean 3392) since 1998, with an average annual reported catch of less than 1000 tonnes, and just a few days of commercial fishing during the last 7 years.

4.3. *Current management arrangements for both species*

CCAMLR has prohibited directed fishing on both species since 1990 and bottom trawling is prohibited throughout their range (CCAMLR, 2024c). The prohibition of bottom trawling is likely to protect adult populations and possible nesting areas on the continental shelf. Both species are taken as bycatch in pelagic fisheries for mackerel icefish (South Georgia only) and Antarctic krill. At South Georgia, the area within 30 km of the island is closed to commercial fishing throughout the year (Trathan et al., 2014), which provides additional protection. The Antarctic krill fishery operates throughout the region and concerns about the impact of the fishery on larval and juvenile fish, including icefish, are being addressed by CCAMLR through improving the quantification of fish bycatch as part of its scientific observer programme.

4.4. *Reconsidering generation time and baselines*

For both species, the Red List assessments are dependent on generation time and changes in biomass. If a longer generation time or more than three generations were considered, it would extend the period to shortly before exploitation and arguably Red List

Table 4
Summary of our revised assessment of IUCN Red List status of *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* using the criteria (A2 b,c,d,e) applied by Williams (2024a), (2024b).

	Chaenocephalus aceratus	*Pseudochaenichthys georgianus*
Proposed category	Least concern	Least concern
Criteria	A2 b,c,d,e	A2 b,c,d,e
Estimated generation time	10 years	6 years
Three generations	30 years (1995–2025)	18 years (2007–2025)
Rationale	Evidence of a slight decline in biomass at South Georgia from 1995 to 2009, followed by stable (2010–2021) then increasing (2023–2035) trend. Less data in South Orkneys, but biomass stable. Limited recent data from South Shetland region.	Biomass has been fluctuating at South Georgia from 2007 to 2021, with evidence of recent increase (2023–2025). Less information from South Orkneys, but population appears stable. Very limited data from South Shetlands, where species is less abundant.
b: Index of abundance	Current population trend South Georgia: stable or increasing. South Orkneys: uncertain South Shetlands: uncertain	Current population trend South Georgia: stable or increasing. South Orkneys: uncertain South Shetlands: uncertain
c: Decline in area of occupancy	No evidence of decline in area of occupancy. White-blooded fish likely sensitive to increased temperature, but no indication of change at northern range limit (South Georgia & Shag Rocks).	
d: Actual or potential exploitation	No directed exploitation (since 1990), but small bycatch in Antarctic krill (*Euphausia superba*) and mackerel icefish (*Champsocephalus gunnari*) fisheries	
e: Effects of introduced taxa, competitors etc	No introduced or invasive species in the regions have been identified as a risk to these species.	
Primary sources of information	Kock and Jones (2005); Reid et al. (2007); La Mesa et al. (2004); La Mesa and Ashford (2008); Riginella et al. (2016); Novillo et al. (2019); James et al. (2026); South Georgia Groundfish surveys.	Kock and Jones (2005); Clarke et al. (2008); Traczyk and Meyer-Rochow (2019); James et al. (2026); South Georgia Groundfish surveys.

assessments should consider pre-exploitation levels of biomass. However, biomass estimates from the period before and shortly after exploitation are less robust than those from surveys in the last 30 years, due to limited numbers of trawl stations, reduced survey areas (focussed on fishing grounds) and uncertain survey design. Furthermore, there is uncertainty about the pristine state of the Southern Ocean ecosystem, and fish populations may have increased following exploitation of krill-eating competitors, such as baleen whales and fur seals (Laws, 1977; Surma et al., 2014), many of which have recovered in recent decades. Thus, the biomass of fish species seen in the 1960s and 1970s may not represent a truly pristine status and hence may not be a suitable baseline for any current assessment of status.

4.5. *Recommended change in category*

In our view the current Red List status of both species is inconsistent with the evidence available. Our evaluation of the assessments (Williams, 2024a, b) identifies some significant errors and suggests that important recent and contemporary evidence was not taken into account and hence the criteria were not accurately applied. We recommend that the status of both species be reconsidered by the IUCN and our evaluation of the available data (Table 4), using the same criteria as the original assessments (A2, b,c,d,e), suggest that Least Concern may be the appropriate category for both species. In this case, any change would be a non-genuine change, meaning the status of the species has not changed, but the original assessment was not appropriate (e.g. due to new data, incorrect application of the criteria) (IUCN, 2024).[22] In our view, there is no scientific basis to include either of these species in the threatened categories.

4.6. *What does this tell us about the Red Listing process?*

Our conclusion that these two icefish assessments are erroneous may raise questions about other species and, more importantly, about the Red List assessment process from species selection to final outcomes. Although these cases may not be representative, and there are clear examples of rigorous application of the Red List (see below), criticisms of the Red List continue to be discussed (Mrosovsky, 1997, 2003; Palacio et al., 2023), and include other examples of inappropriate assessment (e.g. Godfrey and Godley, 2008). A particular concern is that errors and biases affect the allocation of limited conservation resources, potentially diverting them from where they are most needed or would be most effective (Palacio et al., 2023).

Previous Red List assessments have been undertaken for Southern Ocean fish including *Racovitzia glacialis* (Starnes, 2010) and *Pleuragramma antarctica* (Gon and Vacchi, 2010), but Southern Ocean fish are under-represented on the Red List. Given the extent of the Southern Ocean (approximately 34 million km^2), a focused effort to assess the status of fish species is warranted in the context of past, present and future environmental change and other anthropogenic impacts (Morley et al., 2020; Caccavo et al., 2021). While any species can be assessed against Red List criteria, we suggest the prioritisation of species that have, or continue to be, targeted and whose stocks have been depleted, which includes species such as *Notothenia rossii*, *C. gunnari* and *Patagonotothen guntheri*. Any efforts to assess Southern Ocean fish must include input from relevant stakeholders and experts. In the case of the two icefish species, the source information is listed, but it is not clear which organisations or experts were consulted.

With over 169,000 species already assessed and many more likely to be added, the IUCN RLU faces the challenge of maintaining assessment quality while managing workload with limited resources. Some taxa benefit from strong coordination by designated RLAs, such as BirdLife International for birds (Butchart et al., 2004), and the IUCN Shark Specialist Group for chondrichthyans (Dulvy et al., 2014). However, it is possible for individuals who have sufficient knowledge of a species to undertake an assessment (IUCN, 2016). Academics or consultants may seek funding to undertake assessments of taxa in their area of interest or assessments may be undertaken by scientists familiar with the Red List process but lacking taxa-specific expertise.

The current funding model may be problematic. Funded assessors likely require input from experts who are often unpaid and have limited availability. Many assessments rely on voluntary contributions, highlighting the need for sustained funding to support expert involvement and coordination (Palacio et al., 2023). The process for engaging experts also needs to be clarified, with greater transparency about who was consulted.

Consultation should occur before assessments are finalised, whether via workshops or individual review. In the latter case, peer review is especially critical, and reviewers must have appropriate taxonomic expertise. Given the large number of species yet to be assessed, there is a strong case for taxon-specific expert groups, such as SCARFISH for Southern Ocean fish, to play a greater coordination role, either as a RLA or in close liaison with the relevant RLA (here, the IUCN SSC Marine Fishes RLA), ensuring that the right taxa are prioritised and appropriate experts are consulted.

4.7. *Recommendations on the Red List process*

1. Prioritise assessment efforts.

   Assessment efforts should be strategically prioritised, preferably with an initial stage to identify species most urgently in need of assessment, prior to full Red List evaluation.
2. Consult appropriate experts.

   Expert groups or, where these are unavailable, individual experts on the taxa should be consulted throughout the Red List

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[22] IUCN have indicated that they will use the data provided to reconsider the status of the two species

process, including (i) to prioritise taxa; (ii) to provide advice on data sources; and (iii) to provide peer review on provisional evaluations. In the case of exploited fish (including bycatch taxa), the relevant fishery management authority should be consulted in advance of any final decision on Red List status.

3. Capacity building.

   Training and guidance, including on data interpretation and criteria application, should be more widely accessible to build capacity, especially in regions or taxonomic groups currently underrepresented on the Red List.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Martin Collins is the UK Scientific Representative to CCAMLR and previously Chief Executive and Director of Fisheries for the Government of South Georgia and the South Sandwich Islands. Mark Belchier is the current Director of Fisheries for the Government of South Georgia and the South Sandwich Islands (on secondment from British Antarctic Survey). Steve Parker is the Science Manager at CCAMLR. Other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.gecco.2026.e04184.

Data availability

Data will be made available on request.

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