



SOUTH GEORGIA & SOUTH SANDWICH ISLANDS

TERRESTRIAL ENVIRONMENT

This document provides a description of physical environment, historical context and flora and fauna which together contribute to making the protected features of the Terrestrial Protected areas of South Georgia and the South Sandwich Islands.

It will be updated from time to time as more information becomes available

Version	Date	Details
V1	30 th October 2023	Finalised initial text

1. Physical environment

1.1. Geography

The main island of South Georgia is approximately 170 km long and between 2 and 40 km wide located approximately 1,400 km south east of the Falkland Islands and 2000 km south east of Cape Horn. Surrounding the main island of South Georgia are a number of satellite islands including Bird Island and Willis Islands off the tip of the west coast, Annenkov and Pickersgill Islands off the south west coast and Cooper Island to the east. There are also numerous other smaller islands and rock stacks scattered along the north coast. The extremes of land surrounding South Georgia are Shag Rocks and Black Rock which lie 250km to the north-west of the mainland and Clerke Rocks and the Office Boys which lie 65 km to the south east.

The South Sandwich Islands are a string of eleven volcanic islands and associated seamounts approximately 500 km to the south east of South Georgia. The island chain stretches for over 400 km in a north to south direction. From North to south they are Zavodovski, Leskov, Visokoi, Candlemas, Vindication, Saunders, Montagu, Bristol, Bellingshausen, Cook and Thule. The South Sandwich Islands range in size from the largest, Montagu, at 110 km² to the smallest, Leskov, at 0.3 km²



1.2. Topography

The topography of South Georgia is mountainous and rugged. Two mountain ranges, the Allardyce and Salvesen, form the backbone of the main island. The highest peak is Mt Paget which is 2,935 m.a.s.l with twelve other with peaks above 2,000 m.a.s.l. Land at the north west of the island is typically more low lying with greater areas of coastal plateau compared to the south east of the island where mountains rise steeply from the sea. The northern coast of the island is indented with a number of deep bays and inlets many of which are fed from glaciers. There is little standing fresh water or inland lakes. Those which do exist are usually associated with melt from glaciers.

The South Sandwich Islands are rugged and remote. As volcanic islands they typically have a central peak which usually descends steeply into the ocean. Some have collapsed craters and ash plateaus depending on the eruption history. The highest point in the South Sandwich Islands chain is Mt Belinda which is 1,370 m.a.s.l. and is located on Montagu Island. With the exception of Leskov and Bellinghousen islands, which are smaller and more low lying, all of the South Sandwich Islands have peaks in excess of 400m.a.s.l. with three having a peak above 1000 m.a.s.l.

Island	Highest point (m.a.s.l.)	Name of peak
South Georgia	2935	Mt Paget
Montague	1370	Mt Belinda
Cook	1115	Mt Harmer
Bristol	1100	Mt Darnley
Saunders	990	Mt Michael
Visokoi	915	Mt Hodson
Thule	710	Mt Larsen
Candlemass	550	Mt Andromeda
Zavodovski	550	Mt Asphyxia
Bellingshausen	255	Basillisk Peak
Leskov	190	Rudder Point

1.3. Glaciology

It is thought that glaciers first formed on South Georgia around 5 million years ago. During the last glacial maximum, around 20, 000, years ago the island would have been entirely covered by an icecap that extended beyond the land leaving only tiny ice free refugia on the highest peaks. Since then, glaciers have retreated and today around half of the land on South Georgia is permanently covered with ice and snow. There are around 160 glaciers, most of which are retreating at a rate of anything from around 12 m per year on the cooler south side



of the island to 384 m per year on the Neumayer glacier on the north coast. The retreat of glaciers has meant in some cases where glaciers once terminated in the sea, they now terminate on land leaving bare ground which is ripe for colonisation by plants and invertebrates.

Although the extent of ice cover is today much reduced, there is still extensive evidence of its presence and ongoing freezing conditions. Scree slopes and block fields are common and in flatter areas repeated freezing and thawing of the ground results on 'sorting' of loose rock in to stripes and polygons. At sites where glaciers have retreated it is often still possible to identify mounds and ridges of moraine or scooped out lakes in valley bottoms left behind when glaciers melted. Another key feature indirectly caused by glaciation are raised beaches, common on the more sheltered north coast. These are large flat areas of glacial outwash raised 3 to 7 m above current sea-level as a result of isostatic rebound of the land following glacial retreat.

1.4. Geology

South Georgia has a complex and unusual geology that is closely related to the geology of Tierra del Fuego. The geological history of South Georgia began when the precursor to the Pacific Plate was subducted beneath the South American Plate approximately 150 million years ago. At this point South America and Antarctica were still connected by a land bridge which broke apart around 30 million years ago. As a result, the Scotia Sea was formed and small blocks of continental crust, such as the one which South Georgia sits on broke away to form micro-plates.

Because of this unusual history, unlike most isolated oceanic islands the rocks on South Georgia are not entirely of volcanic origin but instead are sedimentary rocks which have been washed down from long extinct volcanoes as they eroded. The main rock types on South Georgia, covering the northern and central part are shale and sandstones of the Cumberland Bay and Sandebugton Formation. Thought to have formed around 130 million years ago during the Early Cretaceous when large deposits of sand and mud were deposited into a basin. As a result this rock has a striking layered appearance. Around 80 million years ago, whilst South Georgia was still attached to South America, movement of tectonic plates caused the closure of this basin and the rocks within it were squeezed, folded and uplifted along a fault known as the Cooper Bay Dislocation Zone

South of the Cooper Bay Dislocation Zone lies the Drygalski Fjord Complex. These ancient rocks are igneous granites, gabbros and metamorphic sandstones thought to have formed during in the Triassic period and are a remnant of the ancient supercontinent of Gondwana.



To the south of Drygalski Fjord and north to Undine Harbour South is the volcanic Larsen Harbour Formation which formed around 50 million years later in at the start of the Jurassic period. This formed the basis for the ash which forms the Annenkov Island mud stone. It is in this mudstone that occasional fossils of marine molluscs and wood are found.

1.5. Volcanism (credit Emma Nicholson)

The South Sandwich Islands are one of the most remote and enigmatic sites of volcanism on Earth. Sporadic observations from rare cloud-free satellite images—and even rarer in situ reports—provide glimpses into a dynamic volcanic environment characterised by persistent gas emissions and frequent eruptive activity. The islands themselves are the emergent portions of deep-rooted volcanoes that extend several kilometres beneath the sea to the ocean floor. Since 1900, expressions of active volcanism—most commonly in the form of gas emissions—have been reported from all islands but Vindication, which represents the eroded remnants of an ancient stratovolcano.

The development of the South Sandwich Islands over the past 10 million years is closely linked with the formation of the Drake Passage, making this one of the youngest known volcanic arcs on Earth and therefore one of the most important for understanding how volcanic systems initiate and mature. This chain of volcanoes was created as the South American tectonic plate began to descend westwards beneath the smaller Sandwich plate; this process of plate “subduction” continues to the present day, generating molten magmas that rise buoyantly from the Earth’s mantle, through the thin oceanic crust above, to erupt at the surface and ultimately build volcanoes. The crust beneath these volcanoes is also exceptionally thin relative to global norms—only ~12 km thick compared to more than 30 km for established continental crust —again raising fundamental questions about where, and over what timescales, magmas are stored in the crust before they are ultimately erupted.

Volcanic activity in the South Sandwich Islands remains ongoing, with hazard implications for future terrestrial operations. Satellite and in situ observations reveal persistent gas emissions, punctuated by sporadic explosive or lava flow activity, to be characteristic eruptive behaviours. Most recently, ash-rich plumes were observed emanating from the main crater of Mt Curry on Zavodovski between March and June 2016, covering the eastern flanks in fresh dark ash deposits. Mt Michael, currently the most persistently active of the South Sandwich Island volcanoes, hosts a lava lake within its summit crater—one of only a handful known globally. Recurrent thermal “hotspots” in satellite imagery over the past few decades suggest that magma remains close to the surface over prolonged timescales. Lava lakes are rare natural phenomena, sustained by continual cycling of magma and gases where the delivery and loss of heat at the surface are perfectly balanced. As a result of this open vent behavior,



Mt Michael sustains voluminous gas emissions of several hundred tons per day is consequently a type example of open vent volcanism to investigate both eruption precursors and the long-term impacts of volcanic gas release on climate and the terrestrial environment (e.g. hydrological systems). The South Sandwich Islands are still developing and in 1962 a submarine eruption at the northern end of the volcanic arc began building a new seamount on the seafloor—Protector Shoal—that may eventually grow to become the newest island in the arc.

Consequently, the volcanoes of the South Sandwich Islands provide unique natural laboratories to investigate volcano development, eruptive processes and hazards, and the intersection between vulnerable ecological systems and natural hazards. The islands are extraordinarily biodiverse and volcanic activity is likely to have had significant and ongoing impacts on local terrestrial and marine ecosystems (e.g., Roberts et al., 2017). Active seafloor hydrothermal venting, important for sustaining chemosynthetic microbial communities key to the evolution of early life, exists within Kemp and Adventure calderas in the southern section of the arc and from the Protector Seamount region in the north. Bathymetric surveys reveal numerous landslide deposits on the submarine flanks of the South Sandwich Islands, highlighting an important yet comparably understudied volcanic hazard that may become increasingly prominent in the face of current climate change and glacial melting.

1.6. Climate

The climates of South Georgia and the South Sandwich Islands are principally driven by the oceans which surround them.

South Georgia is south of the polar front and directly in the path of the Antarctic circumpolar current the cooling effect of the ocean is key to the islands cold, wet, windy maritime climate. Average temperature on South Georgia in the winter at sea level is 0°C to -1°C but the moisture laden air means that in this period precipitation falls as snow which frequently covers the entire island down to sea level from May to October. The maritime climate means that in summer temperatures at sea level range from an average of 3°C to 5°C although there can be significant microclimatic variation locally. On the sheltered north coast temperatures in the summer months regularly exceed 10°C.

More than any other feature it is the wind, and its interaction with the high peaks in the centre of South Georgia, which drives local weather. The prevailing westerly wind and stream of weather systems brings frequent gales, low cloud, rain and snow. The parts of the island exposed to the full force of this weather on the southern coast and both easterly and westerly extremes are typically cooler and damper than the central northern coastline which is



sheltered by the towering peaks of the Allardyce Range. However, whilst ordinarily providing a degree of shelter, being in the lee of these mountains means the bays experience tow unusual wind phenomenon. Katabatic winds occurs when air flowing from the west comes into contact with the heavily glaciated interior of the island, cools rapidly and becoming denser, drains away down slope. Föhn winds occur when the westerly airstream is partly blocked by towering peaks in the centre of the island causing it to be forced around the lower areas. However, a small amount ‘spills’ over the crest of the mountains and drops down the lee of the slope warming rapidly as it decants causing a strong, warm off shore wind. Waves within the föhn winds sometimes trigger violent downdrafts of up to 100 mph known as williwaws.

The lack of permanent human presence and the inaccessibility of the islands mean there are less detailed records for the climate on the South Sandwich Islands. Like South Georgia, their climate is heavily influenced by the surrounding ocean and their position to the south of the Antarctic circumpolar current means that they are on average much colder than South Georgia remaining near zero even in the summer. In the winter months the sea ice extends throughout the chain.

2. Flora and Fauna

2.1. Vascular plants

Relative to plant communities at lower latitudes, the vascular plant flora of South Georgia is poorly developed, probably as a consequence of the island’s isolation from major landmasses. During the Pleistocene, South Georgia is likely to have been almost completely covered with ice, and evidence from peat cores suggests that substantial plant communities only developed 10,000 – 12,000 years ago with wind and birds playing a major role in seed and spore dispersal. The current conditions of high precipitation, low temperatures along with acidic water-logged soils, mean the native vascular plant flora still stands at just 24 native species which consist of 5 grass species, 2 rush species, 1 sedge, 9 dicotyledon herbs, 6 ferns and 1 club moss. The majority of South Georgia flora is derived from the southern tip of South America and the neighbouring Falkland Islands. However, a few species are more cosmopolitan such as the brittle bladder fern (*Cystopteris fragilis*) which has world-wide distribution, and the alpine cat’s tail (*Phleum alpinum*) and water blinks (*Montia fontana*) which have bipolar distributions. South Georgia has just one endemic sub-species of plant which is a natural hybrid between greater and lesser burnet species (*Acaena magellanica* and *Acaena tenera*).



Scientific name	Common name
<i>Acaena magellanica</i>	Greater burnet
<i>Acaena tenera</i>	Lesser burnet
<i>A. magellanica</i> x <i>A. tenera</i>	Hybrid burnet
<i>Callitriche antarctica</i>	Antarctic starwort
<i>Colobanthus quitensis</i>	Antarctic pearlwort
<i>Colobanthus subulatus</i>	Lesser pearlwort
<i>Galium antarcticum</i>	Antarctic bedstraw
<i>Montia fontana</i>	Water blinks
<i>Ranunculus biternatus</i>	Antarctic buttercup
<i>Alopecurus magellanicus</i>	Antarctic foxtail
<i>Deschampsia antarctica</i>	Antarctic hairgrass
<i>Festuca contracta</i>	Tufted fescue
<i>Poa flabellata</i>	Tussock grass
<i>Phleum alpinium</i>	Alpine cats tail
<i>Carex meridensis</i>	Smith's sedge
<i>Juncus scheuchzerioides</i>	Greater native rush
<i>Rostkovia magellanica</i>	Brown rush
<i>Polystichum mohrioides</i>	Shield fern
<i>Hymenophyllum falklandicum</i>	Filmy fern
<i>Blechnum penna-marina</i>	Small fern
<i>Cystopteris fragilis</i>	Brittle bladder fern
<i>Grammitis poeppigiana</i>	Strap fern
<i>Ophioglossum crotalophoroides</i>	Adders tongue
<i>Lycopodium magellanicum</i>	Magellanic clubmoss

In addition to the native flora, there are 83 non-native plant species recorded from South Georgia. Of these, 34 species are historic and presumed extinct, 3 are widespread and naturalised and 5 are common locally.

The volcanic nature of the South Sandwich Islands and the harsh climate means that the flora is very different to elsewhere in the region. Just one vascular plant species, the Antarctic hair grass (*Deschampsia antarctica*), has been recorded.

2.2. Non-vascular plants, fungi and lichen

In contrast to the vascular flora, South Georgia and the South Sandwich Islands support a rich non-vascular flora, although it is understudied. Around 120 species of moss and 100 species



of liverwort have been recorded from the island. In addition, 194 lichen species and 113 fungal taxa including 37 basidiomycetes, 49 ascomycetes, 6 myxomycetes and at least 21 lower fungi some found on rotting timber and other imported materials (and so which may have been introduced) have been described.

Despite depauperate vascular plant communities, the South Sandwich Islands have exceptional bryoflora, with lush moss and liverwort communities around fumeroles. To date, 38 species of moss and 11 species of liverwort have been described along with 46 species of lichen and 5 basidiomycete fungi in association with heated ground.

2.3. Plant Communities

On South Georgia the vascular and non-vascular flora, fungi and lichen combine to form 16 principal plant communities.

Community type	Sub-type	Description
Tussac grassland	Tussac	<i>Poa flabellata</i> dominates with other species largely excluded.
	Tussac and <i>Festuca</i>	<i>Poa flabellata</i> and <i>Festuca contracta</i> are co-dominant
	Tussac and moss	<i>Poa flabellata</i> dominates with sub-dominant moss species including <i>Polytrichastrum strictum</i> and <i>Chorisodontium aciphyllum</i> . <i>Acaena magellanica</i> may also be present in smaller amounts along with various liverwort species
	Tussac and <i>Acaena</i>	Co-dominance of <i>Poa flabellata</i> and <i>Acaena magellanica</i> .
	Tussac, moss and <i>Poa annua</i>	Degraded tussac where fragments of <i>Poa flabellata</i> are interspersed with <i>Poa annua</i> and <i>Polytrichastrum</i> and <i>Chorisodontium</i> mossbank
	Tussac and mud	<i>Poa flabellata</i> with 75-90% of the ground eroded to mud by the action of seals and penguins
Short Grassland	<i>Festuca</i>	<i>Festuca contracta</i> is dominant but <i>Poa flabellata</i> , <i>Acaena magellanica</i> and various bryophytes may also be present
	<i>Festuca</i> -fellfield mosaic	Distinct mosaic of small patches of 'Festuca grassland' and fellfield vegetation including <i>Phleum alpinum</i> , <i>Deschampsia antarctica</i> and <i>Acaena tenera</i> and various bryophyte and lichen



		<i>species which represent less than 50% ground cover</i>
	Short mixed grassland	Varying mixture of <i>Deschampsia antarctica</i> and <i>Poa annua</i>
	<i>Deschampsia</i> grassland	<i>Deschampsia antarctica</i> and mosses growing mainly on flat waterlogged areas with patches of tussac, <i>Callitriche antarctica</i> , <i>Colobanthus quitensis</i> and <i>Acaena spp.</i>
Mire, bog and herb field	Mire and bog	Combination of bog communities composed of <i>Rostkovia magellanica</i> and moss species, with <i>Acaena magellanica</i> and <i>Deschampsia antarctica</i> , and mire communities composed of the moss <i>Tortula robusta</i> and the rushes <i>Juncus scheuchzerioides</i> and <i>Roskovia magellanica</i>
	<i>Acaena</i> herb field	<i>Acaena magellanica</i> dominates sometimes with an understorey of <i>Tortula robusta</i>
Moss dominated	Moss and tussac	<i>Polytrichastrum alpinum</i> and <i>Chorisodontium aciphyllum</i> dominate with <i>Poa flabellate</i> as a sub-dominant species. <i>Acaena magellanica</i> may present, with <i>Deschampsia antarctica</i> , <i>Rostkovia magellanica</i>
	Hard mossbank	Degraded habitat where <i>polytrichastrum alpinum</i> dominates
Fellfield	Moist lowland fellfield	Heterogeneous mosaic with bare ground interspersed with mosses, lichens, <i>Colobanthus quitensis</i> , <i>Acaena</i> species, and the grasses <i>Phleum alpinum</i> , <i>Deschampsia antarctica</i> and <i>Poa annua</i>
	Sparce lowland fellfield	Similar composition to moist fellfield but a greater portion of bare ground

There is no formal habitat classification for the South Sandwich Islands but principal distinctions are between the ground which benefits from geothermal heat from the volcanoes and that which does not. The presence of large seabird colonies and resulting nutrient input is also likely to impact on the floristic composition.

2.4. Invertebrates

The dominant terrestrial invertebrate taxa on South Georgia are mites (acari) with records of 91 free-living species and 47 parasitic species, but there are also a recorded 41 species of fleas and lice, 20 species of collembolla, 14 diptera species and 9 species of coleoptera. However, it is likely this is an under-representation of the true diversity and is more a representation of the taxonomic expertise available. Studies of the freshwater invertebrate fauna have revealed



more than 100 species including 59 species of rotifer, 29 species of arthropod and at least 22 other invertebrate species including various groups of worms and tardigrades.

The terrestrial invertebrate fauna of the South Sandwich Islands is poorly investigated with only two known surveys from the British Antarctic Survey in 1964 and 1997. These surveys have recorded 29 free-living collembola and acari species and with specimens from other taxa others awaiting identification relocated.

2.5. Penguins

Five species of penguin breed on South Georgia and the South Sandwich Islands. Each occupies a slightly different niche but all have a profound impact on the sites they breed in terms of nutrient input and physical changes to the landscape.

The king penguin (*Aptenodytes patagonica*) is a hugely abundant species on South Georgia and present on all of the South Sandwich Islands all be it in small numbers. It listed by the IUCN as a species of Least Concern. King Penguins usually breed on flat wide beaches and glacial outwash planes with glacial melt water streams. The largest colonies are at St Andrews Bay and Salisbury Plain and numerous smaller colonies dotted along the northern coastline including Fortuna, Gold Harbour, Hound Bay and Royal Bay. Unlike many seabirds which leave the island in the winter, because of the breeding cycle of king penguins takes 14 months from courtship to fledging a chick, they have a year-round presence. As such they provide a vital food winter food source both for scavengers and predators. It is estimated that there are in the region of 450,000 breeding pairs on the island. King penguins feed primarily on lantern fish, pelagic squid and krill and often undertake long foraging trips to the polar front or beyond.

Gentoo penguins (*Pygoscelis papua*) are listed by the IUCN as Near Threatened. They are widely distributed around South Georgia and form small colonies all around the coast on bheches or tussock meadows, sometimes several hundred meters inland. It is estimated that the population size is in the region of 105,000 pairs. Small breeding populations are also found on the South Sandwich Islands. Gentoo penguins typically make sort foraging trips within 12 miles of the coast and feed on krill and small fish and are resident year- round.

Macaroni penguins (*Eudyptes chrysolophus*) are listed by IUCN as Vulnerable but are the most abundant species of penguin on South Georgia with an estimated over 1 million pairs. It is estimated that there are several hundred thousand pairs on the South Sandwich Islands with the largest population on Zavodovski intermingled with the chinstraps. Significant breeding colonies are mostly in the northwest of South Georgia on the Willis Islands, Welcome Islands



and Bird Island but colonies are also found along the north coast Cooper Island/Cooper Bay and Annenkov Island. Macaroni penguins usually form colonies on steep slopes that drop steeply into the sea. Indeed, in places claw marks can be seen on the rocks formed over many years of the birds scaling near vertical cliffs to get to their nest. During the breeding season from October to March, macaroni penguins forage for krill over the shelf and as far as the shelf break. Outside the breeding season they disperse throughout the Scotia sea.

Chinstrap penguins (*Pygoscelis antarctica*) are listed by the IUCN as of Least Concern. At the northern extent of their range, they are relatively uncommon on South Georgia, only being found at Cooper Bay and on Annenkov Island with population estimates of just a few tens of thousand. In contrast, it is thought there may be as many as 1.5 million pairs of chinstrap penguins on the South Sandwich Islands distributed throughout the chain. However, the largest colony in both the Territory and the world, is on Zavodovski which is thought to have in excess of 1 million birds. The colony is located on the slopes of Mt Asphyxia and is at risk from significant mortality in the event of an eruption. Such an eruption took place in 2016 and it is not yet clear if or how this has affected the population size. Chinstrap penguins feed almost exclusively on krill.

A species which is more common on the Antarctic continent, Adelie penguins (*Pygoscelis adeliae*) are rare on South Georgia but is estimated that around 80,000 pairs breed on the more southerly South Sandwich Islands including Candlemas, Saunders, Montague, Bristol, Bellingshausen, Cook and Thule. Feeding mainly on krill and small fish they build nests of stones on flat coastal areas.

2.6. Albatross

South Georgia is home to globally significant breeding populations of albatross. The protection of these species largely falls under the Agreement on the Conservation of Albatrosses and Petrels (ACAP), which the United Kingdom (UK) ratified in 2004, and extended to the relevant Overseas Territories, including South Georgia & the South Sandwich Islands.

Wandering albatross (*Diomedea exulans*) are the largest and perhaps most iconic species of albatross. In 2014/15 an archipelago wide survey estimated that South Georgia supports 1,278 pairs of wandering albatrosses, the third largest breeding population, after the Prince Edward and Crozet islands. Populations of wandering albatross on South Georgia declined steeply at 4% per year between the mid 1990's and 2000 and whilst numbers are now more stable, there is no sign of increase to previous abundance and at some sites populations are



still in decline. Although globally the wandering albatross is listed as Vulnerable to extinction by the IUCN, considered as a regional and biogeographic unit, the long-term decline of the South Georgia population meets the IUCN criteria for Endangered. This highlights the perilous state of the wandering albatross population at South Georgia relative to the other breeding populations.

The majority of the wandering albatross population South Georgia population is located in the northwest of the archipelago with the largest population at Bird Island. Significant populations are also found on Annenkov Island, with a handful of sites supporting small numbers of birds at the southwest tip of the archipelago. Wandering albatross engage in elaborate courtship displays and so nests are often found on sheltered valleys or plateaus where there is has sufficient space for them to stretch the full 3 m of their wingspan. Known to travel long distances on circum-polar foraging trips, feeding on fish, cephalopods, jellyfish and crustaceans.

South Georgia is home to approximately 8% of the worlds breeding population of black-browed albatross (*Thalassarche melanophrys*). The population of black-browed albatross on South Georgia has been in steady decline since the 1970 and the most recent archipelago-wide surveys indicate a decrease of the total South Georgia population of black-browed albatross of 1.8% per year between 2003 and 2014. This is in contrast to populations breeding at the Falkland Islands and southern Chile that have shown substantial increases over the last decade or so. As a result, global increase in numbers the IUCN have changed the global threat status of the black-browed albatross from endangered to near threatened. However, the ongoing decline at South Georgia, thought to be largely attributed to fisheries by-catch in the Benguela upwelling region off south-western Africa, remains cause for concern.

On South Georgia, the black-browed albatross is known to breed at about 20 locations on the mainland and offshore islands of South Georgia, sometimes in mixed colonies with the grey-headed albatross. The majority of these breeding sites are located in the northwest of the archipelago, with fewer sites in the south and southeast. Black-browed albatross colonies are typically on steep coastal headlands or cliffs covered in tussock grass. Black-browed albatross feed on squid, fish and crustaceans but are also well known to scavenge waste and offal thrown from fishing vessels.

South Georgia hosts approximately half of the global population of the grey-headed albatross (*Thalassarche chrysostoma*). As with other species, the population of grey-headed albatross is in decline. Between 2003/04 and 2014/2015 there was a 44% decline in populations and



the IUCN global threat status for the species has been increased from vulnerable to endangered based on the persistent decline of the globally important population on South Georgia. As with other albatross, it is thought the decline is thought to be at least in part due to fisheries by-catch potentially in the waters of the south-east Atlantic and south west Indian Ocean

There are nine grey-headed albatross breeding sites, all located in the northwest of the archipelago, with the largest colonies on Bird Island, the Willis Islands and the Paryadin Peninsula. The majority of the diet comprises of squid but they may also feed on some fish and crustaceans.

Light-mantled albatross (*Phoebastria palpebrata*) are perhaps the least well understood and studied of South Georgia's albatross species. Nesting in single pairs or small groups on cliffs their breeding sites are widely distributed around the island and they can often be seen flying above the bays and inlets around the coast. The population is estimated to be in the region of 5,000 but no recent survey data is available to support this. The main diet is squid and krill.

2.7. Petrels and Prions

South Georgia is home to the world's largest population of northern giant petrels (*Macronectes halli*) with a survey in 2005-2007 estimating there to be 15,398 pairs and the second largest population of southern giant petrels (*Macronectes giganteus*) the same survey estimating there to be 8,803 pairs. Both species are widely distributed across the island but the largest concentration of northern giant petrels was located at the northwest end of the archipelago, whereas the central north coast and northwest end were the most important regions for southern giant petrels. The majority of nests are along the coastal zone close at less than 250 m.a.s.l. and close to major penguin and seal breeding colonies which provide an abundant source of food in the form of scavenged carion. It is thought that flexible and opportunistic foraging behaviour, along with increases in king penguin and seal populations on South Georgia, has meant that giant petrels have bucked the declining population trend of more specialist sea birds such as albatross. Across the archipelago, since 1986/87 southern giant petrel populations have increased by 27% and northern giant petrels populations have increased by 74%. However, recent data from Bird Island show different trends and so ongoing monitoring is vital. Both northern and southern giant petrels are recorded from the South Sandwich Islands in association with penguin colonies.

South Georgia is home to the largest population of white-chinned petrel (*Procellaria aequinoctialis*) with an estimated 800,000 pairs. Acting mainly as surface feeders, their diet is



predominantly krill followed by some fish. They have a wide-spread distribution, nesting in burrows on steep tussock banks along the coast. White-chin petrels were impacted both by invasive reindeer, that through over-grazing and antler running destroyed tussock causing the underlying peat to dry out and nests to collapse, and by rats that predated the eggs. With the eradication of these species, it is hoped populations of white-chinned petrels will increase. White-chin petrels are also a species which historically suffered high by-catch rates in South Georgia fisheries but strict by-catch mitigation measures and 100% observer coverage have reduced by-catch levels significantly. White-chinned petrels are not recorded from the South Sandwich Islands.

Other petrel species breeding on South Georgia are the snow petrel (*Pagodroma nivea*) and cape petrel (*Daption capense*) which both nest on inaccessible rocky cliffs at scattered sites throughout South Georgia and feeding on krill, squid and small fish. The nature of breeding sites makes accurate population estimates challenging but it is estimated that populations 3,000 and 10,000 respectively. Both species are also known, in larger numbers, from the South Sandwich Islands, although no formal survey has taken place. The west coast of Thule appears to be the largest breeding aggregation for both species.

Smallest of the petrels, there are three species of storm petrel on South Georgia; black bellied (*Fregetta tropica*), grey backed (*Garrodia nereis*) and, the most abundant, Wilson's (*Oceanites oceanicus*). Once a relatively rare sight in nearshore waters, since the eradication of rats which used to predate eggs and chicks, storm petrels are an increasingly common site 'dancing' on the surface of the water whilst foraging for small fish and crustaceans. Storm petrels are also known from the South Sandwich Islands.

South Georgia diving petrels (*Pelecanoides georgicus*) and common diving petrels (*Pelecanoides urinatrix*) nest in burrows in upland scree slopes and like the storm petrels were likely to have been heavily impacted by rat predation. Nevertheless, they are abundant species on South Georgia with an estimated population of several million pairs of each. Typically, they forage for small crustaceans and fish on the polar front or to the north of it and so are not recorded from the South Sandwich Islands.

Antarctic prions (*Pachyptila desolata*) are thought to be the most abundant species on South Georgia with some estimations placing the population as high as 22 million pairs. Occupying a similar niche, the population estimate for blue petrels (*Halobaena caerulea*) is in the region of 70,000. Both species nest in burrows in scree and sparsely vegetated slopes and feed on marine copepods.

2.8. Other birds (pintail, pipet, gulls, sheathbill, skua, tern)



The South Georgia pipit (*Anthus antarcticus*) is endemic to the Territory and the only songbird in the Antarctic region. Breeding amongst tussock grass and feeding primarily on insects along the shoreline, its populations were severely depleted by invasive rats, limiting its distribution to the rat free south coast and offshore islands. Since the eradication of rodent's, populations of South Georgia pipits have recovered rapidly and dramatically. The rapid rate of the population recover means no recent accurate population estimate is available.

The South Georgia pintail (*Anas georgica*) is an endemic sub-species of duck. Found throughout the South Georgia coastline wherever there are tussock fringed pools, pintails are resident throughout the year and feed on algae and invertebrates. Unusually for a duck species, they are also known to eat carrion and scavenge on dead seals. Pintails were also likely to have been affected by rodent predation but their fecund nature meant that substantial populations remained. During the rodent eradication projects significant numbers of pintail suffered non-target mortality though consumption of the bait pellets. However, it is likely that since the eradication of rodents populations will have increased.

Brown skuas (*Stercorarius antarcticus*) are a frequent sight on South Georgia and are often seen patrolling the skies above penguin colonies and fur seal breeding beaches looking for food. They nest in the short grass land above the colonies and forming 'clubs' where sub-adult birds group together. Although many disperse to sea during the winter months, the year-round presence of king penguins and opportunities for predation on eggs, chicks and carrion means skuas can be seen year-round. Skuas were another species that were heavily impacted by the rodent eradication project. Due to their scavenging habits, they suffered, primary, secondary and tertiary mortality. However, anecdotally it appears that almost all pre-existing territories are now re-occupied suggesting populations have recovered rapidly.

Snowy sheathbills (*Chionis albus*) are a common site around fur seal breeding beaches and penguin colonies around South Georgia where they scavenge carrion, eggs, invertebrates, algae and other detritus. As king penguin colonies provide year-round food, some birds remain on South Georgia throughout the winter but some migrate to the Falkland Islands or South America after the main breeding season when food is less abundant. It is estimated that populations are in the region of 2000 birds. No sheathbills have been recorded on the South Sandwich Islands. Indeed, one of the enduring mysteries of the South Sandwich Islands is "Where are all the sheathbills?" It seems so improbable that they have never colonised these islands with such a rich food resource.

Kelp gulls (*Larus dominicanus*) are widespread throughout the Southern Hemisphere and on South Georgia are often seen in sheltered bays along the north coast which have dense kelp beds. The gulls primarily feed on small invertebrates and fish that shelter amongst the kelp



but are also known to scavenge on the fringes of penguin and seal colonies. It is estimated that the breeding population is in the region of 2,000 although there has been no recent survey.

Antarctic terns (*Sterna vittate*) nest in flat areas close to the coast but away from the disturbance of major seal and penguin colonies. Colonies are hard to see with the naked eye but birds will make high pitched warning cries and divebomb people who stray too close to their nests. It is estimated that the South Georgia population is in the region of 10,000 breeding pairs. The diet is mostly made up of small fish and some krill.

2.9. Seals

The most abundant species of seal on South Georgia is the Antarctic fur seal (*Arctocephalus gazella*). Listed by the IUCN as Least Concern it is estimated there are in the region of 4 million on South Georgia which represents 95% of the worlds breeding population. Although numbers were severally depleted by the early sealers, remnant populations survived and overtime recovered. The densest fur breeding beaches are found in the north-west of South Georgia but fur seals can be found all along the northern coastline. Fur seals are also found on the more northerly of the South Sandwich Islands but in much lower densities. During the breeding season, male fur seals hold territories on beaches and protect a harem of females which they will breed with as soon as they are fertile again after giving birth. The males defend their territories fiercely and so are particularly susceptible to human disturbance in this period as if seals stray into another territory it can result in vicious fights, sometimes to the death. At the most densely packed breeding beaches it can be unsafe for visitors to go ashore. In late summer, females and pups move away from the beaches inland and can often be found sleeping in tussock grass or forming creches near freshwater pools and flat grassy areas. When at high densities, fur seals are known to have an adverse impact tussock vegetation by trampling causing the tussock bogs to dieback and be replaced with mossy stumps. In areas which were subject to reindeer grazing, this problem was exacerbated. Diet varies but typically krill is the dominant food and is particularly important for females during the breeding season. However, fish and squid are also eaten if krill is not available.

With an estimated population of 400,000, comprising of 110,000 breeding females, the Southern elephant seal (*Mirounga leonina*) is a common sight around South Georgia. Diving to depths of 400 – 1000m for up to 20 min the diet is mostly squid and some fish. Elephant seals are also known from the South Sandwich Islands with a few tens of animals present on most beaches throughout the archipelago. Listed by the IUCN as Least Concern, populations are thought to be relatively stable since the mid-1900's with South Georgia being home to



around 50% of the global population. Like fur seals, elephant seals form harems of females guarded by a single dominant male. Elephant seals breeding season is relatively early in the year with females giving birth in October and this is around the time when spectacular battles for dominance amongst the males play out on the beaches. St Andrews Bay is home to the largest concentration of breeding elephant seals with an estimated 6,000 females at its peak. After weaning their pups females go to sea, returning to the island in late summer in order to moult. During the moult elephant seals remain ashore often piled up in muddy wallows in order to keep warm. They are susceptible to disturbance during this time as they are not taking in food and so are widely dispersed away from the main breeding centres.

The only other species of seal known to breed on South Georgia is a small colony of 50-100 Weddell seals (*Leptonychotes weddellii*) at Larson Harbour. At the most northerly tip of their distribution, the South Georgia seals are unusual in that they breed on the shore as opposed to more southerly populations which usually breed on the ice. It is thought only around 20-30 pups are born each year.

Although not breeding on the island, Leopard seals (*Hydrurga leptonyx*) are frequent visitors to South Georgia in the winter months where they predate penguins although their mixed diet also consists of krill, fish and young seals.

3. Historical context

South Georgia has a long history of exploration, exploitation, science, conflict and habitat restoration. Understanding the cultural heritage and historic context that has shaped South Georgia and impacted its environment both directly and indirectly, is key to delivering the conservation objectives of the Terrestrial Protected Area

3.1. Early discovery

The first sighting of South Georgia was by a British merchant named Antoine de la Roche in 1675. When sailing round Cape Horn de la Roche's ship was blown off course and it is thought that it took shelter in what we now call Drygalski fjord. Another brief glimpse of the island was made by Frenchman Ducloz Guyot in 1756 but again no landing was made. It was 100 years after the initial sightings of the island that the first footfall was made on 17th January 1775 by Captain James Cook. When he initially made his landing, Cook thought he was on the long searched for great Southern Continent. As he proceeded round the coast and rounded the western most tip, it became apparent that he was in fact on an island and he named the point Cape Disappointment.



Cook discovered the South Sandwich Islands as he headed farther south on the same voyage. Thick fog and snow storms made exploration difficult but out of the gloom Cook noted eight rocky masses he thought could be islands or headlands on a distant continent. The conditions made navigation extremely dangerous and so Cook did not explore in detail or land on the islands. The region was next visited in 1819 by the Russian Bellingshausen who was able to explore more thoroughly and confirm the rocky masses seen by Cook were indeed islands and there were three further to the north making 11 in total. However, the first landing on the islands was not until 1818 by some of the early sealers.

3.2. *Exploitation*

Although not the great discovery Cook hoped for, the wealth of seal populations on South Georgia made it a valuable commodity and soon the island was a hub for the British and American sealing industry. Sealers often spent months and the coastline is dotted with evidence of their encampments and the tripods used to render the blubber. The sealing industry was brutal and short lived. In its peak in 1800-1801, 112,000 fur seal pelts were taken in a single season and not surprisingly after a few decades, populations were decimated. A few sealers remained operating until the early 1900's mainly focusing on the blubber from elephant seals but soon this became unsustainable too. When British administration took over at Grytviken a licence system and quota system for elephant seals was introduced and the industry persisted, all be it at a much-reduced scale until the mid 1900's.

A century after the peak of the sealing era, attention turned to the exploitation of whales. The first whaling station on South Georgia, Grytviken, was established in 1904 and within a few years other stations were established in Stromness, Husvik, Leith, Ocean Harbour and Prince Olav harbour. The brutal and destructive industry first targeted easy to catch humpback whales but as techniques improved the attention of the whalers turned to blue and fin whales. Initially whalers just took the blubber from the whales casting the rest out to sea but in 1919 William Allardyce, the Governor of the Falkland Island introduced legislation the meant whole carcasses had to be utilised and limits were placed on the number of catchers which could be deployed. However, in 1925 the invention of the pelagic whaling ship meant that the industry was able to move off shore and operating on the high seas beyond Government regulation over 40,000 whales could be killed each year. The rapid growth of the industry proved to be its downfall and due to overproduction soon the price of whale oil crashed. Although some of the stations struggled on and diversified with a brief pick up after WWII when the price of oil was high, the crashing whale stocks and lack of market for the products meant closure was inevitable. Whaling on South Georgia finally ended in 1965. Since the inception of the industry 175,250 whales had been killed and processed on South Georgia

3.3. *Shackleton*



The story of Shackleton is famous throughout the world. After becoming stranded in ice in the Weddell sea on their way to attempt to be the first to cross the Antarctic continent, Shackleton and his men were forced to abandon their ship *Endurance* and make their way to Elephant Island on the South Shetlands. With limited provisions and no hope of rescue Shackleton and five companions crossed 1,300km of storm drenched Southern Ocean in their 6.9m long vessel *James Caird* to reach the south coast of South Georgia on the 10th of May 1916. Knowing their only hope of assistance laid in the whaling stations on the north coast, Shackleton and two crew members who still had strength, Crean and Worsley, made the first overland crossing of South Georgia. After 36 hours of gruelling effort, Shackleton eventually reached Stromness whaling station on 20th May 1916 and was able to raise the alarm and send help to his crew. Remarkably when Shackleton returned to Elephant Island on the whale catcher *Southern Sky*, all of his men were alive. After returning to England to serve in the first world war, Shackleton returned to South Georgia on the vessel *Quest* an expedition to explore the sub-Antarctic islands and survey the Antarctic coastline. Unfortunately, shortly after arriving on South Georgia, Shackleton suffered a fatal heart attack. His body is buried in Grytviken cemetery.

3.4. Scientific Endeavour

The scientific exploration of South Georgia began in earnest in the 1882 International Polar Year during which a German expedition spent 13 months at Köppen Point in Royal Bay observing the transit of Venus. Throughout the early 1900's a number of other expeditions stopped at South Georgia including one by the Swedish Polar Expedition of 1901-1903 led by Otto Nordenskjöld and a second German expedition led by William Filchner in 1911. In 1926, on realising that the levels of whale harvesting being undertaken could not be sustained in the long term, the British Government initiated the Discovery Investigations in order to better understand the marine ecosystem. This was a mile stone in the study of the natural environment and over the course of the project 38 volumes of scientific reports were produced turning South Georgia from a little-known oddity into one of the best studied locations on earth.

Whilst the Discovery Expeditions principally focused on the marine system, the first in depth studies of the islands terrestrial habitats were not made until 1928-29 by the Köhl-Larsen expedition which made detailed glaciological, geological, metrological and biological observations along many parts of the coast. The second major milestone in study of the island's interior came in 1951-1957 through Duncan Carse and the South Georgia Surveys. Carse and his team worked tirelessly to survey the islands rugged interior producing the first accurate map of the island.



At present, there are two main centres for science on South Georgia. King Edward Point, which was the site of the Discovery Expeditions, was subsequently adopted by the British Antarctic Survey on behalf of the Government in 1969 and remains the centre for Government operations and science to date. Bird Island, to the north-west of South Georgia, has been an important site for the long-term monitoring of seabirds since the 1950's and the British Antarctic Survey established a small station there in 1963.

King Edward Point is the focal point for research to support the management of the South Georgia & South Sandwich Islands Marine Protected Area including work to support sustainable fishing of toothfish, icefish and krill. Fisheries research at KEP involves analysis of specimens and data collected from scientific observers on fishing vessels and a bi-annual trawl survey. To help better understand inter-annual variability in the abundance of fish larvae, krill and other plankton the scientists also undertake monthly plankton sampling in Cumberland Bay and the Bay of Isles. Research and monitoring is also conducted in Antarctic fur seals, elephant seals, gentoo penguins and giant petrels as part of long term ecosystem monitoring. In addition to the core work looking at biological processes, at KEP there are also various earth observation projects including a magnetometer and projects investigating gravity waves by tracking meteors.

Research at Bird Island focuses on long-term monitoring of seabird and seal population dynamics, feeding ecology and reproductive performance. In depth research is conducted into fur seal breeding, facilitated by a raised walkway that allows scientists to access the study colony safely and without disturbing the animals. Other key work involves studies of albatross which are known to be in decline and investigating white-chinned petrels, a bird commonly recorded as a by-catch species in the Southern Ocean. Scientists also research macaroni penguins using an innovative weighbridge which scans the identity of penguins going in and out of the colony and how much food is being brought back to provision chicks as well as monitoring populations of gentoo penguins, giant petrels, skua and other seabirds.

3.5. Military

South Georgia and the South Sandwich Islands are subject to a disputed Sovereignty claim with Argentina. On South Georgia this came to a head in 1982 when an Argentine naval vessel posing as a scrap metal merchant landed at Leith Harbour without clearing customs and was subsequently re-enforced by the submarine *Santa Fe* and additional troops and helicopters. The Argentine forces briefly occupied King Edward Point and forcibly removed the BAS staff to the Argentine ship *Bahia Paraiso*. Just 22 days later the British forces launched operation Paraquat and re-took the island. A British military garrison occupied King Edward Point from then until 2001 at which point it was formally handed over to the Government of South Georgia & South Sandwich Islands (GSGSSI) and was operated by the British Antarctic Survey



3.6. *Habitat Restoration*

The interactive effects of climate change, introduced species and increasing levels of global travel pose perhaps the greatest risk to the South Georgia environment. Species that are already established are able to thrive and newly arrived species that perhaps once would not have been able to survive or complete their lifecycle may be able to do so. This compounded with glacial retreat exposing new land available for colonisation by rapidly growing species and providing land corridors between areas that were once separated by ice. Significant progress in habitat restoration has been made in recent years to mitigate against the effects of introduced species.

Rodents were likely introduced to South Georgia with the first sealing expeditions. As human exploration and exploitation on South Georgia prospered, and shore-based whaling and sealing camps were established throughout much of the northern and south-western coast. Rats spread to infest nearly two thirds of the islands coast line causing devastating effects on ground nesting birds. Mice also established but were restricted to a small pocket of coastline on the south east of the island. The initial stage of the eradication project was to establish if populations in different parts of South Georgia were interconnected. Through sampling genetic material, it was established that large tidewater glaciers provided an effective barrier to dispersal and in effect South Georgia could be treated as several islands within an island. Never the less, the huge scale of the task meant the only feasible option for an eradication was to use helicopters to spread poison bait pellets across all rodent infested areas. A trial of the methodology took place in 2011 where 12,800 ha of ice-free ground was treated and subsequent monitoring showed no signs of rodents in the area thus giving the green light for baiting of the rest of the island Phase II of the operation took place in 2013 and involved baiting 57,600 ha. The third and final phase of the operation took place in early 2015 and a further 36,380 ha were baited. Subsequent monitoring using a range of techniques including rodent detector dogs have found no signs of rodents indicating the project was a success.

Reindeer were introduced by Norwegian whalers on to two discreet areas of South Georgia on three occasions between 1909-1925. in order to provide a familiar food source and to vary an otherwise limited diet of whale, seal and penguin. Combined, these two areas occupied equated to the largest snow free, and consequently most biologically productive, part of the island. After their introduction, the reindeer herds were controlled through regular hunts. However, since the 1980s no hunting or management occurred, and as a consequence the herds expanded substantially, to the point where nearly all available grazing habitat had been utilized and significant damage had been caused to native vegetation. After consultation with stake-holders, in 2013, GSGSSI began a project to eradicate the invasive reindeer from the



Island. The first phase used a combination of herding and ground shooting, to eradicate nearly 2000 reindeer from the Busen area. The herding was undertaken by a team of Sami reindeer specialists from the north of Norway, whilst expert marksmen from the Norwegian Nature Inspectorate (SNO) did the ground shooting. In addition, the marksmen reduced the population on the Barff Peninsula by 1,555 animals. The following year the marksmen returned and shot a further 3,140 animals on the Barff. In the months since the main cull of the Barff herd took place, field parties and aerial searches had been undertaken to determine how many reindeer remained and where they were located. Over the course of the next few years a further 47 animals were sighted and shot by expert marksmen bringing the total number of reindeer eradicated throughout the whole project to over 6,800.

The removal of invasive reindeer brought to a head the impacts of invasive plants. Many plant species were introduced by sealers and those involved in shore-based whaling activities through the importation of building materials, livestock and fodder. Although whaling ceased in the 1960s, one of the legacies of the whaling era is the spread of these non-native plants from the stations and other sites of human activity into the surrounding native vegetation. Once the grazing pressure from reindeer was released, non-native plants flourished and if left unchecked would rapidly outcompete slower growing native species. In 2016 the South Georgia non-native plant management strategy was finalised which provided a long-term commitment to conserve the unique vegetated landscapes and biodiversity of South Georgia through the eradication of the majority of non-native plant species by herbicide control. In addition management has been put in place for more wide spread species, where eradication is not feasible, on a site by site basis to minimise impact and reduce the chance of spread to other areas.

South Georgia is also home to a number of introduced invertebrates and was subject of extensive surveys in 2009 as part of the South Atlantic Invasive Species Project. Of particular concern was the introduced carabid beetle *Trechisbus antarcticus*. The species was first described in Husvik in 1982 but since appears to have increased in distribution significantly. The generalist predatory nature of the species appears to be having a damaging impact on an endemic beetle *Hydromedion sparsutum*. With little hope of eradication of invasive invertebrates once they are established the focus is on biosecurity and preventing introduction in the first place.

There are currently no introduced species of any taxa known from the South Sandwich Islands making them almost unique amongst sub-Antarctic Islands.



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