Attachment A

Seismic Source Acoustic Modeling Data

prepared by Lamont-Doherty Earth Observatory

The RVIB Nathaniel B. Palmer (NBP) would tow a pair of 105-in^3 Sercel GI airguns. Seismic pulses would be emitted at intervals of 5 seconds. Data would be recorded on a 100-m long, 24-channel streamer. Acquisition is planned along a series of predetermined lines, all of which would be in water depth >1,000 m.

For the seismic source, the two GI guns would be towed on a string at 3 m spacing from each other, at a tow depth of 3-4 m and between 15 and 40 m astern.. In addition, the string would include a hot spare in case one of the 105-in^3 GI guns breaks down.

As the seismic source is towed along the survey line, the towed hydrophone array (streamer) receives the reflected signals and transfers the data to the on-board acquisition system. Given the relatively short streamer length behind the vessel, the turning rate of the vessel while the gear is deployed is much higher than the limit of five degrees per minute for a seismic vessel towing a streamer of more typical length (>>l km). Thus, the maneuverability of the vessel is not limited much during operations.

The GI guns would be used in harmonic mode, that is, the volume of the injector chamber (I) of each GI gun is equal to that of its generator chamber (G): G=I=105 in^3 (1,721 cm^3) for each gun. The generator chamber is the one responsible for introducing the sound pulse into the ocean. The injector chamber injects air into the previously-generated bubble to maintain its shape and thus prevent further oscillations, and does not introduce more acoustic energy into the water. The Nucleus modeling software used at Lamont-Doherty Earth Observatory of Columbia University (L-DEO) does not include GI guns as part of its airgun library, however signatures and mitigation models have been obtained for two 105-in^3 G guns at 3 m tow depth that are close approximations.

For the seismic source (total generator volume 210 in^3), the source output (downward) is 234.4 dB re 1 μPa·m for 0-pk and 239.8 dB re 1 μPa·m for pk-pk. These numbers were determined using the aforementioned G-gun approximation to the GI gun and using signatures filtered with DFS V out-256 Hz 72 dB/octave. The dominant frequency range would be 20-160 Hz for a pair of GI guns towed at 3 m depth and 35-230 Hz for a pair of GI guns towed at 2 m depth.

The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source. For the source, that would be 228.2 dB pk or 233.5 dB pk-pk. Actual levels experienced by any organism more than 1 m from the GI gun would be significantly lower.

A further consideration is that the rms (root mean square) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (0–pk) or peak to peak (pk–pk) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received level of 160 dB re 1 μPa rms in the far field would typically correspond to ~170 dB re 1 μPa pk, and to ~176–178 dB re 1 μPa pk-pk, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise difference between rms and peak or peak- to-peak values depends on the frequency content and duration

of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

Proposed Exclusion Zones

Received sound levels have been modeled by Lamont-Doherty Earth Observatory of Columbia University (L-DEO) for a number of airgun configurations, including two 105-in^3 G guns, in relation to distance and direction from the airguns (Fig. 2). The model does not allow for bottom interactions, and is most directly applicable to deep water. Because the model results are for G guns, which have more energy than GI guns of the same size, those distances overestimate (by ~10%) the distances for the 105-in^3 GI airguns. Although the distances are overestimated, no adjustments for this have been made to the radii distances in Table 1.

Empirical measurements concerning the 180- and 160-dB re 1 μPa (rms) distances ("radii" around the source) have been acquired for various airgun arrays during acoustic verification studies conducted by L-DEO in the northern Gulf of Mexico in 2003 (6-, 10-, 12-, and 20-airgun arrays, and 2 GI airguns; Tolstoy et al. 2004 [Referenced in PEIS Appendix H]) and 2007–2008 (18- and 36-airgun arrays; Tolstoy et al. 2009; PEIS Appendix H [Diebold et al. 2010]). When compared to measurements acquired in deep water (>1000 m), mitigation radii derived from the L-DEO model are found to be conservative. The surveys also showed that distances to given received levels vary with water depth - these are larger in shallow water, while intermediate/slope environments show characteristics intermediate between those of shallow-water and those of deep-water environments - and documented the influence of a sloping seafloor. Correction factors were thus developed for water depths 100–1000 m and <100 m, such that mitigation radii for intermediate and shallow environments could be obtained from the deep-water radii predicted by the L-DEO model (a simple multiplication by these correction factors is used).

For the 2 x 105-in^3 GI gun source, measurements were obtained only in shallow water. The data suggests the 160 dB RMS distance is ~1500 m (Tolstoy et al., 2004 [Referenced in PEIS Appendix H]; their Table 1) with an upper bound of 1970 m based on interpolation between the highest received levels at distances of 1 km and 2.8 km (Tolstoy et al., 2004 [Referenced in PEIS Appendix H]; their Fig. 3). No direct constraints on the 190 dB or 180 dB distances were obtained due to clipping of arrivals at short distances but the data is compatible with estimates of 294 m for 190 dB and 511 m for 180 dB. Comparison between these shallow-water values and the deep-water L-DEO model results provided correction factors of 14.7 for the 190 dB rms distance, 7.40 for the 180 dB rms distance and 2.94 for the 160 dB rms distance. The only empirical measurements obtained for intermediate water depths (100–1000 m) during either survey were for the 36-aigun array in 2007–2008 (PEIS Appendix H [Diebold et al. 2010]). Following results obtained at this site (PEIS Appendix H [Diebold et al., 2010]; their Fig. 16) and earlier practice, a correction factor of 1.5, irrespective of distance to the array, is used to derive intermediate-water radii from modeled deep-water radii for all array configurations.

Based on the modeling and applications of appropriate correction factors, estimates of the maximum distances from the GI guns where sound levels of 190, 180 and 160 dB re 1 μPa (rms) are predicted to be received in deep (>1000-m) water are shown in Table 1. Specifically, we have compiled the L-DEO model results for the source (2 x 105 in^3 based on modeling of G guns) in deep water for the 2 x 105-in^3 GI gun source.

The PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with

individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m exclusion zone (EZ) for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 105-in^3 GI airguns. A fixed full mitigation zone (FMZ), or 160 dB "Safety Zone" was not defined in the PEIS for the same suite of low-energy sources, therefore, L-DEO model results for 105-in^3 GI airguns are used here to determine the 160 dB radius.

The 180-dB re 1 μPa_{rms} distance is the safety criterion as specified by NMFS (2000) for cetaceans and 190-dB re 1 μPa_{rms} for pinnipeds. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in other seismic projects (e.g., Smultea et al. 2004; Holst et al. 2005a,b; Holst and Beland 2008; Holst and Smultea 2008; Hauser et al. 2008). If marine mammals or sea turtles are detected within or about to enter the appropriate EZ, the airguns would be shut down immediately.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. NSF would be prepared to revise its procedures for estimating numbers of mammals should NMFS implement new acoustic criteria guidelines. However, currently the procedures are based on best practices noted by Pierson et al. (1998) and Weir and Dolman (2007).

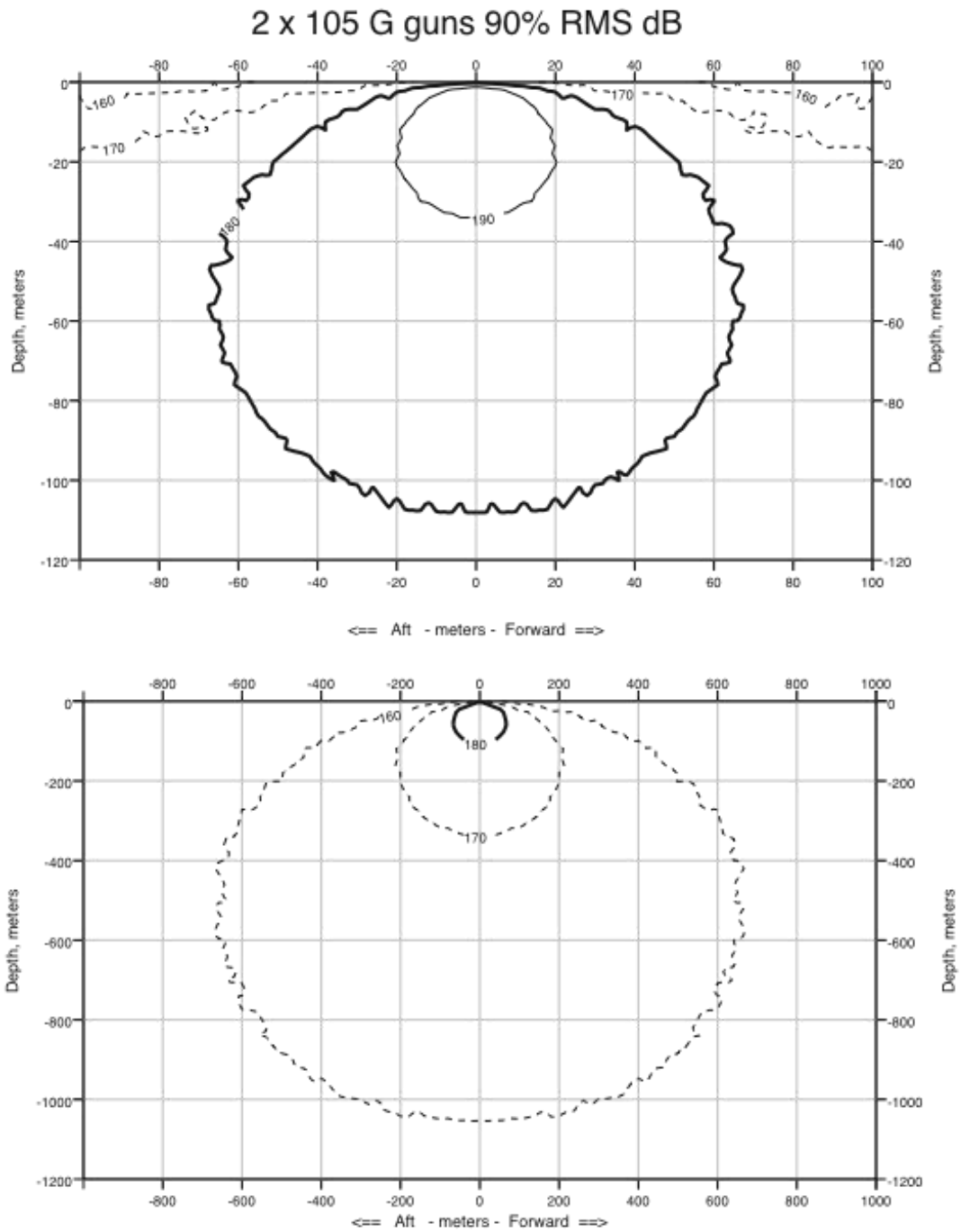


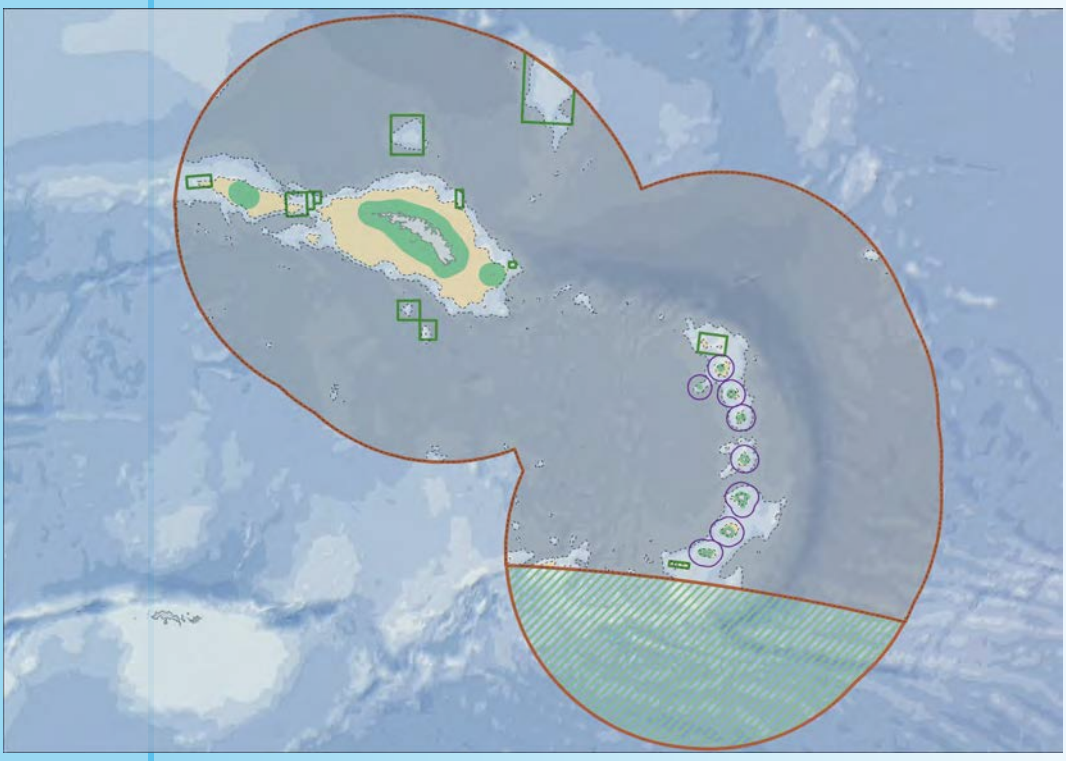
Figure 2. Modeled received sound levels from two 105-in^3 G guns, similar to the two 105-in^3 GI airguns that would be used during the seismic surveys in the Scotia Sea during September 2014. Model results provided by L-DEO.

Table 1. Predicted distances to which sound levels of 190, 180 and 160 dB re 1 μPa (rms) might be received from two 105-in^3 G guns, similar to the two 105-in^3 GI guns that would be used during the seismic surveys in the Scotia Sea during September 2014. Distances are based on model results provided by L-DEO (presented in Fig. 2) and empirical measurements acquired during the 2003 calibration survey in the Gulf of Mexico. The Exclusion Zones (EZs) and Full Mitigation Zone (FMZs) proposed for this survey are provided below and are based on model/empirical measurements and standard EZs established in the PEIS for low energy sources.

Source and volume	Water depth	Predicted RMS radii (m) based on modelling and empirical measurements			Proposed EZ and FMZ based on modelling/ empirical measurements and PEIS [Note]	
		190 dB	180 dB	160 dB	EZ (190/180 dB)	FMZ
2 x 105 in^3 GI guns	>1000 m	20	69	670	100/100	670

Note: The proposed seismic survey in the Scotia Sea will be conducted only in waters > 1,000 m deep; EZ and FMZ are included for this depth only.

South Georgia and the South Sandwich Islands
Marine Protected Area
Management Plan



Government of South Georgia and the South Sandwich Islands

August 2013

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This management plan was prepared by Martin Collins (GSGSSI), with the assistance of Phil Trathan and Susie Grant (BAS), Deborah Davidson (SAERI) and Katherine Ross (GSGSSI). Richard Phillips, Dave Barnes, Pete Ward (all BAS), Jude Brown and Andy Black (GSGSSI), Rebecca Mitchell (MRAG), Paul Brewin (SMSG) and Sally Poncet all contributed text for the plan. Photographs were provided by Martin Collins, Jude Brown, Andy Black, Phil Trathan, Pete Lens and the Shallow Marine Surveys Group. David Herbert and Magda Biszczuk (BAS) produced the maps.

Preface

The waters around South Georgia and the South Sandwich Islands are among the most productive in the Southern Ocean, supporting a tremendous abundance and diversity of wildlife. The territory also supports a range of activities, such as fishing and tourism, which represent potential threats to that wildlife. Fisheries and tourism are therefore highly regulated. The Marine Stewardship Council (MSC) has certified both the South Georgia toothfish and icefish fisheries as sustainably managed, together with a major component of the krill fishery. Tourism is highly regulated with only the smaller cruise ships allowed to visit the islands.

As part of an ongoing programme of sustainable management of the Territory, the South Georgia and South Sandwich Islands Marine Protected Area (MPA) was declared on February 23rd 2012. This created a large sustainably managed MPA (IUCN Category VI), designed to ensure the protection and conservation of the regions rich and diverse marine life, whilst allowing sustainable and carefully regulated fisheries. The initial designation enshrined in law much of the existing protection that had been established under the fisheries licensing regime and created a 1.07 million km^2 MPA, which included the prohibition of all bottom trawling and a ban on bottom fishing at depths less than 700 m. No-take zones (IUCN Category 1) were created around South Georgia, Clerke Rocks, Shag and Black Rocks and the South Sandwich Islands, totalling 20,431 km^2. The No-take Zones provide refuges for fish, protect the benthos and spawning fish and avoid competition between fisheries and land-based foragers.

Following the initial designation the Government of South Georgia and the South Sandwich Islands (GSGSSI) convened a scientific workshop in April 2012 to consider what further protection could be incorporated within the MPA. On the basis of the findings, and following consultation, further temporal and spatial protection has now been implemented. A revised Marine Protected Area Order came into force on June 13th 2013. The additional protection includes a ban on bottom fishing deeper than 2,250 m, additional benthic closed areas in the depths fished for toothfish, a seasonal closure (November 1st until March 31st) of the Antarctic krill fishery, and a 12 nm pelagic closed area around the South Sandwich Islands.

This management plan provides details of the MPA, with the rationale behind each area of the MPA measures and details of surveillance and monitoring that will be established. The MPA is monitored by a series of scientific programmes undertaken by GSGSSI and the British Antarctic Survey. The area is patrolled by a dedicated patrol vessel. The MPA provisions will be reviewed every five years or if new threats or significant new data emerge in the intervening period.

Key Facts

1. South Georgia and the South Sandwich Islands are home to a tremendous abundance and diversity of marine flora and fauna and marine dependent predators.

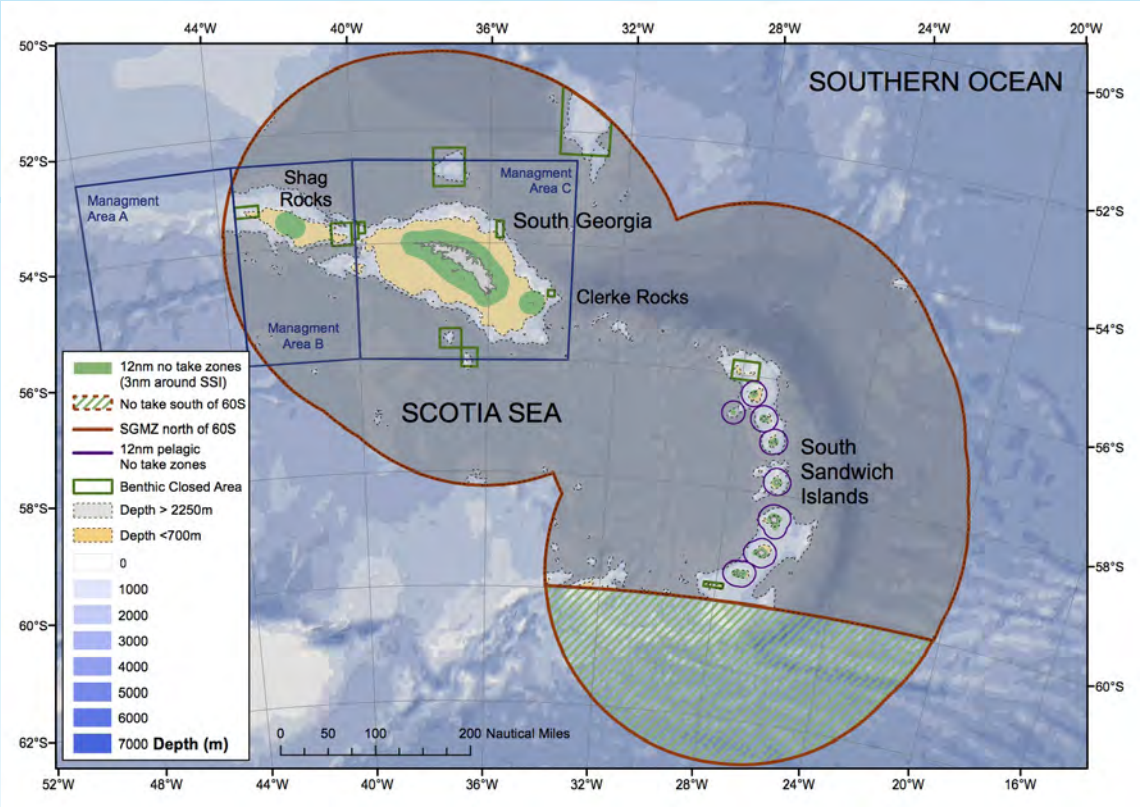
2. South Georgia and the South Sandwich Islands are a 'hotspot' of benthic biodiversity and also support seven species of globally threatened seabirds.

3. The South Georgia and South Sandwich Islands Marine Protected Area (MPA) was first established by Order in February 2012, creating one of the largest sustainably managed MPAs on the planet. Further temporal and spatial protection was added in June 2013.

4. Bottom trawling is prohibited in the MPA and bottom fishing (e.g. with longlines) is only allowed between the depths of 700 and 2,250 m, meaning that only 8 % of the seafloor can be subject to bottom fishing.

5. The no-take zones (IUCN Category I) cover 20,431 km^2 of ocean within the SGSSI MPA and include all areas of shallow sea (<100 m deep) and 47 % of seas in the 100-200 m depth range.

6. Fishing for Antarctic krill is not permitted between November 1st and March 31st, which reduces the risk of competition between the fishery and krill dependent predators.



1. Introduction

1.1 What is a Marine Protected Area?

The marine environment covers 70 % of the planet, and provides crucially important goods and services that sustain human life. However, marine ecosystems and resources have been increasingly degraded by human activities, which threaten their integrity and that of their associated biodiversity. Natural resources have been sequentially over-exploited (in many cases destroying habitats in the process); pollution events frequently destroy local habitats and associated flora and fauna; and species can be transferred from their native habitats to new environments, where they threaten native biodiversity. Overlaying this direct human intervention in the oceans is the increasing threat of global warming and associated ocean acidification.

Marine Protected Areas (MPAs) are recognized as one of the most effective means for achieving ecosystem-level conservation, thereby protecting marine biodiversity, and mitigating key threats and pressures on marine environments and resources. They are able to achieve both conservation and fisheries management objectives, as well as providing a foundation for ecosystem-based management (Toropova et al., 2010).

The International Union for the Conservation of Nature (IUCN) define a protected area as:

"A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008).

IUCN further categorises the different levels of management that such areas can be afforded (Dudley, 2008; Appendix 1), ranging from strictly protected or 'no-take' (Category I) areas to those which are managed for sustainable use of natural resources or other multiple uses (Category VI).

1.2 South Georgia and the South Sandwich Islands

The South Georgia and the South Sandwich Islands are a UK Overseas Territory, administered by the Government of South Georgia and the South Sandwich Islands (GSGSSI) through the Office of the Commissioner in Stanley, Falkland Islands. The Territories have been under UK administration since 1908. Until 1985, South Georgia and the South Sandwich Islands were part of the Falkland Island Dependencies, after which they became a separate UK Overseas Territory. The SGSSI Territorial Sea, which extends 12 nautical miles (nm) from the coast of South Georgia and the South Sandwich Islands was declared in 1989 (see Appendix IV for the Territorial Sea Order 1989 and the associated baselines). The 200 nm Maritime Zone (MZ) was declared in 1993 extending from the outer limit of Territorial Waters to 200 nm from the baselines.

The South Georgia and South Sandwich Islands Maritime Zone (SGSSIMZ) is south of the Antarctic Polar Front and thus falls within the area managed by the Commission for the Conservation of Antarctic Living Resources (CCAMLR). CCAMLR was established in 1982 as part of the Antarctic Treaty System, has 24 member states, and is responsible for managing fisheries throughout the Southern Ocean. The waters around South Georgia are classed as sub-area 48.3 and those around the South Sandwich Islands are sub-area 48.4 (Fig. 1.1). A small part of sub-area 48.2 also falls within the 200 nm Maritime Zone. Fisheries in the SGSSIMZ are managed within the CCAMLR framework and are subject to catch limits and regulations agreed by the Commission, but GGSSSI can (and does) implement more precautionary catch limits, and enforce stricter regulation, than CCAMLR.

The waters around South Georgia and the South Sandwich Islands are among the most productive in the Southern Ocean (Murphy et al., 2007), supporting a tremendous abundance and diversity of wildlife (e.g. Atkinson et al., 2001; Hogg et al., 2011). The region also supports a range of human activities including fishing, scientific research and tourism, which have the potential to impact on the relatively pristine marine environment.

1.3 The development of the SGSSI MPA

As part of the Government's ongoing commitment to the sustainable management of the territory, the South Georgia and South Sandwich Islands Marine Protected Area Order was signed on February 23rd 2012. That Order created a large sustainably managed MPA (IUCN Category VI), which includes the entire Maritime Zone north of 60°S. The relatively small area south of 60°S was already a de facto No-take zone as fishing licences are not issued for this area. The MPA is designed to ensure the protection and conservation of the region's rich and diverse marine life, whilst allowing sustainable and carefully regulated fisheries.

This initial designation enshrined in law much of the existing protection that had been established under the fisheries licensing regime and legislation and created a 1.07 million km^2 MPA that included the prohibition of all bottom trawling and a ban on bottom fishing at depths less than 700 m. No-take zones (IUCN Category 1) were created around South Georgia, Clerke Rocks, Shag and Black Rocks and the South Sandwich Islands, totalling 20,431 km^2. The No-take Zones (NTZs) provide refuges for fish, protect the benthos and spawning fish, and avoid competition between fisheries and land-based foragers.

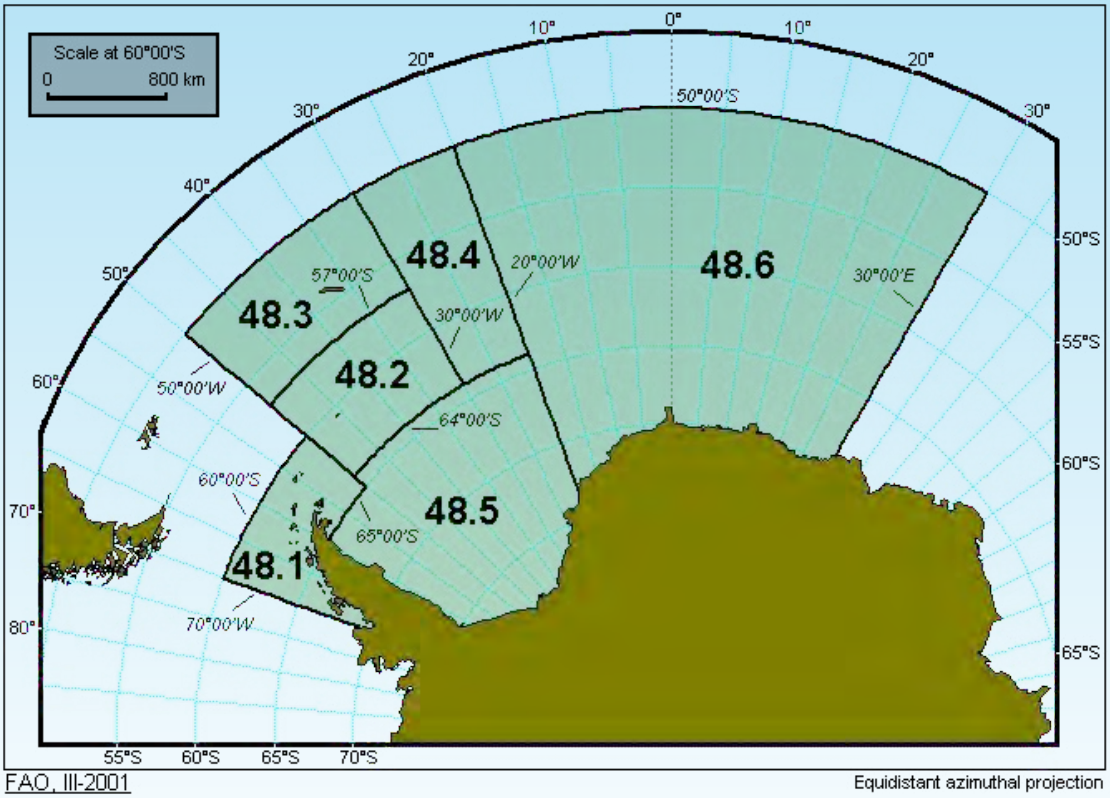


Figure 1.1 CCAMLR/FAO Southern Ocean Fishing Area 48

Following the initial designation GSGSSI convened a scientific workshop in April 2012 to consider what, if any, further protection should be incorporated within the MPA. On the basis of the workshop report, and following a stakeholder consultation, further temporal and spatial protection have now been implemented. A revised Marine Protected Area Order came into force on June 13th 2013. The additional protection includes a ban on bottom fishing deeper than 2,250 m, benthic closed areas in the depths fished for toothfish, a seasonal closure (November 1st until March 31st) of the Antarctic krill fishery and a 12 nm pelagic closed area around the South Sandwich Islands.

The designation of this MPA was a significant contribution towards the achievement of the global commitment (agreed at the 2002 World Summit on Sustainable Development) to establish ecologically representative and effectively managed networks of MPAs by 2012. In 2006, the Parties to the Convention on Biological Diversity agreed targets calling for "at least 10% of each of the world's marine and coastal ecological regions to be effectively conserved" by 2010 (CBD, 2006). However, as of October 2010, only 1.17% (4.2 million km^2) of the world's oceans had been designated as MPAs, with 5,878 sites largely focused in coastal regions (Toropova et al., 2010).

CCAMLR has also committed to work towards the achievement of a representative system of MPAs in the Southern Ocean (CCAMLR, 2009). In 2009, CCAMLR designated the South Orkney Islands southern shelf as its first MPA. This and other protected areas within the CCAMLR Convention Area covered a total of 0.5% of the Southern Ocean (Grant & Trathan, 2011). The designation of the South Georgia and South Sandwich Islands MPA increases this total to 3.5% of the Southern Ocean.

This Management Plan provides background information and the rationale behind the establishment of the South Georgia and South Sandwich Islands Marine Protected Area. It also provides details of the monitoring and patrolling that takes place within the MPA.

GSGSSI will monitor activities throughout the MPA and will undertake a formal review every 5 years. Where appropriate GSGSSI will also seek to address any issues raised between formal reviews. The toothfish and icefish fisheries will also be subject to 5-yearly reassessments by the Marine Stewardship Council (MSC).

	Marine Protected Area	Jurisdiction	MPA km^2
1	**South Georgia & South Sandwich Islands MPA**	**UK**	**1,070,000**
2	Chagos Archipelago (BIOT)*	UK	544,000
3	Phoenix Islands Protected Area	Kiribati	408,342
4	Great Barrier Reef Marine Park	Australia	343,480
5	Papahanaumokuakea Marine National Monument*	USA	334,154
6	Mariana Trench Marine National Monument	USA	247,179
7	Pacifice Remote Islands Marine National Monument*	USA	212,788
8	Prince Edward Islands Marine Protected Area	South Africa	180,633
9	Kermadec Benthic Protection Area	New Zealand	164,840
10	Macquarie Island Commonwealth Marine Reserve	Australia	161,895
11	Motu Motiro Hiva Marine Park*	Chile	150,000
12	Galapogos Marine Reserve	Ecuador	137,795
13	Franz Josef Land Zakaznik	Russia	123,877
14	Antipodes Transect Benthic Protection Area	New Zealand	110,565

*Table 1. The largest Marine Protected Areas in the world. Note that different levels of protection are afforded in the different MPAs. * denotes MPAs that are entirely no-take zones.*

2. Background

2.1 Topography

South Georgia and the South Sandwich Islands are part of the Scotia Arc, which is a chain of islands and submarine ridges that form the northern, eastern and southern boundaries of the Scotia Sea, in the Atlantic sector of the Southern Ocean. The Scotia Arc links the mountains of the Antarctic Peninsula with the Andes in South America. The Arc was formed by the subduction of the South American tectonic plate under the South Sandwich Plate.

2.1.1 South Georgia

South Georgia and its associated smaller offshore islands, islets and stacks lie between 53°30' and 55°S and 34°30' and 42°W. South Georgia itself is a mountainous glaciated island that includes the highest point (Mt Paget; 2,934 m; see below) of any UK Overseas Territory. The coastline, which extends over 600 miles in length, is deeply indented, with steep-sided and deep (>200 m) fjords. The south-west coast of the island is exposed to heavy wave action under the influence of the prevailing westerly wind and ocean swell. The north-east coast is more sheltered, but occasionally subject to swells generated by northerly and, more rarely, easterly winds.

The island is surrounded by a broad area of continental shelf, but with only a small area at depths of less than 50 m. The continental shelf consists of a series of banks and troughs. The large troughs are glacially eroded and linked to the major fjords on the island, they radiate out marking the former pathways of large outlet glaciers and ice streams (Graham et al., 2008). The shelf extends SE to Clerke Rocks. The rocks themselves are around 35 miles SE of the island. Shag Rocks and Black Rock occupy a separate area of shelf, approximately 100 miles NW of South Georgia. The Shag Rocks shelf is separated from the South Georgia shelf by a deep channel (>1,000 m).

2.1.2 South Sandwich Islands

The South Sandwich Islands consist of eleven uninhabited islands and associated rocks. These volcanic islands rise steeply from deep water between 56° and 59°S and between 26° and 28°W and are surrounded by very small areas of shallow shelf. The main islands (Zavodovski, Leskov, Visokoi, Candlemas, Vindication, Saunders, Montagu, Bristol, Bellingshausen, Cook and Thule) extend over 250 miles in a north to south direction.

Much of the 124 miles of coast is exposed, with few sheltered bays or beaches. The islands are volcanically active and the seabed and coastline are subject to periodic topographical changes.

The South Sandwich Trench lies to the east and north-east of the island chain and here depths are in excess of 8,000 m, making it the deepest area of ocean under UK jurisdiction.

2.2 Oceanography

Oceanographically, South Georgia and the South Sandwich Islands are strongly influenced by the Antarctic Circumpolar Current (ACC), which is highly constrained as it flows through the Drake Passage, after which it is able to meander more freely as it crosses the Scotia Sea. The ACC includes high velocity currents associated with four major thermohaline fronts (Fig. 2.1).

The Sub-Antarctic Front (SAF) separates the ACC from temperate waters to the north, with the Southern Boundary (SB) as the southern limit of the ACC. The Southern Antarctic Circumpolar Current Front (SACCF) crosses the central Scotia Sea and wraps around the eastern end of South Georgia, before retroflecting to the north and east of the island (Meredith et al., 2003). The Polar Front (PF) lies between the SACCF and SAF and separates waters with a subsurface temperature minimum to the south from warmer waters to the north. Further south the SB maintains a mostly eastward course through the Scotia Sea, but has a northward topographically induced loop in the vicinity of the South Sandwich Island arc. Within this area of complex oceanography, different water masses may be characterised by different flora and fauna,with fronts potentially providing elevated productivity and putative barriers to stenothermal (temperature sensitive) fauna.

2.2.1 South Georgia

South Georgia lies to the south of the Polar Front and hence the seas surrounding the island are cold throughout the year, ranging from 0°C in August to 4°C in late summer. There is clear evidence of significant warming in the last 80 years (Whitehouse et al., 2008), with temperatures in the upper 100 m having risen by 0.9°C in January and 2.3°C in August. Tidal ranges are generally small (< 1 m).

2.2.2 South Sandwich Islands

The waters around the South Sandwich Islands, which are south of the SB, are cooler than the waters around South Georgia, reaching 1.5°C in the northern area in summer. The southern islands are usually in the seasonal sea-ice zone, which often encompasses the whole island chain between August and October. There is no information available for tidal ranges in the South Sandwich Islands.

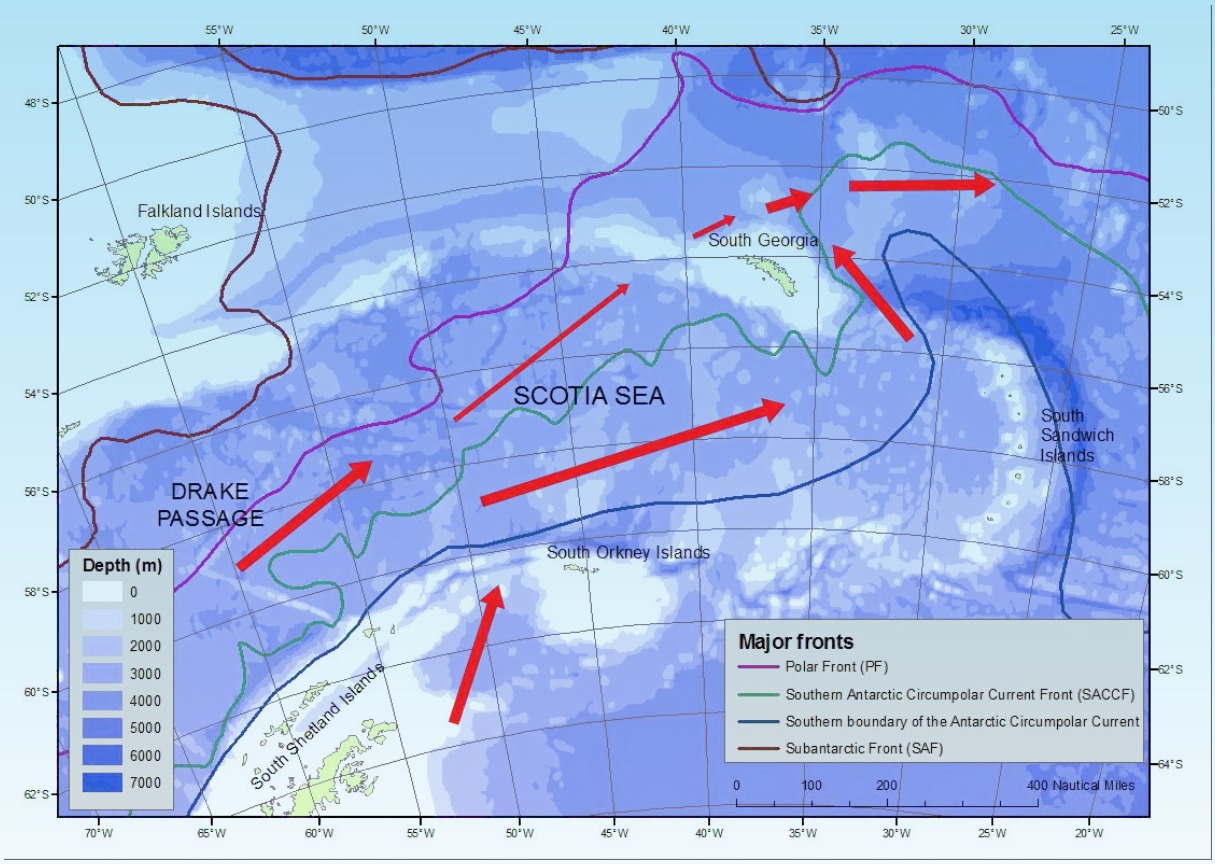


Figure 2.1. The Scotia Sea region of the Southern Ocean illustrating the mean locations of the principal fronts of the Antarctic Circumpolar Current.

3. Marine flora and fauna

The marine habitats of the SGSSI Maritime Zone can be divided into the pelagic and the benthic realms. The pelagic system is relatively uniform with similar species throughout, but with some depth stratification (Ward et al., 2012). Benthic habitats are considerably more diverse extending from the inter-tidal through the shallows to 8,000 m in the depths of the trenches near the South Sandwich Islands. Hogg et al. (2011) recently highlighted the tremendous faunal diversity in the waters of South Georgia, much of which was in the benthos. In general the fauna and flora of South Georgia is far better known (albeit with significant gaps) than that of the South Sandwich Islands.

3.1 Phytoplankton

The waters around South Georgia are amongst the most productive in the Southern Ocean (Atkinson et al., 2001), with large and often long-lasting seasonal phytoplankton blooms usually present throughout the summer months. These blooms, which are typically dominated by large colonial diatoms, such as *Eucampia antarctica*, *Odontella weisfloggii*, *Chaetoceros socialis* and *Thalassiosira* spp. probably result from iron enrichment associated with South Georgia and other islands in the Scotia Arc (Atkinson et al., 2001; Murphy et al., 2007). The patchy diatom blooms are overlayed on a more constant background of smaller autotrophs and heterotrophs, dominated by small diatoms, with prymnesiophytes and dinoflagellates also contributing (Atkinson et al., 2001).

3.2 Zooplankton

The biomass of zooplankton is high around South Georgia, with levels roughly 4 to 5 times higher than those more typical of the Southern Ocean (Atkinson et al., 2001; Murphy et al., 2007). The mesozooplankton fauna is dominated by copepods and euphausiids.

Antarctic krill (*Euphausia superba*; Fig. 3.1) make up almost half the zooplankton biomass in South Georgia waters (Atkinson et al., 2001). Krill, which reaches 60 mm in length, forms dense swarms and is a key species in the pelagic food-web of the Southern Ocean (Fig. 3.2), linking primary production to the abundant vertebrate predators in short and highly efficient food chains (see Murphy et al., 2007; Stowasser et al., 2012). Krill is primarily a species of the seasonal sea ice zone and South Georgia is close to the northern limit of their distribution. Krill are advected to the South Georgia and South Sandwich Islands region from the seas around the Antarctic Peninsula, and at South Georgia the population is dominated by adult stages, with early larvae rarely seen (Marr, 1962; Ward et al., 1990).

Figure 3.1 Antarctic krill, Euphausia superba, a key part of the foodweb in South Georgia waters.

Apart from krill, five other euphausiids (*Euphausia triacantha*, *E. frigida*, *E. vallentini*, *Thyssanoessa macrura* and *T. vicina*) are also encountered in South Georgia waters, but are considerably smaller and less abundant than *E. superba*.

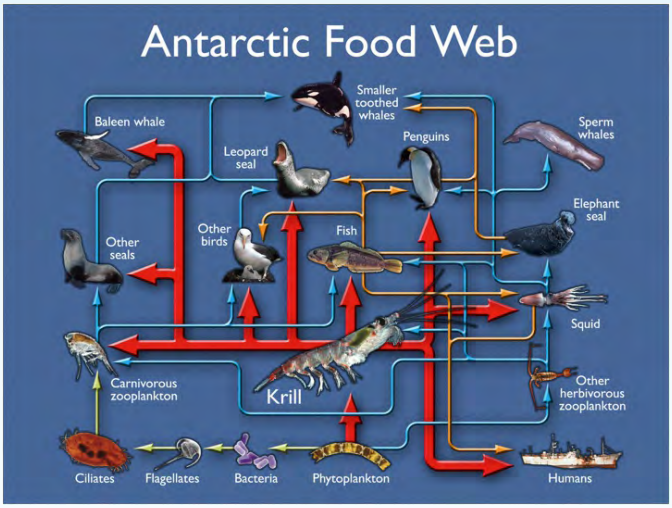


Figure 3.2 Schematic representation of the Southern Ocean foodweb, illustrating the key position of krill

With the exception of krill, copepods are the dominant zooplankton, with well over 25 species recorded in South Georgia waters. Copepod biomass is dominated by the large Antarctic and sub-Antarctic species, *Calanoides acutus*, *Rhincalanus gigas*, *Calanus propinquus* (Fig. 3.3) and *Calanus simillimus*. Small species dominate overall copepod abundance particularly *Oithona similis* and *Ctenocalanus citer*. The small neritic species *Drepanopus forcipatus* is very numerous over the island's continental shelf and is preyed upon by larvae of commercially important fish species (North & Ward, 1989).

Figure 3.3 The copepod Calanus propinquus

Amongst the other zooplankton, salps (principally *Salpa thompsoni*) and amphipods are probably the most conspicuous. Salps are occasionally abundant, particularly in krill-poor years. The pelagic amphipods include around 20 species, the most abundant and ecologically important being *Themisto gaudichaudii* (Fig. 3.4), which is an important alternative to krill for many predators (Watts & Tarling, 2012). Other important zooplankton groups include the chaetognaths, ostracods and pteropods.

Figure 3.4 The planktonic amphipod Themisto gaudichaudii, an important alternative to krill for many predators

3.3 Pelagic fish and squid

The dominant family in the pelagic fish fauna is the Myctophidae or lantern fish, which includes 20 species (Collins et al., 2008a; Collins et al., 2012). The myctophids are small planktivorous fish that live from the surface layers down to the bathypelagic (> 1000 m). The most abundant species in South Georgia waters are from the genera *Electrona*, *Protomyctophum* and *Gymnoscopelus*. The myctophids are important in the diets of many predators, particularly king penguins (*Aptenodytes patagonicus*). *Electrona carlsbergi* was the target of commercial fishing in the early 1990s, with catches taken in the polar frontal zone, north of South Georgia. Myctophids are also occasional by-catch in the icefish and krill fisheries. The other important family is the Bathylagidae or deep-sea smelts, which are abundant at depths greater than 400 m.

Pelagic squid are not easily caught in nets, but frequently encountered in predator stomachs (Collins & Rodhouse, 2006). The species most frequently caught in nets are juveniles of *Galiteuthis glacialis* and *Slosarczykovia circumantarctica*. The most conspicuous is the colossal squid *Mesonychoteuthis hamiltoni* (Fig. 3.5), which can reach 2.5 m mantle length and has occasionally been caught on longlines. *Martialia hyadesi* is a muscular oceanic squid that is frequently found in regurgitates of grey-headed albatross and has been the subject of some exploratory commercial fishing at South Georgia.

Figure 3.5 The head and tentacles of a colossal squid caught in South Georgia waters

3.4 Coastal marine benthic flora

The inshore algal flora is visually dominated by stands of giant kelp (*Macrocystis pyrifera*; see below), with sub-canopies of the large brown algae Himantothallus grandifolius and complex assemblages of foliose red algal species (Rhodophyta). Intertidal seaweeds show distinct zonation, with the most diverse assemblages near low tide areas, consisting of mixed green filamentous and foliose species, *Ulva* sp., *Enteromorpha*, *Acrosiphonia* and *Prasiola*, the brown algae *Adenocystis* and *Caepidium*, with the lower littoral dominated by a band of *Durvillaea* and *Palmaria*. Historic and current species records indicate a species diveristy of over 120 benthic algae from South Georgia with a number being endemic to the area. However evidence of increasing numbers of cosmopolitan species and new species records suggest distributional shifts of some algal species. The biogeographical affinities of the algal flora of South Georgia lies with other sub-Antarctic islands and the southern tip of South America.

3.5 Benthic invertebrate fauna

The benthic fauna is almost certainly the least known of all faunal groups and what is known is focused on the larger mega- and macro-fauna, with remarkably little known about the micro-fauna.

With a small tidal range, the intertidal zone does not have the visually striking species zonation characteristic of shores north of the Polar Front, and has been described as highly depauperate (Davenport & Macalister, 1996), but small molluscs, amphipods and polychaetes can be visually abundant (Barnes et al., 2006). A recent detailed survey has indicated patchiness in the intertidal fauna and demonstrated the presence of pockets of high diversity within the intertidal zone (Brewin, unpublished).

Figure 3.6 An unidentified anemone from the sub-tidal zone on the north coast of South Georgia

Sub-tidal sites are highly variable; some are poor in species diversity and abundance, whilst others are rich and diverse (Barnes et al., 2006). The range and abundance of many higher taxa found indicate that the South Georgia benthic fauna is Antarctic in character, but with many Magellanic species, some species with circum-Southern Ocean distributions, and a number of endemic species. South Georgia may represent the convergence of the northernmost extent of known Antarctic fauna and southernmost extent of South Atlantic fauna. Barnes et al. (2006) identified 53 taxa to genus and 41 to species. A more extensive survey of the shallow sub-tidal habits was undertaken in

Figure 3.7 Nudibranch Flabellina falklandica photographed in shallow water

November 2010 (Brickle & Brewin, 2011), with more than 200 species or putative species identified to date (Brewin, unpublished).

There is limited data on the benthos of deeper water (Ramos, 1999; Lockhart & Jones, 2008), but sampling indicates highly heterogenous habitats, with great variability in the dominant taxa. In reviewing the biodiversity of South Georgia, Hogg et al. (2011) found high levels of endemism in many benthic phyla including bryozoans, cnidarians (Fig. 3.6) and molluscs (Fig. 3.7) and noted that many species are at the edge of their range and thus likely to be susceptible to environmental change.

On the continental shelf (25-500 m) the limited sampling that has been achieved found that the dominant megabenthos were echinoderms (particularly ophiuroids), sponges (Fig. 3.8) and ascidians, with distinct differences between the shelves of Shag Rocks, South Georgia and the South Sandwich Islands (Ramos, 1999; Lockhart & Jones, 2008). At these depths, samples from the Shag Rocks shelf and the north-west of South Georgia were dominated by echinoids, with sponges dominating parts of the shelf north of South Georgia. Ramos & San Martin (1999) also reported a unique serpulid reef on the shelf in the area of Clerke Rocks.

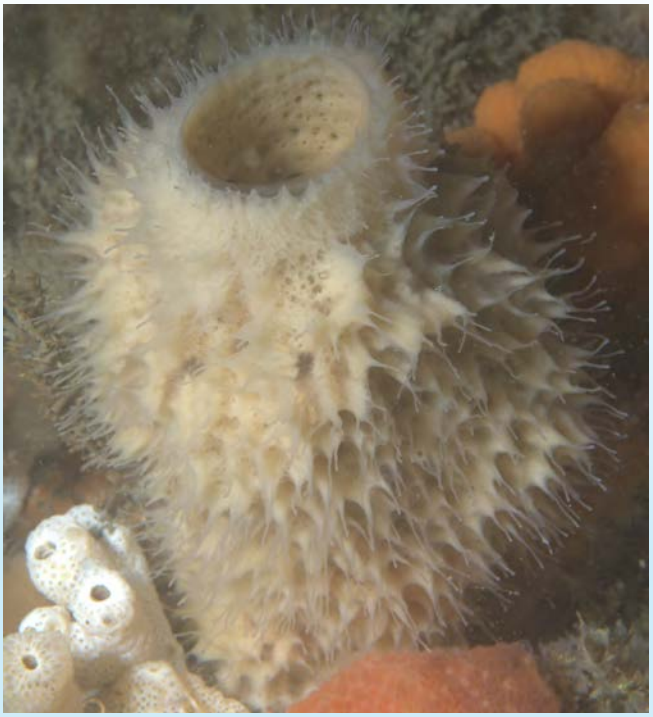


Figure 3.8 A glass sponge, common from shallow to deep water around South Georgia

In deeper waters (500-1500 m), additional sampling of benthic bycatch from toothfish longliners, has identified important areas for octocorals and other vulnerable marine ecosystems (VMEs).

Research into the potential impacts of the fishery on deep-sea benthic communities was initiated by GSGSSI in 2004 in response to a condition applied by the Marine Stewardship Council (MSC) assessment of the toothfish fishery. Since then, analysis of observer data has enabled identification and mapping of broad groupings of benthic fauna encountered as bycatch by the fishery. Benthic bycatch recorded by observers includes a wide variety of taxonomic groups, such as echinoderms including stalked crinoids, basket stars, and pencil urchins; glass and silaceous sponges; bryozoans; ascidians and cnidarians. The latter comprise the greatest proportion of the recorded bycatch (~80% of bycatch samples collected from 2005 to 2009). Phylogenetic research on the Cnidaria shows the majority (72%) of these are Octocorallia, particularly of the family Primnoidae (Taylor, 2011).

Spatial modelling of fisheries and bycatch data was then used to define potential areas for closure in the toothfish fishery as a precautionary measure to protect putative VMEs around South Georgia. This was undertaken by exploring the effects of closing each of these areas on toothfish catches as well as

possible impacts on bycatch species. Using this method it was possible to optimise closed areas so that the highest percentage of VME habitat would be protected, whlst minimising impact on other bycatch species, but alllowing the toothfish fishery. The research led to the establishment of three Reduced Impact Areas (RIAs) in the toothfish fishery in 2008 (Fig. 3.9).

Within the three RIAs (West Shag, West Gully and North South Georgia) a limited amount of research fishing has been allowed, but with a very high fish tagging rate (15 fish per tonne compared to the 1.3 per tonne required in other areas). This is important to ensure good spread of tagging effort and tag detection. Tagging is key to deriving an estimate of toothfish abundance, which is important for fish stock assessment and setting sustainable catch limits.

Areas of hydrothermal activity (vents), with a unique fauna, have recently been identified on the East Scotia Ridge near the South Sandwich Islands (Rogers et al., 2012). Deep-sea hydrothermal vents are usually associated with seafloor spreading at mid-ocean ridges and in basins near volcanic island arcs. These vents support a unique fauna that derive their energy from the oxidation of substances such as hydrogen sulphide that are released by the vents. The fauna of the East Scotia Ridge vents is very different from vents on the mid-Atlantic Ridge and is dominated by a new species of yeti crab (*Kiwa* n. sp.), stalked barnacles, limpets, peltospiroid gastropods, anemones, and a predatory sea-star.

3.6 Demersal fish and cephalopods

The demersal ichthyofauna of the continental shelf is dominated by fish of the sub-order Notothenioidei, including 28 species in 5 families (Nototheniidae, Channichthyidae, Bathydraconidae, Artedidraconidae and Harpagiferidae), which are endemic to the Southern Ocean.

The demersal fauna includes previously exploited species such as the marbled rock cod (*Notothenia rossii*) and the yellow-tailed notothen (*Patagonotothen guntheri*) as well as the currently fished mackerel icefish (*Champsocephalus gunnari*) and Patagonian toothfish (*Dissostichus eleginoides*). The icefish (Channichthyidae) are unique in lacking the pigment haemoglobin in their blood. The three channichthyids that are common in South Georgia waters are all benthic spawners, that lay eggs in reds, which are thought to be guarded by the males.

In deeper depths the fauna is less dominated by the notothenids, although the Patagonian toothfish is caught at depths in excess of 2,000 m. Other abundant groups include the grenadiers (Macrouridae) and Moridae, which are characteristic deep-sea fauna. The chondrichthyans are represented by two species of skate, the Porbeagle shark (*Lamna nassus*) and possibly the sleeper shark (*Somniosus* sp.).

Demersal cephalopods include four species of incirrate octopus, plus the cirrate octopods *Opisthoteuthis hardyi* and *Stauroteuthis gilchristi* (Collins et al., 2004, see Appendix VIII).

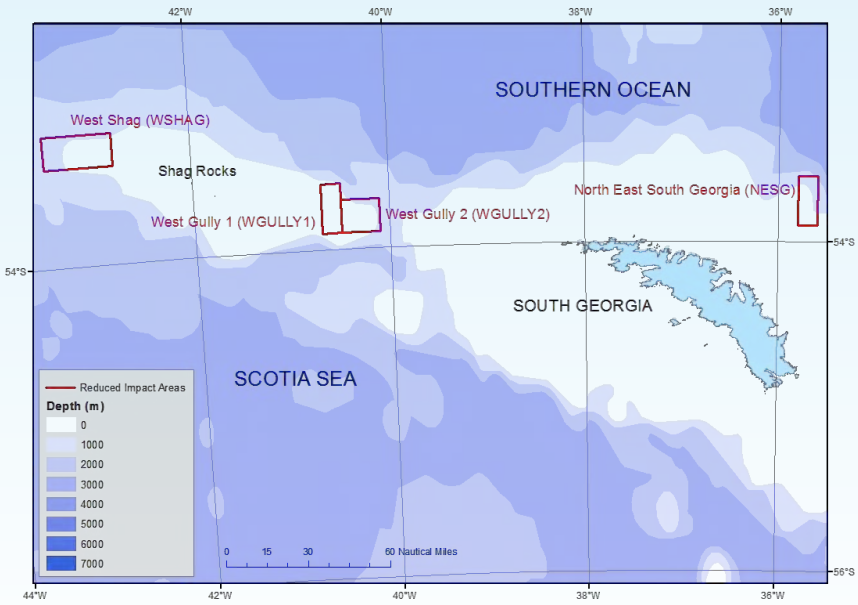


Figure 3.9. The Reduced Impact Areas (RIAs) in the South Georgia toothfish fishery.

3.7 Marine mammals

Seven species of large cetacean are regularly encountered in South Georgia waters (Appendix IX), including six species of baleen whale (blue (*Balaenoptera musculus*), fin (*Balaenoptera physalis*; see below), sei (*Balaenoptera borealis*), humpback (*Megaptera novaeangliae*; Fig 3.10), minke (*Balaenoptera bonaerensis*), southern right (*Eubalaena australis*; Fig. 3.11), plus sperm whales (*Physeter macrocephalus*). Five smaller cetaceans regularly seen are the long-finned pilot whales (*Globicephala melas*), southern bottlenose whales (*Hyperoodon planifrons*), killer whales (*Orcinus orca*), plus the spectacled porpoise (*Phocoena dioptrica*) and hourglass dolphin (*Lagenorhynchus cruciger*).

Figure 3.10. A humpback whale (Megaptera novaeangliae) near Shag Rocks.

The baleen whales are either krill or copepod feeders that migrate to the Southern Ocean during the austral summer and return to tropical breeding grounds in the winter, although many baleen whales are still seen in the area in winter. These whales were all historically heavily exploited in South Georgia waters (see Section 4), but populations are gradually recovering.

Figure 3.11. The fluke of a southern right whale.

Sperm whales are present around South Georgia throughout the year and, at these latitudes, are likely to be adult males. Sperm whales are deep divers, feeding on fish and squid; they also follow fishing vessels and take toothfish off longlines (Collins et al., 2010).

Killer whales are regularly seen in South Georgia waters, particularly in the winter months, when pods follow longline fishing vessels to take toothfish from the lines. There are now thought to be four different ecotypes of killer whale in the Southern Ocean (Pitman et al., 2011) that may be different species (Morin et al., 2010). The whales seen at South Georgia appear to be large “Type D” (Pitman et al., 2011).

Additionally, it is likely that several species of beaked whale (besides southern bottlenose) are present within South Georgia and South Sandwich Island waters (notably Gray's (*Mesoplodon grayii*), strap-toothed (*Mesoplodon layardii*) and Arnoux's beaked whales (*Berardius* arnuxii)). However, very little is known about the distribution of these enigmatic cetaceans.

South Georgia is home to around 4 million Antarctic fur seals (*Artocephalus gazella*) (IUCN Least Concern (LC)), which represents around 90% of the global population. Fur seals were heavily exploited in the 18th and 19th centuries, with numbers reduced to a few hundred, but they have shown a remarkable recovery and now breed in huge numbers on beaches in the north-west of the island and are gradually spreading eastwards along the north coast. Fur seals also breed in the South Sandwich Islands, but numbers there are much lower and largely restricted to the northern South Sandwich Islands.

Figure 3.12. A blond fur seal pup in tussac grass on South Georgia.

Fur seals (particularly females) are primarily krill eaters at South Georgia and breeding success of the seals is reduced in krill-poor years (Forcada et al., 2005). During the breeding season fur seals forage close to South Georgia, notably on the shelf break to the NW of the island and at Shag Rocks. Outside of the breeding season fur seals forage much more widely. In addition to krill fur seals also feed on fish such as icefish and lanternfish and these prey are more important in krill-poor years.

Around 110,000 female southern elephant seals (*Mirounga leonina*) (IUCN LC) breed on South Georgia (Boyd et al. 1996), with small numbers on the South Sandwich Islands. The population size has remained relatively stable over the past 50 years and represents around 50 % of the global population. Elephant seals are deep divers, foraging on fish and cephalopods and have been reported to eat toothfish.

Figure 3.13. An elephant seal ashore on a beach on South Georgia.

There is also a small colony (~30) of Weddell seals (*Leptonychotes weddellii*) in Larsen Harbour. Leopard seals (*Hydrurga leptonyx*) are frequent visitors to South Georgia, but breed further south: they have been seen in the summer months, but these may be non-breeding animals.

Figure 3.14. A Weddell seal near the Harker Glacier.

3.8 Seabirds

South Georgia is home to 28 species of breeding seabirds, with a further species (Antarctic fulmar) breeding only on the South Sandwich Islands (Appendix X). The islands and waters of South Georgia and the South Sandwich Islands are regularly visited by a large number of vagrants and non breeding species (see Clarke et al., 2012).

3.8.1 Penguins

Five species of penguin (king (*Aptenodytes patagonicus*), gentoo (*Pygoscelis papua*), macaroni (*Eudyptes chrysolophus*), Adélie (*Pygoscelis adeliae*) and chinstrap (*Pygoscelis antarctica*)) breed on both South Georgia and the South Sandwich Islands. The largest of these species is the king penguin (IUCN LC), which forms large densely packed colonies typically near sandy beaches and glacial melt water streams. King penguin (Fig 3.15) numbers have been increasing on South Georgia, with new colonies appearing and there are now an estimated 450,000 breeding pairs, the majority of which are in the colonies at St Andrews Bay and Salisbury Plain. There are also small numbers of breeding king penguins on Zavodovski in the South Sandwich Islands. King penguins undertake long foraging trips to the Polar Front (Fig. 3.15) in the summer (Trathan et al., 2008; Scheffer et al., 2010) and south towards the ice-edge in the winter. King penguins feed on lantern fish (e.g. Electrona carlsbergi), pelagic squid and krill.

Figure 3.15 King penguin feeding a chick (left), with a map of a typical foraging trip (right).

Gentoo penguins (IUCN Near Threatened (NT); Fig. 3.16) breed in smaller colonies on beaches and in tussac meadows and are widely distributed around South Georgia but also occur in small numbers on some of the South Sandwich Islands (Black & White, 2011). The population is estimated to be 105,000 breeding pairs at South Georgia. Gentoos generally

Figure 3.16 Gentoo penguin with a pair of chicks.

forage within 12 miles of the coast, feeding on small fish and krill and are resident all year at South Georgia.

There are estimated to be over 1 million pairs of macaroni penguins (IUCN vulnerable (VU); Fig 3.17) breeding on South Georgia (Trathan et al., 2012), the majority of which breed in large colonies to the north-west of the island, such as on the Willis Islands. Macaroni penguins also breed in the South Sandwich Islands (Black & White, 2011) in considerable numbers (tens of thousands). Macaroni penguins are primarily krill-eaters during the breeding season, when they forage to the north-west of the island over the shelf and as far as the shelf break. Outside the breeding season they disperse and forage over a much greater area of the Scotia sea and in the PFZ.

Figure 3.17 A macaroni penguin.

At South Georgia there are small colonies of chinstrap penguins (IUCN LC; Fig. 3.18) at Cooper Bay, with about 13,400 pairs, and on Annenkov Island, but the South Sandwich Islands are home to large numbers. Black & White (2011) found nesting chinstraps on all ten islands they surveyed, and a combination of ground counts and satellite imagery is currently being analysed to determine the size of the population. Convey et al. (1997) estimated 1,500,000 pairs, with the largest colony on Zavodovski (1,000,000 pairs).

Adélie penguins (IUCN LC) do not regularly breed on South Georgia (only two pairs on Annenkov Island), but do breed on the South Sandwich Islands, where the population has been estimated at 70,000 pairs (Convey et al., 1997). More recently Black & White (2011) estimated there were around 80,000 pairs with colonies on Candlemas, Saunders, Montague, Bristol, Bellingshausen, Cook and Thule islands.

Figure 3.18 Chinstrap penguins in the South Sandwich Islands.

3.8.2 Albatross

Four species of albatross breed on South Georgia. The number of pairs of three of these species (wandering (*Diomedea exulans*), black-browed (*Thalassarche melanophris*) and grey-headed (*Thalassarche chrysostoma*)) have been declining by 2-4% for many years (Poncet et al., 2006), which are attributed to mortality associated with fishing activities outside the SGSSI MZ. The four albatross species, together with the two species of giant petrel (southern (*Macronectes giganeteus*) and northern (*M. halli*)) and white-chinned petrels (*Procellaria aequinoctialis*) are listed under the international Agreement on the Conservation of Albatross and Petrels (ACAP). ACAP's goal is to conserve these threatened species addressing in particular fisheries interactions, protection of breeding colonies and the impacts of introduced species.

Wandering albatross (IUCN VU) primarily breed on islands off the coast of mainland South Georgia, with the majority of the population breeding on Bird Island, on islands in the Bay of Isles and on Annenkov Island (Poncet et al. 2006). Wandering albatross undertake extensive foraging trips in search of carrion on the ocean surface, feeding predominantly on dead or dying squid, and to a lesser extent on fisheries discards.

Black-browed albatross (IUCN EN; Fig. 3.19) mainly breed in colonies to the north-west of South Georgia and at Cooper and Annenkov islands. There are approximately 75,000 pairs (Poncet et al. 2006), but numbers are continuing to decline, which has been attributed to fishery related mortality primarily off South Africa and elsewhere in the southeast Atlantic Ocean.

Figure 3.19 Black-browed albatross, white-chinned petrels and giant petrels foraging behind a trawler.

There are an estimated 48,000 breeding pairs of grey-headed albatross (IUCN VU) on South Georgia (Poncet et al., 2006) but, like the wanderering and black-browed albatross, numbers are declining. The grey-headed albatross breeds in colonies in the north-west of the archipelago. The species is principally an oceanic forager, targeting the Polar Front and associated areas of upwelling but also forage in Antarctic shelf-slope waters around the South Shetland Islands and the Antarctic Peninsula, especially during years of low squid availability.

Light-mantled sooty albatross (*Phoebetria palpebrata*; Fig 3.20) (IUCN NT) breed in isolated nests or in small groups on steep cliffs along the north coast of South Georgia. There are estimated to be 5,000 pairs, which forage mainly in Antarctic waters including to the far south of the Scotia Sea and west to the Antarctic Peninsula region.

Figure 3.20 Light mantled albatross with Mt Paget behind.

3.8.3 Petrels

Northern (17,200 pairs; IUCN LC) and southern giant petrels (8,200; IUCN LC) both breed on South Georgia and southern giant petrels breed in smaller numbers in the South Sandwich Islands (1,882 pairs; Black & White, 2011). Males, particularly of northern giant petrels, are scavengers and, during the breeding season, forage around penguin and seal colonies, whereas females of both species feed predominantly at sea, often following fishing vessels.

The 900,000 pairs of white-chinned petrels (IUCN VU; Fig 3.21), which breed in burrows in coastal areas around South Georgia, represent almost half of the global population (Martin et al., 2009). White-chinned petrels forage widely from the ice edge to the northern Patagonian Shelf and regularly follow fishing vessels, making them particularly susceptible to incidental mortality in both longline and trawl fisheries.

Large numbers of smaller petrels and prions (Procellaridae), storm petrels (Hydrobatidae) and diving petrels (Pelecanoididae) also breed on South Georgia. There are an estimated 22 million breeding pairs of Antarctic prion (*Pachyptila desolata*), 3.8 million common diving petrels (*Pelecanoides urinatrix*) and 2 million South Georgia diving petrels (*Pelecanoides georgicus*) (see Appendix X). These species mainly consume zooplankton, including krill, copepods and other crustacea.

Figure 3.21. White-chinned petrel foraging at sea.

3.8.4 Other birds

Other birds that forage in the marine environment include the imperial shag (*Phalacrocorax atriceps*), kelp gull (*Larus dominicanus*), Antarctic tern (Sterna vittata) and the brown skua (*Stercorarias antarcticus*; Fig. 3.22).

Figure 3.22 Brown skua and chick at St Andrews Bay.

4. History of exploitation

Despite its remote location the environment of South Georgia is by no means unspoiled by human intervention. Since it was first claimed by Captain James Cook for King George III in 1775 it has seen sequential exploitation of its rich natural resources. Alerted by Cook's reports of an abundance of seals, commercial sealers arrived in the late 1700s and by the 1820s had exploited the Antarctic fur seal population to the verge of extinction. Sealers also took large numbers of penguins and elephant seals for both oil and food.

Next came the whaling fleet. Carl Larsen established the first shore based whaling station at Grytviken in 1904 and by 1912 there were six in operation, as South Georgia became the focal point of Southern Ocean whaling. Although shore-based whaling was controlled through licences sold by the British Government, stocks of blue and humpback whales were quickly depleted. In 1925 the focus of whaling effort shifted from the shore stations to the pelagic factory ships, which were much harder to control. Concerns about the expansion of whaling led to the establishment of the International Committee for the Regulation of Whaling in 1935, which later became the International Whaling Commission (IWC). Shore based whaling declined in the 1930s, but whaling continued on or around South Georgia until the late 1960s.

During the whaling period, elephant seals continued to be exploited, but only adult males were allowed (by the British Government) to be taken, which meant that females continued to breed and the population was not reduced as much as it might have been.

Following the decline in Southern Ocean whale stocks, attention switched to fish and krill and the 1970s saw large catches of mackerel icefish, the marbled rock-cod and other related species from the rich waters around South Georgia. These fish resources were rapidly over-exploited, although a small sustainably managed fishery for mackerel icefish continues today (see Section 5.3).

Attention then turned to Antarctic krill, and a fishery quickly developed in the 1980s (see Section 5.3) and continues to this day with annual catches in the Scotia Sea of less than 220,000 tonnes (against a quota of 5.6 million tonnes). Catches at South Georgia have been of the order of 20-50,000 tonnes per year (Fig. 5.12). The late 1980s saw another wave of exploitation with the rapid development of the fishery for Patagonian toothfish (see Section 5.1).

5. Current Fisheries

South Georgia currently supports licensed fisheries for toothfish, krill and mackerel icefish, with a small fishery for both Patagonian and Antarctic toothfish in the South Sandwich Islands. Pot fishing has been trialled on lithodid crabs and on Patagonian toothfish, but without any great success. There has also been an exploratory fishery for squid (*Martialia hyadesi*). Fisheries around South Georgia and the South Sandwich Islands are managed under the CCAMLR framework. Quotas and regulations set by CCAMLR must be adhered to, but GSGSSI often imposes stricter regulations and lower quotas than those set by CCAMLR.

5.1 South Georgia Patagonian toothfish (*Dissostichus eleginoides*)

Patagonian toothfish (Fig. 5.1) are a large, long-lived species, belonging to the Notothenidae family (often called Antarctic cods) (Collins et al., 2010). Toothfish show distinct depth preferences with age, with juveniles (< 500 mm TL) living on the continental shelf and moving into deeper water (> 500 m) as they reach maturity (~900 mm TL). Adult toothfish are scavengers and predators, with juveniles primarily feeding on small fish (Collins et al., 2007).

In South Georgia waters the fishery for Patagonian toothfish began in the late 1980s and expanded rapidly during the early 1990s, when considerable illegal, unregulated and unreported (IUU) catches were taken (Fig. 5.2). The fishery, which uses hooks baited with sardine or squid, initially had major problems with seabird by-catch, with large numbers of albatross and petrels attracted to the baited hooks, getting caught and drowned. In response to these issues CCAMLR introduced strict regulations designed to prevent bird by-catch. These regulations, which include seasonal closures, line-weighting regimes (to ensure baited hooks sink rapidly) and night setting requirements, have virtually eliminated the seabird by-catch problem (Fig. 5.3) in South Georgia waters.

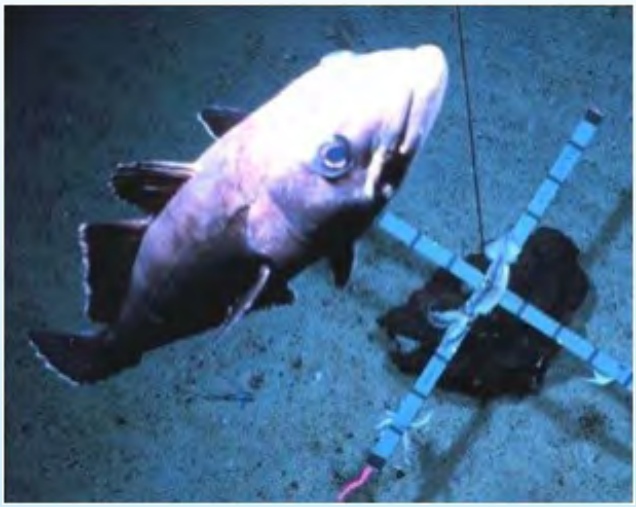


Figure 5.1 Patagonian toothfish (Dissostichus eleginoides), pictured at 1000 m deep.

Since 1998 the fishery has been restricted to the winter months (May 1st to Aug 31st) to minimize interactions with foraging seabirds during their breeding season. Since 2010 CCAMLR and GSGSSI have permitted a gradual extension to the season, with the season starting five days earlier each year, such that the 2013 season started on April 11th. The season extension has had no effect on seabird by-catch, which remains negligible. In 2004 a minimum depth of 500 m was introduced to protect smaller fish. The minimum

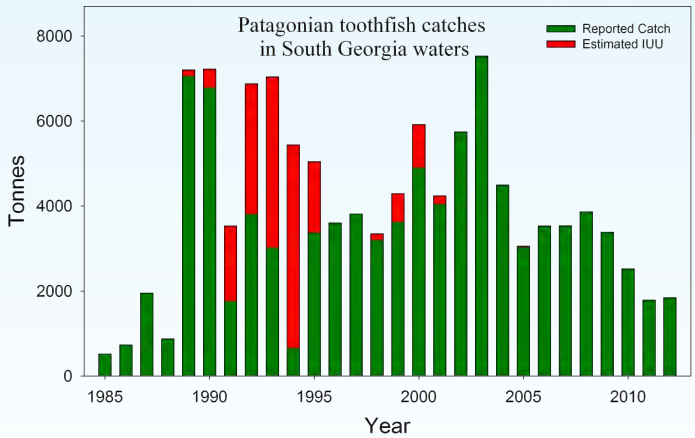


Figure 5.2 Catches of Patagonian toothfish in South Georgia waters since the fishery began.

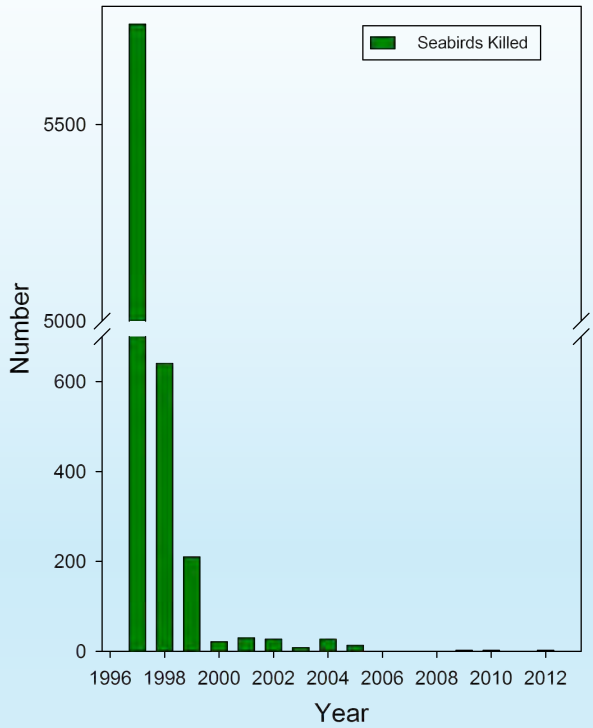


Figure 5.3 Seabird mortality associated with the Patagonian toothfish fishery in South Georgia waters.

depth was increased to 550 m in 2010 and 700 m in 2011. The fishery is now extremely well regulated and was conditionally certified as sustainable and well managed by the Marine Stewardship Council (MSC) in 2004. It was recertified without conditions in 2009. It is due to be recertified again in 2014.

The toothfish fishery employs baited demersal longlines, in which a line of baited hooks are deployed close to the sea-floor at depths up to 2000 m. Surface buoys indicate the presence of lines and vessels typically recover lines after a 'soak-time' of 24-48 hours. Longline vessels are generally small (30-80 m; Fig. 5.4), with lines set in one of three different configurations:

1) The Spanish or double-line system (Fig. 5.5) uses a strong main- or mother- line attached at each end to an anchor and buoy line. The fishing line is attached to the main line by a series of connecting ropes. The hooks are attached to the fishing line with monofilament snoods (short lengths of line that attach hooks to the fishing line), with each section of fishing line comprising around 25 hooks, with around 7,000 hand baited hooks per line. Weights (min. 8 kgs) are attached between each section of hooks to sink the line and keep it on the seafloor. Weights must be metal or concrete and the use of netting bags to hold weights is now prohibited, to reduce risks to the environment.

Figure 5.4 A toothfish longliner (autoliner).

2) The autoline system (Fig. 5.5) has a single weighted line (polypropylene line with integrated weight ~50 gm^{-1}), from which hooks are attached via swivels and multi-filament snoods. The line is divided into magazines, each consisting of 800-1,500 hooks and although the length of lines varies, an autoliner will be able to deploy 30,000 automatically baited hooks per day.

3) The trotline system (Fig. 5.5) is a modification of the Spanish system, in which the fishing line is replaced by a series of vertical branch lines, at around 40 m intervals. Each of the vertical branch lines supports clusters of 8-20 short hook lines and, at its extremity, a bag of weights. The clustering of the hooks near the weights allows the baited hooks to sink rapidly to avoid seabirds, but the method also allows for the use of net sleeves, umbrellas or cacheloteras to reduce depredation by whales. Each branch line can have a buoyant net or sleeve attached that is able to slide up and down the line. During the set, this sleeve remains at the upper end of the branch line, but when the thick main line is hauled, the movement of the vertical branch line through the water causes the sleeve to slide down the line covering the hooks and any captured fish. Trotlines are not ordinarily permitted in the South Georgia or South Sandwich fisheries as the fish tend to be in poorer condition, making tagging difficult.

Longlines, whilst much less destructive than bottom trawls, can still have an impact on benthic fauna, particularly habitat forming species of cold-water corals (Taylor, 2011). Work is in progress to investigate

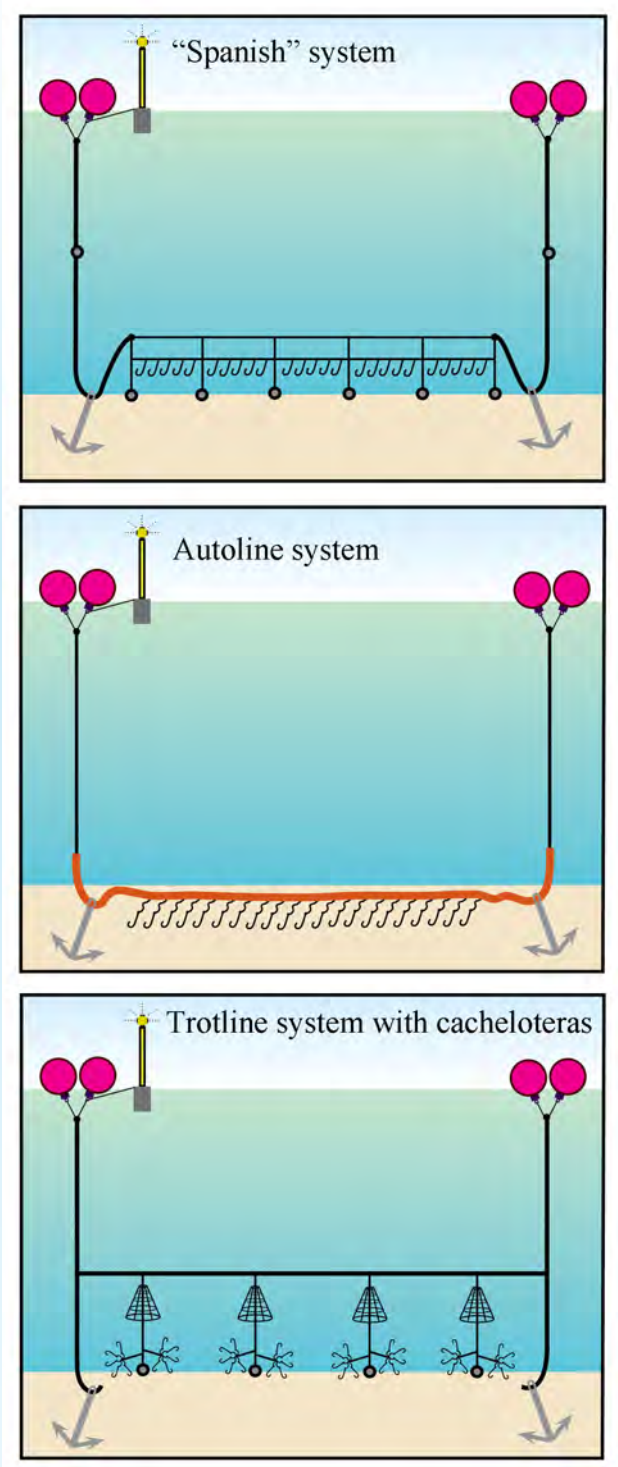


Figure 5.5 Schematic representation of the three methods of toothfish longlining.

the impact of longlines on benthic animals using *in situ* cameras and by examining benthic by-catch. There are now eight benthic closed areas (BCAs) that were previously open to longlining (see Section 7).

The assessment of Patagonian toothfish utilises a programme called CASAL, which implements a generalised age-structured model, taking into account a wide range of parameters including catch per unit effort (CPUE) and population estimates based on a

Figure 5.6 Toothfish being gaffed on board a longliner.

tagging (mark and recapture) programme. To provide data for the tagging programme all vessels are required to tag toothfish at a rate of 1.3 fish per tonne and the size frequency of the fish tagged must mirror that of the catch size frequency. There is a reward for tag returns to ensure any recaptured fish are properly recorded.

The catch limit for the fishery has been reduced in the last few years due to concerns about recruitment. Evidence from research surveys and length-frequency data from the fishery suggests that recruitment is episodic and related to environmental conditions (Belchier & Collins, 2008). A strong year class was detected in trawl surveys in 2003 and 2004 as 2 and 3 yr old fish. Further strong year classes have recently been detected in 2010 at 3 yrs old and 2011 at both 2 and 3 yrs old. The 2013 quota was 2100 tonnes, with 6 vessels licenced.

5.2 South Sandwich Islands toothfish fishery

The South Sandwich Islands support a small fishery for both Patagonian and Antarctic (*Dissostichus mawsoni*) toothfish. The Patagonian toothfish fishery began in 1992 when Chile and the USA notified CCAMLR of their intention to fish. CCAMLR set a catch limit of 240 tonnes, but the USA vessel withdrew and the Chilean longliner abandoned fishing after one week of poor catches. However a Bulgarian-flagged longliner fished in late 1992 and reported a catch of 39 tonnes of Patagonian toothfish. CCAMLR subsequently adopted a catch limit for Patagonian toothfish of 28 tonnes per season. The taking of

Antarctic toothfish, other than for scientific purposes, was prohibited. These limits remained until 2004, when a mark and recapture study was initiated to provide information on stock status and 27 tonnes of Patagonian toothtfish were caught. This study was extended to subsequent seasons with catches of 75-100 tonnes and with fishing limited to the north of the area. In 2008 a similar study began in the southern area with a catch limit of 75 tonnes for both toothfish species. Catch limits in both areas have subsequently been reduced and for the 2013 season were 63 tonnes in the north and 52 tonnes in the south.

5.3 South Georgia mackerel icefish fishery

Mackerel icefish (Fig. 5.7) grow rapidly to a maximum size of 55 cm, reaching a marketable size of 30 cm in three years. Icefish inhabit the shelf all round South Georgia and Shag Rocks. They form large aggregations to feed on krill and their abundance has been linked to interannual variations in krill biomass. During krill-poor years they switch to feed on the pelagic amphipod *Themisto gaudichaudii* and mysids (Main et al., 2009). Spawning takes place on the shelf, with eggs laid on the seafloor. Larvae are planktonic and are caught in coastal areas during winter. Younger (age 1 yr old) fish are less reliant on krill, which may allow a rapid recovery of stocks following krill-poor years (Main et al. 2009). Icefish predators include Antarctic fur seals and gentoo penguins (Reid et al. 2005).

Fishing for mackerel icefish began in South Georgia waters in the late 1970s, with large catches taken by eastern European (then eastern-bloc) vessels. Catches peaked in 1981/82 with a reported 178,000 tonnes, although there is some doubt about the accuracy of the data. Following concerns about the depletion of stocks

Figure 5.7 A catch of mackerel icefish

Figure 5.8 An icefish trawler in Cumberland Bay.

CCAMLR closed the fishery in 1989. The fishery was later re-opened, but with a highly conservative total allowable catch (TAC) and was restricted to pelagic trawling (Fig. 5.8) to avoid impacts on non-target species. In recent years catches have been less than 5,000 tonnes (Fig. 5.9), with four or five vessels operating.

Icefish fishing activity is usually focussed on an area to the north-west of South Georgia. The pelagic trawls, with a minimum mesh size of 90 mm, catch little by-catch and so have little impact on non-target species. Seabirds are occasionally killed in the fishery, usually as a consequence of diving through the large meshes to feed on fish stuck in the net. This can be avoided by cleaning the net, adding weights to the cod-end and

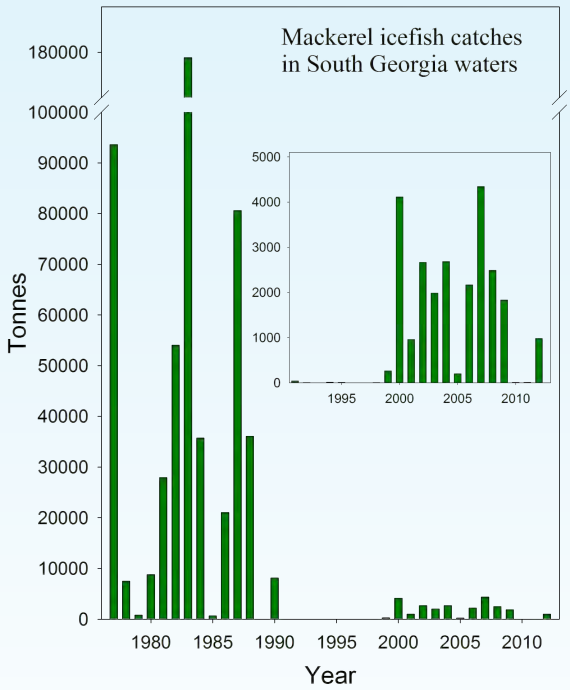


Figure 5.9 Catches of mackerel icefish in South Georgia waters.

binding the net, so that it does not open until the trawl doors are deployed. These measures are now all required under fishing licence conditions. The fishery was conditionally certified as sustainable by the MSC in 2010. Catches in the 2012 were 984 tonnes, with 1,353 tonnes taken to date in 2013.

The mackerel icefish stock assessment uses a two-year projection model. The initial data for the projection is the lower 1-sided 95% confidence interval (CI) of the biomass estimated by the trawl survey. This is projected forward with growth and natural mortality (which assumes 50% die in any year), but assumes no recruitment. The allowable catch must leave 75% of the stock that would remain in the absence of fishing. The use of the lower 1-sided 95% CI of the biomass estimate, plus the assumed high rate of natural mortality and the assumption of no recruitment ensure that the catch limit is highly precautionary.

5.4 Antarctic krill fishery

The krill fishery began in the early 1970s with Japanese and Soviet Union vessels catching krill in the Scotia Sea for human consumption in tinned, frozen or paste form. The fishery focussed in three principal areas, near the South Shetlands (CCAMLR sub-Area 48.1), near the South Orkneys (48.2) and off South Georgia (48.3) (Fig. 5.10; Jones & Ramm, 2004). The fishery was later joined by vessels from Poland, Chile and Korea and peaked in 1981/82 with catches of 528,000 tonnes. Concern about the rapid expansion of the krill fishery and the potential impact on non-target species led to the establishment of CCAMLR in 1982.

Figure 5.11 Krill trawler in Cumberland Bay

Following the establishment of CCAMLR, catches dipped from 1983 to 1985, but remained above 200,000 tonnes between 1985 and 1992. The reduction in catches in 1983 is attributed to the discovery of high levels of fluoride in the exoskeleton and the associated processing problems. The sharp reduction in catches in the early 1990s was due to the break-up of the former Soviet Union and reduction in effort from eastern European states. From 1992 to 2009 catches remained stable at around 100,000-150,000 tonnes per year, but have increased to around 200,000 tonnes in the last few years.

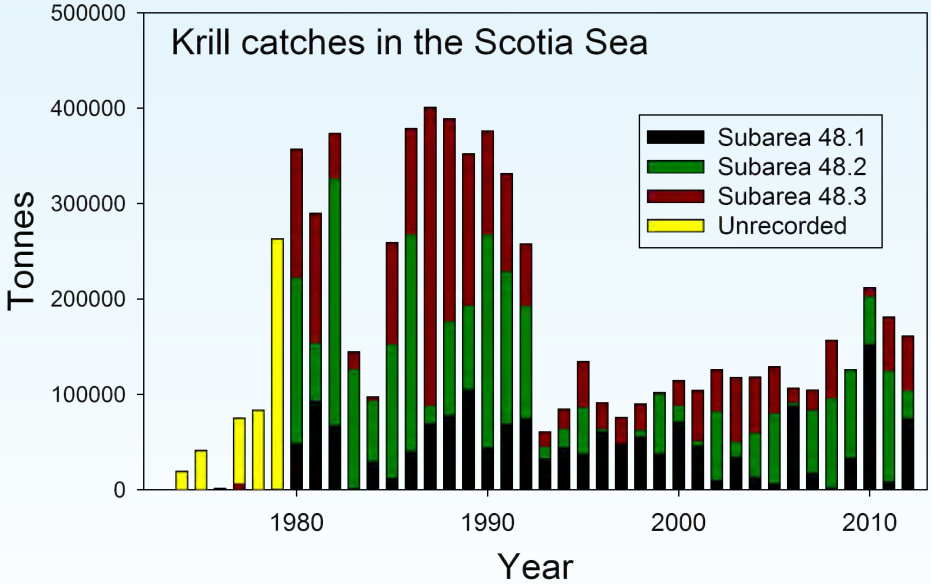


Figure 5.10 Catches of Antarctic krill in CCAMLR Area 48.

Note early catches were not reported by sub-Area

The current CCAMLR TAC for Area 48 is set at 5.6 million tonnes, but with a trigger level at 620,000 tonnes. The lower (trigger) limit is intended to ensure that the impact of the fishery on krill-dependent predators is minimised. The trigger level cannot be exceeded until agreement is reached on spatial management of catches. Most of the krill catch in Area 48 continues to be taken in sub-Areas 48.1, 48.2 and 48.3 and in 2009/10 CCAMLR introduced a trigger-level limit to each sub-Area. The trigger TAC for sub-Area 48.3 is 279,000 tonnes, with a 93,000 tonnes TAC for sub-Area 48.4, although krill has rarely been caught around the South Sandwich Islands.

In sub-Area 48.3 the fishery peaked in 1987 at over 300,000 tonnes, but since 1992 has fluctuated around the 25,000 tonne mark (Fig. 5.12). 2009 was a particularly poor year, in which only 50 kgs were caught. The poor catches in that year were due to environmental conditions that meant krill recruitment had been poor in preceding years. Krill returned to South Georgia in 2010, but vessels were able to fish through the winter in the Bransfield Strait, as ice conditions were favourable and catches remained good, so there was little fishing in South Georgia waters. In the last two years (2011, 2012) the fishery has returned, with 54,800 tonnes caught in 2011 and 56,400 tonnes in 2012. In South Georgia waters the fishery has mainly been a winter fishery, typically operating between April and September. The new MPA order introduces a formal seasonal closure, with no krill fishing allowed between November 1st and March 31st. This reduces the risk of competition between the fishery and krill dependent predators, particularly the land-based predators that are constrained in their foraging during the breeding season.

The fishery operates in two main areas around South Georgia: to the north and north-east of Cumberland Bay and northwest of the Willis Islands.

In the early years of the fishery, vessels employed large conventional pelagic trawls to catch krill (Fig 5.13), with vessels capable of catching and processing up to 300 tonnes per day. The last few years have seen a continuous trawling method employed, with krill pumped continuously from the cod-end of the net to the processing deck. Some vessels no longer use otter trawls, instead using rectangular mid-water trawls, with continuous pumping from the cod-ends. Catches using the using the continuous pumping method can be as high as 800 tonnes per day.

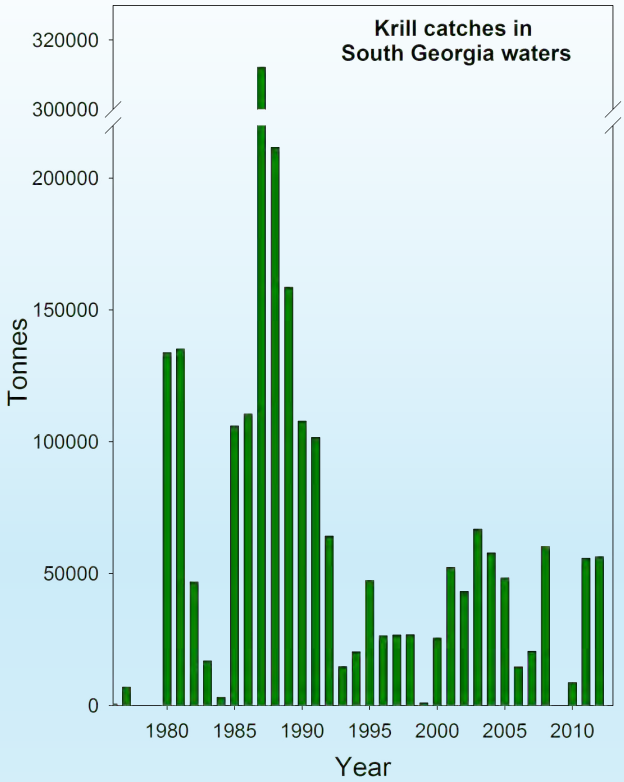


Figure 5.12 Catches of Antarctic krill in South Georgia waters.

Figure 5.13 A pelagic trawl being hauled on the deck of a krill trawler.

Processing varies greatly between vessels, but krill oil is now a major product. Some vessels are utilising all the krill to produce krill oil, dried meat pellets and dried carapaces.

By-catch within the krill fishery is, in general, very low. The main by-catch is larval fish, although numbers of these are relatively few. Fur seals have occasionally been caught in the nets of the krill trawlers, but since the requirement for escape panels became mandatory in 2003 there have not been any captures.

5.5 Lithodid crabs (*Paralomis spinosissima* and *P. formosa*)

A pot fishery for lithodid crabs has occurred sporadically in South Georgia waters since 1992, when the US vessel Pro Surveyer caught 299 tonnes. Five species of lithodid crab occur in South Georgia waters (Yau et al., 2002), but the fishery has focussed on the two most abundant species *P. spinosissima* (Fig. 5.14) and *P. formosa*. *Paralomis spinosissima* inhabits shallow waters at depths of 130-650 m, whilst *P. formosa* is somewhat deeper (400 -1,600 m). The fishery has been limited to mature males only, with all females released alive. Additionally, only males above a minimum carapace size (45 mm) may be retained.

Following the trial by the Pro Surveyer another US vessel, the American Champion, fished in 1995/96, catching 497 tonnes of mostly *P. spinosissima*. Further attempts were made by Japanese and UK vessels between 1999 and 2007, with limited success. Finally between August and October 2010 a Russian vessel, Tamango, caught 62 tonnes of *P. formosa* and *P. spinosissima*. The biology, ecology and fisheries management regime for lithodid crabs was reviewed in 2012 (Belchier et al., 2012). The study identified some significant gaps in knowledge of the crab ecology and suggested that a fishery is not likely to be viable because catch rates of males above the threshold size are prohibitively low. The fishery has now been closed until new data become available.

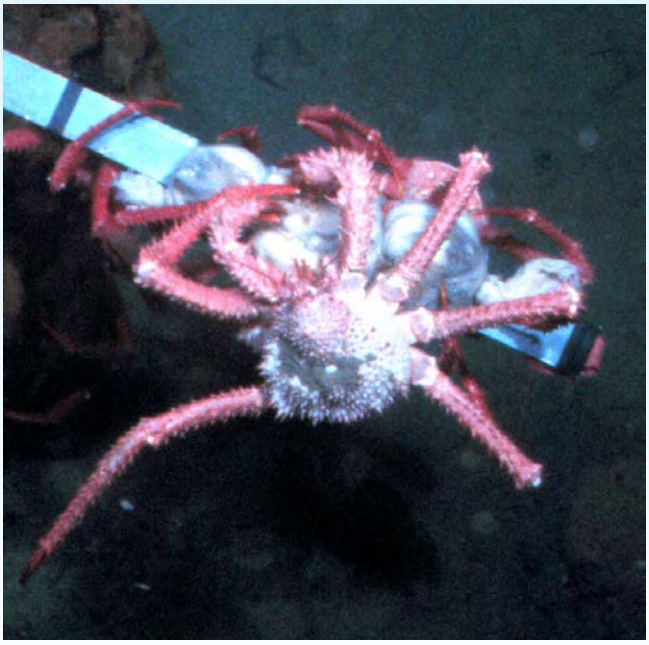


Figure 5.14 The stone crab Paralomis spinosissima at a baited camera.

Crabs are an occasional by-catch in the toothfish fishery, but are released alive where possible.

5.6 Squid (*Martialia hyadesi*)

An experimental fishery for the ommastrephid squid *Martialia hyadesi* took place in February 1989, June 1996, January 1997, June/July 1997 and June 2001 to assess the potential for a commercial fishery (Dickson et al., 2004). Jigging vessels (Fig 5.15) from the far-east undertook the experimental fishery, with powerful deck lights creating a shadow beneath the vessel to concentrate the squid. Lines of plastic lures, hauled through the illuminated area, are mistaken for prey by the squid and a ring of barbless hooks beneath the lure catches the squid and they are landed on board. The experimental fisheries had limited success and a fishery has never developed. The biology and distribution of *M. hyadesi* is poorly understood, but they are frequently associated with the Polar Frontal Zone. There is no realistic prospect of a fishery in the future.

Figure 5.15 A typical jigging vessel.

6. Visiting vessels

Visiting ships and yachts are carefully managed to minimise any threats to the marine environment from pollution, release of non-native species, or through damage to the benthos by anchoring.

All vessels visiting South Georgia must report to the Government Officers at King Edward Point and each vessel visit to Cumberland East Bay has been recorded since 1990 (Fig. 6.1). These figures include repeat visits to Cumberland Bay by the same vessel in a season (such as krill trawler repeat visits to tranship their catch).

As a general rule, fishing vessels only visit Cumberland East Bay (Fig. 6.2), whilst cruise ships, yachts and military vessels visit other inshore sites on the north coast of the island. Popular visitor sites include Bay of Isles (Salisbury Plain and Prion Island), Fortuna Bay, Stromness Bay, St Andrews Bay, Gold Harbour and Cooper Bay.

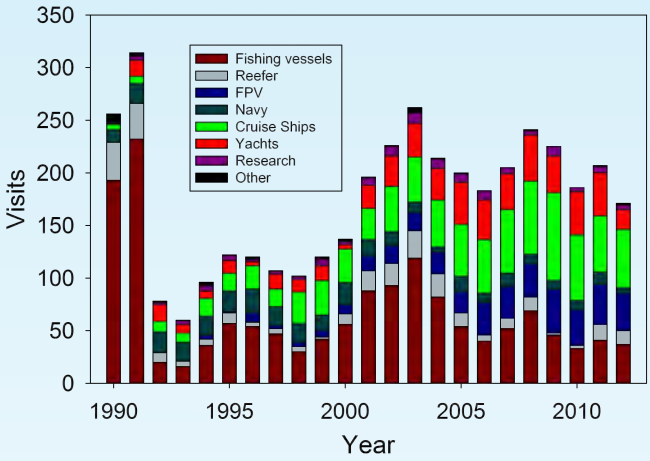


Figure 6.1 Numbers of vessels visiting Cumberland Bay since 1990.

GSGSSI works closely with the International Association of Antarctic Tour Operators to ensure high standards are maintained by visiting cruise ships (Fig 6.2). Strict biosecurity regulations apply to all visitors. Larger cruise ships are more restricted in where they can land than smaller cruise ships and the numbers of passengers allowed ashore at any time is also restricted. Cruise ship visits peaked at 70 in 2008/09 (although visitor numbers were higher in 2007/08), but in the last three years have been around 50.

Figure 6.2. Cruise ship entering King Edward Cove from Cumberland East Bay

The number of vessels visiting South Georgia has fluctuated in the past 20 years with changes in fishing activity and the development of the cruise ship industry (Fig. 6.1), but since 2000 has been relatively stable at around 200 visits per year. In the early 1990s visits were dominated by krill trawlers, their attendant reefers (large refrigerate vessels that support krill trawlers) and naval vessels visiting and supplying the then garrison at King Edward Point.

The krill fishery declined somewhat in the mid-1990s, and resulted in a substantial drop in the number of vessel visits. The number of fishing vessel visits peaked again in 2003 when South Georgia had 17 licenced toothfish longliners. Numbers of cruise ship visits increased steadily from the early 1990s and peaked in 2009, with 83 vessel visits. Naval vessel visits declined after 2000, when the military garrison left King Edward Point and was replaced by a civilian (British Antarctic Survey) presence.

6.1 Pollution

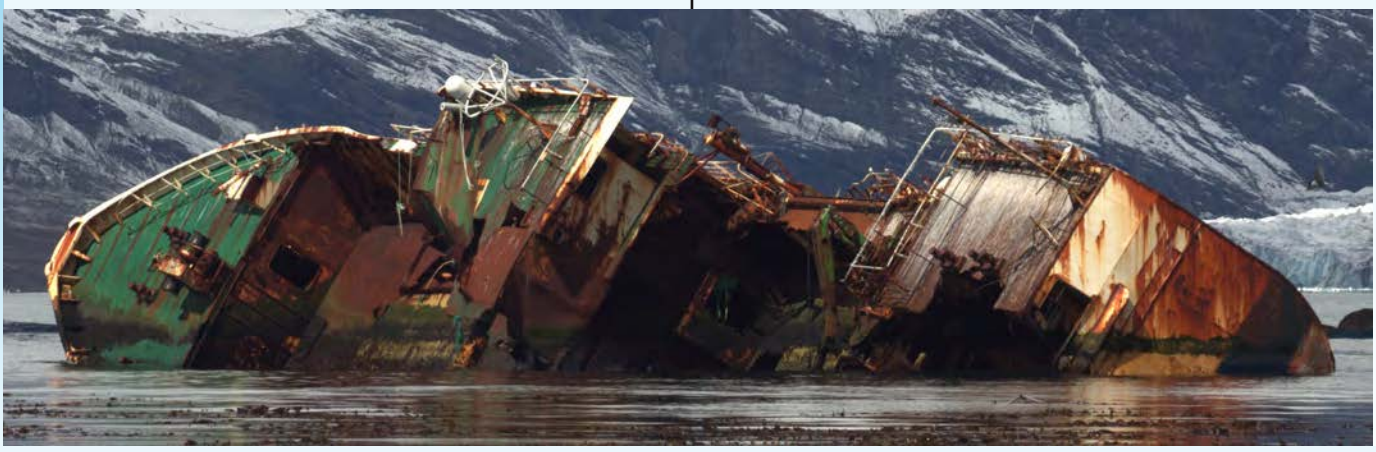
Pollution is a significant threat to the marine environment of South Georgia. Pollution can be in the form of wrecked vessels, discharged oil or fuel, discarded rubbish or fishing gear, or discharged waste or ballast water. In May 2003 there was a major incident in Cumberland Bay East when three long-liners ran aground in stormy weather. One vessel was pulled off the beach near King Edward Point, but two (*Moresko* and *Lyn* (below)) went aground on rocks near the entrance to Moraine Fjord. Despite considerable efforts neither vessel was refloated. Much of the oil was pumped from the vessels and the fishing gear removed, but the wrecks remain in Cumberland Bay and are gradually breaking up. Material, such as insulation foam is regularly washed up on beaches in the bay.

Vessels fishing within SGSSI waters are not allowed to have packing bands on bait and must have a working incinerator for other waste. This is monitored by scientific observers and Government Officers. Fishing gear, either accidentally lost or discarded, can harm wildlife. Fur seals are occasionally encountered with packing bands, loops of rope or sections of fishing net around their necks (Fig. 6.3). Sections of fishing net were previously used to secure line weights on longliners that used the Spanish system, but since 2012 the use of these has been prohibited. Fishing gear is also frequently encountered around the nests of many of South Georgia's larger breeding birds (Huin & Croxall, 1996; Phillips et al., 2010). The majority of fishing gear is found in pellets (boluses) of undigested material regurgitated spontaneously by wandering albatross chicks shortly before fledging. The likely source of this is hooks being left in discarded non-target species (e.g. grenadiers) in longline fisheries (such as grenadiers). Birds are also found "foul-hooked" through the legs or beak (Fig. 6.4), probably due to secondary hooking during hauling. Fishing gear is also found associated with grey-headed and black-browed albatross and giant petrels. In the case of the grey-heads, this is mostly the floats from squid jigs (so therefore taken outside the SGSSI MZ).

Figure 6.3 An Antarctic fur seal entangled in a piece of fishing net.

The discarding of hooks is prohibited in SGSSI fisheries and since 2011 longline vessels in the fisheries must use uniquely marked hooks that can be traced back to the vessel.

Figure 6.4 An albatross foot foul-hooked with a longline hook.



There are occasional incidences of oiled penguins on South Georgia (Fig. 6.5), but the source of the oil is difficult to determine. It is possible that it has been released from old wrecks associated with the whaling stations, but could have come from more recent visiting vessels. GSGSSI now routinely takes oil samples from visiting cruise ships and fishing vessels, so that any oil which is detected in the marine environment can be analysed and compared with the reference samples.

On August 1st 2011 the International Maritime Organisation (IMO) ban on the use and carriage of heavy fuel oil was introduced to waters around the Antarctic continent (south of 60°S). This effectively excludes vessels that burn or carry any fuel other than marine gas oil (MGO) or marine diesel oil (MDO). This will affect cruise ships, fishing vessels and the reefers that support the fishing fleet. Since all cruise ships that visit South Georgia also visit the Antarctic Peninsula, it is likely that in future, no cruise ship visiting South Georgia will be carrying heavy fuel. The fisheries patrol vessel *Pharos SG* burns MGO as do all the longliners. Some of the larger trawlers burn intermediate fuel oil (IFO). GSGSSI is considering restricting the use and carriage of heavy fuels in inshore waters around South Georgia and the South Sandwich Islands.

Figure 6.5 A gentoo penguin that has been "oiled".

6.2 Non-native species

Non-native species may be inadvertently attached to the hulls of visiting vessels (biofouling) and may release larval stages into the marine environment that settle and grow. Such non-native species will compete with native species for space and resources and have the potential to exclude native species. Given the rapid warming of the upper 100 m of the ocean around South Georgia (Whitehouse et al., 2008) it is increasingly likely that species carried from the Falklands or southern South America will not only be able to survive in South Georgia waters, but may be able to out-compete native species. This could result in loss of native biodiversity.

A recent survey of inshore waters at South Georgia was carried out to provide baseline data on the inshore marine flora and fauna (Brickle & Brewin, 2011). Settlement plates, which can be used to detect the presence of non-native species, have also been established at three locations.

7. Climate change

The Southern Ocean is known to have warmed over the latter part of the 20th century (Meredith and King, 2005). This warming is faster than that of the global ocean and is concentrated within the ACC. A longer temperature record from South Georgia (1925–2006) shows that significant warming has also taken place since the beginning of the 20th century (Whitehouse et al., 2008). This record shows differential warming has occurred between summer and winter months with an indication that peak summer temperatures now occur approximately 6 days earlier and mean summer temperatures have warmed from 2.7°C to 3.5°C. The 81-year period of the record has seen a mean increase of around 0.9°C in January and 2.3°C in August that has been evident in the upper 100 m of the water column. Warming at depths below 100 m is much less pronounced and approached 0°C at 200 m. Thus, the long-term ocean warming around South Georgia has been substantial.

7.1 Glacial retreat and freshwater run-off

South Georgia's coastal glaciers show a trend of accelerating retreat over the past 50 years (Cook et al., 2010), with dramatic changes in the glaciers of the north-east coast. For instance the Neumeyer Glacier in Cumberland Bay has retreated by 4.4 km since 1957 (Cook et al., 2010; Fig. 7.1). This retreat has coincided with the recent period of climate warming that began before the 1950s.

The amount and extent of the glacial meltwater will alter both the physical and biological properties of coastal waters (salinity, turbidity, stratification and bacteria) and in turn influence the marine flora and fauna and that influence may extend considerable distances offshore (Dierssen et al., 2002). This could result in community level changes and alteration of food-web structure in inshore areas and potentially effect key spawning sites of both fish and invertebrates.

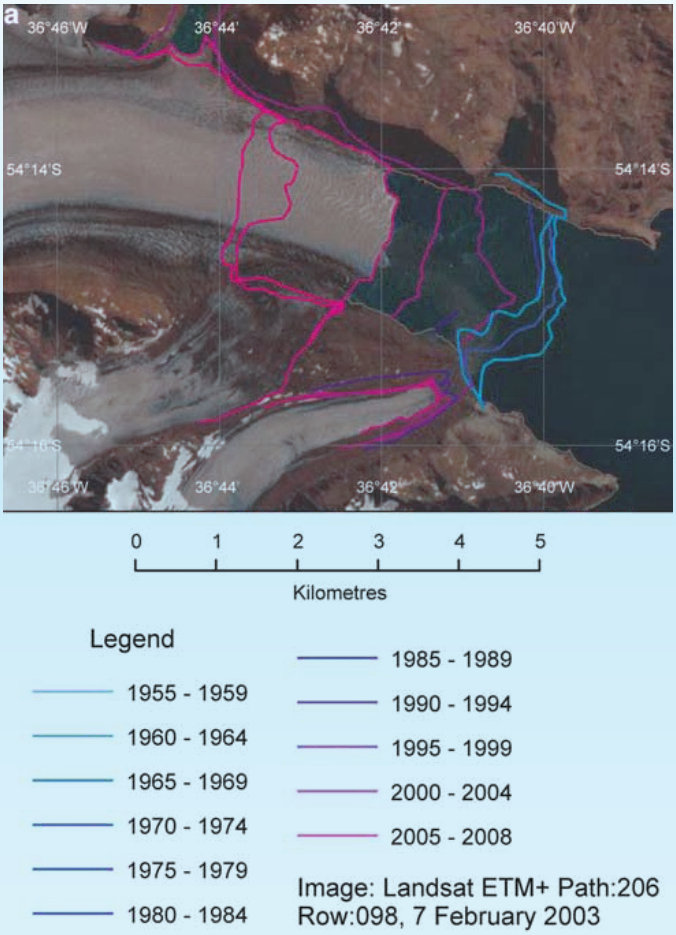


Figure 7.1 The retreat of the Neumeyer Glacier. Reproduced from Cook et al., 2010

7.2 Ecosystem effects of climate change

Antarctic krill, which is probably the single most important species in South Georgia waters, is at the northern limit of its range and particularly susceptible to environmental change. Antarctic krill has adapted to low, stable temperatures and is unlikely to tolerate large temperature changes outside of the main range of its preferred habitat (Atkinson et al., 2008). Changes in krill populations around South Georgia are already evident in warmer years (Murphy et al., 2007; Flores et al., 2012).

Increases in temperature are expected to result in changes in phytoplankton community structure from a large-diatom dominated system to dominance by smaller organisms such as cryophytes. These changes could cascade upwards, altering primary productivity and the structure of marine foodwebs. Changes to Southern Ocean phytoplankton communities are likely to affect krill, which is a dominant grazer of the larger phytoplankton, especially diatoms (Atkinson et al., 2001).

The life-cycle of Antarctic krill is highly dependent upon sea ice. Larval krill have little capacity to store energy from their previous summer, so feed on ice algae and other sea ice associated organisms to survive the winter (Meyer et al., 2009). Sea ice also offers a suitable habitat to protect krill from predators (Meyer et al., 2009). Since the development of krill eggs involves sinking to depths of 850 to 1,000 m (Marr, 1962; Quetin & Ross, 2001), before larvae migrate back to the surface layers to feed, sea-ice must also occur within close proximity to krill breeding grounds.

In a warming ocean the duration and distribution of sea ice is highly likely to change. Recent predictions (Bracegirdle et al., 2008) suggest that trends in Antarctic sea ice will alter; that annual average sea ice extent will diminish by 33 %, and that most of this retreat will be in winter and spring. This is likely to have important consequences for overwintering juvenile krill. Such impacts have already been suggested as causes for observed declines in krill abundance in the Scotia Sea region of the south-west Atlantic sector (Atkinson et al., 2004).

Increased levels of the atmospheric greenhouse gas carbon dioxide (CO_2), released from burning fossil fuels is the major contributor to global warming. CO_2 also dissolves into the ocean, where it increases the acidity (ocean acidification). These elevated levels of dissolved CO_2 may disrupt the distribution and abundance of key zooplankton species.

The combined impacts of regional warming, including, altered physiological limits, changes in phytoplankton community structure, ocean acidification and altered sea ice dynamics may be greater than the sum of the parts. These impacts in combination with the continuing recovery of predators and expanding krill fisheries have the potential to increase pressures on krill populations throughout the Southern Ocean.

An interesting comparison is between the South Georgia shelf and the Kerguelen Plateau, where krill is relatively scarce. At Kerguelen the abundance of predators is considerably lower and those predators are dependent on prey other than krill, with myctophid fish particularly important. If krill become scarce at South Georgia, this system may become more like that of Kerguelen.

8. The South Georgia and South Sandwich Islands Marine Protected Area

Background

The Wildlife and Protected Areas Ordinance (2011) has provision for the declaration, by order, of Marine Protected Areas in the South Georgia and South Sandwich Islands Maritime Zone.

The South Georgia and South Sandwich Islands Marine Protected Areas Order (2012), which came into force in February 2012, created a large sustainable use MPA around South Georgia and the South Sandwich Islands (excluding the area south of 60°S). This large (1.07 million km^2) expanse of ocean became the largest sustainable use MPA (IUCN Category VI) on the planet, protecting the seafloor and associated organisms from the destructive practice of bottom trawling and ensuring the sustainable management of all fisheries. That initial declaration enshrined in law much of the existing protection that was in place around South Georgia and the South Sandwich Islands through fisheries policies.

In parallel with the initial declaration of an MPA GSGSSI convened a scientific workshop to consider what extra protection might be appropriate within the newly created MPA. The workshop produced a series of recommendations, which formed the basis of a stakeholder consultation.

Following that consultation new measures were agreed and the 2012 Order was repealed and replaced with the South Georgia and South Sandwich Islands Marine Protected Areas Order (2013). The new Order added benthic closed areas, a seasonal closure of the krill fishery and a 12 nm closed area around each of the South Sandwich Islands, to the existing protection (see Fig 8.1). These new measures were announced on the 21st January 2013 and came into force when the Order was enacted on the 13th June 2013.

The marine protected area includes areas with depths ranging from 0 to 8,200 m (Fig. 8.2). Much of the MPA is over relatively deep water (2,000-6,000 m), with a peak in shallow depths (< 100 m). The peak in shallow depths is primarily around the coast of South Georgia and on the continental shelf around Shag Rocks.

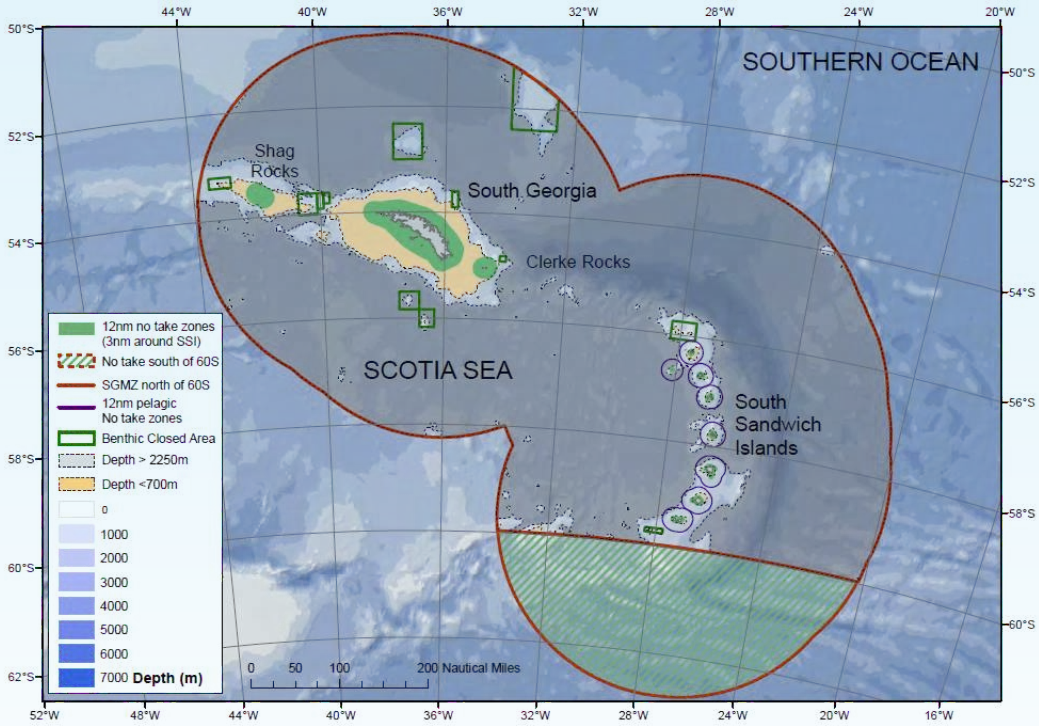


Figure 8.1. Chart illustrating the location of the South Georgia and South Sandwich Islands Marine Protected Area and the additional No-take Zones. The section of the Maritime Zone south of 60 °S is not part of this MPA, but no fishing is licensed in this zone.

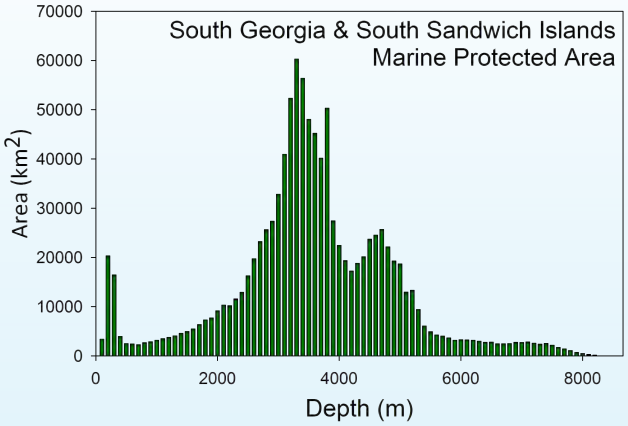


Figure 8.2. Distribution of depths in the South Georgia and South Sandwich Islands MPA. The area is divided into 100 m depth categories.

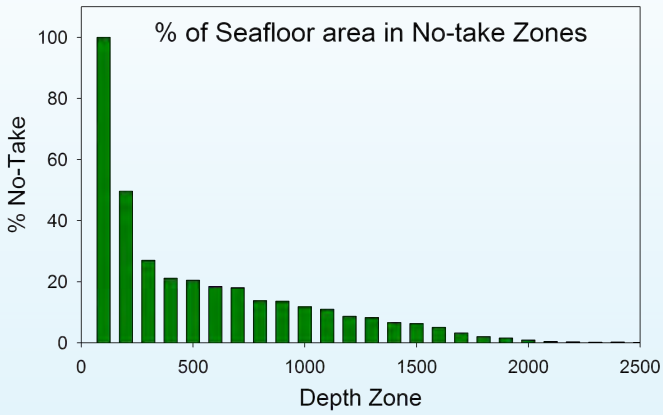


Figure 8.3. Percentage of each 100 m depth zone in No-take Zones in the South Georgia and South Sandwich Islands MPA.

Objectives

- Conserve marine biodiversity, habitats and critical ecosystem function;
- Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems;
- Manage other human activities including shipping, tourism and scientific research, to minimise impacts on the marine environment;
- Protect the benthic fauna from the destructive effects of bottom trawling;
- Facilitate recovery of previously over-exploited marine species;
- Increase the resilience of the marine environment to the effects of climate change;
- Prevent the introduction of non-native marine species.

Restrictions

Within the MPA the following restrictions apply:

- Commercial bottom trawling is banned throughout;
- Fishing for krill is not permitted between November 1st and 31st March to minimise competition between the fishery and krill-dependent predators;
- Fishing activity is highly regulated and only allowed subject to licences issued by GSGSSI;
- No disposal of plastic, fishing materials, or other inorganic waste is allowed.

Permitted Fishing Activities

- Bottom fishing with longlines is permitted at depths of between 700 and 2250 m, subject to a licence issued by the Director of Fisheries;
- Pelagic trawling for mackerel icefish and krill (outside of the closed season), subject to a licence issued by the Director of Fisheries;
- Research bottom trawling may be permitted in certain areas, subject to a permit issued by GSGSSI.

Additional protection within the MPA

Within this MPA are 11 no-take zones (NTZs) in which no fishing is permitted:

- South Georgia No-take Zone;
- Clerke Rocks No-take Zone;
- Shag Rocks No-take Zone;
- South Sandwich Islands no-take zones (8).

These NTZs include depths from 0-1000 m and include all areas of seafloor at depths of less than 100 m (Fig. 8.3), plus 47% of seafloor between 100 and 200 m and 25% of the seafloor between 200 and 300 m. The NTZs protect large areas of ocean and a wide range of flora and fauna. The NTZs are smaller in the South Sandwich Islands than South Georgia, reflecting the considerably smaller shelf area associated with each island.

Within the MPA there are also 10 Benthic Closed Areas in which bottom fishing is prohibited (see p 38).

8.1 South Georgia & Clerke Rocks No-Take Zones

Background

A 12 nautical mile No-take Zone (IUCN Cat I) extends around both the island of South Georgia and around Clerke Rocks (Fig 8.4). The South Georgia No-take Zone, protects 13,900 km^2 from any fishing activity and includes depths ranging from 0-500 m, including all depths shallower than 100 m and over 50 % of depths between 100 and 200 m. The area includes the primary spawning areas of the South Georgia stock of mackerel icefish and the majority of the foraging range of many land-based predators including gentoo penguins, small petrels and South Georgia shags. This NTZ also includes areas of very high benthic biodiversity (Hogg et al., 2011).

The Clerke Rocks No-take Zone protects 1,923 km^2 of sea at depths ranging from 0-1100 m, including all areas shallower than 100 m. The Clerke Rocks No-take Zone includes an unusual and possibly unique reef constructed by the polychaete worm Serpula narconensis at 55º00' S; 34º31' W (Ramos & San Martin 1999).

Objectives

- Protect the shallow inshore environment around South Georgia and Clerke Rocks from any form of fishing activity;
- Protect spawning aggregations of mackerel icefish and other species of benthic-spawning fish;
- Protect the foraging grounds of land-based predators that forage within 12 nm of South Georgia, notably gentoo penguins and imperial shags;
- Facilitate recovery of the marbled rock-cod (*Notothenia rossii*) population, whose juveniles inhabit inshore areas
- Protect the serpulid reef on the shelf in the area of Clerke Rocks

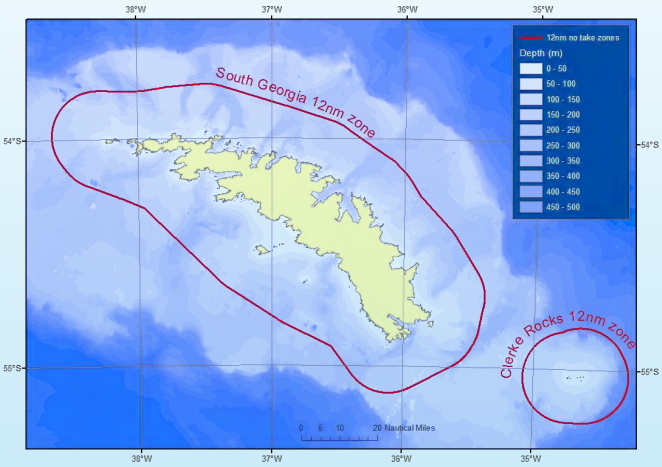


Figure 8.4. Chart illustrating the South Georgia and Clerke Rocks No-take Zones.

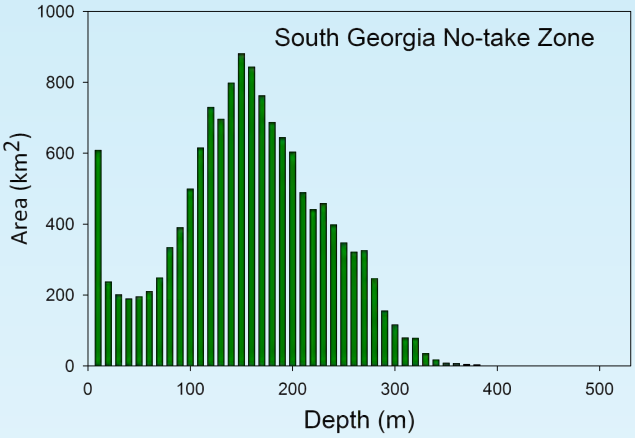


Figure 8.5. Distribution of depths in the South Georgia and Clerke Rocks No-take Zones.

Restrictions

- No commercial fishing activity permitted;
- Licensed fishing vessels are not allowed inside the No-take Zone, except in exercise of their right of innocent passage or under force majeure.

Permitted activities

- Cruise ships, yachts and research vessels are allowed access to the South Georgia No-take Zone;
- Certain scientific research is permitted, but only under a permit issued by the Commissioner.

8.2 Shag Rocks No-Take Zone

Background

A 12 nautical mile NTZ (IUCN Cat I) extends around Shag Rocks (Fig 8.6) and Black Rock, protecting 2,337 km^2 from any fishing activity (Fig. 8.7). Shag Rocks (55°33' S, 42°02' W) and Black Rock (10 miles SE), are small isolated rocks that emerge from an area of shelf around 120 miles NW of South Georgia. There is little shallow water (<100 m) on the Shag Rocks shelf, with the depths in the No-take Zone mostly in the range 100-300 m (Fig. 8.8).

Figure 8.6. Shag Rocks.

The Shag Rocks shelf is the main recruitment area for Patagonian toothfish (Collins et al., 2007), with small fish regularly caught on the shelf. The mackerel icefish stock, which appears distinct to the South Georgia stock, is thought to spawn on the shelf area. The rocks themselves are home to a colony of South Georgia shags, which forage in the surrounding waters. The area is also an important foraging location for Antarctic fur seals, macaroni penguins and cetaceans including southern right and fin whales.

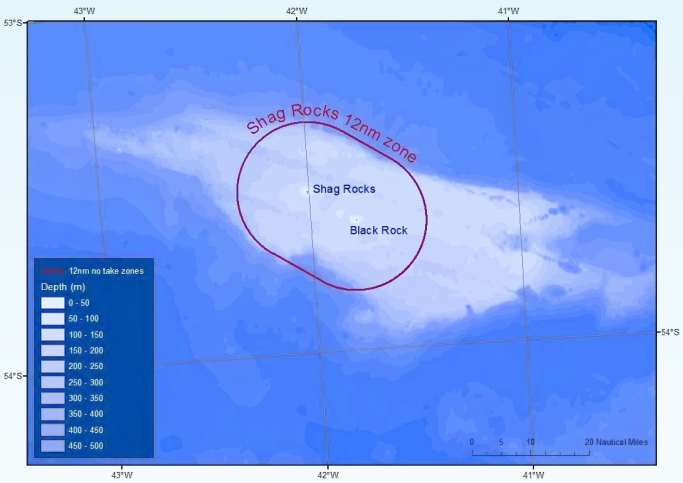


Figure 8.7. The boundaries of the Shag Rocks No-take Zone.

Objectives

- Protection of the shallow inshore environment around Shag Rocks from any form of fishing activity;
- Protection of juvenile toothfish;
- Protection of spawning aggregations of benthic- spawning fish;
- Protection of the benthic fauna from any form of commercial fishing activity;
- Protection of foraging areas of marine predators.

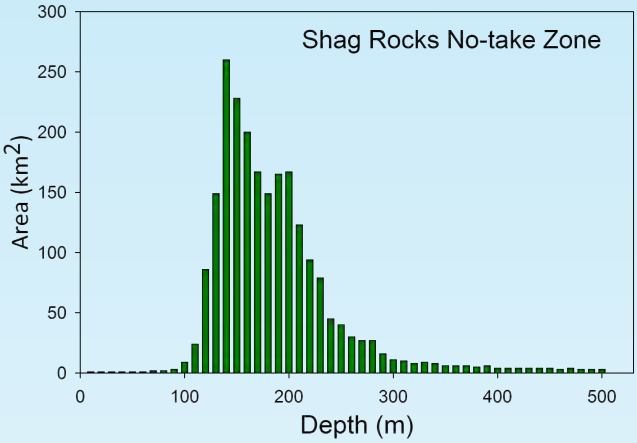


Figure 8.8. Distribution of seafloor areas in each 10 m depth band in the Shag Rocks No-take Zone.

Restrictions

- No commercial fishing activity permitted;
- Licensed fishing vessels are not allowed inside the No-take Zone, except in exercise of their right of innocent passage or under force majeure.

Permitted activities

- Vessels are allowed access to the Shag Rocks No-take Zone for tourism purposes;
- Research fishing may be allowed, but only with a permit issued by the Commissioner.

8.3 South Sandwich Islands No-Take Zones and Pelagic Closed Areas

Background

The South Sandwich Islands support important penguin colonies (Fig. 8.9) but the marine flora and fauna is relatively unknown. A 3 nm No-take Zone (IUCN Cat Ib) extends around each of the South Sandwich Islands (Fig. 8.10), which provides protection for 2272 km^2, encompassing the small areas of continental shelf that surround each of the islands. The 3 nm mile NTZ includes depths ranging from 0-2900 m (Fig. 8.11), including all depths shallower than 100 m. In addition there is a 12 nm area around each of the islands that is closed to pelagic fishing. This protects 15,769 km^2 in addition to the area already protected by the NTZ.

Figure 8.9. View of the chinstrap penguin colony on Saunders Island.

Objectives

- Protection of the shallow inshore environment around the South Sandwich Islands from any form of fishing activity;
- Protection of spawning aggregations of benthic spawning fish;
- Protection of the benthic fauna from any form of fishing activity in the NTZ;
- Protect the foraging grounds of land-based predators that forage within 12 nm of the South Sandwich Islands.

Restrictions

- No commercial fishing activity permitted in the NTZ;
- No pelagic fishing permitted in the Pelagic Closed Area.

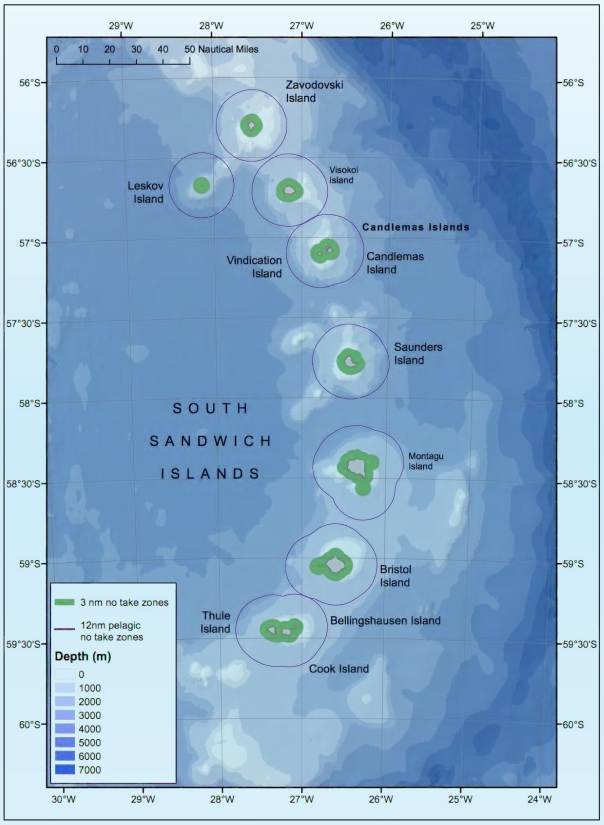


Figure 8.10. The South Sandwich Islands No-take Zones (green shaded) and the Pelagic Closed Areas (dotted line).

Permitted activities

- Vessels are allowed access to the South Sandwich Islands No-take Zones for tourism purposes;
- Research fishing may be allowed, but only with a permit issued by the Commissioner.

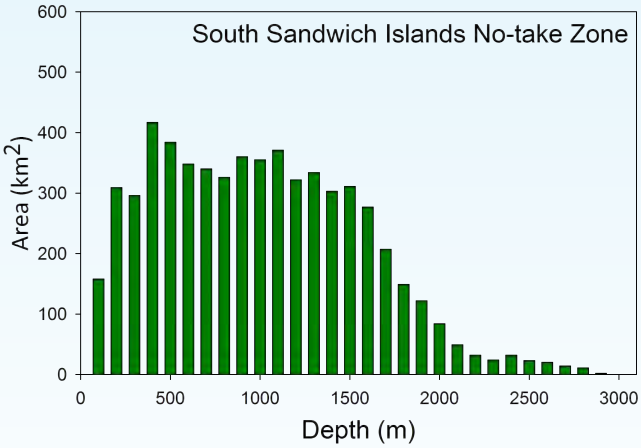


Figure 8.11. Seafloor area in each 100 m depth band in the South Sandwich Islands No-take Zones.

8.4 Benthic Closed Areas

Background

Reduced Impact Areas (RIAs) were established in the Patagonian toothfish fishery in 2008. Initially there were three RIAs (see Fig. 3.9), which were designed to protect vulnerable taxa and juvenile toothfish. Some fishing was allowed in the RIAs to ensure a good spatial distribution of tagging. The West Gully RIA was expanded in 2010 and the Southern Seamounts were closed to the toothfish fishery in 2012. The RIAs have now been incorporated into, and superseded by, Benthic Closed Areas.

The new Benthic Closed Areas (BCAs) include the following:

West Shag BCA

The West Shag BCA (1,039 km^2; with 790 km^2 between 700 and 2,250 m) (Fig. 8.12) is situated on the western end of the Shag Rocks shelf and is intended to protect vulnerable marine fauna and provide refugia for adult toothfish. It was selected as it was an area of high benthic by-catch; particularly abundant in gorgonians, bryozoans and corals. This area became an RIA in 2008 and has had limited fishing effort since. The only fishing since 2008 has been for tagging purposes with 15 fish per tonne tagged.

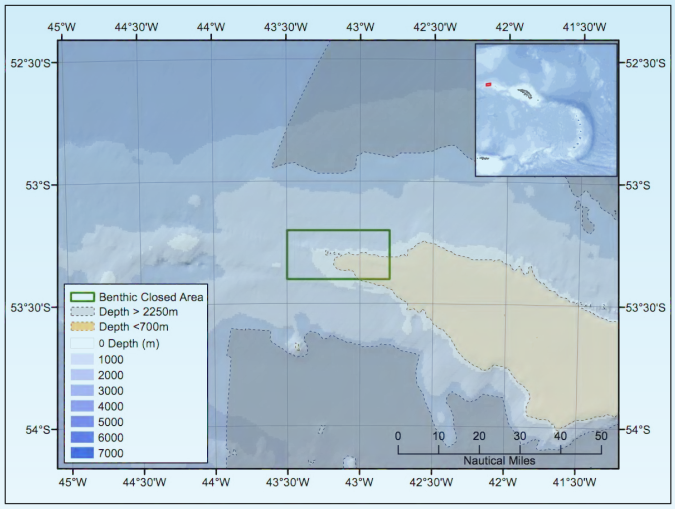


Figure 8.12. West Shag Benthic Closed Area

West Gully BCA

The West Gully BCA (2,236 km^2; with 1,530 km^2 between 700 and 2,250 m) (Fig. 8.13) is situated on the eastern end of the Shag Rocks shelf and is an important area for the dispersion of juvenile Patagonian toothfish. By-catch monitoring identified it as a hotspot of vulnerable marine fauna, notably gorgonians, corals, bryozoans and sponges. Part of this area became an RIA in 2008 and was extended in 2010. It has had limited fishing effort since. The only fishing since 2008 has been for tagging purposes with 15 fish per tonne tagged.

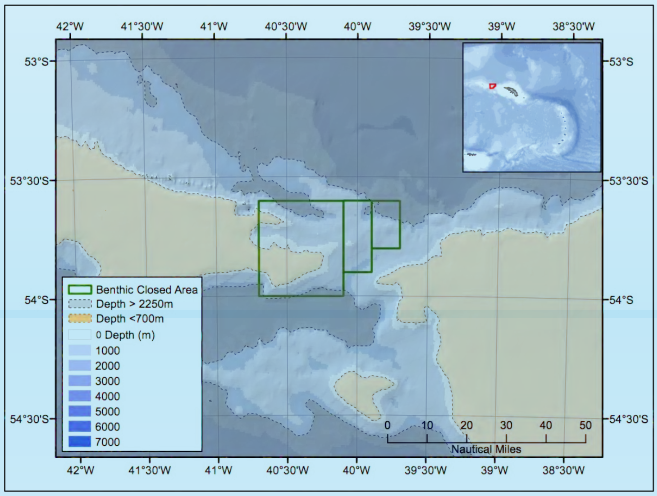


Figure 8.13. West Gully Benthic Closed Area

Northern BCA

The Northern BCA (441 km^2; with 408 km^2 between 700 and 2,250 m) (Fig. 8.14) is situated to the north-east of Cumberland Bay and was selected as a refugia for spawning adult toothfish and to protect vulnerable marine fauna; notably gorgonians, sponges and corals. This area became an RIA in 2008 and has had limited fishing effort since. The only fishing since 2008 has been for tagging purposes with 15 fish per tonne tagged.

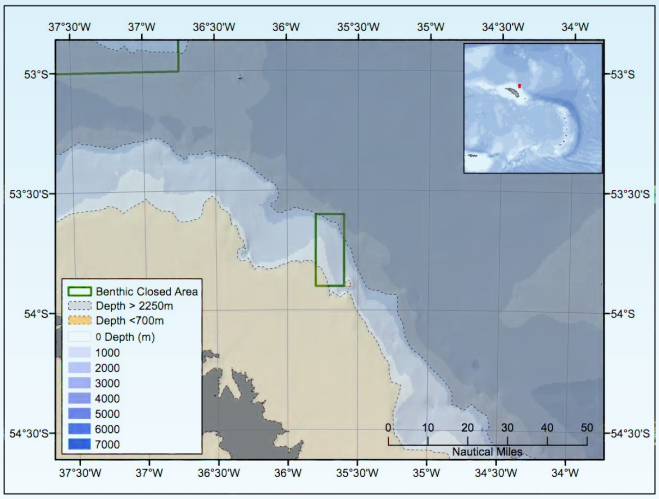


Figure 8.14. Northern Benthic Closed Area

Eastern BCA

The Eastern BCA (143 km^2; with all 143 km^2 between 700 and 2,250 m) (Fig. 8.15) is a relatively small area to the east of South Georgia. It was considered for RIA status in 2008, but remained open to commercial fishing. It was closed for the first time at the start of the 2013 season. It is intended to protect vulnerable taxa such as bryozoans, corals and gorgonians.

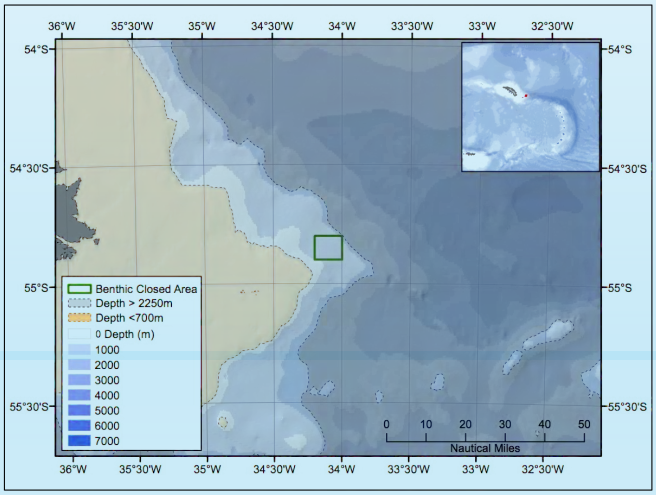


Figure 8.15. Eastern Benthic Closed Area

Southern Seamounts BCAs

The Southern Seamounts BCA (1,557 km2; with 260 km2 between 700 and 2,250 m) (Fig. 8.16) was first closed in 2012. The area had been occasionally fished (with good catch rates), but was closed to provide a refugia for adult toothfish and to protect the largely unknown benthic fauna.

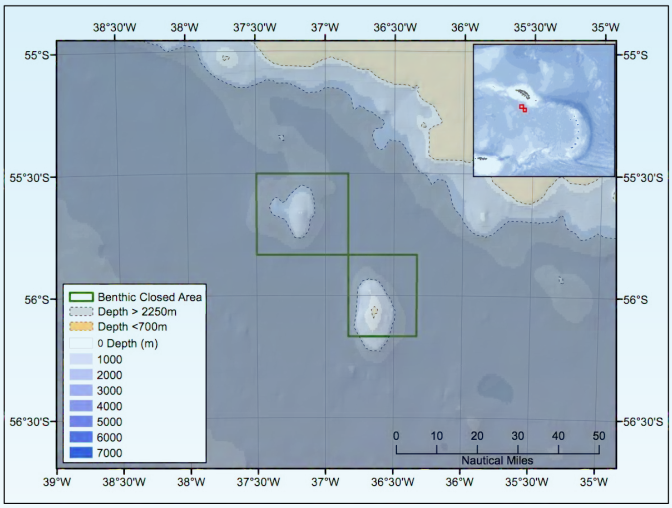


Figure 8.16. Southern seamounts Benthic Closed Area

North Georgia Rise BCA

North Georgia Rise BCA (4,590 km^2 with 2,545 km^2 between 700 and 2,250 m) (Fig. 8.17) is an area that rises from deeper water to a minimum depth of 1700 m. It is north of the normal toothfish fishing area, but has occasionally been fished. This BCA is intended to provide a refugia for adult toothfish and protect the largely unknown benthic fauna.

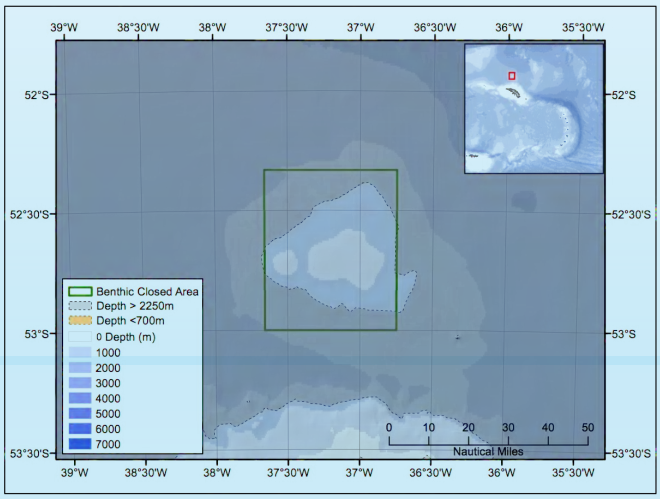


Figure 8.17. North Georgia Rise Benthic Closed Area

North East Georgia Rise BCA

The North East Georgia Rise BCA (9,853 km2; with 6,865 km2 between 700 and 2,250 m) (Fig. 8.18) is outside the normal fishing area and has been closed to licensed vessels since 2005. There is limited data on the benthic fauna, but the large closed area is likely to include a range of habitats and taxa and also provides refugia for adult toothfish.

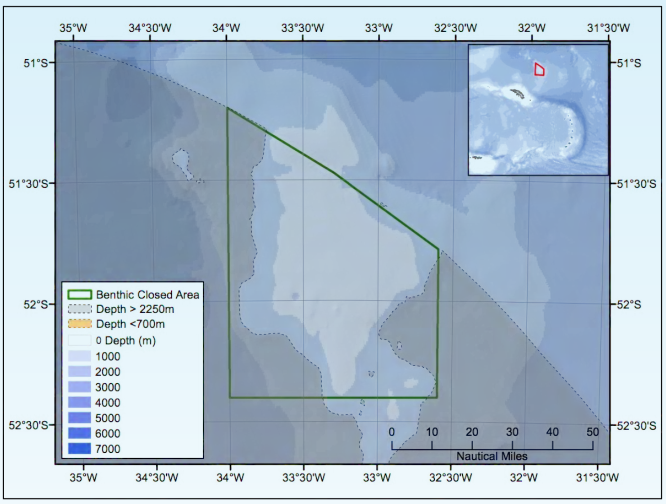


Figure 8.18. North East Georgia Rise Benthic Closed Area

Protector Shoals BCA

Protector Shoals BCA (1,935 km^2; with 1,874 km^2 between 700 and 2,250 m) (Fig. 8.19). This area is to the north-west of the South Sandwich chain and is a likely stepping stone for Patagonian toothfish migrating between South Georgia and the South Sandwich Islands. The area has been fished as part of the South Sandwich Island Patagonian toothfish fishery, but effort has been small. The benthic fauna, which is not well documented, will be fully protected by this closure.

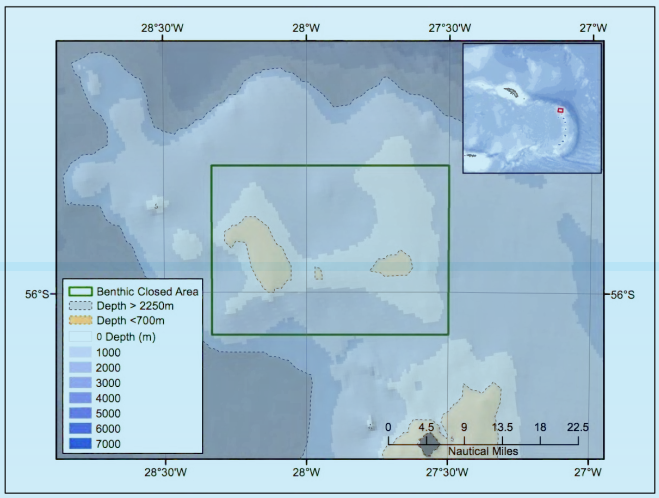


Figure 8.19. Protector Shoals Benthic Closed Area

Kemp Seamount & Calderas BCA

Kemp Seamount & Calderas BCA (352 km^2; with 171 km^2 between 700 and 2,250 m) (Fig. 8.20). This area has recently been identified as an area of hydrothermal activity, which supports a unique fauna dominated by a species of yeti crab (Rogers et al., 2012). This unique fauna is protected by this closure: it is unlikely that any research fishing would be permitted, and careful consideration would be given to any potentially destructive scientific sampling.

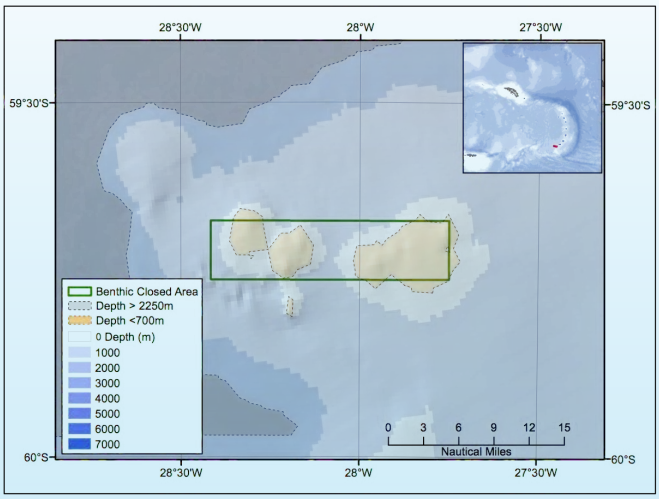


Figure 8.20. Kemp Seamount and Calderas Benthic Closed Area

Objectives

- Protection of sensitive benthic fauna;
- Provide refugia for adult toothfish.

Restrictions

- No commercial bottom fishing activity permitted;
- Research fishing may be allowed for tagging purposes in some of the BCAs, but only with a permit issued by the Commissioner

8.5 Seasonal closure of krill fishery

Background

Antarctic krill are a key species in Southern Ocean ecosystems, including the waters around South Georgia and the South Sandwich Islands. Krill link primary production to large predators in short, efficient food chains. It is thus important that the fishery for krill is carefully managed to reduce the risk of any impact on the many krill-dependent predators. The current CCAMLR TAC for Area 48 is set at 5.63 million tonnes, but with a trigger level at 620,000 tonnes. The trigger level can only be exceeded once agreement (with CCAMLR) is reached for the spatial management of the catch. CCAMLR has now set interim catch limits for each of the main fishery areas (48.1, 48.2, 48.3 and 48.4; see Fig. 1.1), but there is still risk that the catch limit could all be taken at small spatial and temporal scales within each area. A key time for many of the krill-dependent predators is the summer breeding season (see Fig. 8.21), when they are limited in their foraging range (e.g. Antarctic fur seal and macaroni penguin). Whilst the 12 nm No-take Zones provide considerable protection for many of the land-based predators on South Georgia, it would still be possible that krill could be depleted in important predator foraging areas outside the No-take Zones during the key summer months.

Thus, to reduce the risk of the krill fishery having an impact on krill dependent predators, the MPA includes a seasonal closure of the krill fishery to coincide with the main breeding season of birds and mammals (Fig. 8.21).

Objectives

- To reduce the risk of competition between the krill fishery and krill-dependent predators during their breeding season.

Restrictions

- No krill fishing is allowed within the South Georgia and South Sandwich Islands MPA from November 1st until March 31st.

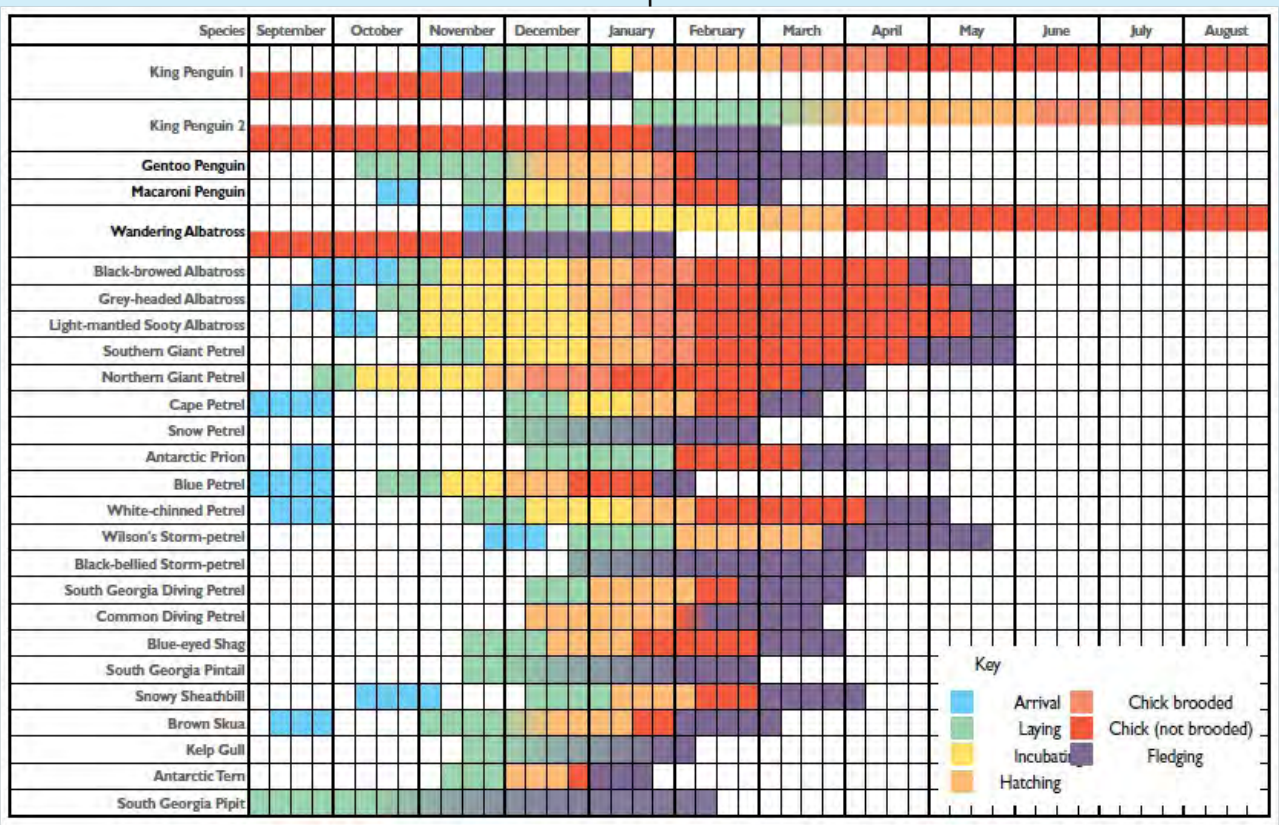


Figure 8.21. Breeding seasons of the birds of South Georgia, taken from Poncet and Crosbie, 2005.

9. Surveillance

9.1 Fishing vessels and activities

All licensed fishing vessels provide daily reports of catch and location to GSGSSI. All icefish and toothfish vessels have a GSGSSI appointed CCAMLR observer on board throughout their fishing activities. Vessels licensed to catch krill will normally have an observer on board for at least 50% of the fishing period in the SGSSI Maritime Zone (MZ). Toothfish and icefish vessels are required to carry satellite Vessel Monitoring System (VMS) and all fishing vessels are required to have an Automatic Identification System (AIS). The Fisheries Patrol Vessel (FPV) Pharos SG (below) patrols both the SGMZ and the SSIMZ. Fisheries Protection Officers on board the Pharos SG carry out regular at-sea inspections of fishing vessels to ensure they are fully compliant with GSGSSI licence conditions and CCAMLR Conservation Measures.

9.2 Fisheries legislation and enforcement

The Fisheries (Conservation & Management) Ordinance 2000 (as amended) provides the legal basis for the regulation of fishing activities in the South Georgia and South Sandwich Islands Maritime Zones.

Although there was considerable illegal fishing targeting toothfish in South Georgia waters in the early 1990s, there is little evidence of any illegal, unlicensed or unregulated (IUU) fishing in recent years. The last vessel to be caught fishing illegally was the Panamanian flagged longliner Elqui, which was arrested by the FPV and escorted to Stanley. Both the vessel owners and the captain were found guilty and fined. The GSGSSI removed all hazardous material and potential pollutants from the vessel and she was scuttled off the coast of the Falklands (Fig. 9.1). All visiting vessels are requested to report any sightings of fishing vessels to GSGSSI.

Figure 9.1. The longliner Elqui being scuttled near the Falkland Islands after being found guilty of illegal fishing in South Georgia waters

9.3 Catch verification and chain of custody

Toothfish is highly valuable (around $25 per kilo first sale price), and to ensure all product from the fishery is properly verified, all longliners undergo a catch verification process at the end of the season. During the season, each vessel must weigh and label each individual carton or sack with the weight, number of fish and details of capture. This data is provided to GSGSSI on a weekly basis. During catch verification all of the retained toothfish catch is weighed to ensure vessels have not exceeded their reported catch and a sub-sample of the cartons or sacks are checked to ensure their labels and contents match information submitted to GSGSSI.

10. Monitoring

10.1 Shallow marine

In November 2010, as part of a larger Darwin Initiative project, the Shallow Marine Surveys Group (SMSG) undertook a baseline survey of the shallow marine environment (< 20 m) on the north coast of South Georgia. Subtidal habitats between 5 and 18 m depth, and intertidal habitats surrounding Grytviken and King Edward Point were surveyed by divers, using transects, photoquadrats and sample collections. Such comprehensive baseline data was previously lacking, but is essential for detecting and monitoring species invasions. In addition, settlement plates were established at three locations. The settlement plates will be checked on a regular (annual) basis for the presence of any non-native species.

10.2 Plankton surveys

Inshore plankton surveys are conducted each month in Cumberland Bay and Bay of Isles by the FPV *Pharos SG*, with samples identified by the scientific team at KEP. The surveys are designed to provide data on the abundance of fish larvae, but provide additional data on general zooplankton abundance (see Belchier & Lawson, 2013). The FPV *Pharos SG* also tows a Continuous Plankton Recorder (CPR) from the Falkland Islands to South Georgia every two months. The resulting samples (sections of silk) are analysed and quantified by the Sir Alistair Hardy Foundation for Ocean Science (SAHFOS) in Plymouth and will provide long-term data on the status of the plankton.

Figure 10.1 Stamp produced to coincide with the first tow of the CPR by the FPV Pharos SG

10.3 Groundfish surveys

Trawl surveys are undertaken on the South Georgia shelf on an annual or biennial basis and provide data on the abundance and biomass of demersal fish. In particular the survey provides a biomass estimate of mackerel icefish for the stock assessment (Main et al., 2008) and provides an index of recruitment of juvenile toothfish (Belchier & Collins, 2008). The GSGSSI trawl survey series dates back to 1990, with additional data collected by US and Polish surveys in the late 1980s. The survey uses a small bottom trawl and provides an important time series of the status of fish populations and valuable samples for ecological studies (e.g. Clarke et al., 2008; Collins et al., 2008b; Reid et al., 2007) that support ecosystem based management of fisheries.

10.4 Predator monitoring

British Antarctic Survey (BAS) has carried out long-term monitoring of land-based predators at Bird Island on the north-west tip of South Georgia since 1968 and more recently at Maiviken, near King Edward Point. This is part of BAS's Long Term Monitoring and Survey (LTMS) programme to measure changes in Antarctic ecosystems and to carry out research on the processes that drive them. BAS LTMS work at these sites also includes collection of data on marine debris and entanglement of seabirds and seals.

The BAS LTMS data provide scientists with seabird and seal indicators for the Scotia Sea. These indicators include estimates of breeding population size, reproductive success and the quality and abundance of food eaten by predators. BAS data are essential for modelling studies that relate population and breeding performance of seabirds and seals to environmental variability and change. Recent analyses show that modes of climate variability, for example, the Southern Annular Mode and the El Niño Southern Oscillation, affect upper trophic level predators (including penguins, seals and whales).

The LTMS data is submitted to CCAMLR to help detect any possible impacts of the krill fishery. BAS and GSGSSI data on seabird populations also support work undertaken on behalf of the Agreement on the Conservation of Albatrosses and Petrels (ACAP) to understand and highlight reasons why these species are declining. This information is used to develop strategies to minimise or eliminate the major threats, including campaigning for the wider use of mitigation measures to reduce the currently high rates of incidental seabird mortality in many Southern Ocean fisheries outside South Georgia waters.

Situated 0.5 km from the northwest tip of mainland South Georgia, Bird Island is small (4km x 0.5km), with natural vegetation dominated by tussac grass from rocky coastal beaches to several hundred metres in elevation. Despite its small size, Bird Island holds an incredible abundance and diversity of land-based marine predators. Breeding species include three penguins, four albatrosses, twelve petrels, two seals, and one species each of skua, gull, tern, shag, sheathbill, duck and pipit. Both the duck and the pipit are endemic. Non-breeding species that regularly visit include leopard seals and king penguins. BAS scientists have carried out targeted research projects on almost all of these species at some point over the last three decades. However, long-term studies have focused primarily on the Antarctic fur seal (Fig. 10.2), macaroni penguin (Fig. 10.3), gentoo penguin, wandering albatross, black-browed albatross, grey-headed albatross and leopard seal. In recent years, BAS has expanded annual monitoring to also include light-mantled sooty albatross, and northern and southern giant petrels.

Figure 10.2 The seal study beach on Bird Island

Figure 10.3 The penguin weigh-bridge at a macaroni penguin colony on Bird Island.

Maiviken, which is situated at the northern tip of the Thatcher Peninsula in Cumberland Bay, is the site of a small monitoring programme on gentoo penguins and Antarctic fur seals undertaken by BAS scientists on behalf of GSGSSI. Data collected here allows scientists to determine whether the indicators collected at Bird Island are representative of the wider South Georgia population.

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Appendix I: Glossary

ACAP – Agreement on the Conservation of Albatross & Petrels

ACC – Antarctic Circumpolar Current

AIS – Automatic Identification System

APF – Antarctic Polar Front

BAS - British Antarctic Survey

CBD – Convention on Biological Diversity

CCAMLR – Commission for the Conservation of Antarctic Marine Living Resources

CPR – Continuous Plankton Recorder

EN – Endangered (IUCN Status)

FPV – Fisheries Patrol Vessel

GSGSSI – Government of South Georgia and the South Sandwich Islands

IFO – Intermediate Fuel Oil

IMO – International Maritime Organisation

IUCN – International Union for the Conservation of Nature

KEP - King Edward Point

LC - Least Concern (IUCN Status)

MDO – Marine Diesel Oil

MGO – Marine Gas Oil

MRAG - Marine Resources Assessment Group

MSC – Marine Stewardship Council

MZ – Maritime Zone

NT – Near Threatened (IUCN Status)

SACCF – Southern Antarctic Circumpolar Current Front

SAF – Sub-Antarctic Front

SAHFOS – Sir Alister Hardy Foundation for Ocean Science

SB – Southern Boundary of the Antarctic Circumpolar Current

SGSSIMZ – South Georgia and South Sandwich Islands Maritime Zone

SMSG - Shallow Marine Survey Group

IWC – International Whaling Commission

TAC – Total Allowable Catch

VMS - Vessel Monitoring System

VU - Vulnerable (IUCN Status)

Appendix II: IUCN Protected Area Categories

Category Ia: Strict nature reserve

Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological / geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.

Category Ib: Wilderness area

Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

Category II: National park

Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.

Category III: Natural monument or feature

Category III protected areas are set aside to protect a specific natural monument, which can be a landform, seamount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

Category IV: Habitat/species management area

Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

Category V: Protected landscape/Seascape

A protected area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

Category VI: Protected area with sustainable use of natural resources

Category VI protected areas conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

Appendix III: The South Georgia and South Sandwich Islands Marine Protected Area Order 2013

SUBSIDIARY LEGISLATION

WILDLIFE & PROTECTED AREAS

Marine Protected Areas Order 2013

S. R. & O. No: 1 of 2013

Made: *30 May 2013*
Published: *13 June 2013*
Coming into force: on publication

IN EXERCISE of my powers under sections 18(1) and 20(1) of the Wildlife and Protected Areas Ordinance 2011 (No 1 of 2011) and being satisfied that the criteria identified in section 18(2) of that Ordinance apply, I make the following order —

1. Title
This order is the Marine Protected Areas Order 2013.

2. Commencement
This order comes into force on publication in the *Gazette.*

3. Interpretation
In this order —

"benthic closed area" means each of the areas described in Schedule 1;

"bottom fishing" —

(a) means fishing on the sea floor;

(b) includes bottom trawling; and

(c) also includes the use of lines, pots, nets or traps on the sea floor;

"bottom trawling" means towing a trawl or fishing net along (and in contact with) the sea floor;

"closed season", means, in respect of fishing for Antarctic krill, the season described in Schedule 2";

The South Georgia and South Sandwich Islands Marine Protected Area Order 2013 (continued)

"fishing vessel" —

(a) means a vessel of any size that is used for, equipped to be used for, or intended for use for the purposes of fishing or fishing related activities;

(b) includes vessels engaged in transshipment of fish or fishery products; and

(c) also includes carrier vessels equipped for the transportation of fish or fishery products;

"no-take zone" means each of the zones described in Schedule 3;

"pelagic closed area" means the area described in Schedule 4;

"pelagic fishery" means a fishery that uses a trawl, long line, jig or other method that is not designed to come into contact with the sea floor during normal fishing operations;

"SGSSI MPA" means the South Georgia and South Sandwich Islands Marine Protected Area designated by article 4; and

"SGSSI waters" means —

(a) the internal waters of the Territory between —

(i) the baselines established by article 3 of the South Georgia and South Sandwich Islands (Territorial Sea) Order 1989 (SI 1989/1995); and

(ii) mean high water at spring tide;

(b) the territorial sea established for the Territory by article 2 of the South Georgia and South Sandwich Islands (Territorial Sea) Order 1989; and

(c) the maritime zone established for the Territory by Proclamation No. 1 of 1993.

4. South Georgia and South Sandwich Islands Marine Protected Area

(1) A Marine Protected Area around South Georgia and the South Sandwich Islands is designated under section 18(1) of the Wildlife and Protected Areas Ordinance.

(2) The name of the Marine Protected Area is the South Georgia and South Sandwich Islands Marine Protected Area (SGSSI MPA).

(3) The SGSSI MPA consists of SGSSI waters northwards of the line of latitude 60 degrees south of the equator.

(4) The purpose of designating the SGSSI MPA is for the conservation of —

(a) the seabed and its overlying waters; and

The South Georgia and South Sandwich Islands Marine Protected Area Order 2013 (continued)

(b) their associated organisms.

(5) The principal conservation objectives for the SGSSI MPA are to —

(a) conserve marine biodiversity, habitats and critical ecosystem function;

(b) ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems;

(c) manage other human activities including shipping and scientific research, to minimise environmental impacts on the marine environment;

(d) protect the benthic marine organisms from the destructive effects of bottom trawling;

(e) facilitate recovery of previously over-exploited marine species;

(f) increase the resilience of the marine environment to the effects of climate change; and

(g) prevent the introduction of non-native marine species.

5. Conservation order prohibitions

(1) The following prohibitions apply within the SGSSI MPA —

(a) bottom trawling is prohibited;

(b) fishing is prohibited in the no-take zones;

(c) fishing vessels are prohibited from entering the no-take zones, except in exercise of the right of innocent passage or under force majeure;

(d) bottom fishing is prohibited in the following waters —

(i) where the depth of the seabed is less than 700 metres or is greater than 2250 metres;

(ii) in the benthic closed areas;

(e) pelagic fishing is prohibited in the pelagic closed area; and

(f) fishing for Antarctic krill (*Euphausia superba*) is prohibited during the closed season.

(2) The prohibitions in this article do not apply to —

(a) anything carried out for research purposes in accordance with a permit granted by the Commissioner under section 21 of the Wildlife and Protected Areas Ordinance;

(b) anything permitted by section 20(8) of that Ordinance.

The South Georgia and South Sandwich Islands Marine Protected Area Order 2013 (continued)

6. Repeal

The Marine Protected Areas Order 2012 is repealed.

SCHEDULE 1
Benthic closed areas

(Section 3)

Area	Boundaries	Protected features	Conservation objectives To conserve & protect:
West Shag Benthic Closed Area	53°12' - 53°24'S; 43°30' - 42°48'W	The seabed, and associated organisms in an area of 1039 km^2	The vulnerable marine fauna identified in this location; provides refugia for toothfish.
West Gully Benthic Closed Area	1: 53°36' - 54°00'S; 40°42' - 40°06'W 2: 53°36' - 53°54'S; 40°06' - 39°54'W 3: 53°36' - 53°48'S; 39°54' - 39°42'W	The seabed, and associated organisms in an area of 2236 km^2	The vulnerable marine fauna in this area and protect juvenile toothfish, which are abundant in this area.
Northern Benthic Closed Area	53°36' - 53°54'S; 35°48' - 35°36'W	The seabed, and associated organisms in an area of 441 km^2	The vulnerable marine fauna identified in this location; provides refugia for toothfish.
Eastern Benthic Closed Area	54°48′-54°54′ S; 34°00′-34°12′ W	The seabed, and associated organisms in an area of 143 km^2	The vulnerable marine fauna identified in this area (particularly gorgonians).
Southern Seamounts Benthic Closed Area A	55°30' – 55°50'S; 37°30' – 36°50'W	The seabed, and associated organisms in an area of 1557 km^2	The potentially sensitive (but largely unknown) benthic fauna; provides refugia for adult toothfish.
Southern Seamounts Benthic Closed Area B	55°50' - 56°10'S; 36°50' - 36°20'W	The seabed, and associated organisms in an area of 1158 km^2	The potentially sensitive (but largely unknown) benthic fauna; provides refugia for adult toothfish.
North Georgia Rise Benthic Closed Area	52°20′ – 53°00′ S; 36°45′ – 37°40′W	The seabed, and associated organisms in an area of 4590 km^2	The potentially sensitive (but largely unknown) benthic fauna of this area; provides refugia for adult toothfish.
North East Georgia Rise Benthic Closed Area	51°12′ – 52°24′ S; 32°36′ – 34°00′W	The seabed, and associated organisms in an area of 9853 km^2	The potentially sensitive (but largely unknown) benthic fauna of this area; provides refugia for adult toothfish.
Protector Shoals Benthic Closed Area	55°45′ – 56°05′ S; 27°30′ – 28°20′W	The seabed, and associated organisms in an area of 1935 km^2	The potentially sensitive (but largely unknown) benthic fauna; provides refugia for adult toothfish.
Kemp Seamount & Calderas Benthic Closed Area	59°40′ – 59°45′ S; 27°45′ – 28°25′W	The seabed, and associated organisms in an area of 352 km^2	The potentially sensitive (largely unknown) benthic fauna of this seamount and caldera. Protects different chemosynthetic habitats, including white smoker vent fields

The South Georgia and South Sandwich Islands Marine Protected Area Order 2013 (continued)

SCHEDULE 2
Closed season (Antarctic krill)

(Section 3)

Description	Season	Protected features	Conservation objectives To conserve and protect:
Seasonal closure of the fishery for Antarctic krill	November-March inclusive.	The pelagic ecosystem in an area of 1.07 million km^2 during a 5 month period.	Mammalian and avian krill dependent predators, such as penguins and fur seals during the key part of the breeding season.

SCHEDULE 3
No-take zones

(Section 3)

Zone	Boundaries	Protected features	Conservation objectives To conserve & protect:
South Georgia No-take Zone	Between: (1) a line 12 nautical miles from the baselines around the coast of South Georgia; and (2) mean high water at spring tide.	The seabed, overlying water and associated organisms in an area of 13899 km^2	The shallow marine environment around South Georgia including: 1. The spawning grounds of many fish species, including mackerel icefish; 2. The inshore foraging areas of marine predators such as gentoo penguins, cormorants, petrels and prions.
Clerke Rocks No-take Zone	Between: (1) a line 12 nautical miles from the baselines around Clerke Rocks and the Office Boys; and (2) mean high water at spring tide.	The seabed, overlying water and associated organisms in an area of 1923 km^2	The shallow marine environment to the SE of South Georgia including: 1. The spawning grounds of many fish species, including mackerel icefish; 2. The inshore foraging areas of marine predators such as gentoo penguins, cormorants, petrels and prions; 3. The "spirulid reef" at approximately 55°00'S, 34°31'W.
Shag Rocks No-take Zone	Between: (1) a line 12 nautical miles from the baselines around Shag Rocks & Black Rock; and (2) mean high water at spring tide	The seabed, overlying water and associated organisms in an area of 2337 km^2	The shallow marine environment of the Shag Rocks shelf incorporating: 1. The principal recruitment area for juvenile Patagonian toothfish; 2. Spawning grounds of mackerel icefish; 3. A key foraging area for black-browed albatross, Antarctic fur seals and baleen whales.
South Sandwich Islands No-take Zones	Between: (1) lines 3 nautical miles from the baselines around the coasts of the South Sandwich Islands; and (2) mean high water at spring tide	The seabed, overlying water and associated organisms in areas that total 2272 km^2	The shallow marine environment around each of the South Sandwich Islands including: 1. The inshore foraging grounds of marine predators; 2. The spawning grounds of fish species.

The South Georgia and South Sandwich Islands Marine Protected Area Order 2013 (continued)

SCHEDULE 4
Pelagic closed area

(Section 3)

Area	Boundaries	Protected features	Conservation objectives To conserve & protect:
South Sandwich Islands Pelagic Closed Area	Between: (1) lines 12 nautical miles from the baselines around the coasts of each of the South Sandwich Islands; and (2) mean high water at spring tide	The pelagic ecosystem around each of the South Sandwich Islands in an area of 18,042 km^2	The pelagic ecosystem and dependent predators in the area around each of the South Sandwich Islands, particularly the highly abundant chinstrap and Adelie penguins.

Made 30 May 2013

N.R. Haywood C.V.O.,
Commissioner.

EXPLANATORY NOTE
(not part of the order)

This order replaces and updates the Marine Protected Order 2012.

Section 18(1) of the Wildlife and Protected Areas Ordinance (No 1 of 2011) allows the Commissioner to designate areas of sea as marine protected areas (MPAs).

The criteria for designation of a marine protected area are set out in section 18(2) and the requirements for orders designating MPAs are set out in the rest of section 18 and in section 19.

Section 20(1) allows the Commissioner to make conservation orders to further the objectives of an MPA. Section 20(3) allows the Commissioner to prohibit or restrict activities in a conservation order and section 20(6) allows for different prohibitions or restrictions to apply in different parts of an MPA.

This order designates the South Georgia and South Sandwich Islands Marine Protected Area (the SGSSI MPA) to protect the seabed and overlying waters and associated organisms.

The SGSSI MPA consists of waters north of a latitude 60 degrees south that are between mean high water at spring tide and the 200 nautical mile limit.

The South Georgia and South Sandwich Islands Marine Protected Area Order 2013 (continued)

SGSSI waters south of 60 degrees south of the equator are similarly protected through the SGSSI fishery licensing regime, which does not permit fishing in these waters.

The order also defines a number of no-take zones: 12 nautical miles around South Georgia Island, Clerke Rocks, Shag and Black Rocks; and 3 nautical miles around each of the South Sandwich Islands. Fishing is prohibited in these zones.

To protect benthic marine organisms, the order prohibits bottom trawling throughout the SGSSI MPA and all bottom fishing in waters of less than 700 m depth and in waters depths greater than 2250 m. Bottom fishing is also prohibited in areas identified in Schedule 2.

Fishing for Antarctic krill is prohibited between November 1st and March 31st. Pelagic fishing is prohibited within 12 nautical miles of the South Sandwich Islands.

These prohibitions do not apply to activities covered by one of the limited exceptions in section 20(8) or by a licence granted by the Commissioner under section 21.

Breach of the prohibitions is an offence against section 20(9) of the Ordinance.

The following maps illustrate the boundaries of the SGSSI MPA, the no-take zones, the pelagic closed areas and the benthic closed areas.

Appendix IV: The South Georgia and South Sandwich Islands (Territorial Sea) Order 1989

Her Majesty, in pursuance of the powers conferred upon Her by the Colonial Boundaries Act I895 and all other powers enabling Her in that behalf, is pleased, by and with the advice of Her Privy Council, to order, and it is hereby ordered, as follows:

1. This Order may be cited as the South Georgia and South Sandwich Islands (Territorial Sea) Order1989 and shall come into force on lst January 1990.

2. The boundaries of the Territories of South Georgia and South Sandwich Islands are hereby extended to include, as territorial sea, that part of the sea which is situated within 12 nautical miles measured from the baselines as established by article 3 of this Order, together lvith the seabed of the territorial sea and its subsoil.

3. (l) Except as otherwise provided in paragraphs (2) to (4) of this article, the baseline from which the breadth of the territorial sea adjacent to South Georgia and South Sandwich Islands is measured shall be the low-water line along the coast of all islands and territories comprised in South Georgia and South Sandwich lslands by virtue of the South Georgia and South Sandwich Islands Order 1985.

(2) For the purposes of this article a low-tide elevation which lies wholly or partly within the breadth of sea which would be territorial sea if all low-tide elevations were disregarded for the purpose of themeasurement of the breadth thereof and if paragraphs (3) and (4) of this article were omitted shall be treated as an island.

(3) The baseline from which the breadth of the territorial sea is measured around the island of South Georgia and the islands in its immediate vicinity shall consist of the series of loxodromes drawn so as to join successivel, in the order in which they are there set out, the points identified by the co-ordinates of latitude and longitude in the first column of the Schedule to this Order, each being a point situated on the low-water line on or adjacent to the feature named in the second column of that Schedule opposite to the co-ordinates of latitude and longitude of the point in the first column:Provided that the baseline between points 19 and 20 in that Schedule shall be the low water line as laid down in paragraphs (1) and (2) of this article.

(4) The provisions of paragraph (3) of this article shall be without prejudice to the operation of paragraph (2) of this article in relation to any island or low-tide elevation which for the purposes of that paragraph is treated as if it were an island, being an island or low-tide elevation which lies to seaward of the baseline specified in paragraph (3) of this article.4.

In this Order -
"island" means a naturally formed area of land surrounded by water which is above water at mean high-water spring tides;

"low-tide elevation" means a naturally formed area of drying land surrounded by water which is below water at mean high-water spring tides; and

"nautical miles" means international nautical miles of 1852 metres.

Appendix V: Baslines for South Georgia Territorial Sea

Point	Latitude	Longitude	Location Name
1	53^0 59' 13"S	38^0 18' 02"W	Ramp Rock - N
2	53^0 59' 25"S	38^0 10' 38"W	Trinity Island
3	53^0 59' 33"S	38^0 01' 28"W	Bird Island
4	53^0 59' 12"S	37^0 55' 21"W	Sãrn
5	53^0 58' 14"S	37^0 44' 31"W	Cape North
6	53^0 57' 35"S	37^0 29' 00'W	High Rock
7	54^0 02' 55"S	36^0 59' 39"W	Cape Constance
8	54^0 04' 30”S	36^0 51' 25"W	The Guides
9	54^0 06' 35”S	36^0 40' 07"W	Hercules Point
10	54^0 06' 51"S	36^0 38' 36"W	Turpie Rock
11	54^0 07' 15"S	36^0 37' 33"W	Humpback Rocks
12	54^0 10' 41"S	36^0 29' 24"W	Jason Island
13	54^0 15' 13"S	36^0 17' 53"W	East Skerry
14	54^0 17' 07"S	36^0 14' 41"W	Cape George
15	54^0 22' 20"S	36^0 09' 15"W	Cape Vakop
16	54^0 32' 20"5	35^0 53' 27"W	Cape Charlotte
17	54^0 41' 38"S	35^0 43' 35"W	Filchner Rocks
18	54^0 47' 32"5	35^0 45' 45"W	Cooper Island - N
19	54^0 48' 00"S	35^0 45' 52"W	Cooper Island - E
20	54^0 49' 13"S	35^0 46' 59"W	Cooper Island - S
21	54^0 55' 14"S	36^0 06' 45"W	First Rock
22	54^0 45' 30"S	36^0 19' 25"W	Kupriyanov Islands
23	54^0 37' 47"S	36^0 46' 08"W	Pickersgill Islands
24	54^0 30' 40"S	37^0 45' 55"W	South West Point
25	54^0 29' 33"S	37^0 08' 20"W	Mislaid Rock
26	54^0 08' 10"S	37^0 45' 55"W	Saddle Island
27	54^0 04' 23"S	38^0 00' 50"W	Olsen Rock
28	54^0 04' 18"S	38^0 01' 42"W	Rock west of Olsen Rock
29	54^0 01' 10"S	38^0 15' 46"W	Bryde Rocks - S
30	54^0 00' 52"S	38^0 16' 15"W	Brvde Rocks - N
31	53^0 59' 17"S	38^0 18' 12"W	Ramp Rock - W
1	53" 59' 13"S	38^0 18' 02"W	Ramp Rock - N

Appendix VI: Proclamation of the South Georgia and South Sandwich Islands Maritime Zone

The South Georgia and South Sandwich Islands Maritime Zone, as defined in Proclamation No. 1 (1993), has as its inner boundaries the outer limit of the Territorial Sea and its seaward boundary a line drawn so that each point on the line is 200 nautical miles from the nearest point on the baselines defined, in the case of South Georgia, in Article 3 (3) and (4) of the Schedule to the South Georgia and South Sandwich Islands (Territorial Sea) Order 1989 and, in the case of the South Sandwich Islands, in Article 3 (1) and (2) of that Order.

Appendix VII: Marine teleost fish of the South Georgia and the South Sandwich Islands Maritime Zone

Family	Species	SG	SSI	Family	Species	SG	SSI
Achiropsettidae	*Mancopsetta maculata*	Y	N	Myctophidae	*Gymnoscopelus microlampas*	Y	Y
Anotopteridae	*Anotopterus pharao*	Y	Y	Myctophidae	*Gymnoscopelus nicholsi*	Y	Y
Bathydraconidae	*Bathydraco joannae*	Y	Y	Myctophidae	*Gymnoscopelus piabilis*	Y	N
Bathydraconidae	*Bathydraco antarcticus*	Y	Y	Myctophidae	*Krefftichthys anderssoni*	Y	Y
Bathydraconidae	*Bathydraco scotiae*	N	Y	Myctophidae	*Nannobrachium achirus*	Y	Y
Bathydraconidae	*Parachaenichthys georgianus*	Y	Y	Myctophidae	*Protomyctophum andriashevi*	Y	N
Bathydraconidae	*Psilodraco breviceps*	Y	N	Myctophidae	*Protomyctophum bolini*	Y	Y
Bathylagidae	*Bathylagus antarcticus*	Y	Y	Myctophidae	*Protomyctophum choriodon*	Y	Y
Bathylagidae	*Bathylagus gracilis*	Y	N	Myctophidae	*Protomyctophum gemmatum*	Y	N
Bathylagidae	*Bathylagus tenuis*	Y	N	Myctophidae	*Protomyctophum luciferum*	Y	N
Bathylagidae	*Bathylagus* sp. 1	Y	N	Myctophidae	*Protomyctophum parallelum*	Y	N
Carapidae	*Echiodon cryomargarites*	Y	N	Myctophidae	*Protomyctophum tenisoni*	Y	Y
Centrolophidae	*Icichthys australis*	Y	N	Nemichthyidae	*Nemichthys curvirostris*	Y	Y
Cetomimidae	*Gyrinomimus grahami*	Y	N	Notosudidae	*Scopelosaurus hamiltoni*	Y	N
Channichthyidae	*Chaenocephalus aceratus*	Y	Y	Nototheniidae	*Aethotaxis mitopteryx*	Y	Y
Channichthyidae	*Champsocephalus gunnari*	Y	Y	Nototheniidae	*Dissostichus eleginoides*	Y	Y
Channichthyidae	*Neopagetopsis ionah*	Y	N	Nototheniidae	*Dissostichus mawsoni*	N	Y
Channichthyidae	*Pseudochaenichthys georgianus*	Y	Y	Nototheniidae	*Gobionotothen marionensis*	Y	Y
Gadidae	*Micromesistius australis*	Y	N	Nototheniidae	*Gobionotothen gibberifrons*	Y	Y
Gempylidae	*Paradiplospinus gracilis*	Y	Y	Nototheniidae	*Lepidonothothen squamifrons*	Y	Y
Gonostomatidae	*Cyclothone pseudopallida*	Y	Y	Nototheniidae	*Lepidonotothen larseni*	Y	Y
Gonostomatidae	*Cyclothone microdon*	Y	Y	Nototheniidae	*Lepidonotothen nudifrons*	Y	Y
Artedidraconidae	*Artedidraco mirus*	Y	N	Nototheniidae	*Notothenia rossii*	Y	Y
Harpagiferidae	*Harpagifer georgianus*	Y	N	Nototheniidae	*Notothenia coriiceps*	Y	Y
Harpagiferidae	*Harpagifer antarcticus*	N	Y	Nototheniidae	*Paranotothenia magellanica*	Y	Y
Liparidae	*Careproctus georgianus*	Y	N	Nototheniidae	*Patagonotothen guntheri*	Y	N
Liparidae	*Paraliparis copei gibbericeps*	Y	N	Nototheniidae	*Patagonotothen ramsayi*	Y	N
Liparidae	*Paraliparis gracilis*	Y	Y	Nototheniidae	*Pleuragramma antarcticum*	Y	Y
Liparidae	*Paraliparis diplopora*	Y	N	Nototheniidae	*Trematomus hansoni*	Y	Y
Liparidae	*Paraliparis tetrapteryx*	Y	N	Nototheniidae	*Trematomus vicarius*	Y	N
Liparidae	*Paraliparis kreffti*	Y	N	Oneirodidae	*Oneirodes notius*	Y	N
Liparidae	*Paraliparis stehmanni*	Y	N	Ophidiidae	*Genypterus blacodes*	Y	N
Macrouridae	*Coryphaenoides subserrulatus*	Y	N	Paralepididae	*Notolepis coatsi*	Y	N
Macrouridae	*Coelorinchus marinii*	Y	N	Paralepididae	*Notolepis annulata*	Y	N
Macrouridae	*Cynomacrurus piriei*	Y	Y	Scopelarchidae	*Benthalbella elongata*	Y	Y
Macrouridae	*Macrourus holotrachys*	Y	N	Scopelarchidae	*Benthalbella macropinna*	Y	N
Macrouridae	*Macrourus whitsoni*	Y	Y	Sternoptychidae	*Argyropelecus hemigymnus*	Y	N
Macrouridae	*Macrourus carinatus*	Y	N	Stomiidae	*Borostomias antarcticus*	Y	Y
Melamphidae	*Poromitra crassiceps*	Y	N	Stomiidae	*Stomias boa boa*	Y	N
Melamphidae	*Sio nordenskjoldi*	Y	Y	Stomiidae	*Stomias gracilis*	Y	Y
Microstomatidae	*Nansenia antarctica*	Y	N	Zoarcidae	*Melanostigma gelatinosum*	Y	Y
Moridae	*Antimora rostrata*	Y	Y	Zoarcidae	*Dieidolycus leptodermatus*	Y	N
Moridae	*Halagyreus johnsonii*	Y	N	Zoarcidae	*Lycenchelys antarctica*	Y	Y
Moridae	*Lepidion* sp.	Y	N	Zoarcidae	*Lycenchelys bellingshauseni*	Y	N
Muraenolepididae	*Muraenolepis microps*	Y	Y	Zoarcidae	Lycodapus antarcticus	Y	Y
Muraenolepididae	*Muraenolepis* sp. 1	N	Y	Zoarcidae	*Lycodapus pachysoma*	Y	N
Myctophidae	*Electrona antarctica*	Y	Y	Zoarcidae	*Oidiphorus macallisteri*	Y	N
Myctophidae	*Electrona carlsbergi*	Y	Y	Zoarcidae	*Seleniolycus laevifasciatus*	N	Y
Myctophidae	*Electrona subaspera*	Y	N	Petromyzontidae	*Geotria australis*	Y	N
Myctophidae	*Gymnoscopelus bolini*	Y	Y	Rajidae	*Bathyraja meridionalis*	Y	N
Myctophidae	*Gymnoscopelus braueri*	Y	Y	Rajidae	*Raja georgiana*	Y	Y
Myctophidae	*Gymnoscopelus fraseri*	Y	Y	Lamnidae	*Lamna nasus*	Y	N
Myctophidae	*Gymnoscopelus hintonoides*	Y	N	Lamnidae	*Somiosus microcephalus*	Y	N

Appendix VIII: Cephalopods from the South Georgia and South Sandwich Islands Marine Protected Area

Order	Family	Species
Decapoda	Bathyteuthidae	*Bathyteuthis abyssicola*
	Batoteuthidae	*Batoteuthis skolops*
	Brachioteuthidae	*Slosarczykovia circumantarctica*
	Chiroteuthidae	*Chiroteuthis veranyi*
	Cranchiidae	*Galiteuthis glacialis*
	Cranchiidae	*Mesonychoteuthis hamiltoni*
	Gonatidae	*Gonatus antarcticus*
	Histioteuthidae	*Histioteuthis eltaninae*
	Mastigoteuthidae	*Mastigoteuthis psychrophila*
	Neoteuthidae	*Alluroteuthis antarcticus*
	Ommastrephidae	*Martialia hyadesi*
	Onychoteuthidae	*Kondakovia longimana*
	Onychoteuthidae	*Moroteuthis ingens*
	Onychoteuthidae	*Moroteuthis knipovitchi*
	Psychroteuthidae	*Psychroteuthis glacialis*
Octopoda	Cirroctopodidae	*Cirroctopus glacialis*
	Octopodidae	*Adelieledone polymorpha*
	Octopodidae	*Graneledone antarctica*
	Octopodidae	*Graneledone macrotyla*
	Octopodidae	*Pareledone turqueti*
	Octopodidae	*Thaumeledone gunteri*
	Opisthoteuthidae	*Opisthoteuthis hardyi*
	Stauroteuthidae	*Stauroteuthis gilchristi*

Appendix IX: Marine mammals present in the South Georgia and South Sandwich Islands Marine Protected Area

Order	Species	Common name	SG	SSI
Cetacea	*Eubalaena australis*	Southern right whale	Y	Y
	Balaenoptera musculus	blue whale	Y	Y
	Balaenoptera physalis	fin whale	Y	Y
	Balaenoptera borealis	sei whale	Y	P
	Balaenoptera bonaerensis	Antarctic minke whale	Y	Y
	Megaptera novaeangliae	humpback whale	Y	Y
	Physeter macrocephalus	sperm whale	Y	Y
	Hyperodon planifrons	southern bottlenose whale	Y	Y
	Orcinus orca	killer whale	Y	Y
	Globicephala melas	long-finned pilot whale	Y	?
	Lagenorhynchus cruciger	hourglass dolphin	Y	Y
	Australophocaena dioptrica	spectacled porpoise	Y	Y
Carnivora	*Artocephalus gazella*	Antarctic fur seal	B	B
	Leptonychotes weddellii	Weddell seal	B	Y
	Hydrurga leptonyx	leopard seal	Y	Y
	Mirounga leonina	elephant seal	B	PB
	Lobodon carcinophagus	crabeater seal	R	Y

Marine mammals in South Georgia and South Sandwich Islands waters with data from Shirihai, H. and Jarrett, B. (2006). Y = present; B = breeding; P= probably present; PB = probable breeder; R = rare.

Appendix X: Seabirds that forage in the South Georgia and South Sandwich Islands Marine Protected Area

Species	Common name	Breeding pairs SG	Breeding pairs SSI	Global	IUCN
Spheniscidae					
Aptenodytes patagonicus	king penguin	450,000	Rare	2,000,000	LC
Aptenodytes fosteri	emperor penguin	NB	NB	270,000	LC
Eudyptes chrysocome	rockhopper penguin	NB	NB	750,000	VU
Eudyptes chrysolophus	macaroni penguin	1,000,000	Abundant	18,000,000	VU
Pygoscelis adeliae	Adelie penguin	2	Abundant	4,500,000	LC
Pygoscelis antarctica	chinstrap penguin	12,000	Abundant	8,000,000	LC
Pygoscelis papua	gentoo penguin	105,000	Common	520,000	NT
Diomedeidae					
Diomedea exulans	wandering albatross	1,500	NB	26,000	VU
Diomedea epomophora	southern royal albatross	NB	NB	28,000	VU
Phoebetria palpebrata	light-mantled sooty albatross	5,000	NB	58,000	NT
Phoebetria fusca	sooty albatross	NB	NB	12,500	EN
Thalassarche chrysostoma	grey-headed albatross	47,800	NB	250,000	VU
Thalassarche melanophrys	black-browed albatross	75,500	NB	1,200,000	EN
Thalassarche steadi	white-capped albatross	1	NB	150,000	NT
Hydrobatidae					
Fregetta tropica	black-bellied storm-petrel	10,000	AB	500,000	LC
Garrodia nereis	grey-backed storm-petrel	Very rare	NB	200,000	LC
Oceanites oceanicus	Wilson's storm-petrel	600,000	Abundant	20,000,000	LC
Pelecanoididae					
Pelecanoides georgicus	South Georgia diving-petrel	2,000,000		15,000,000	LC
Pelecanoides urinatrix	common diving-petrel	3,800,000	NB	16,000,000	LC
Procellariidae					
Daption capense	Cape petrel	10,000	Abundant	2,000,000	LC
Fulmarus glacialoides	Antarctic fulmar	NB	Abundant	4,000,000	LC
Halobaena caerulea	blue petrel	70,000	NB	3,000,000	LC
Macronectes giganteus	southern giant petrel	8,700	1,882	97,000	LC
Macronectes halli	northern giant petrel	17,200	NB	19,000	LC
Pachyptila belcheri	thin-billed prion	NB	NB	7,000,000	LC
Pachyptila desolata	Antarctic prion	22,000,000	Possible	50,000,000	LC
Pachyptila turtur	fairy prion	1,000	Possible	5,000,000	LC
Pachyptila vittata	broad-billed prion	NB	NB	15,000,000	LC
Pagodroma nivea	snow petrel	3,000	Common	4,000,000	LC
Procellaria aequinoctialis	white-chinned petrel	900,000	NB	3,500,000	VU
Procellaria cinerea	grey petrel	NB	NB	400,000	NT
Pterodroma incerta	Atlantic petrel	NB	NB	5,000,000	EN
Pterodroma macroptera	great-winged petrel	NB	NB	1,500,000	LC
Pterodroma lessonii	white-headed petrel	NB	NB	600,000	LC
Lugensa brevirostris	Kerguelen petrel	Rare	NB	1,000,000	LC
Pterodroma mollis	soft-plumaged petrel	NB	NB	5,000,000	LC
Puffinus gravis	great shearwater	NB	NB	15,000,000	LC
Puffinus griseus	sooty shearwater	NB	NB	20,000,000	NT
Puffinus assimilis	little shearwaters	NB	NB	900,000	LC
Thalassoica antarctica	Antarctic petrel	NB	NB	15,000,000	LC
Phalacrocoracidae					
Phalacrocorax atriceps	imperial shag	10,300	Scarce	500,000	LC
Laridae					
Larus dominicanus	kelp gull	2,000	Rare	3,800,000	LC
Stercorariidae					
Stercorarius antarcticus	brown skua	2,000	SB	15,000	LC
Stercorarius maccormickii	South Polar skua	NB	Possible	10,000	LC
Sternidae					
Sterna vittata	Antarctic tern	2,500	Rare	135,000	LC

Attachment B
Seismic Source Acoustic Modeling Data
prepared by Lamont-Doherty Earth Observatory

Elements for the "Airgun Description" section.

The R/V *Nathaniel B. Palmer* would tow a pair of 105-in^3 Sercel GI airguns and would acquire data at a cruising speed of ~ 5 knots. Seismic pulses would be emitted at intervals of 5 seconds or longer. Data would be recorded on a 100-m long, 24-channel streamer. Acquisition is planned along a series of predetermined lines in waters 100 to 1000 m in depth.

The two GI guns would be towed on a string at 3 m spacing from each other, at a tow depth of 3-4 m. The source would include a hot spare in case one of the elements breaks down. The source would be towed between 15 and 40 m astern.

As the survey line progresses, the towed hydrophone array (streamer) receives the reflected signals and transfers the data to the on-board acquisition system. Given the relatively short streamer length behind the vessel, the turning rate of the vessel while the gear is deployed is much higher than the limit of five degrees per minute for a seismic vessel towing a streamer of more typical length (>>l km). Thus, the maneuverability of the vessel is not limited much during operations.

The GI guns would be used in harmonic mode, that is, the volume of the injector chamber (I) of each GI gun is equal to that of its generator chamber (G): G=I=105 in^3 (1721 cm^3) for each GI gun. The generator chamber is the one responsible for introducing the sound pulse into the ocean. The injector chamber injects air into the previously-generated bubble to maintain its shape and thus prevent further oscillations, and does not introduce more acoustic energy into the water. The Nucleus modeling software used at Lamont-Doherty Earth Observatory of Columbia University (L-DEO) does not include GI guns as part of its airgun library, however signatures and mitigation models have been obtained for two 105-in^3 G guns that are close approximations. A tow depth of 4 m is assumed and would result in the largest radii.

The source output (downward) associated with this 210 in^3 total generator volume would be 234.1 dB re 1 μPa·m for 0-pk and 239.8 dB re 1 μPa·m for pk-pk. These numbers were determined using the aforementioned G-gun approximation to the GI gun and using signatures filtered with DFS V out-256 Hz 72 dB/octave. The dominant frequency range would be 20-150 Hz for a pair of GI guns towed at 4 m depth.

The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source, that is, 228.3 dB pk or 234.0 dB pk-pk. Actual levels experienced by any organism more than 1 m from either GI gun would be significantly lower.

A further consideration is that the rms (root mean square) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (0–pk) or peak to peak (pk–pk) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received level of 160 dB re 1 μPa rms in the far field would typically correspond to ~170 dB re 1 μPa pk, and to ~176–178 dB re 1 μPa pk-pk, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise

difference between rms and peak or peak- to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

Proposed Exclusion Zones

Received sound levels have been modeled by Lamont-Doherty Earth Observatory of Columbia University (L-DEO) for a number of airgun configurations, including two 105-in^3 G guns, in relation to distance and direction from the airguns (Fig. 2). The model does not allow for bottom interactions, and is most directly applicable to deep water. Because the model results are for G guns, which have more energy than GI guns of the same size, those distances overestimate (by ~10%) the distances for GI airguns; no adjustment is made to correct for this.

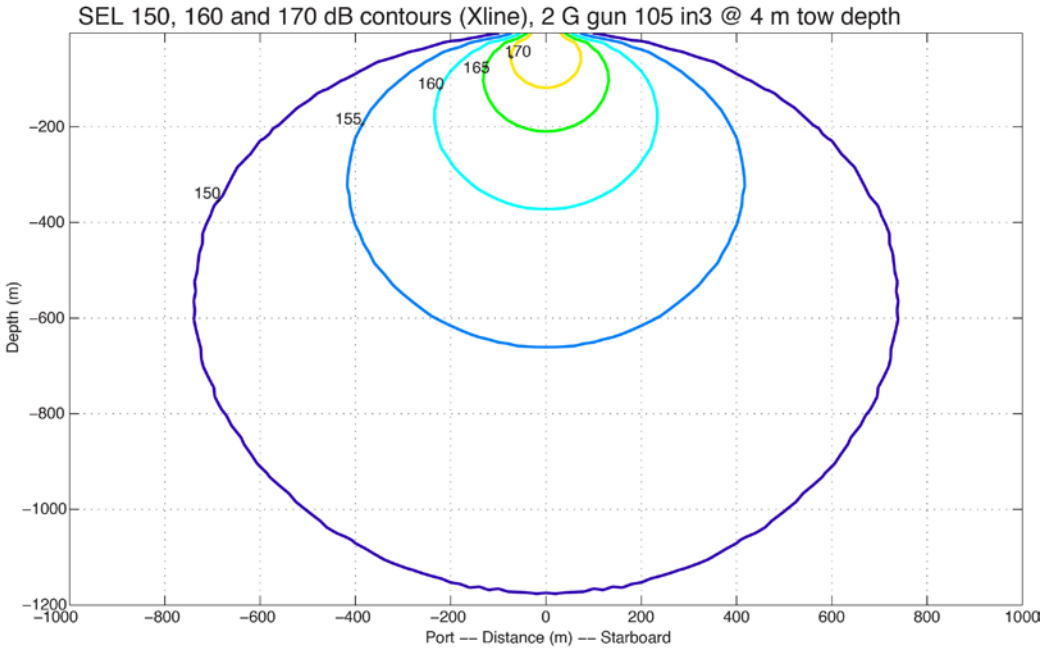
Empirical measurements concerning the 180- and 160-dB re 1 μPa (rms) distances ("radii" around the source) have been acquired for various airgun arrays during acoustic verification studies conducted by L-DEO in the northern Gulf of Mexico in 2003 (6-, 10-, 12-, and 20-airgun arrays, and 2 GI airguns; Tolstoy et al. 2004 [Referenced in PEIS Appendix H]) and 2007–2008 (18- and 36-airgun arrays; Tolstoy et al. 2009; PEIS Appendix H [Diebold et al. 2010]). For the 2 x 105-in^3 GI gun source, measurements were obtained only in shallow water. When compared to measurements acquired in deep water (>1000 m), mitigation radii provided by the L-DEO model are found to be conservative. The acoustic verification surveys also showed that distances to given received levels vary with water depth - these are larger in shallow water, while intermediate/slope environments show characteristics intermediate between those of shallow-water and those of deep-water environments - and documented the influence of a sloping seafloor.

The only empirical measurements obtained for intermediate water depths (100–1000 m) during either survey were for the 36-aigun array in 2007–2008 (PEIS Appendix H [Diebold et al. 2010]). Following results obtained at this site (PEIS Appendix H [Diebold et al., 2010]; their Fig. 16) and earlier practice, a correction factor of 1.5, irrespective of distance to the array, is used to derive intermediate-water radii from modeled deep-water radii. Estimates of the maximum distances from the GI guns where sound levels of 160, 180 and 190 dB re 1 μPa (rms) are predicted to be received in intermediate (100–1000 m) water are shown in Table 1: distances of 739 m, 74 m and 24 m, respectively, are obtained from L-DEO model results in deep water (Fig. 2), which after multiplication by the correction factor of 1.5 become 1109 m, 111 m, and 36 m in intermediate water depth environments.

The PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m exclusion zone (EZ) for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 105-in^3 GI airguns. A fixed full mitigation zone (FMZ), or 160 dB "Safety Zone" was not defined in the PEIS for the same suite of low-energy sources, therefore, L-DEO model results for the 105-in^3 G airguns are used here to determine the 160 dB radius.

The 180-dB re 1 μPa_{rms} distance is the safety criterion as specified by NMFS (2000) for cetaceans and 190-dB re 1 μPa_{rms} for pinnipeds. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in other seismic projects (e.g., Smultea et al. 2004; Holst et al. 2005a,b; Holst and Beland 2008; Holst and Smultea 2008; Hauser et al. 2008). If marine mammals or sea turtles are detected within or about to enter the appropriate EZ, the airguns would be shut down immediately.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. NSF would be prepared to revise its procedures for estimating numbers of mammals should NMFS implement new acoustic criteria guidelines. However, currently the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al (2013), and Wright (2014).



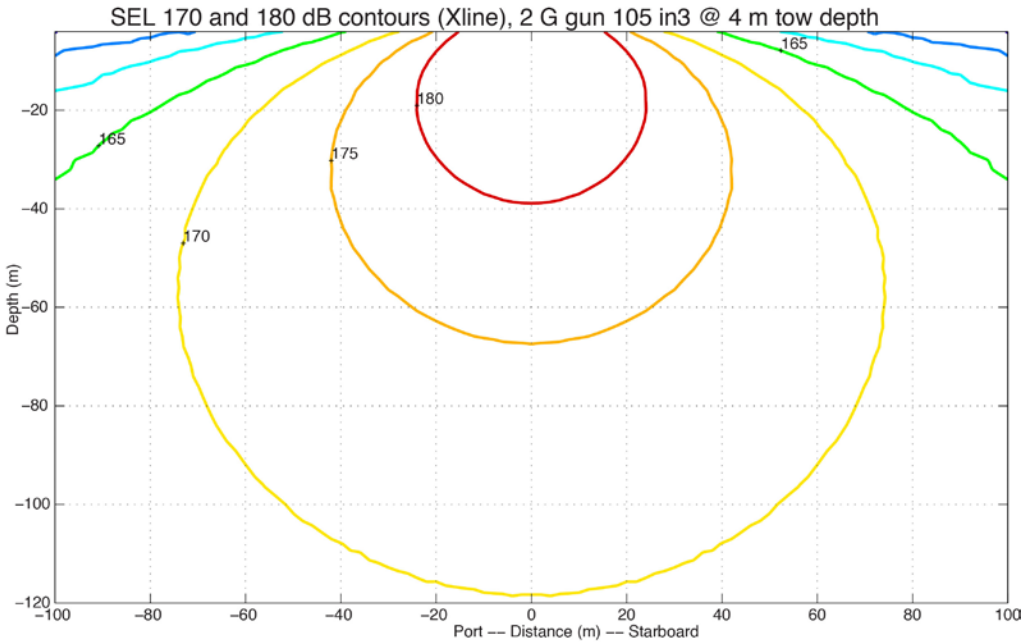


Figure 2. Deep-water model results showing received sound levels from two 105-in^3 G guns at 4 m tow depth, similar to the two 105-in^3 GI airguns that would be used during the *R/V Palmer* survey in the Ross Sea in January 2015. The distance to the 150 dB SEL contour (proxy for 160 dB RMS) is 739 m, the distance to the 170 dB SEL contour (proxy for 180 dB RMS) is 74 m, and the distance to the 180 dB SEL contour (proxy for 190 dB RMS) is 24 m. Model results provided by L-DEO.

Table 1. Predicted distances to which sound levels of 190, 180 and 160 dB re 1 μPa (rms) might be received from two 105-in^3 G guns, similar to the two 105-in^3 GI guns that would be used during the *R/V Palmer* survey in the Ross Sea in January 2015. Distances are based on model results provided by L-DEO (presented in Fig. 2). The Exclusion Zones (EZs) and Full Mitigation Zone (FMZs) proposed for this survey are provided below and are based on model results and standard EZs established in the PEIS for low energy sources.

Source and volume	Water depth	Predicted RMS radii (m) based on modelling			Proposed EZ and FMZ based on modelling and PEIS	
2 x 105 in^3 GI guns 4 m tow depth		190 dB	180 dB	160 dB	EZ (190/180 dB)	FMZ
	100-1000 m	36	111	1109	100/100	1109

Attachment C

Species Cross Reference

Species / Scientific Name	Common Name
Aptenodytes forsteri	Emperor penguin
Aptenodytes patagonicus	King penguin
Arctocephalus gazella	Antarctic fur seal, Kerguelen fur seal
Balaenoptera acutorostrata	Minke whale, dwarf minke whale
Balaenoptera bonaerensis	Antarctic minke whale
Balaenoptera borealis	Sei whale
Balaenoptera edeni	Bryde's whale, Omura's whale
Balaenoptera musculus	Blue whale, sibbald's rorqual, sulphur-bottom whale
Balaenoptera physalus	Fin whale, common rorqual, fin-backed whale, finback, finner, herring whale, razorback
Berardius arnuxii	Arnoux's beaked whale, Southern four-toothed whale
Caperea marginata	Pygmy right whale
Cephalorhynchus commersonii	Commerson's dolphin
Eubalaena australis	Southern right whale
Globicephala melas	Long-finned pilot whale
Grampus griseus	Risso's dolphin
Hydrurga leptonyx	Leopard seal
Hyperoodon planifrons	Southern bottlenose whale, flatheaded bottlenose whale
Hyperoodon spp	Bottlenose whales
Indopacetus pacificus	Longman's beaked whale
Kogia breviceps	Pygmy and dwarf sperm whales
Kogia sima	Dwarf sperm whale
Lagenodelphis hosei	Fraser's dolphin
Lagenorhynchus australis	Peale's Dolphin
Lagenorhynchus cruciger	Hourglass dolphin
Lagenorhynchus obscurus	Dusky dolphin
Lagenorhyncus cruciger	Hourglass dolphin
Leptonychotes weddellii	Weddell seal
Lissodelphis peronii	Southern Right whale dolphin
Lobodon carcinophagus	Crabeater seal
Megaptera novaeangliae	Humpback whale
Mesoplodon grayi	Gray's beaked whale, southern beaked whale
Mesoplodon layardii	Layard's beaked whale, strap-toothed whale
Mirounga leonina	Southern Elephant Seal
Neophocaena phocaenoides	Finless porpoise
Ommatophoca rossiigray	Ross seal
Orcinus orca	Killer whale, Orca

Species / Scientific Name	Common Name
Oreaella brevirostris	Irrawaddy (snubfin) dolphin
Peponocephala electra	Melon-headed whale
Phocoena dioptrica (Australophocaena dioptrica)	Spectacled porpoise
Physeter macrocephalus	Sperm whale
Pseudorca crassidens	False killer whale
Pygoscelis adeliae	Adelie penguin
Pygoscelis antarcticus	Chinstrap penguin
Pygoscelis papua	Gentoo penguin
Sotalia fluviatilis	Tucuxi dolphin
Sousa chinensis	Indo-Pacific humpbacked dolphin
Steno bredanensis	Rough-toothed dolphin
Tasmacetus shepherdi	Shepherd's beaked whale
Tursiops spp.	Bottlenose dolphins
Tursiops truncatus aduncus	Southern bottlenose dolphin
Ziphius cavirostris	Cuvier's beaked whale

Scotia Sea and South Atlantic Ocean Marine Mammals Sightings Data Sources

Reference	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area	Observation Period	Counts (for density calc)	Methodology	Comments
Cetaceans							
Scotia Sea (BAS)	RRS James Clark Ross/Antarctic 2004-2005/March 20 (BAS website screen)	Scotia Sea around South Georgia Island	Sightings data were collected in proximity to the proposed study area (0 miles and near proximity 200 miles)	March 2005		Online summary of species observed	Diary of activities during cruise and species observed
Scotia Sea (James Clark Ross, Cruise JR82) [three different reports]	*Cruise report of cetacean survey in the Scotia Sea from British Antarctic Survey vessel RRS James Clark Ross, 7 January to 23 February 2003* *Large Scale Distibution in the Scotia Sea, JR82 Scientific Cruise, January and February 2003, Cruise Report (Biological Science Division, British Antarctic Survey)* *Baleen whales in the Scotia Sea during January and February 2003 (Sirovic, et al.,)*	Scotia Sea, ~52^0 to 63^{0}S latitude, 25^0 to 60^{0}W longitude	Sightings data were collected in proximity to the proposed study area (2003 RRS Ross cruise report: 0-200 miles)(JR82- 2003 BAS Report: 0 miles and near proximity [200 miles]) (Sirovic: S.Georgia Island to Falklandsto West Penninsula; 0- to 1,000 miles)	7 January - 23 February 2003	√	a) Directed study: predetermined transects; b) IWC Obsevers; c) Single platform observations (per IWC-CCAMLR protocol)	Survey objectives were to collect systematic survey data to determine distribution and abundance of cetaceans
South Georgia (Richardson)	*Evaluating opportunistic sighting records of large whales around South Georgia Island: Changes in distribution, relative abundance, and species composition of sightings and the efficacy of reporting methods (Richardson, May 2012)*	South Georgia, Bird Island	Sightings data were collected in proximity to the proposed study area (Overlaps with proposed study site: Siting area centered on South Georgia Island; zero kilometers)	1991-2010		Summary of whale sightings reported from 1991-2010; semi-quantitative survey (opportunistic)	
Baleen Whales (Williams)	*Modeling Distribution and Abundance of Antarctic Baleen Whales Using Ships of Opportunity (Williams, 2006).*	Scotia Sea and Antarctic Peninsula region	Sightings data were collected in proximity to the proposed study area (started or ended in Ushuaia, Argentina; in the South Atlantic sector of the Southern Ocean (possibly in the Drake Passage and along the Antarctic Peninsula. Distance undetermined but likely several hundred miles distant)	austral summer period, 2000–2001 and 2001–2002			Describes data collection and modeling efforts; number of sightings or density information not provided
AMLR	*AMLR 2009/2010 FIELD SEASON REPORT (SFSC, January 2011)*	Scotia Sea, ~60^0 to 63^{0}S latitude, 54^0 to 63^{0}W longitude	Sightings data were collected in proximity to the proposed study area (South Shetland Islands, Elephant Island and the Antarctic Peninsula; approximately 900 to 1,000 miles SW)	28 January – 05 February; 22 February - 6 March 2010	√	a) Directed study: predetermined transects; b) "experienced observers" c) Sightings were observed in a 180^0 arc forward of and up to 3 km away from the vessel.	Total number of animals/km were reported
South Georgia (Rossi-Santos)	*Cetacean sightings near South Georgia islands, South Atlantic Ocean (Rossi-Santos, et al., 2007)*	South Georgia Island	Sightings data were collected in proximity to the proposed study area (South Georgia Islands a north; partial overlap with proposed study area and north~ 0-400 miles)	28 January to 2 March 2006	√	a) Directed study, 13 different cruises (700 nautical miles); b) observer experience not specified c) Sightings were observed in a 180^0 visual field angle from the bow.	Primary goal of gathering information on a feeding ground of humpback whales
Scotia Sea (Reyes)	*Ocurrence of cetaceans in the Scotia Sea during February-March 2013 (Reyes Reyes, M.V1 and Iñíguez, M., 2013)*	Scotia Sea, around South Orkney Islands	Sightings data were collected in proximity to the proposed study area (South Shetland Islands to South Orkney Islands area to Ushuaia, Argentina; 400 to 900 miles)	19 February - 14 March 2013	√	a) Opportunistic study along predetermined transects (1,812.4 nautical miles); b) observer experience not specified c) Sightings were observed from the bridge and exterior wings of the bridge	Encounter rate (no. ind/nautical mile) were reported

Scotia Sea and South Atlantic Ocean Marine Mammals Sightings Data Sources

Reference	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area	Observation Period	Counts (for density calc)	Methodology	Comments
South Georgia (Moore)	*Relative abundance of Large Whales Around South Georgia (1979-1998) (Moore, et. al., 1999).*	Three databases: 1997 cruise, observations from Bird Island (1979-1998), and mariner sightings (1992 -	Sightings data were collected in proximity to the proposed study area (Bird Island and South Georgia Island; 0 miles)			No information available on methodologies	Report acknowledges that the data indicates relative abundance
Scotia Sea (Polar Stern, CCAMLR)	*Fall feeding aggregations of fin whales off Elephant Island Antarctica (Burkhardt & Lanfredi, 2012)*	Scotia Sea (Elephant Island - South Shetland Island - Joinville Island area)	Sightings data were collected in proximity to the proposed study area (Elephant Island - South Shetland Island - Joinville Island area) ~ 1,253 kilometres (779 mi) WSW of South Georgia	13 March - 9 April 2012	√	a) Opportunistic study during fishery investigation; b) "trained observers" c) Sightings were observed from the bridge of the vessel *Polarstern* during daylight hours.	Although the study was focused on fin whales, all whale species sighted were recorded. Based on data researchers concluded that Elephant Island is an important feeding area for fin whales
Navy Marine Species Density Database, Technical Report (NMSDD)	*Commander Task Force 20, 4th, and 6th Fleet Navy Marine Species Density Database Technical Report (prepared by NAVFAC, 30 March 2012)*	various	Sightings data were collected in proximity to the proposed study area (NMFS line transect protocol) (Undetermined)	various	√	Unknown	Maps with densities for twelve species
NOAA-SWFSC LOA 2013	*Request for Rulemaking and Letters of Authorization under Section 101(A)(5)(A) of the Marine Mammal Protection Act for the Take of Marine Mammals Incidental to Fisheries and Ecosystem Research Activities Conducted by NOAA Fisheries Southwest Fisheries Science Center Within The California Current Ecosystem, Eastern Tropical Pacific Ecosystem, and Antarctic Ecosystem.*	Marine mammal densities presented in this document were based on data provided in *Distribution, Abundance and Behavior of Seabirds and Mammals at Sea Antarctic Marine Living Resources Program 2008-2009 Field Season Report.* NOAA-TM-NMFS-SWFSC-445. Santora, Jarrod A. et al. 2009. The 2008/09 AMLR Survey Area for marine mammals covered ~60^0 to 66^0S latitude, 54^0 to 63^0W longitude.	Sightings data were collected ~ 400 km southwest of the proposed study area	January 2009	√	26 survey days; strip transect methods	Scotia Sea sector of the Southern Ocean, including the continental shelf adjacent to the Antarctic Peninsula, and the South Shetland, South Orkney, South Sandwich and South Georgia archipelagos
Pinnipeds							
Scotia Sea (James Clark Ross, Cruise JR82)	Cruise report of cetacean survey in the Scotia Sea from British	Scotia Sea, ~52^0 to 63^0S latitude, 25^0 to 60^0W longitude	Sightings data were collected in proximity to the proposed study area (0 miles and near proximity [200 miles])	7 January - 23 February 2003	√	a) Directed study: predetermined transects; b) IWC Obsevers; c) Single platform observations (per IWC-CCAMLR protocol)	Observations of seals hauled out on ice and in the water.
Seal Studies on Bird Island (BAS)	*Leopard Seal Studies on Bird Island*	Bird Island	Sightings data were collected in proximity to the proposed study area (0 miles and near proximity [200 miles])	1994-2004			Observations of visible beaches only.
	Antarctic fur seal monitoring on Bird Island	Bird Island	Sightings data were collected in proximity to the proposed study area (0 miles and near proximity [200 miles])	1995-2008			Observations of visible beaches only.

Scotia Sea and South Atlantic Ocean Marine Mammals Sightings Data Sources

Reference	Full Title (author)	Cited Observation Area	Proximity of Observation Area to Proposed Study Area	Observation Period	Counts (for density calc)	Methodology	Comments
NOAA-SWFSC LOA 2013	*Request for Rulemaking and Letters of Authorization under Section 101(A)(5)(A) of the Marine Mammal Protection Act for the Take of Marine Mammals Incidental to Fisheries and Ecosystem Research Activities Conducted by NOAA Fisheries Southwest Fisheries Science Center Within The California Current Ecosystem, Eastern Tropical Pacific Ecosystem, and Antarctic Ecosystem.*	Marine mammal densities based on data provided in *Distribution, Abundance and Behavior of Seabirds and Mammals at Sea Antarctic Marine Living Resources Program 2008-2009 Field Season Report.* NOAA-TM-NMFS-SWFSC-445. Santora, Jarrod A. et al. 2009. The 2008/09 AMLR Survey Area for marine mammals covered ~60^0 to 66^0S latitude, 54^0 to 63^0W longitude.	Sightings data were collected ~ 400 km southwest of the proposed study area	January 2009	√	26 survey days; strip transect methods	Scotia Sea sector of the Southern Ocean, including the continental shelf adjacent to the Antarctic Peninsula, and the South Shetland, South Orkney, South Sandwich and South Georgia archipelagos
South Sandwich Islands, Clerke Rocks (Poncet)	*1997 Distribution and Abundance Survey of Seabirds and Seals at the South Sandwich Islands in the Scotia Sea (Poncet, 1997)*	various	Sightings data were collected in proximity to the proposed study area (0 miles and near proximity [200 miles])	15 January - 15 February 1997			Observations of visible beaches only.

Scotia Sea and South Atlantic Ocean Marine Mammals Sightings Data Sources

Reference	Scotia Sea (BAS)	South Georgia (Richardson)	Baleen Whales (Williams)	AMLR	NOAA-SWFSC LOA 2013 (Table 6.11) (#/km^2)	NMSDD (#/km^2)	South Georgia (Rossi-Santos)	Scotia Sea (Reyes)	South Georgia (Moore)	Scotia Sea (Sirovic, BAS)	Scotia Sea (Burkhardt & Lanfredi, CCAMLR)
Observation period	**March 2005**	**1991-2010**	**2000-2002**	**2009-10**			**Jan-Mar 2006**	**Feb-Mar 2013**	**1979-1998**	**Jan-Feb 2003**	**Mar-Apr 2012**
Numerical counts reported				**√**			**√**	**√**		**√**	**√**
Mysticetes											
Blue whale		X			0.00012	0.0000470			X		
Fin whale	X	X	X	X	0.0839	0.0182040	X	X	X	X	X
Humpback whale		X	X	X	0.0361	0.000661	X	X	X	X	X
Minke whale	X	X	X	X	0.0018	0.155792		X	X	X	X
Sei whale	X	X				0.006359		X	X	X	
Southern Right Whale	X	X		X	0.00041		X	X	X	X	
Baleen Whale (unidentified)											
Odontocetes											
Arnoux's beaked whale					0.0006	0.011379					
Grays beaked whale						0.001885		X			
Hourglass dolphin	X	X		X	0.0015		X	X		X	
Killer whale		X		X	0.0015	0.01538	X		X	X	X
Layard's beaked whale							X				
Long-finned pilot whale	X	X			0.0076	0.214557			X	X	
Peale's dolphin										X	
Shepard's beaked whale						0.006269					
Southern bottlenose whale	X			X	0.0006			X		X	
Southern right whale dolphin						0.006161					
Spectacled porpoise					0.0015						
Sperm whale					0.00065				X	X	
Beaked whale (unidentified)		X							X	X	

Pinnipeds					
Reference	**Scotia Sea (Sirovic, BAS)**	**Bird Island (BAS)**	**South Sandwich Is. (Poncet)**	**Clerke Rocks (Poncet)**	**NOAA-SWFSC LOA 2013 (Table 6.11) (#/km^2)**
Observation period	**Jan-Feb 2003**	**1995-2008**	**1997**	**1997**	
Numerical counts reported	**√**	**√**	**√**	**√**	
Antarctic Fur Seal	X	X	X	X	0.0999
Crabeater	X				0.64865
Leopard	X	X	X		0.01622
Weddell	X		X		0.05405
Elephant			X		0.0003

Notes: √ = data available; X = Species observed during survey

NMSDD = Naval Marine Species Density Database presents density data, by season, for the Scotia Sea and Southern Ocean. and includes models by Kashyner and SMU Ltd.

NOAA-SWFSC 2013 = Request for Rulemaking and Letters of Authorization under Section 101(A)(5)(A) of the Marine Mammal Protection Act for the Take of Marine Mammals Incidental to Fisheries and Ecosystem Research Activities Conducted by NOAA Fisheries Southwest Fisheries Science Center Within The California Current Ecosystem, Eastern Tropical Pacific Ecosystem, and Antarctic Ecosystem.

Cetacean Observed and Estimated Densities in the Scotia Sea and South Atlantic Ocean

Common Name	Area Surveyed (km)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported) Note 1	Estimated Linear Density (#/km)	Half Strip-width (km) Note 3	Visual Transect width (km) Note 4	Areal Density (#/ km^2) Note 5	Data Source	Year/Season/Area	Comments
Mysticetes											
Blue whale								0.0000510	NMSDD	Maximum, year-round for the area	
Blue whale		x Note 2		0					Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Blue whale								0.0001200	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Fin whale								0.0182040	NMSDD	Fall, maximum range in the area	
Fin whale	3,239	63	65	325	0.1003396	2.50	5.00	0.0200679	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Fin whale	4,143	36	36	180	0.0434468	2.50	5.00	0.0086894	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Fin whale	3,000	949	1023	5115	1.7050000	2.50	5.00	0.3410000	Burkhardt & Lanfredi	2012 Mar-Apr, 1200+km WSW	295 hrs observation 3,000 km, 10 km/hr
Fin whale	1,296	20	20	100	0.0771605	2.50	5.00	0.0154321	Rossi-Santos	2005 Jan-Mar, in area and 880 km N	110 hr observation 700 nm (1,296 km)
Fin whale	3,356	79	117	585	0.1743147	2.50	5.00	0.0348629	Reyes	2013 Feb-Mar, 880-1900 km WSW	214 hr observation 1812 nm (3,356 km)
Fin whale								0.0839000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Humpback whale								0.0006610	NMSDD	Fall, maximum range in the area	
Humpback whale	3,239	219	222	1110	0.3426984	2.50	5.00	0.0685397	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Humpback whale	4,143	38	38	190	0.0458605	2.50	5.00	0.0091721	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Humpback whale	3,000	24	8	40	0.0133333	2.50	5.00	0.0026667	Burkhardt & Lanfredi	2012 Mar-Apr, 1200+km WSW	295 hrs observation 3,000 km
Humpback whale	1,296	2	2	10	0.0077160	2.50	5.00	0.0015432	Rossi-Santos	2005 Jan-Mar, in area and 880 km N	214 hr observation 1812 nm (3,356 km)
Humpback whale	3,356	120	196.5	983	0.2929082	2.50	5.00	0.0585816	Reyes	2013 Feb-Mar, 880-1900 km WSW	110 hr observation 700 nm (1,296 km)
Humpback whale								0.0361000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Minke whale								0.1557920	NMSDD	Fall, maximum range in the area	
Minke whale	3,239	14	17	85	0.0262427	2.50	5.00	0.0052485	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Minke whale	4,143	72	72	360	0.0868936	2.50	5.00	0.0173787	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Minke whale	3,000	6	2	10	0.0033333	2.50	5.00	0.0006667	Burkhardt & Lanfredi	2012 Mar-Apr, 1200+km WSW	295 hrs observation 3,000 km
Minke whale	3,356	3	6	30	0.0089392	2.50	5.00	0.0017878	Reyes	2013 Feb-Mar, 880-1900 km WSW	214 hr observation 1812 nm (3,356 km)
Minke whale								0.0018000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Sei whale								0.0063590	NMSDD	Fall, maximum range in the area	
Sei whale	3,356	19	37	185	0.0551251	2.50	5.00	0.0110250	Reyes	2013 Feb-Mar, 880-1900 km WSW	214 hr observation 1812 nm (3,356 km)
Sei whale	4,143	8	8	40	0.0096548	2.50	5.00	0.0019310	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Sei whale								--	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Southern right whale	4,143	33	33	165	0.0398262	2.50	5.00	0.0079652	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Southern right whale	3,239	1	2	10	0.0030874	2.50	5.00	0.0006175	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Southern right whale	1,296	3	3	15	0.0115741	2.50	5.00	0.0023148	Rossi-Santos	2005 Jan-Mar, in area and 880 km N	110 hr observation 700 nm (1,296 km)
Southern right whale	3,356	6	23	115	0.0342670	2.50	5.00	0.0068534	Reyes	2013 Feb-Mar, 880-1900 km WSW	214 hr observation 1812 nm (3,356 km)
Southern right whale								0.0004100	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Baleen whale (unidentified)		9	--						AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	
Odontocetes											
Arnoux's beaked whale								0.0006000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Arnoux's beaked whale								0.0113790	NMSDD	Fall, maximum range in the area	
Gray's beaked whale								0.001885	NMSDD	Fall, maximum range in the area	
Gray's beaked whale	3,356	1	1						Reyes	2013 Feb-Mar, 880-1900 km WSW	
Gray's beaked whale								--	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Hourglass dolphin	3,239	28	28	140	0.0432232	2.50	5.00	0.0086446	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Hourglass dolphin	4,143	58	64	320	0.0772387	2.50	5.00	0.0154477	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Hourglass dolphin	1,296	24	24	120	0.0925926	2.50	5.00	0.0185185	Rossi-Santos	2005 Jan-Mar, in area and 880 km N	110 hr observation 700 nm (1,296 km)
Hourglass dolphin	3,356	73	73	365	0.1087604	2.50	5.00	0.0217521	Reyes	2013 Feb-Mar, 880-1900 km WSW	214 hr observation 1812 nm (3,356 km)
Hourglass dolphin								0.0015000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Killer whale	3,239	25	25	125	0.0385922	2.50	5.00	0.0077184	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Killer whale	4,143	33	39	195	0.0470673	2.50	5.00	0.0094135	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Killer whale	3,000	3	1	5	0.0016667	2.50	5.00	0.0003333	Burkhardt & Lanfredi	2012 Mar-Apr, 1200+km WSW	295 hrs observation 3,000 km
Killer whale	1,296	5	5	25	0.0192901	2.50	5.00	0.0038580	Rossi-Santos	2005 Jan-Mar, in area and 880 km N	110 hr observation 700 nm (1,296 km)
Killer whale								0.0153800	NMSDD	Fall, maximum range in the area	
Killer whale								0.0015000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Layard's beaked whale	1,296	1	1	5	0.0038580	2.50	5.00	0.0007716	Rossi-Santos	2005 Jan-Mar, in area and 880 km N	110 hr observation 700 nm (1,296 km)
Long-finned pilot whale	4,143	85	92	460	0.1110307	2.50	5.00	0.0222061	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Long-finned pilot whale								0.2145570	NMSDD	Fall, maximum range in the area	Fall, maximum range in the area
Long-finned pilot whale								0.0076000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Peale's dolphin	4,143	5	11	55	0.0132754	2.50	5.00	0.0026551	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km

Cetacean Observed and Estimated Densities in the Scotia Sea and South Atlantic Ocean

Common Name	Area Surveyed (km)	Animals (#)	Animals (# including unidentified)	Corrected Sightings (assume only 20% reported) Note 1	Estimated Linear Density (#/km)	Half Strip-width (km) Note 3	Visual Transect width (km) Note 4	Areal Density (#/ km^2) Note 5	Data Source	Year/Season/Area	Comments
Peale's dolphin								--	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Shepherd's beaked whale								0.0092690	NMSDD	Fall, maximum range in the area	
Southern bottlenose whale	3,239	9	9	45	0.0138932	2.50	5.00	0.0027786	AMLR 2009/10	2010 Jan-Mar, ~2,200 km SW	200 hr observation 3,239 km
Southern bottlenose whale	3,356	2	2	10	0.0029797	2.50	5.00	0.0005959	Reyes	2013 Feb-Mar, 880-1900 km WSW	214 hr observation 1812 nm (3,356 km)
Southern bottlenose whale	4,143	31	37	185	0.0446536	2.50	5.00	0.0089307	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Southern bottlenose whale								0.0006000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Southern right whale dolphin								0.0061610	NMSDD	Fall, maximum range in the area	
Spectacled porpoise								0.0015000	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Sperm whale								0.0020690	NMSDD	Fall, maximum range in the area	
Sperm whale	4,143	6	12	60	0.0144823	2.50	5.00	0.0028965	Sirovic, BAS	2003 Jan-Feb, area and 400 km	
Sperm whale								0.0006500	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Beaked whale (unidentified)	4,143	37						Note 6	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km

Notes:

NMSDD = Naval Marine Species Density Database; Sirovic, BAS (RRS James Clark Ross Cruise JR82); SWFSC LOA 2013 (based on Santora, et.al., 2009); Burkhardt & Lanfredi, CCAMLR (RV Polar Stern)

[1] Sightings data accounts for all individuals observed in groups; corrected sightings assumes only 20% of animals present were observed and reported.

[2] No visual sightings of blue whales but animals were detected by acoustic monitoring.

[3] Assumes 2.5 km half strip-width on each side of the vessel.

[4] Visual transect width = half strip-width x 2, representing the total width of observations.

[5] Density values (#/km^2) directly from NMSDD or SWFSC LOA as indicated; density values derived from other references calculated by multiplying the linear density (#/km) times 1/visual transect width (km)

[6] Unidentified beaked whales used to estimated numbers of hourglass dolphins, Peale's dolphin, and Southern bottlenose whales

Pinnipeds Observed and Estimated Densities in the Scotia Sea and South Atlantic Ocean

Common Name	Area Surveyed (km)	Animals (#)	Animals (# including unidentified)	Correction Factor Note 1	Estimated # in the Water Note 2	Estimated Linear Density (#/km)	Half Strip-Width (km) Note 3	Visual Transect Width (km) Note 4	Areal Density (#/ km^2)	Data Source	Year/Season/Area	Comments
Antarctic Fur Seal	4,143	1019	1019	1.66	1,692	0.408289	0.40	0.80	0.5103608	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Antarctic Fur Seal	ND	1030	1030	NA	NA	NA		NA	NA	Bird Island (BAS)		Monitoring at SSB (400 m^2)
Antarctic Fur Seal	ND	320	320	NA	NA	NA		NA	NA	Poncet		
Antarctic Fur Seal	ND	196	196	NA	NA	NA		NA	NA	Poncet		
Antarctic Fur Seal									0.09990	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Crabeater	4,143	27	37	1.66	61	0.014825	0.40	0.80	0.0185313	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Crabeater									0.648650	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Leopard	4,143	13	23	1.66	38	0.009216	0.40	0.80	0.0115194	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Leopard	ND	310	310	NA	NA	NA		NA	NA	Bird Island (BAS)		
Leopard	ND	5	5	NA	NA	NA		NA	NA	Poncet		
Leopard									0.016220	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Ross	4,143	--	--		--		0.40	0.80	0.0000000	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Ross									NA	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Weddell	4,143	5	10	1.66	17	0.002196	0.40	0.80	0.0027447	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Weddell	ND	20	20	NA	NA	NA		NA	NA	Poncet		
Weddell									0.054050	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days
Elephant	4,143	--	--		--		0.40	0.80	0.0000000	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km
Elephant	ND	62	62	NA	NA	NA		NA	NA	Poncet		
Elephant									0.00030	SWFSC LOA 2013	Jan 2009, ~1,500 km SW of area	26 survey days, 3,301 km
Unidentified phocid	4,143	25							Note 4	Sirovic, BAS	2003 Jan-Feb, area and 400 km	220 hrs observation 7,560 km

Notes:

Sirovic, BAS (RRS James Clark Ross Cruise JR82); SWFSC LOA 2013 (based on Santora, et.al., 2009)

ND = No data; observations of visible beaches only. NA = Not applicable.

[1] Correction factor for pinnipeds recommended by NOAA; accounts for animals that may be in the water but were not sighted and reported.

[2] Number of animals x correction factor.

[3] Assumes 400 m visual range on each side of the vessel.

[4] Visual Transect Width = visual range x 2, representing the total width of observations.

[5] Unidentified phocids used to estimated numbers of crabeater, leopard, and Weddell seals observed by Sirovic

Advances through collaboration: Sharing seismic reflection data via the Antarctic Seismic Data Library System for Cooperative Research (SDLS)

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Jonathan R. Childs, U.S. Geological Survey, Menlo Park, CA, USA (jchilds@usgs.gov);
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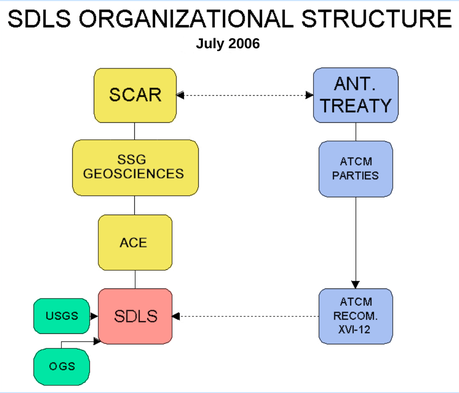
Presented at XXX SCAR 2008, St. Petersburg, Russia, 8-11th July 2008

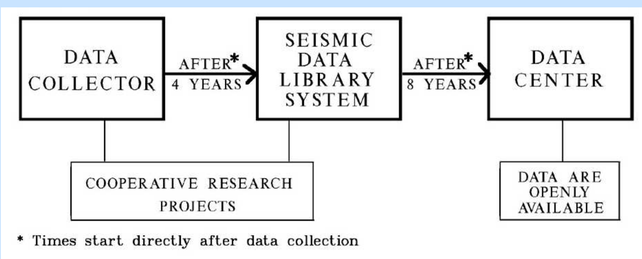


A SCAR COLLABORATIVE (under ATCM recommendation) FOR OPEN ACCESS TO MULTICHANNEL SEISMIC DATA TO FACILITATE COOPERATIVE RESEARCH

SDLS GUIDELINES (from SCAR Report #9)

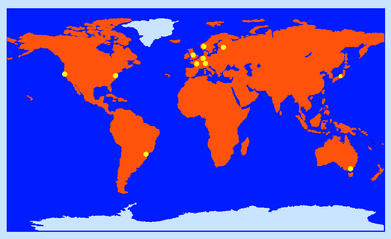
During the period of 4 to 8 years following data collection

1. **Data can only be used for cooperative research projects with the data collector and not for commerce.**
2. **Copies of data can only be made and/or removed from the SDLS branches with the consent of the data collector.**
3. **Data collectors must be offered authorship on papers based on their data, and the source of the data must be properly cited.**
4. **Data collectors must be given a copy of all research products based on their data, including copies of reprocessed data.**
5. **Data collectors must not abuse their preferential "rights" to data.**

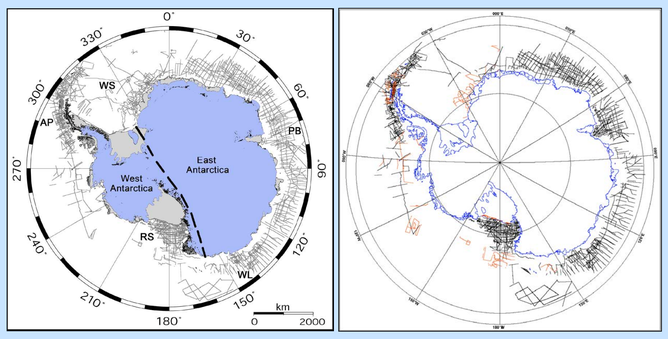


DATA ARE SUBMITTED TO THE SDLS WITHIN 4 YEARS OF DATA COLLECTION

AND SENT TO SDLS AT LIBRARY BRANCHES WORLDWIDE



SDLS Library Branch Locations



Total Antarctic MCS data based on navigation data in the SDLS. (Courtesy Monika Breitzke)

Antarctic MCS data in the SDLS as of July 2008. MCS data in preparation are shown in red

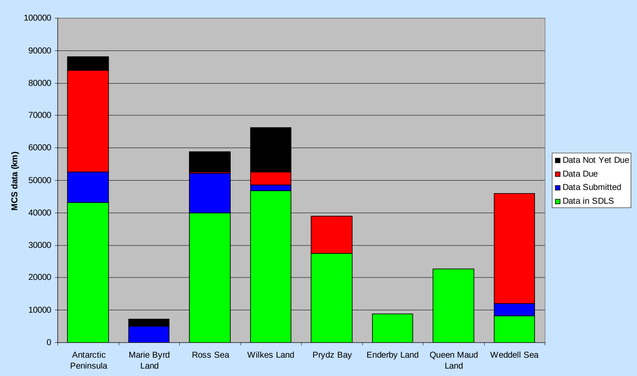
Antarctic MCS data collected and sent to the SDLS by Country

Country	Total MCS data collected to 2008 (km)	Total MCS data collected prior to 2004 (km)	MCS data in SDLS at 1st July 2008 (km)	MCS data in preparation at SDLS (km)	% MCS data submitted to SDLS
Australia	28,652	28,652	28,652	0	100%
Brazil	5,466	5,466	5,466	0	100%
China	2,015	2,015	0	0	0%
France	7,706	7,706	4,900	0	64%
Germany	54,621	52,394	12,599	5,009	34%
Italy	36,168	36,168	28,920	7,248	100%
Japan	48,980	48,980	48,980	0	100%
Korea	6,670	5,250	0	0	0%
New Zealand	3,400	0	0	0	0%
Norway	12,771	12,771	8,924	3,847	100%
Poland	1,100	1,100	0	0	0%
Russia	78,100	64,570	45,350	0	70%
Spain	17,099	14,308	0	0	0%
UK	8,674	8,674	5,034	0	58%
USA	25,604	22,844	8,510	12,174	91%
Totals	337,026	310,898	197,335	28,278	73%

Antarctic Multichannel Seismic Reflection(MCS) cruises by the principal geographic regions (see map below)

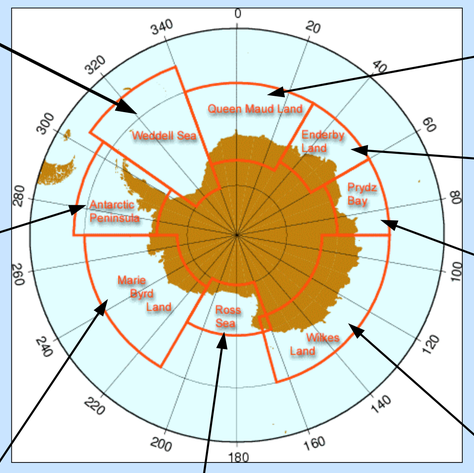
(All MCS data reported up to July 2008)

Area	MCS data	In SDLS	Submitted	Due	Not yet due
Antarctic Peninsula	88136	43181	9461	31283	4211
Marie Byrd Land	7236	0	5009	0	2227
Ross Sea	58832	40008	12174	500	6150
Wilkes Land	66166	46687	1827	4122	13530
Prydz Bay	38931	27565	0	11366	0
Enderby Land	8927	8927	0	0	0
Queen Maud Land	22759	22759	0	0	0
Weddell Sea	46039	8208	3847	33984	0
Total (km)	337026	197335	32318	81255	26118



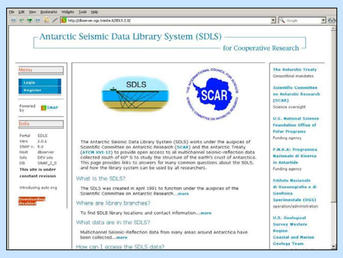
MCS cruises are subdivided into the principal geographic regions around Antarctica and are listed in chronological order.

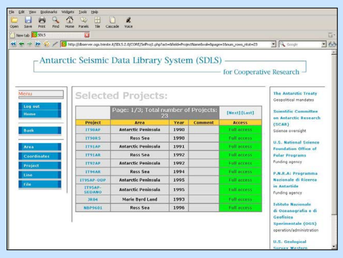
Table Notes:
Cruises for which MCS data exist in the library are shown in **GREEN**.
Cruises for which MCS data have already been submitted and are being prepared for inclusion in the library are shown in **BLUE**.
Cruises for which MCS data are due in the library (i.e. over 4 years old) are shown in **RED**.
Cruises for which MCS data are not yet due are shown in **BLACK**.

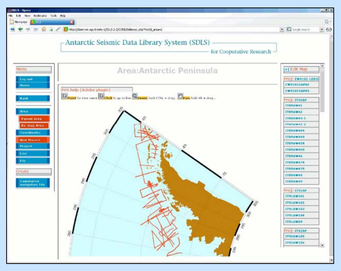


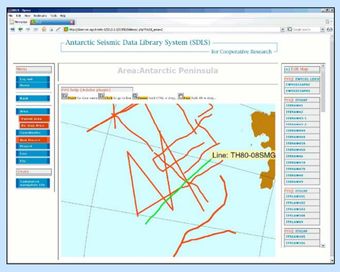
SDLS on the Web

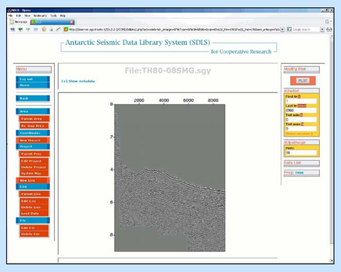
The data over 8 years from collection are accessible at the principal SDLS website: http://snap.ogs.trieste.it/SDLS hosted by OGS in Italy. This SDLS site is based on the SNAP web portal framework; this utilises the LAMP (Linux, Apache, MySQL, PHP) platform and Open Source software such as CWP/SU and GMT.
Seismic data can be selected from the database using user-specific criteria, such as geographic areas or metadata parameters, and interactively displayed at any scale, with zoom or pan, directly from the SEG-Y files. Download facilities are available for both the navigation and seismic (SEG-Y) datasets. The site also lists all the cruises from which the data have been submitted and those data that are now due at the SDLS.
Currently, a secondary SDLS website: www.scar-sdls.org provides additional graphic images (e.g. tiff) of the MCS data.

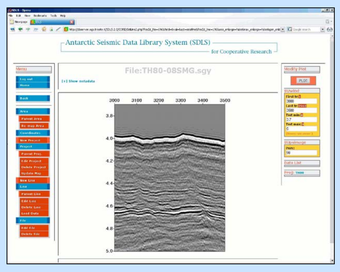












SDLS Goal for IPY

The Goal: In the spirit of Antarctic Treaty Article III and ATCM Recommendation XVI-12, the SDLS seeks to have all Antarctic multichannel seismic reflection data collected more than four years ago submitted to the SDLS before the end of IPY, to further enhance, facilitate and promote cooperative geoscience research efforts in offshore Antarctic regions.

The goal is realistic and achievable with the concerted help of the Antarctic MCS community.

Weddell Sea

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
NARE-77	WS	76/77	UB	Norway	910	X	06/02/05	
BGR-78	WS	78/79	BGR	Germany	5854	X	8/15/93	SDLS 17,18,19
NARE-79	WS	78/79	UB	Norway	134	X	3/10/92 10%	SDLS 20
NARE-79	WS	78/79	UB	Norway	1095	X	6/2/05 90%	
SAE-26	WS	80/81	PMGRE	USSR	750		Data are due	
TH81	WS	81/82	JNOC	Japan	1420	X	01/01/03	SDLS 51
SAE-27	WS	81/82	PMGRE	USSR	820		Data are due	
SAE-30	WS	84/85	SMG/PMGRE	USSR	734		No Stack Data	
NARE-85	WS	85	UB	Norway	800	X	9/15/93 30%	SDLS 20
NARE-85	WS	85	UB	Norway	1842	X	6/2/05 70%	
ANT-IV/3	WS	85/86	BGR	Germany	6263	X	Data are due	
ANT V/4	WS	86/87	AWI	Germany	2800	X	Data are due	
SAE-34	WS	88/89	SMG/PMGRE	USSR	1224	X	No Stack Data	
ANT VIII/5	WS	89/90	AWI	Germany	4100	X	Data are due	
ANT-VIII/6	WS	90/91	BGR	Germany	3213	X	Data are due	
ANT X/2	WS	91/92	AWI	Germany	3900	X	Data are due	
ANT-XII/3	WS	94/95	AWI	Germany	2000	X	Data are due	
BGR-96	WS	95/96	BGR	Germany	3262	X	Data are due	
ANT-XIII/3	WS	95/96	AWI	Germany	500	X	Data are due	
ANT-XIV/3	WS	96/97	AWI	Germany	4418	X	Data are due	

Antarctic Peninsula

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
U6	AP	79/80	PAS	Poland	1100		Data are due	
TH80	AP	80/81	JNOC	Japan	3280	X	01/01/03	SDLS 50
BAS-84S	AP	85	BAS	UK	1750	X	01/01/93 50%	SDLS 16
BAS-84S	AP	85	BAS	UK	1764	X	03/13/98 50%	SDLS 30
TH86	AP	86/87	JNOC	Japan	2655	X	9/30/93	SDLS 23
A5	AP	87/88	PB	Brazil	4914	X	9/20/93	SDLS 26,27
TH87	AP	87/88	JNOC	Japan	2265	X	9/30/93	SDLS 24
D172	AP	87/88	BAS	UK	3640	X	Data are due	
ANT VI/2	AP	87/88	AWI/IG Kiel	Germany	1400	X	Data are due	
SA500	AP	88	PB	Brazil	552	X	9/20/93	SDLS 26,27
TH88	AP	88/89	JNOC	Japan	2200	X	9/30/93	SDLS 25
IT90AP	AP	89/90	OGS	Italy	3406	X	11/15/95	SDLS 31,32,33
SAE-35	AP	89/90	SMG/MAGE	USSR	3010	X	Data are due	
IT91AP	AP	90/91	OGS	Italy	3560	X	11/15/95	SDLS 35,36,37
U39	AP	91	MoG	China	2015		Data are due	
EW9101	AP	91	NSF/UT/LDEO	USA	2880	X	10/15/99	SDLS 43,44
EW9101	AP	91	NSF/UT/LDEO	USA	1320		Data are due	
ANT92	AP	91/92	IAGM/CSIC/UG	Spain	1525		Data are due	
SCOTIA92	AP	91/92	IEO/UB/WHOI	Spain	1500		Data are due	
IT92AP	AP	91/92	OGS	Italy	3423	X	2/15/96	SDLS 39,40,41
RAE-37	AP	91/92	PMGRE	Russia	2900	X	11/22/06	SDLS 84
KSL93	AP	92/93	KORDI	Korea	900		8/15/99	
HESANT 92/93	AP	92/93	IAGM/CSIC/UG	Spain	3560		Data are due	
JCR04	AP	92/93	BAS	UK	1520	X	12/01/01	SDLS 38
IT95AP	AP	94/95	OGS	Italy	1847	X	2/15/99	SDLS 47,48,49
IT95AP	AP	94/95	OGS	Italy	2622	X	2/15/99	
NBP95-7	AP	94/95	NSF/UT	USA	350		Data are due	
TH96	AP	96/97	JNOC	Japan	2475	X	01/01/03	SDLS 68,69
SCAN 97	AP	96/97	IACT/CSIC/UGR	Spain	3778		Data are due	
IT96AP	AP	96/97	OGS	Italy	2799	X	2/15/01	
TH97	AP	97/98	JNOC	Japan	1790	X	01/01/03	SDLS 70,71
ANTPAC 97/98	AP	97/98	IACT/CSIC/UGR	Spain	2685		Data are due	
KSL98	AP	98/99	KORDI	Korea	980	X	27/11/07	
KSL99	AP	99/00	KORDI	Korea	830	X	27/11/07	
KSL00	AP	00/01	KORDI	Korea	750	X	27/11/07	
KSL01	AP	01/02	KORDI	Korea	580	X	27/11/07	
ANT-XIX/2	AP	01/02	AWI/ING	Germany/Italy	2930	X	Data are due	
HE078	AP	01/02	UB/ICM-CSIC/OGS	Spain/Italy	1260	X	Data are due	
KSL02	AP	02/03	KORDI	Korea	570	X	27/11/07	
KSL03	AP	03/04	KORDI	Korea	640	X	Data are due	
KSL04	AP	04/05	KOPRI	Korea	740	X		
SCAN 2004	AP	04/05	IACT/CSIC/UGR	Spain	2791			
KSL05	AP	05/06	KOPRI	Korea	680			

Marie Byrd Land

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
ANT-XI/3	AP/MBL	93/94	AWI	Germany	3448	X	07/09/06	
ANT-XII/4	AP/MBL	94/95	AWI	Germany	989	X	07/09/06	
ANT-XVIII/5a	AP/MBL	00/01	AWI/VI	Germany/Russia	572	X	07/09/06	
ANT-XXIII/4	MBL	05/06	AWI/BAS/VI	Germany, UK, Russia	2227	X		

Ross Sea

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
BGR-80	RS	80/81	BGR	Germany	6745	X	05/01/92	SDLS 3,4,5
ATC82	RS	82	IFP	France	1800	X	12/01/92	SDLS 12
TH82	RS	82/83	JNOC	Japan	1670	X	10/01/92	SDLS 9
L284	RS	83/84	USGS	USA	1850	X	01/01/90	SDLS 1
SAE-32	RS	86/87	SMG/PMGRE	USSR	4320	X	12/01/92	SDLS 13
IT88RS	RS	87/88	OGS	Italy	2323	X	04/01/92	SDLS 2
SAE-34	RS	88/89	SMG/MAGE	USSR	3175	X	12/01/92	SDLS 14
IT89RS	RS	88/89	OGS	Italy	4202	X	11/15/95	SDLS 28,29
IT90RS	RS	89/90	OGS	Italy	2503	X	11/15/95	SDLS 34
IT91RS	RS	90/91	OGS	Italy	554	X	2/15/96	SDLS 42
TH91	RS	91/92	JNOC	Japan	3290	X	01/01/03	SDLS 55,56
TH92	RS	92/93	JNOC	Japan	2765	X	01/01/03	SDLS 57,58
IT94RS	RS	93/94	OGS	Italy	851	X	2/15/98	SDLS 42
NBP94-7	RS	93/94	NSF/UA	USA	100		08/01/99	
TH95	RS	95/96	JNOC	Japan	1980	X	01/01/03	SDLS 64,65,66,67
NBP96-1	RS	95/96	NSF/UC	USA	1980	X	2/15/00	SDLS 45,46
NBP96-1	RS	95/96	NSF/UC	USA	500	X	Data are due	
NBP96-2	RS	95/96	NSF/Scripps	USA	2912	X	10/08/04	
NBP97-2	RS	96/97	NSF/Scripps	USA	3509	X	8/15/04	
NBP03-1	RS	02/03	NSF/UCSB	USA	2253	X	06/19/07	
NBP03-6	RS	02/03	NSF/UCSB	USA	1400	X	09/20/07	
NBP04-1	RS	04	NSF/OSU/UTIG	USA	2000	X	06/14/08	
TAN0602	RS	05/06	LINZ	New Zealand	3400			
NBP07-01	RS	06/07	NSF/UCSD	USA	2750	X		

Queen Maud Land

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
TH85	QML	85/86	JNOC	Japan	2430	X	9/30/93	SDLS 22
RAE-41	QML	95/96	PMGRE	Russia	3451	X	2/14/06	SDLS 85
RAE-43	QML	97/98	PMGRE	Russia	4396	X	2/14/06	SDLS 85
RAE-44	QML	98/99	PMGRE	Russia	4492	X	2/14/06	SDLS 85
NPD-PMGE-2002	QML	01/02	NPD/PMGE	Norway	2600	X	2/14/07	SDLS 87
NPD-PMGE-2003	QML	02/03	NPD/PMGE	Norway	2440	X	2/14/07	SDLS 87
NPD-PMGE-2004	QML	03/04	NPD/PMRE	Norway	2950	X	2/14/07	SDLS 87

Enderby Land

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
RAE-45	EL	99/00	PMGRE	Russia	4390	X	2/14/06	SDLS 86
RAE-46	EL	00/01	PMGRE	Russia	4537	X	11/22/06	SDLS 86

Prydz Bay

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
BMR-33	PB	82	BMR	Australia	5006	X	03/01/92	SDLS 6,7,8
TH84	PB	84/85	JNOC	Japan	2350	X	9/30/93	SDLS 21
SAE-31	PB	85/86	SMG/PMGRE	USSR	930	X	12/01/92	SDLS MF1 *
MD47	PB	86	EOST	France	1612	X	Data are due	
SAE-32	PB	86/87	SMG/PMGRE	USSR	3070	X	12/01/92	SDLS MF1 *
SAE-33	PB	87/88	SMG/PMGRE	USSR	3710	X	12/01/92	SDLS MF1 *
TH89	PB	89/90	JNOC	Japan	1835	X	01/01/03	SDLS 52
MD67	PB	91	EOST	France	1194	X	Data are due	
RAE-39	PB	93/94	PMGRE	Russia	2550	X	11/22/06	SDLS 84
RAE-40	PB	94/95	PMGRE	Russia	3429	X	11/22/06	SDLS 84
TH98	PB	98/99	JNOC	Japan	2490	X	01/01/03	SDLS 72,73,74
TH99	PB	99/00	JNOC	Japan	2195	X	01/01/03	SDLS 75,76
RAE-47	PB	01/02	PMGRE	Russia	4208	X	Data are due	
RAE-48	PB/WL	02/03	PMGRE	Russia	4352	X	Data are due	

Wilkes Land

Cruise	Area	Season	Group	Country	MCS (km)	Nav. data to SDLS	Seismic data to SDLS	CD-ROM No.
ATC82	WL	82	IFP	France	3100	X	12/01/92	SDLS 11
TH82	WL	82/83	JNOC	Japan	680	X	10/01/92	SDLS 9
TH83	WL	83/84	JNOC	Japan	3700	X	10/01/92	SDLS 10
L184	WL	83/84	USGS	USA	1800	X	01/01/90	SDLS 15
IT89WL	WL	88/89	OGS	Italy	3053	X	01/15/07	SDLS 88
IT90WL	WL	89/90	OGS	Italy	1274	X	01/15/07	SDLS 88
IT91WL	WL	90/91	OGS	Italy	1924	X	01/15/07	SDLS 88
WEGA	WL	99/00	OGS/GA	Italy/Aus	1827	X	4/30/06	
TH90	WL	90/91	JNOC	Japan	2095	X	01/01/03	SDLS 53,54
TH93	WL	93/94	JNOC	Japan	3040	X	01/01/03	SDLS 59,60,61
TH94	WL	94/95	JNOC	Japan	2375	X	01/01/03	SDLS 62,63
GA227	WL	00/01	Geoscience Australia	Australia	3427	X	03/10/06	SDLS 77
GA228	WL	00/01	Geoscience Australia	Australia	10612	X	03/10/06	SDLS 78,79,80
GA229	WL	01/02	Geoscience Australia	Australia	9607	X	03/10/06	SDLS 81,82,83
RAE-49	WL	03/04	PMGRE	Russia	4122	X	Data is due	
RAE-50	WL	04/05	PMGRE	Russia	4090	X		
RAE-51	WL	06/07	PMGRE	Russia	4850	X		
RAE-53	WL	07/08	PMGRE	Russia	4590	X		